Domestic water supply in rural Việt Nam – Between self-supply and piped schemes

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Domestic water supply in rural Việt Nam – Between self-supply and piped schemes

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Summary

The question how to improve domestic water supply in rural areas of developing countries has been worrying practitioners as well as researchers since several decades. To date, neither the promotion of self-supply in combination with so-called point-of-use water treatment nor the expansion of piped water schemes turned out to be a panacea for enhancing access to safe water in an affordable and sustainable manner. This thesis analyses and discusses the dissemination of alternative strategies for improving domestic water supply in rural Việt Nam based on statistical micro-data. Currently, water supply in rural Việt Nam is strongly shaped by the coexistence of self-supply and (small-scale) piped schemes. Moreover, practices of domestic water supply, geographical conditions, and the governing environment in the water sector are highly variable across the country and make the analysis of country-wide patterns a challenging task. The Vietnamese water sector has been subject of intensive research endeavours during the past ten years and a rich set of literature allows to draw a detailed picture especially about the political economy of the water sector. Nevertheless a gap remains between in-depth case studies with very limited spatial scope and studies – often in terms of donor reports – which rely on aggregated statistical data to assess progress made in improving domestic water supply but mainly lack systematic analytical insight in the mechanisms which bring about these outcomes. Hence, the present study aims to analyse determinants of domestic water supply on household and communal level in order to identify major obstacles for expanding access to safe water as well as potentials for further improvement. Chapter 1 to 3 recall past and current strategies to approach the problem of insufficient access to water in developing countries and provide an introduction to the country-specific supply and treatment practices as well as the governing framework for the Vietnamese water sector. Subsequently, Chapter 4 makes use of concepts from diffusion research as a theoretical framework in order to structure the further empirical analysis on diffusion determinants for piped schemes and household water treatment. Chapter 5 and 6 are bound by the intention to disentangle the contribution of supply- and demand-side characteristics to hesitant progress in piped scheme coverage. Whereas Chapter 5 elaborates on the *availability* of piped water supply on communal level and sheds light on the role which institutional arrangements play in the diffusion of piped schemes, Chapter 6 focuses on factors influencing the *accessibility* of tap water on household level. The findings show that a large share of the service gap is attributable to supply-side deficiencies, meaning piped schemes simply do not exist within communes. Both the qualitative analysis and the quantitative model reveal that an enabling governing environment on the provincial level exerts substantial influence on the likelihood that piped schemes are under operation in rural communes whereas the influence of the institutional arrangements appears to be limited. Low poverty rates and communal infrastructure projects have been identified as significant drivers for the establishment of piped schemes. In contrast, the empirical findings confirm that the use of tube wells – which once being installed offer convenient supply at low variable costs – poses one of the main obstacles for the establishment of piped schemes as well as individual hook-up. The findings for spatial conditions and settlement structures are ambiguous: those are less relevant for the operation of piped schemes in general, but scattered settlement structures and low population densities make it difficult for households to connect. Thus, supply-side characteristics also pose a crucial limitation to piped scheme hook-up in communes where piped schemes are already under operation. Chapter 7 addresses the application of point-of-use water treatment by rural households as an alternative strategy to improve drinking water and seeks to identify relevant drivers and obstacles in the diffusion of different treatment techniques. Besides boiling, household water treatment (HWT) is not wide-spread and patterns of use vary considerably across the country, whereby spatial disparities can be traced back to 'adoption hotspots' on the level of single communes. Comparing data about HWT application between 2006 and 2011 suggests growing disparities in water safety, because in particular those households consuming the unsafest water sources tend to treat their water less frequently, while those using the safest sources shift to more elaborated treatment techniques. Multivariate regression models show that households with lower educational status, lower disposable income and ethnic minority status significantly less frequently apply HWT. However, despite the fact that households' decisions for or against HWT are understood as 'optional' – meaning that they are taken independently from other adopters – the environmental setting proves much more relevant for explaining HWT use by rural households than their individual socio-economic characteristics. Here, besides spatial characteristics, adoption by other households in their proximity proves most relevant for predicting HWT use.

Zusammenfassung

Die Frage, wie die Wasserversorgung ländlicher Haushalte in Entwicklungsländern verbessert werden kann, beschäftigt Praktiker und Wissenschaftler bereits seit Jahrzehnten. Bisher haben sich jedoch weder sogenannte Point-of-use Aufbereitungstechniken noch der Ausbau zentraler Versorgungssysteme großflächig als bezahlbare und nachhaltige Konzepte durchsetzen können.
Die vorliegende Dissertation untersucht basierend auf statistischen Mikrodaten des Vietnamese Housing and Living Standard Survey (VHLSS) und des Multiple Indicator Cluster Surveys (MICS) verschiedene Strategien zur Sicherung der Wasserversorgung ländlicher Haushalte in Việt Nam. Wenn auch der Fokus in der vorliegenden Dissertation auf den Entwicklungen in Việt Nam liegt, so werden Fragen von länderübergreifender Relevanz addressiert:

- Welche Faktoren begünstigen oder hemmen die Verbreitung zentraler Wasserversorgungssysteme, beziehungsweise die Entscheidung einzelner Haushalte, sich an diese anzuschließen?
- Welche Bedeutung kommt institutionellen Arrangements und Rahmenbedingungen in diesen Prozessen zu?
- Wodurch ist die Nachfrage der Haushalte nach Trinkwasser charakterisiert und welcher Anteil der Versorgungslücke kann auf die Nachfrageseite bzw. die Angebotsseite zurückgeführt werden?
- Welche Faktoren beeinflussen die Verbreitung sogenannter Point-of-use Wasseraufbereitungstechniken in der ländlichen Bevölkerung?
- Inwiefern konterkariert die Verbreitung von Selbstversorgung und Point-of-use-Strategien den Ausbau der zentralen Wasserversorgung?
- Welche Schlussfolgerungen können aus diesen Erkenntnissen für eine koordinierte Strategie zur Verbesserung der ländlichen Wasserversorgung abgeleitet werden?

Nicht zuletzt die politische und wirtschaftliche Öffnung des Landes seit dem Ende der 1980er Jahre und das damit einhergehende stärkere Engagement internationaler Geberorganisationen haben zu einer vertiefenden wissenschaftlichen Auseinandersetzung mit dem vietnamesischen Wassersektor beigetragen. Die vorhandenen (Fall-) Studien erlauben es, ein detailliertes Bild, insbesondere zur politischen Ökonomie des Wassersektors zu zeichnen. Dennoch besteht nach wie vor eine Lücke zwischen vertiefenden Fallstudien mit einer äußerst begrenzten räumlichen Reichweite und Studien – oft in Form von Berichten internationaler Geberorganisationen – die basierend

auf statistischen Sekundärdaten Veränderungen in der Wasserversorgung dokumentieren, jedoch einen analytischen und theoretischen Zugang zur Frage, wie diese zu erklären und bewerten sind, vermissen lassen. Die vorliegende Arbeit widmet sich deshalb der Analyse von Einflussfaktoren auf die ländliche Wasserversorgung und addressiert dabei sowohl die Haushaltsebene als auch den lokalen Kontext.
Việt Nam ist gegenwärtig stark durch das Nebeneinander verschiedener Selbstversorgungsstrategien und zentralisierter lokaler Versorgungssysteme geprägt. Zudem variieren nicht nur die üblichen Praktiken der Wasserversorgung, sondern auch die hydrologisch-geographischen und institutionellen Rahmenbedingungen regional beträchtlich und erschweren die Analyse raumübergreifender Muster in den Versorgungspraktiken. Kapitel 1 bis 3 rekapitulieren grundlegende Paradigmen, die Maßnahmen zur Verbesserung der Wasserversorgung in Entwicklungsländern prägen oder in der Vergangenheit geprägt haben und bieten einen ersten Überblick über die landespezifischen Versorgungs- und Aufbereitungspraktiken sowie die institutionellen Rahmenbedingungen für den vietnamesichen Wassersektor. Obwohl eine Vielzahl staatlicher Akteure auf den unterschiedlichen administrativen Ebenen mit Fragen zur Wasserversorgung betraut ist, was oftmals auch in konfligierenden Zuständigkeiten resultiert, kann der Wassersektor kaum als dezentralisiert bezeichnet werden. Die empirische Analyse lokaler Projekte zur Wasserinfrastruktur weist darauf hin, dass sich der Zentralstaat vor allem in ökonomisch schwachen Gebieten engagiert, während im Süden des Landes die Provinzen dominanter sind und im Red River Delta und der nördlichen Küstenregion vor allem die Kommunen selbst sich an der Finanzierung der Infrastruktur zur Wasserversorgung beteiligen. Darüber hinaus zeigt sich, dass bisher weder partizipative Ansätze im Rahmen des Grassroots Democracy Decrees, noch der privatwirtschaftliche Sektor in der Vergangenheit substantiell zur Verbesserung der Wasserversorgung beitragen konnten.
Kapitel 4 diskutiert anschließend Konzepte der Diffusionsforschung, welche die empirische Analyse der Verbreitung lokaler Versorgungssysteme und Point-of-use Techniken strukturieren. Aus verschiedenen Fallstudien und Diffusionsmodellen werden vier Gruppen von Einflussfaktoren hergeleitet und diskutiert: Eigenschaften der Innovation selbst, solche der „Adopter“, Charakteristika der Umgebung sowie Interventionen zur Unterstützung des Verbreitungsprozesses.
Kapitel 5 und 6 sind verknüpft durch die Intention, den Beitrag angebots- und nachfrageinduzierter Gründe für die geringe Verbreitung und Nutzung zentraler Wasserversorgungssysteme herauszuarbeiten. Kapitel 5 richtet den Blick auf die Verfügbarkeit auf kommunaler Ebene und thematisiert die Bedeutung institutioneller Arrangements für Versorgungssysteme. Es beschreibt und diskutiert zunächst offizielle Empfehlungen für institutionelle Arrangements lokaler Versorgungssysteme basierend auf einer Sekundäranalyse der sektoralen Policies und stellt diese Praxisberichten gegenüber. Die Analyse zeigt, dass der Gestaltung geeigneter institutioneller Arrangements und Etablierung partizipativer und nachfrageorientierter Konzepte zuneh-

mend politische Aufmerksamkeit geschenkt wird, die praktische Umsetzung jedoch durch Unsicherheit und ständige „Kurskorrekturen“ geprägt ist. Obwohl den offiziellen staatlichen Strategien zufolge der private Sektor auch in ländlichen Gebieten mehr Verantwortung übernehmen soll, wird deutlich, dass dieser Anspruch bisher fast ausschließlich in Form direkter Nutzerbeteiligung (z.B. Kooperativen und „water user groups“) realisiert wird. Doch selbst das mancherorts erfolgreiche Modell der Kooperativen ist laut offiziellen Strategiepapieren nur als Übergangslösung akzeptiert und wird seitens verschiedener Akteure ambivalent beurteilt. Die Widersprüche, die sich aus dem Wunsch nach verstärkter Nutzerbeteilung an der Finanzierung, dem Betrieb zentraler Versorgungssysteme und dem daraus resultierenden Mangel an Professionalität ergeben, erscheinen kurzfristig kaum lösbar. Auch die konkrete Ausgestaltung institutioneller Arrangements erweist sich schlußendlich als wenig relevant für deren praktischen Erfolg: erstens, da die staatliche Instanzen auf nationaler und provinzieller Ebene einen strikten regulatorischen Rahmen (z.B. in Form von Preisobergrenzen und Vorgaben für „zulässige“ institutionelle Arrangements) vorgeben und zweitens, da formale Abgrenzungen zwischen den einzelnen Managementmodellen angesichts der überragenden Definitionsmacht der staatlichen Center for Rural Water Supply and Sanitation (CERWASS) praktisch bedeutungslos werden.
Die anschließende Mehrebenenanalyse basierend auf dem Vietnamese Housing and Living Standard Survey bestätigt die Hypothese, dass insbesondere die Konkurrenz durch persistierende Praktiken der Selbstversorgung mit Brunnen einen wesentlichen Hemmfaktor in der Verbreitung lokaler Versorgungssysteme darstellt, während lokale Infrastrukturprojekte sich förderlich auswirken. Anders als erwartet erweisen sich räumliche Faktoren als vergleichsweise unbedeutend: zwar steigt mit wachsender Siedlungsdichte die Wahrscheinlichkeit, dass eine zentrale Wasserversorung in der Kommune betrieben wird, leicht an, doch scheint dieser Effekt beschränkt auf relativ geringe Dichten. Die Größe der Kommune – und somit Anzahl potentieller Nutzer – ist nicht ausschlaggebend. Diese Befunde deuten darauf hin, dass Kommunen nicht per se zu klein sind, um eine zentrale Versorgung zu betreiben, sondern gegebenenfalls Siedlungsmuster zu ungünstig für deren effizienten und rentablen Betrieb. Das Mehrebenenmodell unterstützt darüber hinaus die Hypothese, dass unterschiedliche regulatorische und institutionelle Rahmenbedingungen auf der Ebene der Provinzen die Ausbreitung lokaler Versorgungssysteme begünstigen können. Aufgrund fehlender Daten zur Charaktierisierung der Governancestrukturen auf provinzieller Ebene konnte dieser Effekt jedoch nicht weiter systematisch modelliert werden.
Ausgehend vom empirischen Befund, dass auch dann, wenn in der jeweiligen Kommune eine zentrale Wasserversorgung existiert, im Durchschnitt nur jeder zweite ländliche Haushalt Zugang zu dieser besitzt, fragt Kapitel 6 nach den Ursachen für den schleppenden Zuwachs der Versorgungsquoten innerhalb der Kommunen. In einem ersten Schritt wird die Versorgungquote zunächst analytisch in einen angebots- und einen nachfragebedingten Anteil an der Versorgungslücke zerlegt. Hier bestätigt

sich zunächst, dass die (angebotsbedingte) Verfügbarkeit sich regional stark unterscheidet, während das Defizit im Zugang auf der Haushaltsebene mit Ausnahme des Mekong-Deltas relativ konstant ist. Dieser formale Ansatz zur „Zerlegung“ der Versorgungsquote tendiert jedoch dazu, die angebotsseitigen Defizite zu unterschätzen, da die vorhergehenden Analysen bereits angedeutet hatten, dass nicht zwangsläufig mangelnde Zahlungsbereitschaft oder die Marginalisierung bestimmter Bevölkerungsgruppen ausschlaggebend sind, sondern oftmals Siedlungsmuster (die wiederum mit sozio-demographischen Charakteristika korrellieren), geringe Kapazitäten der Versorgungssysteme oder auch mangelnde Servicequalität. Ein Mehrebenenmodell unter gleichzeitiger Berücksichtigung von Haushalts- und Kontextfaktoren bestätigt, dass Haushalte in Kommunen mit geringen Bevölkerungsdichten weniger häufig an die zentrale Versorgung angeschlossen sind. Weiterhin zeigt das Modell, dass Bohrbrunnen eine konkurrierende Alternative darstellen und auch wohlhabendere Haushalte eher nicht in einen Anschluss an die zentrale Versorgung investieren, sofern sie bereits einen Brunnen besitzen. Dieser Befund stützt die Argumentation von Fallstudien, dass bereits getätigte Investitionen in Bohrbrunnen oder Point-of-use Techniken bzw. niedrige variable Kosten für bisher genutzte Strategien der Wasserversorgung bewirken, dass selbst wenn die variablen Kosten für Trinkwasser reguliert und vergleichsweise gering sind, kurzfristig wenige Haushalte die hohen Kosten für den Erstanschluss aufbringen möchten oder können.
Kapitel 7 wendet sich vertiefend den Point-of-use Aufbereitungstechniken als Alternative zur zentralen Wasserversorgung zu. Es analysiert basierend auf dem Vietnamese Housing and Living Standard Survey (VHLSS) und dem Multiple Cluster Indicator Survey (MICS) räumliche und zeitliche Muster in der Verbreitung von Point-of-use Aufbereitungstechniken und fragt nach Faktoren, die deren Verbreitung begünstigen. Deskriptive Analysen zeigen nicht nur große räumliche Disparitäten auf, sondern deuten auf einen alarmierenden Trend hin: so sind Zuwächse in der Nutzung von Wasseraufbereitungstechniken vor allem unter jenen Haushalten zu verzeichnen, die ohnehin sichere Quellen nutzen, während gerade jene Haushalte, die unsichere Wasserquellen nutzen, zunehmend darauf verzichten. In der multivariaten Analyse bestätigt sich zudem die Hypothese, dass der Diffusionsprozess erstens räumlich hoch konzentriert ist und zweitens der soziale Kontext einer einzelnen Gemeinde weitaus relevanter ist als individuelle Charakteristika der Haushalte. Zwar steigt die Wahrscheinlichkeit, Aufbereitungstechniken zu nutzen mit verfügbarem Einkommen, Zugehörigkeit zur ethnischen Majorität „Kinh“ und steigendem Bildungsniveau leicht an, doch entscheidend ist vor allem die Intensität, mit der in der direkten Umgebung bereits Wasseraufbereitungstechniken von anderen Haushalten genutzt werden und diese somit im Alltag sichtbar werden.

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Acronyms and Abbreviations

ADB	Asian Development Bank
CEMA	Committee for Ethnic Minorities and Affairs
CERWASS	Center for Rural Water Supply and Sanitation
CHC	Communal Health Centre
CPRGS	Comprehensive Poverty Reduction and Growth Strategy
GDD	Grassroots Democracy Decree
GoV	Government of Vietnam
HWT	Household Water Treatment
JMP	Joint Monitoring Programme of WHO and UNICEF
LSMS	Living Standard Measurement Study
M&E	Monitoring & Evaluation
MARD	Ministry of Agriculture and Rural Development
MICS	Multiple Indicator Cluster Survey
MoC	Ministry of Construction
MoET	Ministry of Education and Training
MoF	Ministry of Finance
MoH	Ministry of Health
MoLISA	Ministry of Labour, Invalids, and Social Affairs
MoNRE	Ministry of Natural Resources and Environment
NSRWSS	National Rural Water Supply and Sanitation Strategy
NTP-RWSS	National Target Programme for Rural Water Supply and Sanitation
O&M	Operation & Maintenance
ODA	Official Development Assistance
P 134	Programme 134
P 135	Programme 135

P 143	Programme 143
PAR	Public Administration Reform
PC	People's Committee
POU	Point-of-Use
PSP	Private Sector Participation
RWSN	Rural Water Supply Network
RWSS	Rural Water Supply and Sanitation
SEDP	Socio-Economic Development Plan
SEDS	Socio-Economic Development Strategy
SNV	Netherlands Development Organisation
SOE	State-owned Enterprise
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USD	US-Dollar
VBSP	Vietnam Bank for Social Policies
VHLSS	Vietnamese Housing and Living Standard Survey
VND	Vietnamese Dong
WB	World Bank
WHO	World Health Organisation
WSC	Water Supply Company

Administrative Regions

CH	Central Highlands
MD	Mekong Delta
NCC	North Central Coast
NEA	Northeast
NW	Northwest
RRD	Red River Delta
SCC	South Central Coast
SEA	Southeast

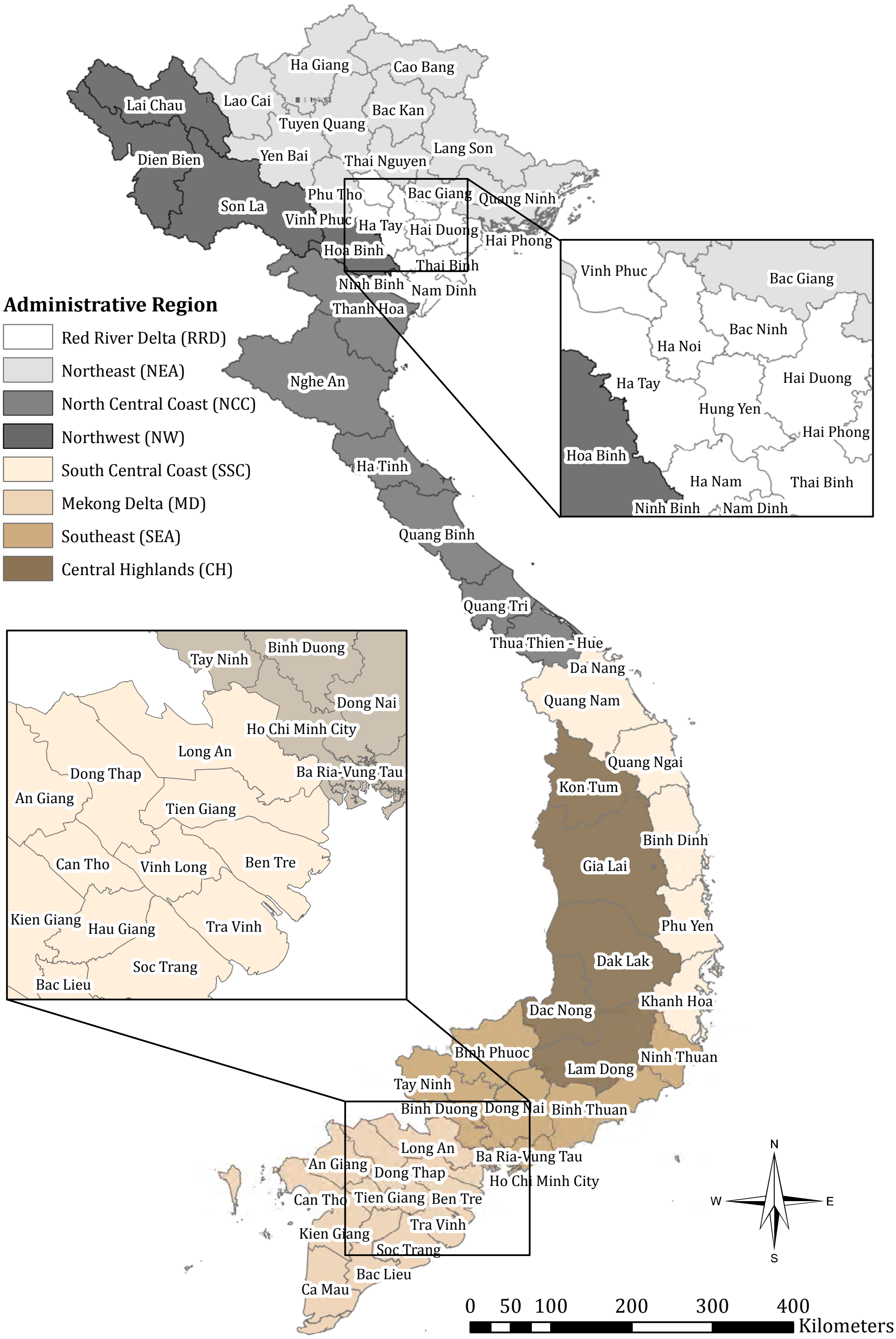
Statistical Terms

$\bar{x}$	Arithmetic Mean
χ^2	Test value for Chi-Square-Test
ρ	Intraclass Correlation (ICC)
σ_e^2	Lowest level residual variance
σ_u^2	Second level residual variance
df	Degrees of Freedom
ll	Log Likelihood
p	Probability Value
r	Pearson's Correlation Coefficient
sd	Standard Deviation
t	Test value for t-Test
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CI	Confidence Interval
EB	Empirical Bayes
FIML	Full Information Maximum Likelihood
iid	Independently and identically distributed
LOWESS	Locally Weighted Scatterplot Smoother
ML	Maximum Likelihood
OLS	Ordinary Least Squares
OR	Odds Ratio
REML	Restricted Information Maximum Likelihood
VIF	Variance Inflation Factor

Currency Equivalents (rounded average for period 2008-2009)

$$\begin{aligned} 1 \text{ EUR} &= 24,000 \text{ VND} \\ 1 \text{ USD} &= 17,000 \text{ VND} \end{aligned}$$

Việt Nam – Administrative Boundaries of Provinces and Regions



Source: Administrative boundaries based on gadm.org (GADM 2013), status 2008/2009

Preface

The question how to improve domestic water supply in rural areas of developing countries has been worrying practitioners as well as researchers since several decades. To date, neither the promotion of self-supply in combination with so-called point-of-use water treatment nor the expansion of piped schemes turned out to be a panacea for enhancing access to safe water in an affordable and sustainable manner. Both approaches produced success stories but likewise suffered from poor implementation and sustainability at other places. Hence, instead of gathering evidence to prove the superiority of the one or other strategy, it seems a more promising approach to elaborate on the conditions under which these strategies fail or succeed, to examine whether they are competing, and how they could be promoted in a targeted and well-coordinated fashion to achieve some progress in safe water supply in developing countries.

This thesis analyses and discusses alternative strategies for domestic water supply in rural Việt Nam mainly based on statistical micro-data and secondary analysis. The basic idea however, originated from field work about point-of-use water treatment techniques for arsenic removal conducted in the Red River Delta, which was funded by the German Federal Ministry of Science and Education (BMBF). From the household survey carried out in this project to gather information on household water treatment practices and talks to experts, it quickly became clear that patterns of use and dissemination strongly vary across communes and that diffusion is less associated to knowledge and awareness about adverse health effects but rather driven by social compliance, norms, and arguably – to an extent that could not be quantified based on the survey data – triggered by interventions. The acknowledgement that the survey finally raised more questions than it was actually able to answer, gave new impetus to fundamentally reformulate the research questions and dedicate more attention to the specific context in which the promotion of water treatment strategies is embedded. Within the course of the project work, it became obvious that for designing sound measures and projects to improve rural water supply, it is inevitable to understand the current practices of domestic water supply, the range of potential alternatives (which also involves the connection to piped schemes), as well as the framing political and institutional conditions in terms of governmental agencies, their functions and objectives, planning and budget allocation procedures, and existing supporting measures.

Lots of these aspects have been addressed by previous research. During the last years, the international scientific communities' interest in the countries' water sector increased in an largely unprecedented amount as compared to other research fields, which is expressed by a growing body of publications and projects. Exemplarily, the following monographs and collected editions should be mentioned here: 'The Mekong Delta System: Interdisciplinary Analyses of a River Delta' (Renaud and Kuenzer 2012), 'Tracing and making the state: policy practices and domestic water supply in the Mekong Delta, Vietnam' (Reis 2012), 'Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance' (Molle et al. 2009a) and 'Water resources and food security in the Vietnam Mekong Delta' (Cosslett and Cosslett 2014). Numerous other aspects are touched upon by research papers. This especially concerns the political economy of the water sector and water management, local practices of domestic water supply, sanitation and irrigation, as well as questions of contamination and pollution of water sources. A large share of these research papers and books have been produced within the framework of large-scale initiatives like WISDOM (Water Information System for the Mekong Delta) and M-POWER ('Mekong Program in Water, Environment and Resilience') or development cooperations (e.g. the Việt Nam Water Sector Review and numerous donor reports).

The soaring number of analyses and initiatives in this domain might be owed to the countries' opening towards developmental, economic, and also scientific cooperation since the 1990es, but also be pushed by the subsequent (financial) support of international and national level donors for these cooperations. In view of the intensified research efforts during the last years, it is a legitimate question to ask whether there is still a need for a comprehensive analysis of rural water supply in Việt Nam and what distinguishes the analysis at hand from existing publications. From the author's point of view, at least four aspects deserve attention here: Firstly, a quick look at the published research output reveals that up to now, first and foremost the Mekong River region has attracted scientists' attention. Empirical investigations about questions of rural water supply have predominantly been carried out in this region, what sometimes rather appears as an artifact of existing cooperations than a genuine research-driven decision. Surely, this region demands for particular attention due to the overriding importance of the river for this region and its dynamic, yet ambiguous development – on the one hand it contributes to the countries' economic progress whereas it is on the other hand shaped by increasing environmental pressures and persisting economic inequalities. Nevertheless, it seems inevitable to systematically cover the countries' diverse regions in order to draw a comprehensive picture about domestic water supply in Việt Nam.

Secondly, a comprehensive analysis and discussion of the recent developments in domestic water supply for rural areas is still pending. Although small-scale studies in Việt Nam already addressed selected aspects of the research questions outlined above, these have neither been discussed with regard to their relevance beyond the specific study area nor sufficiently been embedded in the specific institutional environment and related to the overarching strategical questions of domestic water supply in developing countries.

Thirdly, the use of survey data provides a large untapped potential which has hardly been recognised so far. Although the data sources utilised in this thesis are widely known to the scientific community, in this specific domain they are exclusively used in their aggregated form and have not been analysed in terms of micro-data yet, let alone with regard to their 'hierarchical nature'.

And last but not least, the thesis addresses overarching strategical questions with regard to rural water supply, which are relevant well beyond Việt Nam:

– What affects the diffusion of point-of-use water treatment among the rural population?

– Which factors might drive or inhibit the diffusion of piped schemes and households' decisions to connect to them?

– Which role do institutional arrangements and the country-specific institutional setting play in this process?

– How can rural households' demand for water be characterised and which share of the resulting deficits in coverage are attributable to demand-side characteristics?

– To which extent does the promotion and ensuing use of self-supply and point-of-use water treatment hamper the diffusion of piped schemes?

– Which conclusions can be drawn about measures to promote safe water supply in rural areas?

Many of the issues addressed above are also relevant for other countries: A recent 'cross-cutting analysis of water supply and sanitation in developing countries' (Dondeynaz et al. 2013: 3397) identified Việt Nam as a prototypical representative of a cluster of countries characterised by abundant water resources, considerable gaps between sanitation and water supply coverage, a strong orientation towards agriculture in combination with irrigation, medium human development levels but high levels of external aid, and rather low levels of environmental concerns and governmental accountability (Dondeynaz et al. 2012). So even if the country-specific context might not be relevant for large parts of the 'water community', the problems surely are. That is why the first chapter takes up important discussion lines in the rural water supply and sanitation (RWSS) domain. This introductory chapter recalls past and current strategies to approach the problem of insufficient domestic water supply in rural areas and thereby traces three main trends: the increasing importance of demand-based approaches as a supplement to supply-driven ones, the coexistence of approaches relying on household-based solutions and those aiming at the establishment of piped schemes, and the shift from mono-sectoral, stand-alone measures towards multi-sectoral ones. The second and third chapter dig deeper into the current country-specific water supply and treatment practices as well as the governing framework. Chapter 4 makes use of basic concepts of diffusion research as a theoretical framework in order to structure the further empirical analysis on determinants of diffusion of piped schemes and household water treatment. Chapter

5, 6, and 7 form the core of the empirical analysis based on statistical micro-data. Chapter 5 and 6 are bound by the intention to disentangle the contribution of supply- and demand-side characteristics to deficits in rural water supply. Whereas Chapter 5 elaborates on the *availability* of piped water supply on communal level and also sheds light on the role which institutional arrangements do play in the diffusion of piped schemes, Chapter 6 focuses on factors influencing the *accessibility* of tap water on household level. Chapter 7 addresses the use of point-of-use water treatment by rural households as an alternative strategy to improve drinking water and seeks to identify relevant drivers and obstacles in the diffusion of different treatment techniques.

1. Rural water supply in developing countries - Progress, setbacks and strategies

Contents

Access to safe water plays a crucial role in economic development. On the one hand, efficient and reliable water infrastructure significantly contributes to growth in the agricultural and industrial sector in emerging countries. On the other hand, measures to improve domestic water supply do not only help to reduce the health burden of water-related diseases but are also deemed a powerful instrument for poverty alleviation. Besides physical and financial resources, water is a key resource, especially for the millions of men and women who base their livelihoods on agriculture and small businesses, often in the informal sector. The link between water supply and poverty reduction has already been addressed by White's et al. (1972) famous 'Drawers of water' – which is considered the first study of water use in developing countries from a consumer's point of view (Thompson and Cairncross 2002). Nevertheless, the multiple benefits of safe water supply going beyond health effects had hardly been recognised until the end of the 1990s. Thanks to a bunch of case and meta-studies (e.g. Pickering and Davis (2012); Boone et al. (2011); van Koppen et al. (2006); Aiga and Umenai (2002) or more in general, Sullivan (2006); Moriarty and Butterworth (2003); Sullivan and Meigh (2003); Rosen and Vincent (1999)), there is now a consensus on the positive impact of improved water supply on living standards, poverty reduction, and public health; but still diverging opinions exist about how to achieve the goal of sufficient and safe water supply. The following section compiles numerous indirect and direct impacts of improved water supply, recalls past and current strategies to approach the problem of insufficient domestic water supply in rural areas and discusses how progress in this sector was measured and monitored so far.

1.1. Linking access to safe water and poverty reduction

Households' benefits from improved access to water are manifold, or – put it differently – direct and indirect costs arising from insufficient access are high. Health benefits in terms of reduced prevalence of water-washed and -born diseases[1] in developing countries are widely acknowledged, but still unsafe water, sanitation, and hygiene are ranked on the second place of the leading risk factors for burden of disease – measured by disability-adjusted life years (DALYs) – in low income countries. Beyond that, this risk factor contributes to a rising number of cases and the severity of infectious diseases (WHO 2009a: 9 et seq.). There is sufficient empirical evidence that access to safe water and appropriate water treatment can significantly reduce the relative risk of illness as for example suggest Fewtrell's et al. (2005) meta-analysis of water, sanitation, and hygiene interventions to prevent diarrhoea in developing countries.

Multiple benefits of water

Since the narrow view on first order health effects has been overcome, several empirical studies point to the pivotal role of domestic water supply for improving rural livelihoods and helping people to escape the vicious circle of poverty, consumption of unsafe water, illness, and ensuing lower ability to work, which in turn exacerbates their situation (Rosen and Vincent 1999). Moriarty and Butterworth (2003) list numerous direct and indirect impacts of sufficient domestic water supply, ranging from savings of expenditure and time, over improvements of well-being, food security, and nutrition to strengthening of local capacities and empowerment of marginalised groups, just to name a few. Many of the positive effects are based on the fact that physical effort and time spent to collect water is significantly reduced if water is available directly on premises. Various studies prove those savings for households with improved water supply, especially for women and children who are often responsible for collecting water (Clasen 2012; Pickering and Davis 2012; Boone et al. 2011; Devoto et al. 2011; Kremer et al. 2011; WHO/UNICEF 2011; Arouna and Dabbert 2010). This in turn increases well-being and leaves more time for education, productive and social activities, or enables people to produce food by irrigating their gardens or keeping livestock. Positive effects of better education, increasing incomes from water and non-water-based livelihood activities unlock a potential for larger investments and thereby unfold a multiplier effect. Multiple opportunities for the use of water for household productive activities[2] can be found at the sectoral interface between agriculture, industry, and individual households (Moriarty and Butterworth 2003). Researchers all over the world have elaborated on the contributions of household businesses to poverty alleviation and asked for the role of domestic water supplies

[1] One of the significant contributions of 'Drawers of water' (White et al. 1972) was the classification of water related diseases according to their transmission routes into water-borne, water-washed, water-based diseases and water-related insect vectors.

[2] For a definition of 'productive use of water at the household level', see Moriarty et al. (2004).

in these businesses (Moriarty and Butterworth 2003; van Koppen et al. 2006), but '[i]nformation on household water supply and productivity in rural areas [...] is limited to a handful of original studies, which continue to be cited and recycled in the literature' (Rosen and Vincent 1999: 3). This research was mainly driven by the hypothesis that sufficient water supply is a precondition for establishing micro-enterprises, and by implication, lack of access to water aggravates undertaking household businesses. Typical household-based productive activities like small scale cropping and rearing livestock, but also services like restaurants, washing motorbikes, and food processing only require low start-up costs, so that even poor households might enter the market. Furthermore, they are flexible with regard to labour input and can often be combined with child care. Sufficient domestic water supply is not only necessary for the activity itself but also enables productive activities by reducing time spent for collecting water and thus freeing time or by increasing the labour quantity due to a reduction of water related diseases (Moriarty et al. 2004; Rosen and Vincent 1999).

Water quantity

In view of the central function which water takes for rural livelihoods, it becomes obvious that not only water quality matters but also the quantity of water available for the household (Thompson and Cairncross 2002; White et al. 1972). '[D]uring the 1980s and 1990s, researchers began to argue that insisting on strict water quality criteria at the expense of water quantity may be counterproductive in poor settings' (Schmidt and Cairncross 2009a: 986). In the past, design norms and basic needs targets for water supply only insufficiently reflected the demand for a higher quantity of water for household-based activities. Productive use aside, already in the 1970s the importance of increasing the volume of water provided per capita has been recognised, because fecal-oral diseases are often water-washed not water-borne and drinking water is only one of the transmission routes for water related diseases (Schmidt and Cairncross 2009a; Thompson and Cairncross 2002; White et al. 1972). Already White's et al. (1972) findings suggested that '[i]f a household has only a small quantity of water to use, it is likely that all aspects of hygiene – from bathing and laundry to washing of hands, food and dishes – will suffer. Subsequent research has confirmed the truth of what in 1972 was a bold and radical assertion [...], and led to an increasing interest in the study of hygiene behaviour [...]' (Thompson and Cairncross 2002: 62) and a rising interest in approaches to improve water, sanitation, and hygiene practices under various labels like WATSAN or WASH. As an reaction, newer design norms – for example such as proposed by Gleick (1996) – plead in favour of higher water quantities. But such postulations are judged ambivalently. Some practitioners even deem design norms requesting an amount of 20 litres per person one of the biggest myth of rural water supply (RWSN 2010), because only a small share of this water is actually used for drinking and cooking. However, probably the most important implication from this debate was to recognise that households demand water of different qualities depending on the purpose.

1.2. Measuring progress in access to safe water

Improving water supply for rural households in developing countries has been on the agenda of supranational and national development agencies and subject to debates about water policy since the Mar del Plata UN world conference in 1977 and the International Drinking Water Supply and Sanitation Decade (1981-1990) which was announced subsequently (Mehta et al. 2007). The question how to ensure access to safe water for the poor population in developing countries, and how to monitor progress achieved, entered the public discourse at the latest since the definition of the Millennium Developments Goals (MDG) in 2000. Already in 2012 – several years before the target date – the United Nations (2012) announced that the MDG to halve the number of people without access to safe drinking water is reached now, and thus the 'mission accomplished' (Clasen 2012: 1178). But researchers and practitioners increasingly question the alleged success story and point to the contradiction between official announcements and the 'widely reported high rates of non-functionality of rural water systems' (Moriarty et al. 2013: 329). They especially argue that the strong emphasis on 'headline successes in providing first-time access to water' (Moriarty et al. 2013: 329) masks still existing deficiencies in performance of service providers, hardware maintenance, and service. Figures illustrating progress on the pathway to achieve the Millennium Development Goal 7b (Target 10) are omnipresent in literature about water supply in developing countries. Undoubtedly, the MDGs are a catchy instrument to draw public and political attention to deficiencies in rural water supply, but nevertheless they rather serve as a means of communication than an elaborate monitoring instrument and a reliable foundation to derive evidence-based and targeted recommendations for action. Scholars argue that the MDGs fall short to expectations with regard to conceptual vagueness, monitoring practices, and strategies to achieve the defined goals. Above all, the MGDs were criticised for their simplified view on what is defined as 'safe water' (Brown et al. 2013; Clasen 2012; Amin 2006) and monitoring practices which failed to translate and implement the definitions elaborated by the MDG task force sufficiently (UN Millenium Project Task Force on Water and Sanitation 2005). The Task Force for Water and Sanitation opted for 'safe drinking water' as a criterion instead of 'acceptable quality' as stated by the Water Supply and Sanitation Collaborative Council (UN Millenium Project Task Force on Water and Sanitation 2005). Firstly, this implies that water should be free of contaminants and secondly, that water quality counts directly at the point of consumption not just at the point of distribution, respectively the source (Clasen 2012: 1178). Unfortunately, this definition forfeited its value when it came to operationalisation and monitoring. Due to practical restrictions for measuring water quality, the United Nations (2003) decided to apply the existing Joint Monitoring Programme (JMP) classification which refers to primary water sources used by a household as a proxy. The monitoring system for the MDG indicators harks back on the already existing system of the JMP of the WHO and UNICEF[3], which again builds upon household level surveys conducted in the respective countries and severely restricts options for defining the indicators to measure the above mentioned dimensions of access, water quantity, and quality (Clasen 2012: 1179). Whereas unprotected springs and dug wells, cars with small tank/drum, tanker-trucks, surface water, bottled water where classified as 'unimproved sources'; piped water on premises, public taps or standpipes, tube wells or bore holes, protected dug wells and springs, and rainwater are considered 'safe' irrespective of storage and additional treatment.[4] In the knowledge of the deficiencies coming along with this approach, the JMP piloted a Rapid Assessment for Drinking Water Quality and conducted exemplary field studies[5] which found that 'except for some centrally managed piped water supplies, the so-called "improved sources" were often microbiologically and chemically contaminated and that the level of fecal contamination was significantly worse at the household level' (Clasen 2012: 1179). Especially dug wells, protected springs, and even boreholes are prone to being erroneously classified as safe. More than half of the protected dug wells did not comply to the WHO threshold values, so did a third of the tube wells and still more than every tenth tap on premises (WHO/UNICEF 2011: 34). The finding that piped water on premises benefits over other 'improved sources' has recently been proved for Việt Nam as well (Brown et al. 2013). This and the above mentioned studies underpin that the share of households with access to safe water tends to be overestimated (WHO/UNICEF 2012a) and qualify the optimistic statement gained from the JMP figures that access to safe water is no longer a problem in Việt Nam and other South-East Asian countries. Conceptual vagueness and inappropriate monitoring aside, discussions about strategies to achieve these goals have been lacking. Criticism on the approach to define goals without elaborating on strategies and creating conditions to achieve them has especially been voiced by 'the South' (e.g. Amin 2006). This criticism goes beyond minor conceptual differences about what is understood as 'safe water', but reflects the lingering debates over appropriate strategies in the water and sanitation sector.

[3] A brief introduction to the UNICEF/WHO JMP and the data set on which it builds is given in Section 1.5.2.

[4] For a detailed description of these sources, see http://www.wssinfo.org/definitions-methods/watsan-categories/.

[5] Pilot studies have been completed in Ethiopia, Jordan, Nicaragua, Nigeria, and Tajikistan. For the parameters tested in the study, see WHO/UNICEF (2011: 34).

1.3. Strategies and paradigmatic changes in the rural water sector

Since the mid of the 20th century, water management experienced fundamental changes which had a strong influence on the approaches and strategies to improve rural water supply in developing countries. In particular demand-based approaches, which dominated in rural water supply during the last two decades, are not only an outcome of the increasing interest of supranational and national development agencies in rural drinking water supply since the 1970s. They are also owed to the acknowledgement that large-scale solutions in the manner of the so-called 'hydraulic mission' were hardly able to satisfy the needs of rural households. The first part of this section briefly sketches the main ideas of the 'hydraulic mission' and the 'reflexive modernity' and subsequently discusses its implications for measures to improve household water supply in developing countries during the last decades.[6] The underlying political and theoretical ideas did not only impinge on large-scale infrastructure projects but also on the strategies to improve domestic water supply. The second part of the section elaborates on three major observable trends which currently shape the dialogue about how to improve water supply:

- the increasing importance of demand-based approaches as a supplement to supply-driven approaches,
- the coexistence of approaches relying on household-based solutions and those aiming at the construction of (small-scale) piped schemes,
- and last but not least the shift from mono-sectoral, stand-alone measures to combined approaches including water, sanitation, hygiene, and other sectors.

1.3.1. Paradigmatic changes in strategies to achieve safe water supply – A historical review of approaches and strategies

Understanding the narratives of basic paradigms in water management 'are useful means of accessing changing perspectives on, for example, how natural resource using and policy-making communities have created the environments in which they now operate' (Allan 2004: 135). Already since the 19th century, the belief in hydraulic engineering as an instrument to redress basic societal problems emerged. Driven by the ambitious national goals for economic development and inspired by the idea of technical feasibility, developing countries themselves took over the responsibility for

Hydraulic Mission

[6] For a detailed explanation of the different paradigms in water management with regard to their intellectual and philosophical inspiration, see Allan (2004); with regard to hydrocracies, see Molle et al. (2009b).

water resource development on a large-scale after gaining independence from their colonial rulers.

> Imbued with the fresh legitimacy of technical marvels (high dams, electricity, etc.) and the presumably unlimited power of science, inspired by the mission to tame nature and make the deserts bloom, hydraulic bureaucracies were created to take up the challenges of flood protection, hydropower generation and large-scale public irrigation. These bureaucracies had their secular priesthoods, acting in the name of the common good and in tandem with politicians and national leaders. Not a single drop of water should reach the sea without being put to work for the benefit of Man: the 'hydraulic mission' was born [...]. (Molle et al. 2009b: 332)

During the 1950s and 1960, in many third world countries this mission took the shape of 'postcolonial despotism' (Molle et al. 2009b: 334), which was coined by a massive investment in irrigation schemes and dams, financially and technically supported by industrialised countries.[7] Nevertheless, benefits of the hydraulic mission were judged ambivalently. 'While they [large-scale projects, A.W.] have enormously contributed to actual welfare, including energy and food generation, flood protection and water supply to urban areas, infrastructural development has often become an end in itself, rather than a means to an end, fuelling rent-seeking and symbolising state power' (Molle et al. 2009b: 328). Not least environmental degradation ensuing from large-scale interventions and financial pressure, but also neoliberal criticism of state failure and the decentralisation of power to regional and local levels fueled doubt about the continued triumph of the hydraulic mission and paved the way for participatory and market-based solutions (cf. Molle et al. 2009b). The insight that technical innovations and large-scale interventions alone do not enable developing countries to manage their resources in a sustainable manner and simultaneously enhance economic growth, cumulated in an approach which paid more attention to the issue of institutions and governance. In practice, the paradigmatic change from the hydraulic mission to 'renewed' water governance – subsumed under the label of 'reflexive modernity' – was expressed by the following principles:

Reflexive Modernity

- governments seeking to compensate the reduction of the budget by shifting the financial burden to users and adopting cost-recovery policies (Molle et al. 2009b),
- overall withdrawal of the state in financial and technical terms which came along with an intensive promotion of privatisation and private sector involvement (e.g. in terms of private-public partnerships), mainly fostered by the development banks,

[7] Indeed, Molle et al. (2009b: 333 et seq.) differentiates between three trends.

– ‘diverting, neutralising and reconfiguring institutional reform efforts’ (Molle et al. 2009b: 343),

– decentralisation in combination with new forms of local governance and participation,

– and last but not least, a stronger focus on sustainability and environmental concerns (Perret et al. 2006).

Additionally, with the erosion of traditional political and societal values, which weakened the existing institutional structures, efficiency of centralised structures decreased, while simultaneously the market was promoted as the ultimate solution to foster economic growth and allocate resources efficiently. In line with this paradigm, deregulation and private sector involvement urged the governments to reduce command and control functions (Rogers and Hall 2003). Consequently, in many countries project planning and design capacity now reside with private companies, consultants, or academia (Molle et al. 2009b).[8] Although during the last two decades, the principles of the ‘reflexive modernity’ gained in importance and concepts like Integrated Water Resources Management (IWRM) travelled with donors to developing countries, the hydraulic mission is still prevalent in various developing countries (Allan 2004). One the one hand, the hesitant adoption of the renewed management concepts outlined above might simply be understood as ‘the resistance of hydrocracies to change and their resourcefulness in maintaining their command-and-control and construction orientation’ as state Molle et al. (2009b: 341). On the other hand, empirical research has shown that ‘[t]he historic paths of local institutional change, cultural orientation, and political processes also play a critical role, with state, cooperative, or individual institutions valued differently in different societies and over time [...]’ (Meinzen-Dick 2007: 15200). Both interpretations will be discussed by the example of emerging institutional arrangements of (small-scale) piped schemes in Việt Nam in Chapter 5.

Implications for domestic water supply

But what did the paradigmatic change from the hydraulic mission to the reflexive modernity imply for household water supply in developing countries? Apparently, domestic water supply has never been considered a core task of the hydraulic mission, since this field is less appropriate to epitomise economic and technical progress. Whereas large infrastructural projects are highly visible, require large investment of resources, and a powerful bureaucracy to manage planning, construction, and operation; investments in scattered small-scale schemes for rural water supply are less attractive for rent-seeking or gaining and exerting political influence. Even though water supply for rural households was not placed high on the priority list during the flowering period of the ‘hydraulic mission’, the developments captured by the term

[8] This finding is illustrated by the example of the Vietnamese Center for Rural Water Supply and Sanitation (CERWASS) in Section 3.2.

'reflexive modernity' strongly shaped the approaches applied to increase access to safe water for the rural population. Now more attention was paid to the 'how': How to design appropriate institutional arrangements? How to mobilise resources? How to involve the public sector and other stakeholders? These new ideas materialised in terms of micro-credit programmes, community participation, user groups, and rural marketing.

Box 1: Dublin Principles on water and sustainable development

Principle No. 1: Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment

Since water sustains life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems. Effective management links land and water uses across the whole of a catchment area or ground water aquifer.

Principle No. 2: Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels

The participatory approach involves raising awareness of the importance of water among policy-makers and the general public. It means that decisions are taken at the lowest appropriate level, with full public consultation and involvement of users in the planning and implementation of water projects.

Principle No. 3: Women play a central part in the provision, management and safeguarding of water

This pivotal role of women as providers and users of water and guardians of the living environment has seldom been reflected in institutional arrangements for the development and management of water resources. Acceptance and implementation of this principle requires positive policies to address women's specific needs and to equip and empower women to participate at all levels in water resources programmes, including decision-making and implementation, in ways defined by them.

Principle No. 4: Water has an economic value in all its competing uses and should be recognised as an economic good

Within this principle, it is vital to recognise first the basic right of all human beings to have access to clean water and sanitation at an affordable price. Past failure to recognise the economic value of water has led to wasteful and environmentally damaging uses of the resource. Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources.

Source: UN Documents (1992)

In conjunction with the increasing efforts to fight rural poverty during the 1970s and the recognition of empirical findings about the key role of domestic water supply for rural livelihoods (see Section 1.1), development assistance embarked on a new strategic path, which also manifested itself in international conferences, recommendations, and development targets. An often cited tipping point in the global discourse about water management in developing countries is marked by the Dublin Principles (Box 1). On the International Conference on Water and the Environment in Dublin in 1992, country experts and representatives of various international, intergovernmental, and non-governmental organisations officially adopted a statement which called for holistic and participatory approaches in water management. Additionally, it recognised all human beings' right of access to clean water but simultaneously laid great emphasis upon the character of water as an 'economic good' in order to encourage its efficient use.

The following three subsections discuss strategies to ensure safe water supply for rural households with regard to three dimensions: the first subsection will briefly review the scope of technically appropriate measures for providing safe water ranging from point-of-use household water treatment on the one hand, to piped schemes managed by professionals or local lay people on the other hand. The second one scrutinises different modes for disseminating these technical facilities against the background of the currently observable shift from demand- to supply-based approaches. Last but not least, the third subsection has a look at multi-sectoral or integrated approaches which do not exclusively focus on improving water quality as a stand-alone measure but also take into account the water demand for other purposes than drinking and cooking.

1.3.2. Household water treatment vs. piped water supply

Technically speaking, the debate about appropriate and feasible strategies to improve water supply has mainly been shaped by two approaches: the promotion of self-supply in combination with some kind of point-of-use treatment on the one hand, and the efforts to establish and expand (small-scale) piped schemes on the other hand. The figures of the JMP (cf. Table 1.1) suggest that the past achievements in ensuring access to safe water in Southeast Asia are to a great extent attributable to other improved water sources than piped water on premises. Although this speaks in favour of further promoting household water treatment and self-supply, this finding might still be an artifact of the predominance of this approach until the mid 1990s. Up to now, apparently neither self-supply nor piped schemes turned out to be a panacea to ensure access to safe water in an affordable and sustainable manner for rural households. In the past, both approaches produced success stories but likewise suffered from poor implementation and sustainability at other places.[9] Even with regard to water quality there is no clear evidence for giving preference to one of the approaches. Empirical studies – for example the above-mentioned Rapid Assessments for Drinking Water Quality conducted within the framework of the JMP – have shown that piped water on premises provides greater health benefits than other sources defined as 'improved' by the Joint Monitoring Programme (WHO/UNICEF 2011; Brown et al. 2013). On the other hand there is also sufficient evidence to presume that household water treatment can provide safe water and is a cost-effective measure (Fewtrell et al. 2005; Clasen et al. 2007), which is now even officially recognised by the WHO. A wide range of techniques as boiling, chlorination, filtering, solar disinfection, settling, or straining water through cloth are subsumed under the label of HWT[10], whereby the JMP judges the latter two techniques as 'inadequate' (WHO/UNICEF 2006). Since several years, data about HWT is available from those household surveys which serve as the basis for the JMP. The WHO/UNICEF (2006) opted for two additional questions about HWT which were in the majority of cases incorporated verbatim or sometimes with slight modifications. A meta-analysis of such data from major national survey programmes all over the world revealed 'substantial differences in the prevalence of HWT by country and geographical region. [...] The practice is most common among countries falling within the Western Pacific WHO region (66,8%) and least common in the Mediterranean (13,6%) and African regions (18,2%). However, large variations were also observed within geographical regions' (Rosa and Clasen 2010: 291). Whereas boiling is almost universal in some Asian countries but rare in Africa, other types of HWT are generally less common (Rosa and Clasen 2010: 291).[11] Astonishingly, there is no clear relationship between the use of HWT and the source of water used by the household. In various countries, households with access to 'improved' water sources are more likely to practice some kind of HWT than those relying on 'non-improved' water sources.

Prevalence of HWT

From the technical point of view, there is now doubt that simple techniques which enable households and communities to improve water quality and reduce the burden of disease significantly are available at low costs (Clasen 2008; Sobsey et al. 2008; Sobsey 2002). Thus, according to the WHO, scaling up household water treatment and safe storage 'has been shown to be an effective and cost-effective alternative to conventional improvements in water supplies' (Clasen 2008: 7). Despite growing prevalence and studies proving the efficiency, household water treatment has lost attractiveness in public policy, because it has not always received unequivocal acknowledgement and

Promoting self-supply

[9] Chapter 5 discusses the consequences of a parallel promotion of self-supply and piped schemes by the example of rural Việt Nam.

[10] HWT techniques, their advantages and disadvantages, and their prevalence in Việt Nam are discussed in Section 2.6.

[11] For detailed figures about the prevalence of HWT techniques in various countries, see Rosa and Clasen (2010).

support by influential players like the WHO and UNICEF. On the one hand, this might be attributed to the ongoing debates in the public health community about whether empirical evidence is sufficient to justify scaling up (Schmidt and Cairncross 2009a,b; Clasen et al. 2009). On the other hand, self-supply and HWT might be considered a temporary solution which is not worth spending much effort on. It is, however, not unlikely that temporary solutions also establish in the mid or long run. Anyway, at least from a practical perspective, the question about scaling up HWT rather occurs as an academic one, given a number of 850 million users world wide (Clasen et al. 2009). So the rather reluctant attitude towards HWT and the hesitant support could be interpreted as legacy of the hydraulic mission or ascribed to policy makers and implementers who are unfamiliar with the recent evidence for the impact of household-based solutions (Clasen 2008: 66).

Promoting piped schemes

In contrast, with the promotion of private sector participation and community-based management emerging as management model, the omens were favourable for rapid diffusion of piped schemes superseeding self-supply sooner or later. For the rural water sector in developing countries, private sector involvement opened up new opportunities for raising capital and epitomised the hope to overcome state and market failure by creating an appropriate institutional environment, and thereby to contribute to increased productive and allocative efficiency. In particular in conjunction with community-based management and the so-called demand responsive approach (DRA), a 'win-win situation' was likely to emerge for households and governmental authorities: communities participate in design and implementation, contribute to the initial investment, carry out O&M and in turn receive a made-to-measure piped scheme. Compared to self-supply, access to piped schemes – especially when provided directly on households' own premises – would significantly reduce households' physical effort to collect and treat water, facilitate centralised monitoring of water quality, and with increasing professionalisation, ensure a higher service quality. Governments on the other hand would show up with growing coverage rates and attain national and international targets without putting a too heavy burden on their budget. So far the ideal case. In the meantime, practical experiences tempered the enthusiasm about a speedy expansion of piped schemes. There are numerous reasons adducible, why piped schemes did not turn out to be the ultimate solution to the service delivery problem up to now: Firstly, piped schemes have so far mainly been operated by the communes themselves, a model which will due to a lack of professionalisation hardly be capable to provide higher service levels in the long run. According to practitioners, the potential of community managed systems has almost been fully exploited and the belief that '[c]ommunities are always capable of managing their facilities on their own' (RWSN 2010: 4) is now deemed one of the myths in the rural water sector. Experts even argue that the community-based model builds upon unrealistic assumptions about community cohesion and their willingness and capacity to substitute a professional service provider especially in view of rising service levels (Moriarty et al.

2013; RWSN 2010; Harvey and Reed 2007). Thus the necessity arises to develop alternative institutional arrangements for constructing and operating piped schemes. Secondly, there are still pockets of rural poverty, where people cannot even afford very basic levels of service. Due to low willingness to pay they are also not attractive for private water supply companies and will thus remain unserved unless being heavily subsidised. Thirdly, as will be empirically scrutinised in Chapter 5, there are also sparsely and scattered populated areas in which piped schemes cannot be operated in an economically viable manner due to geographical conditions. What makes the situation worse, is that adverse geographical conditions and remoteness often coincide with economic weakness and low willingness to pay. Last but not least, the nature of households' demand is complex and often hampers successful operation or expansion of piped schemes: water from piped schemes is 'substituted' by other sources, and unless service levels and water quality are low and supply by piped schemes unreliable, households are often not willing to connect or switch completely to piped schemes, which in turn would enable the provider to operate on a cost-recovery basis and to improve service quality in order to attain additional users or stimulate consumption. Understanding the demand side of the problem to facilitate the dissemination of piped schemes, is one of the most challenging questions and will be addressed in Chapter 5 and 6. These chapters will shed light on the increasing (political) efforts to promote piped water by small-scale schemes in rural Việt Nam and elaborate on factors which facilitate or inhibit their successful diffusion.

The nature of demand

Irrespectively which of the strategies – piped schemes or self-supply – will finally succeed in the long run, in view of the simultaneously increasing prevalence of HWT and piped schemes the question is how to promote both approaches in an efficient and coordinated fashion. As Clasen (2008: 75) suggests, national governments should draw on HWT and storage while they extend piped water schemes especially in light of the large investment required by piped water schemes. Since from a technical point of view, piped schemes as well as HWT are basically able to satisfy the rural population's demand for safe water, factors like operability, ease of use, the relation between costs, and perceived benefits of the proposed solutions will impinge on further diffusion. For example, Clasen et al. (2009) are skeptical towards the rapid diffusion of HWT since success stories so far have mostly been exceptional cases. According to Clasen, deficits in design and delivery strategies as well as a lack of basic understanding about the factors which facilitate or deter households from acquiring and using these techniques so far impede that diffusion reaches the tipping point and spreads like an endemic. However, similar applies to piped schemes, whereby in this case mobilising a critical mass of users seems even more crucial for construction and operation. Thus, the subsequent chapters will address the promotion of piped schemes and HWT from the perspective of diffusion theory: Whereas Chapter 4 gives an overview about relevant concepts from diffusion theory and empirical diffusion studies in the water and sanitation sector, Chapter 5 and 7 deal

Piped schemes vs. self-supply

with the diffusion of treatment techniques and piped schemes based on empirical data.

1.3.3. From supply- to demand-based provision or: Who will pay?

The previous section contrasted household water treatment and piped schemes with regard to their potential to solve the problem of domestic water supply in rural areas. It already presages that the practical use of the one or other strategy is not only a matter of technical efficiency and usability but closely linked to by whom and how these strategies are promoted, which also involves the question of funding. Driven by the ambitious objectives in rural water supply, governmental authorities, NGOs, and international donors heavily subsidised hardware (e.g. pumps) in order to show up with quick and visible progress. Still today, in many cases rural water supply is strongly reliant upon those public sector subsidies. For example in Sub-Saharan Africa, 90 to 100 percent of the hardware costs are estimated to be covered by the governmental sector or donors (RWSN 2010). What has been useful to boost first-time access to water, impedes sustainable development in the rural water sector. Firstly, fully subsidising hardware consumes a large share of the incidentally limited financial resources and severely restricts the number of beneficiaries. Secondly, it neglects the opportunity to capitalise on alternative sources of funding, e.g. by communal or user contributions or private sector participation. Thirdly, a strong focus on asset creation diverts attention from sustainable operation and maintenance of existing facilities but also from necessary reformations of institutional structures. With the paradigmatic shift from the 'hydraulic mission' to the 'reflexive modernity', new approaches to raise alternative funds found their way in the rural water sector: privatisation and demand-based approaches. Since the mid 1990s, lots of developing countries – pushed by the World Bank – have embarked on privatisation. This decision was often based on the misconception that poor coverage and service resulted from mismanagement in the public sector and these problems could easily be solved by private sector involvement (Prasad 2006; Tan 2011). Privatisation, however, did not yield the expected results because most of the developing countries were lacking experience with contracting and regulation, and the bulk of the capital invested still comes from the public sector and international donors (Cairncross 2003: 193 et seq.). Besides private sector involvement, demand-based approaches pose a second alternative to substitute public funding in the water sector and to simultaneously overcome the obstacles of supply-based provision. They basically build upon the idea to provide only those facilities and services, users are actually requesting and willing to pay for. Since the path-breaking study 'Drawers of water' (White et al. 1972) and the International Drinking Water Supply and Sanitation Decade (1981-1990) (WHO/GTZ 1987) pleaded in favour of demand-based instead of supply-driven approaches, these only hesitantly became prevalent. Supported by the World Bank, the so-called demand responsive approach (DRA) in conjunction with community management (UNDP - Worldbank Regional Water and Sanitation Group 1997) gained in importance in the late 1990s and in many cases already became the default approach. The DRA concept does not only involve that 'the community initiates and makes informed choices about service options and how services are delivered; [...] contributes to the investment costs relative to the service level and has significant control on how funds are managed' but it also 'owns and is responsible for sustaining its facilities' (UNDP - Worldbank Regional Water and Sanitation Group 1997: no page). As outlined above, this approach has apparently reached its limit and it is questionable whether communes' capacities to manage the facilities have been overestimated. Beyond that, even given user participation, the approach might suffer from a curtailed view of demand, which is rather focused on the willingness to pay without taking into account other characteristics of demand like the existence of substitutes, temporal patterns, price elasticity of demand, and the diversity of users' needs (cf. Kessides 1993).

1.3.4. The shift to multi-sectoral approaches

Traditionally, policy-making and implementation for water-related issues like irrigation, fishery, aquaculture, environmental issues, or domestic water supply resided with distinct actors. Accordingly, single use planning and design have been predominant due to the division of water-related service provision in those different sectors. But why do experts call for multi-sectoral approaches, especially in domestic water supply? In practice, single use planning led to unexpected results. After their implementation, they often turned in de-facto multiple use schemes without having been designed for it, which results in hardware damage, overuse, or even conflicts among the users (van Koppen et al. 2006). Put it differently, planners understood that realising the benefits of improvements in one sector is often inevitably linked to simultaneous improvements in related sectors. Therefore it is 'essential that the development of water resources and services is based on a clear understanding of the full range of uses to which people put (or might put) the water provided' (Moriarty and Butterworth 2003: 23) and various studies have been dedicated to this issue (e.g. Noel et al. 2010; Aiga and Umenai 2002).

The relevance of cross-sectoral or multiple use approaches is striking when it comes to productive purposes[12] and sanitation. In the past, donor activities have been criticised for their strong focus on water supply, whereas sanitation came to the fore only during the last years (Clark and Gundry 2004). Figures about rural areas in Southeast-Asia[13] by the JMP illustrate the results of the past water-centered policies: Sanitation is still lagging far behind domestic water supply, although the share of

Linking water and sanitation sector

[12] Implications for productive use have already been discussed in Section 1.1.

[13] Việt Nam, which lies in the focus of this study, in the MDG classification belongs to South-Eastern Asia (SEA), whereas in the UNICEF classification it belongs to East Asia and the Pacific (EAP).

Table 1.1.: Water supply and sanitation in South-East Asia 1990-2010

Year	Water				Sanitation			
	Piped on premises (%)	Other improved (%)	Surface water (%)	Other unimproved (%)	Total improved (%)	Shared (%)	Other unimproved (%)	Open defecation (%)
1990	5	57	9	29	36	5	20	39
1995	8	59	12	21	42	6	18	34
2000	10	62	9	19	49	7	15	29
2005	13	65	6	16	55	8	13	24
2010	13	70	4	13	60	10	9	21

Source: http://www.wssinfo.org/data-estimates/table/ (WHO/UNICEF 2010)

people using no or unimproved sanitary facilities halvened between 1990 and 2010 as shows Table 1.1. Subsequently, priorities of governmental actors and donors slightly changed, resulting in increasing attention paid to sanitation as it is exemplary illustrated by the case of the National Target Programme for Rural Water Supply and Sanitation (NTP-RWSS) in Việt Nam (Harris et al. 2012). In order to realise the full benefits of safe water, it is reasonable to dedicate a larger share of resources to sanitation. Deficiencies in sanitation behaviour are related to insufficient water supply twofold: On the one hand health benefits achieved by access to safe water sources are destroyed by poor hygiene and sanitation, on the other hand, without a sufficient amount of water available for the household, it becomes less likely that hygiene and sanitation practices will improve (Thompson and Cairncross 2002). Thus, as discussed before, the positive health impact of improved water supply is not only determined by the quality of water but also by the quantity available. Modified design norms reflect the changing attitude towards the importance of quantity of water supply. Whereas the Agenda 21, the UN action plan for sustainable development, recommended a minimum quantity of only 20 litres per person per day which only enabled households to cater their basic needs (WSSCC 2000), now an amount of at least 50 to 60 litres per person per day is considered appropriate (Gleick 1996).

Multiple-use water services

Additionally, concepts have been developed to overcome the shortcoming of single use planning and design. So-called ‘Multiple-use water services’ (MUS) even go a step further and ‘take people’s multiple water needs as a starting point for providing integrated services, moving beyond the conventional sectoral barriers of the domestic and productive sectors’ (van Koppen et al. 2006: v).

1.4. Challenges for rural water supply in Việt Nam

The analysis so far referred to developing countries in general and touched upon basic paradigms in order to lay the foundation for a sound analysis of domestic water supply in Việt Nam. Reflections on multiple benefits of access to safe water broaden the view to intended and unintended by-effects of improved water supply, while the description of paradigmatic changes in the water sector helps to understand the rationales underlying measures in the RWSS sector and country-specific peculiarities. The remaining chapters including the empirical analysis focus on Việt Nam and just occasionally refer to empirical findings from other countries. Nevertheless, most of the overarching questions addressed throughout the book are also relevant for countries facing similar characteristics such as abundant water resources, considerable gaps between sanitation and water supply coverage, strong orientation towards agriculture in combination with irrigation, medium human development levels but high levels of external aid, and rather low levels of environmental concerns and governmental accountability (Dondeynaz et al. 2012: 3805 et seq.).[14] The following section sketches the past and recent developments in rural water supply in Việt Nam to pave the way for a more detailed analysis in the subsequent chapters. Since the Đổi Mới reforms, Việt Nam's economy dynamically developed, but infrastructure development – especially to serve the rural population – has hardly been able to keep pace with the growing demand. Similar to other developing and emerging countries, this development produced contradictions, with production and productivity growth in the agricultural sector on the one hand, and environmental problems and uneven distribution of the newly acquired wealth on the other hand. Since the mid 1990s, the country experienced significant changes in the institutional environment, ranging from sector-specific regulations as the Law on Water resources in 1998 and numerous other new laws and decrees on licensing and pollution control over the restructuring of the responsibilities in the water sector to overarching reform processes such as administrative decentralisation and the introduction of the Grassroots Democracy Decree (GDD). In addition, substantial progress was achieved in poverty eradication and fostering economic growth, both leading to an increased demand for water. The Vietnamese government, supported by international donors, set up ambitious targets to improve rural water supply, which is currently still shaped by the coexistence of self-supply from various kinds of water sources and the emergence of piped water schemes but a strong dominance of the first one. Basically, in rural areas three opportunities to provide safe water are prevalent: collecting rainwater, using drilled wells

[14] According to a recent analysis on the inter-relationship among water, governance, and human development in developing countries, Việt Nam is a prototypical representative of a cluster of countries characterised by these characteristics. Among the countries considered in the study are other Asian countries like Laos, Cambodia, Myanmar, Bangladesh or Sri Lanka, Nepal, and Buthan (Dondeynaz et al. 2013, 2012).

Table 1.2.: Development of water supply in rural Việt Nam 1990-2010

Year	Improved			Unimproved	
	Total improved (%)	Piped on premises (%)	Other improved (%)	Surface water (%)	Other unimproved (%)
1990	49	0	49	19	32
1995	60	2	58	18	22
2000	71	4	67	13	16
2005	82	6	76	8	10
2010	93	8	85	5	2

Source: http://www.wssinfo.org/data-estimates/table/ (WHO/UNICEF 2010)

in combination with additional treatment and connecting to a piped water scheme. The growing demand for piped water in rural areas is not alone an expression of rising living standards but also a reaction to increasing pollution of surface and groundwater due to intensive agriculture, industrialisation, and urbanisation in conjunction with a lack of sewage disposal and sanitation, especially in densely populated areas. Apart from anthropogenic causes, some regions are prone to geogenic contamination by elevated concentrations of arsenic, manganese, fluoride, selenium, chromium, and barium (Winkel et al. 2011; Berg et al. 2007), which are often not reliably removed by household water treatment.

Officially, the United Nations (2010: 58) stated already in 2010 that for South-Eastern Asia the MDG Drinking water target was met. At the same time, the UN admitted that still disparities between urban and rural areas are remaining and increasing contamination of surface and groundwater is creating new challenges. In Việt Nam, according to the Joint Monitoring Programme for Water Supply and Sanitation of the WHO and UNICEF (WHO/UNICEF 2010), the share of rural households relying on improved water sources between 1990 and 2010 grew from 49 up to 93 percent (see Table 1.2). In the past, for the vast majority of the households this improvement resulted from the strongly promoted diffusion of tube wells since the 1980es (cf. Reis 2012; ADB 2008; WHO/UNICEF 2010), whereas only a minor group of 8 percent benefited from access to piped schemes (WHO/UNICEF 2010). Although the number of piped schemes is constantly growing, this expansion is mainly confined to peri-urban regions and rather passes by remote or less densely populated areas. In contrast to urban water supply, access to safe water for rural households only became a political issue in Việt Nam after UNICEF launched the 'Programme for Rural Water Supply and Sanitation' which strongly relied on enabling self-supply by drilling wells and promoting household water treatment. From the point of view of sustainability, this strategy has already become out-of-date due to overexploitation or poor quality of groundwater resources in many parts of the country (Winkel et al. 2011; Fendorf et al. 2010; MONRE 2009a,b). Nevertheless a large share of the rural population still continues to use tube wells since it proves a convenient source and serious alternatives are often not available. Currently, more attention is paid to the expansion of piped water supply in peri-urban and rural areas. In fact, that does not solve the problem of sustainable use of water resources but shifts the responsibility from households to water providers. During the last decade, a variability of schemes operated by governmental, cooperative or private stakeholders emerged, but apparently – in contrast to urban areas – institutional models for piped water schemes are still in a premature stage and develop very dynamically as will be scrutinised in Chapter 5.

On the one hand, the recent trends in domestic water supply are an outcome of the fundamental paradigmatic change in water resources management, on the other hand they are also shaped by the historical legacy of past institutional structures of the country. Water management has a long history in Việt Nam, because the country was and is confronted with water shortage, floods, and the necessity to intensify agriculture. Besides the traditionally strong focus on irrigation, drainage, and flood control, the country has to respond to increasing challenges arising from urbanisation and industrialisation. In this context, Đổi Mới and ensuing market economy did not only mark the beginning of political change in Việt Nam but also created the preconditions to establish adequate natural resource management, including an reorganisation of property rights, the recognition of water as an 'economic good' as suggested by the Dublin Principles, and the attempt to introduce full-cost-recovery practices (Waibel 2010; Miller 2006). Despite this progress, even more than twenty years after the country had embarked on renovation, still fundamental challenges have to be met in the Vietnamese water sector (Staykova 2006: ii). Those concern:

- the provision of basic services,
- the opening up of new sources of finance,
- the refinement of planning processes,
- the efficiency of infrastructure service providers,
- the development of stronger institutions to encourage private finance of infrastructure or direct private provision of infrastructure,
- targeted approaches for poverty alleviation in this sector.

This thesis primarily aims at scrutinising the availability and accessibility of basic services in terms of domestic drinking water supply for rural households and only to a limited extent touches upon the other challenges addressed above. Nevertheless, in view of the albeit hesitantly advancing expansion of piped schemes in the rural areas it is inevitable to elaborate on questions of funding, institutional arrangements, and the role private sector participation plays in these settings.

1.5. Research questions and structure

Although the Vietnamese water sector has been subject of intensive research endeavours during the past ten years and a bunch of literature allows to draw a detailed picture especially of the political economy of the water sector (Harris et al. 2012; Reis 2012; Waibel 2010), still a gap remains between in-depth case studies with very limited spatial scope (Wilbers et al. 2014b; Herbst et al. 2009; Tobias and Berg 2011; Spencer 2008b, 2007; Salter 2003) and studies – often in terms of donor reports – which rely on aggregated statistical data to assess the progress made in improving domestic water but mainly lack systematic analytical insight in the mechanism which brought about these outcomes (WHO/UNICEF 2010; Staykova 2006; Trinh 2007; WB 1996). Undoubtedly, case studies can score by elaborated descriptions of causal mechanisms and conditions leading to success and failure of measures to improve access to safe water. Thereby they provide valuable information for setting up and interpreting quantitative models based on data sets like the Vietnamese Housing and Living Standard Survey and the Multiple Indicator Cluster Survey. However, the potential of these small-scale ad-hoc surveys for deriving generalisable conclusions is often restricted for two reasons. Firstly, due to their limited spatial focus and a lack of sound sampling strategies it is often hard to assess whether their results represent typical cases and to explicate the conditions under which their results are transferable to other communes or regions. Secondly, in Việt Nam the selection of sites for investigation and interview partners might rather be determined by opportunity structures in terms of local leaders' and authorities' willingness to cooperate than by profound scientific arguments, and hence to a great extent defies the control of the (foreign) researcher (see also p. 36). On the contrary, the collection of large-scale statistical data is usually less prone to such kind of selection bias because this data is gathered independently from the purpose of a specific study or analysis and based on a systematic sampling strategy which is expected to create a representative picture of a population (e.g. see p. 32). This allows to control for local and regional peculiarities but multi-purpose data also enforce their 'variable logic' upon the researcher and hardly elucidate the preconditions and mechanism which actually bring about the phenomena reported and cover specific practices and actions only insufficiently as will be discussed in Section 1.5.1.

Objectives

The present study aims to analyse determinants of domestic water supply on household and communal level in order to identify major obstacles, but also potentials for further improving rural water supply in rural Việt Nam. Thereby it focuses on piped schemes as well as the application of household water treatment (HWT). Whereas HWT practices are analysed on the level of individual households, the question of piped scheme coverage is decomposed into two sub-questions. The first one refers to the *availability* of piped schemes which primarily concerns the commune as an entity and targets the supply-side. The second one refers to the *accessibility* of safe water sources by rural households from the demand-side perspective. Nudged by the observation that piped schemes slowly gain in importance in rural areas, this thesis aims to elaborate which factors drive or hinder communes to operate piped schemes. Thereby, it firstly sheds light on institutional factors and secondly assesses by means of multivariate regression analysis, how socio-economic, spatial, and geographical characteristics affect the likelihood that piped schemes are operated in a commune. Subsequently, the focus is shifted back to the household level and the question which factors cause households to connect to piped schemes or to treat their drinking water by point-of-use techniques. Hereby the analysis will simultaneously consider the contribution of household and communal characteristics by applying multilevel regression. Moreover, it discusses how the promotion of self-supply and the expansion of piped schemes as strategies to improve rural households access to safe water are related and interact. Drawing on the case of rural Việt Nam, the thesis attempts to empirically assess whether this relation is rather competitive or complementary by nature and examines the potential impact on the diffusion of piped schemes.

Chapter 2

Chapter 2 sets out by briefly sketching the natural conditions and the availability and quality of water resources in different regions of the country. Subsequently, it has a closer look at current practices of self-supply by portraying typically used water sources according to their advantages and disadvantages, requirements for withdrawal, indirect and directs costs associated as well as the spatial distribution of their use. The overview is complemented by a short analysis of the prevalence of household water treatment techniques commonly applied in Việt Nam. Based on field studies from Việt Nam and own research in the Red River Delta, it will discuss factors which facilitate or deter people from applying household water treatment. The Chapter concludes by examining the relationship between access to safe water and poverty in Việt Nam.

Chapter 3

Chapter 3 gives a brief introduction to the political and institutional settings in the Vietnamese water sector which is indispensable to understand the development and dissemination of piped schemes as well as supporting measures in terms of governmental policies and programmes to improve rural water supply. Whereas the first part of Chapter 3 reviews central political and societal changes in Việt Nam, which are relevant for the development of the rural water sector in general, the following subsection introduces the most important Vietnamese institutions working in this field. This section also involves a detailed review of selected governmental and non-governmental activities. In particular, it addresses basic underlying principles, the

Guiding questions of Chapter 2

- What are the predominant strategies of the rural population to ensure domestic water supply?
- How strongly do geographical conditions predetermine the choice of water sources?
- Which role does household water treatment play in providing access to safe water?
- On which household characteristics does the choice of water sources and consequently access to safe water depend?
- How strongly are poverty and access to safe water interlinked?

relevance of the private sector and the coordination of different programmes and stakeholders. The last part of this chapter assesses based on empirical data how the engagement of distinct actors in water-related infrastructure projects and communes' and households' participation in supporting activities differ across the country.

Guiding questions of Chapter 3

- Which actors shape the policy strategies and their implementation for domestic water supply?
- Which programmes and other supporting measures are set up by the Vietnamese government and how do they contribute to improving rural water supply?
- How does the engagement of different actors in water-related infrastructure projects and communes' and households' participation in supporting activities differ across the country?

Chapter 4

Chapter 4 introduces basic concepts of diffusion research as a theoretical framework to analyse factors which drive or inhibit the adoption of safe water sources. It reviews diffusion studies in the field of rural water supply and sanitation in developing countries to gain insight about determinants of diffusion which are specific for water-related innovations, the specific group of adopters, and the circumstances under which diffusion in rural areas and developing countries proceeds. In a second step, these findings are discussed and organised along groups of diffusion determinants in order to arrive at a set of indicators and hypotheses guiding further analysis about the diffusion of piped schemes on communal level (Chapter 5), piped scheme connections (Chapter 6), and point-of-use treatment techniques on household level (Chapter 7). These are characteristics of water-related innovations, characteristics of communes and households as adopting entities, the environmental context in which diffusion takes place, and interventions as supporting measures and triggers of diffusion processes.

Chapter 5, 6, and 7 are the core empirical and analytical chapters of the thesis. Although piped schemes so far only supply a minor part of the rural population with water, they will gain in importance as their proliferation in some areas and the increasing political attention dedicated to them suggests. Grounded on previously provided background knowledge about the political and institutional setting in the water sector, Chapter 5 continues by examining the evolution and dissemination of piped schemes in rural Việt Nam. It describes and discusses institutional arrangements for piped schemes as they are outlined in official policies for RWSS and contrasts them by a review of practical experiences with different types of arrangements as they are currently in operation in Việt Nam. Contrasting 'officially recommended' models and their actual practical implementation leads to a discussion about the conceptualisation of the private sector, and ensuing the demarcations lines between governmental engagement, private sector, and user participation.

Chapter 5

Guiding questions of Chapter 5

- Which types of institutional arrangements prove successful and why?
- Which role is assigned to the private sector in establishing and operating piped schemes? How do users and governmental players contribute to improving rural water supply?
- How do strategies to promote self-supply and piped schemes interact, respectively, how does the continued use of self-supply and HWT impinge on the diffusion of piped schemes?
- Which relative contribution can be ascribed to socio-economic and spatial characteristics of communes compared to provincial level disparities in explaining the availability of piped schemes in rural communes?

Building upon Chapter 3, Chapter 5 discusses to which extent the private sector is able to satisfy the expectations raised by the governmental target programmes. Additionally, it elaborates on the consequences arising from the coexistence of self-supply and the expansion of piped schemes for an efficient, demand-based, and spatially targeted implementation of programmes and ensuing achievements of water related development goals. Although the finding that self-supply might deter households from connecting to piped schemes is not new (cf. Sy et al. 2014; Spencer 2007; Nauges and van den Berg 2006), it has hardly been investigated systematically on household level, let alone with regard to the implications for strategies to improve rural water supply. In a second step, Chapter 5 builds upon the qualitative results about drivers and obstacles towards the availability of piped schemes and complements it by a logistic regression model. Besides the use of tube wells as a substitute for piped water, the models factor in supporting measures as well as socio-economic and spatial characteristics of the communes in order to assess how these aspects affect the availability of piped schemes in rural communes. Additionally, the model accounts for similar institutional environments within provinces by a random intercept.

Chapter 6 Following the overall research question of the thesis to investigate the relationship between supply- and demand-side determinants of rural water supply in Việt Nam, Chapter 6 sets out by a systematical decomposition of coverage rates into the dimension of household level access to piped water and its physical availability on the commune level. Subsequent multivariate analysis finally brings the household and communal level together, by explicitly considering households as nested in communes. Based on hypotheses derived from diffusion theory and a review of water-related diffusion studies from developing countries, Chapter 6 assesses by means of regression analysis which factors might deter households from connecting to piped schemes, respectively encourage them, given that such service is physically available in their commune.

Guiding questions of Chapter 6

- To which extent is access to piped schemes determined by supply- and demand-side deficiencies?
- How strongly do spatial characteristics and settlement structures shape access to piped schemes?
- Which households do typically not connect to piped schemes given that these are under operation in the respective commune?
- Which role does 'contagion' in terms of piped scheme hook-up in the nearby environment play for households' decisions to connect to piped schemes?
- How relevant is the use of tube wells as a competing alternative for piped scheme hook-up?

Chapter 7 addresses the use of point-of-use water treatment by rural households as an alternative strategy to improve drinking water and seeks to identify relevant drivers and obstacles in the diffusion of different treatment techniques. The empirical analysis sets out by describing spatial and temporal patterns of diffusion as well as individual households' strategies. Subsequently, it digs deeper into the question how these patterns are actually brought about by applying multilevel analysis in order to systematically decompose household and commune level determinants of HWT diffusion. Finally, Chapter 8 concludes by summarising the empirical findings, pointing out research desiderata, and making suggestions for extending the data sources utilised here in order to address open research questions. *Chapter 7*

Further details on the methodological approach – or more correctly *statistical* approach anticipating the subsequent comments – and model diagnostics are outlined in Appendix A. Whereas Chapter 5, 6, and 7 only briefly introduce the models and are explicitly dedicated to the results, the methodological appendix more detailedly sketches the basic idea of multilevel models. It addresses selected methodological aspects which are relevant for the models estimated in this thesis such as estimation methods, assumptions to be met in order to gain proper results (functional relationships, influential observations, multi-collinearity), measures of model fit as well as data requirements for multilevel analysis. On the one hand, this chapter should help readers who are not familiar with these models to understand the results – in particular the interpretation of logistic and multilevel regression models – on the other hand, it provides additional graphs and tables to assess validity and appropriateness of the models. *Methodological Appendix*

1.5.1. In place of a methodological framework

In place of an extensive recap of methodological and theoretical frameworks, this section briefly sketches the main methodological principles which have been guiding this work. As becomes pretty obvious from the structure outlined above, statistical analysis poses one of the main methodological pillars in order to answer the research questions raised by this thesis. A review of research reports and policy documents aside, it primarily builds upon two cross-sectional multi-purpose data sets: the Vietnamese Housing and Living Standard Survey (VHLSS) and the Multiple Indicator Cluster Survey (MICS).[15] A great deal of the analysis could surely declared descriptive, meaning it primarily aims at *describing* practices of domestic water supply. However, also the question *why* households opt for or against specific water sources or treatment techniques, respectively *why* some communes operate piped schemes while others do not, should be answered based on survey data.

[15] The acquisition of the VHLSS 2008 data set was funded by the Graduate School for Climate and Environment (GRACE) at Karlsruhe Institute of Technology.

In the following, I will discuss which difficulties might arise from using survey data for answering these questions and how these problems will be addressed. The approach to explain social phenomena based on survey data has been criticised for two reasons which will subsequently be elaborated in a more detailed fashion: firstly, the often claimed primacy of predictive accuracy of statistical models and the illegitimate equation of statistical associations and causal explanations, and secondly, the often undertheoretised and data-driven operationalisation and conceptualisation of models (Hedström 2005; Goldthorpe 2001; Lüdemann 2000; Esser 1996).

Causation as robust dependence

Technically speaking, this thesis stands in the tradition of 'causation as robust dependence' (cf. Goldthorpe 2001; Lazarsfeld 1955). Setting out from the proposition 'that while correlation – or, more generally, association – does not imply causation, causation must in some way or other imply association', the problem has to be addressed, 'how to establish whether, or how far, the observed degree of association of a variable X with variable Y, where X is temporally prior to Y, can be equated with the degree to which X is *causally significant* for Y' (Goldthorpe 2001: 2). The approach of 'causation as robust dependence', as advocated by Lazarsfeld (1955), implies to test for the robustness of the dependency of Y on X by bringing in more prior variables Z and to observe whether this will reduce the partial correlation between X and Y (cf. Goldthorpe 2001: 2 et seq.). However, following this approach 'causation becomes *entirely* a matter of statistical inference' without involving any kind of theory or background knowledge as Goldthorpe (2001: 3) argues. Correlations and statistical models as such neither offer a theoretically adequate explanation nor do they provide a hermeneutic benefit because they do not foster a deeper understanding of the identified association (Lüdemann 2000: 395). Also Hedström (2005: 23) appreciates 'statistical explanations' as a useful means to focus attention on the right problems but cautions to draw causal conclusions from them because '[s]tatistical regularities are rarely (if ever) as unequivocal and easy interpretable in causal terms as this view would seem to suggest.' In fact, usually a multitude of explanations are conceivable for interpreting a statistical correlation (cf. Stinchcombe 1968). Statistical analysis might be based on implausible assumptions or ad-hoc models lack a proper foundation. Due to these reasons, it is not unlikely to produce artifacts. As Hedström (2005: 23) succinctly boils it down, '[s]tatistical analyses are important for testing proposed explanations, but it must be remembered that a statistical analysis is a *test* of an explanation but not the explanation itself.' Several authors (e.g. Hedström 2005; Lüdemann 2000; Esser 1996) critically illuminate the often (implicitly) claimed primacy of predictive accuracy over the appropriateness of the postulated mechanisms when researchers seek to assess the explanatory value of a theory. From Hedström's (2005) point of view, for many sociologists, as long as assumptions as such appear logically consistent and predictions are accurate, there is no need to worry about the results, even if obviously important factors or mechanisms are ignored. He instead argues that

Primacy of predictive accuracy

> [s]ince it is rather the rule than the exception that concretely observed phenomena are influenced by several different processes, testing a theory by examining the accuracy of its predictions is likely to conflate the truth or relevance of the postulated mechanism with the importance of other processes, and this may lead us to mistakenly reject perfectly appropriate causal accounts (Hedström 2005: 108).

Atheoretical models

Why correlations and statistical models gained from survey data often do not come along with theoretically adequate explanations or a deeper understanding of the identified associations is often attributable to an insufficient operationalisation and primarily data-driven and atheoretical conceptualisation of the respective models. Especially multi-purpose surveys often lack variables to operationalise subject-specific attitudes or action-theoretical models (e.g. the VHLSS as well as the MICS which are used in this thesis provide quite detailed information about domestic water supply but do not contain any information about the households' attitudes, knowledge, and awareness about water related problems or health issues). Consequently, models rather contain easy-to-measure proxy-variables based on standard-demographics, without paying attention to the question whether those adequately reflect the actual processes and underlying mechanisms which bring about the specific behaviour, attitude, or social phenomena to be explained (cf. Lüdemann 2000). Further reservations about the usefulness of survey data are owed to the fact that these usually collect data on attributes of individuals rather than their actions, and sampling strategies often do not pay attention to interactions between individuals, respectively the social environment they are embedded in (Hedström 2005: 109).

How to get from the 'what' to the 'why'?

So given these challenges, how is it possible to come from the description of domestic water supply practices to a sound explanation about how these patterns are actually brought about? Since – except for a case study in Hà Nam province (Bui and Wegner 2011) – no ad-hoc data could be generated which operationalises adoption and decision-making processes, and thus only proxy-variables from the VHLSS and MICS are available for testing the research hypotheses, more attention is paid to the underlying *mechanisms* on which these hypotheses are based. This is done by:[16]

- discussing the appropriateness and validity of measured variables (How precisely do the questions represent the behaviour or issue to be measured and to which extent does the stimulus provided by the questions probably evoke distinct interpretations?),
- identifying systematical measurement errors which could occur (e.g. due to social desirability, cultural differences, artifacts due to asking questions deemed irrelevant by the respondents),

[16] The following questions to structure the have been developed based on Lüdemann (2000).

- explicitly elaborating on the underlying *mechanisms*[17],
- taking into account the conditional nature of hypotheses (Which conditions should be present so that the stated relationship is observable? Which factors probably moderate the relationship?),
- and asking for potential recursive or feedback effects which would enforce a different causal interpretation.

Relating literature review and empirical analysis

In order to provide a solid foundation for the discussion of the hypotheses and their underlying mechanisms, the first part of this thesis aims to depict a structured and comprehensive picture about the local conditions and mechanisms which shape rural water supply in Việt Nam (and other developing countries) based on a review of data sources and theoretical approaches from diffusion theory and development economics. Furthermore, from the beginning, the argumentation is supported by selected empirical findings from two large-scale surveys: the Vietnamese Housing and Living Standard Survey (VHLSS) and the Multiple Indicator Cluster Survey (MICS).[18] The continuous reference to empirical data serves a twofold purpose here: on the one hand it allows to corroborate, further differentiate, or even refute assertions about rural water supply before getting started with the multivariate analysis, respectively to assess the findings from case studies to the overall picture drawn for Việt Nam. On the other hand, a strict distinction between reviewing the current state of research and additional empirical analysis would have led to strong redundancies throughout the thesis. Hence, the major data sources are already introduced in the subsequent section while the chapters dealing with multivariate analysis forgo extensive descriptive analysis to avoid cumbersome revisions of facts which are already known from the previous chapters.

1.5.2. Data sources

To date, information about rural water supply in Việt Nam largely builds on reports by supranational and development aid agencies. These reports often rely on unpub-

[17] Here Hedström's 'Analytical Sociology' provides a quite compelling nudge by pointing to the role of *mechanisms* which explicate how observed empirical regularities are brought about. '[M]echanisms can be said to consist of *entities* (with their properties) and the *activities* that these entities engage in, either by themselves or in concert with other entities. These activities bring about change, and the type of change brought about depends upon the properties of the entities and the way in which they are linked to one another. A [...] mechanism, as here defined, describes a constellation of entities and activities that are organized such that they regularly bring about a particular type of outcome. [...] [M]echanism-based explanations can be described as propositions about probabilities of different outcomes conditional upon general *ceteris paribus* clauses [...] (Hedström 2005: 25-32).'

[18] All statistical analysis has been done by Stata 12.

lished ad-hoc data inquiries or aggregated statistical data and thus can hardly be re-analysed for different purposes, whereas large-scale (multi-purpose) surveys prove an untapped potential also for sector-specific analysis. In contrast to the still common presumption that developing countries are often lacking comprehensive and up-to-date data which can be utilised for gaining insight in living conditions, supporting planning procedures or targeting social problems, various data sources containing information about water related aspects are available in Việt Nam.[19] This looks different with regard to spatial data, where serious problems with data quality urging labour intensive reworks are known (Minot et al. 2006). The comparatively good data availability in Việt Nam is surely attributable to donor activities but arguably also deeply rooted in the Mandarin tradition to control the villages as autonomous units by means of statistical figures (cf. Ngoc 2010: 168).[20] Reis (2012: iv) argues that the practices of data collection are a result of the efforts to keep the extensive planning machinery of the Vietnamese administration alive and criticises the bureaucratic efforts to produce 'arbitrary statistics' as 'mindless routine' as well as the lack of quality control for this data. This reproach might to some extent be reasonable and indeed – as in the case of the newly established monitoring and evaluation indicators for rural water supply gathered by local officials for planning purposes – implementation often falls short behind expectations. However, it barely applies to the large national surveys since those have been utilised for a wide range of secondary studies and provide documentations covering instructions for interviewers, quality control measures as well as descriptions of the questionnaires.

Data quality and coverage

Since the 1990s, Việt Nam has received technical support by organisations like the World Bank to set up a system of surveys which are conducted regularly in order to deliver data about the economic and social development of the country. Most of these surveys are quite well documented and questionnaires publically available online. Usually the data is gathered in face-to-face interviews which requires to build up and train an enormous work-force of skilled interviewers. Response rates in surveys carried out on behalf of governmental authorities are usually extraordinarily high. On the one hand, this might be due to the penetration of everyday life by formal and informal state structures, on the other hand, because Vietnamese citizens are obliged to take part in those official inquiries (for further discussion see Section 1.5.2). Such practices might ensure high coverage rates, but it remains unclear whether

[19] As Duflo (2006) points out, in parallel to the long tradition in development economics to collect primary data in order to test specific hypotheses, initiatives such as the World Bank's Living Standard Measurement Surveys contributed to the generation of large-scale, multi-purpose data sets. This trend has not only been appreciated by researchers which can now draw on these data sources, but also fostered the establishment of standards for empirical evidence in this research field.

[20] For a short summary of the debate about the centrality and decentrality of the Vietnamese state, see Section 3.1.

they produce any kind of systematic bias due to the exclusion of disadvantaged or vulnerable groups. People not registered in the official registration system 'hộ khẩu' (Karis 2013; Hardy 2001) are not included in population statistics, poverty calculations, and social service provision. The impact of non-registration on survey results has not been subject to systematic investigation yet, but for example reports about birth registration in Việt Nam revealed that in the past, a large share of the new-born children have not been registered (Hayton 2010; Cody 2009).[21] So it is reasonable to assume that there is also a substantial number of people, especially amongst temporary residents, who might fall through the cracks of official household registration – and that subsequently the share of households suffering from inadequate water supply is likely to be underestimated based on official data sources like the VHLSS and MICS.

Table 1.3 provides an overview about large-scale data sets for Việt Nam which encompass information about water supply and related issues. The Joint Monitoring Programme of the WHO and UNICEF is not listed separately because it aggregates data from the MICS and Living Standard Measurement Surveys such as the VHLSS. The major part of the empirical analysis in this thesis relies on the VHLSS 2008 but also draws on other data sources. Subsequently, data sets used for own calculations in this study will be portrayed in brief with regard to sampling and sample size, topics covered, and accessibility.

Vietnamese Housing and Living Standard Survey 2008

The Vietnamese Housing and Living Standard Survey (VHLSS) enjoys a good reputation in the scientific community, which is firstly expressed by numerous studies relying on its data (Anderson et al. 2010), and secondly owed to the fact that it is listed by the World Bank Living Standard Measurement Study (LSMS) survey finder, which makes the questionnaires easy to find and access. The VLSS – how it was called in its early years – was implemented for the first time in 1992/93 by the General Statistics Office (GSO) of Việt Nam with funding from the Swedish International Development Agency and the United Nations Development Programme. It is technically supported by the World Bank within the LSMS initiative to collect policy relevant household level data. It is carried out bi-annually and since 2002, parts of three consecutive data sets can be used as a panel. For example, the panel component for the 2008 survey is realised by re-selecting 50 percent of the enumeration areas of the VHLSS 2006, which in turn comprises half of the areas surveyed in 2004. Response rates for the survey are extraordinarily high because the respondents

[21] In Việt Nam, registered children below five years are eligible to free health care services at health stations and hospitals (Cody 2009: 19). Thus, children without birth certificates are probably less likely to receive vaccines and immunisations.

TABLE 1.3.: Selected data sets for Việt Nam 1990-2013

	Year	Sample size	Topics	Status & Accessibility
Living standard surveys by GSO				
Việt Nam Living Standards Survey	1992/93	4,800	Income, expenditure, health, education, housing, assets, fertility, migration	accessible for a fee
Việt Nam Living Standards Survey	1997/98	5,999	Income, expenditure, health, education,housing, assets, fertility, migration, etc.	accessible for a fee
Population Census	1999, 2009	16,661,433	Household composition and housing	
Việt Nam Household Living Standards Survey	2002-2012 biannually	~9,000	Income, expenditure, health, education, housing, assets, etc.	accessible for a fee
Other surveys				
MICS 2,3,4 Việt Nam (UNICEF)	2000, 2006, 2010/2011	8,000 to 11,000	Health, assets, housing, socio-demographics	publicly accessible upon request
M&E system rural WASH sector (MARD/CERWASS)	since 2009 annually	every household	14 water sector and programme related indicators	only partially implemented not publicly accessible
Việt Nam Access to Resources Household Survey (VARHS)	2006, 2008 and 2010	2,200	Demographic-information, agricultural commercialisation, land fragmentation, income shocks, social capital savings, rural credit and welfare dynamics	

Sources: Own illustration

are mandated to participate by law. This policy might also prove disadvantageous when it leads to a systematic exclusion of unregistered households, and hence, to under-representation of households living under worse conditions (cf. Anderson et al. 2010: 8). Sampling and implementation procedures are laid down in the operational handbooks for the respective survey. According to the VHLSS Manual, the sample for income and expenditure is said to be representative on national and regional level (GSO Vietnam 2008a). The survey is not a simple random sample because households are chosen from predefined sites. All provinces are captured, but the number of communes selected in each province bears relation to population size and the number of urban and rural communes. Within the more than 10,000 sampled communes, households are selected based on so-called enumeration areas (EA), which are defined in a master plan. The master sample plan applied by the GSO Việt Nam since 2001 is based on the Population and Housing Census 1999. Thus, the current sample is deemed deficient because the data basis does not account for changes in the population structure. Additionally, boundaries of the EAs are fuzzy which confronts the researchers with the problem that for example in the southern part of the country, a village might comprise more than one EA, whereas in the north, an EA might consist of more than one village (Petterson 2009: 3). Since this data base has become out of date in the meantime anyway, a new master plan has been elaborated with support of SIDA within the framework of the public administration reform project.

Sampling and implementation

Topics and structure

The VHLSS comprises a household and a commune questionnaire. Whereas the household questionnaire is directed to the head of the household, numerous local officials such as commune officers, headmasters, or deputy headmasters of commune schools, clinic officers, or other communal leaders are in charge of providing the information about the commune. The household questionnaire inquires information about all household members and covers topics such as education and vocational training, health care, income and expenditure, fixed assets and consumer durables, housing, and participation in poverty reduction programmes. In addition, specific modules, for example concerning disaster mitigation or governance, have been appended to the incidentally comprehensive set of questions. Besides information about officials providing the information, the communal questionnaire collects data about demographic characteristics of the local population and their general economic situation, communal projects and programmes, employment opportunities, land use and agriculture, infrastructure, education, health, public order, and social issues as well as credits. The VHLSS questionnaire asks for water sources used for drinking and cooking as well as other daily purposes, the frequency of boiling water, and the application of water treatment by filters or chemicals. Moreover, it indicates the main water source used in the commune and hereby distinguishes between the dry and rainy season.

Multiple Indicator Cluster Survey Việt Nam

The Multiple Cluster Indicator Surveys are a monitoring tool providing internationally comparable data for more than 50 countries. It serves as a data source for various international commitments such as the MDGs or other health related target programmes. The MICS is now in its forth iteration, here primarily data from the third and fourth round carried in 2006 and 2011 has been used. In Việt Nam, the MICS has been conducted by the General Statistics Office of Việt Nam (GSO) in collaboration with the Việt Nam Committee for Population, Family and Children (VCPFC) and is supported by the United Nations Children's Fund (UNICEF). Usually, the survey consists of modular tools which are adapted to the specific needs of the target countries. The MICS 3, which has been used here, comprised three questionnaires, one for households, one for women aged 15 to 49 and one related to children under the age of five. The Vietnamese version follows the global templates but has been customised. The household questionnaire includes a household listing, information about education, water and sanitation, other household characteristics, child labour, usage of mosquito nets, child discipline, child disability, and maternal mortality. Like the VHLSS, it asks for households' water sources but in comparison to the VHLSS, this data set contains more detailed information about water treatment techniques applied on household level.

TABLE 1.4.: Structure of MICS data sets for Việt Nam

	MICS 3	**MICS 4**
Number of households	8,356	11,614
- urban	6,294	5,001
- rural	2,062	6,613
Sampling units (EAs)	250 EAs	600 EAs based on sampling master plan from 2009 population census
Number of rural communes in sample	189	323
Sampled households per EA	10-60, average 33.3	20, average 18.9
Regional coverage	Urban and rural districts covered for all administrative regions	
Distinction between urban and rural communes	Equivalent definition of urban and rural communes based on official classification of district	

Sources: GSO Vietnam (2011); GSO/UNICEF (2007)

Sample The MICS covers the whole country and is considered as representative for urban and rural areas and the eight superordinated administrative regions. A two stage-sampling procedure was applied: firstly census enumeration areas (EAs) have been selected covering the administrative regions and secondly, based on a household list a random sample has been drawn from each EA (GSO/UNICEF 2007). Table 1.4 describes the two surveys with regard to their data structure. In order to reduce the design effect, respectively increase effective sample size for the MICS 4, the number of clusters has been increased from 250 to 600 whereas the number of sampled households per cluster was standardised at 20. As in the previous MICS, households within the enumeration areas have been selected by a random selection procedure based on a household list (GSO Vietnam 2011: 216).

Monitoring and Evaluation system for the rural water and sanitation sector

The Vietnamese state collects socio-economic data in order to define and adjust planning targets. Within the framework a bottom-up reporting and top-down planning process for the rural water sector, which is described in Section 3.3.2, the Ministry for Agriculture and Rural Development (MARD) developed a set of fourteen indicators to monitor and evaluate progress in the sector on the communal level (MARD 2010: 16). Approved by MARD's Decision no 51/2008/QD-BNN in April 2008, this system should have been applied nation-wide since 2009. In practice however, the reliability of this data seems sometimes questionable (Reis 2012: 134) and even the official documents complain about untimely and insufficient implementation and reporting (MARD 2010: 27). In the meantime, the system has been revised and the number of indicators reduced (see Table 1.5). Anyway, data gathered for monitoring and evaluation purposes in the water sector is still not accessible for research purposes so far, although it would surely prove a valuable supplement to the data sources listed in Table 1.3.

1.5.3. Why using secondary data?

In comparison to other studies about water-related research in Việt Nam (Reis 2012; Tobias and Berg 2011; Herbst et al. 2009; Spencer 2008b), this study mainly refrained from collecting ad-hoc data[22] for reasons of resources, efficiency, and cultural barri-

[22] With the exception of an own field study in Hà Nam province. The study aimed to quantify, which water resources and treatment methods for arsenic removal are used in rural areas of the Red River Delta and how these point-of-use techniques differ in terms of operability, usability, and acceptance. Furthermore the survey examined which factors influence the use of water resources and treatment methods. This study was embedded in the VIGERAS-project funded by the German Ministry of Science and Education (BMBF) and was co-funded by the Swiss National Centre of Competence in Research (NCCR) North-South Programme. The survey was prepared jointly by the Hanoi School of Public Health (HSPH) and the Institute of Regional Science of

Table 1.5.: M&E indicator set for RWSS (as revised in October 2012)

Indicator	Description
1	Proportion of rural population having hygienic water (%) (1A) and Proportion of rural poor population having hygienic water (%) (1B)
2	Proportion of rural population using clean water meeting National water technical standards (%)
3	Proportion of rural households having latrines (%) (3A); Proportion of rural households having hygienic latrines (%) (3B); Proportion of rural poor households having hygienic latrines (%) (3C) Number of latrines increased annually (3D)
4	Proportion of schools having water and hygienic latrine (%) (4A); Proportion of schools having hygienic water (%) (4B); Proportion of schools having hygienic latrines (%)(4C)
5	Proportion of commune health stations having water and hygienic latrine (%) (5A); Proportion of commune health stations having hygienic water (%) (5B); Proportion of commune health stations having hygienic latrines (%)(5C)
6	Proportion of rural households having hygienic cattle sheds (%)
7	Number of rural households having access to water as designed capacity (7A) and in practice (7B) from the piped water supply schemes newly built and upgraded annually
8	Proportion of functionality of piped water supply schemes (%): Sustainable (8A); Medium (8B); Poorly effective (8C) and not functionable (8D)

Source: MARD (2012)

ers, but primarily relies on statistical data from different sources. Several researchers aptly describe the severe difficulties and restrictions foreign researchers faced and are still facing in Việt Nam (Reis 2012; Bauer 2011; Kerkvliet 1995). After intensive desk research it became obvious that existing data sources provide a sufficient pool of variables to approach the research questions outlined above and test the hypotheses derived from them. Additionally, the applied survey instruments implicitly reflect in-depth knowledge about the peculiarities of the economic structure, infra-

the Karlsruhe Institute of Technology (KIT). Whereas the first one was represented by Bui Thuy Tung, the author of this thesis contributed from the KIT side and was responsible for the design and development of the questionnaire and subsequent data cleaning and analysis. The design and questionnaire has been developed in autumn 2010 and the survey was conducted in January 2011.

structure facilities, and governmental services which can hardly be produced ad-hoc by a foreigner without long-year working experience in Việt Nam. Especially the VHLSS provides such comprehensive information that the effort and costs to conduct an own survey would have been absolutely disproportionate in comparison to using the existing database, even though not all indicators which would be desirable from a theoretical point of view can be operationalised. For me as a single researcher without any substantial financial resources and institutional support it would have been impossible to generate a data set that even begins to compare with regard to wealth of details and coverage of regions which is inevitable for the topics addressed. Given the constraints concerning resources, it would have only been feasible to conduct surveys with a comparatively small sample size. Furthermore, since access to the field especially for foreign researchers is restricted, it is highly questionable, whether it would have been possible to pursue an appropriate sampling strategy based on purposefully selected criteria. The choice of research areas often does not reside with the researcher but depends on the willingness to cooperate of the local authorities and the relations and engagement of the local partner. So finally I preferred to base my analysis on secondary data in lieu of rather anecdotal evidence.

2. Domestic water supply between self-supply and piped water schemes

Contents

Large parts of Việt Nam are shaped by rivers or deltas, whereby two thirds of the water sources originate outside of the country. The abundance of water creates favourable conditions for agriculture, but irrigation also makes up more than four fifths of the country's estimated water demand (ADB 2008; WB 2003). Water landscapes like the Red River and the Mekong Delta form the backbone of Việt Nam's rural economy and the basis for rural households' livelihood – be it for irrigation, farming, raising livestock, or other household businesses. According to official statistics, rural households account for more than two thirds of the total Vietnamese population and nearly every second Vietnamese at the age of fifteen and above is employed in agriculture, forestry, or fishing.[23] This illustrates how tightly the subsistence of the rural population, the agricultural sector, and water supply are interwoven. Although water seems abundant in most parts of Việt Nam, sufficient supply still remains a problem, especially in rural or remote areas. During the last decades intensive research has been dedicated to the Vietnamese water sector, primarily shedding light on the recent changes and reforms in water management and policy (e.g. Waibel 2010; Evers and Benedikter 2009a,b; Molle et al. 2009b), irrigation and aquaculture (e.g. Phuong 2013; Tran et al. 2011; Anh et al. 2010; Hoang et al. 2009; Kirby and Mainuddin 2009), or environmental issues like anthropogenic and geogenic pollution (e.g. Winkel et al. 2011; Fendorf et al. 2010; Berg et al. 2007, 2006). Numerous case studies scrutinise domestic water supply in rural Việt Nam (Reis 2012; Spencer 2011;

Water-related research in Việt Nam

[23] This share decreased from 65 percent in 2000 to 48 percent in 2011 (GSO Vietnam 2013).

Tobias and Berg 2011; Le et al. 2010; Herbst et al. 2009; Spencer 2008b, 2007). Despite the extensive body of literature about the political economy and institutional environment governing the Vietnamese water sector on the one hand, and case studies about domestic water supply on the other hand, still a gap remains in systematically relating the findings from both research areas in order to achieve a comprehensive understanding of the factors influencing access to safe water. Whereas case studies often lack contextual embedding by asking for the relevance of the described practices of use beyond the specific study area or their dependency upon certain institutional and environmental preconditions, political economy studies often fail in drawing conclusions about the practical implications and consequences for access to safe water. This study attempts to build a quantitative model of determinants of households' access to safe water based upon findings from both branches of research. In order to lay the foundation for quantitative assessment, this chapter provides a detailed and comprehensive introduction about domestic drinking water supply in rural Việt Nam and therefore draws on statistical data as well as case studies, which describe specific practices of water supply and treatment utilised in rural Việt Nam.

As was outlined in Section 1.4, in Việt Nam the use of different water sources has undergone substantial change during the last years: on the one hand due to increasing pollution of surface water from rivers, lakes, and ponds; and on the other hand due to rising living standards which come along with an increased demand for piped water. Unfortunately, the expansion of piped water supply was not able to keep pace with the increasing demand for safe drinking water supply amongst the rural population, hence, self-supply is still very common. This chapter aims at providing an overview about current practices of water self-supply and household water treatment in rural Việt Nam and thereby elaborates in detail on:

- the availability of water sources and environmental conditions affecting water quality as a limiting factor for progress in improved water supply,
- advantages and disadvantages of the most common water sources, respectively modes of distribution, namely tube and dug wells, rain, surface and spring water,
- regional peculiarities in access to different water sources,
- and the usage and usability of popular household water treatment techniques.

The chapter concludes by discussing potential linkages between domestic water supply and households' socio-economic status.

2.1. Water sources and environmental conditions as limiting factors towards water supply

Although at the first glance water is an abundant resource in Việt Nam, regional and seasonal disparities in supply and insufficient water quality pose substantial obstacles for expanding access to safe water for the rural population. Besides water scarcity, environmental factors as severe pollution – for example due to intensive industrial or agricultural use – severely limit the opportunities to increase access to safe water and will be explored in the next section. The scorecard (Table 2.1), based on the results of the Việt Nam Environmental Monitor (WB 2003) and the water sector review of the Asian Development Bank (ADB 2008), provides a brief overview about the availability of water sources and major problems in different administrative regions.

Availability of surface water

Surface water in terms of rivers, channels, lakes, or ponds is abundant in many parts of the country but distributed unevenly during the year. About 60 percent of Việt Nam's surface water originates outside the country. Besides the Red River Delta, the Mekong Delta, and the Southeast, also the Northeast and Northwest have available large amounts of surface water, but steep valleys make it much more difficult to access in the later ones. Beyond that, water quality downstream often deteriorates as a result of salt water intrusion and large scale industrial use upstream. The dry season lasts from six to nine months and the natural discharge during that time amounts only up to 20 percent of the year's total.

Availability of ground water sources

Regions suffering most from water scarcity are the coastal and downstream ones characterised by prolonged dry seasons, short and steep river basins which provide only limited opportunities for ground water withdrawal and rainwater harvesting (WB 2003). The ground water potential varies considerably within Việt Nam with 3,770 m^3 per capita and year in the Northwest and only 84 m^3 per capita and year in the Mekong Delta (ADB 2008: 20). Besides the volume available, extractability has to be taken into account when considering ground water as basis for domestic water supply. In the mountainous Northwest and Northeast – characterised by sand stones, clay, and limestone – ground water is hardly extractable at all by simple hand dug wells because the water table is deep and underlies larger fluctuations across the year. Hence, water is often taken from springs. In contrast, the unconsolidated sands and gravels in the delta regions and coastal plains provide better conditions for inexpensive ground water exploitation. The aquifers are closer to the surface and ground water is easy to extract by hand drilled wells and pumps in coastal regions in comparison to the deep aquifers in the Mekong Delta which require the use of deep drilled wells. In general, ground water resources are regarded as underutilised, but at the same time, locally over-exploitation leads to falling water tables and ensuing land subsidence and salinity intrusion (WB 2006, 2003). Where intensive abstraction takes place, like around HCMC and Há Nội, ground water levels have already declined by up to 30 metres within the last years, and to make things worse, this is often accompanied by increased concentrations of arsenic in lower aquifers (Winkel et al. 2011; ADB 2008).

2.2. Water quality and its impact on health

The promising figures from the Joint Monitoring Programme suggest a doubling of the share of rural households with access to 'improved' water sources within the last twenty years (cf. Section 1.4), but it is still unclear how many of these households actually use water that is safe of pathogens or other contaminants. Still, in some areas people are lacking even a minimum amount of water for domestic use or water is of poor quality. This primarily affects saline areas, coastal areas, islands, high mountainous areas, remote areas, karstic limestone areas or drought-stricken areas such as Thanh Hóa, Nghệ Tinh, Quảng Bình, Quảng Trị, Hòa Bình, Cao Bằng, Hà Giang (MoC/MARD 2000: 4). Surface and ground water are often microbiologically contaminated or polluted by high pesticide concentrations, nitrates from fodder additives, fertiliser and human waste or toxic elements. These water-related problems arose during the last two decades as a consequence of intensified agriculture, industrialisation, and urbanisation in conjunction with a lack of sewage disposal and sanitation, especially in densely populated areas.

Contamination by pathogens

Despite increased access to improved water sources, diarrhoeal diseases still remain a problem in Việt Nam and are one of the leading causes of death among children (Brown et al. 2013; WHO 2009b; Hien et al. 2008). The Việt Nam Environment Monitor (WB 2006) reported a coincidence of poor water quality and rate of sickness in the Cầu and Nhuệ - Đáy as well as Đồng Nai - Sài Gòn river basins. Although these findings do not allow to assess the contribution of poor water quality to human health, they clearly suggest a link between use of polluted water and illness: Firstly, the number of digestive infections (e.g. diarrhoea, dysentery) is elevated in downstream provinces and secondly, within the same province extraordinarily high in those districts and communes which are directly located by the river (WB 2006: 45 et seq.). Việt Nam faced direct costs of roughly 100 billion VND each year for treating water-borne diseases like cholera, typhoid, dysentery, and malaria (WB 2003: 11). During the last years, the situation improved and across all provinces, incidences of diarrhoea have been declining (WB 2006). Besides adverse health effects due to the use of drinking water contaminated by pathogens, heavy metals, and pesticides, indirect uptake of contaminants via ingestion of food and subsequent accumulation pose a threat to human health, which has hardly been recognised so far.

Arsenic contamination

Apart from anthropogenic causes, some regions are prone to geogenic contamination. One of the largest epidemiologic threats emanates from ground water contaminated by arsenic (cf. Fendorf et al. 2010). Besides arsenic contamination, which often coin-

TABLE 2.1.: Water resources availability scorecard for Việt Nam

Region	**Surface Water**	**Ground-water**	**Issues**
Northwest Region	+++++	+++	Flashfloods, floods, seasonal drought, reservoir siltation and construction
Northeast Region	++++	+++	Flashfloods, floods, seasonal drought
Red River Delta	+++++	+++++	Floods, cross-sectoral water allocation and use, intensive agriculture, ground water over-exploitation
North Central Coast	+++	+++	Flashfloods, floods, seasonal droughts, low river flow during prolonged dry season in south of region
South Central Coast	++	+++	Flashfloods, floods, severe seasonal droughts, low river flow during prolonged dry season in entire region
Central Highlands	++++	++++	Flashfloods, seasonal droughts, ground water over-exploitation for irrigation, reservoir construction
Northeast of Mekong	++++	+++++	Floods, seasonal drought, sector-wise water allocation and use, ground water over-exploitation (HCMC)
Mekong River Delta	+++++	+++++	Floods, cross-sectoral water allocation and use, intensive agriculture/ aquaculture, ground water over-exploitation

+++++ = water is abundant, + = water is scarce

Source: Việt Nam Environmental Monitor 2003 (WB 2003: 5) cides with high iron levels in the ground water, health problems might also arise from elevated concentrations of manganese, fluoride, selenium, chromium, and barium (Winkel et al. 2011). In the Red River Delta, arsenic contamination of ground water is known since the end of 1990s only (Berg et al. 2007, 2006). After the problem was first recognised in the Bengal Delta in 1989, awareness increased and led to in-depth investigation in several other countries. In Việt Nam, about 10 million people in the Red River Delta and 0.5 to 1 million in the Mekong Delta are estimated to be at risk of chronic arsenicosis because arsenic levels in the drinking water considerably exceed the limit of 10 μg/L set by the WHO (Winkel et al. 2011; Berg et al. 2007). Due to its strong adverse health impact, arsenic contamination of the ground water is considered as the 'largest poisoning of a population in history' (Smith et al. 2000: 1). In the first stages, people concerned show no symptoms although arsenic can be detected in urine or body tissue. After five to ten years to initial exposure, early symptoms like skin pigmentation, gangrene or keratosis occur. The incubation time differs according to the amount of arsenic uptake, nutrition, and immunity of the individual. Finally, long term exposure over a time span of ten to twenty years causes neurological effects and considerably increases the risk to develop skin cancer or cancer of other internal organs like lung, bladder, liver, or kidney (Parvez et al. 2011; Smith et al. 2000). Even chronic exposure to lower arsenic levels inhibits the intellectual development of children (Nahar et al. 2013; Norra et al. 2012; Majumdar and Guha Mazumder 2012; Wasserman et al. 2011; Wang et al. 2007). Since ailments become irreversible after the internal organs have been affected and no immediate cure is available, prevention in terms of ensuring arsenic-free water supply poses a crucial entry-point to improve the situation of rural households.

Whereas in other affected regions like the Bengal Delta or Bangladesh serious health problems are already reported (cf. Paul 2004), only few cases have been recognised so far in Việt Nam (Nguyen et al. 2009) because rural households have only started to use tube wells during the last ten to fifteen years and the use of rainwater is wide-spread in the affected regions. Nevertheless, the number of persons with arsenic ailments is likely to grow in the future, albeit to an unknown extent. Although public awareness about the problem increased tremendously, responsibility for mitigation measures to prevent adverse health effects caused by elevated arsenic or microbiological pathogens often resides with the households. Consequently, so-called point-of-use water treatment technologies play a crucial role for households. Some of them will be introduced in Section 2.6.

2.3. Water sources and distribution

So far we have seen that rural households in Việt Nam rely on various water sources for drinking and cooking, ranging from piped water schemes, private tube or dug wells to springs, rivers, lakes, ponds, or rainwater harvesting. Whereas Chapter 5 and 6 are explicitly dedicated to the question to which extent various factors such as households' socio-economic status or geographical conditions actually contribute to access to safe water, this chapter briefly introduces typical water sources and modes of distribution and subsequently quantifies their use based on statistical data. The MICS aside, the VHLSS is probably the most important source of information for assessing the prevalence of water sources and modes of distribution on household level for Việt Nam; and the only one which allows to correlate it to a wide range of communal and household characteristics. Inspecting descriptive statistics and screening previous research about domestic water supply in Việt Nam does not only serve for quantifying the share of people using the one or other water source but lays the foundation for a sound analysis of determinants for access to safe water. Throughout this section, main implications for multivariate analysis will be discussed.

The following section introduces the most popular water sources in Việt Nam with regard to requirements for withdrawal, distribution and treatment, water quality, costs as well as typical problems, advantages and disadvantages associated with their use. Assessing the relative advantage of the different opportunities to get access to safe water is crucial because it is considered one of the most influential factors driving adoption processes (see p. 118 et seq.). Therefore, each section touches upon perceived benefits as well as costs of the respective water source. In general, perceived benefits from improved water supply refer to water quality and ensuing the reduction of water-related health problems. As will be explored in detail below, households usually appreciate better odour and taste of water, whereas positive effects on health often play a subordinate role because these are often not observable at once – even in case of severe poisoning by arsenic. Besides water quality, continuity, and convenience of supply play an important role for the assessment of potential benefits.

Tap water

Table 2.2 shows how water sources, respectively modes of distribution, have been aggregated for further analysis in this thesis and how their distribution differs across urban and rural districts. Since Chapter 5 is explicitly dedicated to the evolution of piped schemes, this paragraph is confined to some very basic facts about piped schemes. In contrast to urban and peri-urban regions, small scale water stations in rural areas are usually operated by stakeholders like the Vietnamese Centres for Rural Water Supply and Sanitation (CERWASS)[24], cooperatives, user-groups, or even individuals and less by private water supply companies. Usually these schemes serve less than 500 households, whereas in larger cities and small towns piped schemes are thriving and the number of households served by one station is higher. Water provided by the stations either needs to comply with the Standard 09 by MoH or – if more than 500 households are served – with a stronger standard according to MoH

[24] A detailed introduction to CERWASS' roles and functions will be given in on page 91 and 143 et seq.

TABLE 2.2.: Classification and distribution of main water source for urban and rural households

	Urban		Rural			Urban		Rural	
Main source of drinking water (Classification in VHLSS 2008)	**N**	**%**	**N**	**%**	**Main source of drinking water (Own classification)**	**N**	**%**	**N**	**%**
Private tap in house	1,280	54.4	370	5.4					
Private tap outside house	119	5.1	227	3,3	Tap water	1,536	65.3	711	10.4
Public tap	137	5.8	114	1.7					
Drill well	325	13.8	1,650	24.1	Tube well	325	13.8	1,650	24.1
Hand dug, reinforced well	266	11.3	1,849	27.0					
Hand dug, non-reinforced and covered well	33	1.4	266	3.9	Dug well	299	12.7	2,115	30.9
Protected spring	12	0.5	239	3.5	Spring water	17	0.7	499	7.3
Unprotected spring	5	0.2	260	3.8					
Rainwater	119	5.1	1,329	19.4	Rainwater	119	5.1	1,329	19.4
Bottled water	12	0.5	32	0.5					
Small water keg	4	0.2	8	0.1	Bought water	16	0.7	45	0.7
Water tank	0	0.0	5	0.1					
River, lake, pond	31	1.3	403	5.9	Surface water	31	1.3	403	5.9
Other	9	0.4	85	1.2	Other	9	0.4	85	1.2
Total$_{household}$	**2,352**	**100.0**	**6,837**	**100.0**	**Total$_{household}$**	**2,352**	**100.0**	**6,837**	**100.0**

Source: VHLSS 2008, Own calculation

decision No. 1329 (Reis 2012). The costs for piped water vary between 800 and 2,400 VND per m^3 (Staykova 2006).[25] Piped water is valued as a convenient source, which requires less physical effort than self-supply. According to case studies, the positive attitude towards piped water is extenuated for two reasons: firstly, because supply is frequently interrupted due to electricity cuts or poor maintenance so that people still need to store water in tanks or jars, and secondly, because the quality of tap water is not always satisfying (Reis 2012; Spencer 2008b). Tap water is still only used by a minority of the rural households, with the Southern and Delta regions accounting for highest coverage rates (see Table 2.2 and 2.3). In the course of this thesis, access to tap water will be examined on two levels of aggregation: in terms of availability of piped schemes in communes (Chapter 5) and in terms of individuals households' access to tap water (Chapter 6). Disentangling availability of piped schemes and individual access to safe water becomes especially relevant against the background of case studies showing that even in areas where water stations have been constructed, people often do not connect to the grid (Reis 2012; Spencer 2007).

Surface water

Surface water is an important source for drinking water or other purposes during the dry season if ground water or access to piped water schemes are not available or affordable. Water from rivers, lakes or ponds is either transported by buckets to the household and stored in jars or transported by electric pumps to the house. In the latter case, costs for electricity are often high and in addition to those for treatment, total costs might even exceed those for water from piped schemes (Spencer 2007). In comparison to other water sources, it is considered the unsafest one and associated with serious health risks as water-borne and water-washed diseases. Usually, surface water is treated by alum in combination with settling and boiling.[26]

Ground water abstraction by dug and tube wells

Việt Nam has an estimated total renewable ground water potential of 63,000 million m^3 per year, but the amount available per capita varies tremendously between the regions, depending on population density, ensuing withdrawal, and supply provided by the local aquifers (ADB 2010: 4). Still in 2003, the Việt Nam Environment Monitor declared that ground water resources are abundant, while data from the National Monitoring for Dynamic Ground Water already indicated declining levels in several regions and in particular in the major cities as HCMC or Há Nội (WB 2003: 64). How dramatically the public perception of the situation changed within a few years, illustrate press releases of the Ministry of Natural Resources and Environment about overexploitation of ground water resources in the Mekong Region (MONRE 2009a,b) and local attempts to regulate ground water withdrawal by water stations or private wells. For example, the official city government of Cần Thơ aims to limit the number of newly drilled wells because they might cause ground water pollution if the well

[25] Regulation of water prices and other costs associated with treatment are discussed in Section 2.7.1.
[26] For details, see Section 2.6.

is covered by floods or not properly fixed with concrete or sealed when people stop using it. People's Committees[27] often do not sanction people drilling wells illegally because from their point of view, the government fails to meet local people's demand (Reis 2012: 70). Such restrictions vary throughout the country, because not every region is endangered by floods and the right to drill wells is regulated on provincial level.

Ground water resources are either exploited by hand dug wells or tube wells with electric pumps. Drilling wells for domestic water supply has been extensively promoted in several large and small scale projects by UNICEF in cooperation with provincial governments and was later on also triggered by decentralised rural marketing approaches (Badloe and Nguyen 2006; Frias and Mukherjee 2005; Salter 2003). The costs for drilling and constructing wells depend on the depth of the aquifer. Whereas Reis mentions costs of 1 to 2.5 million VND for drilling a well with a depth of 60 to 100 metres (Reis 2012: 71), those in the Red River Delta are considerably lower due to shallow aquifers. Besides for installation and buying pumps, additional expenditures arise for electricity if electric pumps are used. A member of a communal People's Committee in Cần Thơ province calculated that people pay 700 VND per kWh electricity and yield 3 m^3 of water (Reis 2012: 91). In regions where electricity is unreliable, even hand pumps might be perceived as advantageous.

The quality of well water varies considerably within and between regions, which necessitates additional treatment or makes water unusable for households at all. Well users in the Mekong Delta as well as in the Red River Delta are facing severe quality problems due to high levels of iron in the water (Reis 2012; Bui and Wegner 2011). In surveys conducted in Hà Nam and former Hà Tây province, households often reported about yellowish colour and fishy smell. The bad smell is ascribed to hydrogen sulphide emanating from anaerobic processes (Reis 2012: 71). Due to its insufficient sensoric quality, tube well water is often not appropriate for making tea or cooking and therefore substituted by rainwater. In contrast to tube wells, dug well water is withdrawn from a pit with a depth of about 1 to 5 metres, in which the ground water is accumulating. Since those pits are often unprotected, it might be contaminated by microbial or chemicals (Luzi et al. 2004). Dug wells still serve as an important source for drinking water; one third of the rural households uses them as primary source. Their use is especially wide-spread in regions with shallow aquifers and among households which cannot afford to drill tube wells.

[27] Each commune as the lowest administrative unit is equipped with a People's Council and a People's Committee (cPC). The cPC serves as the local branch of the national government and is responsible for routine state administration, the implementation of laws, directives, and decrees issued by upper level authorities or the local People's Council. For further information, see p. 92 and 87.

Spring water

Spring water is the most relevant source of water in the northern mountainous areas. It is distributed by simple above ground distribution systems made of hoses or tubes (see Figure 2.1 (b)). No literature is available about how distribution systems and allocation are organised.

(a) Rainwater tank in the Red River Delta

(b) Hoses from springs in Lào Cai province

FIGURE 2.1.: Practices of self-supply

Rainwater harvesting

Rainwater is a common source of water during the rainy season, but households' storage capacities are usually not sufficient to use rainwater all year round. According to the VHLSS, 20 percent of the rural households state to use rainwater as a main source of drinking water (Table 2.2). Rainwater users are confronted by unpredictable variations of the available amount of water due to delayed rain seasons or generally decreased levels of rainfall. The runoff is typically collected from roofs and stored in tanks made of plastic or brick and concrete, or jars as common in the South (Reis 2012: 58). Whereas the volume of these plastic barrels and clay jugs amounts to about 150 litres (Herbst et al. 2009), households in the Red River Delta construct tanks of brick and concrete with a storage capacity of 1 to 5 m^3 (Bui and Wegner 2011). Although rainwater is storable for weeks or months if properly protected from sunlight and dust and free of geogenic contamination, it is not completely non-hazardous to health since mosquitoes may lay egg in the standing water and transmit malaria and dengue. This might be prevented either by covering jars with a lid or putting small fish in the tank which eat mosquito eggs. Due to its ‘sweet’ taste, rainwater is mainly used for drinking and in particular favoured in areas where ground water shows high iron levels (Luzi et al. 2004; Bui and Wegner 2011).

So far, there are no comprehensive studies available which compare the advantages and disadvantages of different water sources from the consumer’s point of view but case studies from Việt Nam provide at least some indication. Based on a small scale household survey conducted in peri-urban wards of Cần Thơ, Spencer (2008b) compares different water sources like rainwater and surface water with those from wells or water supply stations. Asked about their preferences, the respondents ranked tube well water as the most hygienic source, followed by rainwater and piped water. Although piped water supply is perceived as hygienic and high quality, this does not provide a relative advantage in comparison to tube wells because users of tube wells are more satisfied with the hygienic quality. Surface water on the contrary scores highest concerning affordability, whereas access to rain, well, and piped water is perceived convenient. Additionally, people highly value well water due to its high hygienic quality and the fact that it is directly pumped on-site.

2.4. Quantitative distribution of water sources for domestic supply

This section does not only summarise basic facts about the distribution of water sources used by households in Việt Nam but also points to important implications for further analysis. Table 2.3 gives an overview about the share of households using different drinking water sources with regard to the administrative region and the status of the district. It points to significant differences in water supply between rural and urban areas: rural households can draw from a larger range of alternative water sources and it is obvious that with increasing urbanity, practices of self-supply become less common. As expected, the number of households relying on piped water in urban communes by far exceeds the one in rural areas. Whereas two of three urban households are already connected to piped schemes, in rural areas only every tenth household has access to a private or public tap.

Assumption 2.1 *Urban and rural areas differ so fundamentally that they require a separate analysis.*[28]

Even without elaborating further on urbanity and the ensuing characteristics, it is striking that living conditions and local infrastructure differ so fundamentally

[28] In the statistical analysis, urban and rural areas are distinguished based on the official administrative classification of the districts provided by the VHLSS data set.

between urban and rural communes that pooling them for further analysis on determinants of water supply is hardly expedient. It is reasonable to expect that a joint analysis of an urban and rural sub-sample would severely bias further examinations on the influence of household and communal characteristics: Firstly, because the usage of water sources differs fundamentally between urban and rural areas as illustrates Table 2.3 and secondly, because urban and rural areas differ with regard to spatial and infrastructural characteristics which are expected to impinge on the diffusion of piped schemes and point of use treatment techniques. As a consequence, it is also reasonable to assume that regression coefficients for predicting the use of different water sources in urban and rural districts would differ considerably.[29] By implication, in a global model – including the assignment to urban and rural areas – other predictors would show heterogeneous variances for urban and rural areas.

Assumption 2.2 *The analysis of usage of water sources should control for regional differences to account for the natural disparities in the availability of water sources.*

As outlined above, rural households are more heterogeneous with regard to water supply than urban ones. The majority of the rural population owns private wells; almost one quarter a drilled one and 31 percent dug wells. Additional 20 percent collect rainwater for drinking and cooking. Strong regional disparities are striking and speak for a differentiated view at the regions (Table 2.3). While rainwater harvesting contributes significantly to drinking water supply in the densely populated delta regions, it is almost irrelevant for the remaining parts of Việt Nam. With less than 5 percent of the rural households using surface water, this source does not seem widespread. Broken down by regions, it becomes obvious that for every fifth inhabitant of the Mekong Delta, water from rivers, lakes, or ponds constitutes the main source of drinking water. Similarly, spring water covers the drinking water demand for more than half of the population in the mountainous Northwest and Northeast but does hardly play a role beyond the mountains. So these figures underline what has already been suggested by the findings from the Việt Nam Environmental Monitor (WB 2006): in the absence of piped schemes, the availability of 'natural water sources' still proves a strong determinant of water supply.

Assumption 2.3 *Households might rely on multiple water sources across the year and depending upon the purpose it is used for.*

Case studies, especially from the Mekong and Red River Delta, indicated that the use of multiple water sources is a common practice amongst rural households. Two

[29] Analogous results have been found in a poverty mapping for Việt Nam, where the Chow test for differences in regression coefficients pointed to general differences in living conditions and thus also provided a strong argument for conducting separate analysis in urban and rural areas (Minot et al. 2006: 13). This methodological approach could not be used here because most of the relevant predictors are not available for urban districts at all.

Table 2.3.: Main drinking water source of household by administrative region

	Source of drinking water (Percentage of households)								
	Tap water	**Tube well**	**Dug well**	**Spring water**	**Rainwater**	**Bought water**	**Surface water**	**Other**	**Total**
Administrative Status of commune									
Urban	65.3	13.8	12.7	0.7	5.1	0.7	1.3	0.4	100.0
Rural	10.4	24.1	30.9	7.3	19.4	0.7	5.9	1.2	100.0
Total	24.5	21.5	26.3	5.6	15.8	0.7	4.7	1.0	100.0
Administrative Region									
Red River Delta	22.3	27.9	7.6	0.1	41.9	0.2	0.1	0.0	100.0
Northeastern	19.9	10.6	46.0	17.1	2.1	0.0	1.4	3.0	100.0
Northwestern	9.8	0.7	27.3	52.0	1.2	0.9	5.6	2.6	100.0
North Central Coast	19.0	22.9	44.4	2.3	8.9	0.1	1.4	1.1	100.0
South Central Coast	25.9	21.9	48.4	1.6	0.0	0.7	0.8	0.6	100.0
Central Highlands	13.7	6.2	68.2	5.0	1.0	0.3	3.3	2.2	100.0
Southeastern	38.8	34.1	22.3	0.0	1.4	1.4	0.8	1.1	100.0
Mekong Delta	29.7	23.1	1.1	0.1	26.2	1.4	18.3	0.1	100.0
Total	24.5	21.5	26.3	5.6	15.8	0.7	4.7	1.0	100.0

Source: VHLSS 2008, Own calculation

main reasons have been identified why relying on different water sources might be advantageous for households: firstly, for daily purposes like washing or cleaning, lower qualities might suffice, which enables the respondents to save money. Secondly, households relying on rainwater usually use other sources during the dry season because storage capacities are too small. According to calculations based on the VHLSS, at least 25 percent of the surveyed households use different water sources for drinking and other daily purposes.[30] Almost all households (96%) which collect rainwater for drinking use different sources for other purposes. A similar pattern can be found for households which buy bottled water or store it in tanks: the vast majority of those (85%) uses these water sources exclusively for drinking. In contrast to what has been expected against the background of case studies from the Mekong

[30] On household level the VHLSS does not report separately about water sources used in the dry and rainy season. Additionally questions about water sources for drinking and daily purposes were designed as single choice answers. Thus, the estimated share of people relying on different sources might be underestimated.

region (Reis 2012; Spencer 2007; Herbst et al. 2009), three quarters of the households drinking tap water also use it for other daily purposes. This might be interpreted twofold: one the hand this could indicate that households' efforts to keep the amount of water they obtain from piped schemes low are rather exceptional than usual. On the other hand, there might be a number of households which use additional sources for daily purposes what is not covered by the standardised questionnaire of the VHLSS.

Assumption 2.4 *Assessing access to safe water requires to include information about water quality and water treatment on household level.*

Assessing water safety exclusively based on information about the source of water is fraught with large uncertainty. In contrast to the approach pursued in the JMP, which distinguishes between 'improved' and 'unimproved' water sources and neglects water treatment (cf. Section 1.2), water safety is in the following assessed by taking into account information about the source of water and household water treatment based on the VHLSS data.

2.5. How to assess water safety?

Assessing access to 'safe water' based on a household's statement without considering water quality might lead to severe misinterpretations as the example of the MGDs discussed in Section 1.2 revealed. Self-assessments like in the case of the VHLSS and other large scale LSMS surveys suffer from the strong limitation that they fail in delivering reliable information about water quality and actual exposure to contaminants. Firstly, this is due to the fact that households might use different water sources across the year which is usually not reported in the survey and secondly, even if information about the usage of point-of-use treatment is taken into account, assumptions about the efficiency of treatment methods are fraught with large uncertainties because it depends upon numerous parameters which will be discussed in Section 2.6.
This thesis harks back on the same data sources as the JMP – namely the VHLSS and the MICS – but water safety is here measured by combining households' statements about the source of water and application of treatment techniques, respectively boiling (cf. Table 2.2). The following attempt at classification also takes into account findings of the WHO/UNICEF (2011: 34) and a recent study for Việt Nam (Brown et al. 2013). In line with these results, protected dug wells are rated as less safe than tube wells. Piped water on premises is ranked as the safest water source but only in combination with some kind of treatment either in terms of boiling or filters and chemicals. In contrast to the dichotomous approach pursued in the JMP, it yields a five point scale for assessing water safety whereby the darkest colour in Figure 2.2

FIGURE 2.2.: Classification of water sources according to water safety

	Neither boil nor treat	Treat but not boil	Boil but not treat	Treat and boil	
Piped water*	13,3%	-	86,7%	-	100% (N=2247)
Tube well	15,4%	2,5%	54,1%	28,0%	100% (N=1975)
Dug well	7,7%	0,5%	85,5%	6,3%	100% (N=2414)
Spring water	14,5%	-	83,7%	1,7%	100% (N=516)
Rainwater	15,2%	-	84,8%	-	100% (N=1448)
Bought water	54,1%	-	42,6%	3,3%	100% (N=61)
Surface water	15,5%	7,2%	42,3%	35,1%	100% (N=433)
Other	21,3%	-	74,5%	4,3%	100% (N=94)
	13,1%	1,0%	76,4%	9,5%	100%

Very unsafe · Unsafe · Rather unsafe · Safe · Very safe

Note: * Households using piped water were not asked about treatment by filters or chemicals.
Source: VHLSS 2008, Own classification

indicates the unsafest category. Following this classification, still more than every tenth rural household relies on very unsafe or unsafe water sources (urban: 3%) whereas only 18 percent of the households have access to very safe drinking water (urban: 63%). This leads to the conclusion that rural households do not simply use different sources but are also disadvantaged concerning water safety in general.

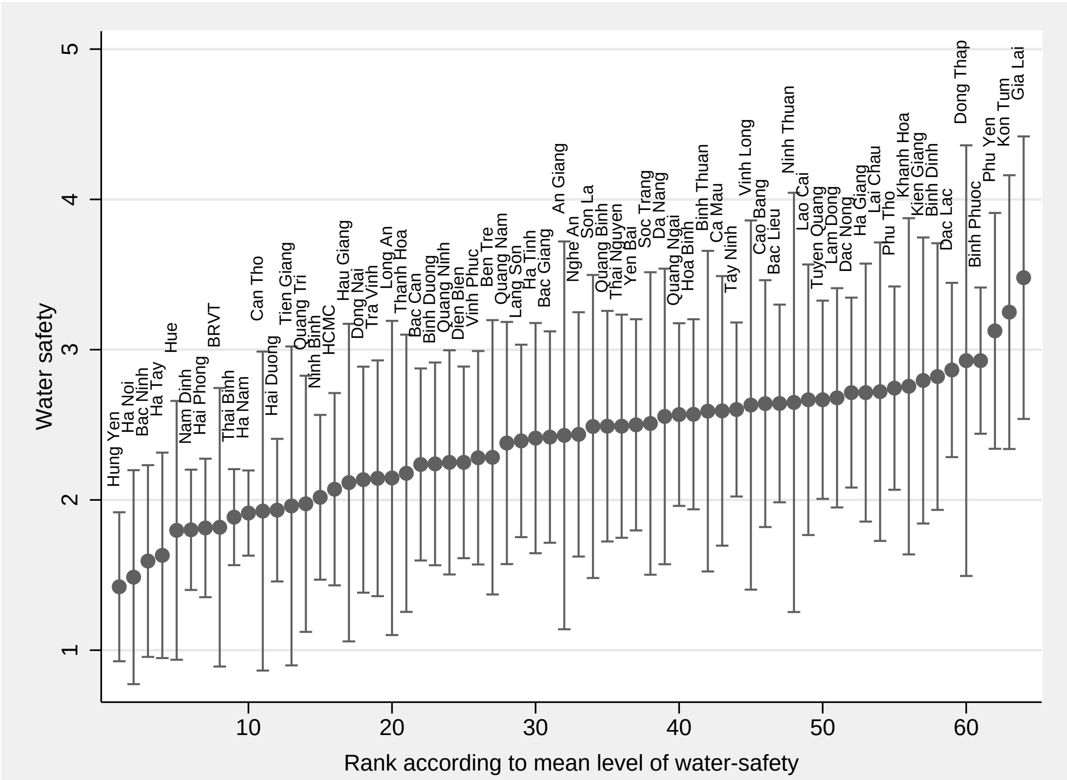
Ranking of provinces

Figure 2.3 ranks the Vietnamese provinces according to the average level of water-safety of rural households in the respective province based on the classification approach just introduced above.[31] Whereas the dots mark the province-specific means, the whiskers illustrate the standard deviation. Figure 2.3 reveals that provinces in the Red River Delta and close to urban areas score high with regard to water safety, whereas the Central Highlands are on average worst off. These results suggest that besides the regions typically targeted by measures to improve rural water supply – which are at least in case of foreign donor involvement concentrated on the Mekong and Red River region – still pockets with very poor water supply exists in the Central Highlands, which are hardly recognised by the water research community so far. At least the current engagement of the World Bank in poverty eradication in the Central Highlands reflects the increasing awareness about this specific target region. Moreover, it is striking that regardless of the mean level, southern provinces like Cần Thơ, Tiền Giang, An Giang, Ninh Thuận, and Đồng Tháp are characterised by extreme within-province disparities in access to safe water. Here the standard deviations are almost twice as high as in the Red River region. As has also been discussed in case of measures for poverty eradication in general (Minot et al. 2006), these findings underline the demand for spatially targeted interventions but also the strong need for further research on the reasons for such significant local level disparities.

However, also the approach to incorporate treatment underlies some limitations: firstly, for example geogenic contamination is characterised by large spatial disparities within the country so that households are exposed to different levels of contamination even if they use the same water source. Secondly, due to locally varying water quality, it is uncertain whether treatment techniques captured by the VHLSS are in principle capable of removing all pathogens and contaminants. And thirdly, as I will show in the next chapter, there are numerous good reasons adducible to doubt in the effectiveness of HWT if households do not apply treatment in a regular and proper manner.

[31] The calculation only includes households from the VHLSS 2008 which have been classified as rural. This also holds true for provinces like Há Nội, HCMC, Đà Nẵng or Huế, which are also represented by with rural districts.

Figure 2.3.: Ranking of provinces according to average level of water safety in rural households



Note: Scale ranging from 1 = 'very safe' to 5 = 'very unsafe'
Source: VHLSS 2008, Own calculation

2.6. Point-of-use household water treatment

Due to a lack of centralised water supply in rural areas, measures to ensure safe water supply and prevent water-related diseases mostly address households themselves and refer to point-of-use treatment technologies. In order to reduce the epidemiological burden arising from contaminated water, much effort has been put into the development and dissemination of household water treatment techniques (HWT) so that at least theoretically a wide range of mitigation measurements is available in developing countries (Sobsey et al. 2008; Murcott 2001, 2003). In view of the slow progress in establishing and extending piped schemes, HWT is considered an indispensable strategy to ensure safe water supply in rural areas but except for boiling, none of the techniques has achieved sustainable and large-scale use so far. According to Sobsey et al. (2008) in order to be applied in a sustainable manner HWT should:

- be able to provide a sufficient quantity of water for daily needs of a household,
- be robust enough to treat a wide range of raw water qualities even if it is turbid and contains high amounts of organic matter,
- ensure microbiologically safe water,
- be easily to maintain and not require much time and effort,
- be affordable in order to avoid that the households stop treatment,
- rely on locally available material or have 'have a reliable, accessible and affordable supply chain for needed replacement units' (Sobsey et al. 2008: 4263) but also for waste disposal,
- and '[m]aintain high post-implementation use levels after cessation of intensive surveillance and education efforts, as in field trials and marketing campaigns' (Sobsey et al. 2008: 4263).

Subsequently, filter techniques typically applied in rural Việt Nam will be introduced and assessed according to the above mentioned criteria.

2.6.1. Common treatment techniques in rural Việt Nam

Across Việt Nam, different types of HWT are applied, ranging from (sand-)filters and aeration in the Red River Delta to treatment by aluminium sulphate or chlorine in the Mekong Delta. In this section, a set of techniques will be briefly introduced and assessed according to their usability and treatment efficacy.

Treatment by chemicals

Household water treatment by chlorination and flocculation has been promoted as a low cost solution for reducing microbiological contamination. Besides laboratory studies, (randomised controlled) field trials have been applied to assess the treatment efficacy. According to a review study, chlorination and coagulation reduced prevalence of diarrhoeal disease on average by 29 percent. Coagulation and chlorination systems are deemed appropriate to remove turbidity, organic matter, and microbes by flocculation and settling which also helps to improve the aesthetic quality of the water (Sobsey et al. 2008: 4262 et seq.). Several studies from Việt Nam report the usage of alum to flocculate suspended particles (Reis 2012; Herbst et al. 2009; Wrigley 2007, 2002). Usually, this kind of treatment is applied to surface water. Reis (2012: 60) describes the typical procedure in the Southern regions as following: 'Traditionally, people treat water from rivers and canals with a crystal stone ("alum"). The water stored in jars is stirred with the alum stone so that the sediments will settle on the bottom of the jars after a few days.' Wrigley (2002, 2007) assessed the effect of alum as flocculant for treating surface water from rivers, ponds, and wells by an experimental design. In this study, two types of materials were tested: rock alum, which is mined in the Mekong Delta and available on local markets and poly aluminium chloride (PAC) which is sold together with hypochlorite. After treatment, the microbial water quality improved significantly, with hypochlorite accounting for the best result, and rock alum for the second best. Nevertheless, it is questionable whether in practical everyday use, the treatment would yield similar results because chemicals are often dosed in an arbitrary manner as has been observed during surveys in peri-urban wards of Cần Thơ (Herbst et al. 2009). Several long term studies about the sustainability of coagulant/chlorine systems showed sharply decreasing levels of usage which have been attributed to unavailability of the product or low willingness to pay (Sobsey et al. 2008; Ram et al. 2007; Makutsa et al. 2001). However, none of the latter problems has been reported for Việt Nam so far. Costs for consumables are not considered as high and continuous supply is provided by local markets.

(a) Sand-filter with additional treatment units

(b) Aeration unit

FIGURE 2.4.: Household water treatment in the Red River Delta

Treatment by sand-filters

Measured against the prerequisites for sustainable use of household water treatment introduced at the beginning of this section, sand-filters are in good contention to spread to other regions and communes: they treat a sufficient amount of water for a household, are easy to operate, and sand is locally available (Sobsey et al. 2008). Usually sand-filters are constructed as two superimposed tanks made of brick and concrete (see Figure 2.4 a). Whereas the upper tank contains the filter-material, the water is stored in the underlying one (Luzi et al. 2004). Often a combination of different filter-materials like black or yellow sand, gravel, or charcoal is used in the upper tank. Depending on the raw water quality, sand needs to be replaced or washed periodically. Commonly used filter materials as black or yellow sand are locally available, thus no logistic infrastructure needs to be established. Sand-filters are used for filtering especially if ground water contains high levels of iron, which can easily be recognised by the yellowish colour and 'fishy smell' of the water. In case high levels of iron in the ground water coincide with elevated concentrations of arsenic, sand-filters are also applied to remove arsenic. Under oxic conditions iron precipitates in form of iron(hydr)oxid on the surface of the sand grains and these coated grains absorb arsenic (Luzi et al. 2004). According to Berg et al. (2006), sand-filters prove to be an efficient method to treat water with elevated arsenic levels because about 80 percent of the arsenic is removed by them. This has been confirmed by an own field study in Hà Nam province[32]: here on average 90 percent of the arsenic was removed by sand-filters. Nevertheless, depending on the amount of arsenic in the tube well water, even after treatment 81 percent of the households exceeded the WHO threshold value of 10 μg/L but only 12 percent the laxer national threshold value of of 50 μg/L. Furthermore, it has been tested whether treatment efficacy depends on maintenance or on the amount or composition of filter material. Each respondent was asked about the material, the thickness of the layer in cm and the order of the material in the filter. Households in Chuyện Ngoại mostly used black or yellow sand in their filter, but the thickness of the material varied considerably. Every tenth filter only contained a thin layer of 20 cm or less, whereas the majority of 62 percent put a layer of 20 to 60 cm in the upper tank and the remaining quarter even up to over 100 cm. However, in this sample, neither the total thickness of filter material or sand layers in particular nor the intervals of maintenance significantly impinged on the reduction rate. In some cases, the sand-filter is coupled with an aeration unit (see Figure 2.4 b) or a settling tank. Settling tanks remove arsenic by the principle of passive precipitation and sedimentation of iron(hydr)oxide particles. The removal rate is similar to those of the sand-filter (Luzi et al. 2004).

Other filter techniques

Besides self-constructed sand-filters and settlement tanks, a variety of filters using different adsorbents, ceramic filters, or reverse osmosis are available in Việt Nam.

[32] In this survey, 150 households belonging to seven different hamlets of Chuyện Ngoại commune have have been surveyed. The commune in Duy Tiên district is located closely to the Red River. Prior to the main survey quick tests for arsenic in several households were done to get rough information about the level and distribution of arsenic in this specific area. The survey in Hà Nam province is in the following cited as Bui and Wegner (2011).

In general, according to Sobsey et al. (2008) ceramic filters work efficiently for long periods and do not cause ongoing costs, except for the replacement of broken parts. They can easily be cleaned manually to restore treatment efficacy and flow rate. The products used by Vietnamese households are usually stemming from China, Taiwan, and South Korea. Whereas some of them are even affordable for rural households (300,000 to 400,000 VND), the costs for more sophisticated solutions, for example based on reverse osmosis, account for 3.5 up to 10 million VND. Commercial filters of brands like 'Kangaroo' or 'Korea King' are available on the local market and their usage has been observed in several villages in the Red River Delta (see Figure 2.5). Usually these systems require some pre-treatment of the raw water, otherwise the filter will be clogged soon. For commercial filters as well as sand-filters, arsenic removal efficacy depends on maintenance, which means to wash or clean the sand, respectively to replace a filter unit or the adsorbents.[33]

FIGURE 2.5.: Reverse osmosis filter in former Hà Tây province

2.6.2. Beyond technology – Which factors do have an impact on the efficiency and sustainable use of HWT?

Whereas HWT proved to work efficiently under laboratory conditions and in several field trials, its actual impact on improving households' access to safe water on a large scale depends on two factors: adoption by individual households and adequate and sustainable use. The recognition of the fact that spending effort on elaborated HWT techniques is futile if no one will adopt them, and efficiency and removal capacity of treatment techniques strongly depend on the proper use and maintenance, attracted the attention of the scientific community to questions of practical imple-

[33] Information about commonly used filter-systems was gained from a survey which the Centre for Environmental Technology and Sustainable Development (CETASD) conducted in parallel to the construction of sand-filters in Mai Động commune and compiled upon request by Lê Văn Chiều (CETASD, Hanoi University of Science).

mentation. An increasing number of empirical studies and meta-studies deals with the implementation and use of filter techniques to improve the microbiological quality of drinking water (Dreibelbis et al. 2013; Parker Fiebelkorn et al. 2012; Albert et al. 2010; Rosa and Clasen 2010; Sobsey et al. 2008; WHO/UNICEF 2012b; Clasen et al. 2007; Sobsey 2002) or to remove other contaminants (Tobias and Berg 2011; Mosler et al. 2010; Opar et al. 2007; Ngai et al. 2006; Paul 2004). The central conclusion to be drawn from those studies is that the availability of filter-techniques or other mitigation options is a prerequisite but not a sufficient condition for improving water quality. In a nutshell, the take home message was that the adoption and continuous and correct use requires a change of habits in everyday life, depends on a variety of social, psychological, and situational factors; and is not necessarily driven by health-related motives (cf. also Thurber et al. 2013).

Motivation of HWT use

Empirical findings from Việt Nam confirm this conclusion. In case of the Hà Nam survey (Bui and Wegner 2011), the motivation to treat water is mainly attributed to the aim to improve water quality or sensoric quality in general rather than to remove arsenic. Only a minority of less than 10 percent of the respondents explicitly mentioned high iron levels. In comparison to iron or other visible impurities, arsenic did not play any role in this context although the ground water was highly contaminated. Furthermore, every sixth household does not name any reason at all which is directly related to water quality but states they just constructed a filter because their neighbour did it, what suggests that primarily imitation or compliance with social norms are responsible for adoption. The findings go in line with a household survey about the influence of psychological and social factors on the adoption of arsenic-removing sand-filters in Hà Tây province (Tobias and Berg 2011). Of the 319 households from four villages in the sample, 162 had a sand-filter and 157 did not. Regression analysis was then applied to investigate which factors have an impact on three types of behaviour: the decision for a sand-filter, its acquisition, and its maintenance. Besides perceived improvements of healthiness and taste of water, monetary costs and social norms proved to be influential. Here again, knowledge about arsenic contamination did not correlate with the decision for, acquisition, or maintenance of sand-filters. The study implies that sand-filters are primarily applied to improve the taste of water in general but not explicitly to remove arsenic. This study also considers competing behaviour and indicates 'that the households do not abstain from competing behaviors in order to acquire a sand-filter. If they can afford both, they acquire a sand filter; if not, only the competing behavior is implemented' (Tobias and Berg 2011: 3265).

Inappropriate application of HWT

Case studies depict a detailed yet ambiguous picture of practices of use in everyday life and call to question whether HWT is always applied in an appropriate manner. A study from the Mekong Delta suggests that treatment techniques '[...] seem to be applied rather by chance. For the treatment of rainwater, a cloth filter is often used (67%), but there is observational evidence that no attention is paid to proper application, e.g. the reverse filter side is used upside down. [...] The dose of aluminium sulphate added is not based on an assessment like a visual check for turbidity, but rather on a hit-or-miss principle' (Herbst et al. 2009: 704). Additionally, a Vietnamese researcher who is involved in the development of different filter techniques reported that filters are acquired but filter units rarely replaced (Le 2010). In case of sand-filters, households often explain that washing and removing sand is hard and time-consuming work, especially for women or older people. On the contrary, the household survey in Hà Nam province (Bui and Wegner 2011) revealed that filters and storage tanks are maintained quite regularly despite low levels of awareness and knowledge about water-related diseases in general and arsenic contamination in particular.[34] So eventually it remains an open question whether inappropriate application or insufficient usability of treatment techniques generally question the benefits of HWT. At least the studies reveal that diffusion and adoption of HWT has so far mainly been driven by social factors and bad sensoric quality but hardly by awareness and knowledge about water-related diseases, especially in the case of arsenic contamination. As an reaction, during the last years numerous information, education, and communication activities with a focus on water-related diseases have been launched ranging from TV campaigns to leaflets or the construction of pilot facilities in selected communes.

2.6.3. The prevalence of HWT in rural Việt Nam

Sand-filters in the RRD region

Experiences from pilot studies and field visits in former Hà Tây and Hà Nam province (Bui and Wegner 2011) – both located in the Red River Region – between 2010 and 2011 suggest that the use of filter-techniques or stored rainwater as a substitute for tube well water varies considerably even within districts or communes. In none of the surveyed areas piped schemes existed, hence adoption decisions are restricted to the choice between different methods of household water treatment or rainwater harvesting. In both communes – Mai Động (former Hà Tây province) and Chuyện Ngoại (Hà Nam province) – ground water shows elevated arsenic levels. As explained in the introduction, slow sand-filtration is usually applied in regions where ground water contains high levels of iron.[35] In the commune Mai Động, only very few households had a sand-filter and additional ones were constructed in the course of a Vietnamese-

[34] A survey about the water consumption from deep tube wells in Bangladesh observed a similar phenomenon. It revealed social norms, taste of the water, and self-efficacy as important determinants of behaviour but unexpectedly, other theoretically derived factors like perceived fear, vulnerability, severity, awareness, and knowledge did not show a significant effect. Here, this result was ascribed to the fact that all respondents displayed high values in these variables (Mosler et al. 2010).

[35] For detailed information about see hydro-chemical atlas Việt Nam provided by EAWAG (http://www.eawag.ch/forschung/wut/gruppen/vietnam/survey/index).

German cooperation project[36], whereas the survey in different hamlets of Chuyện Ngoại revealed that all but one household in the sample used sand-filters and a substantial share even applied additional treatment methods. A similar distributional pattern – communes with almost full coverage in contrast to communes with zero or very low prevalence of sand-filters – was observed in the study about sand-filter use conducted by Tobias and Berg (2011) in Hà Tây province. Studies systematically investigating the spatial diffusion of sand-filters and other household water treatment are lacking so far but the case studies mentioned before suggest that diffusion processes are rather confined to communes and affiliated hamlets.

Each of the case studies from Việt Nam mentioned above (Tobias and Berg 2011; Bui and Wegner 2011; Herbst et al. 2009; Luzi et al. 2004) has been conducted in a very limited number of communes and focusses on the operability, efficiency, and adoption of specific filter techniques. They draw a precise picture about local practices of use, improve the understanding of users' motivation, and provide 'snapshots' of the local state of diffusion but are hardly appropriate to draw reliable conclusions about the dissemination of HWT in Việt Nam in general. Thus in the following, representative data from the VHLSS 2008 and the MICS 3 will be used in order to assess the prevalence of HWT.[37] Whereas this section aims to deliver first insights into the patterns of HWT use based on descriptive statistics, Chapter 7 builds upon these preliminary findings and proceeds by discussing determinants of HWT diffusion by multivariate models.

Prevalence of HWT

First and foremost, cross-country comparisons (Rosa and Clasen 2010) and official statistics suggest that HWT seems a quite well-established practice in the Western Pacific and Southeast Asian region. According to the VHLSS, with the vast majority of households (86%) always or usually boiling its drinking water, at least this practice appears almost ubiquitious in Việt Nam. However, boiling aside, household water treatment is not widely spread. In total, only every eighth household in rural areas applies filters or chemicals, although drinking untreated water from tube wells, dug wells, rivers, lakes, or ponds might pose a substantial threat to health. Every third household using surface water for drinking and cooking and every fourth well user applies some HWT in addition to boiling, but still a share of 15 percent among both groups does not treat its drinking water at all. Furthermore, treatment techniques show an extremely uneven geographical distribution (see also Figure 2.6 based on MICS 3 data). Chemicals and filters are only deployed by households relying on surface water in the Mekong Region, respectively those using tube wells in the Red River Delta Region and the adjacent North Central Coast. Highest treatment rates can be found in some provinces belonging to the Red River Delta like Hưng Yên,

[36] VIGERAS Project, funded by the German Federal Ministry for Education and Research (BMBF), took place between 2008 to 2011.

[37] Chapter 7 gives a more detailed description of the operationalisation of HWT strategies as they are applied in the VHLSS and MICS.

TABLE 2.4.: Household water treatment by source of drinking water in 2006 (multiple answers)

	Source of drinking water								
	Tap water (N=1,323)	Tube well (N=1,517)	Dug well (N=2,989)	Spring water (N=480)	Rainwater (N=1,059)	Bought water (N=55)	Surface water (N=343)	Other (N=3)	Total (N=7,769)
Boiling	97.3	94.1	98.3	98.8	97.5	92.7	89.2	100.0	7518
Add bleach or chlorine	0.3	5.1	0.7	0.0	1.7	3.6	59.2	0.0	326
Strain it through a cloth	5.4	1.6	2.3	1.5	4.6	3.6	3.2	0.0	235
Use water filter	13.7	28.5	9.9	4.0	6.2	10.9	2.0	0.0	1007
Solar disinfection	0.1	0.9	0.3	0.0	0.8	0.0	0.9	0.0	34
Let it stand and settle	5.7	10.6	7.3	2.3	15.9	3.6	12.8	0.0	681
Other	2.1	1.6	1.6	0.8	3.3	0.0	0.6	0.0	140
$\text{Percentage}_{\text{responses}}$	124.6	142.5	120.4	107.3	129.9	114.5	167.9	100.0	128,0
$N_{\text{responses}}$	1,649	2,161	3,598	515	1,376	63	576	3	9,941

Note: Percentages are based on cases

Source: MICS 3 UNICEF (2009), Own calculation, urban and rural districts included, unweighted frequencies

Thái Bình, Hà Nam and Hà Tây as well as in the southern provinces Hậu Giang, Cần Thơ and Bến Tre which are according to environmental monitorings (Berg et al. 2007; WB 2006, 2003) most likely prone to microbiological contamination due to dense population, intensive agriculture, and industrial use as well as geogenic sources. Whether higher treatment rates in these provinces and among tube well and surface water users actually indicate more serious concerns about water pollution and thus express some kind of adaptation strategy to ensure safe water supply or whether they are rather attributable to other factors, remains an open question and will be discussed in Chapter 7.

HWT strategies

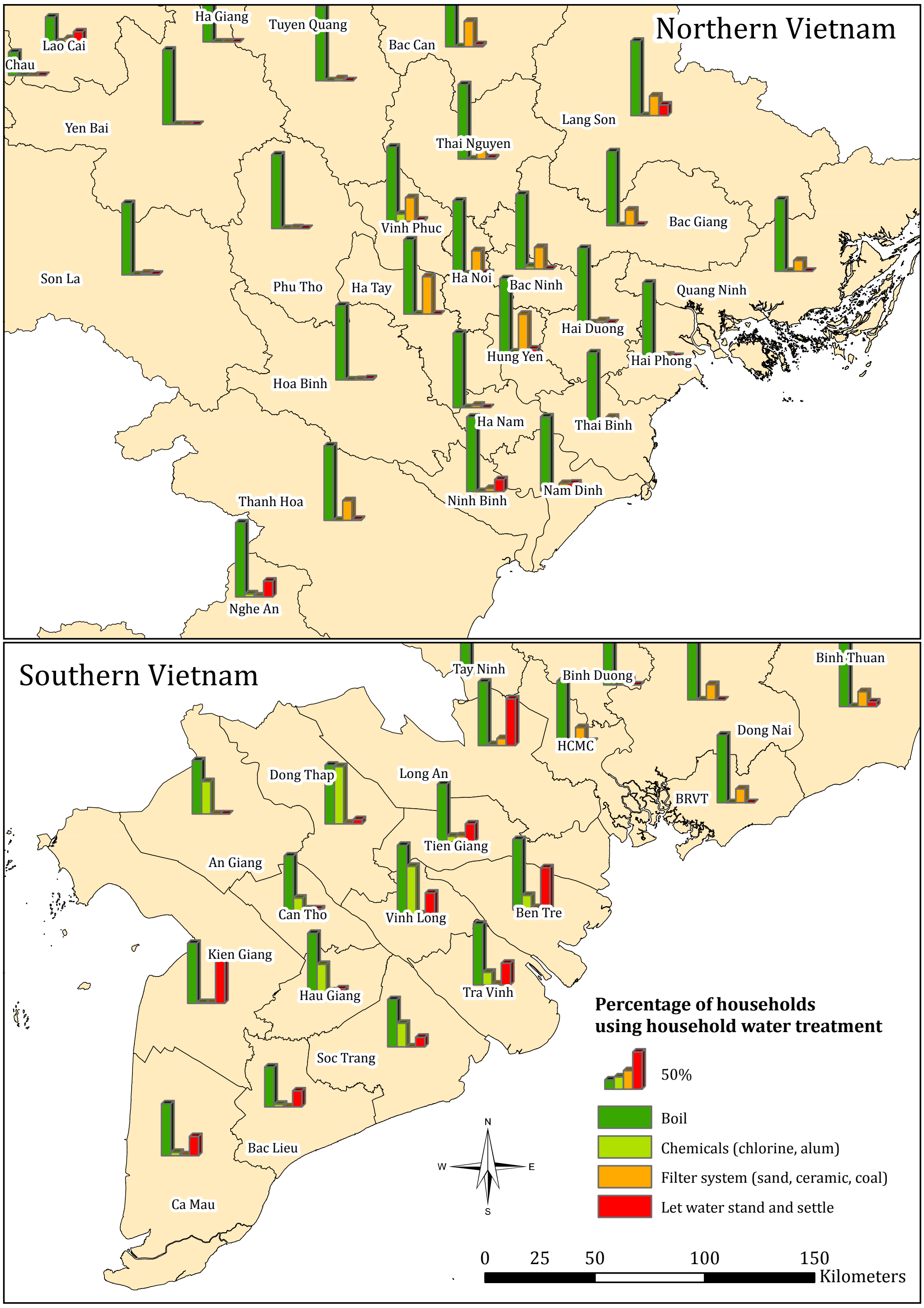
In comparison to the VHLSS, which only allows to estimate roughly the share of households applying filters or chemicals without specifying the exact type of treatment, the MICS 3 enables a more detailed analysis about the question to which extent HWT use is related to the source of drinking water. According to figures given in Table 2.4, boiling water is the predominant strategy for water treatment regardless of the source, whereas the application of other treatment techniques is strongly related to the source of water. More than one quarter of the tube well users in addition to boiling owns a filter like those depicted on page 60 or 61. Unfortunately, thereby the MICS data does not distinguish between self-constructed and commercially available facilities and it is also unclear which treatment techniques are subsumed under the category ‘other’. Adding chlorine and bleach is the method of choice for three of five households using surface water. On the contrary, settling poses a more universal strategy deployed to purify water by removing particles from well, rain, and surface water but is usually not used as a stand-alone measure. Besides boiling, households often prefer a combination of specific treatment methods, whereby households using surface water and tube wells show the most intensive treatment. 14 percent of the surface water users combine boiling, settling, and chemicals, but the majority relies either on just boiling water (65%) or adding chlorine or other chemicals (17%) to purify the water. Tube well users pursue a different strategy and often filter water in addition to boiling (31%).

Mapping the prevalence of applied filter techniques reveals strong spatial disparities in the application of household water treatment. Figure 2.6 illustrates the share of households using selected treatment techniques in Northern and Southern provinces. Whereas boiling appears as an ubiquitous strategy, the use of chemicals and settling tanks is only wide-spread in some of the southern provinces. Treatment by filter systems based on sand, coal, or ceramic are mainly applied in the Red River Region and to a lesser extent in the Southern Coastal provinces. Moreover, even adjacent provinces show distinct patterns of HWT use, in particular in Southern Việt Nam. Since already the above-mentioned case studies in the Red River Delta illustrated that communes with almost full HWT coverage and those with zero or very low prevalence often exist in close spatial proximity, the question arises how these spatial patters of HWT diffusion are brought about. To which extent is the choice of a treatment pratice related to the water source and its quality? Does a combination of strategies suggest an adaptation to more serious pollution of water sources or is it primarily an outcome of local diffusion processes which are triggered by social factors, like observing adoption in their nearby environment ('contagion'), social learning, or mere compliance social norms? The question which factors might drive or inhibit the diffusion of HWT practices will be addressed more in detail in the subsequent Chapters. Whereas Chapter 4 scrutinises diffusion and adoption processes from the theoretical point of view, Chapter 7 analyses potential drivers and inhibitors of HWT adoption and diffusion in rural Vietnam based on empirical data.

2.7. Access to safe water – A matter of costs and funding?

Access to safe water in developing countries has often deemed a matter of affordability but also a key to poverty eradication. Hence, supply-based approaches as promoted during the 'International Drinking Water Supply and Sanitation Decade' either followed the so-called 'first standard paradigm', building upon fully subsidised hardware, or the 'second standard paradigm', arguing for a minimum share of user contributions (The World Bank Water Demand Research Team 1993). With the increasing prevalence of demand-oriented approaches, attention formerly directed to the criteria of affordability shifted to users' willingness to pay. Studies of customers' willingness to pay revealed income as an important – but not overriding – determinant of households willingness to pay for improved access to water supply (Kayaga et al. 2003; Whittington et al. 1990; The World Bank Water Demand Research Team 1993). Other studies suggest that willingness to pay for water services firstly strongly varies between countries (Devoto et al. 2011) and secondly, the willingness to pay for water quality might be lower than those for water quantity and convenient supply (Kremer et al. 2011; Ashraf et al. 2010). This section examines whether sufficient water supply in Việt Nam is a matter of costs and households' ability to pay. Since affordability, respectively willingness to pay, plays a crucial role in further enhancement of piped water schemes and HWT, the first part of the section discusses direct and indirect of costs for water supply. Therefore it introduces different types of costs associated with water supply and compares the costs for typical drinking water sources used in rural Việt Nam. The second part of the section focusses on the question whether and how strongly rural poverty and insufficient water supply are related in Việt Nam. In a first step, it briefly reviews empirical findings about poverty prevalence in rural Việt Nam and in a second step scrutinises based on the VHLSS data to what extent poverty is empirically associated with insufficient access to water. Although the data does not allow for any conclusions about the causal relationship between water supply and the economic status of a household, it is an essential step to approach the central research question, whether access to safe water is a matter of individual eco-

FIGURE 2.6.: Household water treatment in Northern and Southern Việt Nam



Source: Own calculation based on MICS 3 (UNICEF 2009), administrative boundaries of provinces based on gadm.org (GADM 2013) nomic status, other household characteristics or is rather predetermined by regional disparities in the availability of water sources and existing communal infrastructure.

2.7.1. Direct and indirect costs of water supply

There are good reasons adducible, why it is definitely worthwhile to have a closer look at real costs arising from different practices of water supply to understand why households rely on the one or other water source. Studies of rural households' willingness to pay (WTP) have identified costs an important criteria, causing households to opt for or against an improved water source rather than their current one. Hereby the recurrent costs as well as those for first-time connection have been found to serve as significant determinants of demand (Singh et al. 1993; The World Bank Water Demand Research Team 1993; Whittington et al. 1990). Also in Việt Nam, for low-income rural households initial investments for acquiring treatment facilities or connecting to piped schemes pose a substantial obstacle (Reis 2012; Spencer 2007). Generally, the composition of costs to ensure safe water supply varies depending on the water source. Whereas costs for piped water appear high at the first glance, the picture often changes if costs related to water treatment or other indirect costs are taken into account. To discuss these assumptions in a more systematic manner, Table 2.5 disentangles different types of costs associated with water supply from a consumer's point of view.[38] Based on secondary literature (Reis 2012; Spencer 2007; Salter 2003), it compiles direct and indirect costs related to water supply for the use of rainwater, surface water, water from wells and piped water. Table 2.5 distinguishes between fixed costs for acquiring the facilities which are required to gain first-time access to the respective type of water source and variable costs arising for a certain amount of water used. One should keep in mind that the figures given here result from a review of various studies conducted in Việt Nam and do not allow for a quantitative assessment of the total costs related to water supply on household level.

Costs for piped water

In case of piped water supply, the main financial burden results from costs for the installation of a meter and pipes, which cover the distance between the house and the main pipe. In order to ensure affordability, the MoF provides clear guidelines for water from piped schemes: whereas in areas with higher living standards, the MoF allows to charge rates between 5,000 and 8,000 VND per m^3, in areas with average living standards, tariffs range between 3,000 to 5,000 VND per m^3, and in so-called disadvantaged areas between 1,000 to 3,000 VND per m^3 (GoV 2011: 54). Usually the People's Committee sets the tariffs within this framework issued by the MoF. The specific design of the water tariffs still resides with the provinces and the providers. For example, schemes operated by the governmentally administered Centers for Rural Water Supply are reported to charge fees of 2,500 VND per m^3

[38] For a general overview about the 'full costs' of water supply, see Rogers et al. (1998).

(Reis 2012: 77). As will be scrutinised in Section 5.1.4, sometimes block rates with lower tariffs for serving households' essential demand have been introduced.

Costs for private wells

Households using water from private wells often face high expenditure at the beginning because they first need to drill a well and to install a pump, which is usually done by a company. For the Cần Thơ region, Reis (2012) reports costs of 1 to 2.5 million VND for drilling a well.[39] Moreover, once put into operation, costs for electricity and additional treatment arise. In case sand-filters are applied for point-of-use treatment, those demand a substantial investment: the household survey in Hà Nam revealed a very skewed distribution of costs: one third of the respondents paid less than 500,000 VND but every tenth household in the sample more than 3 million VND (Bui and Wegner 2011). Tobias and Berg (2011) yielded similar results and showed that costs are lower if the sand-filter is constructed by the users themselves.

Costs for using surface water

Surface water, which is often used by poor households especially during the dry season, at first sight seems to be a cheap alternative to piped schemes or wells. In practice, the bulk of costs results from additional treatment due to poor water quality, ensuing expenditure for water-related health problems, but also costs in terms of long walking distance or electricity if water is pumped to the house from the river. Wrigley (2007) reports costs of 3,000 VND per kg rock alum, which would imply monthly expenditure of roughly 1,500 VND, assuming a consumption of 500 g per household and month. Poly aluminium chloride in combination with hypochlorite is slightly more expensive, with costs of 300 VND to treat 200 litres of water, which was deemed the average amount of water consumed by a rural household here. These figures are consistent with Spencer's (2007) estimation of monthly treatment costs of 2,500 VND.

Costs for using rainwater

In comparison to surface or well water, rainwater causes low externalities and requires less effort for treatment. Usually it is free of pathogens if stored properly and using rainwater helps to reduce the pressure on ground water resources. Although theoretically everyone might collect rainwater, in particular the poorest are often not able to use it on a larger scale because it firstly requires an appropriate roof to collect the water and secondly a tank or jar to store the water protected from light and dust. In the survey conducted in Hà Nam province in 2011, households reported that they on average spent 4.3 million VND (*sd*: ~2.5 million VND) for constructing their rainwater tank, whereby the costs significantly corresponded with the volume of the tank (r=.525 p=.000). Comparing these costs with those for drilling wells or constructing sand-filters also quickly makes clear that rainwater harvesting on a substantial scale is hardly an alternative for the poorest households. This could also been shown in the Hà Nam survey, where among the households below or closely

[39] Unfortunately, neither the study about sand-filter use in Hà Tây province (Tobias and Berg 2011) nor the authors own field study in Hà Nam province report costs for the construction of wells as a benchmark for the Northern region.

to the poverty line, the share owning a rainwater tank was much lower than for the remaining households (38% compared to 58%).

Costs for first-time access

Expenditure required for first-time access has proved relevant for the question why households opt for or against a water source (Altaf et al. 1993; Singh et al. 1993; The World Bank Water Demand Research Team 1993). Beyond the mere investment for connecting to piped schemes or acquiring facilities for point-of-use water treatment, switching costs[40] are deemed relevant for decision making about household water supply. Users who already invested substantial amounts of capital for drilling wells, constructing sand-filters, or acquiring other filters might refrain from switching to other water sources and especially to piped schemes because they are not willing or able to ante up initial costs again. As a case study from peri-urban Cần Thơ (Spencer 2008b) implies, initial investments for wells and pumps are one of the main reasons why people do not connect to existing piped water schemes.

Variable costs

The same study compares expenses per m^3 households take for water from different sources: Households which receive their water from the piped scheme pay about 2,500 VND per m^3, whereas those with an own well face considerably lower variable costs for water (about 400 VND per m^3), which mainly arise from costs for electricity for pumping. Astonishingly, costs for using surface water on average also amount to roughly 1,000 VND per m^3 due to costs for a motor and electricity in order to pump the water to the household, and are thus sometimes even higher than those for piped schemes if HWT is taken into account.[41] According to Spencer (2007), additional 2,500 VND per month have to be spent for alum in order to purify the surface water. In case water is transported by hand, only costs for alum arise which makes surface water in sum cheaper than tap water. These findings suggest that with regard to the variable costs arising for domestic water supply, using surface water is not necessarily the cheapest alternative.

Affordability vs. willingness to pay

In contrast to mere affordability, willingness to pay for water services proved to depend on lots of other factors than income and costs, such as service levels and reliability of the source, water quality, or demographic characteristics (Merrett 2002; Kayaga et al. 2003; The World Bank Water Demand Research Team 1993; Whittington et al. 1990). Moreover, willingness to pay and affordability might fall apart if people expect free or subsidised services from the government (Whittington et al. 1990). Interestingly, empirical studies which contrast expenditure for water supply with those for other purposes (Sy et al. 2014; Bey et al. 2013; Tobias and Berg 2011)

[40] According to Gatignon and Robertson (1985: 854), switching costs are common in the adoption of production system innovations but are also relevant if ‘the adoption of an innovation might require other changes in the consumption system or the adoption of ancillary services, which would raise the total cost of innovating [...]’.

[41] Spencer (2008b) reports in Table 2 average costs per m^3 of 3,300 VND for surface water which is not plausible analogous to his calculation for other water sources. Costs given here have been re-calculated.

TABLE 2.5.: Direct and indirect costs for domestic water supply

Category	Surface water	Well water	Rainwater	Piped water (e.g. cooperative, CERWASS, pWSC, SOE)
Facilities and constructional requirements	Pumps and pipes or buckets and tanks/jars for storage	Pump, tanks, jars for storage	Tank or jar, appropriate and clean roof	Storage facilities in case supply is interrupted frequently
Connection fees	–	Drilling of wells and installation of pump, licence for drilling wells	–	Contribution for initial investment or share for cooperatives, otherwise connection fee
Costs for raising capital	E.g. credit by Việt Nam Bank for Social Policy or microcredit			
Costs for supply	Costs for electricity to pump water	Costs for electricity to pump water	–	Tariff set by pPC or provider
Costs for additional treatment	E.g. costs for aluminum sulphate other chemicals or filters	E.g. costs for chemicals, sand-filter construction, other filters and boiling	Usually no additional treatment except boiling	Depending on quality, costs for boiling
Opportunity costs	Often long walking distance, time for additional treatment	Time for additional treatment	Time for cleaning roof and tank	–
Indirect costs due to externalities (public health or ecosystem impacts)	High costs for treatment of water born and water-washed diseases	Locally high costs for ecosystem due to exploitation of scarce ground water resources	–	Depending on quality of water lower costs for public health, in case of use of ground water, possibly high environmental costs due to exploitation of scarce ground water resources

Source: Own illustration

suggest that affordability does not necessarily pose the bottleneck for expanding access to water. For example, Bey et al. (2013) found that water users spend a multiple of their water fees for mobile phones and Tobias and Berg (2011) showed that people rather opt for competing behaviour instead of acquiring a sand-filter if they cannot afford both. Such empirical findings are not untypical and increased researcher's interest in understanding poor households rationales for allocating their scarce resources. Meanwhile, especially in behavioural economics a growing body of research is dedicated to answer the question which mechanisms nudge poor people to spend money on consumption purposes which obviously go beyond basic needs or appear less relevant than health prevention (e.g. concerning time-inconsistent preferences or the role of 'temptation' see Tarozzi and Mahajan 2011; Banerjee and Mullainathan 2010; Duflo 2006; Ainslie 2001).

But what is deemed affordable and which burden does expenditure for water supply impose upon rural households in Việt Nam? Following the so-called 'second standard paradigm', experts assume that people can spend at least 3 to 5 percent of their income for water (The World Bank Water Demand Research Team 1993: 48), so in case of Việt Nam (Staykova 2006; MoC/MARD 2000). However, this 'rule of thumb' has been criticised as a bad proxy for demand because it bears no relation to the actual costs for water supply. According to own calculations, 96 percent of the rural households captured by the Vietnamese Housing and Living Standard Survey 2008 (GSO Vietnam 2008b) spent less than 1 percent of their total household expenditure[42] for water supply compared to 67 percent in urban areas. This difference is to a large extent owed to the higher coverage with piped schemes, but also in absolute terms, urban households spend on average and per capita twice as much for piped water supply as rural ones (~150,000 VND per year and capita compared to ~76,000 VND). Whereas these figures are consistent with the findings from Spencer (2007), it is unclear to which extent the VHLSS data reflects the real cost for self-supply. Expenditure for water as reported in the survey might not comprise full costs for acquiring pumps and chemicals to treat the water or electricity for pumping it if people rely on water from wells, river and ponds, springs or rainwater. Regardless whether the household is located in urban or rural areas, those who buy water in bottles or in small tanks, on average spend the highest share of their total expenditure on water (1.80%), even compared to those with piped water on their premises (1.57%). But also if this applies, only very few households[43] spend more than the proposed share of 3 to 5 percent of their income for water supply. This stands in sharp contrast to observations in other regions of Southeast Asia where poor people buy water traded by vendors at exceptionally high prices because they are not served

[42] The original question reads as follows: '*How much has your household paid for water in the past 12 months?*' GSO Vietnam (2008b) The calculation refers to the share of expenditure but basing it on total income produces only negligible differences and does not alter the overall conclusion.

[43] One household has been excluded from calculation of summary statistics due to implausible values.

by formal providers (Kessides 2004: 222). Comparing the overall costs for different strategies to ensure safe water implies that at least variable cost should not pose a substantial obstacle for most of the households. Although users themselves still perceive costs for piped water as too high, the figures suggest that incentives created by lower connection fees, improved access to credits, or subsidies for construction might encourage more households to connect to piped schemes than a reduction of the anyhow low costs per unit would do it. These findings are in line with Devoto's et al. (2011: 5) study about piped water adoption in urban Morocco, which suggested 'that access to credit, rather than costs, may be a significant barrier to improvement in household infrastructure'. Also a recent comparative survey in Bangladesh, Benin, and Cambodia by Sy et al. (2014: 31) revealed that rather variable and irregular incomes of poor households posed a key factor in households' ability to pay for water connections than their total disposable income – a problem which could be addressed by installment payment options.

2.7.2. The nexus between poverty and domestic water supply

The analysis of costs for water supply suggests that probably high costs for first-time access – which are not reflected by yearly expenditure for water – deter households from using safe water sources or applying adequate treatment, whereas affordability of water tariffs does not pose a substantial constraint for households. Thus, this section elaborates more in detail on potential links between rural poverty and deficiencies in water supply or, put differently, it questions whether poverty coincides with poor access to safe water.

Two main sources provide information about the (spatial) distribution of poverty: the Living Standard Surveys conducted by the General Statistics Office (GSO Việt Nam) and the Ministry of Labour, Invalids and Social Affairs (MoLISA) which administers lists of poor households gathered by local officials. Whereas the Living Standard Survey allows to generate estimates which are only representative for the large eight administrative regions of the country, the MoLISA lists provide information for each commune. However, the reliability is questionable due to the fact that local officials might not apply the guidelines in a consistent manner or modify the numbers for strategic reasons (Minot and Baulch 2005: 462). Since the MoLISA poverty head counts are one criteria for equalisation transfers or other financial support for communes, officials might have an interest in overstating the number of poor households. Indeed Minot and Baulch (2005: 471 et seq.) discuss the low correlation between both poverty estimations based on two examples. These findings suggest that per capita expenditure is a better proxy for poverty than the MoLISA poverty headcount.

Moreover, case studies in Vietnamese villages suggest that it is hardly possible to draw a clear-cut demarcation line between affluent and poor areas based on the official poverty ranking because the households are to more or lesser extent endowed with social capital which allows them to borrow money or to receive other support by their family, the other villagers, or official institutions (Norlund 2005).

A multivariate regression analysis based on the 1997/98 Living Standard Survey identifies – besides regional disparities – household size, educational and occupational status of the head of the household, the type of housing, sanitation, electrification, and the source of water as significant predictors for the variation in per capita expenditure of rural households (Minot and Baulch 2005).[44] Holding household variables constant, households in the mountainous North have significantly lower expenditure levels than those in the southern part of the country. Although regression analysis did not identify the ethnic minority status as a significant predictor for per capita expenditure, additional analysis suggested that living standards of households belonging to one of the more than 50 ethnic minorities are lagging far behind those of the majority Kinh Hoa as they are usually living in remote areas (Baulch et al. 2010). Small area estimations based on the VLSS and the Population and Housing Census 1999 revealed strong disparities in the spatial distribution of poverty. Urban areas as HCMC or Há Nội show the lowest poverty rates, the large delta regions of the Red River and Mekong intermediate ones, and the mountainous Northern and Central regions the highest ones. On the contrary, plotting the poverty density which refers to 'the number of poor people living in a given area' (Minot and Baulch 2005: 469), indicates the Red River and Mekong Delta as well as the coastal plains as most concerned regions. This finding would have strong implications for the spatial targeting of policy measures because exclusively addressing regions with highest poverty rates – namely the Northeast, Northwest and Central Highlands – would actually bypass the majority of the poor (Minot and Baulch 2005: 470).

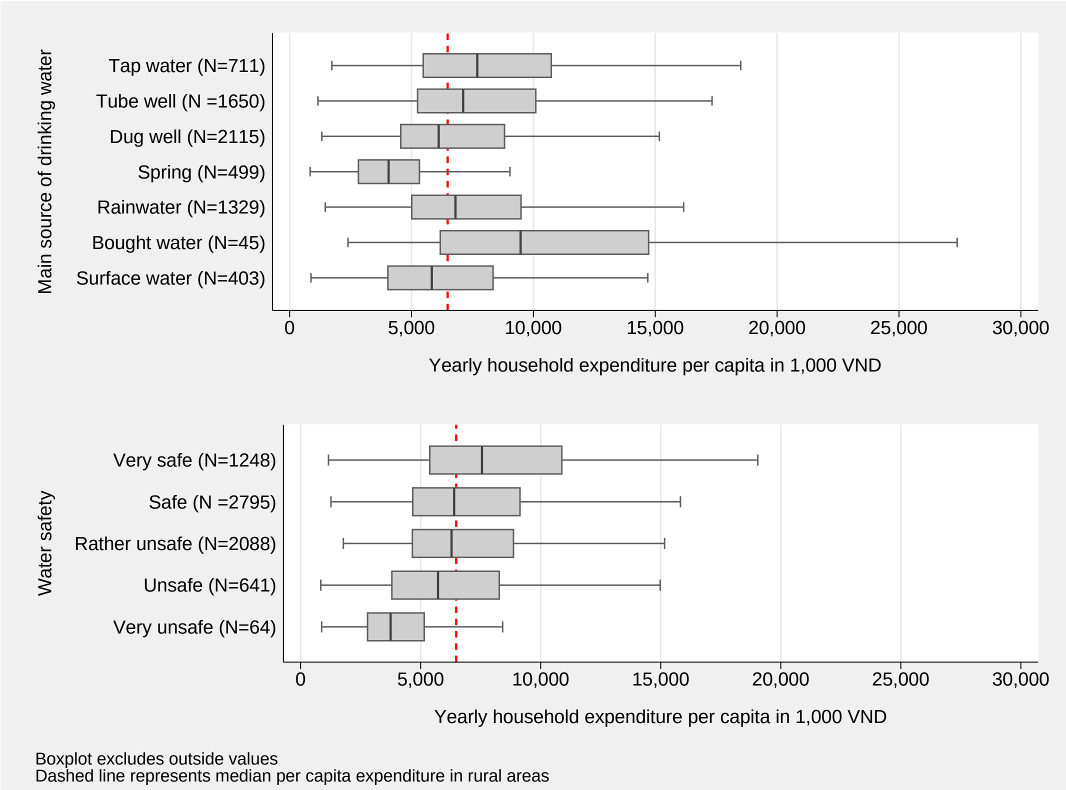
Figure 2.7 illustrates the median level and dispersion of yearly per capita household expenditure – here applied as a proxy for a household's economic strength – for different water sources (upper panel) and water safety as categorised in Section 2.5 (lower panel). For the sake of simplicity, the boxplot[45] excludes outliers which deviate more than 1.5 times the interquartile range from the 25th, respectively the 75th percentile. Due to the fact that the distribution of overall per capita expenditure is skewed to the right, many more outliers are found on the upper end of the scale.

Both figures suggest a positive relationship between rural households' economic resources and water supply: households who buy water show by far the highest median income, but also the highest dispersion. This owes to the fact that this category comprises bottled water, which is typically bought by the most affluent persons whereas

[44] The analysis was carried out separately for urban and rural households. The problem of endogeneity was not discussed because the main interest lied in predicting the expenditure but not in assessing the explanatory contribution of each variable (Minot and Baulch 2005).

[45] The boxplot depicts critical values of the overall distribution: in line with Tukey (1977), the box itself delineates the interquartile range (IQR), whereas the whiskers mark 1.5 times the IRQ. All other values are considered as outliers.

Figure 2.7.: Boxplot of household expenditure per capita and year by main source of drinking water and water safety



Source: VHLSS 2008, Own calculation, only rural households included

water delivered by vendors and stored in tanks is often bought by those who do not have any option for self-supply. However, since this category is only occupied by a comparatively small number of households, the results for this group are fraught with higher uncertainty. This group aside, also users of tube wells, rainwater, and taps show expenditure levels above the overall median for rural households of roughly 6.5 million VND per capita expenditure, whereby those connected to piped schemes account for the highest expenditure. These findings clearly support what has been supposed after analysing the cost structure for water supply from the consumers' point of view: due to the high costs for first-time access, these source are hardly affordable for the poorer households.

According to the lower panel of Figure 2.7, households with below median income are more likely to rely on unsafe sources like surface, spring, or dug well water. Comparing per capita expenditure, shows that households relying on springs are by far worst off with regard to their economic status but also the most homogeneous groups, while dug wells and surface water are used by a substantial share of people with above median income, too. Relating this finding to water safety as in the lower panel is particularly revealing: Firstly, the group of households using very unsafe water – namely surface water without any kind of treatment – by far poses the poorest group in the sample. Secondly, in view of the quite large dispersion of expenditure among the users of surface water it becomes obvious that these do not form a homogeneous group but account for further differentiation: on the one hand there are households with a moderate income which are able to afford some kind of treatment to ensure a minimum level of water safety, on the other hand there is an admittedly small group of 16 percent of surface water users which is even too poor to do anything to improve their water quality.

2.8. Summary

According to the findings presented in Chapter 2, rural water supply in Việt Nam is strongly shaped by the coexistence of piped schemes and self-supply in conjunction with some kind of household water treatment, whereby the latter still poses the predominant strategy for domestic purposes. On the one hand, the prevalence of self-supply practices like water withdrawal from deep or shallow aquifers, springs, rivers and lakes, or rainwater harvesting depends on the accessibility of water sources at the specific location. Regional and seasonal disparities in supply and insufficient water quality have been identified as substantial obstacles for expanding access to safe water for the rural population and exaggerate the development of appropriate strategies for the rural water sector. On the other hand, households' choices of water sources have also found to be influenced by the perceived aesthetics of the water source as well as convenience, reliability, and costs of supply.

Water sources

Across the country, the abstraction of *ground water by tube and dug wells* is the quantitatively most relevant strategy of domestic water supply although the groundwater potential varies considerably in Việt Nam, whereby the delta and coastal regions provide the best conditions for withdrawal by tube and dug wells. Despite being often deemed a microbiologically safe water source (especially if abstracted by deep tube wells), geogenic contamination often poses a substantial health threat if groundwater is not treated adequately. *Surface water* is an abundant source especially in the Southeast and the Mekong Delta but often polluted by high pesticide concentrations, nitrates from fodder additives, fertiliser, and human waste, which leads to a higher incidence of water-borne and washed-diseases among households using surface water. Despite the health risk, a substantial share of households in the Mekong Delta uses it as a drinking water source. *Rainwater* is only used to a notable extent in the Mekong and the Red River Delta. If stored properly, this source is safe; but during the dry season, households are often forced to switch to other water sources. The analysis revealed that the poorest households are often not able to use rainwater for a substantial time period because the construction of rainwater tanks is quite costly and the roofs of their houses are probably not appropriate for collecting rainwater run-off.

Water treatment

In view of the frequent use of self-supply and various sources of anthropogenic and geogenic contamination, so-called *point-of-use treatment* is of utmost relevance for ensuring safe water supply. On average – in Việt Nam in contrast to other developing countries – water treatment is comparatively wide-spread. Whereas boiling appears as an ubiquitous strategy, the choice of other treatment strategies is strongly correlated with the water source. Surface water is usually treated by coagulant/chlorine systems, whereas sand-filters are common for ground water. Hence, the use of chemicals and settling tanks is only prevalent in some of the Southern provinces. In contrast, treatment by filter systems based on sand, coal, or ceramic is mainly applied in the Red River Region and to a lesser extent in the Southern coastal provinces. Moreover, several empirical studies indicate that the motivation to apply some kind of water treatment mainly arises from social factors like norms and the need to improve the aesthetics of the drinking water rather than knowledge and awareness about specific water-related health threats.

Costs and affordability

Ambiguous evidence has been found to answer the question whether access to safe water is a matter of *costs and affordability*. The analysis of direct and indirect costs associated with the use of specific water sources reveals that self-supply by own wells comes along with very low variable costs, whereas those for surface water might vary considerably due to intensive treatment and transportation and might in some cases also exceed costs for piped water. In general, the analysis of data from the VHLSS shows that rural households in Việt Nam spend only a very minor part of their overall consumption expenditure for water supply, whereby those who buy water in bottles or small tanks pay most, followed by those who are served by piped schemes. Users of tube wells, rainwater, and piped water on average show above median levels of per capita consumption expenditure, whereas those with below median expenditure levels are more likely to rely on rather unsafe water from rivers, lakes, springs, or dug wells. The relationship between poverty and access to safe water became clearer once the application of HWT was taken into account: the poorest households do not only tend to use unsafer water sources but often also refrain from treatment. Two main conclusions are drawn from these findings: firstly, affordability does not pose a general obstacle for improving access to safe water, but appears crucial for a small group of the poorest of the poor. Secondly, with regard to affordability, high costs for first-time access in terms of connection fees or acquiring specific facilities pose a large hurdle for economically weak households whereas running expenses are comparatively low.

3. The political and institutional setting in the Vietnamese water sector

Contents

In the previous analysis, two main factors determining access to safe water have been identified: firstly, geographical conditions limiting the availability and quality of different water sources and thus restricting households' scope of choice and secondly, households' rationales in decision making about water sources and HWT, which will be conceptualised in a more systematic manner in Section 6. While the decision for using tube well, rainwater, or surface water, and applying some kind of point-of-use treatment – within the range of available alternatives – is taken on household level, the establishment of piped water schemes concerns larger social entities, such as co-operatives, communes, and the respective local authorities. To adopt this perspective is not to deny that households may impact the availability of piped schemes at their place of residence. As will be scrutinised in the next chapters, households' willingness to invest in cooperatives or to connect to piped schemes are deemed crucial for the establishment as well as expansion of centralised water supply in rural areas. But before adding this factor as an additional component to the analysis, this section creates a basic understanding about the governing environment in the rural water sector by introducing the most relevant stakeholders charged with rural water supply in Việt Nam as well as their sector-specific responsibilities and tasks. Formally, the same structures of governance and local administration exist all over Việt Nam. Whereas the state policies are set at national level, the local administration should bring them down to the deepest levels of society. Below the central state, three levels of local authority exist – provinces, districts, and communes – each of it equipped with a set of line agencies, which is briefly introduced in Section 3.2.

Due to the fact that the institutional setting in the water sector in its current state is strongly shaped by the pervasive administrative and economic reforms in the 1990s, it is inevitable to touch upon privatisation and decentralisation as the main underlying principles of this period of renovation. This chapter also asks for the role ascribed to the state in ensuring access to safe water, and tries to find answers by reviewing programmes and strategies applied by these governmental stakeholders. Therefore Section 3.3 sheds light on the overarching national and sectoral policies related to RWSS but also elaborates on large scale governmental programmes like P 143, P 135, and P 134, which explicitly incorporate infrastructure components, and programmes providing support for individual households like the credit schemes of the Việt Nam Bank for Social Policies (VBSP). A few sentences are devoted to the relevance of international donors and official development assistance (ODA) because a large share of funding in the water sector is contributed by international donors and lots of foreign expertise has been incorporated in RWSS development during the last twenty years in terms of projects or consultancy for policy making (e.g. the ADB water sector reviews in 1996 and 2008 as well as the National Target Programmes for RWSS). This chapter mainly builds upon a review of secondary literature but is supplemented by own analysis of VHLSS data. It concludes by assessing communal and individual participation in the governmental programmes and elaborates on different donors' contributions to (water-related) infrastructure projects on communal level based on empirical data.

3.1. Paving the path: Institutional reforms since Đổi Mới

Probably the most controversially debated scholarly question among political scientists during the last years concerned the nature of the state-society relationship and the conceptualisation of the state on national level (Reis 2012; Gainsborough 2010; Malesky 2004; Kerkvliet 2001; Koh 2001; Kerkvliet 1995). Is the central state retreating, does it come out strengthened of the renovation process, and to which extent did it become subject to reconfiguration? Although these questions appear to be political at first glance, they are of utmost importance for decision-making, planning, and implementation processes in the rural water sector. Based on investigations in the border region of Việt Nam, Gainsborough (2010: 112) argues that 'there is little to suggest that the state is losing ground' and draws a picture of a powerful state that is even extending its reach in some areas. In order to further scrutinise the role attached to the state in the field of water supply, the following section is dedicated to the substantial institutional changes taking place in Việt Nam and the rural water sector in particular. In line with Koh (2001), it refrains from labelling the state as 'strong' or 'weak' as such. Especially the pervasive decentralisation processes call for a differentiated view on how governmental agencies on national, provincial, district, and communal level exert influence on decision-making, planning, and implementation in RWSS.

The subsequent paragraphs briefly sketch the most substantial changes in the public sector and draw the line from these overall tendencies to specific consequences for RWSS. Hereby, particular attention will be devoted to decentralisation and privatisation as the two basic trends characterising the reform process and ensuing development in the rural water sector, whereas the restructuring of governmental agencies in the water sector and their responsibilities will be addressed in Section 3.2.

Public sector reformation after Đổi Mới

The process of economic transition and liberalisation in Việt Nam already started in the 1970s and 1980s, whereas Đổi Mới was declared on the sixth Party Congress only in 1986 and marked the beginning of a broader reform process comprising administrative and legal reforms as well as several sector-specific renovations (cf. Waibel 2010). This process had been accompanied by efforts to advance international integration and to revise governmental agencies and structures. Besides reforming civil service and modernising public financial management, devolution in favour of lower level authorities was probably the most important feature of the public-sector reform (PAR), launched in the mid of the 1990s, in order to reorganise and redefine functions and tasks of the central state (Anderson et al. 2010). Numerous legal documents and amendments testify the attempt to restructure Việt Nam's organisational and institutional setting profoundly but also convey the impression that such a fundamental transition can hardly run smoothly. Indeed, Koh (2001) states that during the 1990s, attention and resources diverted from the efforts to improve governance due to political struggles among the leadership, facilitating the incohesiveness between the state and the party. That might be one reason why even more than ten years after the country embarked on the path of transition, the UNDP criticised deficiencies in resource allocation, cumbersome administrative procedures, a lack of operational efficiency, large time gaps between the promulgation and implementation of decrees as well as between law enforcement and the intended practical implications (UNDP 2001). After initiating a review of the progress achieved by the coordinated strategy for PAR since 1995, the government set up task forces to analyse and address the just-mentioned deficiencies supported by international experts. The recommendations gained from this work found expression in the 'Master Programme on Public Administration Reform for the Period 2001-2010', which encompassed seven reform programmes (Painter 2003: 260). Probably the most influential outcomes of this process for the rural water sector have been the renovation of financial management mechanisms for administrative and public service delivery agencies as well as the redistribution of functions and reorganisation of administrative agencies (UNDP 2001: 17 et seq.).

3.1.1. Devolution and fragmentation of power

Even long before Việt Nam embarked on its path of transition, understanding provincial and communal autonomy was considered a key factor in understanding Việt Nam's politics and political economy as the popular Vietnamese proverb 'the King's law stops at the village gates' (lệ vua thua lệ làng) suggests by pointing to the independence of local structures (Malesky 2004: 308). A bulk of literature is dedicated to disentangle the complex structures and balances of power between the central state and lower administrative levels (Malesky 2004; Rama 2008; Waibel 2010; Harris et al. 2012). For example, Gainsborough (2004), Malesky (2004), and Hicks (2004) in-depth discuss the coexisting and opposing strategies of decentralisation and centralisation on provincial, district, and ward level, whereas Fritzen (2006: 8) arrives at the conclusion that there is no 'overarching decentralisation vision' existing at all. Undoubtedly, centralised structures still play an important role in contemporary Việt Nam, but tendencies of decentralisation manifest themselves in various areas like budget management, provincial investment planning and regional planning, management of natural resources, land, public assets services, state-owned enterprises (SOEs), and last but not least the grassroots democracy decree, which is expected to promote community participation and improve the accountability of the local government (SNV 2010; Waibel 2010; Anderson et al. 2010).

Devolution on provincial level

Since Đổi Mới, the power from the central level was mainly redistributed to the provincial level, while district and communal authorities are said to have benefited less from devolution (Waibel 2010: 14). Only in a few programmes, communes have been assigned responsibility for the budget so far (see discussion of P 135 in Section 3.3.3). Provincial power especially increased during the second decade after Đổi Mới, when provinces gained more autonomy over budget allocation and public investment after the revision of the PAR strategy. Based on the State Budget Law, governing the equalisation transfers from central to provincial level, provincial governments are now allowed to borrow for infrastructure investment, decide about the assignment of revenues on lower level, prioritise resources, and allocate budget to different sectors and lower administrative levels. In 2002, already half of the public expenditure was decided on sub-national level (Anderson et al. 2010: 27). Increased autonomy on provincial level furthermore manifests in the fact that since several years, provincial governments are empowered even to decide about large investment projects and since 2006, provinces' authority has been expanded to foreign and private investment as well.[46] On the contrary, commune and district authorities' decision making power is restricted to small and medium ones, given that they are assigned by the provincial government and authorised by the People's Council on provincial level (Anderson et al. 2010: 28).

[46] Projects with investment costs above VND 200 billion remain under control of the ministries (Staykova 2006: 1).

However, devolution is not exclusively perceived as advantageous: Fritzen (2006) predicts growing disparities between provinces in case the increasing devolution is not encountered by the establishment of reallocation mechanisms. Therefore, within the framework of pro-poor policy, equalisation transfers have established, but so far the system only works partially. Although 'provinces with higher poverty headcount ratios receive larger per capita transfers from the central level,' provinces themselves are not enabled 'to transfer budget from revenue surplus to communes with budget deficits' (Anderson et al. 2010: 27 et seq.).[47] Besides this mechanism, also sectoral programmes such as the NTP-RWSS contribute to the redistribution of resources. Against that background, net contributors are dissatisfied with the reallocation system, fearing that it hinders them to maintain their growth rates. This illustrates that policy makers have to walk a tightrope between creating autonomy, and thereby enhancing individual initiative on provincial level, and adequately supporting those ones which are lagging too far behind in economic development to catch up under their own power.

Communal level authorities and devolution

So far the impression is created that devolution mainly concerns the provincial level. Subsequently, attention will be shifted to the communal level and the question how devolution manifests on the local level. This question cannot be answered sufficiently without referring to the Grassroots Democracy Decree but first and foremost demands for some further explanations on the general set up of the commune level authorities in Việt Nam. Each of the lowest administrative units is equipped with a People's Council and a People's Committee (PC)[48] serving as the executive arm of the Council. In parallel – and probably of higher relevance – is the cPC's function as the local branch of the national government. Therefore the cPC is deemed more powerful than the People's Council. Both agencies on communal level hold vertical and horizontal relationships to other governmental agencies and are accountable to those at levels above. At communal level, the cPC oversees and coordinates departmental specialists from ministries and their associated line agencies (Koh 2001). These multiple responsibilities bear potential for conflicts especially if the line agencies are not willing to give up control. For the sake of completeness, the Việt Nam Communist Party machinery should be mentioned as the third governmental branch on the local level. The main business of the cPCs lies in routine state administration, the implementation of laws, directives, and decrees issued by upper level authorities or the local People's Council. Although the scope of the cPC's responsibilities has been reduced substantially after Đổi Mới reforms, the commune authorities are still in control over numerous administrative procedures, which the inhabitants have to perform in order

[47] Other criteria for equilisation transfer besides poverty headcount ratios are: ethnic minorities, number of districts considered to be in a disadvantaged position, and levels of local revenue.

[48] Since the People's committee is represented at each administrative level, they will subsequently be labelled as following: communal PC (cPC), district level PC (dPC), and provincial level PC (pPC).

to fulfil their duties (e.g. registration of births, weddings, residence, schooling).[49]

Grassroots Democracy Decree

Given this background about commune level authorities, we will now return to our initial question about how devolution did impact local authorities and which role is assigned to the Grassroots Democracy Decree in this context. This decree, shortly labelled as GDD, was issued in 1998 (and amended in 2003 and 2007) as 'an acute response by Communist Party and government to large scale unrest among the rural populace owing to dissatisfactions with a felt mismatch between espoused commitments to "good governance" and its actual practice' (Larsen 2011: 316). Based on Hồ Chí Minh's dictum 'the people know, the people discuss, the people do and the people monitor' it facilitates the expansion of people's participation in local government affairs and thereby plays an important role in establishing downward accountability (Anderson et al. 2010).[50] The right to be informed, to decide, to be consulted, and to supervise applies to a wide range of public activities on communal level from the use of budget funds and peoples contributions, communal development plans, investment projects, administrative procedures, to land use. The implementation of the GDD resides with the communal People's Committee and Council. Due to the fact that the GDD is a quite young initiative, only a limited number of studies – mostly as grey literature – is available so far, most of them relying on the VHLSS module about governance implemented in 2008. They primarily ask to which extent principles postulated in the GDD have been implemented and which effects evolve from that either from the perspective of the local government or rural development professionals (e.g. United Nations / UNDP Vietnam 2012; Larsen 2011). Moreover, they indicate people's demand for information about investment and planning with regard to communal infrastructure. Although being not representative for the whole country, figures from a citizen survey on satisfaction with the communal development programme P 135 illustrate diverging degrees of people's involvement in the provision of communal infrastructure. Almost three out of four inhabitants in the participating communes were aware about water supply works, but only 41 percent of them actually provided some kind of input (Anderson et al. 2010: 33). In case of infrastructure provision, co-determination is mainly restricted to the selection of the work site but far less realised in terms of the involvement in the design and construction process itself or its supervision (Anderson et al. 2010: 29, see also Reis 2012; United Nations / UNDP Vietnam 2012). To make it short, despite some progress in the later phase

Communal participation in infrastructure development

[49] For a comprehensive list of cPC's tasks, see Koh (2000).

[50] Devolution and ensuing higher autonomy of lower level governmental agencies did not only bring benefits but in return requires the installation of accountability mechanism will not evolve automatically (Anderson et al. 2010). The Việt Nam Development Report here ideal-typically distinguishes between 'upward' and 'downward' accountability, accepting that this to some degree simplifies the complex interaction between strategies of decentralisation and centralisation. Whereas the first one is defined as 'compliance with rules, dictates, and instructions coming from within the hierarchy' the latter one refers to 'the results that the person or body is entrusted to deliver' (Anderson et al. 2010: i).

of the programme, the ambitious aim to make communes owners of infrastructure facilities often failed, which is also bemoaned by the final evaluation report (United Nations / UNDP Vietnam 2012: 85 et seq.). These findings, however, are not really surprising given the general disillusion about the contributions of community management in rural water supply and the unrealistic assumptions on which these are based (see p. 14).

3.1.2. Privatisation

'Equitisation'

In the context of economic liberalisation, equitisation (cổ phần hóa) – how Việt Nam's partial privatisation programme is locally called – is a central concept in the government's state enterprise reform (Gainsborough 2010: 71). In addition to governmental support for infrastructure provision and safe water supply, privatisation and private sector participation (PSP) have become an important approach to ensure and improve water supply, allowing non-state actors in terms of private water supply companies, cooperatives, user groups, and individuals to operate as providers. The strong preference for the idea of privatisation and private sector involvement in the water sector has been promoted by governmental authorities as well as development institutions such as the World Bank, which is also reflected in the official policy. The National Strategy for the Rural Water Rector (NSRWSS) clearly argues in favour of private sector participation in rural water supply and sanitation and aims to create 'favourable conditions' such as establishing a competitive market for private stakeholders as well as taxation equality between them, equal access to credit, improving construction management systems to ensure fair and transparent tendering, developing technical and business skills of private sector actors, promulgating regulations, standards and guidelines to enhance user protection and avoid private sector's potential misuse, and enforcing laws on competitive tendering, contract awarding, and penalties (MoC/MARD 2000: 25). Consequently – so the precise wording in the national strategy – water supply companies and state-owned enterprises 'will gradually assume more autonomy on asset management and financial matters' (MoC/MARD 2000: 25).

Up to now, results of this strategic change are hardly visible because financial contributions by the private sector in order to achieve the official objectives for the RWSS sector had not been taken into account in the past iterations of the programme. What private sector participation according to official RWSS policies and strategies ought to accomplish, differs from what can currently be observed in Việt Nam. So far, in the rural water sector neither state-owned nor private water supply companies play a significant role. Hence, further investigations in Section 5.1.3 primarily focus on cooperatives as the currently most popular management model with private sector involvement.

3.2. Governmental institutions in the rural water sector

Whereas the previous chapter briefly outlined the major changes across different sectors in Việt Nam, this chapter is dedicated to the governmental agencies responsible for RWSS. Formally, the same structures of governance and local administration exist all over Việt Nam: State policies are set at national level, whereas the task to implement them on the deepest levels of society resides with line agencies and local authorities. Below the central state, three levels of local authority exist: provinces and central cities, provincial cities and districts, and last but not least communes and – as their urban pendants – wards. On each of these levels, a whole bunch of governmental agencies is either directly or indirectly concerned with rural water supply and sanitation. The most relevant ones will be introduced in this chapter.

Reorganisation of the water sector after 1990

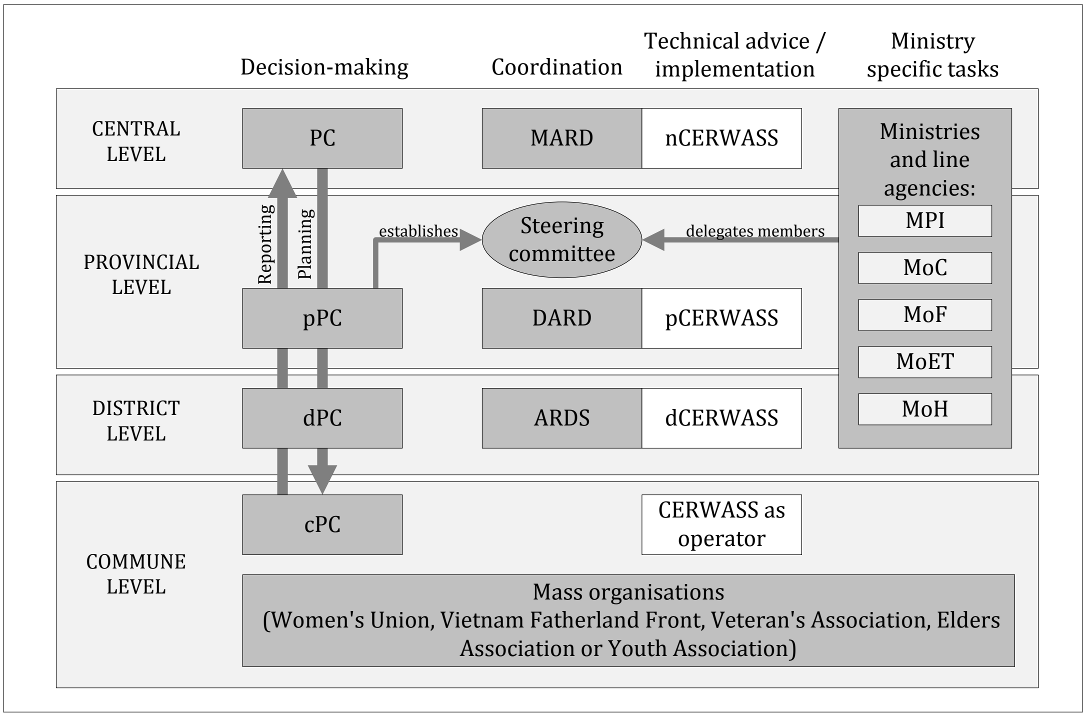
Việt Nam looks back on a long tradition in water management but like other spheres, the water sector in Việt Nam has been subject of comprehensive reforms during the last two decades (Waibel 2010; Evers and Benedikter 2009b). In accordance with the hydraulic mission, in the first half of 1990s, public investment in the water sector was restricted to urban water supply, irrigation, drainage, and flood control, whereas domestic water supply in rural areas was not placed high on the national agenda (WB 1996: 64). Triggered by the first water sector review (WB 1996), during the 1990s management functions in the water sector have been substantially restructured and priorities shifted to industrial and domestic water supply and integrated management approaches. Before 1995, the Ministry of Water Management hold key functions but after merging with the Ministry of Forestry, those were taken over by the Ministry of Agriculture and Rural Development (MARD). At that time, the newly founded MARD was primarily in charge of irrigation, flood, and disaster management, while other tasks like urban water supply and sanitation, waste management, water quality control, and especially the practical implementation were still scattered among different institutions (Waibel 2010; WB 1996). By the foundation of the Ministry of Natural Resources and Environment (MoNRE) in 2002, the Vietnamese government reacted to the long standing recommendation of donor agencies to separate public service delivery and management of water resources. Whereas the first function remained with MARD, MoNRE should capture the link between water sources and environmental issues. However, it took some years until the redistribution of functions between both ministries came to fruition due to conflicts and confusion about the assignment of tasks and responsibilities (Waibel 2010: 8).[51]

Current institutional responsibilities

Currently, responsibilities in the water sector are divided between the central and provincial government whereby overarching strategic questions require the approval of the Prime Minister and the authority over sectoral policy resides with the line

[51] Further details about functions with regard to water management and its sustainable use assigned to MoNRE and the 'National Water Resources Strategy towards the year 2020' can be found in Waibel (2010).

FIGURE 3.1.: Key institutions responsible for RWSS on national, provincial and local level



Source: Own illustration

ministries. At national level, MARD is in charge of RWSS and advised to coordinate the activities of other relevant ministries and People's committees (PC) for implementing RWSS strategies (see Figure 3.1). The Department of Agriculture and Rural Development (DARD), as corresponding agency on provincial level, is responsible for implementation of RWSS. Some of MARD's tasks have been delegated to the so-called Center for Rural Water Supply and Sanitation (CERWASS). National CERWASS including its line agencies on provincial and local level were ad-hoc established by the government in 1997 under MARD. CERWASS' role, functions and organisational structure are specified by Decision No.122/2003/QD-BNN. In a nutshell, it should give technical support to MARD on national level, respectively DARD on provincial level, and is responsible for technical issues in RWSS implementation and project preparation. Practical coordination, day-to-day management, and implementation mainly reside with the provincial arm of CERWASS. In townlets and rural areas, provincial CERWASS is the lead agency responsible for water supply services. At the same time, it might act as investor and owner, operator, service provider, or communicator and advisor for piped schemes, what has been criticised by experts. *MARD*

People's Committee

Whereas coordination, technical advice, and implementation are mainly organised under the umbrella of MARD, decision making and planning remain within the scope of the PCs. The PC's on different administrative levels play a crucial role in the bottom up and top down planning procedure for RWSS, whereby the lower level authorities primarily communicate the users' needs but hardly exert influence on budget allocation (see left side of Figure 3.1 and further explanations on p. 98). Apart from these planning and reporting processes, pPCs act as important players because they set the limits for water tariffs within their jurisdiction and decide about ownership for water supply projects in small towns.

Other ministries

Indirectly, some other ministries and governmental bodies are involved in RWSS issues like the Ministry of Education and Training (MoET), which is in charge of water supply and sanitation at schools, the Ministry of Health (MoH), which sets and monitors quality standards for drinking water, the Ministry of Planning and Investment (MPI), which is responsible for budget coordination for state and donor-assisted projects, and finally the Ministry of Finance (MoF), which defines water resource taxes and fees.

Mass organisations

In Việt Nam, formal state structures reach down to the local level. Political power at the local level is based on three basic pillars; the party chapter, the cPC and the People's Council (see also p. 87), which are supported by various mass organisations like the Womens Union, the Việt Nam Fatherland Front, the Veterans Association, the Elders Association or the Youth Association (Koh 2006: 59).[52] After Đổi Mới, mass organisations did not only receive more independence with regard to finance and their management but are now also allowed to engage in activities which have formerly been under governmental control, like public services and or promoting grassroots democracy (Anderson et al. 2010: 3, 169). Although these mass organisations are officially no subdivisions of governmental agencies, they still 'mobilize their members, disseminate information and implement national and local programmes on behalf of the government [...]. Mass organisations are attractive (and sometimes the only potential) partners of community development projects and also play a (not yet well known) role in the field of local water management.' (Waibel 2010: 11). Within the framework of the National Target Programme as the major policy for RWSS, a key role is assigned to these mass organisations, which act as opinion leaders and change agents on the local level and are mainly responsible for information, education, and communication activities for RWSS (MoC/MARD 2000: 17).

[52] The Việt Nam Fatherland Front functions as an umbrella organisation for about 40 mass organisations.

3.3. Water-related programmes and funding schemes

Like in other sectors, a large number and variety of policy documents is created in the policy making process in Việt Nam. The Socio-Economic Development Strategy (SEDS), which defines the long-term goals, is approved by the Party Congress every ten years. In addition, the Socio-Economic Development Plan (SEDP) sets medium-term goals for a period of five years and is approved by the Party Congress as well. The overarching national policies and strategies related to rural water supply, sanitation, and health are the Comprehensive Poverty Reduction and Growth Strategy (CPRGS) and the National Strategy on RWSS (NSRWSS). The CPRGS is on the one hand based on the Poverty Reduction Strategy Paper, introduced by the World Bank, and on the other hand breaks down the long term SEDP into detailed action plans. The CPRGS aims at poverty reduction and other social targets in general but also defines water-related targets referring to infrastructure provision for the poor and sets ambitious targets. According to the CPRGS, 75 percent of the communities should have been served with access to safe water by 2005 and all of them by 2010 (WB 2005: 2). Current statistics suggest that these aims were far beyond reach. In comparison to these goals, which seemingly lack a realistic assessment of the situation, more feasible ones had been defined in terms of the Việt Nam Development Goals, which translated the Millennium Development Goals into targets on national level. According to them, 60 percent of the rural population were expected to have access to safe water in 2005 and 85 percent in 2010.

Programmatic approach

The predominant form for key policies in Việt Nam are so-called national target programmes. So in case of the water sector.

> The official rationale for such an approach is to concentrate resources, provide clear and target-oriented definitions of roles and responsibilities, and facilitate coordination between different parts of Government. They also, arguably, reflect a certain 'style' of policy-making: the socialist period relied heavily upon exhortation and social mobilisation through a 'campaigns' approach to the solution of social and economic problems, and target programmes reflect this legacy. (Shanks et al. 2004: 11)

Programmes for RWSS

Other scholars argue that the preference for programmatic approaches is not only a legacy of the socialist tradition but a common pattern of state-society-relations in East and Southeast-Asian states (Harris et al. 2012: 12). Below, major governmental programmes are listed and explained briefly. Further decrees, decisions, and circulars are mentioned directly in the respective sections in case they are of importance for analysing the institutional arrangements and understanding incentives and behaviour. The following two sections address main governmental initiatives for RWSS. In the core of the analysis stands the National Target Programme for Rural Water Supply and Sanitation (NTP-RWSS) as an element of the SEDP. The

National Target Programme is the most relevant programme for the water sector in Việt Nam and functions as an umbrella for all RWSS programmes and projects. The principal governing strategy for NTP-RWSS is the National Strategy for RWSS which has been issued in 2000 (MoC/MARD 2000). Since the NSRWSS and the NTP also provide the framework for donor-based activities, its objectives, principles, and implementation mechanisms are scrutinised in detail in the following section. Besides the National Target Programme, there exists a variety of measures – mostly initiated to fight poverty – which also strive for improvements in rural water supply and comprise infrastructure components. The following sections exemplarily refer to the P 135, P 143, P 134 and credits issued by the Việt Nam Bank for Social Policies (VBSP) because these are by far the most relevant initiatives in terms of financial support and regional scope.

3.3.1. The National Target Programme and Strategy for the rural water sector

The National Target Programme for Rural Water Supply and Sanitation (NTP-RWSS) as the main governmental programme for RWSS is now in its third iteration. Table 3.1 lists the objectives of the three NTPs, which clearly express the strong preferences for programmatic approaches (see p. 93). Throughout all iterations of the NTP, MARD has been the leading agency on national level so far. In 2002, a Standing Committee on NTP-RWSS was set up in which representatives of several ministries are included. Besides the Committee, a Standing Office was established in order to support the Committee in implementing the NSRWSS. In some provinces, additional Steering Committees on provincial level have been established to coordinate the NTP with pCERWASS. For information, education, and communication activities, the provincial Department of Health is a key agency but mass organisations like the Womens Union, Youth Union, Farmers' Association play an important role, too. On provincial level, the pPC is responsible for implementation according to conditions in the respective province.

Objectives of the National Target Programmes

In March 2012, the third NTP-RWSS for the period up to 2015 was approved by the Prime Minister (Decision no. 366/QD-TTg). As shows Table 3.1, the programme expects 95 percent of the rural population to receive access to clean water and about 60 percent access to water satisfying the governmental Standard 09.[53] In contrast to its predecessors, two aspects are worth mentioning: firstly, it clearly addresses institutional issues and secondly, the programme pays more attention to aspects of sanitation but still retains the focus on safe water provision as suggests the fact that the share of budget dedicated to water supply is still three times as high as the one for sanitation. Harris et al. (2012) argue that the predominant focus on water supply

[53] For details concerning Standard 09, see p. 152.

Table 3.1.: Objectives of National Target Programme I to III

Criteria	NTP I	NTP II	NTP III
Duration	1998-2005	2006-2010	2011-2015
Percentage of rural population having access to clean water	80%	85%	95%
Percentage of rural population having access to clean water according to MoH standard 09	-	50%	60
Percentage of rural population having access to hygienic latrines	50%	70%	75%

Source: GoV (2011, 2009, 2005)

instead of sanitation is mainly owed to the financial gatekeepers' preferences for projects which create greater visibility and offer opportunities for rent creation and ensuing the 'maintenance of personal, political and social networks that are highly valued in the Vietnamese context' (Harris et al. 2012: vi).

Within the framework of the NTP-III, 3,412 new piped water schemes with average investment costs of 2,500,000 VND per capita should be constructed, 2,396 piped schemes upgraded for 1,000,000 VND per capita and 1,000,000 VND per capita invested in 316,888 small-scale and scattered schemes.[54] The extremely high share of small-scale schemes points to a preference for localised solutions. The total budget of approximately 45,700 billion VND will be mobilised by different sources: About one fifth each by central government and donors, about 10 percent each by local authorities and the users themselves. One third of the amount is provided in terms of preferential loans and 8 percent by private investors (GoV 2011: 47-48). In comparison to the NTP-II, budget has doubled but the composition of funding sources slightly changed: in relative numbers, the expected contributions by users decreased from 30 to 10 percent in the NTP-III, the donors share of funding increased and the private sector was taken into account for the first time. The latter fact strongly reflects the increasing importance which the NTP ascribes to private sector involvement in RWSS. The changes in the NTP-III are not only of quantitative nature, but

> [...] will entail significant, though not total reforms to sector governance arrangements. While changes will not enable total certainty regarding the total funding available to each sub-sector (including public, private and loan funding), NTP3 will go one important step further in role division,

[54] It remains unclear whether the term 'small-scale schemes' only refers to piped water schemes or to facilities for households, too.

> dividing the programme into smaller projects and sub-projects, with each one assigned a responsible implementing agency [...]. Interviews with MoH staff suggest that this new organisational structure will be supported with revised budget-allocation procedures under which separate disbursements will be made to provinces for water supply and sanitation, effectively recentralising some degree of authority and ringfencing a portion of public NTP funds for sanitation [...]. (Harris et al. 2012: 14)

National Strategy on Rural Water Supply and Sanitation

The 'National Rural Water Supply and Sanitation Strategy up to the year 2020'[55], or shortly NSRWSS, was approved in 2000 as the first national policy in the field. It was issued *after* the objectives of first National Target Programme (NTP-I) have been defined (Reis 2012: 171), which in turn means that the core elements of the strategy have not been reflected in the NTP-I. The strategy is based on the principles of demand-responsiveness, cost-recovery, and socialisation. Box 2 explains the core ideas of the NRWSS principles as they are outlined in the official documents.

The NSRWSS reveals a strong preference for piped water by stating that '[w]here feasible and economic, piped water systems need to be promoted in rural areas under the assistance of the government to make these systems more financially' (MoC/MARD 2000: 10). In general, on paper strong emphasis is put on sustainability instead of speed of implementation. The development should not 'produce harmful effects for the future and water resources shall be reasonably exploited' (MoC/MARD 2000: 13). The NSRWSS distinguishes between three kinds of sustainability. Financial sustainability refers to sufficient resources for construction but also for operation and maintenance (O&M) of facilities. Utilisation sustainability encompasses the clear assignment of ownership which is expected to rise the interest in protection of the facilities and the continuous use. Last but not least, operational sustainability should be achieved by a designing appropriate management systems, skilled staff, and sufficient supply networks for service and the provision of spare parts. This incorporates technologies that are easy to operate and locally produced in Việt Nam. Since in many cases non-professionals are expected to take the responsibility for O&M of water supply facilities, special attention is paid to information, education, and communication activities, which should help people to understand technologies, O&M, financial, and credit issues.

[55] In literature, variant forms of spellings for the National Rural Clean Water Supply and Sanitation Strategy up to the year 2020 exist. In the following I will refer to this national policy by the abbreviation NSRWSS.

Box 2: Principles of the National Strategy on Rural Water Supply and Sanitation

Demand responsiveness

Decision-making and management should be assigned to the lowest appropriate level: households and communes shall take the main responsibility for infrastructure development while being actively supported by the government which provides them with guidance and creates the necessary prerequisites. In accordance with the principle of decentralisation, implementation and planning in RWSS should take place at communal, district or province level. In line with the principle of *demand-responsiveness*, rural household and communities shall actively participate in planning, design, construction, and operation of facilities ,whereas government agencies will ensure the adherence to standards and regulations. Households and communities are expected to decide themselves which type of service they want and they are willing to pay for in a process of informed choice.

Cost recovery

The issue of cost recovery is addressed with regard to financial contributions by households and communes but does not involve a discussion of pricing or efficient operation of piped schemes. Willingness to pay refers to contributions to the construction costs but also for operation and maintenance. Subsidies are provided for 'the poor, the very poor and the social policy target households who suffer difficulties' (MoC/MARD 2000: 15). The combination of informed choice and demand-responsiveness is expected to result in *cost-recovery*. Community participation shall be realised in terms of financial support for the construction, joint management of piped schemes, and joint applications for government support in form of grants or loans (MoC/MARD 2000: 20). Women who are supposed to stand half of the group will get key positions and user groups should also serve as savings groups.

Socialisation

The principle of *socialisation* encompasses the mobilisation of 'all economic sectors and communities [...] to participate in the financing, construction of facilities, production of equipment, provision of repair and services, and management and operation of facilities. Government encourages private sector to invest in and to construct RWSS facilities, in particular the full piped water supply schemes. The government management agencies will withdraw from WSS construction and business, and this will be given to state-owned or private contractors through competitive tendering. The market for RWSS services will be developed under the government's orientation.' (MoC/MARD 2000: 15).

All statements concerning the NSRWSS refer to an unofficial translation of the official Vietnamese version of the National Rural Clean Water Supply and Sanitation Strategy up to year 2020 (MoC/MARD 2000).

3.3.2. Planning and budget allocation in the rural water sector

Planning procedures in the rural water sector remained the same across the iterations of the NTP. On commune level, requests for the construction of water supply and sanitation facilities are collected and integrated in a communal RWSS workplan (respectively the SEDP) which is approved by the cPC and passed on to the district level PC. Communal data submitted to the higher level PCs includes 'the number of people having access to clean water, the number of households, having hygienic latrines, the number of trade villages having waste treatment systems, the number of water supply schemes to be constructed, the number of hygienic latrines to be constructed (or improved), investment demand and demand for credit and non-productive capital' (GoV 2005: 33). In this bottom-up reporting and top-down planning processes, commune and district level authorities rather serve as communicators for the population's demands, but apparently no standard procedures are implemented for gathering and reporting this information.[56] Whereas some communes pass on documents as they are provided by the local population, others aggregate data in terms of tables and statistics or post a local official to CERWASS to get a better hearing (Reis 2012: 104 et seq.). Also on district level, authorities do not handle this issue in a uniform way: some simply combine information delivered by the communes, whereas others already appraise and subsequently adjust figures with regard to what they deem feasible (Reis 2012: 114 et seq.). Subsequently, summarised and approved reports are submitted to the pPC and DARD. Based on these reports, funding will be allocated to the provinces.[57] Within the NTP-III, funds are transferred to provinces as a lump sum, thus responsibility for allocation to different actors and sectors now resides with provincial authorities, which allows them to demonstrate their growing political power (cf. Harris et al. 2012: 13).

Despite the extensive bottom-up-reporting system, the allocation process has been criticised as being too much concentrated on creating and managing assets instead of operating and maintaining them (cf. Trinh 2007: 50). In fact, decision making processes are fragmented. Whereas the power in allocating funds is mainly concentrated at MARD and MPI, concrete implementation resides with pCERWASS. From the viewpoint of authorities on commune and district level, CERWASS is perceived as being the most powerful player in RWSS planning as revealed an influence mapping conducted in southern Việt Nam (Reis 2012: 123 et seq.).

[56] For detailed information about public participation in Việt Nam see also Porter (1993).

[57] For a detailed description of the planning procedure on provincial and central level please see SNV (2010: 12-13), GoV (2011) or Reis (2012: 104 et seq.).

3.3.3. Governmental programmes directed to domestic water supply

WATSAN

WATSAN is an existing national RWSS programme implemented by (p)CERWASS offices, which is supported by UNICEF, DFID, and other donors. In contrast to the principles proposed in the NSRWSS, the programme is essentially supply-driven but involves community planning of water supplies and cost-sharing. Communes should contribute 50 percent of the costs for piped water schemes and full costs for household connections. According to assessments of the World Bank, the programme is not explicitly targeted to the poor (WB 2005: 6). Either those remain underserved or whole communes are excluded from the programme due to a high share of poor households. The lack of demand-responsiveness is said to lead to over-designed systems with high maintenance costs, which are not in line with the consumers' willingness to pay. According to a World Bank report, in recent years, UNICEF did not draw from the allocated financial resources because of lack of demand.

Governmental Programme 143

Besides the sector specific programmes, there are three basic programmes primarily targeting poverty reduction but which also incorporate infrastructure components. The National Target Programme on Poverty Reduction and Employment (NTP-HEPR) – also known under the label Programme 143 (P 143) – has been initiated under the umbrella of the CPRG in 1998. In contrast to the Programme 135 (P 135), it rather addresses households but also whole communes and is coordinated by MoLISA. The programme offers subsidised credits, school fee exemptions, and free health care for households whose income is below the poverty line defined by MoLISA (Swinkels and Turk 2007: 263).

Governmental Programme 135

P 135 has been implemented since the 1990s as an 'action plan' and public investment programme derived from the SEDP. It targets poor communes especially in ethnic minority regions. Four main objectives have been on its agenda: production, infrastructural development, improvements of rural livelihoods and training for capacity building (CEMA/UN Vietnam 2009: 15). It offers grants to communes under difficult circumstances to be invested in small-scale infrastructure (SNV 2010; Swinkels and Turk 2007). Governmental funds of 805 million USD are complemented by World Bank and IFAD loans and grants from other development agencies such as Irish Aid, AusAID, DFID, Finland, and SIDA (CEMA/UN Vietnam 2009). On national level, the programme is administered by the Committee for Ethnic Minorities and Affairs (CEMA). During the first phase lasting from 1998 until 2006, districts have been the recipients of funds but afterwards even communes were entitled to manage the investment projects launched within the framework of P 135 (Anderson et al. 2010: 29). This devolution of decision-making power accounts for the objective not only to provide communal infrastructure but also to strengthen planning, evaluation, monitoring, and budgeting capacities in the communes. In order to achieve this goal, the programme strongly relies on commune ownership in investment as a guiding principle.[58] Communes are selected based on their geographical characteristics, the share of poor and ethnic minority households, as well as essential infrastructure deficiencies: less than 50 percent of the villages in the target area should have piped water supply or expressed in terms if households – more than 40 percent lack access to safe water (CEMA/UN Vietnam 2009: 39). Usually there is a strong overlay between poor communities and those with a high share of ethnic minority households (Swinkels and Turk 2007: 277). At the beginning of its second phase in 2006, the programme covered more than 1,600 communes comprising nearly 2,500 villages and hamlets in 47 provinces (CEMA/UN Vietnam 2009). In order to foster budget allocation for O&M purposes in preference to asset construction, separate budget lines have been allocated. The achievements of P 135 regarding improvements of water supply had rather been low in the past. As the mid-term review revealed, less than half of the households benefited from the water supply works which had been constructed in their communes. Consequently, the overall goal of 80 percent of the households having access to safe water had not been accomplished at that time. The evaluators attributed this low progress to the fact that water works had been set up in villages, respectively hamlets, which practically excluded those households in more remote hamlets (CEMA/UN Vietnam 2009: 67).

Governmental programme 134

In contrast to Programme 135, Programme 134 (P 134) targets individual households. This programme emanated from the land reallocation process in the Central Highlands under Decision 132, which primarily targeted ethnic minority households (WB 2009: 37), but has then been expanded on housing and water supply issues. Besides policies which aims at distributing land for residential and production purposes it comprises financial support for households of 5 to 6 million VND, and 300,000 VND or 0.5 t cement for constructing filters, wells, or latrines on household level (Pham et al. 2011: 15 et seq.).

Loans by the VBSP

In addition, the Việt Nam Bank for Social Policies (VBSP) provides loans for financing the construction of water supply and sanitation facilities on household level. The VBSP itself was set up in 2003 only and superseded the Bank for the Poor when the Vietnamese government started to expand microcredit schemes (Reis and Mollinga 2009: 14). Microcredit schemes of the VBSP constitute one element of the National Strategy for the rural water sector. The credit programme started in 2004 as a pilot project in ten provinces (Reis and Mollinga 2009) and has been expanded to the whole country in 2006. Usually, mass organisations like the Farmer's Union, Veterans Union, Youth Union, Womens Union administer the group-based lending schemes (VBSP 2013). In order to receive a loan, households have to join the local

[58] Generally, the strive for stronger communal participation in decision making about infrastructure projects and fostering communal ownership has only partially been successful so far as some case studies conducted by van Koppen et al. (2012) revealed. Communes most likely contribute in terms of selecting construction sites rather than intervening in choice and design of projects in general (Anderson et al. 2010: 29).

credit group, which will decide about the amount and terms but also needs the subsequent approval by the cPC and the local branch of the VBSP.[59] The VBSP focuses on remote and mountainous areas and especially communes under P 135. According to the VBSP instructions, only households which are officially classified as poor and have a long term residence permit in the commune are eligible to take the loan of maximum 7 to 8 million VND (Seward 2004: 4 et seq.). Beyond that, they have to prove their demand, which in this case is given if they do not have any, or just substandard facilities for water supply and sanitation. Generally, the period is adaptable but the loan has to be repaid within 60 months. In the past, interest rates were low and thus had to be subsidised (Seward 2004) but in the meantime raised substantially (VBSP 2013). In general, first evaluations suggested that the credit programme proved effective in terms of increasing households' income and reducing poverty, but so far nothing can be said about the specific impact on rural water supply. According to the official VBSP website, so far 57,527 credits for water-related construction works and 47,987 ones for sanitation have been granted (VBSP 2013). Apparently, only a part of the accommodated credits is granted to poor households (Seward 2004: 11) and not all demanding households actually benefit from the VBSP loans because the overall amount of funding is restricted. Whereas Reis and Mollinga (2009: 20) observed that just households without identification documents and legal residence permission are cut from the lists of demanding households, Dufhues et al. (2002: 6 et seq.) argue that the institutional arrangements for accommodating the loans put poor households by nature at a disadvantage due to their lower creditworthiness but also because they are not part of the social network which decides about the allocation of the loans.

3.4. The prevalence of measures for safe water supply

In view of the multitude of programmes related to rural water supply, the question about spatial targeting and coordination of the various supporting measures arises. Hence, this section aims at quantifying communal and individual level involvement in programmes based on the VHLSS 2008.[60]

[59] For a detailed description see VBSP (2013); Reis and Mollinga (2009); Nguyen (2007); Dufhues et al. (2002).

[60] This data however does not allow for conclusions about causal inference and programme impact because participation and the current status of water supply as outcome variables are measured at the same point of time. Subsequently, access to safe water cannot be causally attributed to a specific programme.

3.4.1. Assessment of programme participation on household and communal level

Table 3.2 compares households which participate in different programmes for improving water supply according to selected socio-economic characteristics. Whereas the 'Clean water for poor people' programme is directed to individual households, the other ones address entire communes, respectively parts of them. According to own calculations based on the VHLSS, every third rural household belongs to a commune in which infrastructure programmes for safe water took place during the previous ten years[61], but less than 3 percent of the households have been involved in the programme 'clean water for poor people' in the two years prior to the survey. These households have a considerably lower per capita expenditure (t=10.2 df=6,835, p=.000), which is on average only half of that of non-participating rural households, and even significantly lower than the median expenditure of other rural households which have been classified as poor (t=4.8 df=1,387, p=.000). Households are also significantly larger (t=-6.56 df=6,835, p=0.000), and on average, the head of household attended school three years less than the head of household of non-participating rural households (t=11.33 df=6,835, p=.000). Three quarters of the beneficiaries are ethnic minority households, whereas among the non-participants their share accounts only for 17 percent. Moreover, in the communes where beneficiaries are located, the share of poor households is on average more than twice as high as in the remaining rural communes. Thus we can conclude that this programme actually targets the poorest of the poor. Households benefiting from this programme can be found in all parts of the country, but compared to the overall number of rural households, most frequently such in the Northwestern (12% of rural households), Northeastern (5%), South Central Region (5%) and the Central Highlands (3%) benefit from individual programme participation.

The individual programme aside, 18 percent of the households reside in a commune under P 135. As reveals Table 3.2, households in P 135 communes also show lower average per capita expenditure, lower levels of education, are larger, and more frequently belong to ethnic minorities than those in other communes. Compared to the programme targeting individual households, the difference between households in participating and non-participating communes is slightly less pronounced. This even more applies to inhabitants of communes which carried out water-related infrastructure projects during the last ten years: as the comparison of households' characteristics in the last two columns of Table 3.2 shows, differences appear rather minor ones, which indicates that communal infrastructure projects do not explicitly

[61] This variable has been generated based on a VHLSS subset of data which lists the ten most important infrastructure projects during the last 10 years (for details see next subsection). Here, communes with at least one project for safe water supply are compared to those without any such project.

Table 3.2.: Rural households' characteristics by programme participation

	Clean water for poor people		Programme 135*		Communal project*	
	yes	no	yes	no	yes	no
Share of households in %	2,7	97,3	18,2	81,8	34,0	76,0
Share of ethnic minority hh in %	75,7	17,4	58,7	10,4	31,5	12,8
Per capita expenditure in 1,000 VND (mean)	3,992	7,854	5,902	8,129	7,534	7,824
Household size	5,0	4,2	4,8	4,1	4,4	4,1
Grade completed by head of hh (mean, in years)	3,7	6,7	5,3	6,9	6,0	6,9

Note: * P 135 and infrastructure projects refer to commune not to individual households
Source: VHLSS 2008, Own calculation

target poor communes. Probably this is owed to the fact that communes or districts usually have to contribute to the investment costs which will be discussed in detail in the next subsection. Similar to the programme 'Clean water for poor people', in relative numbers the population of the mountainous Northwest (59% of rural households), followed by the Northeast (29%) and the Central Highlands (35%) is most likely to live in P 135 communes, but in absolute terms also a large number of households in the Mekong Delta resides in communes covered by P 135. Communal infrastructure projects for safe water even reach a higher number of inhabitants. Figure 3.2 illustrates the share of communes participating in water-related projects per province. Besides the regions which also show high participation in the before-mentioned programmes, such infrastructure projects seems highly prevalent in the Mekong Delta where 44 percent of the rural households are potentially affected – which accounts by far for the highest absolute number of households compared to other regions. Nevertheless, these figures can only serve as a proxy for the actual number of beneficiaries, since the constructed facilities might no be equally accessed by all inhabitants of an administrative unit due to reasons of spatial distance or also affordability, as suggests the mid-term evaluation of P 135 (CEMA/UN Vietnam 2009: 67). Also own calculations for water-related infrastructure projects based on the VHLSS data reveal large disparities in coverage rates: whereas every eighth project leads to improvements for 90 to 100 percent of the permanent households in a commune, two of three projects reach less than 50 percent and one quarter even less than 10 percent of the permanent households in the target commune.

Spatial targeting

A comparison of the spatial distribution in programme participation suggests a quite

Overlap in programme participation

strong overlap. The VHLSS data confirms that two thirds of the households in the 'Clean water programme' actually reside in P 135 communes and are thus also affected by commune level measures. Put it differently, in P 135 communes, 10 percent of the households additionally participate in household level programmes, whereas in the remaining communes this only holds true for a mere 1 percent. This points to a strong overlap between programmes but also reveals that individual support is not exclusively restricted to P 135 communes. Moreover, P 135 communes significantly more frequently conducted infrastructure projects for safe water supply during the last ten years than non-participating communes (53% compared to 30%, χ^2=73.9, p=.000). Hence, in order to account for the overlap between the different supporting measures and to elaborate on their potential joint effects on households access to safe water, it seems reasonable to account for these different projects as well as their potential interaction effects in the multivariate models.

3.4.2. Communal infrastructure projects for safe water supply

This subsection elaborates on the contribution and ensuing the impact of different governmental agencies and other donors by tracing their financial contribution to infrastructure projects. Therefore it draws on data about communal infrastructure projects from the VHLSS 2008.[62] Funding patterns have been found to differ tremendously according to the type of infrastructure. Here only results for projects about safe water supply are presented.

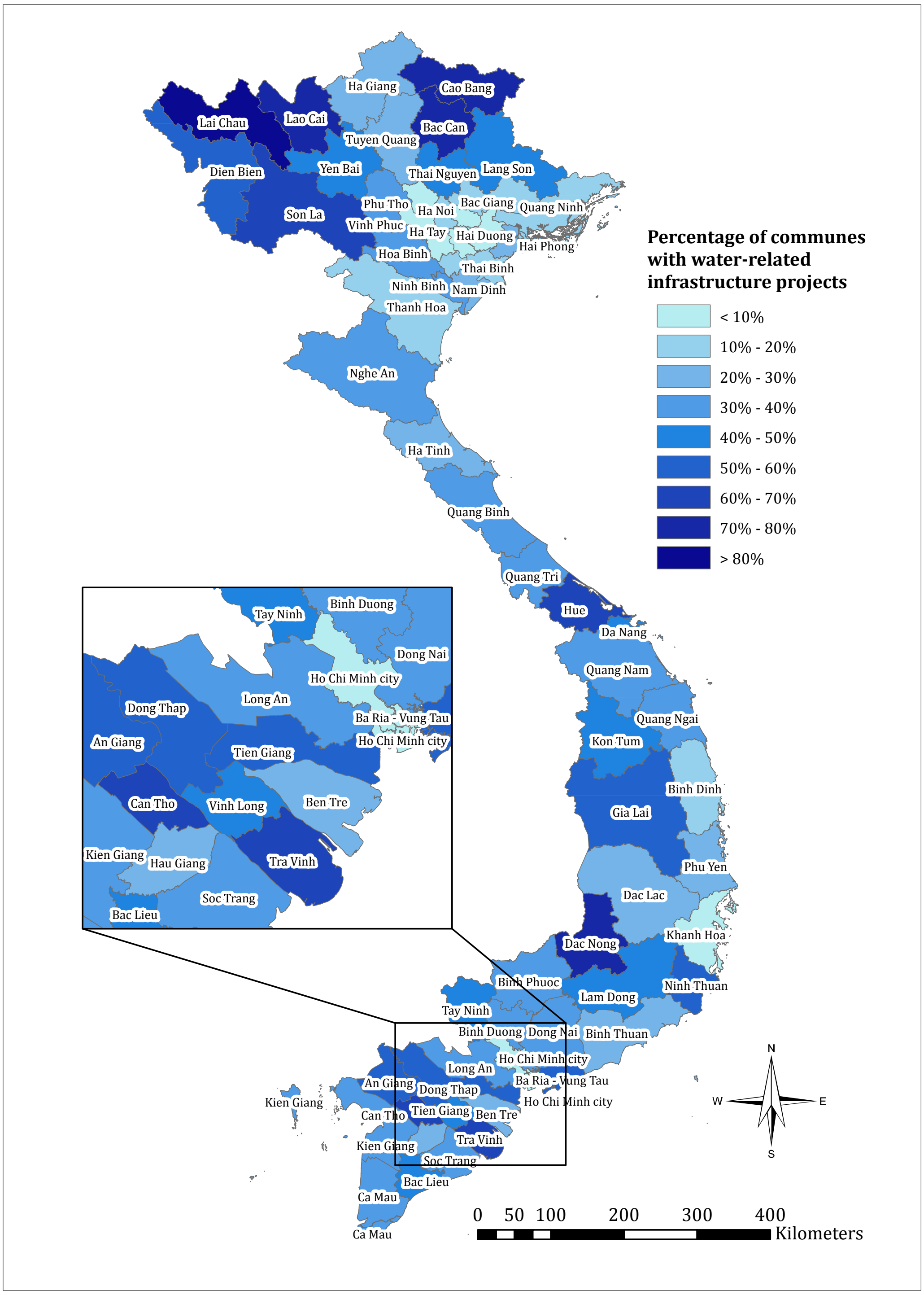
Funding patterns

For 30 percent of the water supply projects, the VHLSS lists two donors per project, but does not specify which share of funding is attributed to each of them. At least this information allows to identify typical patterns of co-funding and collaboration for rural water supply projects. District level projects are most likely conducted without any involvement of other donors (83%), whereas communes are in 41 percent of the cases found to cooperate with provinces, districts, hamlets and other donors. In the sample, in every fifth project, national level authorities collaborate with the provincial level but hardly with other partners. For the sake of simplicity, the following analysis always refers to the first donor mentioned in the VHLSS and will shed light on regional disparities and different donors' contributions across all water supply projects captured in the data set.

Whereas the upper panel of Figure 3.3 depicts the share of communal projects for safe water supply initiated by a certain donor in a specific region, the lower panel refers to

[62] The VHLSS commune level questionnaire lists up to 10 infrastructure projects implemented in the commune within the last ten years e.g. with regard to sector, donor, extent of funding, start and number of beneficiaries. The complete list and exact wording of items can be taken from the list in the appendix (see p. 281). 14 different types of infrastructure projects are covered ranging from the construction of roads, bridges over measures for water supply and waste disposal, irrigation networks to social infrastructure like kindergartens and schools just to name a few.

Figure 3.2.: Spatial distribution of communal projects for safe water supply

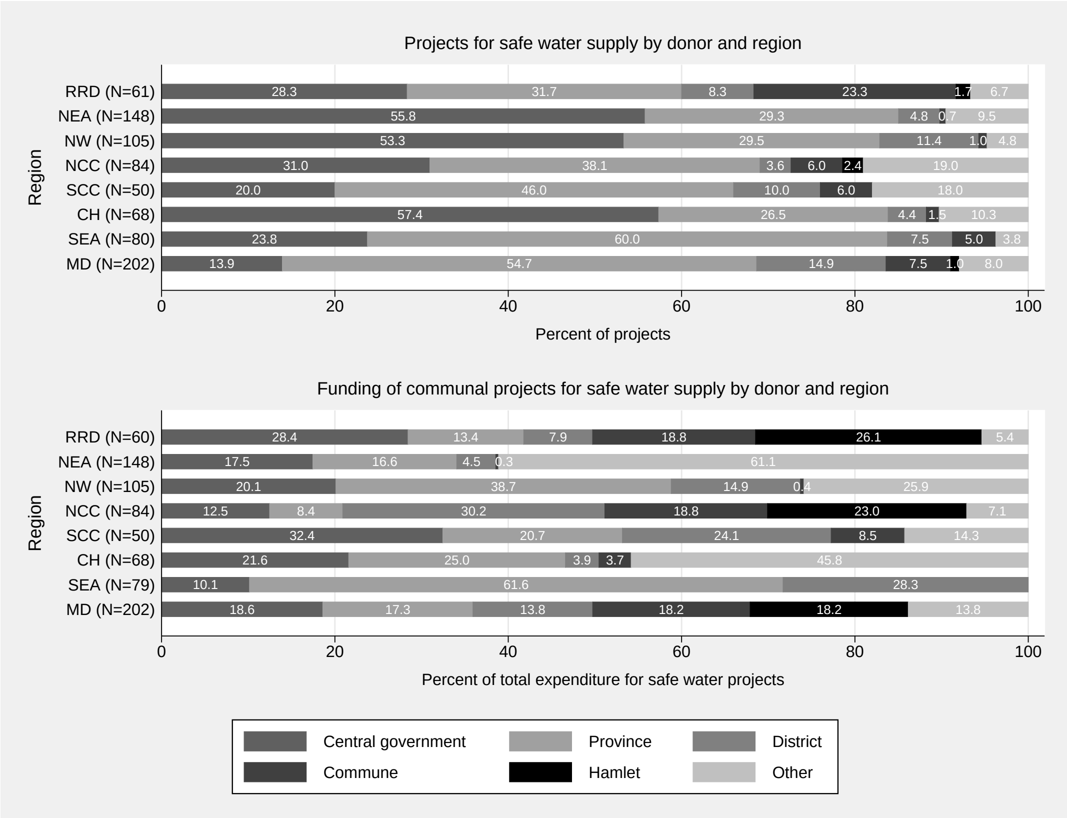


Source: Own calculation and map based on VHLSS 2008 commune data set (GSO Vietnam 2008b), administrative boundaries for provinces based on gadm.org (GADM 2013) the share of funding contributed by specific donors in relation to the overall amount of funding provided by all donors in this region. Because the mere number of projects supported by a certain donor does not necessarily tell much about the actual scope of its influence, this number is supplemented by the relative share of funding the donor contributed to the respective projects. In return, limiting the analysis to the amount of funding might also distort the impression one might get about the relevance of this donor if large amounts are directed to very limited spatial area. There is strong evidence, that especially the latter argument is gaining in importance in Việt Nam. An evaluation in the context of the Paris Declaration revealed that ODA is increasingly concentrated on a small number of large donors such as the development banks and the average amount of funding per project increasing – which is mainly due to large budget support projects (Cox et al. 2011: 10). Something similar applies to infrastructure projects: in the lower panel of Figure 3.3, two projects have been excluded – one in the Red River and one in the Southeastern region – because their extraordinarily high amount of funding strongly altered the overall picture.

Figure 3.3 suggests that despite all country-wide processes of devolution and changes in allocation mechanisms, the regions have retained their distinct governance cultures. It becomes obvious that the central state does not withdraw from infrastructure projects on communal level and especially engages in economically weak regions such as the Northeast, Northwest, and the Central Highlands which also suffer from largest deficiencies in water supply as has been shown in Section 2.5. There, more than every second project is financed by the central government, but as the lower panel shows, in terms of funding, the contributions by the central state only account for one fifth of the total spending for water supply infrastructure on communal level.

Moreover, Figure 3.3 reveals that provincial level agencies play a more substantial role in the southern regions, whereas in the northern part, responsibility for funding water supply is assigned to lower level authorities. In the three northern administrative regions, three out of ten projects are financed by the provinces, while in the Mekong Delta and the Southeastern Region these are almost twice as many. Communal contributions, respectively those by hamlets, do not play any role in the mountainous areas and the Central Highland but account for more than 40 percent of the financial contributions in the Red River Delta and the North Central Coast. Whether this is attributable to the economic strength of communes in this area or rather their traditionally higher level of autonomy is questionable. Since liberalisation destroyed the state subsidy system, the shortfall was to be thrown in by the population. According to Hayton (2010: 39), substantial parts of the communal funding are generated through local taxes and roughly 30 percent by 'voluntary contributions and donations' either as cash but also to a large extent in terms of work on local development projects (see also United Nations / UNDP Vietnam 2012; Anderson et al. 2010; Le et al. 2010). Thus it seems reasonable that especially rather affluent communes are able to raise larger proportions of their revenues from people's contri-

Figure 3.3.: Communal infrastructure projects by type of donor



Source: Own calculation based on VHLSS 2008 commune data set

butions which enables them to invest in communal infrastructure. Contrasting the mean communal poverty rates for project funding by different donors underpins the hypothesis that the central state in particular supports disadvantaged communes. Communes in which the central state funds water supply projects show an average poverty rate of 29 percent compared to 11, respectively 8 percent, if the project is funded by communes or hamlets.

Contributions by ODA

In contrast to what has been stated in literature, funding contributed by other donors – here 16 percent of the overall expenditure for communal projects about safe water supply – is apparently not of overriding relevance although it makes up a large part of overall funding in the three mountainous regions. Whereas according to Cox et al. (2011: 9) Việt Nam is not an aid-dependent country[63] and ODA equaled only 12 to

[63] 'The ODA profile is dominated by lending from the Six Bank group (World Bank, ADB and development banks from Japan, France, Germany and Korea), which between them supplied 85 percent of total ODA to Việt Nam since 2000, and more than 90 percent in 2009 as a result of

13 percent of the total state investment budget, the water sector was said to be by far stronger dependent with 85 percent of one billion USD invested for (primarily urban) water supply and sanitation emanating from ODA (Staykova 2006: 6; ADB 2008: 8). This discrepancy might be attributed to the fact that the way how information about donors is captured in the VHLSS commune questionnaire disguises, whether and how funds originating from ODA are redistributed. In order to understand the relevance of ODA for RWSS, tracing the origin of funds is inevitable in view of the steadily increase in ODA in the past. Here it might be reasonable to assume that ODA is only assigned to the residual category if foreign donors themselves act as implementing agencies which is usually not the case in large scale investment projects (e.g. for the NTP-RWSS), since those are rather administered by higher level governmental agencies.

Obstacles in assessing funding patterns

In general, there are numerous reasons adducible why figures referring to the amount of funding should be interpreted cautiously. Firstly, the category of ‘other’ donors comprises a conglomerate of private sector contributions and ODA. Secondly, as discussed above, it is unclear which share of communal funding can actually be ascribed to people’s contributions e.g. in terms of fees or ‘voluntary donations’. A report about P 135 stated that between 2007 and 2010, cash and in-kind contributions by households increased tremendously (United Nations / UNDP Vietnam 2012: 90 et seq.). Thirdly, in the sample, several projects with an extraordinarily high funding volume compared to numerous others with quite low amounts of funding could be identified. Subsequently, aggregating this information might result in misleading conclusions about the general relevance of specific donors in the rural water sector. And last but not least, pooling projects conducted within a time period of roughly 20 years neglects that in absolute terms expenditure for communal infrastructure almost grew exponentially since the beginning of the 1990s as illustrates the following example: the absolute amount of funding by other donors in the period between 2001 and 2005 equals that of the central government in the period between 1996 and 2000. At that time, this accounted for almost one quarter of the whole amount spent for communal infrastructure, whereas in view of the overall growing expenditure in the following period, it melted down to one twentieth.

3.5. Summary

Agencies

The institutional landscape in the Vietnamese water sector is highly fragmented and has undergone pervasive restructurings within the context of the administrative and economic reforms since Đổi Mới. Various governmental agencies and their respective line agencies on the provincial, district, and communal level are concerned with

some large stimulus packages. Of all new ODA commitments in 2008, 92 percent were loans and 83 percent came from the World Bank, ADB and Japan.’ (Cox et al. 2011: 9).

water-related issues, which sometimes results in conflicting responsibilities. In principle, MARD is responsible for water service delivery in rural areas and coordinates the activities of other agencies like MoH, MoET, MPI, MoF or the mass organisations, but some of MARD's tasks have been delegated to CERWASS. CERWASS takes a key position in the rural water sector because it assists MARD in technical questions and practical implementation but also serves as an operator of piped schemes. The People's Committees on the local level mainly serve as communicators of users' needs whereas their provincial branches exert much more influence because they set water prices and allocate the funding in the water sector. Despite the allocation of responsibilities to different administrative levels, the institutional environment in the water sector can hardly be labelled as decentralised. National sectoral policies and targets are defined in a top-down manner, whereas processes to initiate practical measures and actions to improve rural water supply are institutionalised in terms of a bottom-up reporting and top-down planning process, which involves a complex interplay between the above-mentioned actors. To make things even more complex, the engagement of specific actors apparently differs across the administrative regions as was illustrated by the example of local infrastructure projects. The influence of the private sector seems to be very limited up to now. Although with the Grassroots Democracy Decree, an official foundation for public participation was created, it hardly took effect in practice in rural service delivery in the past. Similarly, private sector participation found entrance into the official policies for RWSS but did barely yield any observable results so far. In general, the review of donor and governmental documents points to a style of policy making in RWSS which is shaped by programmatic approaches and a strong preference for target numbers, whereas less attention is paid to the means to achieve them. Target definitions in the water sector mainly enter the realm of political discourse and documents from the donors and supranational actors but reappear in the context of different programmes for communal development. The assumptions on which these figures are based and adjusted remain untold and thus appear as somehow arbitrary definitions. Besides genuine sector specific programmes to support individual households and communes to improve access to safe water, a number of programmes like P 143, P 134, P 135 or loans by the VBSP has been explored. Those primarily aim at poverty eradication and often explicitly target ethnic minorities but also comprise infrastructural components. Systematic evidence about to which extent these programmes actually contribute to improve access to safe water is lacking, but the mid-term review of P 135 suggests that the impact so far is rather minor. Moreover, although these poverty related programmes are also governed under the umbrella of the CPRGS, it remains unclear how measures and targets are reconciled and potential overlaps are addressed in pratice. Empirical analysis about the above-mentioned programmes based on the VHLSS 2008 reveals regional disparities in programme participation and distinct funding patterns for local, water-related infrastructure projects across

Policy making

Policies and targets

the administrative regions. According to this analysis, the central state in particular engages in economically weak regions. Provincial level agencies play a substantial role in the Southern provinces, whereas in the North Central Coast and the Red River Delta in particular the local level significantly contributes to fund communal infrastructure for water supply.

4. Diffusion and adoption in the rural water sector

Contents

Statistical data as such from the JMP and the VHLSS suggests that access to safe water in terms of using improved water sources and piped schemes or applying household water treatment increased over time – but did not spread evenly. A closer look at the current patterns of use reveals that these are first and foremost shaped by urban-rural and regional disparities, whereby the later ones are at least partially conditioned by the natural availability of water sources (see Section 2.3 and 2.6.3). Furthermore, case studies about the dissemination of specific household water treatment methods showed that in particular interventions and imitation played an important role in their adoption. Last but not least, I already briefly touched upon the hypothesis that access to safe water is a matter of income and affordability (see p. 68 et seq.).

Diffusion theory

With the help of diffusion theory as a theoretical framework, this chapter aims at putting together these and other pieces in the puzzle in order to draw a more comprehensive picture about the drivers and obstacles in the dissemination of access to safe water. Diffusion theory has been applied in numerous research fields ranging from agriculture to information technology and a remarkable variability of diffusion studies addressing distinct aspects of the diffusion process emerged during the past sixty years (cf. Rogers 2003). In general, the concept of diffusion asks for 'the flow of information, ideas, practices, products, and services within and across cultures and subcultures, or markets and market segments' (Gatignon and Robertson 1985: 849). Diffusion scholars from different research traditions and disciplines are likely to agree on the least common denominator that this spread of information is based on social interactions and contributes to adoption, but their conceptions about how this actually happens and can be explained differ tremendously. The theoretical roots of diffusion research are originated in rural and medical sociology, geography, cultural anthropology, and industrial economics but the concept also found entrance into studies of consumer behaviour during the 1960s. Whereas in most cases, consumer diffusion literature applied the same concepts like general diffusion literature, considerable progress has been achieved in (quantitative) modelling of diffusion processes (cf. Geroski 2000).[64] Across the variety of disciplines and subjects, a basic set of concepts has been established addressing (Rogers 2003):

- the generation of innovations,
- the adoption and decision making process,
- attributes of innovations and their influence on adoption speed and rate,
- adopter categories with reference to the diffusion process over time conceptualised by the characteristically sigmoidal curve,
- diffusion networks (including opinion leadership, the concepts of the critical mass, heterophily, and homophily),
- and last but not least the role of change agents.

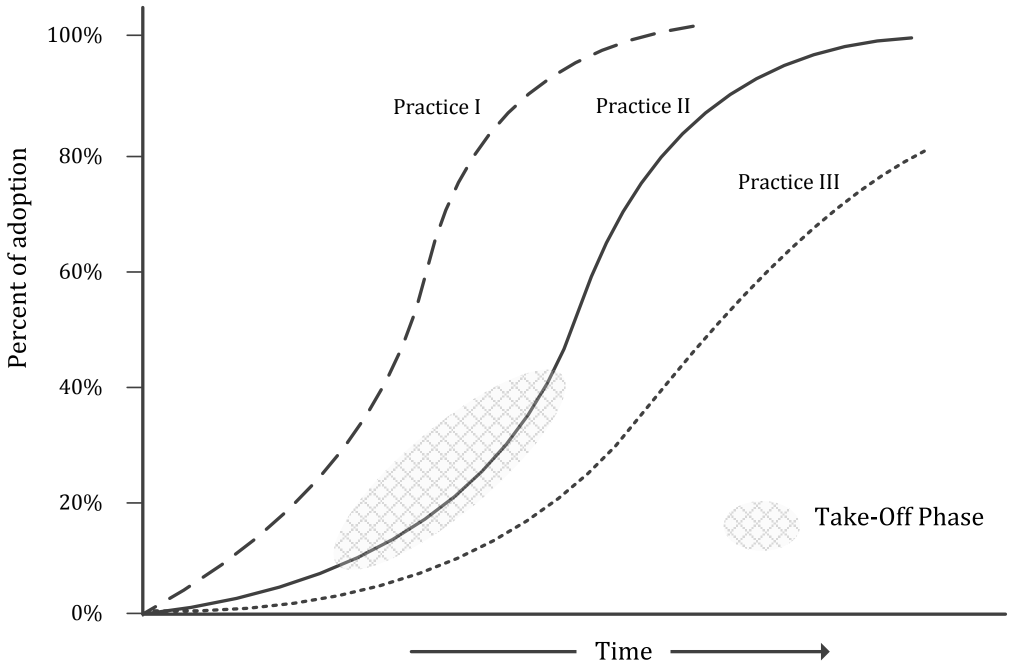
From the author's point of view, Rogers' (2003) main contribution bears on the conceptualisation of diffusion as a social process, the condensation of a multitude of empirical studies across various disciplines to some catchy concepts, and the vivid description of the diffusion process by the characteristic diffusion curve (see Figure 4.1). Plotting the cumulated number of adopters over time, yields an s-shaped curve because the number of adopters is firstly expected to increase slowly, then growth accelerates, and finally slows down once only few non-adopters are left. From consumer behaviour perspective, Gatignon and Robertson (1985: 850) add two crucial elements to the conceptual framework proposed by Rogers: marketing, respectively change agents' actions, and competitive actions. Gatignon and Robertson (1985) argue that besides personal characteristics, perceived characteristics of the innovation and personal influence; marketing and competitive actions have an impact on adoption decisions, whereby competitive actions again impinge on the perceived characteristics. Both approaches provide basic categories to structure the analysis of diffusion processes and direct attention to its specific dimensions – but at the same time fail in systematically relating them to each other. Neither Gatignon's and Robertson's, nor Rogers' approach provide any guidance to draw conclusions about the relative contribution of characteristics of the innovation, the innovator, and the environmental context (see also Rogers 2003: 223),[65] as well as their interactions in

[64] Given the restriction of cross-sectional data in this thesis, and thus the inability to account for a processual perspective, this branch of diffusion research is not discussed here in detail. For further information, see Young (2009); Geroski (2000); Mahajan and Peterson (1989); Strang and Meyer (1993).

[65] The analytical distinction between characteristics of the innovations, the innovators, and the environmental context is based on a conceptual framework for the integration of different diffusion models based on Wejnert (2002).

a specific case, let alone to compare these relations systematically between diffusion studies.

Figure 4.1.: The diffusion process



Source: Own illustration based on Rogers (2003: 11)

Before approaching the question about driving forces and obstacles in the dissemination of piped schemes, safe water sources, and household water treatment in rural Vietnam by means of empirical analysis, I will consult the extensive body of diffusion studies. Therefore, in a first step, this chapter reviews diffusion studies in the field of rural water supply and sanitation in developing countries to gain insights about determinants of diffusion which are specific for water-related 'innovations', the specific group of adopters, and the circumstances under which diffusion in rural areas and developing countries takes place. In a second step, these findings are discussed and organised along four groups of diffusion determinants in order to arrive at a set of indicators and hypotheses guiding further analysis about the diffusion of piped schemes on communal level (Chapter 5), access to safe water on household level (Chapter 6), and point-of-use water treatment (Chapter 7). In line with diffusionists like Rogers (2003), Wejnert (2002), and Gatignon and Robertson (1985), this chapter elaborates on characteristics of water-related innovations, characteristics of communes and households as adopting entities, the environmental context in which diffusion takes place, and finally interventions as supporting measures and triggers of the diffusion process.

4.1. Diffusion studies in the field of rural water supply and sanitation

This section introduces four exemplary diffusion studies, which examine water and sanitation related innovations in terms of techniques as well as preventive behaviour in developing countries. These studies refer to:

- the diffusion of latrines in rural Benin (Jenkins and Cairncross 2010),
- rural sanitation marketing in Vietnam (Devine and Sijbesma 2011),
- the dissemination of Kanchan arsenic filters in Nepal (Ngai et al. 2006),
- the adoption of sand-filters in Vietnam (Tobias and Berg 2011).

In order to deliver insight into these studies, they are reviewed briefly with regard to their design and background and summarised with regard to their most important findings. Whereas they all have in common the thematic focus on diffusion of water- and sanitation related facilities in developing countries, they differ considerably in the way how they methodologically and theoretically approach the diffusion process. While Jenkins and Cairncross (2010) put strong emphasis on spatial determinants and contextual characteristics of the environment in which latrine diffusion takes place, Devine and Sijbesma (2011) strongly focus on the diffusion networks and the role which communication and social mechanisms play in promoting rural sanitation. Ngai et al. (2006) examine measures to enhance dissemination but especially elaborate on the question how to develop appropriate technologies that meet the local demand. In contrast, Tobias and Berg (2011) scrutinise distinct steps in the diffusion and adoption process with special regard to people's motivation for performing and keeping up household water treatment.

Latrine diffusion in Benin

Jenkins and Cairncross (2010) investigate diffusion patterns for latrines in 502 villages in Benin. The study harks back to existing geographic, census, and infrastructure data sets from different sources and also draws on spatial data. Since household latrines were privately financed and locally built, the data set provides a picture of a diffusion process which is barely shaped by external interventions. The study examines a set of 17 independent variables representing the village environment, individual lifestyle, and latrine exposure. Jenkins and Cairncross apply a logistic regression to analyse which of the variables explain varying levels of latrine coverage across the villages. Contagion, measured as nearby latrine adoption rate, proves to be the most relevant factor for latrine adoption, at least in the initial phase. Other spatial factors and characteristics of the environment gain in importance during the take-off phase. What makes the study especially worth to look at, is the operationalisation of the indicators to measure characteristics of the environment and latrine exposure (see Table 4.1).

Rural sanitation marketing in Vietnam

From 2003 to 2006, a pilot initiative for rural sanitation marketing took place in two provinces in Vietnam which increased coverage by sanitary toilets substantially. The outcome of the project was monitored by an evaluation study (Devine and Sijbesma 2011; Sijbesma et al. 2010). The approach, combining social and commercial marketing best practices, involves three basic principles: 'the need for products that meet user needs to be available, the need to strengthen the supply chain and the use of marketing principles to "sell" sanitation in order to generate sustainable markets' (Devine and Sijbesma 2011: 53). Local leaders, masons, producers, and shop-keepers were trained. The follow-up study – based on local sanitation statistics and various methods, among them focus group discussions and structured interviews – revealed that two years later, already 59 percent of the target population had built an unsubsidised sanitary toilet. Local entrepreneurs still kept on promoting sanitation facilities and even expanded product and consumer range. A lack of funds was reported to be the most important barrier to build a toilet but even those households had either started to set aside funds, knew how much they wanted to invest, or articulated clear preferences for a model (Devine and Sijbesma 2011).

Dissemination of Kanchan arsenic filters in Nepal

The article of Ngai et al. (2006) describes the development and dissemination of an arsenic filter in rural Nepal. In a cooperational project of the MIT and two local partners from Nepal, a filter for simultaneous arsenic and pathogen removal has been constructed using locally available material and labour. The article does not only describe dissemination activities to build up long term safe water supply but also reviews the technology development process, which was accompanied by background research on socio-economic conditions and the evaluation of various technologies based on technical performance, social acceptability, and costs in the field and laboratory. Like in the study about rural sanitation marketing, a demand-responsive approach was applied involving community based organisations and private businesses for construction, maintenance, promotion, and sales techniques. Implementation activities also included a training of local entrepreneurs, guidelines for maintenance, even 're-invention' of filters, as well as micro-financing mechanisms.

Adoption of sand-filters in Việt Nam

Tobias and Berg (2011) examined the influence of psychological and social factors on the adoption of arsenic-removing sand-filters in Việt Nam by a household survey. Of the 319 households from four villages in the sample, 162 had a sand-filter whereas 157 did not. Regression analysis was then applied to investigate which of the factors have an impact on three types of behaviour: the decision for a sand-filter, the acquisition, and maintenance. The impact of social, psychological, and situational factors on each type of key behaviour were assessed separately. Besides perceived improvements of healthiness and taste of water, monetary costs, and social norms proved to be influential. The study also considers competing behaviour (to be defined by the respondent) and indicates 'that households do not abstain from competing behaviors in order to acquire a sand-filter. If they can afford both, they acquire a sand-filter; if not, only the competing behavior is implemented' (Tobias and Berg 2011: 3265).[66] In this study, knowledge about arsenic contamination did not correlate with the decision for, acquisition, or maintenance of sand-filters. The study implies that sand-filters are primarily applied to improve the taste of water in general but not explicitly to remove arsenic.

Conclusions from case studies

The review of the above-mentioned diffusion studies delivers valuable clues about what should be taken into account when empirically investigating the diffusion of water-related practices in rural Việt Nam. First and foremost the studies underscore that the researcher is well advised to be clear about the unit of investigation and focal point to be considered: Do we investigate individuals or households as adopting entities or rather collective ones such as organisations or communes? Do we scrutinise adoption and decision-making processes on a micro-level or rather dissemination within a population on a macro-level? Secondly, adoption and diffusion might be triggered by a whole bunch of factors. Here, five aspects deserve particular attention: (1) the conceptualisation of attributes of the innovation as user perceptions (but not as expert opinion); (2) the contribution of social factors as norms and compliance with them; (3) the role of competing alternatives to the practice as hindering or delaying factor, (4) the role of interventions, their specific design, and underlying assumptions about causal mechanisms, and (5) the finding that determinants might unfold different impact across the phases of a diffusion and adoption process. The following sections will further elaborate on these ideas by consulting diffusion theory and the extensive body of empirical studies in order to arrive at working hypotheses that guide further analysis in Chapter 5, 6, and 7.

4.2. Determinants of diffusion

4.2.1. Characteristics of the innovation

There is broad consensus about some central characteristics of innovations that foster successful and rapid diffusion, so here a brief wrap-up of these attributes of innovation as they are discussed by Rogers (2003) and Moore and Benbasat (1991) should suffice:

[66] Also other studies scrutinising the adoption of household health technologies found that health preventive behaviour is not always prioritised even if the consumers are aware about the potential health benefit(s) (cf. Thurber et al. 2013: 1738).

- The *relative advantage* refers to 'the degree to which an innovation is perceived as being better than its precursor' (Moore and Benbasat 1991: 195) or a competing innovation which aims to fulfil the same purpose. The relative advantage is expected to be the most influential factor for diffusion but is a very vague concept. The attribute relative refers to 'the ratio of expected benefits and the costs of adoption. Subdimensions of relative advantage include economic profitability, low initial cost, a decrease in discomfort, social prestige, a saving of time and effort, and immediacy of reward' (Rogers 2003: 233).
- *Compatibility* denotes 'the degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters' but is also confounded with the relative advantage according to results of Moore and Benbasat (1991).
- *Complexity*, also labelled as ease of use in the Technology Acceptance Model (TAM), describes 'the degree to which an innovation is perceived as relatively difficult to understand and use' (Rogers 2003: 257) and negatively related to the rate of adoption.
- *Trialability* is 'the degree to which an innovation may be experimented with on a limited basis' (Rogers 2003: 258) and positively related to the adoption rate.
- *Observability* measures 'the degree to which the results of an innovation are observable to others' (Moore and Benbasat 1991: 195). According to Moore and Benbasat (1991), observability rather comprises two constructs than a single dimension: the result demonstrability and visibility.

There is merit in considering one aspect here: The above-mentioned criteria compiled by Moore and Benbasat (1991) and Rogers (2003) resemble those adduced by Sobsey et al. (2008) for HWT techniques – except for the fact that the latter ones are derived from an expert's point of view (see Section 2.6), whereas in diffusion theory characteristics of innovations are conceptualised as genuine users' perceptions. This on the first sight minor difference might have strong implications because users' adoption decisions are eventually based on their perceptions and experiences regardless of the scientific assessment as the empirical studies reviewed above and experiences described in Section 2.6.2 corroborate. Emphasising users' perceptions is not to deny the relevance of scientific assessments of HWT but to draw attention to the question how scientific evidence about advantages of the technique can be deployed as arguments for promotion.

Measuring comparative advantage

Measured against the importance which is ascribed to comparative advantage as a criterion for successful and speedy diffusion, empirical evidence for the field of rural water supply is scarce and scattered. In contrast to expert judgements, systematic evidence for users' preferences and comparative assessments of advantages and disadvantages of water sources and treatment techniques is barely reported. Albert et al.'s (2010: 4431) study on end-user preferences for different HWT techniques in Kenya revealed that overall attractiveness for end-users does not necessarily coincide with highest treatment efficiency. Whereas the preference for a certain technique was in most of the cases ascribed to ease of use, bad odour or taste of treated water rather led to a rejection of the technology. Consequently, one might conclude that odour and taste act as 'negative criteria', meaning: a technique is more likely to be rejected if taste and odour are bad – but is not necessarily preferred if those are good. Spencer (2008b) examined the comparative advantage of different water sources in southern Việt Nam. He concludes that piped water is preferred due to high quality but rejected due to unreliable supply; water from wells is appreciated as a hygienic, convenient, and reliable source but associated with high initial costs; and last but not least, surface water assessed as an affordable and convenient but low quality source. Albeit the study provides valuable insights in households' perceptions of comparative advantages of water sources, it fails in relating the criteria to each other and the actual choice of water sources.

The lack of comprehensive empirical assessments about the role which comparative advantages play for adoption and diffusion, might be owed to the fact that – albeit the concept proves a promising figure of thought to understand households' rationales from a theoretical point of view – it requires sound prior assumptions about the mechanisms at work in order to specify the 'right' hypotheses and yield proper empirical results. This concerns at least three aspects which will be briefly discussed in the following: the operationalisation of subdimensions, a sound concept about to what 'comparative' or 'relative' specifically refers, and what 'advantage' means with regard to preventive behaviour. Firstly, assessing the relative advantage of water treatment or switching to safe water sources requires to define relevant subdimensions including such as different types of costs associated with water supply, water quality, reliability of service and supply (cf. Section 2.7.1), but also indirect benefits for household production or health (cf. Section 1.1). Secondly, scrutinising the diffusion of a certain water source or treatment technique should involve a concurrent inquiry of these criteria for competing alternatives and the status quo. Switching to a new treatment technology or piped water might not be perceived advantageous given that the household already uses a reliable and affordable water source. Thirdly, but of utmost importance, Rogers (2003) and also findings from development economics (e.g. Duflo 2006) direct the attention to the question of immediacy of rewards when switching to safe water sources or applying HWT. Empirical studies have shown that spontaneous diffusion of household water treatment and safe water sources is unlikely and adoption speeds up slowly even if the technique or source itself is perceived as advantageous. This is mainly ascribed to the fact that household water treatment – or health preventive behaviour related to water in general – require an action at a certain point of

Diffusion of preventive behaviour

time in order to avoid unwanted consequences like water-borne or -washed diseases in the future. 'The rewards to the individual from adopting a preventive innovation are often delayed in time, relatively intangible, and unwanted consequence may not occur anyway' (Rogers 2002: 991). In consequence, the comparative advantage, which proved to be the most important predictor for the rate of adoption, is low. Given that firstly, people tend to value small immediate rewards higher than larger gains in the future (cf. Tarozzi and Mahajan 2011; Banerjee and Mullainathan 2010; Duflo 2006) – what is in a nutshell the main message of time-inconsistent preferences – and secondly, the expected advantage of applying preventive behaviour in the future is as low and uncertain as today, then of course also the likelihood that households spend time, effort, and money on it would be quite low if no other benefits are standing to reason. Moreover, assuming that the lack of immediately visible (health) effects at a specific point of time is indeed one of the main reasons for hesitant adoption, the effect could also be pervasive for 'contagion' and learning effects. If potential adopters do not observe any positive effects or benefits arising from adoption among adopters in their surrounding, then their own expectations about positive effects could even be lower than before any diffusion set out in their immediate environment (for a more detailed argumentation, see Duflo (2006)). Kremer and Miguel (2003) observed such an effect for a programme to fight intestinal worms in Kenya: children who had more friends in the treatment group were less likely to take the treatment themselves. These examples illustrate, that understanding the relative advantage might pose a crucial control point to avoid diffusion getting stuck in its early stage. In order to get out of the predicament that benefits of preventive innovations are uncertain and only become visible in the future, different approaches are conceivable. Rogers for example concludes that increasing the perceived advantage must build upon different criteria than health benefits, which could here mean to point to improved taste and odour of water, reduced maintenance effort or, in case of tap water, reliable supply; whereas studies in development economics argue for providing small but immediate incentives (Duflo 2006: 9).[67]

4.2.2. Characteristics of adopters

Adoption and diffusion might concern different entities such as individuals and households, but also collective ones like organisations, communities, or even countries. The type of entity is expected to impinge on the nature of diffusion: adoption decisions of collective actors usually refer to different types of innovations, evoke consequences of different extent, and are based on different modes of interaction than decisions taken by individual actors (Wejnert 2002: 302). More precisely, Rogers (2003: 28 et seq.) distinguishes between three types of innovation decisions:

[67] The role of interventions in diffusion will be discussed in Section 4.2.4.

- *Optional innovation-decisions* as choices in which an individual may adopt or reject the practice independently from other members of the system. The notion of independence here does not exclude social norms or mutual exchange of information as will be discussed on page 130.
- *Collective innovation decisions* 'are made by consensus among the members of a system. All units in the system usually must conform to the system's decision once it is made' (Rogers 2003: 28).
- *Authority innovation-decisions* 'are made by a relatively few individuals in a system who possess power, status, or technical expertise. An individual member of the system has little or no influence in the authority innovation-decision; he or she simply implements the decision once it is made by an authority' (Rogers 2003: 28-29).

Within the scope of this thesis, two types of adopters are relevant: firstly, individual households which decide to apply HWT, to connect to piped schemes, or to use a specific source of water and secondly, communes as collective entities which are involved in the construction and operation of piped schemes. Following Rogers' (2003) terminology, it is quite straightforward to assume that households face optional decisions when adopting or rejecting HWT, whereas it is less clear whether communes' decisions about the operation of piped schemes are rather collective or authoritative ones.

Assumption 4.1 *Households' decisions about the use of HWT or safe water sources are conceptualised as optional innovation decisions independent from other members of the system, whereas decisions about the establishment of piped schemes are understood as collective or authoritative.*

Households and individuals as adopters

In diffusion studies, much attention has been dedicated to the question who adopts first. Commonly, early adopters are characterised by higher income, higher education, greater mobility, a favour for risk, greater social participation, and are of young age (Rogers 2003; Gatignon and Robertson 1985). Keeping in mind Hedström's criticism on mere statistical explanations[68], I will focus on approaches which aim to explain *why* households or individual persons adopt health-preventive behaviour or water-related innovations in place of an extensive review of early adopters' characteristics. Factors influencing on adoption and use of mitigation measures and

[68] According to Hedström (2005), statistical explanations identify correlations between 'attributes' of an entity and an observed phenomena at interest while they are often lacking assumptions about reasonable mechanisms which bring about the observed phenomena (see Section 1.5.1).

preventive behaviour are often conceptualised in line with psychological concepts like the Protection Motivation Theory or the Theory of Planned behaviour (e.g. Tobias and Berg 2011; Mosler et al. 2010).[69] They comprehend factors such as knowledge and awareness about the specific problem encountered as well as perceived threat and vulnerability. For example in their study about the use of arsenic safe drinking water from deep wells in Bangladesh, Mosler et al. (2010) considered personal, social, and situational factors. Personal factors in this study comprise perceived severity of arsenicosis, perceived vulnerability, self-efficacy, response-efficacy, fear of health threat, behaviour-enhancing personal experiences, and awareness and knowledge of arsenic contamination and arsenicosis. Besides self-efficacy, none of the personal factors proved to have an significant influence on the use of deep tube wells. Primarily social norms and perceived taste of water determined the use of tube wells. Tobias' and Berg's (2011) study about sand-filters in Việt Nam yielded similar results. Interestingly, the survey did not reveal any relationship between knowledge about arsenic contamination and acquisition and maintenance of sand-filters. Also the survey conducted by the author of this thesis in Hà Nam in January 2011 goes in line with this finding (Bui and Wegner 2011). Despite generally low levels of knowledge and awareness about arsenic, various HWT techniques were applied and facilities maintained regularly to improve water quality in general. The survey reinforces the assumption that arsenic removal by sand-filters primarily poses a fortunate side-effect than an intended decision for prevention of adverse health effects.

The empirical results of the studies discussed so far imply that households are motivated to adopt HWT because they expect a noticeable improvement of water quality in terms of taste and smell or want to comply with social norms but are less driven by concrete concerns about health threats even if their water is severely contaminated what mainly results from a lack of detailed knowledge and awareness about water-related diseases. Recently, a meta-study confirmed that 'health considerations alone are rarely sufficient motivation for households to adopt and use [...] technologies' (Thurber et al. 2013: 1736). This is not to deny in general the impact of factors directly related to the health threatening potential but indicates that in the absence of awareness and knowledge about specific water-related problems other factors turn out to be influential. Given the strong emphasis on sensoric quality and social norms, one might arrive at the conclusion that inter-individual differences in general seemingly play a minor role for predicting who will adopt water treatment techniques or safe water sources. This is supported by the observation that adoption rates for HWT within villages are either very high or very low indicating that once a diffusion process was initiated, the whole com-

[69] Indeed, there are numerous more similar models which seek to explain individual actions by referring to intentions, norms, beliefs etc. (e.g. so-called Desires-Belief-Opportunities models, Hedström 2005).

mune is likely to adopt, which also goes in line with the high relevance of social norms.[70]

Assumption 4.2 *The relevance of health considerations for adopting health preventive behaviour has often found to be less relevant than compliance with social norms.*

Communes as adopters

In contrast to diffusion among individuals, the spread of practices among collective entities such as organisations, communes, or even nation states is said to differ with regard to:

- its complexity (because it involves a number of individuals or subunits),
- the type of practices which are subject to dissemination,
- the consequences of its adoption which are often of public relevance,
- and the nature of communication processes by which collective entities interact (cf. Rogers 2003; Wejnert 2002).

Structural characteristics of collective entities

Although I am here interested in answering the same questions, namely, which collective entities do adopt (early) and why, the approach to answer them differs from that outlined above for households or individuals. Examining collective entities as adopters demands for a new perspective on methods but also on concepts to grasp the determinants of the process. Gathering data on the aggregated level of collective entities poses a methodological challenge because it is anything but obvious who is an eligible 'representative' and delivers information which is valid for the entire collective entity. In practice, this often leads to simplification because the collective entity is 'reduced to the equivalent of an individual' and 'treated as a single unit of analysis' (Rogers 2003: 407). From its inceptions, studies about diffusion among collective entities (which in particular focused on organisations) tried to identify characteristics of collective entities which coincide with increased innovativeness. Indeed some equivalent attributes were found, but in general '[t]he organisational innovativeness studies found rather low relationships between the independent variables (measuring qualities of the organisation) that were investigated and the dependent variable of innovativeness' (Rogers 2003: 408). Consequently, this approach was finally discarded in favour of the focus on the processual perspective during the 1980s. Nevertheless, several attributes of collective entities which are apparently related to adoption could be identified – characteristics of leaders (e.g. attitude towards change) but also

[70] This pattern of diffusion will be further discussed in the following section.

structural characteristics of the entity like centralisation, formalisation, and complexity (Rogers 2003: 411 et seq.).[71] At the first glance, structural characteristics are deemed less relevant for diffusion of piped schemes in communes because the governing structures are at least on paper the same across the communes in Việt Nam (see p. 87). Despite these structural similarities, several reasons are adducible why it might be reasonable to assume that communes' inclinations to establish piped schemes differ. First of all, while officially the same mechanisms for planning and implementing water-related targets are established across the country, the analysis in the previous chapters revealed distinct practices and capabilities how these are actually implemented in the communes and districts (see p. 98 and 92). This might suggest that the communes' power to exert influence on the allocation of funding by higher level authorities varies. Secondly, regression analysis about the relationship between the 'quality' of commune leading cadres and the living standard in their communes revealed a significant effect of political and higher occupational degrees (Ngo and Nguyen 2012). Hence, it might be reasonable to expect that communes with highly qualified and politically well-connected leaders are also equipped with better infrastructure like piped schemes. Thirdly, the analysis of funding sources for water-related communal infrastructure projects revealed distinct patterns of engagement by communes, districts, and provinces across administrative regions which reflect communes' distinct opportunities to mobilise resources and capabilities to establish piped schemes (see Section 3.4.2).

Assumption 4.3 *Although local level governmental agencies and their practices are officially organised in the same way across the country, the likelihood that a commune operates piped schemes might differ due to distinct governance practices and patterns of local leadership, respectively capacities of local leaders.*

4.2.3. Characteristics of the environment and spatial determinants of diffusion

Different conceptualisations are conceivable about how environmental characteristics and geographical conditions impinge on diffusion processes (e.g. Wejnert 2002): Firstly, they might affect the applicability of an innovation; e.g. certain treatment techniques are only applicable if raw water meets specific criteria or modes of water withdrawal and distribution depend upon specific geographical conditions. Secondly, environmental characteristics allow to draw conclusions about social interactions and the flow of information, which in turn pose the foundation for diffusion. This section

[71] Communes are here not considered as organisations but as collective entities. Most of the research findings apply to organisations but it is assumed that they are (with certain qualifications) also applicable to collective entities in general.

exemplarily discusses how spatial and social distance, exposure to previous adoptions, and the so-called homophily-hypothesis are related to diffusion, and last but not least touches upon the question whether a critical number of adopters is required to enter the take-off phase in diffusion.

Research traditions in investigating spatial diffusion reach back to the 1960s and 1970s and were predominantly shaped by three approaches – (i) the mapping of diffusion processes based on empirical observations, (ii) Monte Carlo Simulations to test the influence of specific parameters (e.g. Hägerstrand 1965; Morrill and Manninen 1975; Brown et al. 1976), and more recently, (iii) regression analysis (e.g. Jenkins and Cairncross 2010). Regardless of the methodological approach and spatial pattern observed, it is important to recognise what stands behind the notion of spatial diffusion. Most studies dealing with this topic more or less explicitly agree on the least common denominator that spatial patterns are manifestations of communication processes and social interactions, and that ensuing characteristics like population density, spatial proximity, or remoteness are not direct determinants of the diffusion process itself but rather shape the intensity and frequency of social interactions. Moreover, diffusionists usually assume that the flow of information is more likely if physical and social distance is low, or put the latter differently, communication partners are more homogeneous (Rogers 2003; Wejnert 2002; Strang and Soule 1998).

Going beyond these very general assumptions; which spatial patterns of diffusion have been observed so far and which parameters found to explain them? For answering these questions, I will firstly focus on spatial patterns in terms of their physical appearance and secondly discuss the social dimension of distance. Indeed, early research on spatial patterns of diffusion reveals that both dimensions of distance are closely interlinked (Gatignon and Robertson 1985; Brown et al. 1976). Two types of diffusion patterns are prevailing: the so-called neighborhood or contagion effect and the hierarchy effect. In their 'Propositional Inventory for New Diffusion Research' Gatignon and Robertson (1985: 852) summarise that '[t]he spatial pattern of diffusion is determined by a hierarchy effect when market and infrastructure factors controlling the availability of the new product are dominant and a neighborhood effect when terrestrial or social factors are dominant'. The hierarchy effect 'stresses the importance of market and infrastructure factors that control the availability of the innovation to potential adopters' (Brown et al. 1976: 100), whereas the neighbourhood effect characterises the pattern of diffusion when 'the time of adoption is a function of the distance between communicators' (Gatignon and Robertson 1985: 858).

Spatial patterns of diffusion

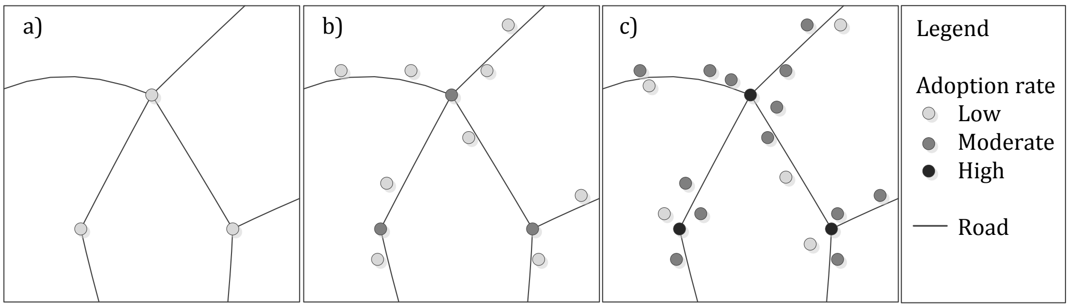
What becomes apparent here, is the close linkage between diffusion patterns and the nature of the good, technique, or idea to be spread. Consequently, in case HWT requires any kind of supply chain for first time acquirement, continuous use, and maintenance; the spatial path of diffusion is assumed to be bound to the availability of local markets, (rural) marketing approaches, and sales systems (cf. Devine and Sijbesma 2011; Sijbesma et al. 2010). As addressed above, this factor proves of utmost practical importance for HWT: treatment techniques which do not rely upon locally available materials (e.g. sand, rock alum, or plastic bottles) are prone to fall into disrepair and disuse (e.g. Sobsey et al. 2008; Wrigley 2007). In addition, also interactive innovations, especially those which are based on some kind of network infrastructure, are more likely to develop hierarchical patterns of diffusion.

Assumption 4.4 *The spatial pattern of diffusion depends on the characteristics of the innovation, especially if the good or technology to be spread requires some kind of supply chain or network infrastructure.*

Stages in spatial diffusion

Hägerstrand (1965) delivers a well-documented example of spatial diffusion. In his ground-breaking study 'Innovation Diffusion as a Spatial Process', he elaborates on stages in spatial diffusion of agricultural practices in Sweden and subsequently 'reproduces' his findings gained by visual inspection in Monte Carlo simulations. According to him, the initial stage was characterised by local concentrations of early adopters, whereas in the second stage, dissemination spread radially outwards, the number of secondary agglomerations rose, and adoption in the initial agglomerations continued to grow (see Figure 4.2). In the third stage saturation occurred (cf. Casetti 1969; Hägerstrand 1967).

FIGURE 4.2.: Typical pattern of spatial diffusion



Source: Own illustration based on Hägerstrand (1967)

Similarly, Jenkins' and Cairncross' (2010) results about latrine diffusion in Benin corroborate the hypothesis of spatially controlled diffusion. Again, visual inspection revealed that diffusion spreads outwards from large urban centres and along road networks. With increasing distance from the centres, adoption rates dropped steadily. Table 4.1 lists the variables covering village environment and latrine exposure as potential determinants of diffusion. Whereas population density and the availability of infrastructure mainly serve as proxies for enhanced communication opportunities, the nearby adoption rate refers to greater exposure and thus visibility and trialability.

According to findings from different studies (see p. 64 and Figure 2.6), it is reasonable to assume that diffusion in the rural water sector in Việt Nam follows similar distributional patterns like those described by Jenkins and Cairncross (2010) and Hägerstrand (1965). In the field studies about sand-filter and HWT use conducted in Hà Nam and Hà Tây province in the Red River Delta, primarily communes with almost full coverage in contrast to communes with zero or very low prevalence of sand-filters prevailed (Tobias and Berg 2011; Bui and Wegner 2011). Studies which systematically investigate spatial diffusion are lacking so far, but the before-mentioned case studies suggest that diffusion processes are first and foremost concentrated on communes and affiliated hamlets before they radiate to surrounding villages. Such patterns are also likely in view of the strong village structures and the hierarchical organisation of political structures on the local level (see Section 3.1.1).

Assumption 4.5 *Physical distance as diffusion determinant refers to the distance to other adopters but also to the distance to information sources.*

Spatial proximity and population density

In the following, I return to the question how exactly spatial parameters like (population) density and spatial proximity do impinge on diffusion and which empirical evidence has been found so far with special regard to water-related innovations. Strang and Soule (1998: 275) argue that spatial proximity does not provide any kind of distinctive logic but 'often provides the best summary of the likelihood of mutual awareness and interdependence'. The basic idea behind the impact of spatial proximity and population density is that diffusion is more likely if adopters are in close spatial contiguity, which supports contagion by higher communication frequencies and stronger interactions between potential adopters (Rogers 2003).[72] In particular, so-called epidemic models strongly build upon the notion of contagion in explaining diffusion and the stylised fact of an s-shaped diffusion curve (cf. Geroski 2000). The concept of epidemic models, which rely on the transmission of information from two sources – namely a central one and word of mouth, meaning that each adopter contacts a non-adopter with a given likelihood (cf. Geroski 2000; Strang and Soule 1998; Mahajan and Peterson 1989) – points to two important factors which trigger contagion: the contact to individuals which already adopted in previous periods and the contact to other sources of information.[73] The first factor could be operationalised as exposure by 'nearby adoption rates', as it is done in Jenkins' and Cairncross' (2010) study of latrine diffusion in Benin (see Table 4.1). The latter one might be captured by the physical distance to distinct places at which the innovation might actually be

[72] The effect of spatial proximity has not only been observed on the micro-level but also with regard to adoption of policies, programmes and institutional settings in administrative units (Wejnert 2002: 312). Here geographical proximity alone has not been found to have a significant effect.

[73] Epidemic models do not per se involve spatial proximity as a determinant of diffusion but may incorporate this and other factors (Geroski 2000: 607).

TABLE 4.1.: Variables capturing village environment and latrine exposure in Jenkins and Cairncross (2010)

Indicator	Definition of indicator	Expected direction of influence
Size	Population	+
Population density	Population within 2.5 km radius of village divided by area (persons per km^2)	+
Socio-economical homogeneity*	95% or more of population is engaged in agriculture	–
Infrastructure level	Infrastructure index capturing improved water access, commercial and public activities, regional integration	+
Proximity to Abomey-Bohicon	1/square root of the straight-line distance between village and Abomey-Bohicon	+
Far from any road	Located more than 5 kilometers from paved and dirt roads	–
Near paved road	Located within 2 km of a paved road	+
Nearby latrine adoption rate	Latrine adoption rate of households surrounding the village within 2.5 km radius (excluding the village itself)	+
School	Primary school in village (1 latrine provided for director)	+

Note: * Expected to have a negative influence because serves here as indicator for traditional, agricultural communities but not for homophily
Source: Jenkins and Cairncross (2010), modified

observed or experienced, respectively from which information about the innovation originates (e.g. larger towns, schools, locations with pilot projects or information centers).

Assumption 4.6 *Diffusion is more likely in homogeneous social systems.*

Social distance and homophily

Besides physical distance, also social distance has been identified as a relevant obstacle towards diffusion. The frequency of communication, nature of personal interaction, and consequential adoption and diffusion is not only expected to be more likely in densely populated areas but also in more homogeneous social systems. Diffusion theory proposes the basic assumption that communication about innovations is more likely in case of homogeneous partners. Homophily here describes '[t]he degree to which two or more individuals who interact are similar in certain attributes' (Rogers 2003: 474). Commonly, heterogeneity – respectively homogeneity – is captured by attributes such as status, ethnicity, or religion. Whether these are appropriate indicators depends on the specific context of the diffusion study and the unit of analysis. For example, in the case study from Benin, socio-economic homogeneity was defined by a high share of population engaged in agriculture which stands for a more traditional, socio-economically undifferentiated agricultural community. The theoretical assumption was validated in the regression analysis: homogeneity was a significant factor for initial diffusion but not for reaching higher levels of adoption (Jenkins and Cairncross 2010: 171).

Assumption 4.7 *Once a critical mass of adopters and the tipping point is achieved, diffusion is expected to become self-sustaining.*

The critical mass

Once a diffusion process gets started, the question arises whether a tipping point or a critical number of adopters has to be reached so that diffusion enters its take-off phase and becomes self-sustaining (see Figure 4.1). In order to understand the concept of the critical mass[74], it is necessary to consider (mutual) dependency of early and late adopters in realising benefits of adopting an innovation. Assuming that future adoptions do not provide any further advantage for past adopters – as it is usually the case for non-interactive adoptions – Rogers (2003: 344) speaks about a sequential effect. Following this argumentation, late adopters perceive the adoption as increasingly beneficial as they watch more and more individuals applying the new behaviour or technology. 'The critical mass is thus a kind of 'tipping point' [...] or social threshold in the diffusion process. After the critical mass is reached, the norms of the social system encourage further adoption by individual members of the

[74] According to Rogers, '[t]he critical mass occurs at the point at which enough individuals in system have adopted an innovation so that the innovation's further rate of adoption becomes self-sustaining' (Rogers 2003: 343).

system' (Rogers 2003: 352). Whereas Rogers leaves open how exactly the mechanism works, this gap could be filled by drawing on socio-psychological concepts about the impact of norms on behaviour (cf. Cialdini et al. 1991, 1990). Studies about the dissemination of HWT suggest that social factors as the compliance with descriptive norms[75] might push the laggards to adopt as well (cf. Tamas et al. 2013; Thurber et al. 2013; Tobias and Berg 2011; Mosler et al. 2010; Heri and Mosler 2008). Social norms aside, it is conceivable that late adopters value increasing adoption rates as a 'confirmation' of the benefits associated with the innovation.
However, in case of interactive innovations, also previous adopters benefit from additional adoptions, what Rogers (2003: 344) calls a reciprocal effect. This effect of reciprocal interdependence between early and late adopters – and ensuing mutual benefits – is often illustrated by the example of new communication technologies which become increasingly valuable for all of its users once the number of adopters increases and more people can be reached by them. Although access to piped water cannot be considered as an interactive innovation as such, the concept of the *critical mass* seems also beneficial for analysing the diffusion of piped water supply. Piped schemes build upon economies of scale and natural monopolies (cf. Kessides 2004, 1993) but require a critical number of adopters to be constructed and put into operation at a specific location. The reciprocal effect for early and late adopters here mainly arises in terms of better service quality or water quality if a sufficient number of users is connected to the scheme and makes its operation and further improvement viable for the operator. These arguments and the question whether and to which extent a critical commune size or number of potential users plays a relevant role in the diffusion of piped schemes will be discussed further in Chapter 5.

Assumption 4.8 *The influence of diffusion determinants shifts across distinct stages of diffusion and depends on the characteristics of the specific innovation.*

It is likely that at least some of the diffusion determinants discussed above unfold a different impact across the distinct stages of the diffusion process as they rely on varying causal mechanisms (cf. Strang and Soule 1998). As Jenkins' and Cairncross' findings (2010) suggest, contagion and nearby adoption – and ensuing the coverage of a critical number of adopters – are deemed relevant in the initial stage, whereas further spread appears to be dependent on spatial and other environmental characteristics. Evidently, first-hand experience of the relative advantage – or in diffusion terminology, observability and trialability – initially poses a limiting factor, but once the previously new technology or behaviour becomes more and more habitual routine at a specific location, the marginal effect of observing one household more applying it becomes negligible. Besides growing visibility and familiarity, numerous other

[75] For further explanations about descriptive and injunctive norms and their impact on behaviour, see Cialdini et al. (1991) and Cialdini et al. (1990).

factors are conceivable why causal effects might shift across diffusion stages. By nature, typical characteristics of early adopters like higher educational levels or social status become less distinctive features for discriminating between adopters and non-adopters once the majority of households starts using the innovation. Hence, it might get then more enlightening to focus on the laggards and the question why of all potential adopters exactly they abstain. Also supply chains or market infrastructure which aggravate access to spare parts or consumables (e.g. chemicals or filter materials) rather turn out to be a limiting factor in early stages but are probably irrelevant once the supply infrastructure is well established.

4.2.4. Interventions and supporting activities

In view of the often observed finding that especially preventive innovations are unlikely to diffuse automatically and that diffusion requires a critical mass to become self-sustaining, diffusionists paid surprisingly little attention to interventions.[76] General diffusion frameworks rather implicitly refer to diffusion triggering or supporting activities by pointing to the role of opinion leadership. Whereas promotional activities in Rogers' framework (Rogers 2003) are to a certain extent captured by the concepts of opinion leadership and change agents, Gatignon and Robertson (1985) conceptualise them as marketing activities. According to them, diffusion even in consumer behaviour research 'has been viewed from a passive perspective' (Gatignon and Robertson 1985: 860). This might mainly be owed to the fairly optimistic attitude towards diffusion in this research field which builds upon the assumption that diffusion will become self-sustaining if the innovation is perceived as advantageous and meets the users' needs. On the contrary, public-health related research often takes a less optimistic perspective about the speed and sustainability of adoption given the experience that spontaneous diffusion of health-preventive innovations is often unlikely and also interventions to promote them often proved disappointing (cf. Thurber et al. 2013; Rosa and Clasen 2010; Clasen et al. 2009). Consequently, public-health researchers dedicated more attention to the design and effectiveness of measures to promote diffusion. These opposing attitudes about the necessity and role interventions play for initiating and boosting diffusion are reflected in the design and conception of empirical diffusion studies. If diffusion is expected to be self-sustaining anyway, one will hardly refer to interventions in the model or design. In contrast, if supporting activities are deemed essential, respective variables are taken up or even the intervention itself might be part of a quasi-experimental design or randomised control studies (cf. Banerjee et al. 2013; Devoto et al. 2011). Hence, the bulk of studies elaborating on the design and impact of interventions on the diffusion can be

[76] For example, the question how to initiate behavioural change has rather been raised by behavioural economists, psychologists, or public health practitioners (e.g. the 'nudge' principle in Thaler and Sunstein 2009).

found in public-health related research (e.g. Thurber et al. 2013; Devine and Sijbesma 2011; Heri and Mosler 2008; Ngai et al. 2006).

Moreover, especially Chapter 5 applies a broader notion of the term supporting activities which goes beyond targeted interventions. Whereas interventions here refer to measures which directly aim at promoting specific techniques or behaviour, also governing conditions such as regulations, institutional support by advisory services, subsidies or credit programmes might contribute to enhance diffusion by creating favourable conditions for potential adopters. Various kinds of support are conceivable here: micro-credits or governmental programmes as these outlined in Section 3.3 might provide financial or in-kind support for constructing or acquiring water treatment facilities or funds to set up piped schemes. Governmental policies might impinge on the regulation of prices and tariffs, subsidies to ensure affordability for specific target groups, or foster the implementation of specific strategies for improving water supply by offering technical advice or outlining sectoral strategies and policies. Last but not least, the effect of mass media and targeted information, education, and communication activities in the field of rural water supply might also be subsumed under the overarching term intervention and supporting activities.

4.3. Summary

Setting out from the observation that piped scheme coverage but also the prevalence of HWT practices differ considerably across Việt Nam, this section elaborated on potential explanations for these varying levels of adoption by drawing on theoretical concepts from diffusion theory. Discussing diffusion here involves households as well as communes as 'adoption entities'. Households' decisions about the use of HWT or safe water sources are conceptualised as optional innovation decisions, which are taken largely independently from the decisions of other members of the system but linked to them by social norms, mutual exchange of information, and last but not least the observability of adoption in the nearby environment. In contrast, decisions about the establishment of piped schemes are understood as collective or authoritative ones. Communes' inclinations to adopt piped schemes are expected to differ for example due to distinct governance practices, patterns of local leadership, or capacities of local leaders, although the setting of agencies and mechanisms is officially organised in an equivalent manner across the country. In order to gain a better understanding about what stands behind the notion of 'a commune' as an adopting entity, the following chapter sheds light on different models for piped schemes and the specific stakeholders involved in their practical implementation.

Adopting entities

Based on general diffusion literature, this chapter addressed four groups of determinants which are deemed relevant for analysing the diffusion of self-supply, respectively HWT practices, as well as piped schemes in rural Việt Nam: attributes of the innov-

Diffusion determinants

ation, those of the adopter, environmental characteristics, and supporting measures. The review of specific case studies from the RWSS sector in developing countries delivers valuable clues about which aspects deserve particular attention. Firstly, advantages or disadvantages of a specific behaviour or technique should be assessed in relation to competing alternatives or the status quo, meaning an adoption decision for a specific option is not independent from the perceived characteristics of alternative treatment methods or water sources. Secondly, both access to piped water and HWT, are preventive innovations. They require an action at a certain point of time in order to avoid unwanted consequences like water-borne or -washed diseases in the future, what makes it unlikely that health benefits are perceived as an immediate reward for adoption. By implication, other characteristics such as odour and taste of the water as well as convenient supply are probably deemed more relevant for adoption. Beyond that, studies suggest that the need to comply to social norms often provides a stronger incentive to adopt than health considerations or other inter-individual differences. Thirdly, given that preventive innovations are unlikely to diffuse spontaneously and adoption often speeds up slowly, interventions and other supporting measures expected to trigger or facilitate diffusion should be taken into account. Targeted interventions aside, supporting activities also refer to governmental regulations, subsidies, and policies creating an enabling or hindering setting for the promotion of piped schemes or HWT. Fourthly, given that diffusion is conceptualised as spread of information based on social interactions, environmental and spatial determinants of diffusion have been discussed. Even if these factors are not considered to impinge directly on the adoption decision, they are expected to shape the intensity and frequency of social interactions and thereby provide a link between the spatial and the social dimension of distance. The social dimension aside, spatial factors such as remoteness, spatial density, or proximity to supply chain infrastructure should be considered depending on the practice or technique to be spread. If diffusion requires a network, like piped schemes or supply chains e.g. for chemicals or spare parts, the spatial pattern of diffusion is expected to follow a hierarchical pattern; and a neighbourhood effect if primarily social factors matter. Last but not least, diffusion determinants might unfold a different impact across the phases of the diffusion and adoption process. Whereas some of them are essential for triggering diffusion in its initial stage but loose in importance once a certain level of adoption is reached, others turn out relevant to reach the take-off phase or saturation.

5. The availability of piped water schemes in rural Việt Nam

Contents

In Việt Nam, according to the Joint Monitoring Programme for Water Supply and Sanitation of the WHO and UNICEF (2010) the share of rural households relying on improved water sources increased from 49 up to 93 percent from 1990 to 2010, but only a minor part of this increase resulted from the expansion of piped water supply. Up to 2010, only 8 percent of the households benefited from access to piped schemes so far and large regional disparities in coverage retained (WHO/UNICEF 2010). Although the number of piped schemes is constantly growing, this expansion is mainly confined to peri-urban regions and rather passes by remote or less densely populated areas. As has been discussed in Section 3.3, some lessons have been drawn from these rather disappointing results and triggered changes in the official strategies for RWSS. In order to encounter the slow diffusion of piped schemes, the Vietnamese government adjusted its national strategy for the rural water sector. In contrast to its predecessors, the National Target Programme for RWSS for the period from 2011 to 2015 announces the facilitation of private sector investment and the construction of more than 300,000 ‘small scale and scattered schemes’, but leaves open what exactly is captured by this term (GoV 2010: 46). Although it does not outline precisely how many households are expected to benefit, the successful accomplishment of the construction goals would theoretically provide access to piped water for several million rural inhabitants. This strategic change in sectoral policies ahead, an analysis of reasons for the weak progress in establishing piped schemes in Việt Nam is already overdue. However, in view of poor outcomes in the past, numerous revisions of water-related objectives, and deficiencies in the current institutional framework, rather cautious optimism is indicated. While the previous chapters introduced basic facts about water sources used and treatment techniques applied by rural households, outlined regional disparities and peculiarities in rural water supply, scrutinised the national policies and objectives for the rural water sector as well as the governmental agencies engaged with them, the following chapters empirically assess which factors on household, communal and – especially in case of piped schemes – provincial level impinge on households' access to safe water. This chapter, which is explicitly dedicated to small scale piped schemes, pursues a twofold approach: whereas it firstly examines in a qualitative manner how and in terms of which institutional arrangements piped schemes spread, the second part assesses the availability of piped schemes in rural communes in a quantitative manner by applying random intercept logistic regression. Both approaches are complementary: the qualitative analysis explores the institutional arrangements for small scale piped water schemes, which evolved during the last two decades, and the drivers and obstacles which impinge on their diffusion. Subsequently, random intercept regression models have been set up, wherein availability of piped schemes serves as dichotomous outcome variable.

5.1. The development and dissemination of institutional arrangements for piped water schemes

This section aims at analysing the evolution of institutional arrangements for (small-scale) piped schemes in rural Việt Nam with regard to their institutional design and dissemination. Although since the 1990s a variability of schemes operated by governmental agencies, cooperatives, or private stakeholders emerged, the development of institutional arrangements for piped water schemes is still in its infancy. Based on policy documents, statistical data, and secondary analysis of project reports, this section traces the evolution of institutional arrangements a) with regard to the policy strategies for rural water supply and sanitation on national level and b) with regard to piped schemes as they are actually operated in different regions of rural and peri-urban Việt Nam. What makes it worthwhile to study institutional arrangements for small-scale piped water schemes in rural Việt Nam, is that those are emerging nearly from scratch and their evolution is currently still in progress. Little attention has been paid so far to the role which specific institutional models play in disseminating piped schemes, the circumstances under which they develop, and the incentives associated with them (with exception of Staykova (2006)). Following Saleth and Dinar (2004), the analysis distinguishes between the institutional arrangement and the institutional environment.

Institutional arrangements

> The institutional environment covers the rules of the game whereas institutional arrangements include the governance structure and its evolution within and interaction with the institutional environment. Governance structure incorporates the economic and political organization that form part of the institutional arrangement [...]. (Saleth and Dinar 2004: 25)

More specifically: an institutional arrangement is here characterised by a typical set of rules that provides a structure by which a certain stakeholder or groups of stakeholders set up and operate piped water schemes and which is shaped by the governance structures and the institutional environment.

5.1.1. Institutional arrangements for piped water supply: Is there a 'right choice'?

This section sets out by addressing overarching questions with regard to the institutional economics in the water sector in general and institutional arrangements in particular. Firstly, I will ask for the criteria and preconditions for the emergence of institutional arrangements for domestic water supply and secondly discuss the role which private sector participation (PSP) plays in this process. Since the 1980s, there have been numerous debates about how appropriate and efficient institutional arrangements for infrastructure supply should look like (cf. Bakker et al. 2008; Meinzen-Dick 2007; Kessides 1993; North 1990). Whereas some researchers put strong emphasis on elaborating criteria to design appropriate institutional arrangements for infrastructure supply, others – in context of the rising popularity of new institutional economics – put stronger emphasis on the dynamics of institutional change, with strong implications for the concept of institutional arrangements. Put it differently: one of the underlying questions expressed by these two positions concerns the rivaling notions of designability and path-dependency of institutional arrangements.

The notion of designability

According to Kessides (1993), whether an institutional arrangement is considered adequate depends on the economic and technological characteristics of infrastructure services, the incentives provided by the specific arrangements, the issues involved in implementing them and finally potential reasons for market failure. In case of water supply infrastructure, especially two potential sources of market failure deserve attention: firstly natural monopolies and secondly, characteristics of demand and service use such as the existence of substitutes, the price elasticity of demand, consumers' access to information, temporal patterns of demand, and the extent of diversity of user needs. Water supply infrastructure is usually characterised by high fixed and sunk costs, which deter other suppliers from entering the market. High fixed costs relative to variable costs result in declining average costs (economies of scale) and facilitate the emergence of a natural monopoly. The organisational monopoly is not necessarily the most (allocatively) efficient structure because the supplier has an incentive to charge prices beyond marginal costs. Due to the low unit value compared to transportation costs, water is often supplied by highly spatially decentralised systems under municipal or provincial jurisdiction (Foster 1996). Furthermore water is not a homogeneous product; its quality and service quality for delivery varies significantly. To sum it up: following the conception of designability, an efficient institutional arrangement can be designed once one understands the mechanisms of the economics of water supply.

The notion of path-dependency and institutional change

In contrast to a scholarly perspective which suggests a conscious and intentional design of institutional arrangements and conceptualises the emergence of institutional arrangements rather as a purposeful selection process drawing on a large range of alternative possibilities (cf. Kessides 1993), the analysis here traces the pathway of institutional development and elaborates on the factors that drive or inhibit their implementation. It examines how strongly the 'historic paths of local institutional change, cultural orientation, and political processes' (Meinzen-Dick 2007: 15200), previous experiences and the influence of international donors (Reis 2012) shape the space of conceivable alternatives. According to North (1995: 20), '[i]nstitutional path dependence exists because of the network externalities, economies of scope and complementarities that exist with a given institutional matrix.' In the dynamics of institutional change, 'individuals and organisations with bargaining power as a result of the institutional framework have a crucial stake in perpetuating the system' (North 1995: 20). Applying this perspective means to abandon 'efficiency' as an inherent characteristic of the institutional arrangement itself but to explain differences in the performance (of systems) by the distinction between organisations and institutions and institutional changes as the results of their mutual interaction (North 1990: 7).

Public or private sector?

The second important issue in the choice or emergence of institutional arrangements – which is still discussed controversially – concerns the question which responsibilities to assign to the private and public sector. Not in every case it is suitable to rely on the competitive market to provide the facilities. This especially holds true if investment requirements are high, it is likely that a natural monopoly develops, or social objectives are targeted (Kessides 1993: ix). Empirical studies draw a heterogeneous picture of the effects of PSP (Prasad 2006; Braadbaart 2002). Scholars argue that it leads to higher efficiency and cost-recovery, enables potential service providers to leverage additional funds, and often yields higher connection rates amongst poor households (Bakker et al. 2008: 1893). The specific arrangements to raise funds depend on various factors such as the local economic situation, cost of borrowed capital, cost of water source development, users ability to pay, and the amount of capital available (Salter 2003: 6 et seq.). On the contrary, PSP is said to affect performance negatively 'through raising the cost of capital, reducing long-term investment in infrastructure repair and replacement, increasing corruption, or reducing affordability due to tariff increases [...]' (Bakker et al. 2008: 1893).

The alleged success story of PSP – pushed by players such as the World Bank – has been accompanied by a debate asking for the relative importance of ownership and institutions, especially in light of the discussion about state and market failure (Bakker et al. 2008; Newbery 2000: 1893). Several scholars assume that ownership does not predict efficiency or performance of water service providers (Estache and Rossi 2002) and 'there is no association between the formal-legal status of a public service provider and its service delivery performance' (Bakker et al. 2008: 1893). By implication institutions gain in importance. Others suggest that the effect of ownership – be it positive, negative, or neutral – just does not find an expression unless institutions are determinant of utility performance (Bakker et al. 2008: 1893). But regardless which position one basically adopts in the dispute about the design and efficiency of institutional arrangements, both provide useful concepts for structuring the analysis of institutional arrangements for piped schemes in rural Việt Nam. Whereas basic concepts like natural monopolies, characteristics of demand, or switching costs help to understand suppliers' and consumers' rationales, new institutional economics emphasises that there is no unique institutional solution for infrastructure supply across different contexts (Meinzen-Dick 2007) and sharpens the view for the dynamics of institutional change and the impact of specific institutional environments and governance structures. The analysis pays attention to aspects like characteristics of demand, legal barriers, regulations, financing and participation of users and other interest groups which are expected to impinge on the implementation of piped schemes (cf. Kessides 1993). In particular the often cited benefits of participation call for a differentiated view (cf. van Koppen et al. 2012): firstly, because the term participation encompasses a wide range of activities and secondly, not in every case participation on the local level guarantees higher accountability or equal benefits for all potential water users. Besides a whole bunch of positive effects (cf. Kleemeier 2000), examples for project failure due to elite capture, free-riding, and upward instead of 'downward' accountability or conflicts have been documented (cf. van Koppen et al. 2012; Funder et al. 2012) and show that the costs for coordination and cooperation sometimes exceed the benefits of participation.

Ownership or institution?

5.1.2. The institutional environment in the water sector – A short wrap up

In contrast to individual adoption decisions for household water treatment, decisions to establish and operate piped schemes usually concern collective entities. Moreover, institutional arrangements for operating piped schemes have to comply with the official governmental strategies and regulations. Those again have undergone substantial changes, not at least due to the involvement of international donors in the water sector and the pervasive political and societal transformation in Việt Nam. Since relevant stakeholders and programmes in the Vietnamese water sector have been introduced in detail in Chapter 3, here a short wrap-up of the most relevant stakeholders, policies, strategies, and programmes that explicitly concern piped schemes will suffice.

Stakeholders The institutional environment in the Vietnamese water sector is highly fragmented and shaped by conflicting responsibilities. Various governmental agencies and their respective line agencies on the provincial, district, and communal level are concerned with water-related issues. In principle, MARD is responsible for water service delivery in rural areas and coordinates the activities of other agencies like MoH, MoET, MPI, MoF, or the mass organisations, but some of MARD's tasks have been delegated to the Centres of Rural Water and Sanitation (CERWASS). CERWASS takes a key position in the rural water sector because it assists MARD in technical questions and practical implementation, but also operates own piped schemes. Besides MARD and CERWASS, the People's Committees serve as central players in planning and decision making processes for RWSS. The allocation of resources within the framework of the National Target Programme (NTP) for the rural water sector is administered in a bottom-up reporting and top-down planning process in which provincial level authorities take an influential position because they are responsible for distributing the funding to different actors. The PCs on the local level mainly serve as communicators of users' needs whereas their provincial branches exert stronger influence because they set water prices and allocate the funding in their respective jurisdiction.

Targets The style of policy making in the rural water sector is shaped by programmatic approaches and a notable preference for target numbers which are fixed in the national policies like the National Strategy for Rural Water Supply and Sanitation (NSRWSS) and the respective National Target Programmes (NTP-RWSS). With the accomplishment of the third NTP in 2015, 95 percent of the rural population should have access to clean water and 60 percent of them even to water meeting the official Standard 09. However, it is unclear to which extent these targets should be realised by the establishment and expansion of piped schemes. The announcement to construct thousands of 'small scale and scattered schemes' (GoV 2010: 46) is probably the most striking evidence for a shift in sectoral policies towards the promotion of piped schemes instead of self-supply.

Measures As a consequence from the poor achievements during the first two iterations of the National Target Programme for RWSS between 1998 and 2010, stronger emphasis has been put on the facilitation of private sector involvement and cost-recovering prices as a precondition to enable sustainable operation and stimulate initiative by the private sector. The composition of budget funds in order to accomplish the ambitious goals outlined in the NTP III, clearly expresses the rising expectations ascribed to private sector participation. Nevertheless, compared to the contributions from the central government, donors, local authorities, and users themselves, the private sector still plays a minor role. Still, international donors and also users themselves bear a substantial share of the financial burden for sectoral progress, but funding patterns have been found to vary substantially across the administrative regions (cf.

page 104 et seq.). In addition to the NTP, which defines the overall framework for further development in the rural water sector, there are other programmes which might promote access to piped water either by supporting households or communes. Probably the most important one is P 135, which – amongst other objectives – aims at infrastructure development and improvement of rural livelihoods in poor and ethnic minority communes by offering grants for investments in small-scale infrastructure such as piped schemes.

5.1.3. Institutional models for piped schemes in rural Việt Nam

This section exemplarily introduces three management models as they are currently operated in Việt Nam. Whereas the first one describes a popular type of non-profit administration model, the latter ones represent two different styles of private sector participation, which strongly rely on user participation. In principle, state-owned or private water supply companies (WSCs) are according to the NTP III also eligible to operate piped schemes but in pratice do not play a significant role in rural areas up to now. In contrast to its predecessors, the National Target Programme III went one step further with regard to institutional issues. It does not only define so-called 'approved' schemes but assesses the field of applications and reflects previous practical experiences with the respective models. Table 5.1 summarises the models mentioned in the NTP III (GoV 2011: 86-89) with regard to their most important characteristics, strengths, and weaknesses as they are outlined in the official documents. By the end of 2011, in each piped water scheme one of these approved management models should have been in place. Indeed, the current status of diffusion cannot be assessed due to the so far poor implementation of the monitoring and evaluation survey.[77] In addition to the lack of quantitative data, the overall strategy to improve rural water supply embodied by the outlined management models raises a bunch of questions about the practicability of the suggested solutions and compatibility with the basic principles stated in the NSRWSS. Hence, the following section elaborates on schemes operated by CERWASS, cooperatives, and local households with regard to asset ownership, their incentive structures, financial viability, and the ensuing level of diffusion based on experiences reported from Việt Nam by practitioners.

Non-profit administration models by CERWASS

Schemes operated by the CERWASSs are the most popular type of self-financing and non-profit administration models. These are said to be working successfully especially in the provinces Bà Rịa - Vũng Tàu, Bình Thuận, Bến Tre, Bạc Liêu, Vĩnh

[77] Since 2009 a nationwide Monitoring and Evaluation system (see p. 36) based on 14 indicators has been implemented in order to enable the Standing Office and executive agencies to draw conclusions about programme achievements and aid effectiveness (GoV 2011).

TABLE 5.1.: Management models outlined in NTP III

Criteria	**Enterprises**			**Self-financing and non-profit administration model**	**Individually run models**	**Cooperatives**
	Model A	Model B	Model C	(CERWASS)		
Legal foundation	private company (Law on Enterprises)	joint stock, limited	state-owned	Governments Decree 43/2006/ND-CP	Individuals under Civil Law	Law on Cooperatives
Asset ownership	enterprise	public-private owned	public	public	public	public + private (users)
Investment in assets	enterprise	enterprise	public	public	public	state subsidies + user contributions + private
Investment in management	enterprise	enterprise + state subsidies	public	public	public	user contributions
O&M	enterprise	enterprise	enterprise	assigned groups and teams	individuals	ad-hoc or existing cooperatives
Strengths	works well in densely populated areas, run by professionals			cross-subsidisation of unprofitable schemes, flexible and adaptable: O&M might be transferred to individuals, cooperatives or enterprises	high responsibility and motivation of operator	technical support by CERWASS
Weaknesses	less suitable for small-scale systems in remote or mountainous areas, low economic viability in economically deprived areas			conflict of interest between roles as operator, asset owner, technical advisor	usually unskilled staff, lack of technical support, limited size of scheme	usually unskilled staff, considered as temporary and 'second best' solution, economic risk

Source: Own illustration, description of all models based on GoV (2011: 86-89)

Long which belong to the Mekong Delta or Southeastern region (GoV 2011: 87), but no precise information about their economic viability and the number of households actually served by them is available. CERWASS usually does not only own the assets but is responsible for operation and maintenance (O&M), for which it normally sets up certain groups or teams.[78] In addition to variable costs charged for each m^3, households have to make an initial payment in order to connect to the grid, which usually consists of a fixed rate for the installation of the water meter and costs for water pipes from the house to the main pipe. The fee charged for a m^3 is about 2,500 VND. Since this price is perceived as high by the households, most of them use other water sources in parallel and try to keep the amount of water purchased from stations as low as possible (Reis 2012: 77). Similar observations have been made by Spencer (2007). Costs aside, the parallel use of other water sources is also a strategy to compensate frequent interruptions due to electricity cuts, which force people to store water in jars or tanks (Reis 2012: 79-80).

From an institutional point of view, CERWASS takes too many roles. It acts as owner of assets, operator and service provider, communicator in the bottom-up reporting process and technical advisor (Reis 2012; SNV 2010; ADB 2010). In the capacity of an advisor, CERWASS represents the interest of local households, while as a service provider, it is reliant upon cost-recovering prices. Beyond that, the manifold functions ascribed to the agency are in conflict with the guiding principle of the NSRWSS that '[g]overnment bodies will not participate in production, construction or business activities. They only carry out their state management responsibility and provide advisory guidance to users' (MoC/MARD 2000: 21). The World Bank fears that overlapping and conflicting responsibilities of MARD and CERWASS and their dual role are resulting in a conflict of interest and a focus on asset creation rather than sustainable operation (WB 2005). At least for piped schemes in urban areas there is some empirical evidence that water schemes often tend to be over-designed, meaning that only a small fraction of the capacity available is actually used (van den Berg 2002: 22). In general, the production capacity ratio is expected to increase with the number of years the scheme is in operation, but especially in case of schemes run by communal authorities like the PC and private WSCs this has not been confirmed in the past. In contrast, schemes operated by cooperatives or communes are expanded gradually and more closely follow demand (van den Berg 2002: 23).

Last but not least, against the background of experiences from other countries[79], it

[78] Reis (et seq. 2012: 75) gives an example for water supply constructed and operated by CERWASS in the province of Cần Thơ City.

[79] Experiences from Côte D'Ivoire and Senegal show that the approach failed to establish one monopolistic provider in order to cross-subsidise unprofitable schemes by the revenues generated in densely populated areas (Kessides 2004: 229). In both countries the system is superseded by the decentralisation of the water market in favour of competitive private providers. Since services have not been expanded to rural areas, community based systems under guidance of village

is questionable whether the presumption to cross-subsidise unprofitable CERWASS schemes by revenues gained in other schemes is realistic. As a provider, CERWASS does not take a monopolistic position in the market, and densely populated areas in which revenues might be generated will rather attract private water supply companies leaving the remainder of disadvantaged regions to be served by CERWASS.

Cooperatives and entrepreneurial schemes

Besides state administered initiatives, *private sector participation* (PSP) is expected to gain in importance in the rural water sector. Whereas neither state-owned nor private water supply companies played a significant role in the past, cooperatives and user groups proliferate in the Southern part of the country. By considering two examples, which embody different styles of private sector participation, namely cooperatives in Tiền Giang province and a localised privatisation scheme in Cần Thơ province, I will scrutinise the hypothesis that not privatisation per se, but mainly in combination with (financial) contributions of users, led to a significant increase of coverage with piped water.

Cooperatives in Tiền Giang

The diffusion of cooperatives in Tiền Giang province provides an impressive example how provincial authorities might facilitate the dissemination of certain institutional arrangements, although this development is rather exceptional than representative for Việt Nam.[80] Like in other provinces, households usually relied on different water sources like rainwater, surface water, or hand dug wells, when – in response to households' demand – private operators began to construct small piped water schemes (Salter 2004). Since no regulations existed, the private investors raised capital directly from consumers by charging a connection fee of 60 to 100 USD. Although users did not receive the ownership of the constructed facilities, they were willing to contribute. Two main types of management models emerged: 'informal user groups supported by commune-level governments that managed and invested in their own system; and [...] cooperative-managed systems' (Salter 2004: 4).

Within six years, the number of user groups in Tiền Giang increased by 800 percent and that of cooperatives by 320 percent with full coverage in sight within the following three to five years. The bulk of the investment was covered by private investors or users themselves, whereas subsidies contributed by the state only accounted for 10 percent of the total investment (Salter 2004). But why did leveraging funds from households and in particular cooperatives become a real story of success? Until 1998,

water committees evolved. The ensuing reforms of the legal standing of the village committees is expected to further enhance the promotion of local small-scale private providers (Kessides 2004; Trémolet et al. 2002; Trémolet 2002).

[80] Tiền Giang has also been a model region for implementation of Integrated Water Resources Management which included the establishment of water user groups and community participation (Le 2012).

no regulations about financial contributions of users existed, when the question of ownership suddenly popped up in Nam Giang district. Despite their substantial contributions of 375 million VND, users and the commune PCs had not been recognised as shareholders of the cooperative (van den Berg 2002: 21). The provincial government of Tiền Giang province reacted to this problem and issued a decree for the water and sanitation sector, which regulated pricing, drilling, water quality and stipulated specific institutional arrangements. Based on this decree, the provincial government denied state-owned and private water supply enterprises the opportunity to raise capital from their customers, whereas user-groups and cooperatives were still allowed to do so. In addition to the enhancing legislative context, the great success of these models is ascribed to the social structure of the village community, which suggests security of the investment and provides a monitoring system which encourages and motivates communal leaders because their performance is judged according to their achievements in improving local infrastructure (Salter 2003: 6).

Assessment of cooperatives

Despite their successful implementation, schemes operated by individuals and cooperatives are judged ambivalently and experts did not arrive at a consensus about the assessment of cooperatives. Although cooperatives might suffer from a lack of professionalism, they provide a feasible solution for remote areas which are not attractive for enterprises. For example, the Netherlands Development Organisation (SNV 2010) clearly argues in favour of these models, testifies them a high sustainability, and points to their ability to raise funds directly from users. On the contrary, the NTP III perceives cooperatively run models as a temporary solution but casts doubt on the sustainability and economic viability. The authors of the NSRWSS perceive the often unclear regulations on ownership, supervision, management, and operation of cooperatives as an important obstacle to promote this kind of schemes (MoC/MARD 2000). Furthermore, there is some evidence that local participation in cooperatively organised schemes might go along with high costs for cooperation and coordination and makes them susceptible to elite capture and free-riding (van Koppen et al. 2012; Pham et al. 2011).

Localised privatisation schemes

In contrast to the success of cooperatives in Tiền Giang, the following example illustrates that well-defined incentives of the institutional model are a necessary but not a sufficient precondition for the adoption of piped schemes by rural households. By the late 1990s, the local government in peri-urban Cần Thơ introduced a ‘localized privatisation scheme that neither fits into the current model of corporate participation in water services, state-run systems, nor local community control and management of water resources’ (Spencer 2008b: 2016).[81] The municipal water company financed private households to construct deep wells in order to serve between 100 and 150 households within a radius of 1.5 to 2 kilometres (Spencer 2008b). Those households were allowed to keep the benefits from managing water supply. In return, the house-

[81] For a detailed description of the development of this scheme see Spencer (2008a: 110 et seq.).

hold provided the land on which the SOE, the Cần Thơ City Water Company, dug the wells and built the distribution stations. Additionally, the landowner must have been willing to manage, operate, and repair the scheme with assistance of the municipal water company. The local operators of the scheme received 3 m^3 per month free and an in-kind payment depending on the amount of water sold by the station to other households. In order to connect to the scheme, households had to pay a fee, buy a meter, and the pipes to their house. Although local people acted as operators, diffusion did not reach its 'take-off' phase in this case. After four years of operation, less than one fifth of those who lived within the radius of 2 kilometres around a well connected to the system. The majority kept on using water from their private wells or rivers, canals, and ponds. Spencer (2008b: 217) argues that the costs for establishing access to the schemes explain lower connection rates among the low-income households, whereas high initial costs for drilling and installing wells are responsible for lower connection rates among the wealthier ones. According to a user survey, supply by piped schemes is often interrupted, hence people are either forced to store water or to rely on alternative sources (Spencer 2008b). So finally, not only the costs deter people from connecting to piped water schemes, but also the use of other water sources which pose a reliable alternative to piped schemes. Consequently, it becomes unlikely that a natural monopoly quickly establishes on communal level, unless service and water quality in piped schemes do not convince households to give up water self-supply at all.

5.1.4. Drivers and obstacles of adoption and dissemination

These practical experiences impressively illustrate that neither governmentally administered schemes nor models relying on private sector initiative have proved a panacea for establishing piped schemes in rural Việt Nam. Independently from the specific institutional arrangement, adoption might fail even if adequate incentives seem to be set by the design of the institutional arrangement. Inherent characteristics and mechanisms of an institutional arrangement might successfully trigger and facilitate its dissemination and adoption in one case while they fail in their effect under different circumstances. Thus, in the following I will discuss how certain characteristics of a scheme like the extent and mode of private sector involvement, the associated opportunities to raise initial capital for investment, the tariff structure, and the quality of services delivered might trigger or inhibit the diffusion of piped schemes.

The impact of institutional characteristics

What distinguishes cooperatives and other privately operated schemes from the CERWASS models is their stronger demand-orientation, meaning that they will only start operation if users are willing to contribute to the scheme either by becoming a member of the cooperative or finding a person who will donate the land and manage the station. In a nutshell: demand-orientation is mainly realised in terms of user contributions but less by granting them more rights of co-determination in formal reporting and planning processes. Participation turns out to be the fulcrum in successfully setting up piped water schemes in rural Việt Nam – but unfolds its positive effect primarily through offering a new opportunity for raising funds (cf. Staykova 2006; van den Berg 2002). By contrast, the involvement in designing and decision-making plays a subordinate role. Thus, user participation degenerates into a convenient means to an end rather than a useful instrument to ensure sustainability in operation by creating commitment among the households and local operators. Two observations nourish that suspicion: Firstly, financial contributions are not always reflected by the ownership status of a scheme. In general, a closer look at the ownership status of assets in different models gives rise to strong doubts whether the state will and can withdraw from construction and business activities in domestic water supply as expected if he wants to accomplish the objectives set in the NTP III. The current strategy tends to delegate O&M activities only, while asset creation and initial investment in most cases still reside with the state. This strategy is also reflected by the allocation of subsidies: whereas for construction governmental subsidies range from 40 up to 90 percent of the costs, there are only few to support O&M (Staykova 2006: 31). Secondly, individually and cooperatively run models are not acknowledged as a permanent solution by governmental authorities and thus continuously threatened of being handed over to professional operators (GoV 2011). Unless user participation is appreciated to overcome the problem of raising capital but ignored in decision-making and planning, it is unsure whether cooperatives in the long run turn out to be more successful than governmentally administered models.

Dissecting the influence of institutional characteristics and definatory power

Participation aside, in view of the omnipresence of CERWASS – be it as an operator, advisor, or investor – the differences between the institutional models become blurred, anyway. The impact of the features of the institutional model on choice, adoption, and diffusion is strongly confounded by the influence which CERWASS and other governmental institutions exert on a) the autonomy of potential providers in planning, designing, and operating piped schemes and b) the formal and legislative framework for piped schemes on provincial level. Staykova (2006: 27) arrives at a similar conclusion and states that '[t]he autonomy in managing the water supply business and proper tariff levels may be better predictors of success than the management models per se'. Consequently, elaborating on specific schemes and the accompanying planning, decision-making, and implementation processes in terms of case studies like in Section 5.1.3 might be more insightful than simply comparing management models. Even if policies as the NSRWSS have only recommending character and the concrete institutional design is not 'enforced' by the state via the PCs, MARD, CERWASS, or the respective line agencies, their influence is substantial. They might push or impede dissemination either by giving recommendations, expressing preferences, utilising their information advantage to non-experts or defining regulations which promote certain arrangements, respectively make them less attractive and economically viable.

Basically, two modi operandi how definatory power manifests itself in the rural water sector can be identified: whereas CERWASS exerts its influence primarily indirectly by its information advantage against non-professional stakeholders and through its advisory function, provincial authorities' power builds upon the competencies which have been assigned to them in the decentralisation process. CERWASS has been ascribed the role of a technical advisor for governmental institutions like MARD and the People's Committee but also for cooperatives or user groups which want to establish or already operate a piped water scheme. Its definatory power largely arises from the information monopoly CERWASS takes. Firstly, the overall coordination of information, education, and training activities as mentioned in the NSRWSS usually lies in the hands of CERWASS. It takes its role as a technical advisor on different administrative levels seriously, provides a set of information materials, issues handbooks about the operation of piped water schemes (Reis 2012: 132), and supports its information, communication, and education activities by a e-library. Secondly, technical and managerial skills in the private sector, especially in case of cooperatives, are still on a low level. In spite of the lack of professionalism, the NSRWSS clearly argues in favour of users as central players in investing, managing, and operating what makes the potential operators of the scheme dependent on the technical advice which will usually be given by CERWASS (GoV 2011). These examples indicate that state agencies take a monopolistic position concerning knowledge about adequate management and operation of water supply facilities. Additionally, from the viewpoint of authorities on commune and district level, CERWASS is perceived as being the most powerful player in RWSS planning as revealed an influence mapping conducted in southern Việt Nam (Reis 2012: 123 et seq.). This is mainly attributed to the fact that finally CERWASS decides where water stations are constructed and takes over responsibility for a longer period and not only for initial investment.[82]

CERWASS' definatory power

Provinces' pecuniary power

By contrast, the power of state agencies on provincial level is substantial due to funding mechanisms. Already in NTP II, funding was provided to the provincial level as a lump sum, leaving the decision about allocation for different sectors and activities to provincial agencies (Harris et al. 2012: 13). National policies define the objectives for RWSS, but in fact the responsibility for implementation resides with the provincial and communal level agencies. This contradicts the official guidelines

[82] DARD and CERWASS itself instead regard local authorities as influential (Reis 2012).

that government bodies should discharge their task in water supply management and provide only advice to the users excluding participation in production, construction, or business activities (MoC/MARD 2000: 25).

Regulation of water tariffs and water quality

Beyond the allocation of funds, national and provincial level authorities take a key position in setting the framework within small-scale water providers operate by defining water tariffs and quality standards providers have to comply with. In contrast to the subtle process of assisting communes and cooperatives in designing and implementing piped water schemes described before, these regulations express a more direct way of exerting influence on the expansion of piped schemes. The autonomy in setting water prices is regarded as a substantial determinant of the economic viability and sustainability of piped schemes. A uniform tariff mechanism for the whole country has been introduced by Decree 104 of the Ministry of Finance in 2004 and its predecessor Circular No. 3 in 1999 (MoF 2009). Hence, water supply providers have only limited autonomy in setting water prices. On the one hand, the National Urban Water Supply policy proposes tariffs designed to ensure full cost-recovery – thus include water supply operation and maintenance – but this policy has not been enforced yet due to the political constraints. On the other hand, the MoF provides clear guidelines in order to ensure affordability: whereas in areas with higher living standards, the MoF allows to charge rates between 5,000 and 8,000 VND per m^3, in areas with average living standards, tariffs range between 3,000 to 5,000 VND per m^3 and are subsidised by the government. In disadvantaged areas the charged rate of 1,000 to 3,000 VND per m^3 is sufficient to cover costs for O&M and small repairs but not for depreciation, major repairs, and initial investment (GoV 2011: 54). Usually the People's Committee sets the tariffs within this framework issued by MoF. The specific design of the water tariffs within the above-mentioned limits resides with the provinces and the providers. Flat rate tariffs are most common, but some provinces introduced block rates in order to serve the essential households' demand (up to $15m^3$ per month) for low tariff rates (van den Berg 2002: 15). These block rates are expected to support poor households but their actual benefit remains low. Poor households either do not connect to existing piped water schemes due to high fees or do not get access to the network at all. From the investor's and operator's point of view, the rigid regulation of water prices aggravates the market entry, although it is unsure whether the mere affordability really poses the main obstacle for the expansion of piped schemes. As has been outlined on page 74, the vast majority of the rural households spends less than 1 percent of their total household expenditure for water supply, while experts apply the rule of thumb that considers a share of 3 to 5 percent as reasonable (Staykova 2006; MoC/MARD 2000). For the households included in the VHLSS 2008, this limit is even satisfied if water is bought and stored in tanks. However, users themselves still perceive costs for piped water as too high, but those figures strongly suggest that incentives created by lower connection fees or subsidies for construction might encourage more households to connect to piped schemes than a reduction of the anyhow low costs per unit would do it.

Water quality standards

Besides the regulations for raising capital from users, also those defining quality standards suggest an overall propensity to favour small-scale providers like CERWASS or cooperatives. MoH issued two standards defining the quality for water delivered by piped schemes: Whereas the Standard 1329 (MoH decision No. 1329/2002/QD-BYT) is valid for schemes serving more than 500 households, the laxer Standard 09 (MoH decision No. 09/2005 QD-BYT) applies to water supply stations serving less than this number (Reis 2012: 77).[83] Schemes constructed by CERWASS in rural areas often serve a comparatively low number of households. Thus, usually Standard 09 is applied whereas private water works in urban areas have to adhere to Standard 1329. One the one hand, this might be interpreted as a lower barrier for CERWASS and local initiatives to ensure at least basic water supply. On the other hand, households served by small water plants are worse-dispositioned and might face health threats due to the lower standards.[84]

Self-supply as competing strategy

Although in peri-urban areas piped schemes proliferate, rural areas lag far behind (WHO/UNICEF 2010). Even if piped schemes have been established there, households often hesitantly adopt them (Spencer 2008b). The wide-spread use of self-supply as a substitute for piped water is deemed one of the major reasons for slow diffusion and adoption of piped schemes in rural areas. Households simultaneously use multiple water sources because they demand water of different qualities according to the purposes for which it will be used. According to calculations based on the VHLSS 2008 (GSO Vietnam 2008b), 25 percent of the rural households rely on different water sources for drinking and cooking and other purposes like washing and cleaning. Typically, these are households which collect rainwater for drinking and thus can only store a limited amount of water, or those who buy water from vendors and store it in small tanks. Owners of wells and those drinking surface water instead are very likely to use this sources for other daily purposes as well. Due to the substitutability by surface, well, and rainwater, households' demand is often very elastic. Even if they are connected, households try to keep the amount of water consumed from piped schemes low in order to reduce costs (Spencer 2008b; Reis 2012). Additionally, initial costs for installing wells, constructing tanks, or in-

[83] In comparison to Standard 1329 and the WHO standards for drinking water (WHO 2008) it contains less regulations.

[84] Different standards are not only applied with regard to water quality but also to quality control (Reis 2012: 78).

vestments in household water treatment and low variable costs for self-supply deter people from switching (completely) to piped water. From a household's perspective, both strategies – self-supply and connecting to piped schemes – serve as substitutes and using multiple sources provides them with a certain degree of flexibility and prevents them from becoming fully dependent on piped water.

In contrast, for operators of small-scale schemes this consumption behaviour results in a highly volatile demand across the day and year which makes the economically viable operation of piped schemes difficult and slows down the establishment of new piped schemes. A recent study in Cambodia revealed that the sales of small-scale suppliers serving less than 750 households during the rainy season halvened and still larger networks were confronted with a 25 percentage drop in demand (Sy et al. 2014: 32). High uncertainty about the actual demand does not only impinge on the operation of a scheme once it has been established, but also on the initial decision to construct it because it is hardly predictable how many households are willing to connect. Consequently, neither private nor governmental providers can build on economies of scale like in a natural monopoly.

Table 5.2.: Main drinking water source of household by main water source in rural commune

	Source of drinking water (% of households)								
Main source of water (commune)	Tap water	Tube well	Dug well	Spring water	Rainwater	Bought water	Surface water	Other	
Tap water	45.5	12.5	10.5	1.4	18.9	1.2	9.6	0.4	100.0
Tube well	4.4	54.1	16.3	0.5	21.8	0.6	2.1	0.1	100.0
Dug well	3.7	10.4	73.7	4.6	5.3	0.1	0.5	1.7	100.0
Spring water	5.6	1.8	12.0	68.9	1.1	0.0	7.1	3.6	100.0
Rainwater	3.2	6.7	4.1	1.7	83.2	0.2	0.9	0.0	100.0
Bought water	18.2	18.2	3.0	0.0	36.4	15.2	9.1	0.0	100.0
Surface water	12.0	3.2	3.4	7.6	21.8	1.1	49.4	1.4	100.0
Other	10.0	0.0	16.7	30.0	6.7	3.3	1.7	31.7	100.0
Total	10.0	23.9	31.9	7.5	19.0	0.6	6.0	1.2	100.0
N	656	1,569	2,099	490	1,248	40	393	81	6,576

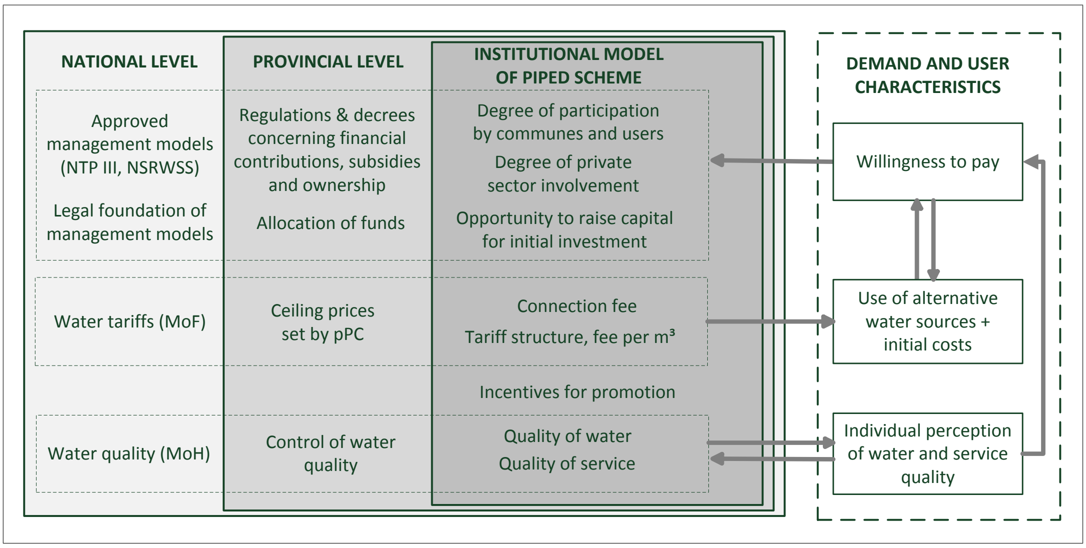
Source: VHLSS 2008 (GSO Vietnam 2008b), Own calculation

Table 5.2 suggests that access to safe water sources is not only a question of household's individual willingness to invest in wells or a connection to a scheme but is strongly related to the availability and spatial dissemination of other water sources in the commune. Cross-tabulating the household's main source of drinking water by the main source of drinking water used in the commune (Table 5.2) reveals a substantial intra-communal heterogeneity in domestic water supply and underlines the assumption that piped water schemes so far barely built up natural monopolies in rural communes. More than half of the households living in communes for which the local leaders stated piped water as the main source for drinking water, indeed rely on other sources. Almost every fifth household still prefers to drink rainwater and every eighth tube well water. Similar applies to communes in which tube wells or using surface water are common.

5.1.5. Summary and research desiderata

Although access to piped schemes is currently only available for a minority of the rural households and those often hesitantly connect to them, the success story of institutional arrangements like cooperatives suggests that a further increase of the coverage rate is not completely unlikely if an enabling environment is created and piped water perceived as an advantageous alternative for self-supply. Figure 5.1 summarises and illustrates major diffusion determinants for piped schemes. Inherent features of the institutional arrangement, characteristics of users' demand, and the legal and regulatory framework set by national and provincial authorities have been identified as the major factors which impinge on the dissemination of piped schemes.

FIGURE 5.1.: Interrelationship of factors influencing the dissemination of piped schemes on national, provincial, institutional and household level



Source: Own illustration

During the last two decades, domestic water supply in rural Việt Nam has become a playground for institutional experiments, but in view of the emerging private sector involvement, the necessity arose to introduce and enforce regulations. The analysis of official documents like the NTP-RWSS in its three iterations as well as the NSRWSS indicates that the Vietnamese government – influenced by international donors – increasingly pays attention to designing appropriate institutions and instruments for regulating the provision of piped water. In practice, the implementation of abstract principles like user-participation and demand-responsiveness has been characterised by a continuous revision and refinement of the objectives, regulations, and recommendations to react to apparent deficiencies and disincentives in the existing framework. Ambiguous and changing policies concerning cooperatives or private sector involvement are exemplary and express the uncertainty of political stakeholders in pre-structuring adequate institutional arrangements to serve rural households. One striking example is the controversial discussion of cooperatives: from the governmental perspective they are only an acceptable solution in the short run, despite their successful implementation in some provinces. Cooperatives are currently the only type of arrangement which is allowed to collect user contributions for initial investment, which provides them with a significant comparative advantage for raising funds. Nonetheless, local authorities are advised to hand over O&M of such schemes to professional water supply companies if possible. The inconsistent attitude towards cooperatives expresses the contradiction arising from the demand for a user-centred strategy in the NSRWSS and the ensuing lack of professionalism in the O&M of piped schemes if this strategy is pursued in practice.

However, in general the influence of the institutional arrangements appears to be limited. Whereas the design of the specific scheme ideally resides with the providers themselves, they have to comply with price regulations or restrictions for raising capital, which are set primarily on provincial level. Additionally, a comparison of management models as outlined in the official documents and case studies revealed that in practice, theoretical demarcation lines between management models become blurred, especially in view of the definatory power CERWASS exerts on the design and implementation of piped schemes in rural communes.

Apart from the specific institutional setting, the dissemination of piped schemes will be shaped by the geographical conditions and future development in the regulation of water prices. Whereas the first ones will be addressed in the second part of this chapter, which takes a first step in assessing the influence of settlement patterns and spatial proximity on inter-communal disparities in the availability of piped schemes, assumptions about the effects of price regulation are of hypothetical nature. At least it seems reasonable to assume that private water supply companies will only set up schemes in remote or sparsely populated areas if they expect them to be economically viable. In contrast to CERWASS, they have little incentive to cross-subsidise disadvantaged communes based on the profits gained by other schemes if a natural monopoly is unlikely to evolve. In consequence, areas which are currently not attractive for private water supply companies need to be served by CERWASS or user based initiatives. These face the challenging situation to provide piped water with cost-recovering prices in economically weak areas with a low willingness to pay. Whether user participation and engagement of the communes are able to compensate this lack of private sector activities and bridge the gap between served and unserved regions is still an open question.

Conclusions for further research

Finally I arrive at three conclusions which could guide further research about the evolution and dissemination of piped schemes: Firstly, future analysis is well advised to dissect institutional arrangements in terms of certain features and mechanisms rather than considering them as a coherent and distinctive conceptualisation. Management models as outlined in official documents are not implemented on a one-to-one basis but in line with decisions of local authorities and in accordance to existing social structures of the community. Consequently, ignoring the local context might lead to misinterpretations and creates an oversimplified picture of the mechanisms and impact of specific features of an institutional arrangement. Hence, selecting cases for further investigation should involve theoretical sampling with regard to specific features like asset ownership, initial investment, O&M, mode of participation, tariff structures, but also communal characteristics like settlement structures, available water sources, or the overall economic situation. Secondly, dynamics should be taken into account: institutional arrangements are not static but underlie ongoing revisions. Unfortunately, data to assess how efficiency, viability, and sustainability of piped schemes are currently not open to the public. First steps to get the process off the ground are done by creating an indicator set and utilising data which is gathered in reporting and planning processes anyway. However, it still leaves room for improvement, especially with regard to enforcement on a large scale and making the data available for academic purpose. Last but not least, it seems a promising thought to explicitly ask for the role which intensive usage of self-supply plays in households' decisions to connect to piped schemes. A first step to systematically assess the influence of competing water sources on the establishment of piped schemes will be taken in the following.

5.2. A quantitative assessment of the dissemination and availability of piped water schemes

The previous analysis suggested that the slow diffusion of piped schemes may be attributed – amongst others – to two main deficiencies: the lack of well established institutional arrangements which receive unequivocal support by governmental authorities and an institutional framework which rather thwarts than encourages private sector initiative. Additionally, it touched upon the relation between the demand and the supply-side of the problem by pointing out households' and operators' rationales. Building upon the qualitative findings in the first part of the chapter, the following analysis firstly aims to identify factors which inhibit or facilitate the availability of piped schemes in rural communes by means of regression analysis. Secondly, it also scrutinises whether these factors show a distinct impact in early and more advanced stages of piped schemes adoption.

The chapter proceeds as following: the next section deals with the question which factors might impinge on the likelihood that piped schemes are under operation in rural communes and asks why piped schemes spread only slowly in Việt Nam up to now. Thereby it draws on a handful of empirical studies about rural water supply in Việt Nam and other developing countries, but also harks back on more general assumptions derived from diffusion theory. Methodologically, the research questions outlined above will be approached by applying logistic random intercept models to the commune level data derived from the VHLSS 2008. Section 5.2.2 provides some basic information about the data set, outlines the operationalisation of the indicators included in the model and introduces the methodological approach. Subsequently, empirical findings are presented and interpreted against the background information provided before.

From the conceptional point of view, the model incorporates the ideas gained in the previous section: firstly, it controls for communal characteristics which are deemed relevant for the availability of piped schemes and thus addresses one of the central deficiencies, case studies are often suffering from (see p. 64). It considers spatial and geographical conditions, the socio-economic status of the commune, supporting measures in terms of governmental programmes, and infrastructure projects. Secondly, the model systematically captures the use of tube wells conceived as competing behaviour. Thirdly, it accounts for similar institutional and regulatory settings in communes nested in a specific province by explicitly taking into account the hierarchical data structure. Thereby it allows to approach the question which importance should be attached to the provincial setting when explaining inter-communal differences in the availability of piped schemes.

5.2.1. Why do piped schemes diffuse only hesitantly?

For answering the question, why piped schemes spread only hesitantly in some parts of the country whereas others succeed – at least as the slender empirical evidence suggests – I will build upon the concepts of diffusion theory and empirical diffusion studies from the water and sanitation sector in developing countries (cf. Chapter 4). Reasons for the hesitant adoption of piped schemes in Việt Nam can be found on the demand- as well as on the supply-side (see Figure 5.1). Although a systematic analysis about the dissemination of piped schemes in rural Việt Nam is lacking so far, several empirical studies and donor reports provide some first indications about potential obstacles from the suppliers' as well as the consumers' perspective. Those empirical studies about domestic water supply in Việt Nam usually rely on small-scale surveys and are confined to a negligible number of communes in a few selected districts or provinces (Reis 2012; Tobias and Berg 2011; Herbst et al. 2009; Spencer 2008b; Salter 2003). All these studies focus on the household level and do not control for commune and provincial level effects. Notwithstanding these deficiencies, they point to three main obstacles hampering the rapid establishment and diffusion of piped schemes from the demand-side which will be discussed briefly in the following: the insufficient quality of piped water supply, the use of multiple water sources and low variable costs for self-supply, and last but not least switching costs.

The demand-side

According to Reis (2012), Herbst et al. (2009), and Spencer (2007), the quality of tap water is often ranked lower than that of well or rainwater and its supply frequently interrupted due to electricity cuts forcing people to store water in jars or tanks. Put in terms of diffusion theory: piped water especially scores low with regard to the perceived advantage if other sources like tube wells are available. This is in particular critical, since the perceived advantage is deemed the most relevant characteristic of innovations driving diffusion (see p. 118). Due to the deficiencies outlined above and perceived high costs per m^3, households often rely on multiple water sources for drinking and daily use depending on the purpose. Households who already invested in drilling tube wells, the construction of storage facilities, or acquiring treatment facilities often face only very low variable costs for water supply (cf. Spencer 2008b). Thus, there are only little incentives to ante up initial connection fees or to switch completely to piped schemes. Given this knowledge about the demand-side of the problem, two implications can be drawn for the quantitative model: firstly, it should take into account consumers' willingness or ability to pay and secondly, it should scrutinise how the use of tube wells impinges on the diffusion of piped schemes.

The supply-side

But what about the supplier's perspective? Whereas from a household's point of view the 'substitution strategy' is advantageous, it confronts operators of small schemes with a highly volatile demand across the day and year. Subsequently, this aggravates the economically viable operation, lowers the willingness to invest, and impedes the emergence of economies of scale. The households' demand aside, slow diffusion of piped schemes might also be attributed to the institutional environment in which potential providers are operating (cf. Section 5.1.4). In the Vietnamese water sector, private and public providers coexist, whereby in the rural areas cooperatives and the Centres for Rural Water Supply and Sanitation (CERWASS) as a governmental agencies are prevailing. Potential operators are confronted with a highly fragmented institutional setting in the water sector. Particularly provincial level authorities play a pivotal role in the rural water sector because they decide about infrastructure investment, set tariff levels in their respective jurisdiction, establish quality control mechanisms, and have the authority to decide about legitimacy and eligibility of certain institutional arrangements (Waibel 2010; Staykova 2006; Salter 2003). Two conclusions can be drawn about the institutional environment: firstly, in view of the restrictions, fixed ceiling prices impose on the viability of piped schemes and the uncertainty about legal conditions, it is doubtable whether the current institutional settings encourage private sector and user participation. Secondly, these settings (e.g. prices, eligible arrangements, regulations about ownership and opportunities to raise capital) but also funding structures in the water sector, administrative practices, governance cultures, and economic performance differ substantially across the provinces and regions (cf. Malesky 2013, 2009, 2004). Thus, the clustering of communes in administrative units, which significantly shape their institutional environment, should be explicitly captured by the model.

5.2.2. Data, variables, and modelling approach

The analysis draws on the VHLSS 2008, which has been introduced with regard to the sampling, data generation, and content of the questionnaires in Section 1.5.2. Data used subsequently is mainly derived from the communal questionnaire, but some indicators have been aggregated from household level information. In total, the VHLSS 2008 comprises 3,063 communes nested in 64 provinces. 2,278 of them are officially categorised as rural but eventually, several cases clearly showing urban characteristics have been dropped from the sample in order to prevent bias in the estimation due to intermingling districts with urban and rural character.

Measures and operationalisation

Dependent variables

The model explores the relationship between different communal settings and the diffusion of piped schemes in rural communes. In order to capture different stages in the diffusion process, a three stage variable based on a combination of household and commune level data has been defined. The first stage comprises communes for which I assume that no piped schemes are in operation. As Table 5.3 outlines, the *early stage* of diffusion refers to communes in which only a minor share of households relies on piped schemes, whereas the *advanced stage* here covers communes in which already a majority uses piped schemes. Due to the comparatively small number of genuine early and advanced stage communes and the high number of covariate patterns, no separate models with pairwise comparisons for these three stages of diffusion could be estimated. Thus, the dependent variable for the logistic model has been recoded as a dichotomised variable based on the information that either piped water is the major source of drinking water in a commune or at least one household in the commune has access to piped water on its premises compared to the situation where piped water is lacking at all.[85]

[85] The approach of operationalisation suggested here rather tends to underestimate the share of communes in which piped schemes are already existing, especially if only a very limited number

Table 5.3.: Operationalisation of dependent variables

Three stage model	Variable definition	$N_{communes}$
No diffusion	0=piped water used by none of sampled hh *and not* main source of drinking water in commune	1,808
Early stage	1=piped water used by at least one but not all sampled hh in commune *and not* main source of drinking water in commune	145
Advanced stage	2=piped water used by all sampled hh in commune *or* main source of drinking water in commune	325
Two stage model	**Variable definition**	$N_{communes}$
No diffusion	0=piped water used by none of sampled hh *and not* main source of drinking water in commune	1,808
Diffusion	1=piped water used by at least one sampled hh *or* main source of drinking water in commune	470

Note: Only rural communes included
Source: VHLSS 2008, Own calculation

Independent variables

A set of determinants which are expected to impinge on the diffusion of piped schemes in rural Việt Nam has been derived: the use of substitutes, supporting measures and environmental characteristics like spatial, geographic and socio-economic characteristics of the communes. Whereas Chapter 4 addressed the most relevant diffusion determinants, their underlying assumptions about causal mechanisms, the expected direction of influence, and cross-references to studies, which theoretically and empirically elaborate on these factors, the subsequent paragraphs elaborate on their operationalisation based on the VHLSS data set.

Competing behaviour

The use of tube wells has been taken into account as a substitute for piped water and in order to test the hypothesis that the use of tube wells hampers the diffusion of piped schemes. Two alternative definitions of the indicator had been tested: in the first definition, similar to the two stage dependent variable, the dichotomous variable for tube wells is coded 1 if at least one of the sampled households uses tube wells or it is even the main source of drinking water in the commune. In the second definition, which has finally applied in the model, the dichotomous variable for use of tube wells has been coded 1 if tube wells pose the main source of drinking water

of households is so far connected to them, and subsequently these households are unlikely to be included in the sample for the respective commune. The definitions provided in Table 5.3 – in particular in the three stage model – are fraught with some uncertainty because communes are represented by a small number of households. Nevertheless, the combination of the commune and household level data provides sufficient evidence to conclude about the rough overall stage of diffusion on communal level in terms of a dichotomous variable.

in the commune during the dry season and hence, their use is wide-spread and not only exceptional. In the model, the information about the use of tube wells in the commune indicates whether this source can realistically be taken into consideration as a substitute for piped water. The underlying intention of this predictor is not to measure groundwater availability as such but to indicate whether it is a source accessible by a reasonable number of households at this specific location.

Infrastructure index

The communal infrastructure endowment is represented by a composite index which captures health infrastructure, access to markets, and other social infrastructure which is deemed relevant for 'measuring' the intensity of communication and information exchange in the respective commune. The summative index theoretically ranges between 0 and 10, whereby 4 points can be achieved at maximum for health infrastructure, 3 for access to markets, and 3 for other social infrastructure. The rules for the assignment of points on the infrastructure index are outlined in Table 5.4. The accessibility of communes by car, electrical power supply, and the availability of communal health centres are not included in the index because the overwhelming majority of the communes are equipped with these facilities and hence those do not serve as distinctive features. The conjunction of conditions bases on preliminary considerations and descriptive analysis to find out, whether specific facilities substitute each other or whether they imply some kind of hierarchy of services offered. Empirically, for the rural communes in the sample the index ranges between 0 and 8 ($\bar{x}$: 2.66, *sd*: 1.40) and follows a normal distribution.

Communal characteristics

Based on the number of permanent and temporary households residing in the commune and those of poor households according to the national poverty reduction Programme 143, the percentage of poor households for each commune has been calculated as a proxy for the economic situation.[86] Communal participation in P 135 (see p. 99) has also been taken into consideration as an alternative for this indicator, but eventually discarded due to collinearity with the percentage of poor households. Omitting this indicator appears also reasonable because firstly, the percentage of poor households provides a more differentiated proxy for the overall economic status of the communes and secondly, the dimension of support for infrastructure is more precisely addressed by the indicator for communal infrastructure projects related to water supply. Additionally, a dichotomous variable was introduced to identify ethnic minority communes. In the model, a commune has been classified as ethnic minority commune if the most important ethnic group is not Kinh – the majority ethnic group of Việt Nam, comprising more than four fifth of the population.[87]

[86] The income limit for poor households applied in P 143 for the VHLSS 2008 amounted to 200,000 VND per capita and month in rural areas.

[87] Alternative definitions of ethnic affiliation of communes have been tested, but in view of the empirical fact that the vast majority of communes is inhabited by a smaller fraction of ethnic minority households, the definition outlined above seemed most appropriate. Similar definitions have been applied in other studies in Việt Nam (Baulch et al. 2010; Swinkels and Turk 2007;

Table 5.4.: Composition of infrastructure index

Assigned points	**Definition**	$\mathbf{N_{communes}}$
Health infrastructure		
0	*Neither* private nurse *nor* private assistant doctor *nor* private doctor	582
1	(Private nurse *or* private assistant doctor) *and no* private doctor	380
2	(Private nurse *or* private assistant doctor) *and* private doctor	990
3	Local Clinic	139
4	District hospital *or* Provincial hospital *or* other specific hospital	0
Access to markets in commune		
0	*Neither* daily *nor* periodical *nor* wholesale market	1,425
1	Daily *or* periodical market	570
2	Daily *and* periodical market	85
3	(Daily *or* periodical market) *and* wholesale market	80
Other social infrastructure		
each	Communal radio system post-office	425
1 point	Cultural house	1,259
	Cultural and post-office	229

Note: Only rural communes included, number of communes for subindexes differs exclusively due to missing values, all cases could be assigned to one of the categories
Source: VHLSS 2008, Own calculation

Supporting measures

Ethnic minority or remote communes as well as specific disadvantaged groups are often eligible to receive support by governmental programmes in order to improve rural livelihoods and infrastructure. As has been outlined in Section 3.3.3; P 134, P 135, and P 143 are the most relevant programmes which primarily target poverty reduction but also incorporate infrastructure components. Besides the number of households benefiting from P 143, the VHLSS also includes a variable which indicates, whether a commune participates in P 135. This programme offers grants to communes under difficult circumstances to invest in small-scale infrastructure (SNV 2010; Swinkels and Turk 2007). Communes are selected based on their geographical characteristics, the share of poor, and ethnic minority households, as well as essential infrastructure deficiencies. Thus, the participation in P 135 implies by definition an above average share of poor households and ethnic minority households and the simultaneous consideration of all three variables is expected to result in multi-collinearity. The

Minot et al. 2006).

model estimated below accounts for supporting measures by considering communal infrastructure projects targeting safe water supply as a dichotomous variable.

Spatial and geographic characteristics

Last but not least, the model includes four variables to describe the commune with regard to spatial and geographical conditions. Firstly, the classification as delta, coastal, midland, low mountainous, or mountainous region serves as a proxy for the availability of different water sources like springs, groundwater, or surface water, and the ensuing disparities in use of different drinking water sources (see Section 2.1). Secondly, the number of households residing in the commune is included to control for the size of the commune and to scrutinise whether piped schemes demand for a certain critical number of potential users to be established and operated in a sustainable manner. Small commune sizes are assumed to lower the probability that a sufficient number of households, ergo potential adopters, will invest in the establishment of piped schemes. Thirdly, the population density – calculated from the number of households and the area in square kilometres – serves as indicator for the settlement structures. Scattered settlement structures, here represented by low population densities, are expected to deter households from connecting to piped schemes due to increasing costs for connections (see p. 143) and hence, slowing down or even hampering the diffusion process within the commune. Furthermore, it is assumed that a potential positive effect of increasing numbers of households and population density will become weaker once a certain threshold is reached. Finally, the models accounts for the distance from the hamlet to the nearest town. It is expected that with increasing distance to larger towns, which are more frequently served by water supply companies, spill-over effects of water service providers from urban to peri-urban and rural areas become less likely.

The random intercept model

Subsequently, I will assess how strongly the factors addressed above impinge on the likelihood that piped schemes spread in rural communes by means of a logistic random intercept model.[88] Given the fact that the pattern of dissemination of piped schemes in rural Việt Nam is influenced by unobserved characteristics of the province – e.g. in terms of regulatory conditions or ceiling prices for water – also the probability that a piped scheme is a available in a commune is likely to be correlated among communes belonging to the same province. Hence, the standard logistic regression model would lead to bias (Rabe-Hesketh and Skrondal 2005). The random intercept model relaxes the assumptions of conditional independence – meaning normally distributed and independent errors with mean of zero and equal variances – among the communes by adding a random intercept for the provincial level. The random intercept model

[88] The Methodological Appendix A provides a more detailed introduction to multilevel level regression models, critical issues in estimation, diagnostics and measures to assess model fit.

supposes the likelihood that a commune is equipped with a piped scheme to be given by:

$$logit\{Pr(y_{ij} = 1 \mid x_{ij}, u_j)\} = \alpha + \beta' x_{ij} + u_j \tag{5.1}$$

where α is the intercept, β is the column vector of regression coefficients, in this case exclusively commune level covariates x_{ij}, and u_j symbolising the random intercept. The random intercept α is assumed to be normally distributed with zero mean and variance σ_u^2 (Rabe-Hesketh and Skrondal 2005: 116). Here, the random intercept represents the combined effect of all provincial level characteristics and peculiarities on the availability of piped schemes not included in the model in terms of explanatory variables on provincial level. Put it differently, unobserved as well as observed heterogeneity is modelled by adding respective terms to the linear predictor. Thus, the random intercept model allows to decompose variability in the availability of piped schemes within and between provinces. The correlation between the observed outcome for two communes i and i' which have been randomly drawn from a province j is quantified by the intraclass correlation[89] ρ as:

$$\rho = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_e^2} \tag{5.2}$$

The model was concurrently estimated by Stata procedures `xtlogit` and `gllamm` using adaptive quadrature, because `xtlogit` does not allow to calculate predicted probabilities or residuals which account for the posterior distribution of the random intercept, respectively to gain empirical Bayes predictions for the random parameters in general.[90] Both estimation procedures yield exactly the same results for the random intercept models reported here. Comparisons of nested models are based on the likelihood ratio test whereas those of non-nested ones refer to Akaike's Information Criterion (AIC). For detailed information about the interpretation of the logistic model, the estimation procedures, the prediction of the random effect, and methods for overall model fit and comparing nested models, see Section A.2.

5.2.3. Results and discussion

Descriptive Statistics

The model covers 63 of the 64 provinces existing in Việt Nam in 2008, whereby the number of rural communes within the provinces differs between 2 and 75 and on average equals 31. The unbalanced cluster size is owed to the sampling strategy for the VHLSS, which takes into account the population size of provinces and follows a

[89] For further information about the calculation of the intraclass correlation in case of binary dependent variables see page 263.

[90] For further explanations about the empirical Bayes predictions see p. 269.

sampling master plan (GSO Vietnam 2008b). Inspecting the frequency distribution for the dependent variables in Figure 5.2 reveals skewed distributions for population density, poverty rate, and the distance to the nearest town, whereas the number of households almost follows a normal distribution. Although the skewed distribution might call for transformations, e.g. in terms of logarithmic functions, they have been included in the model without any further transformation to ensure better interpretability.[91] On average, 157 households occupy one square kilometre in rural communes but large disparities show up across the country. Whereas in one quarter of the rural communes less than 40 households reside on one square kilometre, in another quarter of the communes, the same area is populated by more than 230.[92]

Outliers

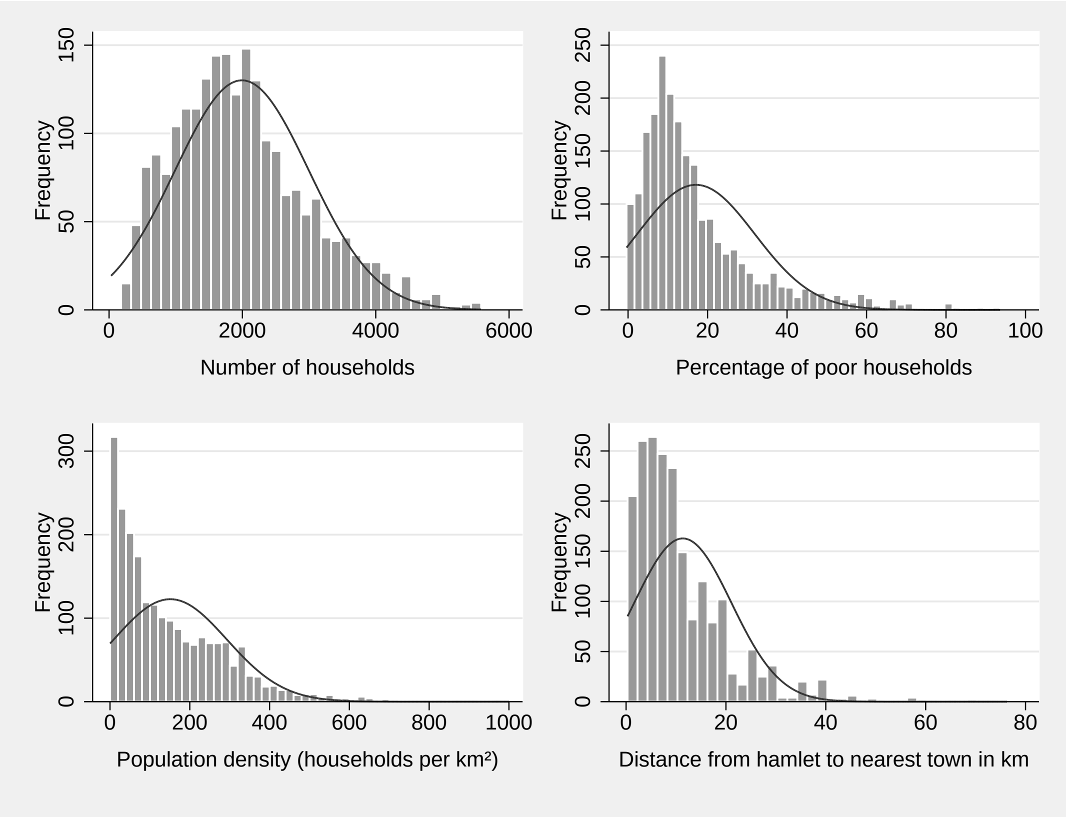
Inspecting the 'upper' end of the distribution of population size and density strongly suggests that some of the communes rather bear urban characteristics although they are officially classified as rural in the VHLSS data set. This concerns single communes with a population density above 1,000 households per km^2 or more than 6,000 registered households. Communes which do not match these criteria have been excluded from the sample for the regression models. Such obvious misclassifications are barely surprising and occur frequently because the restructuring of administrative boundaries and reclassification of administrative units are apparently not able to keep pace with the rapid population growth and urbanisation in Việt Nam (Reis 2012; Waibel 2010; Malesky 2009). In total, 420 of the 2,278 rural communes have been dropped from the sample: 407 due to missing values on independent variables and additional 13 because they cannot be considered as rural. High numbers of missing values especially occur for the infrastructure index and the distance from the hamlet to the nearest town. Nevertheless, no evidence could be found for systematic bias in the estimations due to these missings.

Roughly every sixth household in the sampled communes lives below the official poverty line. This average value is strongly shaped by some communes showing extraordinarily high poverty rates above 50 percent of the households. 17 percent of the communes are primarily populated by ethnic minority households. These show significantly higher poverty rates with much higher dispersion than communes inhabited by Kinh households ($\bar{x}$: 36% vs. $\bar{x}$: 13%). In order to answer the question whether lacking access to piped water supply is a question of poverty or rather a result of the marginalisation of specific groups, an interaction effect between both

[91] The models have also been estimated with transformed variables – logarithmised values for population density, distance to towns, and poverty rates – what did not result in significant changes in the estimations compared to the results presented in Table 5.6.

[92] These figures for populations densities are not directly comparable to overall countrywide figures such as given by the WB (2013) because these refer to the number of inhabitants – not households – and rely on different definitions for the countries' (land) area. Nevertheless, the number of households has been preferred here because the discussion about piped schemes usually refers to this level of aggregation.

FIGURE 5.2.: Distribution of continuous variables on commune level



Note: Only rural communes included, solid line represents normal distribution
Source: Own calculation based on VHLSS 2008 commune dataset

variables has been included in the models.

Table 5.5 provides the summary statistics for commune level predictors separated by the stage of diffusion in the communes as operationalised above. It reveals that communes in early and advanced stages of diffusion on average show lower poverty rates, higher numbers of households in absolute terms but also per hamlet, are better equipped with infrastructure and less frequently inhabited by ethnic minorities. With regard to population density, the picture is less clear: advanced stage communes have the highest values but communes without access to piped schemes also score high but show a very heterogeneous distribution. The high average population densities in communes without piped schemes mainly result from the large number of communes in this group which are located in the Red River Delta and is by far the most densely populated region of the country. Communes in which piped schemes are already available, much more frequently carried out infrastructure projects for safe water supply. Early stage communes differ from those in advanced stages first and foremost concerning the support they receive for poverty reduction and communal development (in terms of P 135 and the remote decree[93]). With regard to programme participation – except for genuine infrastructure programmes – and the share of ethnic population, early stage communes much more resemble communes without piped water schemes.

Different impact across diffusion stages

The findings from Table 5.5 suggest that factors take different effects in early and advanced stages of diffusion. Firstly, one could conclude that the initial stage of diffusion is rather triggered by supporting programmes and requires a critical number of potential adopters but is less dependent on settlement structures, respectively population density. Secondly, further progress in diffusion in terms of increasing coverage seems primarily a matter of settlement structures and households' ability to pay. These hypotheses cannot be tested in a multivariate model which simultaneously controls for the other predictors, but from a methodological point of view it becomes clear that pairwise comparisons of communes in terms of dichotomous dependent variables should be favoured against proportional odds models based on the three stage dependent variable because coefficients are expected to differ across these stages. Although the approach of pairwise comparisons seems promising, it has finally been discarded because the sample size for the 'sub-models' proved too small to estimate similar models like the ones displayed here.

Multi-collinearity

The inspection of the tolerance and the Variance Inflation Factor (VIF) for the dependent variables, which have finally been included in the model, do not point to serious problems with multi-collinearity among the dependent variables although the inclusion of the interaction effects goes along with increasing VIF and tolerance for the respective variables. This effect reduces after substituting the raw continuous variable by a mean-centred one, which demonstrates that the effect is mainly attributed to non-essential collinearity (Cohen 2003). Collinearity statistics for all included variables are reported in the Appendix (see Table B.2.4).[94]

Estimation and interpretation of logistic random intercept model

Table 5.6 summarises three logistic random intercept models drawing on *piped scheme availability* as the dependent variable, which contrasts communes with at least one household using piped schemes with the ones without a single household doing so.[95] Model (1) and (2) differ with regard to the operationalisation of the spatial characteristics: whereas Model (1) includes the communes total population as predictor, in Model (2) this indicator is replaced by the average number of households per hamlet,

[93] Since it is unclear, which role the remote decree plays for rural water supply, the indicator has been dropped from the regression model.

[94] For further information about tolerance and VIF – especially with regard to interaction effects – please see Section A.4.2 and A.3.1.

[95] For definition of the variable see Table 5.3.

TABLE 5.5.: Descriptives for rural communes by stage of diffusion (N=2,278)

	No piped schemes (N=1,808)		Early stage (N=145)		Advanced stage (N=325)	
Continuous variables	$\bar{x}$	*sd*	$\bar{x}$	*sd*	$\bar{x}$	*sd*
Share of poor hhs in % (SEC)	18.26	15.37	14.27	12.34	11.70	10.60
Infrastructure index (SC)	2.58	1.37	2.93	1.55	2.95	1.40
Distance to nearest town in km (SC)	11.78	10.89	11.44	9.73	9.82	7.99
Number of hhs (in 1,000) (SC)	1.90	1.00	2.29	1.25	2.47	1.03
Number of hhs/hamlet (in 1,000) (SC)	0.26	0.20	0.30	0.21	0.39	0.28
Households per km^2 (SC)	152.07	168.47	123.81	112.16	195.45	180.40
Dichotomous variables	in % (col)		in % (col)		in % (col)	
Use of tube wells (S)	37.2		31.0		4.0	
Safe water project (SM)	29.7		50.0		51.6	
Remote commune (SM)	24.3		31.8		16.7	
P 135 commune (SEC)	19.5		21.8		8.3	
Ethnic minority (SEC)	19.1		16.5		7.1	
Geographical region						
- Coastal	6.2		10.5		6.9	
- Delta (reference group)	48.4		54.9		52.0	
- Midland/hilly land	8.0		3.0		7.1	
- Low mountainous	18.8		17.3		17.7	
- Mountainous	18.7		14.3		16.4	

Note: (S) substitute, (SM) supporting measures, (SEC) socio-economic characteristics, (SC) spatial and geographical characteristics
Source: VHLSS 2008, Own calculation, only rural communes included

which is deemed a more precise proxy for settlement structures and the number of potential adopters for a piped scheme. Model (3) includes an additional interaction effect between the dummy for the Red River Region (RRD) and the population density in order to control for the considerably higher population densities in this specific region. In addition, the intercept-only model as the benchmark for comparing overall model fit has been estimated. This model without explanatory variables (not displayed in Table 5.6), gives a log likelihood of -784.3 and an intra-class-correlation of .33, indicating that at the maximum one third of the variance in the availability of piped schemes across communes is explained by the affiliation to a specific province. Model (1) and (2) produce quite similar results with regard to overall model fit. Model (2) predicts for 86 percent of the cases the correct outcome, but given the fact that even based on the marginal distribution a large share is classified correctly, the adjusted R_{count} was calculated. In comparison to the prediction exclusively based on the marginal distribution, the prediction error is reduced by almost one third (adj. R_{count}: 0.30). In addition to the R_{count}-measures, the actual rate of communes with piped schemes has been compared with the predicted rate for specific groups defined on the basis of selected predictors.[96]

Overall model fit

Table 5.6 reports the estimated coefficients and significance levels for the three estimated models. To facilitate interpretation, the estimated coefficients are converted to odds ratios (OR). Instead of standard errors – which cannot be used in the exponentiated form for constructing confidence intervals and testing hypotheses – significance levels are given (cf. Rabe-Hesketh and Skrondal 2005: 104). If nothing else is stated, the results reported in the following refer to Model (2). In general, the explanatory variables show the expected direction of the effect, but it becomes obvious that the relative contributions of spatial and socio-economic characteristics, supporting measures, and competing behaviour differ considerably. The results from the regression analysis strongly support the hypothesis that using tube wells is a main obstacle for the diffusion of piped schemes in rural Việt Nam. The odds that communes in which tube wells prove the main source of drinking have access to piped water are almost ten times lower than for those relying on other drinking water sources. Holding all other predictors at their mean, the probability[97] of access to piped schemes is only 0.03 in communes using tube wells compared to 0.20 in those which primarily draw on other water sources. As expected, communal infrastructure projects impinge positively on the availability of access to tap water. Those communes which invested in infrastructure for safe water during the last ten years, are almost three times more likely to have piped schemes as those which did not. Holding other predictors at

Interpretation of regression coefficients

[96] This approach is explained in detail on page 273 and the results for Model (2) can be found in the Appendix (Table B.5).

[97] All adjusted probabilities (so-called 'adjusted predictions' in Stata's terminology) have been calculated by Stata's `margins` command assuming the random effect to be zero. For further explanations see Section A.3.2.

Table 5.6.: Random intercept models for availability of piped water

Availability of piped water	**Model(1)** exp(b)	**Model (2)** exp(b)	**Model (3)** exp(b)
Competing behaviour			
Use of tubewells	0.128***	0.127***	0.126***
Supporting measures			
Project for safe water	2.729***	2.720***	2.719***
Socio-economic characteristics			
Ethnic minority	0.765	0.772	0.745
Percentage of poor households	0.961**	0.962**	0.963**
Ethnic minority * % poor hh	1.036*	1.036*	1.036*
Communal infrastructure index	1.157*	1.154*	1.151*
Spatial characteristics			
Distance to nearest town	0.983	0.983	0.984
Number of hh (in 1,000)	1.071		
Number of hh/hamlet (in 1,000)		2.028	1.961
Hhs per km^2	1.002**	1.002**	1.003***
RRD * Hhs per km^2			0.996**
Geographical region†			
Coastal	2.328**	2.335**	2.123**
Midland	0.264**	0.265**	0.235**
Low mountainous	0.723	0.755	0.721
Mountainous	0.259**	0.273**	0.254**
Constant	0.229***	0.217***	0.229***
Random part			
σ_u	1.104	1.095	0.997
ρ	0.270	0.267	0.232
R^2_{count}	86.12%	86.28%	86.12%
Adj. R^2_{count}	28.33%	29.17%	28.33%
Log likelihood (ll)	−674.00	−673.08	−668.21
AIC	1378.00	1376.16	1368.42
N	1,859	1,859	1,859

Note: †Dummies, reference region is delta region; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: VHLSS 2008, Own calculation, only rural communes included their mean, with communal programmes for safe water inhabitants face a chance of 0.20 to have piped schemes in their commune compared to 0.08 in communes without infrastructure projects. This positive effect of infrastructure projects reduces with increasing poverty rates. Given a below average poverty rate of 5 percent, the predicted probability for communes with water-related projects is 0.27 compared to 0.12 in those without projects. This gap between the communes decreases to slender 0.08 in terms of probability at a poverty rate of 30 percent and 0.05 at a rate of 50 percent. In general, elevated poverty rates coincide with low availability of piped schemes. A ten percentage point increase in the share of poor households decreases the chance that a commune has access to piped water by the factor 0.84 and a twenty percentage point increase in the poverty rate even by factor 0.71, assuming mean values for all other variables including the random effect. Expressed in terms of probabilities, a commune without poor households shows a 18 percentage probability compared to 8 percentage given a poverty rate of 40 percent. In contrast to the expectations, communes which are primarily populated by ethnic minorities are not worse off with regard to access to piped schemes than other communes. Holding other predictors constant, they do not differ significantly from Kinh communes with regard to piped water supply. This might be due to the fact that the often deplored disadvantage of ethnic minority communes is already captured sufficiently by the dummies for the geographical region or the poverty rate. The former argument has been tested by omitting regional dummies, which had been expected to partially reflect the variation in ethnicity, but even then, no statistically significant effect for ethnic minority communes showed up. The latter argument is standing to reason, because descriptive analysis of the VHLSS 2008 revealed that ethnic minority communes suffer from significantly higher poverty rates.

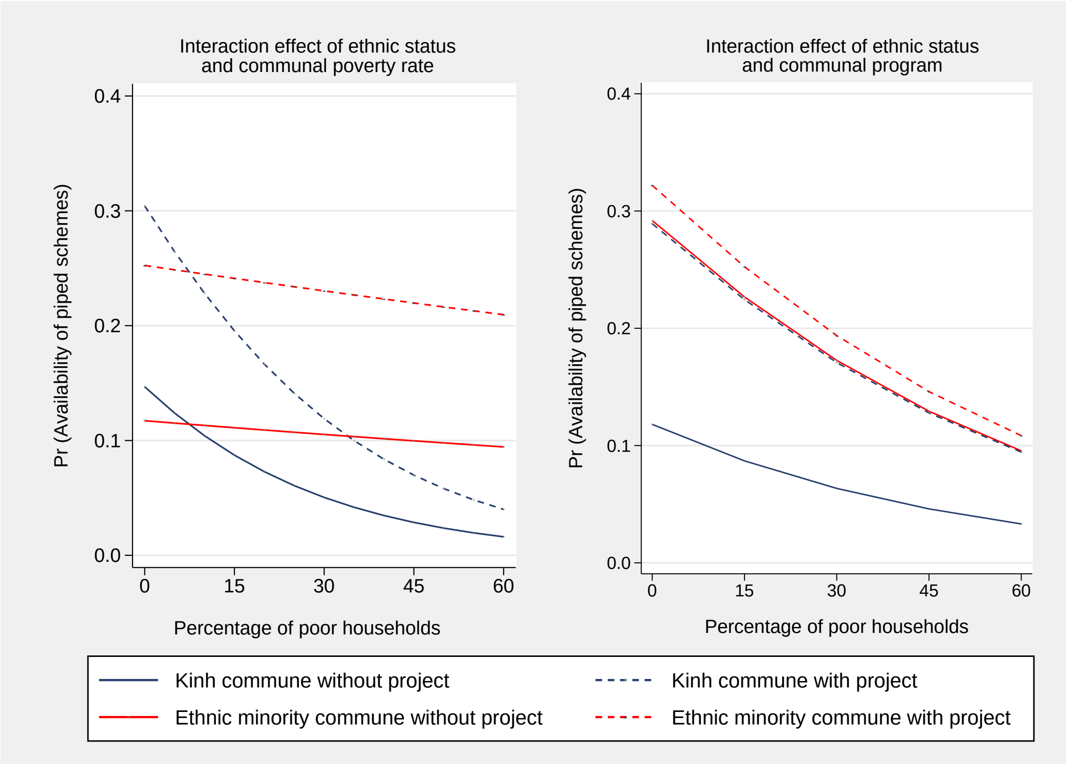
Interaction effect between ethnic status and poverty rate

Differences between Kinh and ethnic minority communes become more pronounced when the poverty rate is simultaneously taken into account (see Figure 5.3). All models in Table 5.6 show a significant interaction effect between the ethnic minority status and the poverty rate. The interaction effect has been introduced in order to further elaborate on the hypothesis that increasing poverty unfolds a different effect on chances in access to safe water in Kinh and ethnic minority communes. Adding the interaction effect only slightly, but significantly improves goodness of fit (Likelihood ratio test: χ^2=4.32 p=.037). The interaction effect here indicates to which extent the influence of the poverty rates differs between Kinh and ethnic minority communes. In Model (2), given a poverty rate of zero, ethnic minority communes have a by factor 0.77 lower chance of piped scheme availability. In Kinh communes, an increase in poverty rates to 30 or 60 percent comes along with a decrease in chances to one third, respectively one tenth of the initial chance of piped scheme availability given a zero poverty rate. In contrast, in ethnic minority communes chances drop much less and are reduced by factor 0.68 only for a poverty rate of 30 percent and factor 0.60 for a rate of 60 percent compared to Kinh communes with a zero poverty rate. This rather surprising finding could possibly be explained by supporting projects which target ethnic minority communes but could not be incorporated in the model. Such ‘sources’ of unobserved heterogeneity are not unlikely in view of the multitude of projects aiming at poverty alleviation and rural development. Although Việt Nam has in general not been characterised as an aid-dependent country (cf. Cox et al. 2011: 9), Section 3.4.2 revealed that in the water sector supporting measures play a crucial role and that especially in the mountainous regions, where most of the ethnic minority communes are located, only a minor share of the contributions is contributed by the local level agencies. The left panel in Figure 5.3 illustrates the described effect of increasing poverty rates in ethnic minority and Kinh communes on the availability of piped schemes supposed a random intercept of zero and mean values for all other predictors not considered on the graph.[98] Two conclusions can be derived from the graph and the adjusted probabilities: Firstly, both – ethnic minority as well as Kinh communes – are significantly more likely to operate piped schemes if they carried out infrastructure projects for safe water in the last ten years. Secondly, the positive effect of infrastructure project becomes lower as poverty rates increase, whereby this effect seems more pronounced in Kinh communes. Whereas the difference in piped schemes availability ascribed to infrastructure projects remains almost constant with increasing poverty rates in ethnic minority communes, it is declining in Kinh communes. Since the interaction term in Model (2) does not directly include project participation but has just used it for displaying the marginal effect, an additional model which considers the interaction between water-related infrastructure projects and ethnic minority status has been estimated in order to test whether the effect of projects indeed differs between ethnic minority and Kinh communes.[99] The right panel in Figure 5.3 illustrates the interaction effect between participation in communal infrastructure projects in Kinh and ethnic minority communes across different poverty rates. It confirms that the positive effect of communal infrastructure programmes is much stronger in Kinh than in ethnic minority communes. This effect can also be shown by simple cross-tables. The much higher baseline chances for ethnic minority communes suggested by the graph should always be interpreted against the fact that these communes show far higher communal poverty rates. Moreover, it has to be taken into account that due to smaller numbers of cases the predictions for ethnic minorities are fraught with larger uncertainty as is expressed by larger confidence intervals. Thus, the (interaction-)effects of ethnicity have to be interpreted cautiously and one should keep in mind that in many Kinh communes there might exist other improved water sources which are not accessible by ethnic communes in the mountainous regions.

[98] The calculations before are directly based on the b-coefficients and thus consider a situation where other predictors like project participation are assumed to be zero.

[99] Due to small case numbers it was not possible to estimate a threefold interaction between poverty rate, infrastructure project and ethnic minority status. The model is not displayed in Table 5.6.

FIGURE 5.3.: Marginal effect of ethnic status and poverty rate



Note: No CI displayed, random effect assumed to be 0 and other predictors fixed at mean
Source: VHLSS 2008, Own calculation, only rural communes included

Impact of geographical conditions

As expected, the dissemination of piped schemes differs according to geographical conditions. Here, the delta regions are set as the reference group. Compared to them, especially the midland and mountainous communes suffer from a lack of piped schemes, whereas in coastal communes the chance to find piped schemes is even more than twice as high as in the delta regions. Given equal poverty rates, support, and other spatial characteristics, inhabitants of the mountainous and midland communes have already a four times lower chance to get access to piped water due to sheer geographical conditions. In general, this pattern corresponds with the availability of water resources: ground water is much easier to extract from the shallow aquifers in coastal regions in comparison to the deeper aquifers in delta regions. The midlands and mountainous regions are not only disadvantaged concerning ground water but also with regard to surface water, what might explain the significantly lower availability of piped schemes, even if all other covariates are taken into account.

Spatial effects

Apart from the disparities related to natural conditions, the results show that the availability of piped schemes is less a question of overall population size and remoteness but rather one of settlement structures. Whereas the effect of increasing population densities could not clearly be determined in the bivariate analysis because it was strongly confounded by the varying densities across the regions, the multivariate model reveals a significant positive effect of population density on the availability of piped schemes.[100] Holding population size and the other covariates at their averages, the probability of access to piped schemes more than doubles when the population density increases from 100 to 500 households per square kilometre. Marginal effects plots suggest a quite rapid growth of probabilities for increasing population densities which slows down, once a critical value is reached. Moreover, they illustrate that a commune's population density is only a good predictor if the density is small whereas with increasing densities – and ensuing a more urban character – the uncertainty of the prediction grows considerably. The total number of households residing in a commune, respectively hamlet, has not been found a significant predictor for the availability of piped schemes. Apparently, small numbers of households do not pose an obstacle towards the diffusion of piped schemes. This seems plausible, since small-scale schemes operated by non-professionals often serve only a double-digit number of households and even professional operators in rural areas usually supply less than 500 households as suggest the distinct standards for water quality for small and large scale providers. However, this does not necessarily imply that the concept of the critical mass is irrelevant for explaining diffusion of piped schemes in general. Here only a cross-sectional perspective was captured, but nothing can be concluded about how the adoption rate within a commune relates to the number of potential adopters and whether in the communes considered the diffusion is already self-sustaining.

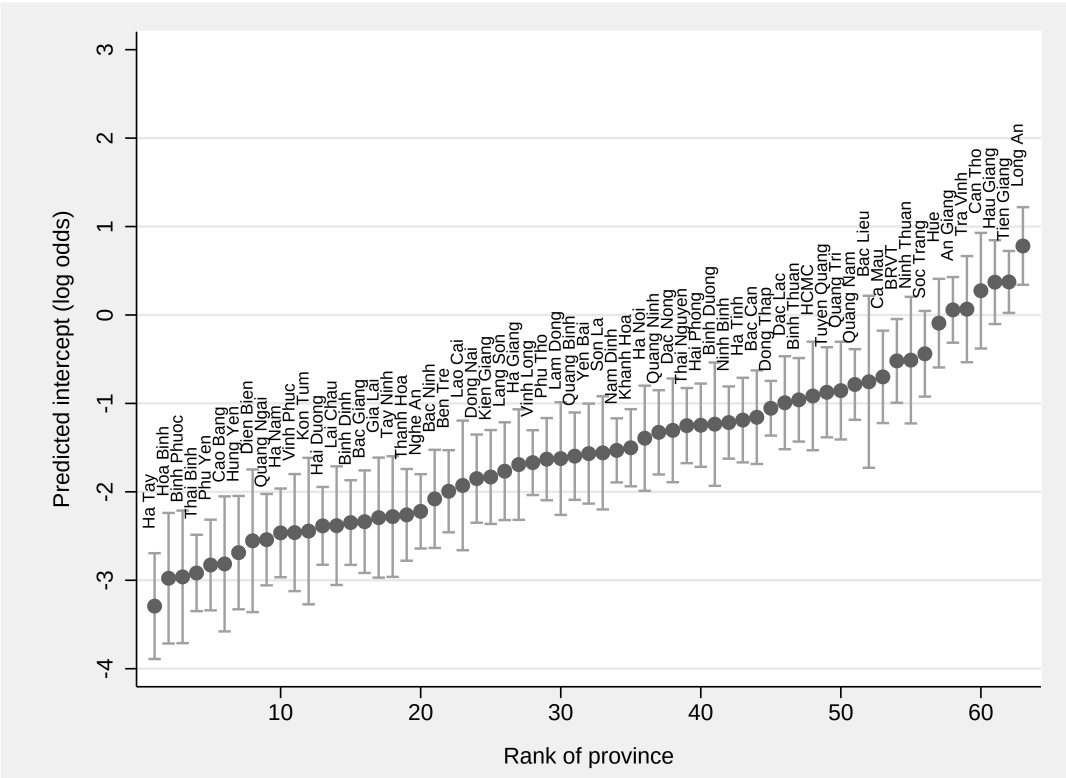
In contrast to other diffusion studies (e.g. Jenkins and Cairncross 2010), spatial proximity to towns[101] as such does not impinge on the availability of piped schemes. On the one hand, this might be plausible because contagion seems less relevant for adoption decisions of collective entities like communes. On the other hand, the finding might indicate that so far no spill-over effects of water service providers from urban to peri-urban and rural areas take place. However, validating this hypothesis would involve an analysis of spatial information that goes beyond the affiliation to

[100] Locally Weighted Scatterplot Smoother (LOWESS) plots revealed a reverse u-shaped curve for the relationship between the probability and population density which disappeared when controlling for the other independent variables as showed local mean regression (for a description of the procedure see Kohler and Kreuter 2006: 291 et seq.). In order to control for the much higher population densities in the Red River Delta (RRD) a separate interaction effect has been introduced in Model (3).

[101] The distance to major towns and larger cities such as Hà Nội, Đà Nẵng, Hải Phòng and HCMC has also been tested but also did not prove significant.

administrative units. Whereas the increasing commune sizes and spatial proximity to larger towns do not necessarily coincide with the prevalence of piped schemes, communes endowed with a larger number of social infrastructure facilities such as local, periodical, or wholesale markets, roads, electricity, and suchlike are significantly more likely to operate piped schemes. Households residing in communes that score one scale point higher on the infrastructure index have a 1.16 higher chance that they can access piped schemes.

Figure 5.4.: Empirical Bayes prediction of province-specific intercepts (based on Model 2)



Note: Empirical Bayes prediction based on Stata's `gllapred, u` postestimation command
Source: VHLSS 2008, Own calculation, only rural communes included

Unobserved heterogeneity on provincial level

But besides commune-specific characteristics, which role does the provincial affiliation of the commune play for the availability of piped schemes? A likelihood ratio test of the variance components reveals that the residual cluster variance σ_u^2 significantly differs from zero. Hence, the explicit consideration of the hierarchical structure is indeed required to gain accurate estimates.[102] The random intercept was

[102] For further explanation see p. 269.

added to the model in order to account for the unobserved heterogeneity on provincial level. 27 percent of the overall variance captured by the model are attached to the provincial level, what is in line with the hypothesis gained from the qualitative analysis that provinces play a pivotal role in decision making and planning for rural water supply. The model suggests that even after controlling for all communal level covariates, a substantial variation between the communes belonging to different provinces is left. Figure 5.4 depicts the predicted province-specific intercepts in log odds metrics based on the Empirical Bayes estimates gained from Model (2). Even after controlling for communal characteristics, piped schemes are much more likely found in the Southeastern provinces than in the mountainous Northern ones or in the Red River Delta, but also some of the central coastal provinces around Huế and Đà Nẵng show elevated probabilities. Besides these general tendencies, also large disparities between provinces directly bordering each other are striking (e.g. Quảng Ngãi vs. Quảng Nam or Bến Tre vs. Trà Vinh). Unfortunately, no explanations for these provincial disparities can be derived from the data used here. A systematic comparison across provinces about province-specific governance cultures – e.g. in terms of attitudes towards private sector participation, sector-specific regulations, tariff levels, eligible institutional arrangements for construction, investment, and operation of piped schemes would have been desirable but did not prove successful due to a lack of data.[103] Nevertheless, based on the previous analysis it is reasonable to assume that especially provincial autonomy in defining rules and thereby creating favourable conditions for the dissemination of piped schemes might be an important factor. As has be shown by the examples of Tiền Giang and Cần Thơ in Section 5.1.3, provinces might intentionally create enhancing conditions, clear out potential obstacles for investment and operation, and thereby pave the way for the establishment of institutional arrangements and their successful diffusion. In general, suchlike efforts to actively encourage regional and economic development seem to be more prevalent in the Southern part of the country where also the so-called practice of fence-breaking as an expression of a probably more liberal and proactive attitude towards policy making was more common (cf. Rama 2008; Malesky 2004).

Last but not least, I will return to the question about relative contributions of communal characteristics and provincial affiliation. Overall, the coefficients in Table 5.6 suggest that spatial characteristics play a minor role in the diffusion of piped schemes compared to communal infrastructure projects and the use of tube wells as competing alternatives. Low poverty rates and communal infrastructure projects appeared as significant drivers for access to piped schemes. In order to the illustrate effect of specific covariate patterns across provinces with distinct 'baseline conditions' in

[103] Matching data from the Provincial Competitiveness Index (PCI) for Việt Nam has performed successfully but did not yield any value added for the interpretation. The indicators included cover governance cultures and enabling conditions for privatisation in general but do not contain sector specific information which is deemed necessary here.

TABLE 5.7.: Predicted commune-specific probabilities* for selected covariate patterns and provinces

Province	Poverty rate 5%		Poverty rate 30%		Poverty rate 50%	
	No tube well	Tube well	No tube well	Tube well	No tube well	Tube well
Without communal infrastructure project						
Thái Bình	6.4	0.9	2.5	0.3	1.2	0.1
Lào Cai	15.3	2.2	6.4	0.9	3.0	0.4
Thái Nguyên	27.1	12.3	6.0	4.5	1.7	0.8
Tiền Giang	64.5	40.6	23.8	18.7	8.0	3.8
With communal infrastructure project						
Thái Bình	15.7	2.3	6.5	0.9	3.1	0.4
Lào Cai	33.0	5.9	15.6	2.3	7.8	1.1
Thái Nguyên	50.3	27.5	14.8	11.4	4.6	2.2
Tiền Giang	83.2	65.0	45.9	38.5	19.1	9.7

Note: *multiplied with 100 to improve readability, ethnic group fixed at Kinh, other predictors fixed at mean

Source: VHLSS 2008, Own calculation, only rural communes included

terms of the random intercept, Table 5.7 outlines selected predicted probabilities for four provinces. The provinces listed in the table have been chosen because of their varying intercepts. All probabilities have been calculated for the majority ethnic group Kinh and average values for all independent variables not explicitly mentioned in the table.

5.2.4. Summary and research desiderata

Based on the hypotheses derived from diffusion theory and empirical studies about rural water supply in Việt Nam, this section scrutinised how competing behaviour, interventions in the water sector, socio-economic, spatial, and geographical characteristics of rural communes impinge on the likelihood that piped schemes are under operation in rural communes. The logistic random intercept model strongly corroborates the hypothesis that the use of tube wells poses one of the main obstacles in the diffusion of piped schemes whereas interventions and supporting measures – here operationalised in terms of communal infrastructure projects – prove to be one of the most important drivers. Additionally, access to piped schemes is more likely if the communal poverty rate is low. In contrast to expectations, spatial effects and settlement structures are less relevant. Indeed, population densities turned out to be a significant predictor of piped scheme availability – but compared to infrastructure projects and the use of tube wells as competing behaviour, the effect is rather minor. The critical mass, measured as the number of potential adopters in a commune, does not have any significant effect on diffusion. This is not to deny the effect of a tipping point in intra-communal diffusion processes in general. At least it leads to the conclusion that communes are not per se ‘too small’ to operate a piped scheme but rather their inhabitants to scattered to connect. Even after controlling for communal and spatial characteristics, the geographical setting proved a significant determinant of diffusion. Compared to the delta regions, midland and mountainous communes less frequently operate piped schemes whereas the coastal communes show much higher probabilities. These differences correspond to distinct patterns of ground- and surface water availability.

The analysis reveals that besides communal characteristics, also provincial peculiarities exert substantial influence on the likelihood that piped schemes are under operation in rural communes. The significant random intercept for the provincial level corroborates the hypothesis that governance structures and the institutional environment, in which the dissemination of piped schemes takes place, differ among the provinces. However, it demands for further empirical research to substantiate and differentiate more precise hypotheses about the impact of different governance cultures, regulations, tariff structures, and suchlike for the rural water sector.

Although the hypothesis that determinants of diffusion unfold a different impact across the diffusion process could not be examined by multivariate analysis, the inspection of summary statistics indicated that competing behaviour like the use of tube wells and low population densities might not thwart diffusion in its initial stage but rather pose substantial obstacles to reach the take-off phase or even saturation.

The empirical results firstly lead to the conclusion, that in regions where water sources are not easily withdrawable or households already use own wells on their premises it is very unlikely that self-supply and HWT will be replaced by piped schemes in the short run. Secondly, the analysis suggests that local and provincial authorities definitely bear the potential to enhance the diffusion of piped schemes – the former ones by fostering local level infrastructure projects, the latter ones by creating an enabling institutional environment.

Limitations and desiderata

From the methodological point of view, the data set imposed some restrictions for further investigating factors which determine the adoption and diffusion of piped schemes in rural communes. Firstly, the parameter estimates for some dependent variables are fraught with higher uncertainty, expressed by larger confidence intervals, because the number of communes for specific covariate patterns is quite small (e.g. for remote or mountainous areas). Secondly, the very limited number of households surveyed in each commune does not allow for any precise conclusion about the share of households connected to piped schemes within communes. The descriptive analysis presented here at least delivered first clues which corroborate the assumption, that some factors unfold a different impact across early and advanced stages of diffusion. Larger samples of households per commune, respectively aggregated information about the number of households connected to piped schemes, would allow to distinguish more precisely between communes in early or late stages of the adoption process – or even to calculate a commune-specific adoption rate. Consequently, this would enable researchers to further elaborate on the hypothesis about a shift in causal effects during the diffusion process, or put it differently, to answer the questions which factors drive or inhibit diffusion in its initial stage and which ones during take-off.

Thirdly, in addition to the cross-sectional perspective applied here, it would be desirable to trace the diffusion process over time to analyse whether and under which conditions (1) completely new piped schemes emerge in rural Việt Nam, (2) piped schemes in their early stages reach the take-off phase or get stuck in this stage, and (3) piped schemes reach full coverage or at least become the main source of water in a commune. Moreover, panel analysis would allow to draw conclusions about the causal impact that go beyond mere 'timely coincidence'. Since the VHLSS is carried out bi-annually, it could serve as an appropriate basis for panel analysis to actually elaborate on causal effects, but since at maximum three subsequent panel waves can be taken into account and the number of piped schemes is still low, it is not clear whether sample size would prove sufficient for such kind of analysis.

Fourthly, the analysis in the first section of this chapter suggested that provincial regulations might pose an important factor for fostering the diffusion of piped schemes which was confirmed by the random intercept model estimated in the second section. Unfortunately, no systematic data is available to incorporate distinct regulations about water prices, eligible institutional arrangements like cooperatives, opportunities for raising initial capital or suchlike factors on provincial level in order to test the hypothesis that favourable institutional rules and environments might support the dissemination of piped schemes. The Provincial Competitiveness Index (PCI) provides a good example for how such kind of provincial-level data can be inquired and made accessible for the wider public. The PCI proved a valuable data source to examine provincial peculiarities in governance with regard to business and economic development but no reasonable sector specific candidates for variables could be identified.

6. Piped scheme accessibility in rural Việt Nam

Contents

Starting from the mere statistical fact that less than every tenth rural household in Việt Nam has access to tap water, Chapter 5 scrutinised the ‘supply-side’ dimension of the problem. It discussed under which conditions it is likely that piped schemes are available in rural communes and which types of institutional arrangements proved successful for expanding service supply to rural areas. By focusing on the aggregate level of communes, I so far dismissed the question of individual households’ access to tap water and just occasionally touched upon the reasons why people might opt for or against consuming water from piped schemes, respectively establishing first time access. But before turning attention to the household level in the second part of this section, I will start with some more general reflections about whether *availability* in communes or *accessibility* by individual households *within* communes proves the bottleneck in expanding service coverage in rural areas. Thus, this section sets out by discussing how coverage can be analytically decomposed into these two components before shedding light on potential determinants of access to piped water supply. The underlying idea of this ‘decomposition approach’ is to get an impression about to which extent slow diffusion and low coverage rates are attributable towards demand- or supply-side barriers and what this does imply for practical measures to increase access to piped water.

6.1. Decomposing availability and accessibility

Decomposition approach

Following the approach supposed by Foster and Araujo (2004) and Banerjee and Morella (2011), I distinguish between the access rate, which here denotes the percentage of households using tap water in a commune where at least one household has service coverage, and the availability rate, which refers to the percentage of households residing in communes with piped scheme coverage.[104] Whereas the availability rate indicates potential supply-side deficiencies, the access rate accounts for demand-side deficits, which are – amongst other factors – attributable to unwillingness or inability to connect due to financial constraints, societal factors, or the use of competing alternative water sources. Based on the equations given below, it can easily be shown that the coverage rate can be obtained by multiplying access and availability rate.

$$\text{Access rate} = \frac{\text{Number of hh using tap water}}{\text{Total number of hh in communes with piped schemes}}$$

$$\text{Availability rate} = \frac{\text{Number of hh in communes with piped schemes}}{\text{Total number of households}}$$

$$\text{Coverage rate} = \text{Access rate} \times \text{Availability rate}$$

Source: Foster and Araujo (2004: 75)

Figure 6.1 depicts access and availability rates for urban and rural districts in Việt Nam across administrative regions which have been calculated based on the approach just outlined above. *Urban districts* Urban districts exhibit availability rates ranging between 55 and 82 percent, whereby the Central Highlands and Northwestern region have the lowest share of population living in communes which are endowed with piped schemes. Also access rates appear much higher than in rural districts: between 70 and 94 percent of the local population are connected here. Whether higher take-up rates in urban regions are attributable to higher population densities, greater spatial proximity to grids, higher service levels, increased affordability, or simply the lack of alternative water sources cannot be answered here.

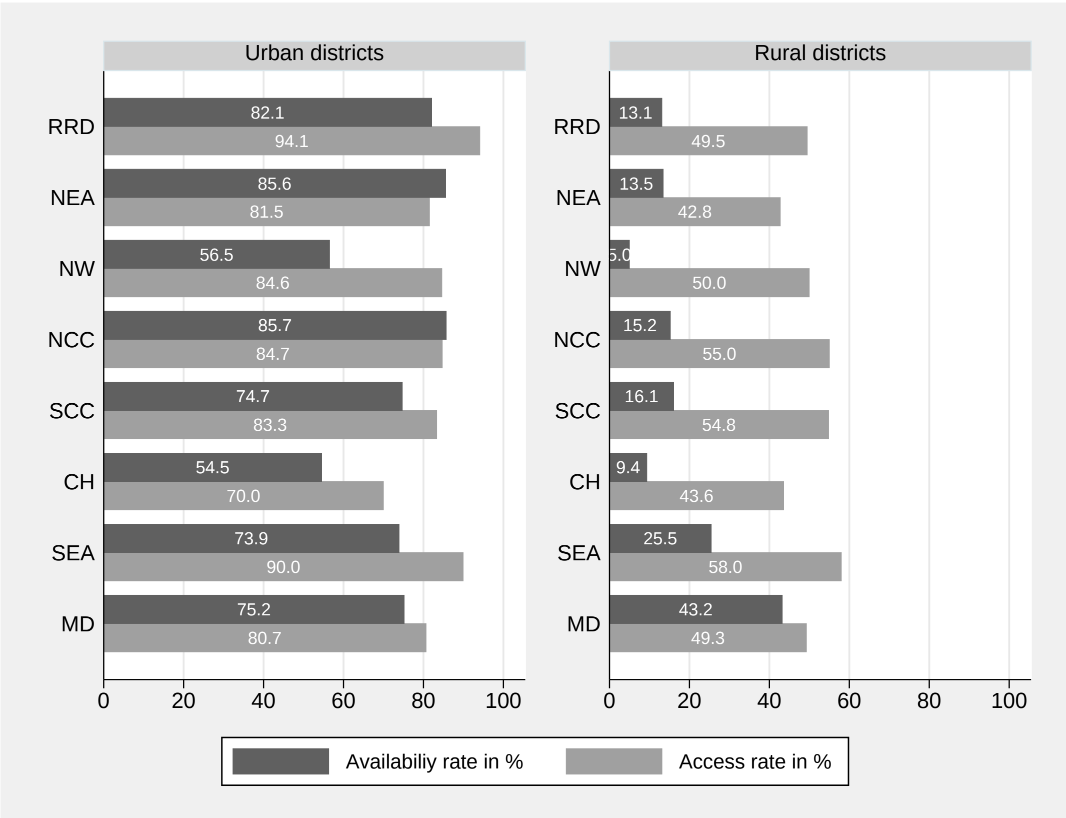
Rural districts In contrast, in rural areas availability ranges between 5 percent in the Northwestern region and 9 percent in the Central Highlands on the lower end of the scale and 43, respectively 26 percent, in the Southern provinces on the upper end of the scale. With regard to access rates, less differences across the regions show up: on average every second household in those communes where piped schemes are available is actually connected to them or consumes water from a public tap. Among the rural regions, the Central Highlands and the Northeast account for lowest rates, whereas the Southeast, South Central Coast, and North Central Coast score with highest access rates.

So far, at least for rural areas I can conclude that even if piped schemes exist, their coverage is far from being universal. Also the previous analysis in Section 5.1.4 revealed that water supply within communes does hardly follow a homogenous pattern:

[104] Foster and Araujo (2004) use a slightly different terminology, but the definitions applied here are equivalent.

Cross-tabulating the households' main source of drinking water and the main source of drinking water used in the respective commune as in Table 5.2 revealed substantial intra-communal heterogeneity and underlined the assumption that piped water schemes barely reached full coverage in rural communes yet. More than half of the households living in communes for which the local leaders stated piped water as the main source for drinking water, indeed rely on other sources. Almost every fifth household still prefers to drink rainwater, roughly one quarter has a tube or dug well, and every tenth primarily drinks surface water.

FIGURE 6.1.: Decomposition of coverage rate for urban and rural districts across administrative regions



Note: Calculation according to definitions by Foster and Araujo (2004); Banerjee and Morella (2011)
Source: VHLSS 2008, Own calculation

In the following, I will have a look at the question, how strongly supply- and demand-side factors contribute to the share of unserved households. Based on the decomposition of the overall coverage rate, demand- and supply gaps in absolute terms and as a relative measure in terms of the share of unserved population attributed to demand-and supply-side deficits have been calculated in line with the approach suggested by Foster and Araujo (2004):

$$\begin{aligned}
\text{Unserved population} &= 100 - \text{Coverage rate} \\
\text{Pure demand side gap} &= \text{Availability rate} - \text{Coverage rate} \\
\text{Supply side gap} &= \text{Unserved population} - \text{Pure demand side gap} \\
\text{Pure supply side gap} &= \text{Supply side gap} \times \text{Access rate}
\end{aligned}$$

Source: Foster and Araujo (2004: 75)

Table 6.1 provides the calculated indicators for demand- and supply side effects for urban and rural districts in the eight administrative regions. In all rural regions, except for the Mekong Delta, less than one eighth of the unserved population is attributed to the demand-side gap. Contrasting the relative contribution of demand- and supply-side factors to the service gap suggests that in rural Vietnamese communes, low coverage is mainly attributable to supply-side factors, whereas demand-side factors only play a substantial role in the Mekong Region. Compared to other regions, it comes up with the highest overall availability (43%), but simultaneously the access rate (49%) still remains on the same level as in other rural regions. This finding raises the question about adequate policy responses to address the supply- and demand gap. Obviously an expansion in availability does not necessarily come along with increasing levels of accessibility. Compared to rural districts, the relative deficit due to demand- and supply-side factors is much more heterogeneous in urban areas. Whereas in the Red River Delta, the Northwest, and the Southeast more than 70 percent of the service deficit are attributable to the availability within communes, in the Northeast and North Central Coast accessibility on household level poses the larger hurdle to increasing piped scheme coverage.

Assessment of the decomposition approach

When applying this approach of an analytical decomposition of demand- and supply side effects, one should be aware about potential sources of bias (cf. Banerjee and Morella 2011). Firstly, given that households are located too far from the grid in order to connect or the capacity of the existing system is too low in order to serve all households, this would lead to an underestimation of the supply-side deficiencies, respectively overestimation of the actual availability in this commune. In order to control for this bias, Diallo and Wodon (2007) propose an adjustment of the access rate based on a simulated maximum connection rate among the richest households. However, this approach is deemed less appropriate for rural areas with lower popu-

TABLE 6.1.: Decomposition of coverage rates in urban and rural districts across administrative regions

Administrative region	Number of hh in communes with tap water	Total number of hh	Number of hh with tap water	Availability rate	Access rate	Coverage rate	Unserved population	Pure demand side gap	Supply side gap	Pure supply side gap	Proportion of deficit due to demand side factors only	Proportion of deficit due to supply side factors only
Rural												
Red River Delta	198	1,509	98	13.1	49.5	6.5	93.5	6.6	86.9	43.0	7.1	46.0
Northeastern	138	1,026	59	13.5	42.8	5.8	94.2	7.7	86.5	37.0	8.2	39.3
Northwestern	18	360	9	5.0	50.0	2.5	97.5	2.5	95.0	47.5	2.6	48.7
North Central Coast	129	846	71	15.2	55.0	8.4	91.6	6.9	84.8	46.6	7.5	50.9
South Central Coast	93	579	51	16.1	54.8	8.8	91.2	7.3	83.9	46.0	8.0	50.5
Central Highlands	39	417	17	9.4	43.6	4.1	95.9	5.3	90.6	39.5	5.5	41.2
Southeastern	162	636	94	25.5	58.0	14.8	85.2	10.7	74.5	43.2	12.5	50.7
Mekong Delta	633	1,464	312	43.2	49.3	21.3	78.7	21.9	56.8	28.0	27.9	35.6
Total	1,410	6,837	711	20.6	50.4	10.4	89.6	10.2	79.4	40.0	11.4	44.7
Urban												
Red River Delta	357	435	336	82.1	94.1	77.2	22.8	4.8	17.9	16.9	21.2	74.2
Northeastern	249	291	203	85.6	81.5	69.8	30.2	15.8	14.4	11.8	52.3	38.9
Northwestern	39	69	33	56.5	84.6	47.8	52.2	8.7	43.5	36.8	16.7	70.5
North Central Coast	144	168	122	85.7	84.7	72.6	27.4	13.1	14.3	12.1	47.8	44.2
South Central Coast	204	273	170	74.7	83.3	62.3	37.7	12.5	25.3	21.1	33.0	55.8
Central Highlands	90	165	63	54.5	70.0	38.2	61.8	16.4	45.5	31.8	26.5	51.5
Southeastern	408	552	367	73.9	90.0	66.5	33.5	7.4	26.1	23.5	22.2	70.0
Mekong Delta	300	399	242	75.2	80.7	60.7	39.3	14.5	24.8	20.0	36.9	50.9
Total	1,791	2,352	1,536	76.1	85.8	65.3	34.7	10.8	23.9	20.5	31.3	59.0

Note: Calculation according to definitions by Foster and Araujo (2004); Banerjee and Morella (2011), access to taps here also involves public taps
Source: VHLSS 2008, Own calculation

lation densities. Secondly, it might be misleading to interpret low accessibility rates generally as matter of affordability, marginalisation of specific groups, or general eligibility to connect because households might intentionally decide not to connect to the grid. As the previous analysis has shown, it is reasonable to assume that in rural Việt Nam, in particular more affluent households are likely to buy bottled water or rely on own tube wells and treatment facilities. Consequently, demand-side characteristics are here to a considerable extent also conditioned by competing alternatives and not exclusively by affordability. Thus, instead of applying some kind of adjustment as proposed by Diallo and Wodon (2007), for the case of rural Việt Nam, it seems more appropriate to further elaborate on the nature of demand-side deficiencies and on the respective sources of demand-side problems – namely affordability, social drivers, or the use of competing alternatives – and their relative contribution to the demand-side gap.

6.2. The nature of the demand-side gap

So far, the diffusion of piped schemes has primarily been considered as collective, respectively authoritative adoption decision from the communal perspective. Chapter 5 discussed the supply-side dimension – meaning the availability of piped schemes in rural communes – and identified the wide-spread use of tube wells and high poverty rates as the most crucial obstacles and communal infrastructure projects and high population densities as relevant drivers of piped scheme availability. Furthermore, the decomposition of coverage rates revealed that even if piped schemes exist, within-commune coverage is far from reaching universal level and on average every second household relies on different kinds of self-supply. Thus, the question arises which factors might deter households from connecting to piped schemes, respectively encourage them, given that such service is physically available in their commune. Are there any specific supporting measures triggering connections? Which groups of households are most likely or unlikely to connect and which role does 'contagion' play? Does a household's inclination to connect to piped schemes rather depend on its individual endowment or are there also relevant commune level factors?

Optional decisions

Following Rogers (2003: 28), the decision to connect to a piped water scheme can be conceived as an 'optional innovation' decision, meaning the individual household may adopt or reject hook-up independently from other communal residents and users of the system. As has been explained in detail in Chapter 4, this conception of 'independence' does neither exclude the effect of social norms nor that of mutual benefits between early and late adopters (see p. 130). Undoubtedly, there is a bunch of factors which might impinge on individual households' access to a private tap and which are related to the social environment or the behaviour of 'significant others' (e.g. the marginalisation of households due to their social status or ethnicity, the need to comply with descriptive norms, or social learning). Moreover, especially in the stage when piped schemes are established for the first time at a specific location, the individual decision for connection and initial investment might also be relevant for the collective decision to operate a piped scheme on the hamlet or commune level. So despite being conceptualised as 'optional' innovation decision, the aggregation of such household level decisions might also affect the collective level as has been illustrated in Figure 5.1.

This chapter proceeds by discussing potential determinants of private tap ownership. The regression models estimated in Section 6.4.2 explore the relationship between household and commune level characteristics and individual households' access to private taps in their houses or on their premises. By applying multilevel regression models, this chapter finally brings the household and commune level together by explicitly considering households as nested in communes. After deriving and discussing the central hypotheses to be tested subsequently, their operationalisation, the modelling approach, and the data source will be introduced. This chapter concludes by discussing the results and interpreting them with regard to what has been found out about determinants of piped scheme availability on the communal level.

6.2.1. What does access mean?

But before I dig deeper into the discussion of potential determinants of piped scheme connection, it seems worthwhile to dwell on the question what exactly the term *access* denotes here. How can *access* be interpreted in the context of diffusion studies, which aspects does it probably dismiss, and what does that imply for interpreting the findings of the models to be build up in this chapter?

First of all, *access* is not necessarily equivalent to *use*. Whereas studies of willingness to pay (e.g. Nauges and van den Berg 2006; Merrett 2002; Whittington et al. 1990) often refer to the amount of water consumption in order to derive price elasticities or demand functions for piped water services, here it will exclusively be considered whether a household relies on water from a private tap in its own house or on its premises, regardless of the amount of water it does actually consume from it and the purpose this water is used for.[105] Surely, in particular to answer the questions about competing alternatives or strategies about the diversification of water use, it would be desirable to measure water consumption more precisely, but the data sources utilised here do not offer such information. Secondly, measuring household and commune level characteristics and access to piped schemes at a certain point of time does not necessarily mean that these conditions have also been relevant for households' *adoption decisions*. On the one hand, this is simply because cross-sectional snapshots do not allow for causal inference in general, on the other hand because household as

[105] For a definition of the dependent variable see Table 6.2.

well as commune level characteristics might have changed between the point of time when the decision for or against hook-up was taken and when access was measured by a survey. Thus, in the narrow sense, here nothing can be said about the decision-making process itself but only about its observable outcome.

6.2.2. Determinants of access to piped schemes

This section discusses potential determinants of access to safe water based on secondary literature and previous findings and summarises important effects in terms of hypotheses. Hypotheses usually seek to transfer assumptions about the phenomena to be observed into terms of empirically measurable relations between variables. But even if this expected regularity or relationship is also 'statistically detected', this does not necessarily imply that it is unequivocally interpretable. Presuppositions about the mechanisms which are suggested to bring about the observed relationship might be wrong or lacking at all (see Section 1.5.1). Hence, this section does not only address the hypotheses to be tested but also discusses diverging interpretive approaches and underlying mechanisms.

Hypothesis 6.1 *Households with higher disposable income are more likely to use a private tap because obtaining first time access often requires a substantial initial investment and variable costs are perceived as high. (Affordability Hypothesis)*

As Section 2.7 discussed, studies of customers' willingness to pay, revealed income as an important – but not overriding – determinant of households' willingness to pay for improved access to water supply (Kayaga et al. 2003; Whittington et al. 1990; The World Bank Water Demand Research Team 1993). There are numerous reasons adducible why the affordability hypothesis demands for further differentiation: first of all, affordability and willingness to pay do not necessarily mean the same. In contrast to mere affordability, willingness to pay for water services has been found to depend on lots of other factors than income and costs, such as service levels and reliability of the source, water quality, or demographic characteristics (Merrett 2002; Kayaga et al. 2003; The World Bank Water Demand Research Team 1993; Whittington et al. 1990). Some studies suggest that willingness to pay for water quality might be lower than those to pay for water quantity and convenient supply (Kremer et al. 2011; Ashraf et al. 2010). Willingness to pay and affordability might also fall apart if people expect free or subsidised services from the government (Whittington et al. 1990). Interestingly, empirical studies which contrast expenditure for water supply with those for other purposes (Sy et al. 2014; Bey et al. 2013; Tobias and Berg 2011) suggest that affordability does not necessarily pose the bottleneck for expanding access to water. The contradiction that a wide range of measures for improving rural water supply are in principle assessed as 'affordable' by experts while deemed 'too expensive' by their potential users, supports Banerjee's and and Duflo's call (2006) to pay more attention to understanding poor households' rationales for consumption. Probably the most discussed finding about poor households' consumption behaviour was that those tend to value small immediate rewards more than larger gains in the future – which is usually referred to as time-inconsistent preferences (cf. Tarozzi and Mahajan 2011; Banerjee and Mullainathan 2010; Ainslie 2001) – and would explain why households prefer to spend money on other consumption purposes instead of connecting to piped schemes.

Secondly, when assessing affordability of tap water by considering average disposable income, one neglects the fact that the main financial burden for getting access to tap water does not arise from the variable costs for the consumed amount of water but for connection fees and initial investment. Costs for first time access have been identified as a major factor why households opt for or against a water source (Altaf et al. 1993; Singh et al. 1993; The World Bank Water Demand Research Team 1993). As has been reported for Việt Nam, initial costs for piped scheme connection result from costs for the installation of the meter and the pipes. Moreover, user contributions can also make up a large share of the overall investment to establish a piped scheme (e.g. van den Berg 2002; Salter 2004).

Thirdly – although access to infrastructure is often deemed a matter of income – in many developing countries even among the upper-income groups access is far from universal and highly variable (cf. Banerjee et al. 2008). But why do households – given that they are located within the scope of a piped scheme – do not connect to them even if they could afford it? Following the argumentation from diffusion theory as outlined in Chapter 4, households will adopt an innovation if they perceive it as advantageous compared to other alternatives or the status quo. Studies about rural water supply in Việt Nam confirm that there is no unequivocal preference for tap water: A household survey in Cần Thơ province revealed that rural households rank tube well water as the most hygienic source, followed by rainwater and piped water. Although piped water supply is perceived as hygienic and high quality, that does not provide a relative advantage in comparison to tube wells because users of tube wells are more satisfied with hygienic quality. Surface water on the contrary scores highest concerning affordability whereas access to rain, well, and piped water is perceived most convenient (cf. Spencer 2008b and p. 52). The role of the relative advantage will be further discussed in Hypothesis 6.5. At least these examples show that numerous moderating factors have to be kept in mind when assessing the relationship between access to piped schemes and households' economic endowments and that thinking about the mechanisms behind potential statistical correlations of variables is inevitable for interpreting the empirical findings.

Hypothesis 6.2 *Larger households are more likely to connect to piped schemes because costs for initial investment might be spread on more persons.*

Larger households are expected to have more frequently access to tap water because initial costs (and also block rate tariffs) are spread on a larger number of household members, and thus, the financial burden would be relatively lower compared to small households.[106] However, when testing this hypothesis confounding effects have to be taken into account, since especially very large households or single person households are often economically disadvantaged (cf. Banerjee and Duflo 2006: 3).

Hypothesis 6.3 *Households participating in programmes to improve safe water on individual level or on communal level are more likely to have access to safe water.*

As has been outlined in Section 3.3.3, numerous programmes provide support to communes and households for improving water supply and sanitation and thereby increase coverage, respectively reduce coverage gaps between poor and more affluent households. Besides targeted financial or in-kind support, such measures might comprise micro-credits which compensate a lack of financial means to improve water supply. For example, the implementation of the National Strategy for the Rural Water Sector also incorporates a micro-credit scheme of the VBSP and numerous credits have already been granted for water-related construction works within the framework if this scheme (VBSP 2013). Moreover, programmes might also facilitate households to connect to piped schemes by raising awareness and triggering behavioural change.

Hypothesis 6.4 *Households with higher educational status and small children are more likely to be connected to piped schemes.*

Water-related diseases still pose one of the most relevant causes of death or illness in Việt Nam and in particular among children (see Section 2.2). Thus, it should be tested whether households whose members have a higher educational status or small children are more likely to consume piped water because they are probably more aware about the transmission routes of water-washed or water-borne diseases or feel more seriously threatened by them. In line with psychological concepts like the Protection Motivation Theory (Rogers and Prentice-Dunn 1997; Prentice-Dunn and Rogers 1986) or the Theory of Planned Behaviour (Ajzen 2002, 1985), households facing higher subjective health threats or vulnerability and showing higher levels of knowledge and awareness about water-related diseases are theoretically more likely to perform preventive behaviour, such as using water from safe sources or applying some kind of point of use treatment. Albeit in practice, empirical evidence casts doubts on the predictive quality of these factors. Higher awareness and knowledge about

[106] Banerjee and Morella (2011: 38) outline another argumentation concerning the effect of household size. They argue that coverage rates languish in African countries because population growth and decreasing household sizes eat up the meager growth in the number of connections. Whether this also holds true for Việt Nam cannot be assessed based on cross-sectional data and is not of relevance for analysing coverage rates at a certain point of time like it is done here.

water-related diseases have often proved only weak predictors of health-preventive behaviour (cf. Section 2.6.2 and 4.2.2). Field studies in Bangladesh and Việt Nam failed in detecting a relationship between knowledge, awareness, and preventive behaviour but identified social norms and perceived odour and taste of water as significant determinants of preventive behaviour (Bui and Wegner 2011; Tobias and Berg 2011; Mosler et al. 2010). That these observations do not pose an unfortunate and accidental exception but are rather typical patterns, has recently been confirmed by a meta-study (Thurber et al. 2013: 1736). This is not to deny in general the impact of health considerations but indicates that in the absence of awareness and knowledge about specific water-related problems others factors turn out to be influential. Thus, also for the individual inclination to connect to piped schemes health-related considerations are expected to play a rather minor role compared to other factors.

Hypothesis 6.5 *Households using own tube wells are less likely to connect to piped schemes. (Competing Strategies Hypothesis)*

The hypothesis that households which own tube wells are less likely to connect to piped schemes is based on three basic arguments which have been introduced in Chapter 4. Firstly, as has been discussed above, tube wells are highly valued by rural households due to the hygienic quality and convenient supply of water directly on premises. Secondly, after initial investment for drilling wells, constructing sand-filters, or acquiring other filters, variable costs for self-supply are usually lower than fees for piped water. And thirdly, so-called switching costs raise the total costs for using piped water. Users who already invested substantial amounts of capital might refrain from switching to other water sources and especially to piped schemes because they are not willing or able to ante up the initial costs again (cf. Spencer 2008b). In order to disentangle, whether mere availability of groundwater – and thus the availability of an advantageous alternative – makes the difference or indeed the costs for drilling a well or lower variable costs for tube well water, the model has once been estimated including the main source of water as commune level variable and once as household level variable.

Hypothesis 6.6 *Positive effects of increasing income, respectively expenditure levels are expected to be lower if households already use tube wells. (Differentiation of Competing Strategies Hypothesis)*

If switching costs are expected to increase the total costs for connecting to a piped scheme, it is reasonable to assume that the negative effect of tube wells as competing water source diminishes once the household income goes up and ensuing, initial costs already spent for drilling the well and installing pumps become less relevant. Put it differently, if households already invested in drilling a well, acquiring pumps and other necessary facilities, rising income levels are expected to have a negligible impact until a certain level of income is reached and households can afford further investment into piped water supply.

Hypothesis 6.7 *Lower connection rates among poor or ethnic minority households are more likely attributable to spatial and economic factors than to mechanisms of social exclusion.*

Descriptive analysis clearly indicates lower connection rates among ethnic minority and poor households. Whether these are attributable to some kind of social exclusion or are primarily a corollary of the coincidence of remoteness and a lack of affordability and alternative water sources needs to be clarified. Inevitably, a strong linkage between ethnicity, poverty, and geographical conditions is prevalent in rural Việt Nam. Besides regional disparities; household size, educational and occupational status of the head of the household, the type of housing, sanitation, electrification, and the source of water have been found to correlate with rural households' per capita expenditure (see Section 2.7.2 and Minot and Baulch 2005). Although the ethnic minority status has not been found a significant predictor for per capita expenditure, living standards of households belonging to the more than 50 ethnic minorities are lagging far behind those of the majority Kinh as they are usually residing in remote areas (Baulch et al. 2010). Yet, disparities in livelihood conditions between major ethnic groups and minorities do not only show up between regions but also within communes. For example, Pham et al. (2011: 15) observed that Kinh or Thái households live along the main road and in areas accessible by transportation whereas ethnic minority households reside in more remote parts. But beyond spatial factors and livelihood strategies, are there any additional social barriers to piped scheme hook-up? Does coverage reach higher levels and increase faster among a ethnically or socially homogenous population as Rogers' (2003) homophily-heterophily hypothesis suggests? Or does ethnicity only turn out to be a disadvantage if the household's ethnicity differs from that of the major group in the commune?
So far, for Việt Nam no explicit evidence has been found witnessing exclusion from piped scheme connection due to ethnic minority or low social status as such. However, it also needs to be taken into account that differences in status or marginalisation are arguably expressed in a more subtle way and might thus remain 'invisible' when simply focusing on categories like having physical access to piped schemes. In view of scarce resources, the investigation of water-related conflicts has become a hot topic, whereas less attention has been paid to intra-communal conflicts arising from the heterogeneity in access and control due to social status, gender, or ethnicity (Mehta 2005). In fact, numerous conflicts about water for domestic and productive purposes are staged at the local level and poor households often remain passive and abstain from taking actions due to dependency relations (Funder et al. 2012; van Koppen

et al. 2012). For example, case studies from Nghệ An province documented enduring conflicts about illegally cutting pipes of communal water systems to divert water for private purposes. Additionally, commune leading cadres have been found to take advantage of their position by influencing the selection of construction sites to their own benefit (Funder et al. 2012; Le et al. 2010).
Furthermore, it seems likely that mechanisms of exclusion of specific households or groups are moderated by the institutional arrangement of the respective piped scheme. Given that it is organised by the commune itself or a water user group, small conflicts and social exclusion as just described above are probably more relevant for restricting access than mere financial constraints because these can be compensated by in-kind labour contributions. In contrast, if the operator of the piped scheme is less involved in commune issues and there is less scope for negotiating individual 'advantages', the influence of affordability is expected to gain in importance relative to social factors.

Hypothesis 6.8 *Households are more likely to adopt if households in the nearby environment are also connected to piped schemes. (Contagion Hypothesis)*

In line with epidemic models, diffusion is conceived as a contagion process triggered by the transmission of information from a central source and word of mouth, meaning that each adopter contacts a non-adopter with a given likelihood (cf. Geroski 2000; Strang and Soule 1998; Mahajan and Peterson 1989). Applying this notion points to two important sources of contagion: contact to individuals which already adopted in previous periods and contact to other sources of information. Whereas here the central source of information could be conceptualised as larger towns, where piped water coverage is higher or health centres which provide health messages, the likelihood to get into contact to previous adopters is supposed to increase if coverage in the proximate environment increases. Indeed, explaining adoption by nearby adoption puts a black box around the phenomenon and requires to conceptualise mechanisms how contagion actually is expected to proceed and which factors moderate these mechanisms (e.g. supply chain requirements, reciprocal interdependency see p. 130). Do adopters carry information to potential other adopters which are socially linked to them or at least alike with regard to social status? Does mere spatial proximity increase observability and trialability regardless of adopter characteristics? Does the reinforcement of adoption as a social norm impose pressure on other households to connect as well and is this 'pressure' (e.g. in terms of injunctive or descriptive norms or reflections about status) dependent on the level of adoption at the specific location in general, meaning low social pressure for early adopters and high pressure for the laggards? There are numerous mechanisms conceivable to explain contagion effects. As the study about sand-filter use (Tobias and Berg 2011) and own field research (Bui and Wegner 2011) suggested, compliance to social norms and social learning in the village environment play a crucial role for the diffusion of HWT techniques in rural Việt Nam and thus it is likely to assume that similar mechanisms are import to explain piped scheme connections. For the investigation of contagion effects, here also the question for their scope and spatial nature seems to play a role.

Hypothesis 6.9 *Households residing in communes with lower population density and scattered settlement structures have lower chances to be served by piped schemes.*

Potential relationships between households' probabilities to connect, population densities, and settlement structures can be interpreted in terms of two different mechanism. The first one builds upon the concept of contagion and proximity to previous adopters. Strang and Soule (1998: 275) argue that spatial proximity does not provide any kind of distinctive logic but 'often provides the best summary of the likelihood of mutual awareness and interdependence' (cf. p. 128). The basic idea behind the impact of spatial proximity and population density is that diffusion is more likely if adopters are in close spatial contiguity, which supports contagion by higher communication frequencies and stronger interactions between potential adopters (Rogers 2003). Here this means that more compact settlement structures are expected to support contagion processes because information about advantages of using tap water travels faster and observability and trialability increase if an area is more densely inhabited.
The second interpretation refers to the nature of network infrastructure and the physical availability of piped schemes. In particular small-scale piped schemes are often of limited scope and only designed to serve a limited number of households or a specific hamlet (cf. Le et al. 2010). Especially if households belonging to a commune are scattered across different hamlets or a large area, piped schemes might not be physically accessible, respectively the effort too large to connect to them. Costs for first time access have to be paid by the household and are often higher in sparsely populated areas because they depend on the distance to be bridged between the household and the grid. Moreover, the share of user contributions to initial and recurrent costs for establishing and maintaining a piped scheme might be relatively higher if less households are connected. Such linkages between supply- and demand-side factors have been discussed throughout Chapter 5 and illustrated by Figure 5.1. Surely, against this background it would be misleading to automatically denote the complete share of unserved population as a matter of demand characteristics. But likewise, even when considering only communes in which piped schemes are under operation, supply-side effects are not completely partialed out. Whether capacities of piped schemes in rural areas actually impose a severe restriction can hardly be assessed on the data at hand. Whereas for urban and peri-urban areas some empirical evidence has been found which points to over-designed systems operated by the PCs or private WSCs, those managed by cooperatives and communes tend to follow more

local demand more closely by gradual investments in their expansion (van den Berg 2002: 22 et seq.). As has been outlined in detail in Chapter 5, rural areas are rather served by non-professionally operated schemes which are often dependent upon user contributions whereas private WSCs up to now hardly play an important role in rural areas. So although no evidence-based conclusion can be drawn about whether the capacity of the system severely restricts the number of users, (temporary) shortages in supply seem fairly more likely than over-designed systems.

6.3. Data, operationalisation, and modelling approach

The analysis draws on the Vietnamese Housing and Living Standard Survey 2008, which has been introduced with regard to sampling, data generation, and content of the questionnaires in Section 1.5.2. In contrast to the models in Section 5.2, here the primary unit of analysis are households nested in communes. In total, the VHLSS 2008 comprises 6,837 households belonging to 2,278 communes. Thus, the number of households per commune is very small but balanced. For the analysis of piped scheme accessibility, only those 470 communes (comprising 1,410 households) in which at least one household states to use piped water or in which tap water poses the main source of drinking water have been taken into account (for the definition see Table 6.2 and further explanations on page 199). This restriction has been introduced because attention is directed to the question of piped scheme hook-up by individual households given that some kind of centralised water supply already exists in the commune.

6.3.1. Measures and operationalisation

The model estimated here explores the relationship between household and commune level characteristics and individual households' access to private taps in their houses or on their premises. Therefore, the subsequent section discusses the operationalisation of the dependent and selected independent variables.

Dependent variable

The regressor for the logistic model has been recoded as a binary variable based on the information that either water from a private tap is the major source of water for drinking, respectively other purposes, or not used at all. It indicates that the household is physically connected to some kind of centralised distribution network regardless of the amount of water which is actually consumed from this source.

Competing behaviour

Households' habits in using alternative water sources and substitutes for tap water are captured by three variables: Firstly, households' access to private tube wells has been taken into account in order to test Hypothesis 6.5 that the use of tube wells hampers the diffusion of piped schemes. Secondly, the information that tube wells are the main source of water in the commune – regardless whether the specific household owns a well or not – is considered as a proxy for the physical feasibility of ground water abstraction by tube wells in the commune. Whereas the first indicator in particular aims to measure the influence of a competing alternative to piped water which has in other studies often been assessed as cheaper, more reliable, and of good odour and taste; the second indicator has been introduced to test whether the influence of competing behaviour arises from its mere availability or only if households already invested in the facilities to perform the competing behaviour. Thirdly, to control for the simultaneous use of multiple water sources, a dummy variable has been added. It is coded 1 if the household uses different water sources for drinking, cooking, and other daily purposes, and 0 if it always relies on a single source. This third indicator accounts for the finding that households use water of different qualities depending on the purpose and try to keep the amount of water consumed from piped schemes low (see Implication 3 on p. 53, Table 5.2 and p. 152).

Socio-demographic characteristics

Water-related behaviour aside, a number of variables describing households with regard to socio-demographic and economic characteristics have been included, some of them explicitly referring to the head of the household (e.g. educational status, sex, ethnic status). A dichotomous variable was introduced to identify ethnic minority households. Here, a household has been classified as ethnic minority if the head of the household does not belong to the major ethnic group of Kinh, which comprises more than four fifth of the population.[107] The educational level refers to the highest grade which the head of household has completed and ranges from 0 to 12. Grades from different education systems as the current one have been converted to the standard education system (GSO Vietnam 2008a: 48).

Household structure

Household structure is captured by three variables: household size, sex of the head of household (coded 1 if female and 0 if male), and children living in the household. Since for the latter, the main interest is in scrutinising whether households with small children are probably more concerned about water-related diseases and thus more likely to connect to piped schemes, only young children have been taken into account (Hypothesis 6.4). Households are coded 1, if at least one child below six years lives in the household. Household size has been taken into account in order to test whether larger households are more likely to connect to piped schemes because the share of initial and fixed costs is spread on more persons. Since the relationship between household size and the probability of being connected to a piped scheme followed a reverse u-shaped pattern – meaning increasing chances for rising household size but decreasing ones for households with more than seven or eight persons – household size has been recoded into three groups. Whereas households comprising four to seven persons served as reference group, dummies for smaller and larger households have been added to the model to test whether these households have significantly lower, respectively higher chances to own a private tap compared to medium-sized ones.

[107] Equivalent approaches of dichotomisation have been applied in other studies in Việt Nam (Baulch et al. 2010; Swinkels and Turk 2007; Minot et al. 2006).

Table 6.2.: Operationalisation of dependent and selected independent variables

Selection variable	**Variable definition**
Commune without piped scheme	0=Tap water used by none of sampled households *and not* main source of drinking water in commune
Commune with piped scheme	1=Tap water used by at least one sample household *or* main source of drinking water in commune
Dependent variable	
Access to private tap	Household uses access to tap water on own premises as main source for drinking and cooking *or* for other daily purposes
No access to private tap	Household uses access to tap water on own premises *neither* as main source for drinking and cooking *nor* for other daily purposes
Independent variables	
Poor hh with programme	Poor household which participates in programme ‘Safe water for poor people’ (dummy with reference group non-poor household)
Poor hh without programme	Poor household which does not participate in programme ‘Safe water for poor people’ (dummy with reference group non-poor household)
No private tube well	0=Household uses private tube well *neither* as main source for drinking and cooking *nor* for other daily purposes
Private tube well	1=Household uses private tube well as main source for drinking and cooking *or* for other daily purposes
Use of single water source	0=Household uses same water source for drinking/cooking and for other daily purposes
Use of multiple water sources	1=Household uses different water sources for drinking/cooking and other daily purposes
Nearby adoption rate	Share of households in district with access to piped water compared to total number of households in district
Small household	Household consists of less than 4 persons (dummy with reference group medium-sized household)
Large household	Household consists of more than 7 persons (dummy with reference group medium-sized household)
Expenditure (quintiles)	Yearly per capita consumption expenditure in quintiles to reduce effect of right-skewed distribution
Expenditure (ln)	Yearly per capita consumption expenditure logarithmised to reduce effect of right-skewed distribution
Infrastructure project for WS	Commune carried out at least one infrastructure project for safe water supply during last ten years (see also p. 104 et seq.)

Economic status

Households' economic status and hence ability to pay for water is measured by yearly per capita consumption expenditure. Consumption expenditure has here been preferred compared to overall expenditure and income because it allows to estimate how much money rural households can actually spend on daily purposes excluding expenditure for productive purposes or repaying debts. Since the focus is on disposable income rather than an overall 'wealth measure', no additional index including assets, livestock, and land ownership or the like has been calculated.[108] Like it is often found for monetary variables (e.g. income, expenditure), the distribution of expenditure is slightly right skewed, respectively log-normally distributed (see Figure 6.2) and Locally Weighted Scatterplot Smoother plots revealed problems with the functional relationship with the predicted probabilities due to extreme values. Thus the expenditure variable has been modified to overcome this problem: firstly, it has been logarithmised in order to 'compress' the large values of the predictor variable and 'spread' the small ones. This transformation accounts for the fact that for groups on the lower end of the income distribution, equal absolute increases in expenditure might provoke larger increases in the probability of access to piped schemes than for more affluent groups. Meaning, an increase in disposable income by 100,000 VND per month may enable a rural household with a monthly per capita consumption expenditure of 500,000 VND to accumulate some capital to improve water supply or sanitation facilities which might not have been possible otherwise; whereas this amount might hardly provoke a fundamental change in spending for water supply if the household already spends 2 or 2.5 million VND per capita and month for consumption purposes. A second approach to deal with the skewed expenditure distribution has been the grouping into income quintiles to reduce the influence of extreme values. Both approaches have been applied in model estimation, but eventually the categorisation in quintiles has been preferred because it allows for a more intuitive interpretation.

Supporting measures

In order to control for the effect of individual households participation in the programme 'safe water for poor people', two dummy variables are included to contrast poor households with, respectively without programme participation with non-poor households, which are generally not eligible to support within the scope of this programme. The categorisation of a household as poor is based on the official local registration according to the MoLISA guidelines.[109] Since the economic status of the household in the model is already more precisely captured by per capita consumption expenditure, no 'main effect' for the official status as a poor household has been

[108] For a composite poverty measure for Việt Nam, see Pham et al. (2011) or Rutstein and Johnson (2004). The latter one also involves a discussion of restrictions of income and expenditure measures in contrast to composite wealth indexes.

[109] For an explanation and discussion of the MoLISA poverty ranking as a proxy for the households economic status, see p. 75. The income limit for poor households applied in P 143 for the VHLSS 2008 amounted to 200,000 VND per capita and month in rural areas.

added to the model to avoid redundancy and collinearity between the predictors. Besides this programme, it would have also been desirable to account for additional individual level support in terms of micro-credits used for improving water supply. However, the analysis of the VHLSS 2008 data on micro-credits revealed that credits for this purpose make up only a very small share (0.4% of all credits mentioned) and it remains unclear whether the credit is used for improving self-supply (e.g. by drilling wells, constructing tanks or acquiring treatment facilities) or getting access to piped schemes. Thus the variable has been dropped from the model. As in the commune model in Chapter 5, the model accounts for commune level support in the improvement of water supply infrastructure by considering communal infrastructure projects explicitly dedicated to water supply during the last ten years.[110] Beyond these (infrastructure) projects captured by the VHLSS data, it is reasonable to assume that a range of additional initiatives took place (e.g. Le et al. 2010) but cannot be considered in the model.

Nearby adoption

In order to measure whether 'contagion' (e.g. due to social learning, observability, or trialability) plays a relevant role, a proxy for piped scheme hook-up in the nearby environment has been calculated. Due to a lack of spatial reference for the households and communes, this nearby adoption rate refers to the district as administrative unit. Based on the aggregated survey data, the nearby adoption rate is defined as the share of households in the district which are connected to piped schemes compared to the overall number of households in the district. The calculation relied on households which are included in the VHLSS sample and did not draw on other data. This nearby adoption rate for piped schemes empirically varies between zero and hundred percent.

Spatial and geographical characteristics

In order to scrutinise, how spatial characteristics impinge on the likelihood that households connect to piped schemes, the population density has been included. Ideally, household level measures for the distance between the household and the central point of distribution (e.g. water work or pumping station) would be useful to identify potential 'physical constraints' for connecting to piped schemes. Since those are not available, the population density here serves as a proxy for settlement structures. The population density is calculated from the number of households and the communal area in square kilometres. Last but not least, seven dummy variables for the administrative regions have been added to the models. However, in contrast to the availability model where dummy variables for the geographical (*not* administrative) region have been included to control for distinct opportunities to use water sources, no regional disparities in individual accessibility are expected to be found here. Following the mechanism-approach, it is deemed more revealing – even at the costs of forfeiting predictive accuracy in the statistical sense – to refer to characteristics like spatial distance, density, and suchlike in place of including catch-

[110] For further analysis about these projects, see Section 3.4.2.

all variables for geographical regions which represent a not further approachable conglomeration of spatial, natural, and maybe also economic conditions. That is why the final model omits dummy variables for the administrative models and also other factors which did not prove relevant although they would surely further push up overall model fit.

6.3.2. The random intercept model

Subsequently, I will assess by means of logistic random intercept models how strongly the factors addressed above impinge on the likelihood that households are connected to a water supply network.[111] Given the fact that the pattern of use is likely to be influenced by communal characteristics which are equal for all households belonging to a specific commune, also the probability that a household is served by a piped scheme is likely to be correlated among households belonging to the same commune. Hence, the standard logistic regression model would lead to bias (Rabe-Hesketh and Skrondal 2005). Basically, the modelling approach is equivalent to that described on page 163 and Equation (5.1), but includes predictors on both hierarchical levels. The likelihood that a household has access to piped water is supposed to be given by:

$$logit\{Pr(y_{ij} = 1 \mid x_{ij}, u_j)\} = \alpha + \beta_1' x_{ij} + \beta_2' z_j + u_j \tag{6.1}$$

where α is the intercept, β is the column vector of regression coefficients for household level predictors x_{ij} and communal level predictors z_j, and u_j symbolises the random intercept. The random intercept is assumed to be normally distributed with zero mean and variance σ_u^2 (Rabe-Hesketh and Skrondal 2005: 116). Here, the random intercept represents the combined effect of all commune level characteristics and peculiarities on access to private taps which are not included in the model in terms of explanatory variables on communal level. The test of variance components by the likelihood ratio test refutes the null hypothesis that the residual cluster variance σ_u^2 is equal to zero. The model was concurrently estimated by Stata's `xtlogit` and `gllamm` using adaptive quadrature.

6.4. Results and discussion

6.4.1. Descriptive statistics

Table 6.3 contrasts households with and without private tap with regard to relevant household and communal level characteristics. 46 percent of the rural households located in communes with piped schemes actually have access to an own tap on their

[111] The Methodological Appendix A provides a more detailed introduction to multilevel level regression models, critical issues in estimation, diagnostics, and measures to assess model fit.

premises. Summary statistics reveal that tap owners have a slightly, but not significantly higher educational status, are slightly but again not significantly larger, show higher per capita consumption expenditure, and do more frequently belong to the major ethnic group Kinh. Whereas among the tap owners only 6 percent belong to ethnic minorities, these are 15 percent in the reference group. The share of households with female heads and small children does not differ substantially in both groups. Per capita consumption expenditure differs significantly between both groups (t=-5.47 df=1,408, p=.000). Rural tap owners do on average spend one million more per capita and year on consumption purposes than the reference group. Cross-tabulating expenditure quintiles for individual households with private tap ownership reveals that hook-up increases substantially from 29 percent in the lowest expenditure quintile to 59 percent in the highest group, but does not reach universal coverage even among the most affluent households. This finding clearly indicates that besides affordability, there might be other relevant reasons why people abstain from connecting to piped schemes like competing practices or insufficient coverage of the distribution system. Average poverty rates of the communes are almost equal, but with roughly 12 percent in general below those for rural communes without private taps, which are not considered here. Taking into account the findings from the previous chapter, it seems plausible that once a piped scheme exists within a commune, the question of individual connection seems independent of other households' economic status.

With regard to practices of domestic water supply, strongest differences show up for the use of private wells: whereas among the tap owners only 4 percent also own a private tube well, among those without private taps on premises almost every third does so. In contrast, piped scheme connection does not seem to be correlated with the use of tube wells in general in the communes. Every eighth household – tap owners as well as the those in the reference group – lives in a commune where tube wells pose the main source of drinking water. This finding firstly corroborates Hypothesis 6.5 that tube wells definitely pose a relevant obstacle for hook-up but that this effect apparently only turns out once the individual household actually invested in drilling an own well and is hence not attributable to the mere *option* to abstract ground water by wells at this specific location. Also households which already rely on different water sources are not less likely to be connected to piped schemes: every third of the tap owners and the households in the reference groups pursues such a strategy of diversification. Moreover, diversification of water sources is neither exclusively pursued by private tap users nor low income households – as the frequently stated rationale of 'keeping consumption of tap water low' (Reis 2012; Spencer 2007) gave reason to expect – but is rather observed among medium income households. Various explanations are conceivable: firstly, diversification does not come at zero costs but also requires some investment, e.g. for constructing rainwater tanks, connecting to piped schemes, or digging wells (see Chapter 2). Secondly, saving money might not be the only reason for diversification. And thirdly, a quite large share of users of

TABLE 6.3.: Descriptives for rural households in communes with piped water schemes by dependent variable (N=1,410)

	Without private tap (N=761)		With private tap (N=649)	
Continuous variables	$\bar{x}$	*sd*	$\bar{x}$	*sd*
Household size (HH)	4.09	1.75	4.20	1.60
Highest grade completed (HH)	6.00	3.63	6.63	3.62
Share of poor hhs in % (C)	13.75	12.39	11.01	9.28
Number of households per km^2 (C)	157.74	147.05	194.30	185.14
Yearly per capita consumption expenditure in 1,000 VND (HH)	6912.79	3669.90	8081.64	4347.13
Nearby piped scheme adoption in % (C)	21.64	21.60	46.81	29.25
Dichotomous variables	in % (col)		in % (col)	
Female head of hh (HH)	21.21		23.88	
Children below 6 years (HH)	28.12		31.28	
Ethnic minority hh (HH)	15.24		5.55	
TW main source of water (C)	12.48		12.17	
Use of private tube well (HH)	30.09		4.01	
Use of multiple water sources (HH)	28.78		28.66	
Improved sanitation (HH)	47.83		59.48	
Poor hh with programme (HH)	2.63		3.08	
Poor hh without programme (HH)	15.37		7.70	
Infrastructure project for WS (C)	50.96		51.36	
Administrative region	in % (row)		in % (row)	
Red River Delta	50.00		50.00	
Northeastern	65.22		34.78	
Northwestern	55.56		44.44	
North Central Coast	48.84		51.16	
South Central Coast	62.37		37.63	
Central Highlands	82.05		17.95	
Southeastern	50.00		50.00	
Mekong Delta	51.82		48.18	

Note: (HH) household level covariate, (C) commune level covariate

Source: VHLSS 2008, Own calculation excluding urban communes and rural communes in which no piped schemes are available multiple sources does so because they collect rainwater which is simply not sufficient to cater all their water needs. So the share of households applying diversification strategies might be equally high among the tap owners and the reference group but due to different reasons.

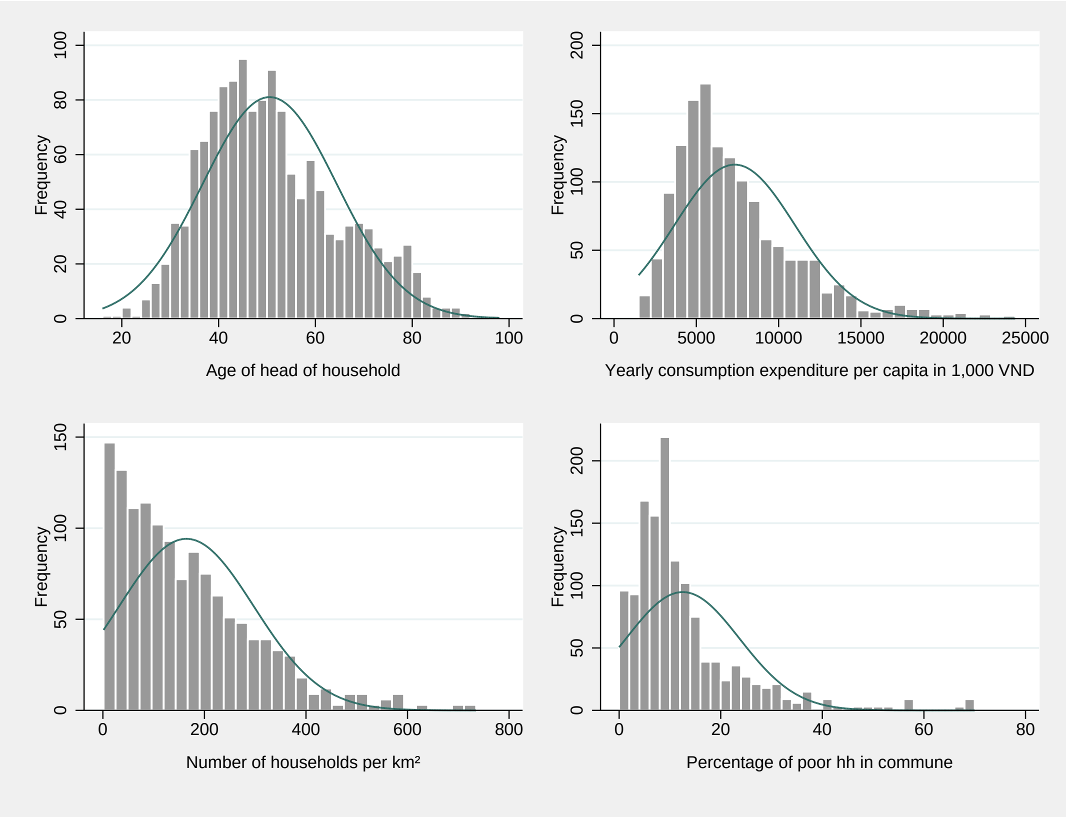
Competing alternatives aside, households might also not connect to the distribution system because they reside in parts of scattered settlements which are not within its spatial scope or the scheme has not been designed to cover a large amount of users. Comparing the population densities shows that piped scheme coverage is higher when population densities go up.[112] Whether the conclusion that settlement structures are not only relevant predictors for the availability of piped schemes but also for individual access within communes also holds true when simultaneously controlling for other covariates will be scrutinised in the multivariate model.

Table 6.3 depicts an ambivalent picture about the relationship between private tap ownership and water-related programmes. Households, which have officially been classified as poor and take part in the programme ‘safe water for poor people’, make up 3 percent of the tap owners and the reference group each. In contrast, poor households which do not benefit from the programme are underrepresented among the tap users compared to the reference group. Infrastructure projects on communal level do not seem to correlate with individual access to piped schemes, although they proved highly relevant for the availability of piped schemes in general. Half of the tap owners and the reference group resides in communes which carried out infrastructure projects for water supply during the last ten years.

Last but not least, Table 6.3 outlines the share of private tap users across the different administrative regions. Access rates here appear lower compared to those in Table 6.1 because access to taps is restricted to those on private premises whereas access rates in Table 6.1 also include public taps. When considering private taps only, in the Central Highlands by far less households are connected. Also the Northeast and the South Central Coast score lower than one would expect based on the figures given by Table 6.1. Furthermore it is worth noting, that this way of displaying coverage rates neglects the question about the spatial concentration of tap users and pools all households residing in the administrative region. Thus, without commune level connection rates it largely remains unclear, to which extent accessibility varies across communes and whether some of them already reach full coverage. Since such data is not yet available, the multilevel model is conceived a promising approach to disentangle the role of individual and communal context. That nearby adoption exerts a strong positive effect on adoption at a specific location is supported by Table 6.3: households owning private taps are residing in districts which reach an average connection rate of 47 percent, whereas in the districts in which the reference group is residing on average only every fifth households uses tap water.

[112] For a general discussion of the population density, see p. 165.

FIGURE 6.2.: Distribution of continuous dependent variables on household and commune level



Note: Includes only rural communes in which piped schemes are existing, solid line represents normal distribution
Source: Own calculation based on VHLSS 2008

Skewed distributions

Figure 6.2 depicts the frequency distributions for selected continuous predictors. The histograms depicted in Figure 6.2 reveal skewed distributions for population density, per-capita-consumption expenditure, and the communal poverty rate, albeit to a different extent. Potential distortions due to extreme outliers in the income distribution are mitigated by the log transformation, respectively the grouping into quintiles. The remaining predictors have been included without any kind of transformation if no problems showed up concerning functional relationships in order to ensure better interpretability.[113]

[113] LOWESS plots and local mean regression (see p. 276) resulted in the decision to transform the expenditure variable and split the household size into two dummy variables. Figures B.5 and B.6 in the appendix shows the functional relationship for the logarithmised expenditure variable.

Multi-collinearity

The inspection of the tolerance and Variance Inflation Factor (VIF) for all dependent variables which have finally been included in the model do not point to serious problems with multi-collinearity among the predictors. As a comparison of Table B.15 for Model (2) and Table B.16 for Model (4) reveal, including the interaction effect causes the VIF and tolerance to go up for the respective variables what is mainly due to non-essential collinearity, which would disappear after mean-centering the predictors (cf. Cohen 2003).[114]

6.4.2. Model estimation and results

Sample

From the initial sample of 1,410 households, further 123 ones have been excluded: 15 of them due to missing values on the independent variables and 108 because they are located in communes which obviously bear an urban character.[115] After applying these criteria, the sample for the estimation of the multilevel model contained 1,281 rural communes nested in 427 rural communes, which is deemed sufficient to get unbiased estimates for fixed as well as random parameters. According to Maas and Hox (2005) and Hox (2010), the number of second-level units should exceed 50, respectively 30, if the main interest lies in the fixed parameters as it is the case here.[116] Additional eight households have been dropped from the sample as outliers with a quite strong influence on the estimates (absolute Pearson residuals above 3.2), yielding a significant improvement of overall model fit and a final sample of 1,273 households (see p. 292 and Figure B.3). The models displayed in Table 6.4 have been re-estimated after dropping these eight influential observations. Due to the sampling strategy, each of the 427 communes in the final sample is represented by three households.

Table 6.4 reports the estimated coefficients and significance levels for five different specifications of the model. To facilitate interpretation, the estimated coefficients are converted to odds ratios. In place of standard errors – which cannot be used in the exponentiated form for constructing confidence intervals and testing hypotheses – significance levels are given (cf. Rabe-Hesketh and Skrondal 2005: 104). The models displayed in Table 6.4 differ with regard to their specification of the income effect, the role of substitutes and nearby adoption. Whereas Model (1) includes the logarithmised yearly per-capita consumption expenditure, Model (2) to (5) refer to

Model specification

Diagnostic plots did not reveal serious problems for the remaining predictors.

[114] For further information about tolerance and VIF – especially with regard to interaction effects – see Section A.4.2 and A.3.1.

[115] Here the same criteria are applied as in the piped scheme model estimated in Section 5.2 see page 165. A population density above 1,000 households per km^2 and population size exceeding more than 6,000 registered households have been defined as cut-off points. For details and reasons for such misclassifications see p. 165.

[116] For more detailed information about the questions of adequate sample size in multilevel models, see Section A.4.1.

expenditure quintiles which also account for the skewed distribution of the raw values but are more intuitively interpretable. Furthermore Model (4) and (5) consider the moderating effect of tube well use on the expenditure effect to test Hypothesis 6.6. Model (2) differs from the remaining ones with regard to the operationalisation of the competing strategy Hypothesis 6.5: in place of the use of private tube wells by the respective household, it considers the use of tube wells in the commune in general. Therefore Model (2) is expected to show whether even the mere option to use tube wells in the commune already reduces households chances of access to tap water or whether only the actual investment into an own tube well matters for the household's decision. The remaining predictors are equally defined across the four models. Model (5) additionally accounts for contagion effects by including the nearby piped scheme adoption rate in the district as an predictor but omits the geographical dummies due to their unclear explanatory added value in terms of mechanisms.

Communal level effects

Again, the intercept-only model (not displayed) does not only provide the log likelihood benchmark value (*ll*= -770.528) for comparing nested models but also delivers the second-level variance which allows to calculate the share of overall variance in the predicted outcome attributed to commune level differences based on the residual variance σ_u^2 on the communal level. A likelihood ratio test of the variance components reveals that the residual cluster variance σ_u^2 for all models significantly differs from zero, meaning it indeed makes sense to apply a multilevel model.[117] The random intercept was added to the model in order to account for the (unobserved) heterogeneity on communal level and to scrutinise which role a household's affiliation to a specific commune plays for its chances to have access to a private tap. Here at maximum 61 percent of the overall variability in individual households' access to piped water is attributable to commune level predictors, suggesting that access is still to a large extent determined by the communal context even though the sample here only comprises communes with piped schemes. This finding inevitably forces the question if firstly, the principle to disentangle supply- and demand-side factors as it is done above poses an appropriate solution and secondly, whether within-commune coverage of piped schemes is indeed so poor that individual households' characteristics simply do not take such a strong effect as expected because a bulk of the households does not reside within the scope of the currently existing grid. Due to a lack of proxies for piped scheme coverage within the respective communes, models including terms for the share of households in the commune which benefited from water-related infrastructure projects have been estimated but did not show any significant effect and have thus been discarded. Also adding commune level predictors such as poverty rate, infrastructure projects, or population density did not help very much to unravel the mystery of the communal context. At least the significant positive effect of the population density provides some evidence that more compact settlement structures

[117] For further explanation see p. 269.

do not only make it easier for providers to operate piped schemes in general (see p. 174) but also for households to connect to them (Hypothesis 6.9). Given an increase of the population density from 100 households per square kilometer to 600, the probability of having access to piped schemes doubles from 0.33 to 0.69 holding all other covariates at their mean and assuming a random intercept of zero (based on Model (5)). Other factors like communal poverty rates or infrastructure projects for water supply which have been found to relate significantly to piped scheme availability (Section 5.2.3) are not relevant for explaining individual access.

Overall model fit

Table 6.4 shows that across the distinct specifications in Model (1) to (4), neither the estimated effects of the remaining predictors nor overall model fit change substantially. The models yield roughly 90 percent of correct predictions. Given that already a large share can be predicted correctly based on the marginal distribution, the adjusted R^2_{count} has been calculated. In comparison to the prediction exclusively based on the marginal distribution, the prediction error in the estimated models is reduced by 75, respectively 80 percent. In addition to the R_{count}-measures, the actual rate of households with private taps has been compared with the predicted rate for specific groups defined on the basis of selected predictors. This approach confirms the high predictive accuracy.[118] Interestingly – just as in the Piped Scheme Availability Models – also the Accessibility Models (1) to (4) are slightly more likely to produce 'false negative' predictions than 'false positive' ones as the classification tables in the appendix show (Table B.8 to B.11). The fact that this pattern is consistent across the availability and accessibility model supports the hypothesis about the existence of a factor which facilitates access to piped water but is not covered by the models here. Adding the nearby adoption rate in Model (5) results in a more balanced relationship between false positives and false negatives and hence corroborates Hypothesis 6.8, meaning, contagion on the spatial scale of adjacent communes might be responsible for a great deal of variation between communes which is expressed by a considerable drop in the intra-class-correlation. Whether the contagion effect is also related to some kind of local intervention or an intervention was the initial trigger for adoption at a specific location cannot be assessed here.

Interpretation of coefficients

There is a number of household level determinants which impinge on private tap availability. First of all, all models displayed in Table 6.4 show a highly significant positive effect of increasing expenditure levels on access to private taps. For each quintile in the expenditure distribution, chances go up by factor 1.4, suggesting that despite all potential moderating factors, Hypothesis 6.1 seems to apply. Secondly, the model reveals an ambiguous effect of household size[119]: in line with Hypothesis 6.2, households consisting of less than four persons are less likely to use tap water than

[118] This approach is explained in detail on page 273 and the results for Model (5) can be found in the appendix (Table B.13 and B.14).

[119] The relationship between the probability of access to private taps and household size resembled rather a reverse u-shaped curve, the predictor has been split up into two dummies.

TABLE 6.4.: Random intercept models for accessibility of piped water

Accessibility of piped water	**Model (1)** exp(b)	**Model (2)** exp(b)	**Model (3)** exp(b)	**Model (4)** exp(b)	**Model (5)** exp(b)
Household characteristics					
Age of head of hh	1.001	1.005	1.002	1.002	1.008
Highest grade of head of hh	1.061^{+}	1.061^{+}	1.067^{+}	1.066^{+}	1.094**
Head of hh female	1.361	1.337	1.373	1.374	1.276
Small household[1]	0.576*	0.668^{+}	0.578*	0.578*	0.622*
Large household[1]	0.481	0.425	0.446	0.445	0.280^{+}
Children <6 years living in hh	1.477	1.610*	1.488	1.488	1.504^{+}
Ethnic minority household	1.024	0.809	0.982	0.983	0.628
Log cons. expenditure per cap/year	3.094***	-	-	-	-
Per capita cons. expenditure (quintiles)	-	1.347***	1.415***	1.423***	1.402***
Use of private tube wells	0.007***	-	0.008***	0.010***	0.033**
Tube well*Expenditure (quintiles)	-	-	-	0.921	0.828
Use of multiple water sources	1.395	0.973	1.411	1.411	1.870**
Improved sanitation	1.871*	1.584*	1.900*	1.906*	1.734*
Poor household with programme[2]	2.776	4.205*	2.593	2.605	2.363
Poor household without safe water programme[2]	0.447*	0.502*	0.432*	0.433*	0.496*
Communal characteristics					
Tube well main source of water	-	1.054	-	-	-
Nearby piped scheme connection	-	-	-	-	1.060***
Infrastructure project for WS	1.413	1.191	1.426	1.424	1.485
Share of poor households	0.996	0.987	0.995	0.996	1.011
Number of hh per km^2	1.004*	1.002	1.004*	1.004*	1.003**
Administrative region[3]					
Northeast	0.386	0.642	0.415	0.415	-
Northwest	1.284	1.881	1.366	1.370	-
North Central Coast	2.099	2.525	2.175	2.179	-
South Central Coast	0.863	0.764	0.914	0.917	-
Central Highlands	0.143^{+}	0.183	0.154^{+}	0.154^{+}	-
Southeast	2.036	1.264	2.130	2.141	-
Mekong Delta	2.073	2.049	2.195	2.195	-
Constant	0.000***	0.064**	0.061**	0.060**	0.008***
Random part					
σ_u	2.324	2.259	2.318	2.316	1.745
ρ	0.621	0.608	0.620	0.620	0.481
R^2_{count}	90.07%	88.30%	90.81%	90.81%	89.00%
Adj. R^2_{count}	79.09%	73.81%	79.44%	79.43%	75.40%
AIC	1327.82	1507.16	1330.35	1332.27	1199.39
Log likelihood (ll)	−638.91	−728.58	−640.17	−640.14	−579.70
N	1,273	1,273	1,273	1,273	1,273

Note: Model includes only rural communes in which at least one household has access to tap water on premises, excludes 6 outliers with standardised Pearson residuals larger than 3.2; [1]Dummies, reference medium size households,[2]Dummies, reference are non-poor households, [3]Dummies, reference region is Red River Delta; $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

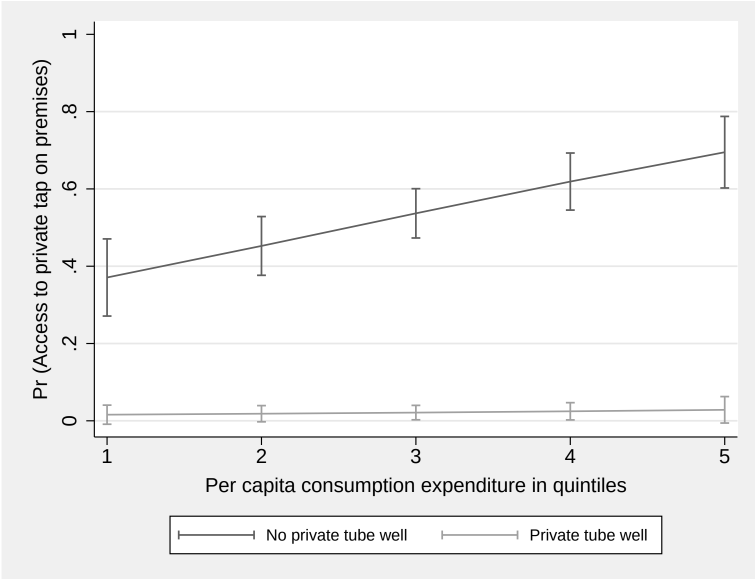
medium-sized ones, but households comprising more than seven members do, according to Model (5), also tend to connect less frequently compared to the reference group when controlling for other covariates such as per capita expenditure. The effect is not strongly statistically significant, most likely due to the small numbers of very large households in the sample. Nevertheless the negative effect for large households appears more severe with regard to magnitude than the effect for the small households. Probably, the anticipated effect of a 'per-capita-reduction' in the initial financial effort for increasing household sizes does not play a substantial role once a critical size is reached. Anyway, the same effect should apply to the costs for drilling wells and acquiring other facilities.

Effect of competing alternatives

The estimation results clearly corroborate Hypothesis 6.5, which states that tube wells as competing alternatives deter people from hook-up. In fact, the use of private tube wells is by far the most important obstacle to acquiring access to piped schemes. The chances for tube well users in the lowest expenditure quintile are roughly six times lower than for those without a private tube well. But does this negative effect also hold true for more affluent households? The interaction effect between per-capita-consumption expenditure and the availability of a private tap has been introduced to test whether the hypothesis about lower connections rates among tube well owners also applies if expenditure goes up (Hypothesis 6.6). Following a similar argumentation like Tobias and Berg (2011), one could expect that affluent households can afford both – drilling a well and connecting to piped schemes, whereas poorer households keep on using their tube well instead of investing additional money to get access to tap water. However, Model (4) and (5) and Figure 6.3 do not confirm the expected effect. Even in the highest expenditure quintile, households' likelihood to have access to a private tap on premises still remains very low. At least this finding is in line with the argumentation stated above about why also affluent households do not show full coverage. Arguably private wells offer such a substantial relative advantage (e.g. in terms of convenient and hygienic supply) compared to tap water that even those who can afford do not have an incentive to switch. Put it differently and considering expenditure as focal variable, Figure 6.3 illustrates that the effect of growing expenditure levels is moderated by the use of tube wells. If a household does not own a well, the probability of having access to piped schemes increases for each expenditure quintile by the factor 1.4. In contrast, if a household already owns a private well than the positive effect of income is neutralised by the strong negative effect of the competing alternative, so that finally for this group, the chances of access to piped schemes hardly differ across expenditure levels if all other covariates are fixed at their means.

Furthermore, comparing Model (2), which includes a commune level predictor for tube wells as the main source of water, to all remaining models, makes clear that the negative impact of tube well use as a competing alternative does not arise from the mere availability of abstractable groundwater resources at the specific location

FIGURE 6.3.: Interaction effect between expenditure and use of private tube well



Note: 95% CI displayed, random effect assumed to be 0, and other predictors fixed at mean
Source: Own calculation based on VHLSS 2008, includes only rural communes in which piped schemes are existing

but exclusively takes effect if the household already invested in drilling and installing a private well. As reveals Model (2) in Table 6.4, the fact that tube wells pose the main source of drinking water in the commune does not impinge at all on a individual households likelihood to connect to a piped scheme holding the other covariates constant.

Poor vs. none-poor households

Besides communal level infrastructure projects, here the respective household's participation in the programme 'safe water for poor people' as the only indicator for individual supporting measures for RWSS has been taken into account. Since only households which have officially been categorised as poor are eligible, only two coefficients for contrasting poor households with, respectively without, programme participation each with none-poor ones are added to the model. Astonishingly, even when controlling for per capita consumption expenditure, non-poor households chances to own a private tap are twice as high compared to households which are officially classified as poor. In contrast, poor households which take part in the programme do seem to have much higher chances of access to piped schemes than non-participating households. Most likely this difference only does not appear significant here because the number of programme participants is very small compared to the reference group (see Table 6.3). Conjectures about whether the significant negative effect for poor households without programme participation arises from marginalisation due to the 'official recognition' of the status and is related to disadvantages in access to credit or participation processes would be mere guesswork. On the one hand, there is evidence that poor households are eligible to specific support, but on the other hand also examples can be found that households might be subject to discrimination as has been discussed in the context of Hypothesis 6.7 (cf. van Koppen et al. 2012; Funder et al. 2012; Pham et al. 2011; Le et al. 2010; Dufhues et al. 2002). Moreover, the models simultaneously control for the ethnic group, which – similar to the commune level model in Section 5.2.3 – does not make a difference for private tap ownership when taking into account other covariates. As Table 6.3 shows, this by no means implies equal connection rates for ethnic minority and Kinh households, but arguably, the disadvantage does not arise from the ethnic status as such but from other factors like lower disposable income, remoteness, or settlement structures.

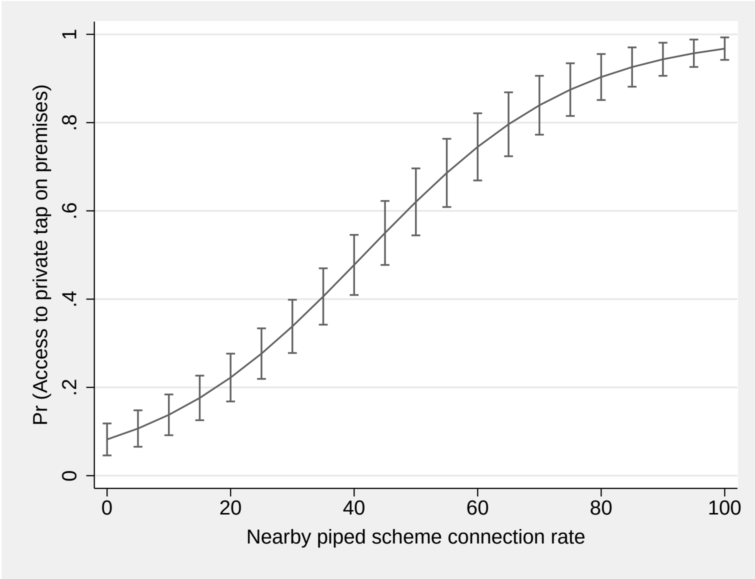
Contagion effects

Model (5) additionally accounts for the adoption of piped schemes in spatial proximity to the household. With each percentage point increase in piped scheme coverage in the district, the likelihood that the household also has access increases by factor 1.06. Figure 6.4 illustrates the increase in an individual household's probability of having a private tap depending on coverage in the district it is located in. Moreover, including the nearby adoption rate also allows to control for the general level of piped scheme adoption in the district when assessing the effects of other predictors. Comparing model (4) and (5) reveals that the effect of other covariates – such as the educational level, household size, children living in the household, and the use of multiple water sources, become more pronounced when comparing households located in a district with equal levels of piped scheme diffusion but do not change substantially with regard to magnitude or direction.

6.5. Summary and research desiderata

As a supplement to the analysis of piped scheme availability in rural Vietnamese communes, this chapter sought to discuss whether the availability of piped schemes on communal level or the accessibility on household level proves the bottleneck for expanding piped scheme coverage in rural areas. It set out by applying a 'decomposition approach' based on aggregate data survey data, which dissects coverage rates and thereby aims to identify whether rather demand-side characteristics or supply-side characteristics contribute to low piped schemes hook-up. While availability rates have been found to differ tremendously across the administrative regions, with regard to access rates, less differences show up. In communes where piped schemes are apparently under operation, only half of the households actually use tap water for drinking and cooking. Coverage is even far from being universal among more affluent households what corroborates the assumption that piped water schemes barely built up natural monopolies in rural Vietnamese communes yet. Contrasting the

Figure 6.4.: Marginal effect of nearby piped scheme adoption in district



Note: 95% CI displayed, random effect assumed to be 0, and other predictors fixed at mean
Source: Own calculation based on VHLSS 2008, includes only rural communes in which piped schemes are existing

relative contribution of demand- and supply-side factors to the service gap suggests that in rural Vietnamese communes, low coverage is mainly attributable to supply-side factors, whereas demand-side factors only play a substantial role in the Mekong Region. Given that communes exist in which piped schemes are in operation but where households are simply located too far from the grid in order to connect or the capacity of the existing system is too low in order to serve them, the decomposition approach even tends to underestimate the supply-side deficiencies.

The second part of the chapter had a closer look at household and communal level characteristics that impinge on households' probabilities to connect to piped schemes, given that such service is physically available in their commune. The multilevel model confirmed what has been discussed in the first part of this chapter: even in communes in which any piped scheme is under operation, scattered settlement structures and low population densities make it difficult for households to connect. This implies that supply-side characteristics also pose a crucial limitation to piped scheme hook-up *within* communes. In general, the high intraclass correlations for all models underpin that for understanding within-commune accessibility, more attention should be paid to commune level characteristics.

The logistic random intercept model strongly corroborates the hypothesis that the use of private tube wells as competing alternative poses one of the main obstacles in the diffusion of access to piped schemes, whereas nearby adoption of piped schemes in the district proves to be one of the most important drivers. However, the overriding importance of competing alternatives needs to be considered in a differentiated manner: it only takes effect once the households already own a private tube well. The mere availability of groundwater resources instead is not sufficient to deter people from connecting to piped schemes. Moreover, the strong negative effect of tube wells as alternative water source does not disappear with increasing income levels, meaning also affluent households in the sample do not afford both, tube wells as well as piped scheme hook-up. In contrast, the use of multiple water sources is rather a facilitating than an inhibiting factor for hook-up. Whether the positive effect of multiple source usage is attributable to the rationale to safe money or to diversify water sources for different purposes remains an open question. As expected, piped scheme hook-up is a matter of income. Furthermore, even when accounting for expenditure levels, households officially ranked as 'poor' have lower chances of access to piped schemes. Two options are conceivable to explain this finding: the expenditure variable is not able to capture the economic status sufficiently, or other more subtle mechanisms of inclusion, respectively exclusion, related to the official status of 'being poor' impinge on piped scheme connection. At least the finding that the admittedly very small number of households which take part in a specific programme have equal chances compared to non-poor households suggests that rather the first explanation is standing to reason. Despite lower access rates among ethnic minority households, no evidence for a general discrimination of ethnic minorities with regard to piped scheme connection as such has been found. This does not mean that they show equal connection rates, but at least disparities in access to piped schemes are attributable to other factors than the ethnicity.

Limitations and desiderata

In order to answer the question whether rather demand- or supply-side factors are responsible for low coverage, it seems inevitable to consider whether a household lives within the scope of a piped scheme which is able to provide a connection. Given the fact that even in rural communes which operate piped schemes only every second household connects, the discussion of within-commune coverage deserves more attention. For planning purposes it would be desirable to develop indicators and generate data which allow to apply the decomposition approach on communal level and to assess quickly the actual state of adoption at a specific location.

Due to a lack of data, not all hypotheses could be operationalised and tested sufficiently. This especially applies to the role of micro-credits, potential interventions, and programmes administered by governmental and non-governmental players. Furthermore, the operationalisation of households' water use demands for a differentiated assessment which captures the use of multiple water sources across the year and for different purposes in a more detailed fashion.

7. Diffusion and adoption of household water treatment in rural Việt Nam

Contents

The debate about appropriate and feasible strategies to improve water supply has mainly been shaped by two approaches: the construction and expansion of (small-scale) piped water schemes and the promotion of self-supply in combination with point-of-use treatment (see Section 1.3.2). Whereas Chapter 5 and 6 discussed the availability and accessibility of piped water schemes in rural Việt Nam, this chapter addresses the second approach: so called point-of-use treatment techniques. The umbrella term point-of-use household water treatment – shortly POU HWT – subsumes a wide range of techniques ranging from boiling, chlorination, filtering, solar disinfection to settling, or just straining water through cloth. From the technical point of view, there is no doubt that some of these simple techniques enable households and communities to improve water quality and reduce the burden of disease significantly at low costs (Clasen 2008; Sobsey et al. 2008; Clasen et al. 2007; Fewtrell et al. 2005; Sobsey 2002). Nevertheless, HWT did neither receive unequivocal acknowledgement and support by the scientific community nor by political players.

Two major reasons are adducible which justify further efforts to promote HWT in Việt Nam even if the National Target Programme for the period from 2011 to 2015 announces a massive expansion of the efforts to construct piped schemes (GoV 2010). Firstly, piped water schemes will not fully be able to cover the demand for safe drinking water at least in the short run. Both, the qualitative analysis of institutional arrangements as well as the quantitative analysis of availability and accessibility of piped schemes suggest that even with growing coverage, pockets of unserved households or even communes are likely to persist, not at least due to the perceived advantages of self-supply practices and geographical conditions. Secondly, HWT might also be relevant for tap water users because in rural areas, piped schemes are often operated by lay people and national as well international standards for water quality are not always adhered to (see p. 152). For example, water samples from different supply stations in the Mekong Delta exceeded the Vietnamese and WHO drinking water guidelines for pH-value, turbidity, chlorine, ammonium, iron, mercury, and coliform bacteria (Wilbers et al. 2014a).

Objective of chapter

In this chapter, I will have a closer look at the dissemination of different HWT techniques and ask for potential drivers and obstacles in their diffusion. The empirical analysis sets out by describing spatial and temporal patterns of diffusion as well as individual households' strategies and subsequently digs deeper into the question how these patterns are actually brought about. After introducing the hypotheses, data base, and operationalisation of the indicators for the regression model, the second part of the chapter is dedicated to patterns of HWT diffusion across different regions by means of regression analysis.

7.1. What affects the use of HWT practices? – Research questions and hypotheses

If treating water comes along with lower turbidity, better odour and taste, or decreased prevalence of water-related diseases compared to the status quo that would – at least in theory – provide strong arguments for rural households to apply HWT. In practice however, empirical studies have shown that the spontaneous diffusion of household water treatment and safe water sources is unlikely, adoption speeds up slowly (cf. Section 2.6), and adoption is not necessarily driven by health-related motives (see p. 118).

Reasons for slow adoption

According to diffusion theory, slow adoption could be ascribed to the fact that benefits from applying household water treatment – and health-preventive behaviour related to water in general – will rather be realised in the future, while they require an action in the present (cf. Rogers 2002). Furthermore, given that the expected future advantage of applying preventive behaviour is uncertain and people tend to value small immediate rewards higher than larger gains in the future (cf. Tarozzi and Mahajan 2011; Banerjee and Mullainathan 2010; Duflo 2006), then of course also the likelihood that households spend time, effort, and money on it would be quite low if no other obvious benefits are standing to reason. To make things worse, assuming that the lack of immediately visible (health-)effects at a specific point of time is indeed one of the main reasons for hesitant adoption, the effect would also be pervasive for 'contagion' and learning effects. If potential adopters do not observe any positive effects or benefits arising from adoption among the adopters in their surrounding, then their own expectations about positive effects could even be lower than before any diffusion set out in their immediate environment (cf. Duflo 2006; Kremer and Miguel 2003).

While the preventive nature of HWT practices provides a plausible explanation why diffusion often fails to reach its take-off phase or saturation in general, I will address further determinants of adoption and diffusion below and seek to answer the question whether diffusion is primarily a matter of households' characteristics or rather driven by their joint communal environment and adoption in the nearby environment. Analogous to the previous chapter, potential determinants of HWT diffusion are discussed in terms of hypotheses to be tested subsequently based on the empirical data.

For each hypothesis, arguments are compiled which corroborate or further specify the assumptions about expected causal relationships and mechanisms of adoption and diffusion. The discussion of diverging interpretive approaches and underlying mechanisms seems inevitable, given that 'statistically detected' regularities or relationships in the empirical data are often not unequivocally interpretable.[120]

Hypothesis 7.1 *Households are more likely to adopt HWT if households in the nearby environment already apply HWT. (Contagion Hypothesis)*

Equivalent to Hypothesis 6.8 for access to piped schemes, it should be tested which role contagion plays for the diffusion of HWT. As discussed before, two important sources of contagion are considered: the contact to individuals which already adopted in the past and the contact to other sources of information. With regard to HWT, the central source of information could be conceptualised as larger towns, where water treatment facilities and chemicals are sold or health messages are more prevalent. The likelihood to get into contact with previous adopters is supposed to be higher if coverage in the nearby environment increases or if environmental conditions foster communication among the population at a specific location.

Explaining adoption by nearby adoption requires to elaborate on the mechanisms how contagion actually is expected to proceed and which factors moderate these mechanisms (e.g. homophily and heterophily, supply chain requirements, reciprocal interdependency, see p. 130). Since there are numerous mechanisms conceivable which explain, respectively moderate, contagion effects, those deemed most relevant for the diffusion of HWT are addressed by the subsequent hypotheses in a more detailed fashion.

Hypothesis 7.2 *Communal and environmental characteristics exert a stronger influence on the use of HWT than individual households' characteristics.*

Despite the fact that individual households may adopt or reject HWT independently from other members of the system, throughout Chapter 4 several reasons have been adduced for the assumption that communal characteristics might even prove more relevant for diffusion than those of individual adopters. Firstly, personal factors such as perceived health threat, awareness, and knowledge about the contamination of water sources proved far less important for adoption of health preventive behaviour than social norms (Tobias and Berg 2011; Bui and Wegner 2011; Mosler et al. 2010). Secondly, adoption has been observed to spread within communes until it reaches saturation whereas between communes larger disparities in coverage rates persist (see also Hypothesis 7.3). Thirdly, the analysis of spatial patterns of diffusion suggests that contagion is strongly shaped by spatial distance and remoteness. Both,

[120] For further explanations see Section 1.5.1.

the proposed relevance and strength of social norms as well as the trend towards spatially bounded diffusion processes appear closely associated with the nature of the Vietnamese village as a social entity and will be discussed in the next hypothesis. Assuming that predominantly the communal or village level context shapes adoption is not to deny the optional or individual character of the decision to apply HWT and the existence of intra-communal disparities but to explain why individual households' characteristics are probably found less relevant than the environmental context in which diffusion proceeds.

Hypothesis 7.3 *Adoption of HWT is more likely to spread within communes before it will spill over to adjacent regions.*

The proposition that diffusion first and foremost spreads within a village before it spills over to others, builds upon the prominent position which the village as a social entity takes in the Vietnamese society. Traditionally, the village served as a bastion against nature and foreign invaders. The Vietnamese village 'is an autonomous administrative, economic and cultural unit' (Ngoc 2010: 190) which has its own communal rules (*hương ước*) and shows a strong internal differentiation besides the typical administrative structure described on page 87.[121] According to a field study (Norlund 2005), there is evidence that the communal network of mutual relief, supported by the organisation of cooperatives, is still strong and continuous but the study also revealed that outsiders do not always benefit from it, social differentiation is increasing, and that such structures are rather typical for the lowland villages of the major ethnic group. So in spite of the altering rural scenery, it still seems plausible that the village, respectively a commune[122], is more than just an administrative entity and agglomeration of households, but also poses a social entity with strong networks, own rules, and distinctive structures of power. Thus, the commune is expected to constitute the relevant social and spatial unit in which diffusion takes place first before it spills over to neighbouring entities.

Hypothesis 7.4 *The diffusion of point-of-use treatment practices is more likely in more densely populated areas and in spatial proximity to urban areas.*

Strang and Soule (1998: 275) argue that spatial proximity does not incorporate any kind of distinctive logic for explaining diffusion but 'often provides the best summary

[121] However, in spite of this demarcation of villages, often neighbouring but also more distant villages are bound by a practice which is called *giao hiếu* or *giao hảo*. The villages provide mutual aid to each other, send delegations and organise joint festivals (Ngoc 2010: 190). Whether such inter-communal twinnings still play a significant role and facilitate an increased exchange of information among those villages could not be be answered based on the existing literature.

[122] In the strict sense, the social unit of a *village* does not necessarily equate to the administrative unit of a *commune*.

of the likelihood of mutual awareness and interdependence' (cf. Section 4.2.3). The basic idea behind the impact of spatial proximity and population density is that diffusion is more likely if adopters are in close spatial contiguity, which supports contagion by higher communication frequencies and stronger interactions between potential adopters (cf. Rogers 2003). Here this means that more compact settlement structures are expected to support contagion processes because information about advantages of applying HWT travels faster and observability and trialability increase if an area is more densely inhabited.

Hypothesis 7.5 *The diffusion of HWT techniques is moderated by the local availability of required facilities for HWT and the respective supply chains for consumables and spare parts.*

Reliable, accessible, and affordable supply chains for spare parts and consumables are deemed a key feature for HWT in order to become a sustainable everyday practice (cf. Sobsey et al. 2008). Thus, access to shops, markets, or vendors which sell chemicals, filters, or spare parts is a vital precondition not only to initial adoption but first and foremost to prevent that people cease treating their water once consumables run out of supply or filter units or materials need to be replaced. Hereby the relevance of access to spare parts and consumables depends on the kind of treatment applied. Techniques which build upon material which is locally available (e.g. like sand) might be largely independent from market infrastructure but probably require other means of transportation, whereas those which require externally manufactured spare parts or continuous replenishment are reliant upon access or the spatial proximity to shops, vendors, or larger towns where the consumables can be acquired (see Implication 4.4 on p. 127). In line with Gatignon and Robertson (1985: 852) and Brown et al. (1976: 100), if such market and infrastructure factors restricting the accessibility to the product are dominant, the resulting pattern of diffusion should be shaped by the *hierarchy effect*, meaning the diffusion of the product follows the diffusion of the supply chain infrastructure. In contrast, the *neighbourhood effect* as described above, is rather dominant if 'the time of adoption is a function of the distance between communicators' (Gatignon and Robertson 1985: 858) or their homophily. Whether it is possible to empirically distinguish between both effects here is questionable because firstly, only cross-sectional data is available and secondly, the VHLSS does not differentiate between treatment methods so that treatment techniques with distinct requirements for supply chains are intermingled. Vice versa, the MICS data differentiates between distinct HWT practices but provides no information about communal infrastructure and spatial distances to larger towns. Moreover, it is even conceivable that the relevance of both effects changes across the stages of diffusion (see also Assumption 4.8 on p. 131). Supposed that especially in the early stages of diffusion access to supply chains turns out a restriction, once this supply infrastructure has at least been established to a certain extent, other diffusion drivers like homophily or social norms might become more relevant than further improvements of the supply chain. Findings from Việt Nam so far draw a heterogeneous picture of the role of supply chains in the RWSS sector: in contrast to other countries (Sobsey et al. 2008; Ram et al. 2007; Makutsa et al. 2001), case studies and own field research in the Red River Delta suggest that filter materials (e.g. sand or bauxit as raw material for producing filter substrates) or chemicals like rock alum, which is mined in the Mekong Delta, are available on local markets (Wrigley 2002, 2007). On the other hand, spare parts for reverse osmosis or ceramic filters might be more difficult to obtain in remote areas. In addition, there is only scarce evidence available to assess whether the establishment of ad-hoc supply chains for promoting specific facilities proves a sufficient means to foster their dissemination in rural areas. For example, a programme promoting low cost toilet models which also involved the training of local providers suggested that spending more effort on establishing supply chains pays off in terms of increasing coverage rates in the pilot communes even after the cessation of the programme. However, spill-over effects to adjacent communes which did not participate in the pilot study appeared fairly modest (see Devine and Sijbesma (2011) and p. 117).

Hypothesis 7.6 *Households with higher disposable income are more likely to apply point-of-use treatment due to the costs arising for treatment facilities and their maintenance. (Affordability Hypothesis)*

As in the previous chapter, it should be tested whether the application of HWT practices is a matter of affordability or willingness to pay. Costs for HWT vary considerably depending on the technique and the required facilities (see Section 2.6 and 2.7.1). Whereas treatment by chemicals implies for a household monthly expenditure of roughly 1,500 to 2,500 VND (Spencer 2007; Wrigley 2007), filters usually cause no ongoing but high initial costs ranging from 300,000 to 400,000 VND for simple filters, and up to 3,500,000 up to 10,000,000 VND for more sophisticated solutions. Thus, it is reasonable to assume that affordability rather poses an obstacle for acquiring filters than chemicals to purify water.
Moreover, I will take into account that even if lower application rates would be observed among low income households compared to more affluent ones that does not necessarily suggest that affordability poses the bottleneck for expanding access to water and that households willingness to acquire HWT facilities, respectively chemicals or filter materials is moderated by numerous factors.[123] In particular, two arguments should be kept in mind for explaining the relationship between HWT use and households' financial endowments: given that preferences tend to be time-inconsistent (cf.

[123] For a discussion of the relationship between affordability and willingness to pay, see p. 190.

Tarozzi and Mahajan 2011; Banerjee and Mullainathan 2010; Ainslie 2001) and benefits of applying HWT are not experienced immediately (Rogers 2002) this would help to explain why households often prefer to spend money on other consumption purposes instead of water treatment. Indeed, empirical studies which contrast expenditure for water supply with those for other purposes (Sy et al. 2014; Bey et al. 2013; Tobias and Berg 2011) found that households often prefer to spend money on other consumption purposes instead of improving water supply. Consequently, mere affordability does not pose the strongest limiting factor for HWT adoption.

Hypothesis 7.7 *Households with more detailed knowledge about water-related diseases and a higher perceived health risk due to water-related diseases are more likely to apply HWT.*

Households facing higher subjective health threats or vulnerability and showing higher levels of knowledge and awareness about water-related diseases are theoretically more likely to perform preventive behaviour – such as using water from safe sources or applying some kind of point-of-use treatment – albeit health-related considerations are expected to play a rather minor role for adoption compared to other factors (cf. p. 192). Neither the VHLSS nor the MICS, which serve as the data base subsequently, provide indicators which directly measure knowledge, awareness, or perceived health threats due to water-related diseases. Thus two proxy variables are defined based on the pool of available variables in order to assess whether health considerations probably prompt households to treat their drinking water. Equivalent to Hypothesis 6.4, it should firstly be tested whether households whose heads have a higher educational status are probably more aware about the transmission routes of water-washed or water-borne diseases and consequently more frequently apply HWT. Secondly, since water-related diseases still pose one of the most relevant causes of death or illness in Việt Nam in particular among children (see Section 2.2), it should be tested whether households with small children are more likely to apply HWT.

Hypothesis 7.8 *Households nudged by interventions or financial, respectively in-kind support to improve safe water are more likely to apply point of use water treatment.*

Numerous programmes provide support for improving water supply and sanitation although only a part of them explicitly supports and encourages HWT practices (cf. Section 3.3.3). Besides targeted financial or in-kind support, such measures might comprise micro-credits which compensate a lack of financial means to improve water supply. Beyond that, programmes might also nudge households to apply HWT by raising awareness and triggering behavioural change. Due to independence of HWT from any kind of large scale infrastructure which would arguably involve a larger number of governmental players and require higher coordination and negotiation efforts (e.g. van Koppen et al. 2012; Pham et al. 2011), it is very much likely that a vast number of small scale initiatives took place to promote specific types of HWT, but are not captured by the VHLSS.

Hypothesis 7.9 *The application of a specific treatment strategy is influenced by the use of competing HWT strategies. (Substitutes vs. Complements Hypothesis)*

Households can draw on a set of alternative treatment methods as has been shown in Section 2.6. Hence the question arises which treatment strategies are applied jointly and which ones rather serve as substitutes, meaning the household tends to apply only a single type of treatment. Hereby it should be tested to which extent different treatment techniques are applied in parallel, serve as substitutes and how their prevalence has changed during the last years.

7.2. Determinants of HWT use – An empirical assessment based on the VHLSS and MICS

7.2.1. Data, operationalisation of HWT, and modelling approach

The current state of HWT use in Việt Nam can be assessed based on large scale surveys such as the MICS and the VHLSS[124], whereas case studies provide more detailed insights into local practices and reveal potential problems in handling point-of-use treatment (see Section 2.6). The analysis here draws on the MICS and the VHLSS as complimentary data sources because both cover distinct sets of variables which prove relevant for analysing the diffusion of HWT techniques in rural Việt Nam. Whereas the VHLSS 2008 does not differentiate between household water treatment techniques but contains a rich set of commune level variables, the MICS 3 and 4 surveys do not cover the communal and environmental context but allow to distinguish between different treatment techniques. Thus a complementary strategy was pursued to compensate lack of information.[125]

In case of the MICS, two cross-sectional surveys have been pooled: the MICS 3 conducted in 2006, and the MICS 4, carried out in 2010/2011.[126] While the overall sampling procedure slightly changed across the MICS 3 and 4, the variables of interest

[124] For a basic introduction about these data sources see Section 1.5.2.

[125] It is not possible to merge commune level data with the MICS household level data, since there is no joint identifier and not necessarily an overlap between the sampled communes.

[126] The MICS 2 carried out in 2000 could not be used because it did not contain information about HWT practices. For a description of the MICS 3 and MICS 4 sample, see Table 1.4 and page 35.

for the analysis have been considered in an equivalent form, thus no major restructuring was required to harmonise the data sets. Both MICS for Việt Nam gather information about water sources and water treatment on household level. Due to the larger number of households sampled for each cluster, which here for rural areas means one commune per district, it was possible to calculate nearby adoption rates for different treatment techniques within the communes (see p. 228).

Operationalisation of HWT practices

HWT practices in the MICS

The following section briefly introduces the operationalisation of variables utilised in the subsequent descriptive analysis and the regression models. The MICS distinguishes between six treatment techniques: boiling, adding chlorine or bleach, straining through cloth, water filters, solar disinfection and settling. The questionnaire allows for multiple responses for specific types of water treatment and – in contrast to the VHLSS – for all combinations of water sources and treatment techniques and does not preclude any combination in advance (e.g. for rain or tap water users). Thus it is not necessary to drop rainwater or tap water users from the sample of 'potential adopters' when assessing diffusion because all households theoretically had the opportunity to provide information on their HWT practices.

HWT practices in the VHLSS

The VHLSS questionnaire does not further specify the kind of treatment applied. In verbatim the respective item reads as following: *Do you use a filter or chemicals to purify your cooking/drinking water?* (GSO Vietnam 2008a). The survey manual does not provide any further instructions about which techniques should actually be reported by the interviewers. At least the supplement 'filter and chemicals' suggests that techniques like settling and solar disinfection are not captured by the item in the VHLSS household questionnaire. Based on the above-mentioned survey question, a binary variable has been recoded which indicates if a household applies chemicals or filters to treat its drinking water, regardless whether and how frequently it also boils it. Since the question about additional HWT beyond boiling was not asked for tap water and rainwater users, those have been excluded from calculation, respectively the sample when assessing adoption rates. In addition, the very small group of rural households which buy water in bottles or small tanks have been dropped from the sample because HWT does not seem relevant for them. Thus, only households drinking water from tube and dug wells, springs, rivers, lakes, ponds, or tanks are eventually kept in the VHLSS sample for calculating adoption rates and estimating multivariate models (see Table 7.1).

Operationalisation of determinants of HWT use

In order to test the hypotheses stated in Section 7.1, a set of indicators and proxy variables are defined to characterise households as potential adopters of HWT practices as well as their communal environment.

Household level indicators On household level, age, educational status, sex, ethnic status, children, household size, and per capita consumption expenditure have been included as socio-demographic and economic characteristics and are coded as described in Section 6.3.1. The household structure is captured by three variables: household size, sex of the head of household, and children below 6 years living in the household. Household size has been taken into account in order to test, whether larger households are more likely to apply HWT because the initial costs for constructing or acquiring treatment facilities are spread on more persons. In contrast to the piped schemes accessibility model estimated in the previous chapter, this factor is expected to be less relevant because the expenses for treatment by filters and chemicals are also increasing if more water needs to be treated. Also the functional relationship between household size and treatment probability appeared monotonic and thus no transformation was applied.

Household structure

Economic status

Households' economic status and hence ability to pay for water treatment is measured by yearly per capita consumption expenditure (see p. 200). The distribution of expenditure is again slightly right skewed, respectively log-normally distributed (see Figure 7.1) but in contrast to the piped scheme accessibility model, the Locally Weighted Scatterplot Smoother plots did not point to problems concerning the functional relationship (see Figure B.4.3). The availability of improved sanitation facilities is here used as a proxy for higher living standards but also for awareness about health issues. In line with the classification of the Joint Monitoring Programme (WHO/UNICEF 2010), flush toilets and septic tanks, suilabhs, and double vault compost latrines are coded as improved sanitation, whereas toilets directly over the water, other types, and open defecation are categorised as unimproved.

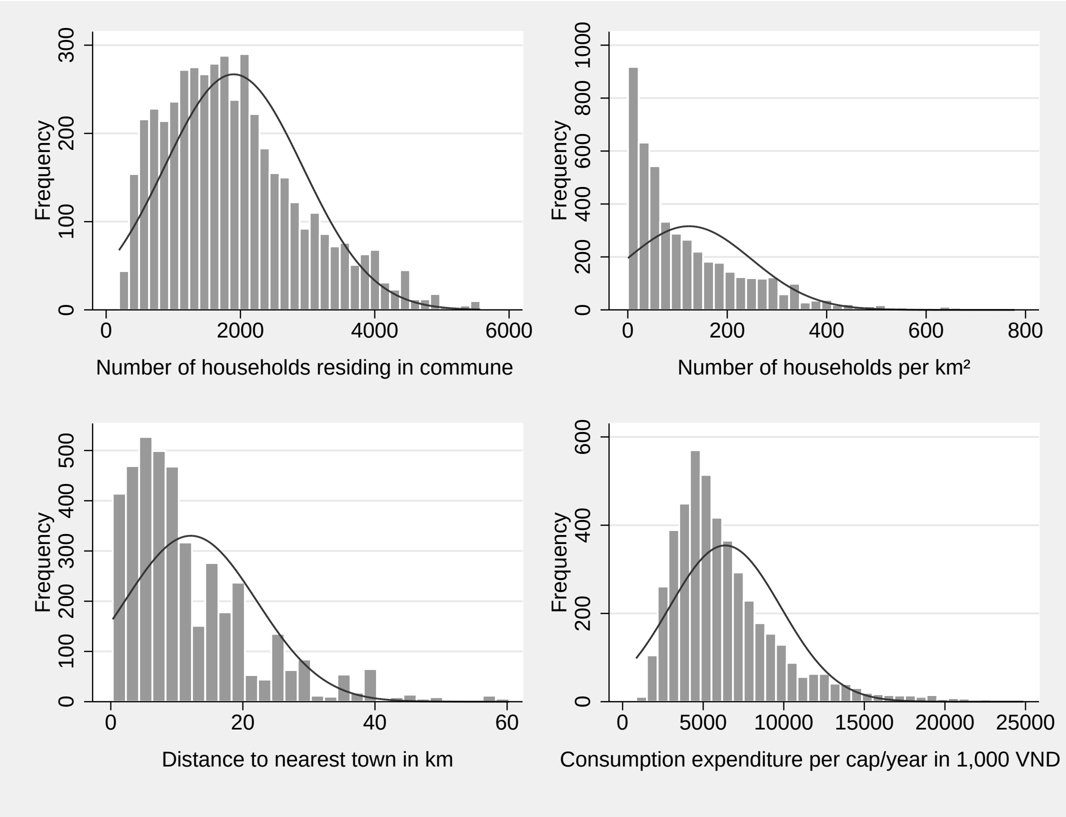
Nearby adoption

Commune level indicators In order to measure whether 'contagion' (e.g. in terms of social learning, observability, or trialability of treatment techniques) plays a relevant role, an indicator for the nearby adoption of HWT in the village environment has been calculated for the VHLSS and the MICS. Based on the aggregated survey data, the nearby adoption rate is defined as the share of households in the district which use HWT compared to the overall number of 'potential adopters'. Whereas in case of the MICS all households in the district are 'counted' as potential adopter, for the VHLSS households using tap and rainwater, or buying bottled water have been excluded because they were not asked about HWT practices. For the MICS – where data has been pooled from two survey waves – nearby adoption rates have been calculated separately for each survey wave, because diffusion is expected to change over time. The resulting nearby adoption rates for HWT empirically range between zero and hundred percent but also illustrate that in most of the communes so far no adoption took place at all (cf. Table 7.2).

Table 7.1.: Operationalisation of dependent and selected independent variables for HWT models

Selection variable	**Variable definition**
Not in sample	Households using water from private or public taps, rainwater, or bottled water as main source of drinking water
In sample	Households using water from tube and dug wells, springs, rivers, lakes, ponds, or tanks as main source of drinking water
Dependent variable	
Use of HWT	Household treats drinking water by chemicals or filters (regardless of boiling)
No use of HWT	Household does not treat drinking water by chemicals or filters (regardless of boiling)
Independent variables	
Unimproved sanitation	0=toilet directly over the water, other type or open defecation
Improved sanitation	1=flush toilet with septic tank, suilabh, and double vault compost latrine
Nearby adoption rate	Percentage of HWT users in the same district among households which do not use tap water or bottled water
Size of commune	Number of households residing in commune
Population density	Number of households per square kilometre
Distance to town	Distance from hamlet to nearest town in km
Communal market	Availability of communal market
Health project	Project about health and community health carried out in commune during last three years
Water project	Project about environment or safe water carried out in commune during last three years

Figure 7.1.: Distribution of continuous dependent variables on commune level



Note: Includes only rural communes, excluding households using tap water, rainwater or bottled water for drinking, solid line represents normal distribution
Source: Own calculation based on VHLSS 2008

Spatial variables

Nearby adoption aside, further variables are defined to measure how spatial proximity and local infrastructure impinge on the diffusion of HWT practices. In contrast to the models in Chapter 5 and 6, no dummy variables representing the administrative or geographical region have been added to the model. Undoubtedly, large regional disparities in the application of HWT show up across the country (Figure 2.6), but including 'catch-all' variables for specific regions does not provide any analytical value added for explaining these regional disparities and forgoes the opportunity to examine which spatial characteristics exactly might bring about specific patterns of diffusion.[127] Spatial and infrastructural characteristics of the village, in which the

[127] Table B.21 and B.22 in the appendix compare the predicted and observed probabilities for specific subgroups and impressively illustrate that even *without* regional dummies, prediction of HWT-use works very well for the specific regions, meaning the covariates included in the regression

respondents are residing, are captured by the following variables: size of commune, distance to nearest town, population density, and access to markets. Density and distance variables are used to measure a) the spatial proximity to central sources of information which here refers to a place where living standards are higher and water treatment techniques more common or easier to acquire, and b) the distance to other adopters as a proxy for increasing opportunities to exchange information with them (cf. Section 7.1). Due to a lack of data about social networks and actual information exchange is available, the population density, measured by the number of households per square kilometre and the distance from the hamlet to the nearest town have been applied as proxies. Figure 7.1 depicts the distribution of the commune size, population density, and the distance to the nearest towns for the households included on the sample. The distribution of these variables is right skewed. However, Locally Weighted Scatterplot Smoother plots (see Figure B.4.3) did not point to problems concerning the functional relationship in the regression model, thus no transformation was applied in order to make the model interpretable in a more intuitive manner than it would be for transformed values.

Supply chain infrastructure

In order to elaborate on whether supply chain requirements impose restrictions on the dissemination of HWT, the availability of a communal market has been included as an indicator. In Việt Nam, markets play a crucial role in the traditional village culture (Ngoc 2010). Thus, the availability of markets is expected to reflect two factors: the possibility to exchange information, but also the opportunity to buy spare parts, chemicals or filter materials required to maintain the treatment facilities, respectively proceed treatment. Here, the availability of markets in the commune is primarily understood as a proxy for the ease of getting access to consumables like filter materials and chemicals. Since supply chains are deemed more relevant for treatment by chemicals, which is usually applied to surface water. Consequently, interaction effects have been introduced to account for distinct effects across treatment methods. 40 percent of the households in the sample live in communes which do not have a communal market. This does not necessarily imply that there are not any small stalls or shops in the village, but beyond markets, the VHLSS questionnaire does not contain additional variables which indicate whether such shopping facilities do exist in the commune.[128]

Sources of information and interventions

In order to account for the influence of measures which might either nudge households to apply HWT by providing financial and in-kind support or health-related information, three indicators have been defined, two of them accounting for commune level programmes and projects and the remaining ones for individual households' pro-

model are indeed able to capture the regional disparities.

128 Furthermore, the distance to markets has been tested as predictor, but since these variables by far contain more missing values and including the distance to markets in place of the availability did not alter the results, only the dichotomous variable for communal market availability has been kept.

gramme participation.[129] Analogous to Table 6.2, two dummy variables to control for the effect of individual households participation in the programme 'safe water for poor people' are included to contrast poor households with and without programme participation with non-poor households which are generally not eligible to support within the scope of this programme. The categorisation of a household as poor is based on the official local registration according to the MoLISA guidelines. Since the economic status of the household is in the model already more precisely captured by per capita consumption expenditure, no 'main effect' for the official status as a poor household has been added to the model to avoid redundancy and collinearity between the predictors. The remaining indicators refer to the communal level. In contrast to the communal infrastructure projects discussed in Section 3.4.2, these dummy variables about programmes capturing health as well as water and environment related programmes refer to the last three years prior to the survey only. By definition, these programmes could be implemented by governmental as well as other international or non-governmental organisations (GSO Vietnam 2008a: 166). Information about water-related infrastructure projects has been considered irrelevant for the adoption of HWT practices by individual households.
The availability of a communal health centre (CHC) as a separate indicator has been discarded because 99 percent of the communes in the sample state to have a CHC. Furthermore, despite some improvements during the last years, these CHCs are often poorly endowed with regard to staff and equipment and suffer from low utilisation (Sepehri et al. 2008; Tuan et al. 2005), and thus it is largely questionable to conclude from the mere availability of such an CHC in a commune about an active role in communicating about water-related health problems and preventive behaviour.

The random intercept model

Model specification

After setting out by a descriptive analysis of the spatial and temporal patterns of HWT use in Việt Nam, it should be assessed by means of logistic regression models how strongly the factors addressed above impinge on the likelihood that households treat their drinking water by chemicals or filters. Supposed that the pattern of HWT use is influenced by communal characteristics, for households belonging to the same commune also the probability to apply HWT is likely to be correlated. The modelling approach is equivalent to that described on page 163 and in Equation (6.1). Here, the random intercept represents the combined effect of all commune level characteristics and peculiarities on HWT application which are not included in the model in terms of explanatory variables on communal level. As in the previous models, the test of variance components by the likelihood ratio test refutes the null hypothesis that the

[129] Information about micro-credits could not be used because only a very minor share of the micro-credits reported in the VHLSS data refers to measures to improve domestic water supply (see p. 201).

residual cluster variance σ_u^2 is equal to zero. This means that even given equal covariate patterns on communal and household level, households' average probabilities to treat drinking water differ significantly due to the fact that they are residing in different communes. The model was concurrently estimated by `xtlogit` and `gllamm` using adaptive quadrature.

7.2.2. Results

Descriptive analysis of the spatial and temporal patterns in HWT use

Overall dissemination of HWT

Case studies and survey data convey an ambiguous picture of the application of HWT practices among rural households in Việt Nam (see Section 2.6.3). The descriptive analysis of typical treatment strategies based on the VHLSS and the MICS confirms that besides boiling, household water treatment is not wide-spread. In total, according to the VHLSS, only every eighth household in rural areas applies filters or chemicals although drinking untreated water from tube wells, dug wells, rivers, lakes, and ponds might pose a substantial health threat. Based on the MICS 3 and 4 surveys, one arrives at a share of roughly one quarter of the rural households applying HWT and even if households with access to tap water or buying bottled water are excluded from the analysis, the re-calculated treatment rate does not exceed 30 percent (cf. Table 7.3).[130]

Spatial patterns of HWT diffusion

Regardless of the water source, boiling water is the predominant strategy for treatment, whereas the application of other techniques is strongly correlated with the source of water and, by implication, with the geographical region (see Figure 2.6 and Table 7.3). The spatial dissemination of specific HWT practices varies strongly across the provinces, with the Mekong and Red River Delta as well as the Southeast accounting for the highest rates but completely different preferences for treatment techniques. Whereas the Mekong Delta is the only region where chemicals are applied to a notable extent, most of the households in the Red River Delta and the Southeast rely on filters. Settling is applied in all three regions but to a varying degree.

Local level diffusion patterns

Case studies from the Red River Delta (Tobias and Berg 2011; Bui and Wegner 2011) suggest a strong spatial concentration in 'adoption hotspots' on the level of single communes. That this pattern is rather typical than an exception is corroborated by district-specific adoption rates based on the MICS and VHLSS data (see p. 228). Table 7.2 outlines some descriptive statistics for the nearby adoption rates based on the MICS and confirms that the districts differ tremendously with regard to the dissemination of HWT. For each of the treatment techniques, single clusters reaching almost full coverage can be found, whereas the vast majority of the sampled clusters

[130] The higher share of HWT users in the MICS is attributable the broader definition of HWT practices. Whereas the VHLSS only covers filters and chemicals, the MICS also includes methods like solar disinfection or settling.

shows very low or zero adoption rates. For boiling the distribution appears strongly left-skewed, meaning districts with low coverage are rather an exception. On the contrary, for the remaining treatment techniques strongly right-skewed distributions prevail. Nearby adoption rates based on the VHLSS are defined as the share of households in the district which apply filters or chemicals compared to the overall number of households in the district relying on self-supply (tap and rainwater users as well as those who buy bottled water have been excluded because they were not asked about HWT). Also the nearby adoption rate for HWT based on the VHLSS empirically ranges between zero and hundred percent, whereby in 59 percent of the rural districts, no household treating water by filters or chemicals was found at all.

TABLE 7.2.: Summary statistics for nearby adoption rates in percentage of households for sampled districts

Nearby adoption rate	Median	Mean	SD	Min	Max	$N_{districts}$
MICS 3 and 4						
Boiling	96.5	85.2	22.6	0.0	100.0	508
Chemicals	0.0	3.1	11.7	0.0	94.3	508
Filters	5.0	11.9	17.2	0.0	100.0	508
Settling	0.0	8.2	14.8	0.0	93.3	508
HWT (excl. boiling)	15.0	22.6	23.3	0.0	100.0	508
VHLSS 2008						
HWT (excl. boiling)	0	12.7	22.8	0	100.0	569

Source: Own calculation based on MICS 3, MICS 4 and VHLSS 2008
Note: Only rural districts included

These figures put into question whether the spatial patterns are indeed so patchy that higher average coverage rates for some regions are mainly attributable to a small number of communes with extremely high coverage rates. If this applies, aggregate statistics on provincial or even regional level might be very sensitive with regard to selection of communes in the survey sample.[131] Furthermore, setting out from the observation that specific HWT practices reach almost full coverage in some villages whereas those are not observable at all in villages in their spatial proximity, the multivariate model will direct the attention to the relative contribution of household level characteristics compared to contextual factors. Hypotheses 7.2 and 7.3 discussed conceivable explanations for spatial concentration in HWT application based on diffusion theory and contextual information about the status of the Vi-

[131] The potential impact of cluster sampling strategies in presence of high within-cluster correlations is addressed on page 254 and in footnote 139

etnamese village as a social entity. Due to the strong village structures and social cohesion it seems plausible that diffusion is first and foremost bound to a specific commune (see also the example of rural sanitation marketing by Devine and Sijbesma (2011) and p. 117).

Temporal patterns of HWT diffusion

Merging MICS 3 and MICS 4 conveys an impression about the dynamics in the diffusion of HWT during the last years. Table 7.3 outlines the share of households using a specific treatment technique in 2006 and 2011, supposed that they did not have access to piped schemes and did not buy bottled water. Overall, the figures gained from the MICS suggest that no tremendous changes in the diffusion of HWT took place during the last years. Whereas a slight growth is detectable for water filters, the share of households adding chemicals even diminished, which is most likely due to the decreasing number of surface water users. A closer look at the regional patterns points to diverging trends: In the Red River Delta, water filters as well as settling gained in importance between 2006 and 2011. Also in the Northern Mountainous and Southeastern region, water filters became more popular, but here the share of households using settling dropped by roughly 10 percentage points. The strongest change in HWT use appeared in the Mekong Delta. Whereas compared to the remaining regions, the share of households boiling water before drinking is by far the lowest, both in 2006 and 2011, in 2006 two thirds (*sic!*) of the households applied other HWT techniques. Astonishingly, this region experienced an enormous drop in the use of chemicals until 2011 (-30 percentage points) whereby it remains unclear, if this is attributable to those households which switched from surface to other water sources like tap water or tube wells. Although at the same time practices like settling or straining water through cloth spread, in total these figures suggest a declining prevalence of HWT practices in the Mekong Delta from 2006 to 2011. Among households which neither use piped nor bottled water for drinking, the share of households using other treatment techniques than boiling dropped from 66 to 49 percent, whereas it increased in the Red River Delta (+11 percentage points) and at least roughly remained stable in all other regions.

Individual treatment strategies

On the level of individual households, the treatment which is applied is correlated with the source of drinking water. Besides boiling, households often prefer a combination of specific treatment methods, whereby households using surface water and tube wells showed the most intensive treatment in 2006. However, the picture slightly changed until 2011: rainwater is treated more frequently, whereas surface water has been treated less compared to 2006. Still, adding chlorine or bleach is the method of choice for treating surface water but lost significantly in importance (77% to 43%). This finding firstly makes clear that the overall decrease in the use of chemicals for treatment does not result from the shift to other water sources, as has been argued before, but from a genuine change in HWT practices among households drinking surface water. On the contrary, water filters became more popular regardless of the water source, but experienced highest growth rates among households drinking tap

Table 7.3.: Application of water treatment techniques in rural Vietnamese households across regions 2006 and 2011

	Red River Delta		Northern Midlands and Mountain area		North Central and Central Coastal area		Central Highlands		South East		Mekong River Delta		Total	
Year	2006	2011	2006	2011	2006	2011	2006	2011	2006	2011	2006	2011	2006	2011
Boiling	99.8	99.7	98.2	99.9	98.1	99.1	99.9	99.8	98.1	95.5	81.7	82.7	95.5	96.6
Add bleach/chlorine	1.3	1.0	0.0	0.2	1.3	0.9	0.4	1.1	0.0	0.2	40.2	10.8	8.5	2.3
Strain it through a cloth	1.0	0.8	0.8	0.2	1.3	1.1	3.3	0.0	3.2	0.0	5.9	12.9	2.3	2.6
Use water filter	24.6	30.9	6.1	10.9	13.6	14.3	8.6	7.0	15.3	21.8	3.0	3.6	13.5	16.0
Solar disinfection	0.1	0.0	0.0	0.0	1.4	0.4	0.1	0.0	0.0	0.7	1.3	0.3	0.6	0.2
Let it stand and settle	2.5	8.4	2.2	2.2	6.8	4.7	6.2	1.6	18.8	7.6	33.6	41.1	11.0	10.9
Other	3.5	2.8	0.4	1.5	2.2	1.2	0.0	1.8	0.0	4.0	0.4	1.0	1.7	1.9
Total	132.9	143.7	107.7	114.9	124.6	121.7	118.6	111.2	135.5	129.7	166.1	152.3	133.1	130.5
No HWT (excl. boiling)	72.3	61.2	92.6	87.1	79.7	80.4	86.0	91.3	72.4	73.8	33.6	51.1	70.3	72.5
No HWT (incl. boiling)	0.0	0.0	9.8	1.1	3.1	3.2	7.2	9.1	10.6	12.6	7.1	9.4	5.0	4.1

Source: Own calculation based on MICS 3 and MICS 4

Note: Rural households only, households using tap water or bottled water excluded, weighted values water, rainwater, or bottled water – which pose the safest sources, anyway. Settling is a more universal strategy deployed to purify water by removing particles from well, rain, and surface water but is usually not used as a stand-alone measure. While settling lost importance among the well and surface water users between 2006 and 2011, it is increasingly applied for treating rainwater (16% to 25%). Whether these figures actually indicate growing disparities in water safety is questionable. At least the finding that in particular those households consuming the unsafest water sources tend to treat their water less frequently, while those using the safest sources shift to more elaborated treatment techniques suggests that the diffusion of HWT is no automatism and more emphasis should be given to understand why households adopt or reject water treatment.

Determinants of HWT use

Bivariate analysis Table 7.4 contrasts households applying chemicals and filters to treat their drinking water with those who refrain from HWT with regard to relevant household and communal level characteristics. Here only rural households[132] which do not use tap water, rainwater, or bottled water for drinking have been included, since in the VHLSS only those have been asked about HWT practices. In this 'reduced' sample, 17 percent of the households use filters or chemicals for water treatment. The figures provide first evidence for the hypothesis that HWT is a matter of affordability, but they confirm that also among more affluent households coverage rather remains low (Hypothesis 7.6). Whereas in the lowest expenditure quintile 10 percent of the households apply chemicals or filters to treat their drinking water, 21 percent percent of the highest quintile treat it. Per capita consumption expenditure differs significantly between both groups (t=-5.40 df=4,559, p=.000). HWT users do on average spend 800.000 VND more per capita and year on consumption purposes than the reference group. Furthermore, HWT seems also more common in communes with lower poverty rates. On average the share of poor households is 7 percentage points lower in communes where HWT users reside.

Furthermore, summary statistics reveal that HWT users have a higher educational status (Mann-Whitney-Test: z=-6.77, p=.000), are larger (t=5.36 df=4,559, p=.000), and less frequently belong to one of the ethnic minority groups. Whereas among the HWT users only 4 percent belong to ethnic minorities, these are 30 percent in the reference group. Households with children below six years are underrepresented among the HWT users compared to the reference group which suggests that in contrast to Hypothesis 7.7, these households do not treat water more frequently due to a higher perceived vulnerability of small children to water-related diseases.

[132] As before also households belonging to communes which are officially classified as 'rural' but show population densities above 1,000 households per km^2 or more than 6,000 registered households are excluded (see p. 165).

Households' or communes' participation in health- or water-related projects do not come along with more frequent use of HWT. On the contrary, programme participation here rather serves as an indicator for the need of improvements in water supply: while among the HWT users 15 percent live in communes where water or environmental projects took place, compared to 23 percent among those who do not treat their drinking water. Similar holds true for the household level programme 'safe water for poor people'. This programme reaches only a very minor share of the rural population and the frequencies displayed in Table 7.4 do not suggest that programme participation coincides with an increase in HWT use.

Concerning the characteristics of rural communes in which HWT users reside, clear differences show up: these are not only significantly larger (t=-7.94 df=4,559, p=.000) and more densely populated (t=-26.48 df=4,538, p=.000), but also more closely located to towns (t=9.94 df=4,108, p=.000). Hence it is reasonable to assume that compared to individual households' characteristics, a communal environment which makes access to and exchange of information more easy contributes to enhancing diffusion of HWT techniques. However, here also an alternative explanation is standing to reason because high population densities and commune sizes often come along with increasing pollution of water sources. It is also plausible to assume that the growing prevalence of HWT poses a reaction to stronger pollution than an outcome of stronger interactions among the (potential) adopters.

In contrast to Hypothesis 7.5, access to communal markets apparently does not pose any advantage for diffusion of HWT in general. However, the results suggest that market infrastructure might be more relevant if chemicals for treating surface water need to be acquired. Given that surface water users reside in a commune where a market takes place, 45 percent apply HWT, compared to 36 percent in communes without markets. Last but not least, Table 7.4 provides strong evidence for the Contagion-Hypothesis (see p. 221): in districts where HWT users are residing, every second household in the nearby environment also applies HWT compared to 7 percent for those respondents who state that they do not treat their drinking water.

Sample

Model estimation and results The analysis of HWT use based on the VHLSS 2008 considers households as primary units of analysis. Those are nested in communes and consequently share a similar setting in which the dissemination of HWT takes place. For the multivariate analysis, the total number of 6,837 households belonging to 2,278 rural communes in the sample has finally been reduced to 4,092 households nested in 1,533 communes due to missing values on the predictor variables and other selection criteria. By definition, 2,072 households which use water from taps, rainwater, or bottled water are excluded from the sample, as for them no information about HWT use is given in the data set (see Table 7.1). Furthermore, analogous to the previous multivariate models, 77 households have been dropped because they

TABLE 7.4.: Descriptives for rural households by dependent variable (N=4,561)

	No HWT (N=3,781)		HWT (N=780)	
Continuous variables	$\bar{x}$	*sd*	$\bar{x}$	*sd*
Age of head of hh (HH)	48.35	13.63	49.98	13.00
Household size (HH)	4.37	1.74	4.02	1.48
Highest grade completed (HH)	6.32	3.57	7.28	3.28
Yearly per capita consumption expenditure in 1,000 VND (HH)	6336.92	3873.71	7160.50	3924.82
Share of poor hhs in % (C)	20.65	17.01	13.11	9.24
Distance to nearest city (C)	13.40	12.23	8.78	6.68
Number of households (C)	1831.81	1031.95	2148.59	929.00
Number of households per km^2 (C)	98.71	100.07	213.46	133.36
Nearby HWT adoption in % (C)	6.91	12.67	49.71	28.86
Dichotomous variables	in % (col)		in % (col)	
Female head of hh (HH)	19.33		20.90	
Children below 6 years (HH)	33.69		26.28	
Ethnic minority hh (HH)	30.02		3.97	
Drinking water: tube well (HH)	27.29		61.03	
Drinking water: dug well (HH)	51.56		17.05	
Drinking water: spring water (HH)	12.75		1.03	
Drinking water: surface water (HH)	6.03		20.26	
Improved sanitation (HH)	44.99		60.13	
Communal market (C)	60.17		62.18	
Project about health (C)	14.78		11.79	
Project about environment or water (C)	23.30		15.26	
Programme 'Safe water for poor people' (HH)	3.65		0.90	
Administrative region	in % (row)		in % (row)	
Red River Delta	49.20		50.60	
Northeastern	95.25		4.75	
Northwestern	98.22		1.78	
North Central Coast	79.46		20.54	
South Central Coast	92.91		7.09	
Central Highlands	97.42		2.58	
Southeastern	94.52		5.48	
Mekong Delta	64.06		35.78	

Note: (HH) household level covariate, (C) commune level covariate

Source: VHLSS 2008, Own calculation based on rural households, excluding households using tap water, rainwater, or bottled water for drinking belong to communes which bear clearly urban characteristics despite being officially classified as rural.[133]

Table 7.5 reports the estimated coefficients and significance levels for four different specifications of the model. The intercept-only model (not displayed) does not only provide the log likelihood benchmark value (ll= -1,549.5) for comparing nested models but also delivers the second-level variance σ_u^2. A likelihood ratio test of the variance components reveals that the residual cluster variance σ_u^2 for all models significantly differs from zero, meaning it indeed makes sense to apply a multilevel model.[134] Here at maximum 83 percent of the overall variability in HWT use are attributable to commune level predictors, suggesting that water treatment is strongly influenced by the environmental context and less a matter of households' characteristics (Hypothesis 7.2).

Communal level effects

Model specification

The models displayed in Table 7.5 differ with regard to their specification of supporting programmes, access to markets as a proxy for supply chain infrastructure, and nearby HWT adoption. Models (2), (3), and (4) account for contagion effects by including the nearby HWT adoption rate in the district as a predictor. Whereas Model (1) and Model (2) contain information on the communal poverty rate and different types of supporting measures which could probably have an effect on HWT, these variables have been dropped from the remaining models because they did not prove relevant. Furthermore, the insignificant main effect for communal markets has been replaced by interaction effects for surface water users in Models (3) and (4). As bivariate frequency tables suggest, access to markets is more relevant for surface water users which usually rely on chemicals for treating water and are thus more dependent on supply chain infrastructure. Models (1), (2), and (3) account for a moderating effect of the drinking water source on the effect of the commune size: whereas in Model (1) for users of surface water an increasing commune size comes along with a higher likelihood of HWT application, for the remaining respondents exactly the opposite effect is observable, meaning HWT is more likely in smaller communes. However, adding the nearby adoption rate in Model (2) and the interaction effects for communal markets in Model (3) shows that the alleged disparate effect of the commune size disappears. Consequently, the effect of commune size observable in Models (1) and (2) is rather to be explained by improved access to markets in larger communes, and hence is addressed more precisely by the respective interaction effects than the commune size as a more general proxy.

Model fit

Overall model fit has been assessed by R_{count}-measures, AIC as well as classification tables.[135] All models yield more than 90 percent of correct predictions. In comparison

[133] This concerns single communes with a population density above 1,000 households per km^2 or more than 6,000 registered households. For details, see p. 165.

[134] For further explanation see p. 269.

[135] Diagnostics (e.g. multi-collinearity, functional relationships, influential observations) and tables for assessing the model-fit can be found in Section B.4 in the Appendix.

to the predictions exclusively based on the marginal distributions, the prediction errors in all estimated models are reduced by more than 58 percent (adj. R^2_{count}). While according to the R_{count}-measures, Model (1) should have been favoured, the above mentioned reflections about the model specification as well as the comparison of the AICs suggested that the parsimonious Model (4) is eventually more appropriate for explaining HWT use. However, independently from the minor differences due to the distinct model specifications, the classification Tables B.17 to B.20 in the appendix show that again false negative predictions – meaning the models do not predict HWT use although the households actually apply it – much more frequently occur than false positives. This suggests that probably relevant facilitating factors for HWT diffusion (e.g. small-scale interventions or micro-credits) could not be captured based on the VHLSS data. In addition to the R_{count}-measures, for assessing overall model-fit the actual rate of HWT users has been compared with the predicted rate for specific groups defined on the basis of selected predictors (see Table B.21 and B.22 in the Appendix). This approach confirms the high predictive accuracy and shows that even *without* including dummy-variables based on administrative regions, the prediction of HWT use works very well for the specific regions, meaning the remaining covariates included in the regression model are able to explain regional disparities sufficiently.

Interpretation of regression coefficients

Comparing the results of Model (1) and (2) impressively illustrates that nearby adoption – meaning contagion effects – proves the most relevant driver of HWT adoption even if covariates e.g. like educational level and household expenditure are taken into account (Hypothesis 7.1). As Figure 7.2 illustrates, with growing nearby adoption rates in the district, the probability that the individual household also applies HWT increases tremendously. This is in line with the finding that diffusion in rural Việt Nam is highly 'localised' and social norms play an overwhelming role for diffusion compared to the remaining factors (Tobias and Berg 2011; Bui and Wegner 2011).

Effect of socio-economic characteristics

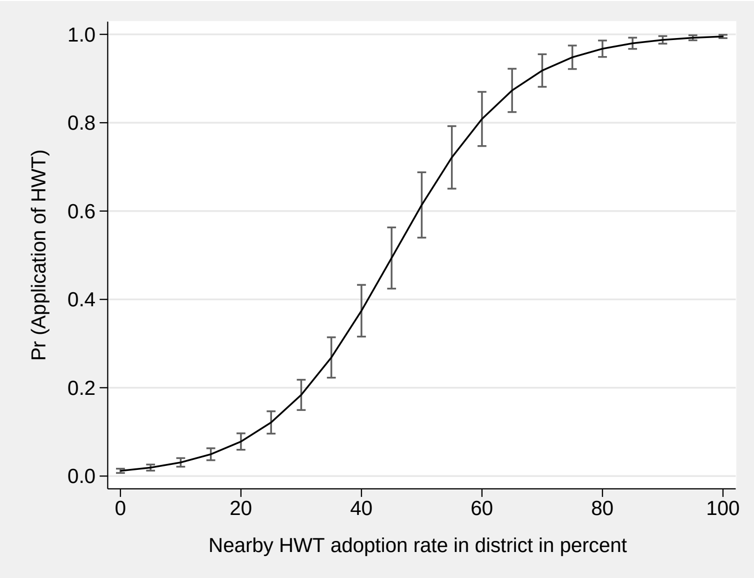
The models displayed in Table 7.5 suggest that the inclination to treat water by filters and chemicals is also significantly influenced by individual households' socio-economic characteristics, albeit to a minor extent. While the overall economic situation in a commune does not prove relevant for adoption, applying HWT is still a matter of individual affordability. With each increase of the yearly per capita consumption expenditure by 100,000 VND, the likelihood that a household applies filters or chemicals to treat the drinking water increases by factor 1.06, respectively factor 1.66 for a per capita increase by one million VND. Figure 7.3 depicts the distinct effect of the per capita consumption expenditure for surface water users and households relying on other water sources for drinking and cooking. It illustrates that for surface water users an increase of household per capita consumption expenditure from 5 to 30 million VND results in a doubling of the probability from 0.3 to 0.6, whereas for the remaining households the probability increases from 0.06 to 0.12 only in the same expenditure interval.

TABLE 7.5.: Random intercept models for application of household water treatment

Use of filters and chemicals for treating drinking water	**Model (1)** exp(b)	**Model (2)** exp(b)	**Model (3)** exp(b)	**Model (4)** exp(b)
Age of head of hh	1.002	1.004	1.004	1.004
Household size	1.066	1.024	1.025	1.025
Children <6 years living in hh	0.791	0.972	0.976	0.976
Highest grade of head of hh	1.062*	1.060*	1.063*	1.062*
Ethnic minority household	0.139***	0.433*	0.440*	0.439*
Cons. expend. per cap/month in 1,000 VND	1.060*	1.054*	1.052*	1.052*
Improved sanitation	1.088	1.222	1.243	1.242
Share of poor households	0.991	1.000	-	-
Commune size (in 1,000 hh)	0.563***	0.852	0.889	0.887
Surface water use * Commune size (in 1,000 hh)	3.490***	1.420***	0.983	
Distance to nearest town in km	0.959**	0.979+	0.982+	0.982+
Number of hh per km^2	1.013***	1.003**	1.002**	1.002**
Poor household with programme[1]	0.516	0.907	-	-
Poor household without safe water programme[1]	0.958	1.042	-	-
Communal project about env. or water	0.856	1.201	-	-
Communal project about health	1.056	1.180	-	-
Communal market	0.749	1.057	-	-
Surface water and access to communal market[2]	-	-	6.281*	5.994***
Surface water and no access to communal market[2]	-	-	1.994	1.911*
Nearby HWT adoption rate	-	1.103***	1.103***	1.103***
Constant	0.016***	0.005***	0.005***	0.005***
Random part				
σ_u	2.814	1.265	1.259	1.259
ρ	0.707	0.327	0.325	0.325
R^2_{count}	94.03%	92.57%	92.61%	92.60%
Adj. R^2_{count}	66.71%	58.53%	58.80%	58.72%
AIC	2685.18	1977.56	1962.76	1960.77
Log likelihood (*ll*)	−1323.59	−968.78	−965.38	−965.38
N	4,092	4,092	4,092	4,092

Note: Model includes only rural households which do not use rainwater, tap water or bottled water for drinking, excludes 5 outliers with standardised Pearson residuals larger than 5.8; [1]Dummies, reference are non-poor households, [2]Dummies, reference other water sources; $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

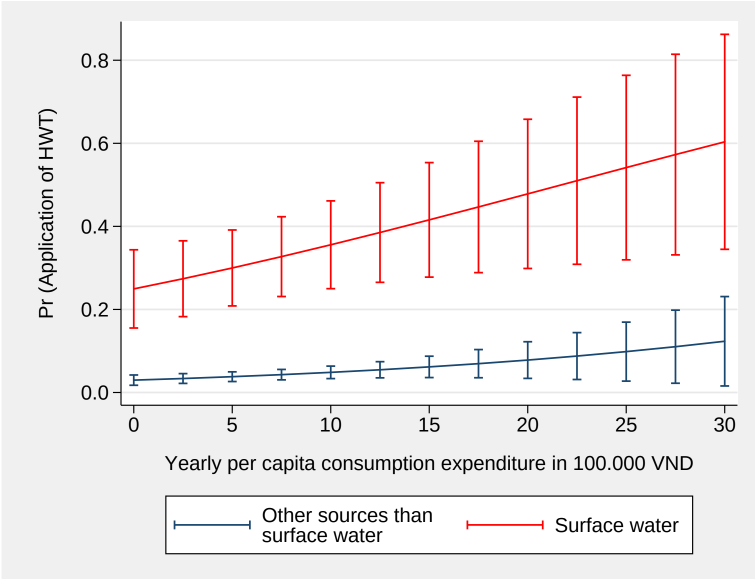
FIGURE 7.2.: Marginal effect of nearby HWT adoption



Note: 95% CI displayed, random effect assumed to be 0 and other predictors fixed at mean
Source: VHLSS 2008, Own calculation, only rural households which do not use rainwater, tap water or bottled water for drinking

Educational status and the presence of small children in the household have been introduced as proxies to measure whether households with more detailed knowledge about water-related diseases and higher perceived health risks due to water-related diseases more frequently apply HWT. While according to the regression models small children living in the household do not encourage households to treat their water more frequently, the model shows that at least a higher educational status impinges positively on HWT application, which provides some support to Hypothesis 7.7. For each grade more completed, the likelihood increases by factor 1.06, meaning the effect is exactly of the same magnitude as for an increase of yearly per capita consumption expenditure by 100,000 VND. Both effects, expenditure and educational level, appear very stable across all model specifications.
Economic status and educational level aside, for HWT adoption also the ethnic status proves relevant. While differences in access to piped schemes between Kinh and ethnic minority households and communes rather have been attributed to economic and spatial disparities, but less to the ethnic minority status as such (see Table 5.6 and 6.4), the HWT regression models clearly point to a significantly negative effect of ethnicity. Kinh households tend to apply HWT twice as often as ethnic minority households even when simultaneously controlling for expenditure effects, educational level, the spatial setting, and other covariates. Comparing Model (1) and (2) shows that after

FIGURE 7.3.: Marginal effect of households expenditure



Note: 95% CI displayed, random effect assumed to be 0 and other predictors fixed at mean
Source: VHLSS 2008, Own calculation, only rural households which do not use rainwater, tap water or bottled water for drinking

taking into account the level of adoption in the nearby environment, the effect of the ethnic minority status becomes slightly weaker but remains significant. Thus, even given the same level of adoption in the nearby environment, ethnic minority households adopt HWT practices much less frequently. In line with the homophily-heterophily hypothesis (see p. 130), this could be attributed to the fact that exchange of information or social learning (e.g. due to observability and trialability of HWT use) rather fosters diffusion among ethnically alike households.[136] However, whether *within-communal heterophily* with regard to socio-economic characteristics actually poses a relevant obstacle for HWT adoption could hardly be assessed by the VHLSS because the small number of households surveyed per commune does not allow to construct sound measures for social and economic distance on commune level. The effects identified here for the educational status, available income for consumption purpose, and the ethnic status confirm that households' preferences for HWT differ

136 Jenkins and Cairncross (2010) observed that the effect of heterophily disappeared in later stages of diffusion, while here ethnic minority households also in districts with high adoption rates still tend to apply HWT to a lesser extent compared to Kinh households. To account for a moderating effect of the diffusion stage on the effect of ethnic status, an interaction effect between the nearby adoption rate and the ethnic status has been included in the regression model but did not prove relevant.

and are not completely determined by the communal setting. Yet they do not allow to conclude about whether these effects are associated with the social distance between potential adopters in the same commune. Households' characteristics are here used in terms of an 'absolute' description, meaning an ethnic minority household treats water generally less frequently, regardless whether it is located in an ethnic minority commune (which would imply homophily), or a Kinh commune (which would imply heterophily).

Commune characteristics

As already the bivariate results suggested, spatial characteristics of the commune play a relevant role for HWT diffusion (Hypothesis 7.4). In contrast to the commune size[137], population density, which is here used as a proxy for stronger interactions among potential adopters, proves a significant predictor for HWT use. An increase of the population density by 100 households per km^2 increases the chance that the household treats water by factor 1.3. Furthermore, the larger the distance from the village, respectively hamlet, to the nearest town, the lesser households applying HWT can be found in rural communes. For a household living within a distance of five kilometres to the next town, the probability to apply chemicals or filters just marginally decreases by factor 0.9, but if it is located 40 kilometres away, the probability already more than halvens if all covariates are kept constant. However, here the alternative explanation based on a correlation between dense population, stronger pollution, and ensuing larger needs for treating water might be relevant.

Effects of supply chain infrastructure

Access to communal markets did not show a significant effect on HWT use as Model (1) and (2) show. However, markets as a proxy for supply chain infrastructure prove highly relevant for surface water users (Hypothesis 7.5). While surface water users in general tend to apply HWT more frequently as descriptive statistics confirm, once they have access to communal markets, the likelihood of HWT use considerably increases. Surface water users without access to markets twice as often apply chemicals or filters compared to users of other water sources which show the same characteristics, but surface water users with access to communal markets are even six times more likely. Taking into account the interaction effect for surface water users and communal markets also reveals that the disparate effect of commune size in Model

[137] As explained above, the alleged disparate effect of the commune size in Model (1) does result from the omission of the nearby adoption rate and becomes irrelevant after controlling for the market infrastructure. While according to Model (1), among surface water users applying HWT is much more common in larger communes, for users of the remaining sources a strong opposite effect has been found. In order to scrutinise whether the varying effect for commune size is attributable to regional disparities, regression analysis with regionally mean-centered commune sizes has been performed but did not lead to different results. Thus, the uncentred variable was kept. After controlling for the nearby adoption rate in the district in Model (2), the effect for commune size disappeared for households which do not use surface water, whereas the positive effect of commune size for surface water users persisted. Commune size and adoption rate are only slightly correlated, so that the fact that commune size becomes an insignificant predictor after controlling for nearby HWT adoption is not attributable to collinearity.

(1) is actually an effect of access to markets or supply chains: comparing Models (2) and (3) reveals that the interaction effect for commune size and surface water use becomes insignificant, once the dummies for surface water users with and without access to communal markets are introduced.

7.2.3. Summary and research desiderata

This chapter sought to describe the current state of diffusion of HWT techniques in rural Việt Nam and to elaborate on the household and commune level factors which might inhibit or facilitate adoption. In this thesis, the umbrella term POU-HWT subsumes a wide range of techniques ranging from boiling, chlorination, filtering, solar disinfection to settling, or just straining water through cloth. The survey data revealed that although the vast majority of the households boils its drinking water, other HWT techniques are not wide-spread among rural households. The spatial dissemination of specific HWT practices varies strongly across the country, with the Mekong and Red River Delta as well as the Southeast accounting for the highest rates. Considering district-, respectively commune-specific adoption rates for different treatment techniques revealed that spatial disparities can be traced back to 'adoption hotspots', meaning communes reaching almost full coverage can be found, whereas the vast majority shows very low or zero adoption rates. Patterns of HWT use do not only vary spatially but are also associated with the source of drinking water. The Mekong Delta, where most of the surface water users are residing, is the only region where chemicals are applied to a notable extent, while most of the households in the Red River Delta and the Southeast rely on filters. Settling is applied in all three regions, but to a varying degree.

Patterns of HWT use

Comparing the MICS data from 2006 and 2011, pointed to growing disparities in HWT application. In general, water filters became more popular regardless of the water source but experienced highest growth rates among households drinking tap, water, rainwater, or bottled water which pose the safest sources, anyway. In contrast, the use of chemicals for treatment declined in the same period. This trend is especially alarming because the overall decrease in the use of chemicals for treatment does not result from a shift from surface water to safer water sources but indeed indicates that less households treat surface water before they drink it. The reasons for the decreasing intensity of HWT in the Mekong Delta and especially among surface water users remained unclear and demand for further inquiries: Do households cease treatment because they do not observe any positive effects? Do they perceive costs and efforts as to high or simply cannot afford treatment anymore?

Growing disparities in HWT use

Households with lower educational status and lower disposable income tend to apply HWT significantly less frequently. While ethnic minority households have not been found to be less frequently connected to piped schemes when controlling for economic and spatial characteristics, those significantly less apply HWT. In line with

Determinants of diffusion

Hypothesis 7.2, the multivariate regression models confirmed that despite the fact that households' decisions for or against HWT are taken independently from other adopters, the environmental setting proved much more relevant for explaining HWT use by rural households than their individual socio-economic characteristics. Nearby adoption proves most relevant for predicting HWT use. Furthermore, in line with diffusion models, spatial characteristics as high population densities and proximity to larger towns have been found to increase HWT adoption significantly. Whereas these findings suggest that 'contagion' is facilitated by increasing intensity of communication and observability of HWT use or suchlike mechanisms, the question whether these mechanisms are sufficient to trigger spill-over effects to adjacent communes and regions remains unanswered. Access to supply chain infrastructure like markets first and foremost poses a limiting factor for adoption of HWT among surface water users only, while it is not significant for users of other water sources. However, since the VHLSS does not allow for a more sophisticated operationalisation of Hypothesis 7.5, it would be desirable to gather more precise information about households' efforts required to obtain chemicals and spare parts. Furthermore, a separate assessment for distinct treatment techniques would be useful to identify potential bottlenecks in supply chains.

Research desiderata

Although the models confirm that nearby adoption proves highly relevant for predicting HWT adoption and that spatial factors – and to a minor extent socio-economic characteristics – play an important role for HWT diffusion, three crucial questions remain unanswered: Firstly, given that there is a large number of communes in which diffusion did not set out at all, which are the initial drivers for adoption? Commune level projects about health and environment as well a poverty eradication programmes did not reveal any positive effect here. However, case studies suggest that numerous small scale interventions take place, which are probably not all captured by the VHLSS data. Hence, in further inquiries special attention should be paid to small scale interventions which could serve as triggers for HWT diffusion in the respective communes. Secondly, contagion effects in terms of nearby adoption explain a great deal of the current state of diffusion in rural communes, but no final conclusions can be drawn about the underlying mechanisms of this process. Whether social norms and simple imitation are responsible for adoption or rather planned interventions, respectively initiatives by local level governmental authorities, should be subject to further inquiries. Thirdly, due to the small number of households sampled per commune, based on the VHLSS no final conclusions can be drawn about potential intra-communal barriers to diffusion, e.g. in terms of heterophily. The data set allows to identify groups which generally tend to apply HWT more or less frequently, but not whether the characteristics of these groups imply smaller or larger social distance, respectively similarity, to other adopters in their proximate environment.

8. Conclusion and research desiderata

Setting out from the observation that domestic water supply in rural Việt Nam is shaped by the coexistence of various practices self-supply and the emergence of small scale piped schemes, this thesis examined the dissemination of piped schemes and HWT application as alternative strategies for improving domestic water supply in rural Việt Nam based on statistical micro-data.

Conclusion 1 *Monitorings for the rural water sector should recognise the diversity of existing practices of self-supply and household water treatment.*

Given that existing practices of domestic water supply, geographical, and hydrogeological conditions are highly variable across the country and distinct trends have been observed in the countries' regions, more attention should be dedicated to the question whether these heterogeneous 'starting conditions' should be reflected in the monitoring systems for measuring progress in the RWSS sector and in the overall sectoral targets. Neither access to piped schemes nor what the JMP defines as 'improved water sources' seem sufficient proxies to assess water safety, and subsequently to identify households or regions which demand for special support. Especially HWT practices should be recognised as a serious alternative to ensure access to safe water, since it seems unlikely that the diffusion of piped schemes will speed up considerably in the short run and pockets of unserved households will continue to exist. The below-mentioned adjustments in data inquiries (Conclusion 5) could lay the foundation for designing additional indicators to get better estimates for water safety at the point of consumption based on the water source and potential treatment strategies.

Conclusion 2 *Diffusion processes in the rural water sector are strongly shaped by the specific environmental and institutional setting in which households are embedded but less by their individual socio-economic characteristics.*

The empirical analysis revealed that disparities in water supply do not only show up between urban and rural areas but also between and within regions and provinces. This raised the question about how localised patterns of water supply practices are actually brought about and to which extent households' decisions to apply HWT and connect to piped schemes are driven by their individual characteristics or are rather a result of their shared environmental or institutional setting. The analysis revealed that the communal setting strongly determines HWT adoption and piped scheme hook-up, while in comparison households' educational level, disposable income, and (at least for HWT adoption) ethnicity play a significant but rather subordinate role. Moreover, for HWT diffusion – and to a lesser extent for piped scheme hook-up – contagion effects prove of utmost importance. The analysis here confirmed the so far anecdotal observation from case studies that HWT use is spatially highly concentrated – with a small number of communes reaching high coverage and a large number of communes where HWT diffusion has not set out at all. As these findings suggest, fostering initial adoption in rural Vietnamese communes seems the more challenging task than pushing diffusion towards saturation. Obviously effective institutional and social mechanisms facilitate within-commune diffusion once initial adoption took place. Nevertheless, exploring the nature of these mechanisms (e.g. role of change agents, intra-communal communication, and social networks) would be highly relevant for designing interventions.

Conclusion 3 *Affordability poses an impediment to improving access to safe water but is primarily relevant for initial connection to piped schemes and acquiring HWT facilities.*

Ambiguous evidence has been found to answer the question whether access to safe water is a matter of costs and affordability. In general, according to the VHLSS data rural households in Việt Nam spend only a very minor part of their overall consumption expenditure for water supply. However, households' economic status and water use practices are interlinked: the poorest households do not only tend to use unsafer water sources but often also refrain from treatment. Also multivariate models confirm that disposable income has a significant effect on piped scheme hook-up and HWT application. Even when controlling for nearby adoption rates, spatial characteristics, and other household level covariates, lower per capita consumption expenditure comes along with lower probabilities that households connect to piped schemes or apply HWT. However, this effect is weaker than expected, in particular compared to 'contagion' effects or to the communal context in general. This, in conjunction with the finding that the share of expenditure spent on water is generally low, leads to the main conclusion that affordability does not pose the most relevant obstacle for improving access to safe water but appears crucial for a small group of the poorest of the poor. Since variable costs for water supply are comparatively low, rather high costs for first-time access in terms of connection fees or acquiring specific facilities are deemed a large hurdle for economically weak households.

Conclusion 4 *Self-supply poses the most relevant impediment to the establishment and expansion of piped water schemes.*

One of the main questions to be answered by this thesis concerned the interaction between the use of self-supply and the diffusion of piped schemes. Case studies in rural Vietnamese communes suggest that due to low variable costs for self-supply, the low comparative advantage for tap water, and high initial costs for piped scheme hook-up, households will give preference to self-supply instead of connecting to piped schemes. The quantitative models strongly corroborate that the use of tube wells indeed poses one of the largest obstacles towards the establishment *and* expansion of piped schemes. Firstly, if tube wells are used by the majority of households in a commune, it is extremely unlikely that piped schemes will be set up in the commune. Secondly, even if piped schemes are already existing in a commune, households who already use an own well will most likely not connect. Subsequently in the short run, in communes where households already use own wells on their premises, even the creation of favourable institutional conditions for the establishment and expansion of piped schemes will hardly provoke any effect unless the perceived advantages of piped schemes hook-up (e.g. in terms of water quality and convenience of supply) will outweigh benefits from self-supply. Thus, here it might be more useful to promote HWT techniques than to strive for the implementation of piped schemes in each and every commune.

Buying bottled water – Means of last resort?

While this thesis focused on access to piped schemes and HWT application as the most relevant strategies to ensure safe water supply, the MICS data strongly suggests that also buying bottled water gains in importance in rural Việt Nam. Up to now, the use of bottled water seemed to play a very marginal role in Việt Nam, especially in rural areas, and had ensuing hardly been subject to investigation in the RWSS sector in the past. However, according to the MICS data, more attention should be dedicated to this topic. Whereas between 2002 and 2012 according to the VHLSS, the share of households stating to rely primarily on bottled water for drinking and cooking has never exceeded 2 percent of the population even in urban districts, the MICS 2 and MICS 4 data astonishingly shows significantly higher rates of up to 10 percent. Moreover, scrutinising the regional distribution of the respective households points to a strong spatial concentration. Whereas in 2000, elevated rates have only been found in the Red River[138] and the Mekong Delta, in the 2011 survey the Southeast (31%) and the Mekong region (17%) scored exceptionally high. Beyond that, households relying on bottled water are highly spatially concentrated in specific communes. For none of the other water sources such high volatility in the overall distribution was observable what raises the question why households at a specific location switch to a water source which is otherwise used very rarely in Việt Nam and deemed expensive?[139] So far, it appears plausible that these pockets of bottled water users

[138] Figures for the Red River Delta in the MICS 2 are from the author's point of view not reliable since this MICS wave did not consider rainwater harvesting which was already a relevant source in the RRD region in 2000 and thus is likely to distort the overall results.

[139] When assessing the volatility, distinct sampling strategies applied in the MICS and VHLSS should be taken into account. Given that the VHLSS samples only three households per commune whereas the MICS on average samples 20 households, it seems plausible that communes with extremely high rates of bottled water users lead to a stronger distortion of the overall distribution due to the design effect (*deff*) (cf. Kish 1965). It can easily be illustrated by the intraclass correlation and the design factor that bottled water use is highly spatially concentrated on specific communes (see Table B.1). The reduction of the cluster size in the MICS 4 (GSO Vietnam 2011) reduced the design effect but nevertheless, the extremely high intraclass correlation suggests that the high share of bottled water users is largely attributable to a quite small number of communes.

are an expression of households' short-term strategies to respond to extreme pollution of ground or surface water, drought, or salt water intrusion at specific localities and thus rather a means of last resort to ensure drinking water supply than an intentional and sustainable strategy to organise water supply for rural households. Based on the surveys, no reasons for these peculiarities could be identified but these findings make think about whether buying water poses a serious alternative to applying HWT or extending piped water supply.

Conclusion 5 *Adjustments in routine data collection and the combination of data sources provide a large potential for further analysis of the rural RWSS sector.*

This thesis illustrated how the existing data sources may contribute to analyse and assess developments in rural water supply in a more detailed fashion. However, it also pointed out the difficulties in applying this data base to identify drivers and obstacles for progress in rural water supply. I will conclude by briefly addressing four aspects with regard to the benefits and limitations of the data base applied in this thesis: (1) the sensitivity of survey results towards sampling strategies, (2) the lack of temporal reference, (3) constraints with regard to the operationalisation, and (4) the untapped potential of merging VHLSS and MICS data with other data available for Việt Nam.

Relevance of sampling strategies

As has been illustrated by the example of HWT and bottled water use, practices of water supply are characterised by extreme spatial disparities even within administrative units and adoption might be highly concentrated on single communes. Thus, for assessing the prevalence of HWT or water use practices based on survey data, considering the sampling approach is more than a methodological subtlety. Given that high intraclass correlations – as in case of HWT or bottled water use – coincide with large cluster sizes and a small number of clusters, conclusions about the prevalence of practices in the overall population might be biased. On the contrary, a high number of sampled clusters in conjunction with small numbers of households as in the VHLSS increases the effective sample size and delivers more precise results but does hardly allow to draw conclusions about *within-commune* adoption rates and thus to assess whether diffusion did not set out all, is currently in its take-off phase, or has even reached saturation. As is briefly outlined below, combining samples with low design effects and aggregated commune level information (e.g. about piped schemes coverage) might pose a helpful compromise to get out of this predicament.

Lack of temporal reference

Conclusions about drivers and obstacles of diffusion have been drawn based on cross-sectional data. Since the diffusion concept by definition involves a processual perspective, accounting for the temporal dimension by longitudinal data would pose a more adequate approach to draw causal conclusions. In addition to the cross-sectional perspective, tracing the diffusion process over time would allow to assess more precisely whether and under which conditions (1) diffusion of HWT practices set outs at all, respectively piped schemes emerge, (2) diffusion or coverage reaches its take-off phase, and (3) to assess which diffusion drivers or obstacles turn out relevant in the distinct stage of the diffusion process. Since the VHLSS is carried out bi-annually, it would – at least theoretically – pose an appropriate basis for panel analysis to actually elaborate on causal effects. But since at maximum three subsequent panel waves can be taken into account and up to now only a small share of households connects to piped schemes or starts using HWT, it is not clear whether sample size would prove sufficient for such kind of analysis.

Suggestions for operationalisation and merging data

Although the VHLSS as well as the MICS data sets prove valuable data sources, they impose some constraints on the operationalisation of the hypotheses to be tested. In order to enable more detailed analysis of HWT and water use practices, I propose the following adjustments in the VHLSS household level inquiry:

- Due to the fact that the use of water sources often changes across the year, the question about water sources used for drinking and cooking, respectively other daily purpose should allow for multiple answers, respectively distinguish between the main water source and those used temporarily in addition.
- The household questionnaire should allow for *all* combinations of water sources and statements about water treatment. As the example of the MICS shows, HWT practices are also applied by tap and rainwater users.
- Instead of a general question about water treatment, the household questionnaire should either account for different treatment techniques (e.g. in accordance to the categories offered by the MICS data set) or at least provide more precise interviewer instructions about which treatment techniques are covered by the item.

Last but not least, on the commune level, the following extensions in terms of modifications in the VHLSS or merging data with other inquiries would be useful for further analysis:

- In addition to the source of water typically used in the commune, information about the coverage of piped schemes either in terms of the percentage of households or number of households served should be provided if piped schemes are under operation in the commune. This could also be realised by merging the VHLSS with data from the M&E indicator set for RWSS budget allocation and planning (see Section 1.5.2).
- In order to quickly identify areas which are especially prone to water-related health problems, the commune level inquiry could refer to water-related problems, e.g. due to serious environmental pollution, insufficient quality or accessibility of water sources, and geogenic contamination. This would provide

valuable information to (1) design sound sampling strategies to conduct more detailed risk assessments or surveys to learn more about knowledge and awareness about water related health threats and preventive behaviour, and (2) to plan interventions to promote preventive behaviour. Alternatively, these objectives could be achieved by linking survey data to existing information from environmental monitorings or hazard mappings.

A. Statistical Appendix – Random intercept models for binary dependent variables

Contents

The models estimated in Chapter 5, 6, and 7 do not only aim at revealing the influence of provincial, communal, and household characteristics on specific practices of water supply but also at disentangling the effects of 'adopter characteristics' and those of the 'environmental context'. In case of the Piped Scheme Availability Model this means to assess the contribution of the provincial affiliation in contrast to commune level variables. The models in Chapter 6 and 7 instead consider to which extent piped scheme hook-up and the adoption of treatment practices can be attributed to household characteristics and households' embeddedness in a specific communal setting which it shares with other households in the same commune. Thus, technically speaking, multilevel regression models have been considered as the most appropriate way to represent the hierarchical data structure and to analyse the within-cluster and between-cluster relations in a single model (Snijders and Bosker 1999). The following sections provide detailed information on the type of regression models estimated in this thesis. It sketches the basic idea of multilevel models and reviews basic facts about the estimation, interpretation, and assessment of random intercept regression models. The last part reports relevant diagnostics for the multivariate models estimated in this thesis.

A.1. Why is there a need for multilevel regression models?

The VHLSS 2008 data set is hierarchically structured (cf. Section 1.5.2). Besides information about the household and its members, it also contains information about

the commune and province, the respective household is belonging to.[140] But what does this hierarchical data structure imply for the analysis by regression models? Considering context information in terms of group-level variables enables researchers to systematically investigate their effect on the outcome variable but also confronts them with some methodological challenges. Hierarchical data implies clustered observations, meaning that measured and unmeasured characteristics of the context impinge on the individual-level dependent variable. Consequently, the number of independent observations is actually lower than the overall number of observations which leads to severe consequences for inferential statistics. This phenomena is known as the *design-effect* (cf. Kish 1965). The smaller the number of clusters in relation to the overall number of observations and the more homogeneous the units within a cluster, the larger would be the design effect.
In order to produce unbiased and efficient estimates by Ordinary Least Squares (OLS) regression, the residuals are required to be independent from each other, homoscedastic, and identically distributed, which is commonly referred to as the so called *iid*-assumption. Consequently, the affiliation, respectively dependency of the first-level units on their assigned second-level units is likely to come along with violations of central assumptions about the distribution of residuals in OLS regression. When clustering of observations is ignored, standard errors tend to be underestimated, which eventually results in too narrow confidence intervals and ensuing null-hypotheses are discarded too hastily in a F- or t-Test. Whereas this problem might be solved by the estimation of robust standard errors, the question about the genuine contribution of commune and household level variables and their interactions remains. If the number of clusters is limited, separate regression analysis for each cluster, the introduction of dummy variables or interactions terms might pose feasible strategies to cope with the problem of clustered observations.[141] Another popular approach is multilevel analysis which explicitly 'represents within-group as well as between-group relations within a single analysis, [...]' and conceives '[...] of the unexplained variation within groups and unexplained variation between groups as random variability' (Snijders and Bosker 1999: 38). The multilevel approach here is not only applied to cope with the violation of the *iid*-assumption and to obtain correct standard errors – which could also be achieved by estimating robust standard errors – but first and foremost to:

- decompose the variability in the outcome according to the different hierarchical levels (intraclass correlation ρ),

[140] Indeed the VHLSS 2008 data set contains several sub-data sets which refer to different units of analysis such as communal projects, socio-demographic data for single household members, or data about commune leading cadres/village staff, which provide information on the specific commune.

[141] Snijders and Bosker (1999: 43) provides some useful guidance on the decision whether to use models with fixed or random coefficients.

– account for unobserved heterogeneity on communal or provincial-level which has not been captured by the covariates included in the models (random intercept),[142]

– scrutinise whether the communal affiliation of a household, respectively the provincial affiliation to a province, has a significant effect on the outcome,

– examine whether specific effects of commune and household level characteristics vary across the context units (random effects).

A.2. The basic logic of (logistic) random-effects models

Random coefficient models are also known as 'variance components', 'hierarchical' or 'mixed effects models' (Hox 2010: 11). Although these models differ slightly, they all have in common that they are able to deal with hierarchical data, whereby the outcome variable is measured on the lowest level and covariates and predictors might be included on all hierarchical levels. But what does the *fixed* and *random* part mean in this case? Let's assume separate linear regression[143] for each second-level unit j with two explanatory variables:

$$Y_{ij} = \alpha_j + \beta_{1j} x_{1ij} + \beta_{2j} x_{2ij} + e_{ij} \tag{A.1}$$

This delivers for each second-level unit j a different intercept α_j and different slope coefficients β_{1j} and β_{2j}. Since they are varying between the second-level units – in our case communes or provinces – they are referred to as *random coefficients.* In a next step, one could try to explain the variance of the commune-specific regression coefficients α_j, β_{1j} and β_{2j} by explanatory variables z on the higher hierarchical level (Equations A.2).

$$\begin{aligned} \alpha_j &= \gamma_{00} + \gamma_{01} z_j + u_{0j} \\ \beta_{1j} &= \gamma_{10} + \gamma_{11} z_j + u_{1j} \\ \beta_{2j} &= \gamma_{20} + \gamma_{21} z_j + u_{2j} \end{aligned} \tag{A.2}$$

In this case, the regression coefficients γ are constant across the clusters because all variation between the clusters included in the βs which cannot be attributed to the

[142] Put it differently, omitting random effects by implication means to agree a priori with the assumption that the hierarchical data structure is entirely captured by the explanatory variables in the respective model, which is practically always unfounded (cf. Snijders and Bosker 1999: 40).

[143] For the sake of simplicity, here an example for linear outcomes is illustrated. Similar explanations can be found in Hox (2010) or Snijders and Bosker (1999).

cluster-level variable z is now captured by the residuals u. Therefore the regression coefficients γ are referred to as *fixed coefficients*. On all levels, the respective residuals are assumed to have a mean of zero whereas the variances σ_e^2, $\sigma_{u_0}^2$, $\sigma_{u_1}^2$, and $\sigma_{u_2}^2$ are to be estimated. The residual terms on commune level u_{0j}, u_{1j}, and u_{2j} are assumed to be independent from the lowest-level residuals e_{ij}, while the covariances between the second-level residuals are not expected to equal zero.
Substituting α_j, β_{1j}, and β_{2j} from Equation (A.2) in Equation (A.1) and rearranging gives the following regression equation, in which the *fixed* and the *random* part – which here comprises a random intercept as well as a random slope – can clearly be identified:

$$Y_{ij} = \overbrace{\gamma_{00} + \gamma_{10}x_{ij} + \gamma_{01}z_j + \gamma_{11}x_{ij}z_j}^{\text{Fixed Part}} + \overbrace{u_{1j}x_{1ij} + u_{0j} + e_{ij}}^{\text{Random Part}} \tag{A.3}$$

Coming back to the residuals: Equation (A.3) inherently covers the problem of heteroscedastic errors addressed in the introduction because the group-level residuals u also depend on explanatory variables on the lowest level. In distinction from ordinary single-level regression, multilevel models are not estimated by OLS but by maximum likelihood (ML) estimation[144] which delivers also standard errors for most of the parameters estimated, which can be applied for significance testing. Another useful 'by-product' of ML estimation is the deviance indicating the fit of the model. In case of nested models – meaning models that build upon each other in terms of adding explanatory variables – the deviance allows to assess whether the fit of the more complex model improves significantly in comparison to the parsimonious one. Some more comments on parameter estimation by ML procedure can be found in Section A.2.2.

A.2.1. Steps in building up a model

This section briefly summarises useful steps to specify a multilevel model in a systematic manner which have been applied in this thesis. The procedure described here is mainly a synthesis of Hox (2010) and Langer (2009). Model specification always sets out by estimating the so-called 'empty' or 'intercept-only model' without predictor variables.

Step 1: 'Empty model' without explanatory variables (intercept-only model)

$$Y_{ij} = \gamma_{00} + u_{0j} + e_{ij} \tag{A.4}$$

[144] For a general introduction to ML estimation, see Eliason (1993) and Urban and Mayerl (2011).

Although the intercept-only model does not explain any variance of the outcome variable Y, it is useful for decomposing the total variance into the variance of the lowest level residual variance σ_e^2 and the second-level residual variance σ_u^2. Thereby, the model helps to estimate the intraclass correlation ρ (Equation A.5) and simultaneously gives a benchmark for the deviance, which can subsequently be applied to assess the fit of nested models by various Pseudo-R^2-measures.

$$\rho = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_e^2} \tag{A.5}$$

The intraclass correlation in the intercept-only model indicates the maximum share of variance which can be explained by the context variables. In case of a logistic model, the term for ρ simplifies because by assumption the estimated lower-level variance σ_e^2 is constant and equals $\frac{\pi^2}{3}$ (Hox 2010: 117). Consequently, for logistic models it should be kept in mind that ρ is simply rescaled with changing values for σ_u^2 when comparing the intraclass correlation across nested models. Nevertheless it is reasonable to expect, that σ_u^2, and thus also ρ, decreases after adding lower-level predictors.

Step 2: Model including household and commune level explanatory variables

$$Y_{ij} = \gamma_{00} + \gamma_{p0} x_{pij} + \gamma_{0q} z_{qj} + u_{0j} + e_{ij} \tag{A.6}$$

When adding explanatory variables on household level, σ_e^2 is of course expected to decrease (in a linear model). After specifying the basic random intercept model, more complex relationships could be added to the model either in terms of random-coefficients or (cross-level) interaction effects. If it is reasonable to assume that the effect of an explanatory variable – or technically speaking its slope – varies significantly between clusters, a random effect might be introduced for the respective predictor (*Step 3*). In order to examine, how the effect of one specific predictor on the dependent variable depends on the magnitude of a second (or third) predictor variable, an interaction effect might be specified (*Step 4*).

Step 3: Random coefficient model

$$Y_{ij} = \gamma_{00} + \gamma_{p0} x_{pij} + \gamma_{0q} z_{qj} + u_{pj} x_{pij} + u_{0j} + e_{ij} \tag{A.7}$$

Step 4: Random coefficient model including (cross-level) interactions

$$Y_{ij} = \gamma_{00} + \gamma_{10} x_{ij} + \gamma_{01} z_j + \overbrace{\gamma_{11} x_{ij} z_j}^{\substack{\text{cross-level} \\ \text{interaction-term}}} + u_{1j} x_{1ij} + u_{0j} + e_{ij} \tag{A.8}$$

A.2.2. Estimation of multilevel models for binary outcomes

As explained above, OLS regression is not applied here for two reasons: first, because it does not account for the hierarchical data structure and the ensuing violations of the *iid*-assumption, and second, because the outcome variables are binary ones. The following section briefly explains why OLS regression fails in the latter case and introduces the estimation procedures applied here.

The models outlined in the previous section assume a continuous dependent variable and normal error distribution, which would both not be given for a binary outcome. Applying OLS regression to a binary variable would at least violate two central assumptions: firstly, residuals will by nature be heteroscedastic and will secondly never follow a normal distribution (cf. Urban and Mayerl 2011: 324). If OLS is not the adequate estimation method due to the above described violation of central assumptions, parameters, and standard errors could be derived by ML estimation, which is usually applied in logistic and multilevel regression. Besides ML, some other methods like generalised least squares (GLS), generalised estimating equations (GEE), Markov Chain Monte Carlo (MCMC) and bootstrapping have been applied in estimating multilevel models so far but will not be discussed here.

Maximum likelihood estimation

'The maximum likelihood (ML) method is a general estimation procedure, which produces estimates for the population parameters that maximise the probability [...] of observing the data that are actually observed, given the model [...].' (Hox 2010: 40). Put it differently, optimal parameters are those which - if inserted in the regression equation - reproduce with the highest probability the observed outcome in the sample. The estimates gained by ML estimation show three desirable properties: they are asymptotically consistent, meaning that distortions and variances of the parameters estimated are decreasing with increasing sample size, asymptotically efficient, and asymptotically normally distributed and can thus be used to test for statistical significance (Urban and Mayerl 2011: 331).

In ML estimation, optimal parameters are to be found in an iterative procedure. Starting from values which are usually gained by single-level regression, the procedure tries to improve the parameters until the ML for obtaining the sample data which has actually been found is reached and the estimation procedure converged. If an estimation does not converge even after a large number of iterations, this might indicate a misspecified model, e.g. due to too many random effects included which are close to zero (Hox 2010: 42). In multilevel regression, two ML-functions are used: the so-called full information maximum likelihood function (FIML) which includes regression coefficients and variance components, whereas the restricted information maximum likelihood function (REML) partials out the fixed part, estimates only variance components, and subsequently considers fixed coefficients in a second step. Although both methods produce similar estimates for fixed and random parameters, their standard errors, and the deviance, the REML is expected to deliver less biased estimates of the variance components. However, differences in estimation results gained by FIML and REML are deemed immaterial if the size of groups is large (cf. Snijders and Bosker 1999: 56). In contrast, FIML is the method of choice in order to compare models which differ in the fixed part based on the deviance (cf. Hox 2010; Snijders and Bosker 1999).

ML estimation delivers standard errors for most of the parameters, which can be used for significance testing (Wald test for significance of coefficients), as well as the likelihood, which – transformed into the deviance – indicates how well the model fits the data (lower deviance fits better than higher deviance). For nested models, the deviance can be compared in order to check whether goodness of fit improved after adding, modifying, or deleting inappropriate predictors. The difference in the deviance follows a χ^2-distribution, whereby degrees of freedom equal the difference in the number of parameters that are estimated by both models. Further details about evaluating the model fit are outlined in Section A.3.4.

Estimation with Stata

The selection of the respective estimation procedure determines the choice of the statistical software used for the calculation because not all procedures are implemented in each and every application.[145] In Stata, logistic random intercept models can be estimated using `xtlogit`, `xtmelogit`, and `gllamm`. Random coefficients instead can only be estimated by the latter two procedures. `gllamm` relies on numerical integration – more precisely Gaussian adaptive quadrature – which is computationally intensive but produces accurate results (Rabe-Hesketh and Skrondal 2005; Rabe-Hesketh et al. 2005). It uses FIML but does not comprehend estimation methods like REML or MCMC (Grilli and Rampichini 2005: 19).[146] Estimates gained by FIML and numerical integration allow to apply test procedures and goodness-of-fit measures based on the deviance, which would not be appropriate in case of REML (Hox 2010: 121). Since there is no per se guarantee that reliable estimates have been achieved, the stability of the estimation procedure has been assessed by comparing the estimates gained with different numbers of quadrature points (Rabe-Hesketh and Skrondal 2012: 523). When increasing the number of integration points in `gllamm` from 12 to 30, results remained stable. Furthermore, `xtlogit` and `gllamm` yield exactly the same results for the random intercept models.

[145] For further descriptions and an overview about the estimation methods implemented in other multilevel and statistical software packages, see Hox (2010); Langer (2009).

[146] For further information about the estimation procedures implemented in `gllamm`, see Rabe-Hesketh et al. (2005, 2004).

A.3. Interpreting and assessing results of multilevel logistic regression

The following section briefly recalls methodological basics about logistic regression analysis. On the one hand, it is intended to help readers unfamiliar with this topic to understand, interpret, and evaluate the findings, on the other hand it makes transparent why and under which circumstances specific procedures and measures have been applied. After setting out with a few comments on data preparation, it discusses how to:

- interpret the outcome of logistic regression,
- compare models and coefficients,
- assess the overall model-fit,
- evaluate whether crucial requirements to obtain reliable results are met.

A.3.1. Data preparation

Whereas in the past some researchers advocated mean-centering of predictor variables as some kind of standard preparatory procedure, especially before computing interaction effects in order to avoid multi-collinearity and improve interpretability (Hox 2010; Cohen 2003; Aiken et al. 1991), it seems now a consensus that mean-centering still makes sense in the latter case but is inappropriate to reduce 'essential collinearity' (Dalal and Zickar 2012; Cohen 2003). Dalal and Zickar (2012); Shieh (2011) and Echambadi and Hess (2007) demonstrate that this strategy 'does not change the fit of regression models, does not impact the power to detect moderating effects, and does not alter the reliability of product terms' (Dalal and Zickar 2012: 339).

Practical arguments against mean-centering

Thus, within the course of data preparation, no mean-centering has been applied because for all the independent variables the zero-value is interpretable – even if this value does not actually occur in the data set. Besides the fact that the continuous variables included in the models here have a meaningful zero-point, theoretical reflections support the decision to refrain from centering of predictors for the models estimated in Chapter 5, 6, and 7. Firstly, in case of population density, grand-mean centering would distort results since the population density varies strongly across regions and high population densities in the RRD region (which also contributes a high share of cases) strongly influence the overall mean. Secondly, group-mean centering – as an alternative strategy to account for regional differences in population densities – does not seem appropriate either because it removes all between-group variation and does not allow to compare the overall influence of an increase in population densities because the reference value would not be the same across regions. Thirdly, in case of expenditure levels – another candidate for centering – the argumentation would be different: Since ceiling prices for piped water and financial support also differ according to average regional income levels, group mean-centering would pose a strategy to direct attention towards within-region differences in expenditure levels which could here probably be more meaningful and informative given regional economic inequalities. However, the model re-specification based on region-centered per capita consumption expenditure did not alter the results and was thus discarded. This might be due to the fact that disparities in expenditure level across the regions are in the non-centered model already compensated by differences in purchasing power.

A.3.2. Interpreting the outcome of logistic regressions

Understanding the implications of non-linearity in models for categorical dependent variables is of utmost importance for interpretation. Unlike in linear models, the effects of the predictor variables on the probability of the outcome are more difficult to interpret because neither the marginal nor the discrete change in outcome with respect to the independent variable are constant (Long and Freese 2006: 116). Here the binary outcome is 'transformed' to the *logit* in order to construct a linear relationship between the outcome in terms of the logit and the linear predictor ($\alpha + \beta x_i$). The estimated results of a logistic regression can be presented in terms of three different metrics: the probability ($\hat{p}_i$), the odds ($Odds = \frac{\hat{p}_i}{1-\hat{p}_i}$) or the logit ($Logit = \ln(\frac{\hat{p}_i}{1-\hat{p}_i})$). Equations (A.9) below illustrate the relationship between probabilities, odds and logits.

$$\begin{aligned} \text{Logit} = \ln(\frac{\hat{p}_i}{1-\hat{p}_i}) \quad &\Leftrightarrow \quad \frac{\hat{p}_i}{1-\hat{p}_i} = e^{(\alpha+\beta x_i)} \\ \text{Odds} = \frac{\hat{p}_i}{1-\hat{p}_i} \quad &\Leftrightarrow \quad \hat{p}_i = \frac{e^{(\alpha+\beta x_i)}}{1+e^{(\alpha+\beta x_i)}} \end{aligned} \tag{A.9}$$

Coefficients are either presented in terms of the typical regression coefficients or odds ratios (OR). Like in OLS regression, b represents the coefficients for the predictor but is interpreted differently. The b-coefficient 'indicates the linear increment in the logit for a one-unit increment in the predictor' (Cohen 2003: 492) and thus allows to draw conclusions about the direction of the influence of the independent variable but is barely interpretable intuitively due to the quite unfamiliar *logit*-form. Hence, effects are often interpreted in terms of the changes in the odds, which are defined as the chance that the outcome y is observed compared to the chance that the outcome does not occur. Consequently, the odds ratio indicates the ratio between the odds of y=1 for a specific value of the predictor x and the odds of y=1 for one unit increment in the predictor x (Long and Freese 2006; Cohen 2003). This approach takes advantage of the fact that changes in the odds ratios are constant for changes in the predictor. Odds ratios are obtained by taking the exponential (e^b) of the b-

coefficients. They are multiplicative, meaning they give the amount by which the odds of y=1 are multiplied if the predictor x increases by one unit. Thus, an odds ratio equal to one corresponds with a b-coefficient of zero. In this case, the chance of having an outcome of y=1 does not change with increasing or decreasing values for the predictor. Correspondingly, odds ratios larger than 1.0 indicate increasing chances, and odds ratios lower than 1.0 lower chances to show an outcome of y=1 for a one unit increase in the predictor. For comparing the magnitudes of positive and negative effects, the inverse of the respective effect should be considered, e.g. an odds ratio of three suggests the same magnitude of a negative odds ratio of one third (Long and Freese 2006: 179 et seq.).
In this thesis, the following approaches for interpreting and illustrating the results of the logistic models are used:

- the transformation, respectively exponentiation, of the coefficients (b) to odds ratios (OR) as explained above,
- the calculation of predicted probabilities for meaningful covariate patterns,
- and calculation and illustration of predicted probabilities for discrete changes in the independent variables and specific covariate patterns.

Predicted probabilities

Two alternatives are conceivable for getting the predicted probability in a random effects model: either the random effect is assumed to be zero (for xtlogit: `predict newvar, pu0`) or based on a prediction of the posterior distribution for the random effect. In the latter case, predicted probabilities can be calculated by the `gllamm` postestimation command `gllapred newvar, mu` or the prediction of the linear predictor by `gllapred newvar, linpred` which can be subsequently be rearranged to yield $\hat{p}$ (see Equation A.9). The approach chosen here depends on the focal point of the analysis. If the primary objective is to illustrate the effect of specific covariate patterns, the random effect is fixed at zero. However, if the analysis aims at demonstrating cluster-specifics, the predicted probability is substituted by the predicted probability which accounts for the random part by considering the posterior distribution(s) of the random effect(s).

Marginal effects

Marginal effects and marginal effects plots pose a useful means to graphically illustrate the effect of predictor variables on the predicted probability for the outcome variable, which can be displayed in the three different metrics described above. The marginal effects plots depict the predicted probabilities for the outcome variable and the respective confidence interval as a function of selected values for an independent variable. Please note that in case of probability metrics, the relationship between the outcome and the predictor is non-linear. Here, these ‘adjusted predictions’ are produced by holding the other predictors at their means (or other specified values) and assuming the random effect to be zero (Mitchell 2012: 26 et seq.).

Moreover, especially the interpretation of interaction effects often caused debates, especially in case of logistic models. Here I will stick to the notation offered by Jaccard and Turrisi (2003). ‘An interaction effect is said to exist when the effect of the independent variable on the dependent variable differs depending on the value of a third variable, called the moderator variable. [...] The moderator approach to interaction analysis requires that a theorist specif[ies] a moderator variable and what we call a focal independent variable. The focal independent variable is the variable whose effect on the dependent variable is thought to vary as a function of the moderator variable.’ (Jaccard and Turrisi 2003: 3). In this framework, the simple main effect is considered to be a conditional one, since it denotes the effect of the focal independent variable at a particular value of the moderator variable. Furthermore, an interaction effect only exists if the effect of this focal independent variable differs depending on the level of the moderator variable (cf. Jaccard and Turrisi 2003).

Understanding interaction effects

In non-linear models, things are getting more complicated. Several authors point to a common mistake when interpreting the interaction effect in logistic models in terms of the marginal effects metrics (e.g. Norton et al. 2004; Ai and Norton 2003). Fortunately, there is also an option to circumvent this problem by interpreting the effect in the multiplicative notion of odds ratios. However, Buis (2010: 306) points to the fact that interpretation as marginal or multiplicative effects answers slightly different questions. In this thesis, interaction effects involving categorical variables have been interpreted following the approach outlined by Kohler and Kreuter (2006).

A.3.3. Testing parameters and predicting random effects

Testing significance of single parameters in regression equations can either be done by the Wald test or the χ^2-difference-test of the deviance, which both yield asymptotically equivalent results. For testing variance components, usually the χ^2-difference-test based on the deviance performs better. Although there are concerns that this holds true for logistic multilevel models, where the likelihood function is often only a fairly bad approximation (Hox 2010: 49), here also tests based on the deviance are applied because the estimation procedures are based on FIML and numerical integration, which are expected to deliver precise estimates (see p. 265 and Hox 2010: 121). Thus, a likelihood ratio test for the variance components has been performed in order to decide whether the null hypothesis that the residual variance σ_{u^2} is zero has to be rejected or not. If this hypothesis can be rejected based on the test – meaning the model estimation yields a significant between-province, respectively between-commune variance – the multilevel approach gains more accurate estimates compared to the ordinary regression model (Rabe-Hesketh and Skrondal 2012: 536).

Empirical Bayes prediction

After obtaining estimates for the fixed model parameters and the variance of the random intercept, one might be interested in predicting cluster-specific random intercepts or coefficients (cf. Figure 5.4 on p. 175). In a two-level model as in Chapters 5 and 6, the random intercept represents the combined effect of all higher-level characteristics (unobserved heterogeneity) on the outcome y_{ij} that are not included in the model in terms of explanatory variables. In contrast to the fixed coefficients, the random effects are rather latent variables than statistical parameters (Snijders and Bosker 1999: 58). Whereas for linear components, random parameter estimates can also be obtained by treating the random effect as fixed and applying ML estimation, in the logistic model they can only be obtained by Empirical Bayes prediction (EB), which produces so called posterior means (Rabe-Hesketh and Skrondal 2005: 16 et seq.). Based on the artificial assumption that the estimated parameters are true, the prior distribution of the random effect (with mean equal to zero and the estimated variance σ_u^2) is combined with the likelihood of the outcome y_{ij} given the random intercept, yielding the posterior distribution of the random intercept given the observed responses and covariates. The EB-prediction for the cluster-specific intercept is then the mean of the posterior distribution with model parameters plugged in (Rabe-Hesketh and Skrondal 2005: 129). The posterior means and intercepts are not identical with the ones which would result from separate regression for each cluster. The EB-predictions are less variable – hence also called 'shrinkage estimates' – since they are based on a weighted average of the parameter estimates in separate cluster-specific regressions and the overall regression coefficient (Hox 2010; Snijders and Bosker 1999). 'The shrinkage weight depends on the reliability of the estimated coefficient. Coefficients that are estimated with small accuracy shrink more than very accurately estimated coefficients. Accuracy of estimation depends on two factors: the group sample size, and the distance between the group-based estimate and the overall estimate' (Hox 2010: 29 et seq.). Cluster-specific predictions gained by this procedure are biased but usually more precise, meaning closer to the unknown values of α. Here, EB-predictions are produced by Stata's `gllapred, u` postestimation command.[147]

A.3.4. Comparing models and assessing overall goodness of fit

Goodness-of-fit-measures are important for assessing the models' overall fit to the data but also for comparing nested and non-nested models. Therefore the following measures are applied and will subsequently be explained in brief:

- Pseudo-R^2 measures (cf. Kohler and Kreuter 2012)
- Classification tables
- R^2_{count} measures (cf. Kohler and Kreuter 2012)

[147] I am aware that in non-linear models, the posterior standard deviations produced by `gllapred, u` differ from the prediction error standard deviations. For obtaining standardised 'diagnostic' residuals `gllapred, ustd` should be applied (Rabe-Hesketh and Skrondal 2005: 129).

Whereas the latter two are based on predicted probabilities, the first ones draw on the deviance as an outcome of the ML estimation. The deviance is based on the value of the likelihood function (ll) at its point of convergence and defined as $-2\ln(ll)$. The deviance of the *intercept-only* model provides a good benchmark for the explanatory power when comparing nested models.[148] In case of nested models, the Likelihood-Ratio-Test based on a χ^2-distribution allows to compare whether the simpler model fits better than the more complex one. For comparing non-nested hierarchical models, usually the AIC and BIC as deviance-based measures are applied (cf. Equations A.10). Here the AIC is preferable to the BIC because for calculating the BIC, it is unclear whether n refers to the number of first or second-level units (Hox 2010: 50). Both measures take into account the number of coefficients to be estimated (including the intercept) – denoted as m in Equations (A.10) – and favour the parsimonious model given equal fit (Cohen 2003: 509). The smallest AIC in this cases indicates best model fit.

$$\begin{aligned} AIC &= -2\ln(ll) + 2m \\ BIC &= -2\ln(ll) + m\ln(n) \end{aligned} \tag{A.10}$$

Pseudo-R^2 measures

In contrast to OLS, in logistic regression there is no 'accounting for the variance' measure like R^2 because in logistic regression, the variance is fixed as the variance of the standard logistic distribution (Hox 2010: 117). Instead, some measures based on the deviance are calculated which are not directly comparable to R^2 although commonly referred to as Pseudo-R^2 measures.[149] Except for Nagelkerke's R^2, which includes an adjustment, none of the measures can reach the maximum value of 1. Although neither McFadden's nor Cox and Snell's nor Nagelkerke's R^2 can be interpreted as explained variance or even compared between different data sets, they provide a useful orientation to compare models referring to the same outcome variable and data set (Tabachnick and Fidell 2007). Whether these measures are also applicable in case of multilevel logistic regression depends on the estimation procedure chosen: if the likelihood is estimated accurately, then indexes based on the deviance and likelihood are deemed appropriate. Since `gllamm` relies on FIML estimation and numerical integration and hence provides a precise estimate for the deviance, the following Pseudo-R^2 measures could theoretically be applied (Hox 2010; Grilli and Rampichini 2005):

[148] Models are nested if a model is derived from a more complex one simply by omitting variables.

[149] For details about the calculation, advantages and disadvantages of these measures, see Backhaus et al. (2011); Hox (2010); Cohen (2003). In contrast to single-level models, standard postestimation commands for Stata as `estat classification` or `fitstat` for logistic regression cannot be applied in case of random intercept or random slope models.

$$
\begin{aligned}
R^2_{\text{McFadden}} &= 1 - \frac{Deviance_{full}}{Deviance_{null}} \\
R^2_{\text{Cox\&Snell}} &= 1 - \left(\frac{Deviance_{full}}{Deviance_{null}}\right)^{\frac{2}{n}} \\
R^2_{\text{Nagelkerke}} &= \frac{R^2_{\text{Cox\&Snell}}}{1 - (Deviance_{null})^{\frac{2}{n}}}
\end{aligned}
\tag{A.11}
$$

Classification tables

Besides by Pseudo-R^2 measures, the overall model fit can also be assessed by classification tables and R^2_{count}-measures generated from the predicted probabilities. Whereas in linear regression, residuals as the difference between the predicted and actually observed outcome play a crucial role in assessing model fit, in logistic regression, classification tables are constructed by assigning each observation one of the two outcomes of the dependent variables based on the predicted probability. Thereby the positive outcome is assigned if the predicted probabilities $\hat{p}$ exceed a specific cut-off value. Cohen (2003: 517) discusses the selection of appropriate cut-off points but also shows that – in contrast to sensitivity and specificity – measures of model fit based on the derived classification tables are barely sensitive to them.[150] Following the standard approach, here a cut-off value of 0.5 was assumed, meaning a positive outcome is assigned if the predicted probability is larger than 0.5, respectively a negative outcome if the probability is lower than 0.5 (see Stata-code A.1).

R^2_{count}-measures

Classification tables provide the basis for calculating the share of correctly predicted observations displayed on the main diagonal of the table. However, when considering this share – referred to as R^2_{count} – one should keep in mind that even if only the marginal distribution of the outcome variable is known, a substantial number of observations might be classified correctly (so called base-rate). This is taken into account by the adjusted R^2_{count} (Equation A.12), calculated '[b]y comparing the correct classification obtained from the marginal distribution with the correct classification obtained with the knowledge of the independent variable [...]' (Kohler and Kreuter 2012: 266).

$$
R^2_{AdjCount} = \frac{\sum_j n_{ij} - max_c(n_{+c})}{n - max_c(n_{+c})} \tag{A.12}
$$

In Equation (A.12), $\sum_j n_{ij}$ is the sum of cases displayed on the main diagonal of the classification table, n_{+c} is the sum of column c and $max_c(n_{+c})$ is the column with the higher values of n_{+c}. The adjusted R^2_{count} then indicates by which percentage the error rate drops when including the independent variables compared to the prediction

150 Sometimes ROC curves are applied to define a cut-off point that simultaneously maximises sensitivity and specificity. This procedure, however, also involves a subjective decision about how to value sensitivity and specificity.

made exclusively based on the marginal distribution of the outcome variable.

Alternative measure of model fit

As indicated above, defining cut-off values in classification tables might involve subjectivity, especially since these values are barely stated explicitly in reports and publications. In order to avoid the pitfall of assessing the model accuracy only based on R^2_{count} and adjusted Count R^2_{count}, a second approach was pursued. For specific groups – which are created based on the predictors included in the model – has been checked to which extent the actual rates of occurrence of the outcome variable (e.g. availability of piped schemes) match the predicted probabilities gained from the model.[151] This strategy accounts for the fact that the estimated probabilities refer to groups characterised by certain manifestations of the independent variables rather than to specific individuals. Following this rationale, it seems more realistic to compare the actual rate of occurrence in this subgroup with the predicted proportion of occurrence, assuming that if both correspond quite well that indicates a high degree of accuracy. Practically, this was done by calculating the mean predicted probability for specific subgroups and comparing this with the respective fraction in the subgroup that actually shows the outcome on the dependent variable. For an example, see Table B.5 which presents the results for the Piped Scheme Model estimated in Section 5.2.3 for specific subgroups and reveals that estimated probabilities match the actually observed fractions of communes which have piped schemes well.

A.4. Regression diagnostics and critical issues in estimating multilevel models

A.4.1. Critical issues in estimating multilevel models

Data requirements to yield accurate estimates when applying multilevel models have been debated intensively, especially with regard to the question for a sufficient sample size (Hox 2010: 233 et seq.). Most of the work done in this field so far focused on the question which sample size is required to arrive at accurate estimates for fixed and random effects, whereas less attention has been paid to standard errors. Maas and Hox (2005) provide a list of factors which proved to have an impact on estimates gained by simulation studies:

- number of groups,
- size of higher-level groups,
- number of lower-level units,
- the intraclass correlation ρ,

[151] This approach was developed based on a comment posted by Maletta (2009) about optimal cut-off points for classification in logistic regression in SPSSX forum.

FIGURE A.1.: Stata code for classification table (Example for Model (2) in Table 5.6)

```
**Script for estimation of predicted probabilities and
**predicted outcome based on gllamm estimates

*set local for outcome variable and stored estimates
local model "pw_avail_model3_gllamm"
local outcome "pw_avail"

estimates restore ‘model’

cap drop ‘outcome’_linpred
cap drop ‘outcome’_prob
gllapred ‘outcome’_linpred, linpred
gen ‘outcome’_prob=(exp(‘outcome’_linpred))/(1+exp(‘outcome’_linpred))

cap drop ‘outcome’_hat

gen ‘outcome’_hat=.
replace ‘outcome’_hat=1 if ‘outcome’_prob > 0.5
replace ‘outcome’_hat=0 if ‘outcome’_prob < 0.5 & ‘outcome’_prob!=.
replace ‘outcome’_hat=. if ‘outcome’_prob ==.

*classification table
tab ‘outcome’_hat ‘outcome’
local N_total=‘r(N)’

cap drop false_positive false_negative
gen false_positive=1 if ‘outcome’_hat==1 & ‘outcome’==0
gen false_negative=1 if ‘outcome’_hat==0 & ‘outcome’==1

quietly: tab false_positive if false_positive==1
local FP=‘r(N)’
quietly: tab false_negative if false_negative==1
local FN=‘r(N)’

*correctly predicted
local CP=‘N_total’-‘FP’-‘FN’
*max_c
quietly: tab ‘outcome’ if ‘outcome’==0 & e(sample)
local maxc=‘r(N)’

*Calculate R-count
display (‘CP’)/‘N_total’

*Calculate adjusted R_count
display (‘CP’-‘maxc’)/(‘N_total’-‘maxc’)
```

– and the estimation method (REML vs. FIML see Section A.2.2).

Sample size

According to Maas and Hox (2005), in simulation studies sample sizes have proven to be a major restriction: standard errors of fixed parameters are slightly biased downwards if the number of higher-level units is less than 50 (Maas and Hox 2004, 2005). Standards errors for higher-level variances are estimated too small if the number of groups is below 100 (Maas and Hox 2005). The power of tests on lower- and higher-level regression coefficients also strongly depends on the number of higher-level units, whereas the power of the Wald test applied to assess the significance of first-level predictors rather depends on the total number of observations (Hox 2010). In general the number of second-level units is deemed more relevant for accuracy and power than the total number of observations. However, recommendations for sample size depend on the major interest of the researcher: if the primary interest is in fixed parameters, the number of groups should be at least 30, but if there is a strong interest in random effects and the associated standard errors, the ratio between the number of second and first-level units should rather be 100/10 (Hox 2010: 235). For both, fixed and random parameters, the largest absolute bias in estimation has been found if a small small size coincides with a high intraclass correlation. Nevertheless, the percentage relative bias even in this case was extremely small (Maas and Hox 2005: 89). Given that the household level models estimated in Chapter 6 show comparatively high intraclass correlations but are based on a substantial number of communes, this problem seems negligible here.

Intraclass correlation

A.4.2. Model assumptions and regression diagnostics

Inspecting residuals, outliers, and multi-collinearity among the independent variables is a standard procedure in multiple regression analysis to examine whether crucial assumptions of the model are met. Whereas for OLS and logistic regression a set of standard tools is available (cf. Kohler and Kreuter 2012; Urban and Mayerl 2011; Tabachnick and Fidell 2007), the procedure becomes more complicated in case of logistic multilevel models. Inspecting residuals and testing central assumptions for logistic random intercept, respectively multilevel models here implies testing for:

- an appropriate model specification, meaning that no relevant variables are omitted and the model model is not over-fitted by including extraneous variables which are irrelevant for testing the hypotheses,
- the functional link, namely that true conditional probabilities are a logistic function of the independent variables,
- multicollinearity to ensure that independent variables are no linear combinations of each other,

– and influential observations.

Model (re)-specification

Testing model specifications concerns 'both sides' of the model equation. Thus it has been analysed:

- whether the functional relationship between the probability and the linear predictor is s-shaped,
- and whether no relevant variables are missing and no extraneous ones are included.

In contrast to linear regression, the functional form between the probabilities and the independent variable does not have to be linear – since a linear relationship is only assumed between the logit and the linear predictor – but should ideally take an sigmoidal form. However, the empirical data often captures only a specific section of the curve.
As a first approach, for continuous predictors included in the model the relationship to the probabilities has been tested by means of graphical inspection in Locally Weighted Scatterplot Smoother (LOWESS) plots and – when additionally controlling for other covariates – an equivalent to local mean regression (Kohler and Kreuter 2012: 269 et seq.). In the latter approach, the continuous predictor is recoded and replaced by a series of dummy variables in the model. Then the estimated b-coefficients are plotted consecutively for increasing values of the original predictor. If the relationship between the b-coefficients and the logit is linear, the coefficients should increase, respectively decrease continuously (Kohler and Kreuter 2012: 270).
As a second approach for re-specifying the models, 'false positive' and 'false negative' predictions based on the parameter estimations have been analysed to assess whether these prediction errors are caused by specific covariate patterns or rather occur randomly. Furthermore, different definitions and operationalisations of indicators have been applied to test the 'stability' of the model. Reasons for opting for or against specific modifications are discussed alongside the presentation of the final models.

Multi-collinearity

Multi-collinearity appears as a common problem in regression analysis, since independent variables measuring theoretically related constructs are often also empirically correlated. In cases of severe multi-collinearity, estimated regression coefficients are often unreliable and their standard errors tend to be inflated. In addition to the mere inspection of the magnitude of changes in estimated coefficients and standard errors in different model specifications, the tolerance and the variance inflation factor

(VIF) have been inspected to detect collinearity among the included predictor variables. The tolerance of a variable is defined as the difference between 1 and the R^2 yielded from a regression of this variable on the other variables to be included in the model (see Equation A.13). The VIF instead is defined as the inverse of the tolerance and indicates how much of the inflation of the standard error is attributable to collinearity (cf. Urban and Mayerl 2011; Tabachnick and Fidell 2007):

$$\begin{aligned} Tolerance =& 1 - R^2 \\ VIF =& \frac{1}{tolerance} \end{aligned} \tag{A.13}$$

If all variables are orthogonal, VIF and tolerance would equal 1. On the contrary, if variables are highly correlated, the tolerance approaches 0, whereas the VIF grows tremendously. According to rules of thumb, a tolerance of 0.1 to 0.5 or less, respectively a VIF of 5 to 10 or greater would be cause of concern (Urban and Mayerl 2011: 232). Here Stata's `collin` programme has been applied to calculate collinearity diagnostics for the independent variables included in the model. Multi-collinearity often occurs when interaction or polynomial terms are included. Interaction terms here as in other cases are used to examine how the effect of one independent variable on the dependent variable depends on the magnitude of a second (or third) independent variable. Since the respective independent variable usually enters the model in terms of a main and the interaction effect, this is likely to result in multi-collinearity (see Table B.6 and B.7 for this effect). Whereas in the past some researchers advocated mean-centering of predictor variables before computing interaction effects in order to get rid off multi-collinearity, others demonstrated that this strategy only reduces non-essential collinearity and does not provide any advantage for the detection of moderator effects (Dalal and Zickar 2012; Shieh 2011; Echambadi and Hess 2007). Section A.3.1 explains why mean-centering is not applied here although interaction effect appear in the models and Section B.2.4 illustrates how VIF and tolerance change when (a) interaction effects are excluded and (b) centered instead of uncentred predictors are added to the model.

Multi-collinearity and interaction effects

Influential observations

Influential observations are single data points which might not necessarily be obvious outliers showing extreme values on the outcome or the predictors but which have a significant influence on the estimated coefficient (cf. Kohler and Kreuter 2012; Urban and Mayerl 2011). Since residuals in logistic regression are by nature non-normally distributed and heteroscedastic, diagnostics are more complex than for OLS regression. Typically, deviance or Pearson residuals are applied in such cases. In line with Kohler and Kreuter (2012: 275) and Cohen (2003: 515), Pearson residuals have been calculated based on the `gllamm` estimations as a measure to identify influential

observations (`gllapred newvar, pearson`). Identifying cases with high residuals allows to discuss which covariate patterns might not be captured well by the model. Findings from this analysis are outlined in the respective diagnostics sections for the commune and household models (cf. Sections B.2, B.3, and B.4).
In addition to this formal criterion, outliers have been identified based on content-related criteria. For the estimation of the multivariate models, communes, respectively households residing in communes with rather urban characteristics have been excluded from the analysis in order to avoid bias by mixing urban and rural communes. This concerns communes with:

- population density of more than 1,000 households per km^2,
- number of households in commune above 6,000,
- one commune which obviously belongs to a larger city.

These limits have been defined based on the inspection of frequency distributions. For further information, see page 165.

B. Complementary tables and analysis

B.1. Additional information about surveys

B.1.1. Commune level Questionnaire Section 5: Infrastructure

In the following selected question and items of the VHLSS and MICS questionnaires are displayed in verbatim. No adjustments or corrections with regard to grammar or style have been made.

Please let us know all the infrastructure projects/works in the commune over the last 10 years, starting with the most recent project/work (if there are more than 10 projects/works, surveyor will only record the 10 largest projects/works

Which project/work is it?

- road to district or province
- inner communal road
- bridge
- irrigation expansion
- consolidating irrigation network
- power
- safe water, hard disposal treatment
- health station
- school
- kindergarten
- residential land conversion/expansion
- reclamation of cultivable land
- forest plantation
- other (specify it ...)

Who are the main donors for this projekt/work?

– central government

– province/city

– district

– commune

– hamlet

– other donor

– other (specify it ...)

What is the total funding of project/work? (cash and in-kind included)

How many households in the commune are this project/work beneficiaries?

B.1.2. Effect of sampling strategies on survey results

Table B.1 outlines the intraclass correlations and the design effects (*deff*) for the MICS data sets used in this thesis and illustrates how a decrease in the cluster size and simultaneous increase in the number of clusters affects the design effect given the high intra-communal homogeneity with regard to the use of water sources (cf. Piazza 2010: 160 et seq.). Case numbers for bottled water users in the VHLSS 2008 are too low to gain a reliable estimate for the ICC as a reference for the MICS here.

TABLE B.1.: Design effect for bottled water use in MICS surveys

Survey	ICC	Average cluster size	*deff*
MICS 2	0.83	31.80	26.57
MICS 3	0.69	33.40	23.42
MICS 4	0.51	18.70	10.10
MICS pooled	0.63	30.90	19.89

Note: Intraclass correlations based on random-intercept model calculated by `xtlogit` with clusters for communes, includes urban and rural households
Source: Own calculation based on MICS 2, MICS 3, MICS 4

B.2. Multivariate models in Chapter 5

B.2.1. Assessment of model fit - Classification tables for models including R-count measures in Piped Scheme Availability Model

For further explanations about the calculation see page 273.

TABLE B.2.: Classification table and model fit for Piped Scheme Model (1)

Predicted outcome	**Observed outcome**		
	No piped scheme	Piped scheme	Total
No piped scheme	1,440	199	1,639
Piped scheme	59	161	220
Total	1,499	360	1,859

$R^2_{count} = 86.12\%$ $Adj.\ R^2_{count} = 28.33\%$

TABLE B.3.: Classification table and model fit for Piped Scheme Model (2)

Predicted outcome	**Observed outcome**		
	No piped scheme	Piped scheme	Total
No piped scheme	1,442	198	1,639
Piped scheme	57	162	220
Total	1,499	360	1,859

$R^2_{count} = 86.28\%$ $Adj.\ R^2_{count} = 29.17\%$

TABLE B.4.: Classification table and model fit for Piped Scheme Model (3)

Predicted outcome	**Observed outcome**		
	No piped scheme	Piped scheme	Total
No piped scheme	1,440	199	1,639
Piped scheme	59	161	220
Total	1,499	360	1,859

$R^2_{count} = 86.12\%$ $Adj.\ R^2_{count} = 28.33\%$

Table B.5.: Comparison of observed and predicted probabilities for availability of piped schemes in specific subgroups based on Piped Scheme Model (2)

	Availability of piped schemes in subgroup	
	Fraction observed	Average predicted probability
Major ethnic group not Kinh		
No	0.21	0.21
Yes	0.11	0.10
Tube well as main source of drinking water		
No	0.25	0.24
Yes	0.08	0.07
Communal projects about environment and safe water		
None	0.14	0.14
At least one	0.30	0.29
Percentage of poor households (classified)		
<5%	0.26	0.25
5-10%	0.29	0.27
10-20%	0.17	0.17
20-30%	0.13	0.13
>30%	0.10	0.08
Population density in hh per km^2 (quartiles)		
1st quartile	0.12	0.11
2nd quartile	0.20	0.20
3rd quartile	0.26	0.26
4th quartile	0.19	0.18
Distance to nearest town (quartiles)		
1st quartile	0.22	0.20
2nd quartile	0.17	0.20
3rd quartile	0.21	0.20
4th quartile	0.16	0.16
Coastal region		
No	0.19	0.18
Yes	0.28	0.28
Delta region		
No	0.13	0.12
Yes	0.25	0.25
Midland/hilly region		
No	0.20	0.20
Yes	0.06	0.06
Low mountainous region		
No	0.20	0.20
Yes	0.15	0.15
Mountainous region		
No	0.22	0.21
Yes	0.07	0.06

Source: VHLSS 2008, Own calculation

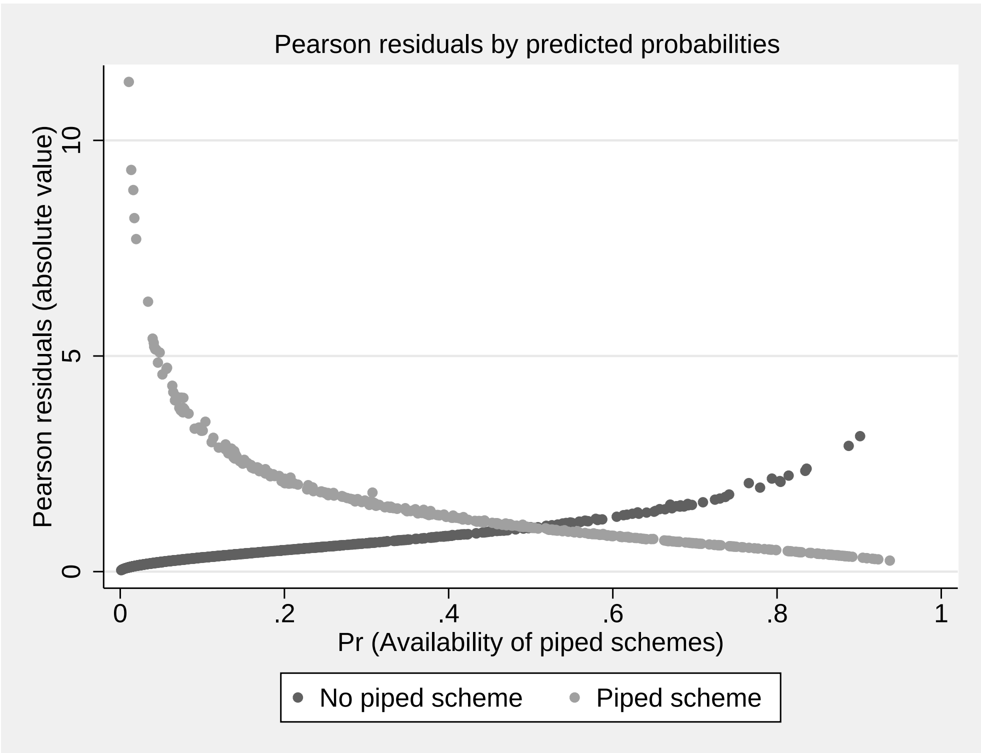
B.2.2. Influential observations and exclusion of cases in Piped Scheme Availability Model

The analysis of the standardised Pearson residuals delivers a negligible number of cases with extremely high residuals. First of all, it is striking that all but one case showing high Pearson residuals show a positive outcome, meaning that the model is much more likely to produce 'false negative' predictions than 'false positive' ones (see Figure B.1). These finding is fully in line with the analysis of false positive and negatives based on the classification tables (see tables in Section B.2.1). Secondly, the analysis of these cases with high residuals allows to discuss, which covariate patterns might not be captured well by the model. Here, this mainly concerns communes in which piped schemes are available and which are characterised by:

- use of tube wells + absence of infrastructure programmes
- high poverty rates + low number of hh + low population density
- high poverty rates + absence of infrastructure programmes

However, given that the number of cases for each of the specific covariate patterns stated above is very small, the model could not be further respecified. Moreover, due to the diverse covariate patterns among the false negatives it is reasonable to assume that the model misses out an additional factor that substantially increases the likelihood of piped scheme availability like interventions which are not captured by the information in the data set at hand. This finding strongly corroborates the need for further systematic research about the prevalence and impact of interventions in the rural water sector.

FIGURE B.1.: Influential observations in Piped Scheme Availability Model: Pearson residuals by predicted probabilities

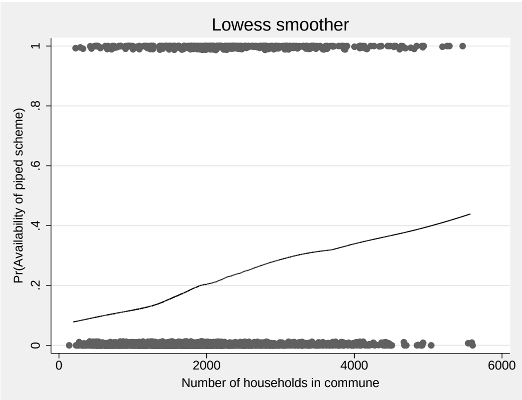


Note: Pearson residuals calculated by `gllapred, pearson`
Source: VHLSS 2008, Own calculation

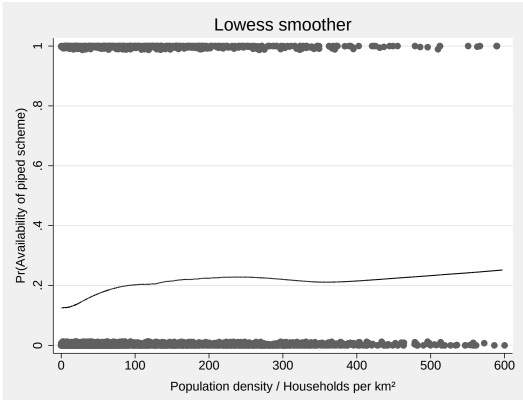
B.2.3. Functional relationships in Piped Scheme Availability Model

Although in Panel (a) of B.2 the overall number of households shows a positive relationship with the probability of piped schemes availability, this effect is not significant when controlling for other covariates as in Model (1) to (3) in Table 5.6. Even when the population density or the infrastructure index – as a predictors which are probably 'redundant' to a certain extent – are dropped from the model, the total number of households in the commune or hamlet does not prove a significant predictor.

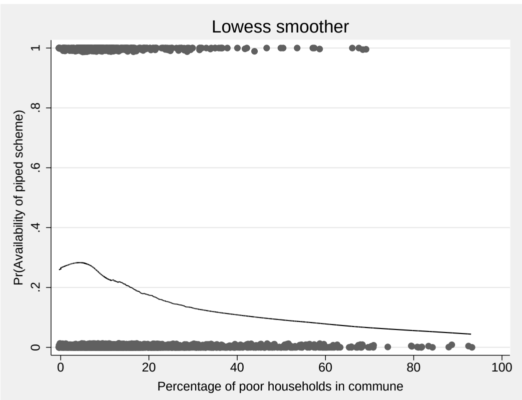
FIGURE B.2.: LOWESS plot for functional relationship between availability of piped scheme and continuous predictors



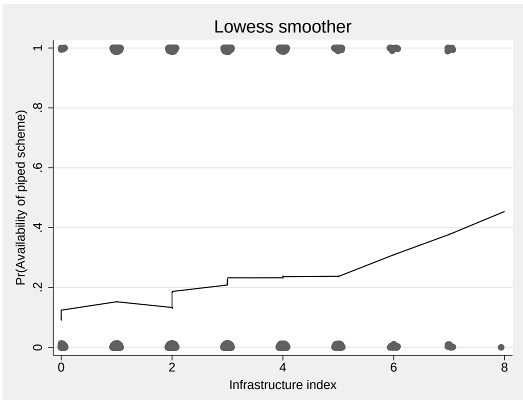
(a) Number of households



(b) Population density



(c) Communal poverty rate



(d) Communal infrastructure endowment

Note: For further information about `lowess` see Kohler and Kreuter (2012: 269)
Source: VHLSS 2008, Own calculation

B.2.4. Multi-collinearity in Piped Scheme Availability Models

Table B.6.: Collinearity diagnostics for Piped Scheme Model (2) including interaction effect

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Use of tube wells	1.21	1.10	0.83	0.17
Project for safe water	1.12	1.06	0.89	0.11
Ethnic minority	5.31	2.30	0.19	0.81
Percentage of poor hhs	3.19	1.79	0.31	0.69
Ethnic minority * % poor hh	7.94	2.82	0.13	0.87
Communal infrastructure index	1.11	1.06	0.90	0.10
Distance to nearest town	1.26	1.12	0.79	0.21
Number of hh/hamlet	1.54	1.24	0.65	0.35
Hhs per km^2	1.60	1.26	0.62	0.38
Coastal region	1.09	1.04	0.92	0.08
Midland/hilly region	1.11	1.05	0.90	0.10
Low mountainous region	1.64	1.28	0.61	0.39
Mountainous region	2.51	1.59	0.40	0.60

Source: VHLSS 2008, Own calculation by Stata's `collin` command

Table B.7.: Collinearity diagnostics for Piped Scheme Model (2) without interaction effect

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Use of tube wells	1.21	1.10	0.83	0.17
Project for safe water	1.12	1.06	0.89	0.11
Ethnic minority	2.15	1.47	0.47	0.53
Percentage of poor hhs	1.77	1.33	0.56	0.44
Communal infrastructure index	1.11	1.06	0.90	0.10
Distance to nearest town	1.26	1.12	0.79	0.21
Number of hh/hamlet	1.52	1.23	0.66	0.34
Hhs per km^2	1.59	1.26	0.63	0.37
Coastal region	1.08	1.04	0.92	0.08
Midland/hilly region	1.11	1.05	0.90	0.10
Low mountainous region	1.62	1.27	0.62	0.38
Mountainous region	2.50	1.58	0.40	0.60

Source: VHLSS 2008, Own calculation by Stata's `collin` command

After grand-mean centering of the communal poverty rate, the VIF for the interaction effect decreases to 3.60, that for main effect of the poverty rate to 3.19 and the VIF of the main effect for ethnic minority communes to 2.53. Since this centering does not impinge on the model estimates ('removal of so-called unessential collinearity' see Cohen 2003), no model with mean-centered poverty rates is displayed here. For further explanations about the purpose of mean-centering and its relation to multi-collinearity see Section A.3.1 and A.4.2.

B.3. Multivariate models in Chapter 6

B.3.1. Assessment of model fit - Classification tables for Piped Scheme Accessibility Models including R-count measures

For further explanations about the calculation see page 273.

Table B.8.: Classification table and model fit for Private Tap Model (1)

Predicted outcome	Observed outcome		
	No private tap	Private tap	Total
No private tap	646	61	707
Private tap	58	508	566
Total	704	569	1,273

$R^2_{count} = 90.07\%$ $Adj.\ R^2_{count} = 79.09\%$

Table B.9.: Classification table and model fit for Private Tap Model (2)

Predicted outcome	Observed outcome		
	No private tap	Private tap	Total
No private tap	641	86	727
Private tap	63	483	546
Total	704	569	1,273

$R^2_{count} = 88.30\%$ $Adj.\ R^2_{count} = 73.81\%$

Table B.10.: Classification table and model fit for Private Tap Model (3)

Predicted outcome	Observed outcome		
	No private tap	Private tap	Total
No private tap	646	59	705
Private tap	58	510	568
Total	704	569	1,273

$R^2_{count} = 90.81\%$ $Adj.\ R^2_{count} = 79.44\%$

TABLE B.11.: Classification table and model fit for Private Tap Model (4)

Predicted outcome	**Observed outcome**		
	No private tap	Private tap	Total
No private tap	647	60	707
Private tap	57	509	566
Total	704	569	1,273

$R^2_{count} = 90.81\%$ $Adj.R^2_{count} = 79.43\%$

TABLE B.12.: Classification table and model fit for Private Tap Model (5)

Predicted outcome	**Observed outcome**		
	No private tap	Private tap	Total
No private tap	638	74	712
Private tap	66	495	561
Total	704	569	1,273

$R^2_{count} = 89.00\%$ $Adj.R^2_{count} = 75.40\%$ $R^2_{McFadden} = 24.83\%$

TABLE B.13.: Comparison of observed and predicted probabilities for accessibility of piped schemes in specific subgroups based on Model (4) - Part I

	Availability of piped schemes in subgroup	
	Fraction observed	Average predicted probability
Age of head of household (quartiles)		
1st quartile	0.44	0.45
2nd quartile	0.46	0.46
3rd quartile	0.47	0.45
4th quartile	0.42	0.42
Sex of head of hh		
Male	0.44	0.44
Female	0.48	0.48
Household size		
Small	0.42	0.42
Medium	0.46	0.46
Large	0.38	0.38
Children below 6 years in hh		
No	0.43	0.43
Yes	0.47	0.47
Ethnicity of head of household		
Kinh	0.47	0.47
Ethnic minority	0.24	0.24

Source: VHLSS 2008, Own calculation

TABLE B.14.: Comparison of observed and predicted probabilities for accessibility of piped schemes in specific subgroups based on Model (4) - Part II

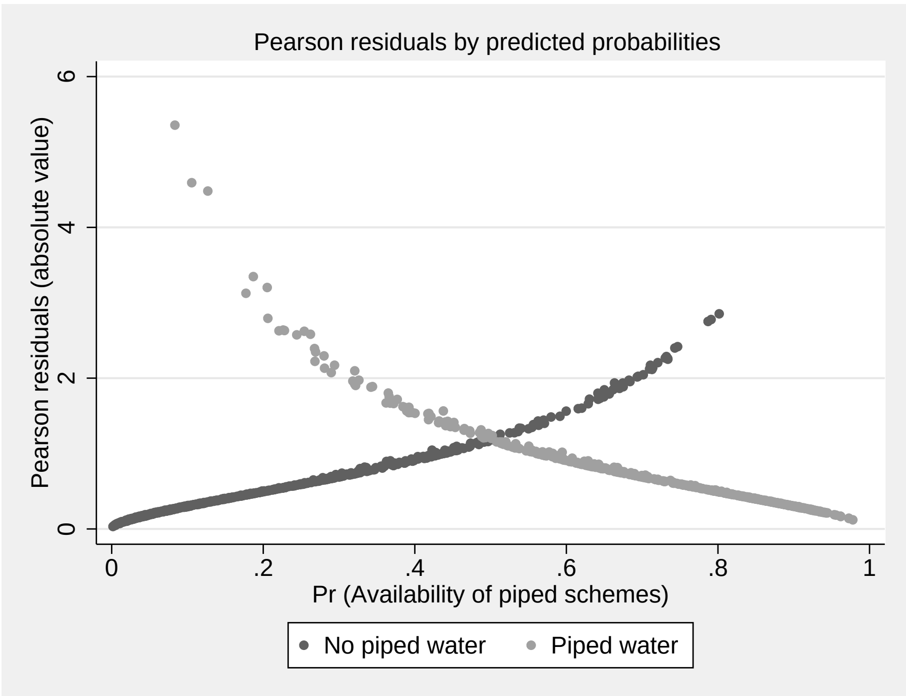
	Availability of piped schemes in subgroup	
	Fraction observed	Average predicted probability
Participation safe water for poor people		
Poor hh with programme	0.44	0.44
Poor hh without programme	0.29	0.29
Communal projects about environment and safe water		
None	0.44	0.44
At least one	0.45	0.45
Hh uses private tube well		
No	0.52	0.52
Yes	0.07	0.07
Use of multiple water sources		
No	0.45	0.45
Yes	0.44	0.44
Improved sanitation		
No	0.39	0.39
Yes	0.50	0.50
Monthly per capita consumption expenditure		
1st quartile	0.29	0.30
2nd quartile	0.46	0.44
3rd quartile	0.43	0.45
4th quartile	0.48	0.47
Percentage of poor households		
<5%	0.50	0.50
5-10%	0.48	0.48
10-20%	0.44	0.44
20-30%	0.41	0.39
>30%	0.24	0.24
Population density (quartiles)		
1st quartile	0.35	0.36
2nd quartile	0.41	0.41
3rd quartile	0.54	0.53
4th quartile	0.49	0.50
Administrative Region		
Red River Delta	0.46	0.45
Northeastern	0.34	0.36
Northwestern	0.44	0.37
North Central Coast	0.51	0.49
South Central Coast	0.38	0.38
Central Highlands	0.18	0.27
Southeastern	0.44	0.48
Mekong Delta	0.47	0.47

Source: VHLSS 2008, Own calculation

B.3.2. Influential observations and exclusion of cases in Piped Scheme Accessibility Model

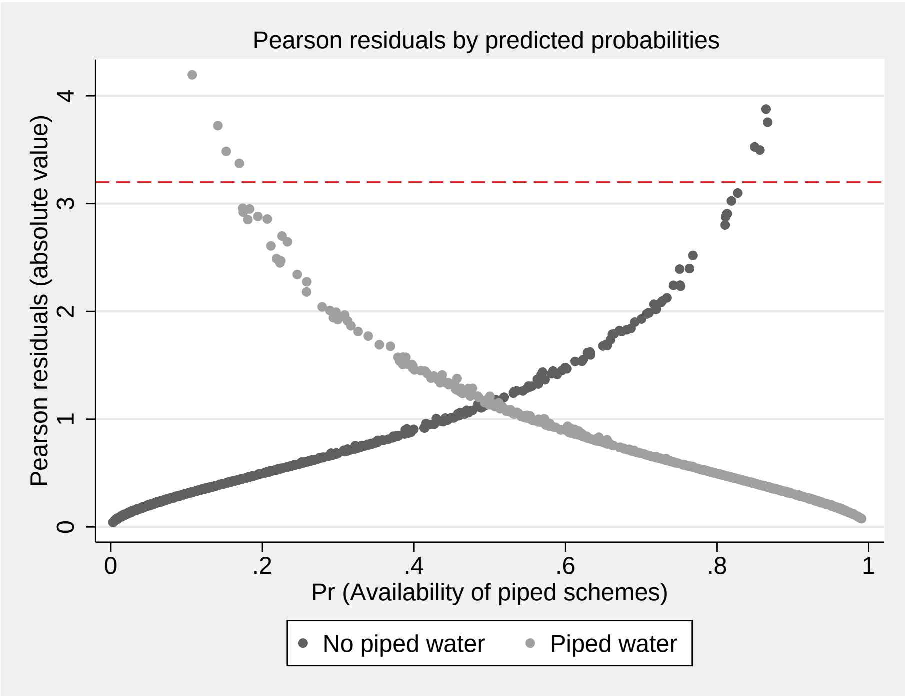
As in the commune model, it is striking that Model (4), which does not include the nearby adoption rate as predictor, produces rather 'false negative' predictions than 'false positive' ones. These are the light grey cases on the upper left part of Figure B.3. The fact that this pattern is consistent across the availability and accessibility model supports the hypothesis about an additional factor which facilitates access to piped water but is not covered by the models so far. Figure B.4 shows that this effect disappears in Model (5) after including the nearby piped scheme adoption rate. Based on the Pearson and deviance residuals calculated for Model (5), eight cases showing absolute Pearson residuals larger than 3.2 have been identified and dropped from the sample (see Figure B.4). The models displayed in Table 6.4 have been re-estimated after deleting these cases.

FIGURE B.3.: Influential observations in Model (4): Pearson residuals by predicted probabilities



Note: Pearson residuals calculated by `gllapred, pearson`
Source: VHLSS 2008, Own calculation

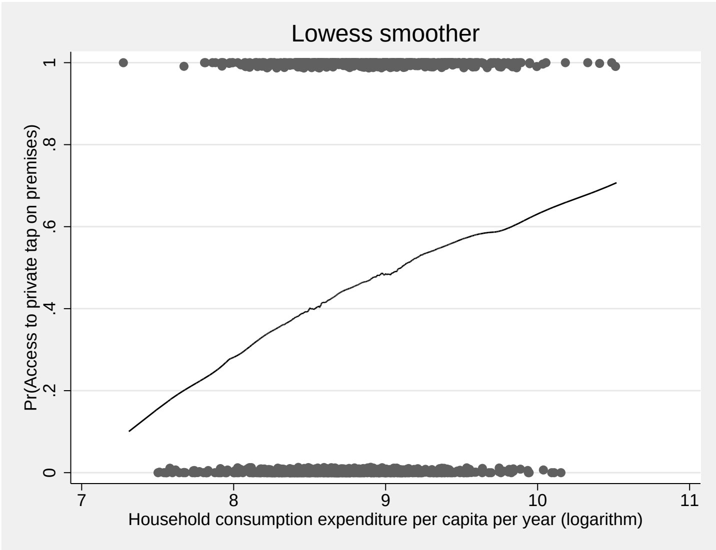
FIGURE B.4.: Influential observations in Model (5): Pearson residuals by predicted probabilities



Note: Pearson residuals (`gllapred, pearson`), dashed line marks cut-off value for outliers
Source: VHLSS 2008, Own calculation

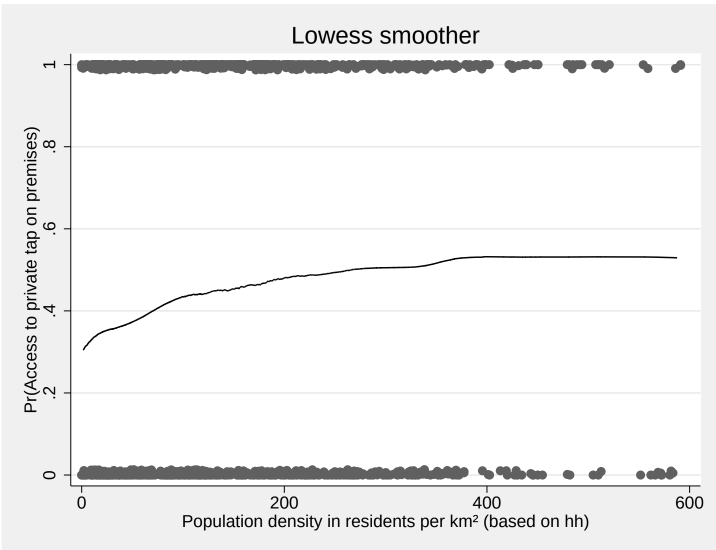
B.3.3. Functional relationship in Piped Scheme Accessibility Model

Figure B.5.: LOWESS plot for functional relationship between access to private tap and log con. expenditure per cap./month



Note: For further information about `lowess` see Kohler and Kreuter (2012: 269)
Source: VHLSS 2008, Own calculation

Figure B.6.: LOWESS plot for functional relationship between access to private tap and population density



Note: For further information about `lowess` see Kohler and Kreuter (2012: 269)
Source: VHLSS 2008, Own calculation

B.3.4. Multi-collinearity in Piped Scheme Accessibility Model

TABLE B.15.: Collinearity diagnostics for Private Tap Model (2)

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Age of head of hh	1.26	1.12	0.7908	0.2092
Highest grade of head of hh	1.52	1.23	0.6560	0.3440
Female head of hh	1.18	1.09	0.8442	0.1558
Small hh	1.26	1.12	0.7916	0.2084
Large hh	1.08	1.04	0.9233	0.0767
Children below 6 years	1.22	1.10	0.8191	0.1809
Ethnic minority hh	1.71	1.31	0.5863	0.4137
Expenditure in quintiles	1.52	1.23	0.6598	0.3402
Tube well main source of water in commune	1.07	1.04	0.9322	0.0678
Use of multiple water sources	1.13	1.06	0.8865	0.1135
Share of poor hh	1.61	1.27	0.6207	0.3793
Improved sanitation	1.51	1.23	0.6604	0.3396
Number of hh per km^2	1.63	1.28	0.6144	0.3856
Poor hh with programme	1.21	1.10	0.8267	0.1733
Poor hh without programme	1.16	1.08	0.8602	0.1398
Communal project for safe water	1.05	1.03	0.9515	0.0485
Northeastern region	2.20	1.48	0.4548	0.5452
Northwestern region	1.28	1.13	0.7829	0.2171
North Central Coast	1.81	1.34	0.5539	0.4461
South Central Coast	1.75	1.32	0.5717	0.4283
Central Highlands	1.47	1.21	0.6782	0.3218
Southeastern region	2.33	1.53	0.4296	0.5704
Mekong Delta	3.63	1.91	0.2753	0.7247

Note: Produced by Stata's `collin` command
Source: VHLSS 2008, Own calculation

Table B.16.: Collinearity diagnostics for Private Tap Model (4) including interaction effect between expenditure and use of private tube well

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Age of head of hh	1.28	1.13	0.7812	0.2188
Highest grade of head of hh	1.52	1.23	0.6558	0.3442
Female head of hh	1.18	1.09	0.8441	0.1559
Small hh	1.26	1.12	0.7910	0.2090
Large hh	1.08	1.04	0.9225	0.0775
Children below 6 years	1.22	1.11	0.8189	0.1811
Ethnic minority hh	1.72	1.31	0.5830	0.4170
Expenditure (quintile)	1.73	1.31	0.5784	0.4216
Use of private tube well	6.21	2.49	0.1610	0.8390
Expenditure (qintile) * Tube well	6.43	2.54	0.1556	0.8444
Use of multiple water sources	1.13	1.06	0.8824	0.1176
Share of poor hh	1.62	1.27	0.6181	0.3819
Improved sanitation	1.51	1.23	0.6614	0.3386
Number of hh per km^2	1.64	1.28	0.6113	0.3887
Poor hh with programme	1.21	1.10	0.8234	0.1766
Poor hh without programme	1.16	1.08	0.8598	0.1402
Communal project for safe water	1.05	1.03	0.9512	0.0488
Northeastern region	2.22	1.49	0.4508	0.5492
Northwestern region	1.28	1.13	0.7811	0.2189
North Central Coast	1.81	1.35	0.5517	0.4483
South Central Coast	1.70	1.30	0.5872	0.4128
Central Highlands	1.48	1.22	0.6768	0.3232
Southeastern region	2.34	1.53	0.4275	0.5725
Mekong Delta	3.57	1.89	0.2799	0.7201

Note: Produced by Stata's `collin` command
Source: VHLSS 2008, Own calculation

B.4. Multivariate models in Chapter 7

B.4.1. Assessment of model fit - Classification tables for HWT Models including R-count measures

Table B.17.: Classification table and model fit for HWT Model (1)

Predicted outcome	Observed outcome		
	No HWT	HWT	Total
No HWT	3,306	191	3,497
HWT	53	542	595
Total	3,359	733	4,092

$R^2_{count} = 94.04\%$ $Adj.\ R^2_{count} = 66.71\%$ $R^2_{McFadden} = 14.57\%$

Table B.18.: Classification table and model fit for HWT Model (2)

Predicted outcome	Observed outcome		
	No HWT	HWT	Total
No HWT	3,283	228	3,511
HWT	76	505	581
Total	3,359	733	4,092

$R^2_{count} = 92.57\ \%$ $Adj.\ R^2_{count} = 58.53\ \%$ $R^2_{McFadden} = 37.48\%$

Table B.19.: Classification table and model fit for HWT Model (3)

Predicted outcome	Observed outcome		
	No HWT	HWT	Total
No HWT	3,285	228	3,513
HWT	74	505	579
Total	3,359	733	4,092

$R^2_{count} = 92.61\%$ $Adj.\ R^2_{count} = 58.80\%$ $R^2_{McFadden} = 37.70\%$

Table B.20.: Classification table and model fit for HWT Model (4)

Predicted outcome	**Observed outcome**		
	No HWT	HWT	Total
No HWT	3,285	229	3,514
HWT	74	505	579
Total	3,359	734	4,093

$R^2_{count} = 92.60\%$ $Adj.\ R^2_{count} = 58.72\%$ $R^2_{McFadden} = 37.70\%$

Table B.21.: Comparison of observed and predicted probabilities of HWT application in specific subgroups based on HWT-Model (4) - Part I

	HWT application in subgroup	
	Fraction observed	Average predicted probability
Age of head of household (quartiles)		
1st quartile	0.14	0.14
2nd quartile	0.18	0.19
3rd quartile	0.20	0.20
4th quartile	0.19	0.19
Sex of head of hh		
Male	0.18	0.17
Female	0.19	0.20
Children below 6 years		
No	0.19	0.19
Yes	0.15	0.15
Major ethnic group not Kinh		
No	0.23	0.23
Yes	0.02	0.02
Household expenditure (quartile)		
1st quartile	0.12	0.11
2nd quartile	0.18	0.18
3rd quartile	0.20	0.21
4th quartile	0.22	0.22

Source: VHLSS 2008, Own calculation

Table B.22.: Comparison of observed and predicted probabilities of HWT application in specific subgroups based on HWT-Model (4) - Part II

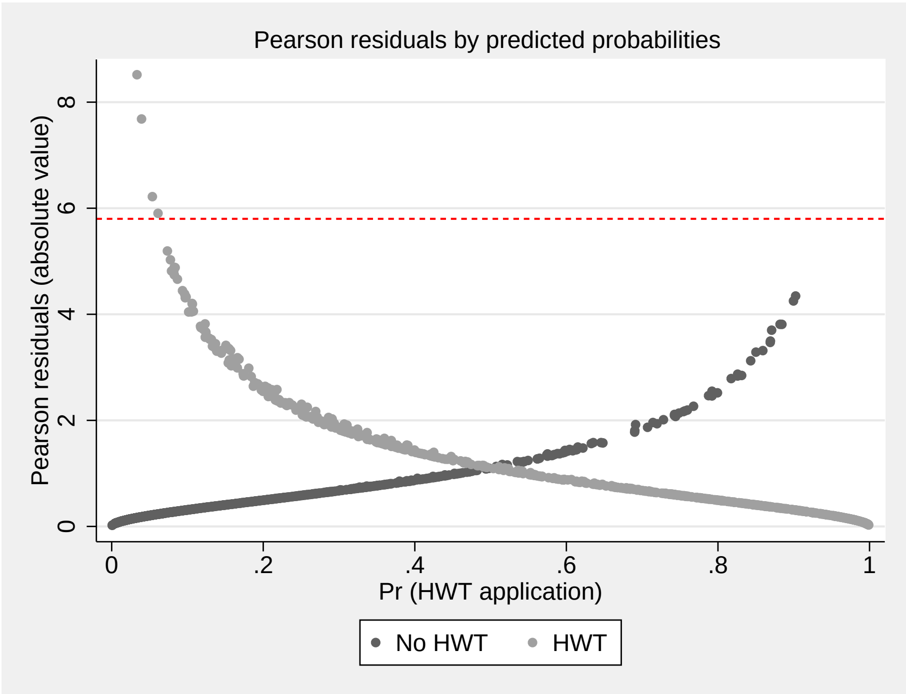
	HWT application in subgroup	
	Fraction observed	Average predicted probability
Surface water user * Commune with market		
No	0.17	0.17
Yes	0.51	0.51
Surface water user * Commune without market		
No	0.17	0.17
Yes	0.38	0.38
Distance to nearest town (quartiles)		
1st quartile	0.24	0.23
2nd quartile	0.21	0.22
3rd quartile	0.18	0.18
4th quartile	0.07	0.07
Number of households (quartiles)		
1st quartile	0.08	0.07
2nd quartile	0.18	0.19
3rd quartile	0.25	0.25
4th quartile	0.21	0.21
Population density (hh per km^2, quartiles)		
1st quartile	0.04	0.04
2nd quartile	0.08	0.08
3rd quartile	0.22	0.21
4th quartile	0.39	0.39
Nearby HWT adoption (quartiles)		
1st quartile	0.00	0.02
2nd quartile	0.07	0.04
3rd quartile	0.13	0.09
4th quartile	0.60	0.60
Administrative region		
Red River Delta	0.51	0.50
Northeastern	0.05	0.05
Northwestern	0.01	0.01
North Central Coast	0.21	0.22
South Central Coast	0.08	0.07
Central Highlands	0.02	0.03
Southeastern	0.06	0.07
Mekong Delta	0.39	0.37

Source: VHLSS 2008, Own calculation

B.4.2. Influential observations and exclusion of cases in HWT Models

The models in Table 7.5 tend to produce rather 'false negative' predictions than 'false positive' ones. These are the light grey cases on the upper left part of Figure B.7. This finding supports the hypothesis about an additional factor which facilitates HWT use but is not covered by the models so far (e.g. specific local projects and interventions which are not reported in the VHLSS data). Figure B.7 depicts the Pearson and deviance residuals calculated for Model (4). Five cases showing absolute Pearson residuals larger than 5.8 have been identified and dropped from the sample. The models displayed in Table 7.5 have been re-estimated after deleting these cases.

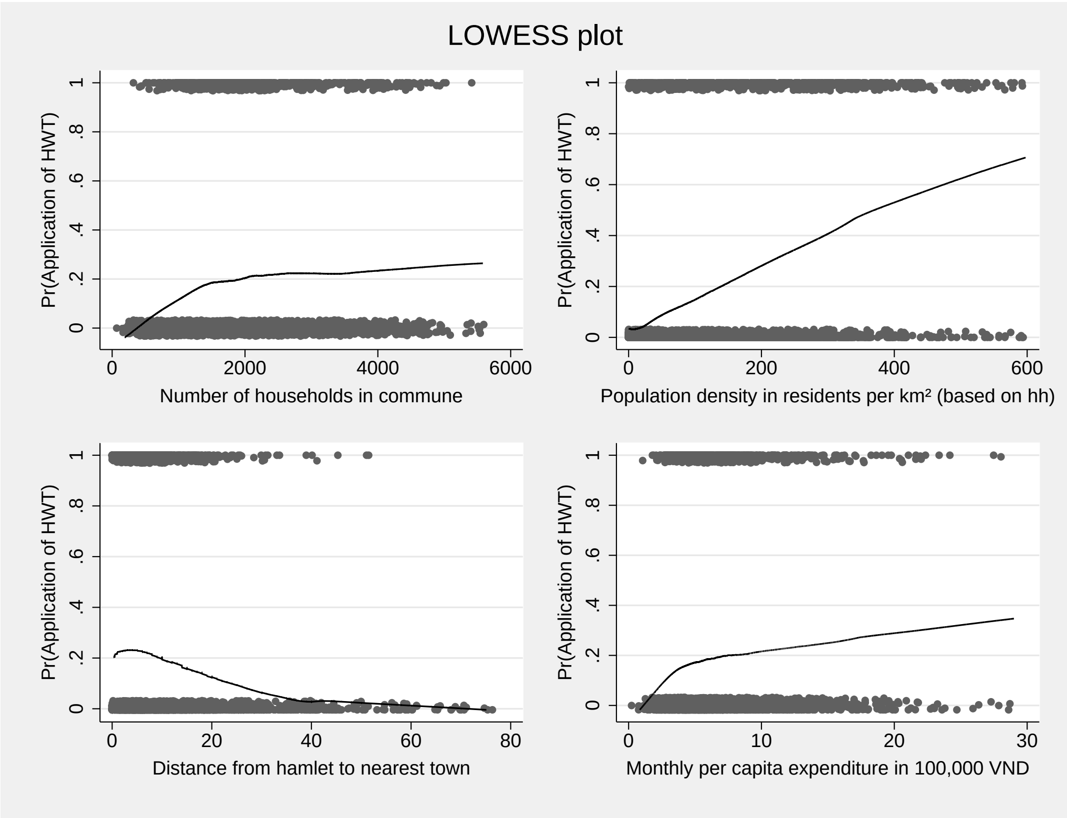
FIGURE B.7.: Influential observations in HWT Model (4): Pearson residuals by predicted probabilities



Note: Pearson residuals calculated by `gllapred, pearson`, dashed line marks cut-off value for outliers
Source: VHLSS 2008, Own calculation

B.4.3. Functional relationship in HWT Models

FIGURE B.8.: LOWESS plot for functional relationship between HWT use and continuous predictors



Note: For further information about `lowess` see Kohler and Kreuter (2012: 269)
Source: VHLSS 2008, Own calculation

B.4.4. Multi-collinearity in HWT Models

Table B.23.: Collinearity diagnostics for HWT Model (4) including interaction effect for communal markets

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Age of head of hh	1.22	1.10	0.8222	0.1778
Household size	1.30	1.14	0.7687	0.2313
Children below 6 years	1.26	1.12	0.7948	0.2052
Highest grade of head of hh	1.36	1.17	0.7332	0.2668
Ethnic minority hh	1.60	1.27	0.6232	0.3768
Cons. expenditure per cap/year	1.23	1.11	0.8161	0.1839
Improved sanitation	1.39	1.18	0.7180	0.2820
Commune size	1.36	1.17	0.7339	0.2661
Distance to nearest town	1.22	1.11	0.8165	0.1835
Number of households per km^2	1.38	1.18	0.7226	0.2774
Surface water user * Commune with market	1.05	1.03	0.9490	0.0510
Surface water user * Commune without market	1.10	1.05	0.9109	0.0891
Nearby adoption rate	1.15	1.07	0.8660	0.1340

Note: Produced by Stata's `collin` command
Source: VHLSS 2008, Own calculation

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