A Drop in the Bucket:

Impact Evaluation of a Water and Sanitation Program in Rural Benin

Dissertation

zur Erlangung des wirtschaftswissenschaftlichen Doktorgrades der Wirtschaftswissenschaftlichen Fakultät der Universität Göttingen

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Elena Groß

aus Stuttgart

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Contents

List of Tables

List of Figures

List of Abbreviations

BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
CF	Counterfactual Mean
DAC	Development Assistance Commitee
DD	Difference-in-difference
DG-Eau	Direction Générale de l'Eau
DHS	Demographic and Health Survey
EMICOV	Enquête Modulaire Intégrée sur les Conditions de Vie des Ménages
FAO	Food and Agriculture Organization
FCFA	Franc de la communauté financière africaine (West Africa)
GPS	Global Positioning System
HDI	Human Development Index
IEG	Impact Evaluation Group
INSAE	Insitute national de la statistique et de l'analyse economique du Benin
IOB	Policy and operations evaluation department Netherlands
KfW	Kreditanstalt für Wiederaufbau
MDG	Millennium Development Goals
NGO	Non-Governmental Organization
OD	Open defecation
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PHA	Promotion de l'hygiene et de l'assainissement
POS	Point-of-sale
POU	Point-of-use
RCT	Randomized control trail
SSA	Sub-Sahara Africa

TV	Television
UN	United Nations
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
USD	United States Dollar
WDI	World Development Indicators
WHO	World Health Organization
WTP	Willingness-to-pay

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Introduction

Filthy water cannot be washed.

West African Proverb

In August 2010 the General Assembly of the United Nations passed the resolution on the human right to water and sanitation, which recognizes the *"right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights"* Everybody knows that water is indispensable to life, and already ten years earlier the Millennium Development Goals (MDG) were announced by the member countries of the United Nations (UN), where water and sanitation became a special target in goal seven:

"Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation."

In March 2012 the UN announced that the drinking water target had been met. However, access to water was increased mainly in China and East Asia, whereas Sub-Saharan Africa (SSA) is not on track to meet this MDG target. Thus, when thinking about the achievement, one has to keep in mind those regions where water access is still very low or even worsening over time. In general, the population that is still lacking improved water infrastructure is about twelve percent of the world population (780 million people). In SSA 40 percent of the total population still has no access. The disparities are even greater for rural areas, where often less than 50 percent of the population is served with water from improved drinking water sources (WHO/UNICEF, 2012).[1] Even if the population uses an improved water supply, there are reasons to doubt the impact on households' water quality and health outcomes,

[1] See Fewtrell et al. (2007) for a list of improved water and sanitary facilities.

given that scientific evidence points towards the ineffectiveness of the infrastructure in producing desirable outcomes (see e.g. Wright et al., 2004; Kremer et al., 2011).

For sanitation coverage the situation is even worse and the MDG target of halving the population without access to improved sanitation will most likely not be achieved. It is estimated that about 2.6 billion people still practice open defecation or use unimproved sanitary facilities (UNICEF/WHO, 2012). It is important to recognize that a lack of improved sanitation is often considered to be a cause of bad hygienic and health conditions in general, although the evidence is limited to a few studies (Kumar and Vollmer, 2012; Esrey et al. 1992). The World Health Organization (WHO), however, published a study by Prüss-Üstün et al. (2008) which highlights that the oral-fecal pathogen load only decreases to a low level if 98 percent of the population is served with improved water and sanitation facilities and if it improves its hygiene practices concomitantly.

To determine whether improved water and sanitary infrastructure leads to the desired outcomes of improved water quality and human health, one needs to use methods that go beyond the measurement of correlations, and which make causal inference possible. To do this, one must ensure the internal validity of the study, to address the *Problem of Causation* described by David Hume:

"We then call the one object, cause; the other, effect. We suppose that there is some connection between them; some power in the one, by which it infallibly produces the other, and operates with the greatest certainty and strongest necessity. I say then, that, even after we have experience of the operations of cause and effect, our conclusions from that experience are not founded on (a priori) reasoning, or any process of the understanding." (David Hume, 1737).

One acknowledged scientific method for analyzing causal relationships are quasi-experiments. Quasi-experiments are experiments "[…] in which units are not assigned to conditions randomly." (Shadish et al., 2002). An epidemiological study by Snow (1854) is considered to be the first study to apply a rigorous method to compare differences in the outcomes of cholera transmission across two neighboring areas in London in the mid-19th century. He was able to show that cholera is transmitted via "bad" water and not via "bad" air in a natural experiment[2]. This analysis was possible because the populations in the areas under observation were similar and because, at first, both neighborhoods used water from the same (bad) source, although provided by different companies. Then one company changed the water source and some neighborhoods received water from a cleaner source upstream of the Thames River. Snow showed that the outbreak of cholera was less likely for households that used

[2] A natural experiment is an experiment where the cause cannot really be manipulated (see Shadish et al., 2002). In Snow's case the assignment of households to the water companies and the change in water sources was not planned within his study frame.

water from the recently provided, cleaner source.[3] Through observing similar groups over time and measuring the impact of an exogenous change in water provision, causal inference about the cholera outbreak was possible. Now, 250 years later, quasi-experimental methods are constantly used to identify causal mechanisms with research designs constructed to meet all challenges. In this study a difference-in-difference (DD) approach is applied that supports causal inference in quasi-experiments. [4]

The lack of improved water and sanitary infrastructure still kills many people in developing countries each year. Children, in particular, suffer from water-related and water-borne diseases.[5] It is estimated that about eight percent of the total disease burden in developing countries can be attributed to unsafe water, sanitation and hygiene. Additionally, about 75 percent of the diarrheal disease burden in children could be prevented by providing infrastructure for water and sanitation, as well as better hygiene practices (Fewtrell, 2007). Researchers realized that the provision of improved public water in villages and sanitation infrastructure alone does not improve water quality (Wright et al., 2004; Kremer et al., 2011) or health outcomes (Waddington and Snilsveit, 2009; Fewtrell et al., 2005; Peterson Zwane and Kremer, 2007; IEG, 2008). The countries of the Development Assistance Committee (called DAC countries) allocate about seven percent of total aid (OECD/DAC, 2010) to basic water infrastructure as village public water points, e.g., public standpipes or pumps, a form of access found often in low-income countries. However, simply increasing coverage rates, as aimed by the MDG 7, does not lead to the fulfillment of the intention of improving water quality and health outcomes consistently. The question of how to make these interventions effective remains. How do programs have to adjust to not only improve coverage but also to have a sustainable impact on the higher-order goal of improving global health outcomes, the situation for women and children in particular, and living conditions in general?

This thesis contributes towards answering these questions in several ways: it measures how water supply interventions at the village and household levels improve water and sanitation coverage, water quality and health outcomes. The innovative content is the focus on the behavioral aspects of these interventions. Apart from improved water quality and a reduction of water-related diseases (see e.g. Fewtrell et al., 2005) time savings are considered an important objective of improved water supply in poor rural areas (FAO, 2008; Hutton et al., 2006). This aspect is analyzed in Chapter 2. As in previous studies, health conditions do not improve, and therefore Chapter 3 investigates which key factors of household behavior that might affect water quality

[3] See Eyler (2001) for a discussion of the study.

[4] I will describe all advantages, problems and shortcomings and show how to approach them in detail throughout the thesis.

[5] For a list of water-borne and water-related diseases see the WHO homepage: http://www.who .int/water_sanitation_health/diseases/diseasefact/en/index.html.

and health outcomes change as a consequence of water interventions. While water coverage increases, villages experience different phases, from basic to high access. Consequently, Chapter 4 shows the prevailing effects when the first water source is installed within a village. Sanitation coverage worldwide is still lacking, hence Chapter 5 focuses on sanitation demand. The results show the driving factors for sanitation demand in rural areas and contribute to new insights in this area, where empirical findings are still scarce.

This work focuses on the measurement of water and sanitation coverage and, equally, on behavioral outcomes, which is a major advantage to previous studies. The design, presented in detail in Chapter 1, is a quasi-experimental approach with a comparison of treatment and control groups before and after a water supply intervention has taken place, in rural Benin. We will show that causal inference is possible and determinants can be unambiguously identified. The research questions analyzed are as follows:

Chapter 1 explains the setting of the study and the focus on Benin, Western Africa.

Were the infrastructure targets for water and sanitation improvements achieved?

Which villages receive water infrastructure in the period under study?

Is there any observable strategy for selection of villages into the program?

Chapter 2 focuses on the time-saving effects and their consequences:

What has been the change in the time used for the collection of water?

What has been the change in the distance to the water source?

What has been the change in the share of the population responsible for fetching water?

Has there been a change in practice of productive activities?

Chapter 3 shows water quality and health outcomes

What has been the change in the proportion of the population with access to an improved water source and what is the proportion actually using it?

What has been the change in the quality and quantity of water provided and consumed for drinking water and hygiene purposes?

What has been the change in hygiene practices?

What have been the effects on water related disease incidence of the population?

Which water interventions work best with regard to quality and health impacts and why?

Chapter 4 focuses on whether there are different outcomes for the first modern water source

How do the measures used above change if a village receives its first modern water source?

Chapter 5 contributes to the understanding of persisting low sanitation coverage

What has been the change in the access of the population to an improved sanitary facility?

Are there differences across socio-economic groups and gender with regard to the use of sanitary facilities?

What are households willing to pay for improved sanitation and what is the optimal price?

For the analysis of these questions a sample of 200 villages from rural Benin is used. The sample is described in detail in Chapter 1. Benin is a small country in West-Africa with about 9 million inhabitants. It ranks in position 167 (out 187) in the Human Development Index (HDI) 2011 and faces persisting deficiencies in life expectancy at birth (56 years), primary education (63 percent completion rate) and poverty (40 percent headcount).[6] According to UNICEF, 69% of the rural population in Benin had access to an improved water source in 2008, while coverage rates in neighboring countries were only at 47% in Togo, 42% in Nigeria and 39% in Niger.[7]

In the two graphs below, the development of water and sanitation coverage in Benin is plotted using data from the World Development Indicators (WDI).[8] In recent years some progress has been made and Benin is on track to achieve the MDG of halving the population without access to an improved water source by 2015. In the sample of villages studied in this thesis, the proportion of the population already using an improved water source before the intervention took place was about 50 percent (baseline survey in 2009).

[6] Data from World Development Indicators 2012.
[7] http://www.unicef.org/infobycountry/ accessed 21-08-2012
[8] As we see, coverage rates are similar as in the UNICEF data described above.