Voluntary cooperation in the provision of a semi-public good

Community-based soil and water conservation in semi-arid India

PROEFSCHRIFT

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Foreword

"One doesn't discover new lands without consenting to lose sight of the shore (..)"
André Gide

I started studying economics because I wanted to change the world. Economics was bad, economists were evil and I was going to be brave and face it all. When I graduated, I realized I had not learned much about economics. In fearing to lose sight of the shore, I had clung to my old beliefs, and failed to learn anything new.

Since I was not sure how to change the world either, I started to work as an environmental economist at the Institute for Integrated Water Management and Waste-Water Treatment (RIZA) of the Dutch ministry of Transport, Public Works and Water Management (V&W). It was there that I really started to discover economics, not in the least because of the post-graduate courses I was allowed to take. Prof. Gunning of the Vrije Universiteit Amsterdam opened my eyes to the empirical relevance of economics and Prof. Burgess at the London School of Economics made economics look exciting and down-to-earth again.

Although working on Dutch water management was interesting enough, water issues in the rest of the world seemed more urgent and I wondered whether there would be anything I could do. Also, despite the course-work and the experience gained, I felt limited in my capabilities as an economist and in my analytical capacity to deal with the complex reality of natural resource management. Hence, when I got the opportunity to work in India at the International Water Management Institute (IWMI) and was offered the possibility to combine work with PhD research, this seemed a once in a lifetime chance to deepen my knowledge and figure out what I could do. Max, my partner, quit his job as a lawyer, and off we went, to discover new lands.

It was not always easy, losing sight of the well-known shore, but the new lands we discovered made all efforts disappear. Living in India broadened our horizon in every possible way and the opportunity to conduct PhD research proved inspiring and made it possible to discover new lands within. However, in both cases, merely losing sight of the shore was not sufficient to discover new lands. The friends we made in India, the colleagues, neighbours, NGO partners, respondents, all patiently taught us how, and where, to look. Also, my supervisors provided important guidance, in teaching me to remain focused on what I was trying to do. Still, discovering new lands also requires an inner sense of direction and a trust that one is not left to drown. In this, I have been blessed with a partner, Max Haan, who makes me feel that the shore is always near, and parents, Johan and Marianne Bouma-Wiebols, who raised me with a sense of direction that has always helped me find my way. Since it is my father who inspired me to start this journey in the first place, I dedicate this dissertation to him. It is he who taught me science can have a real impact and that, one day, it might actually help to change the world.

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Then, I have had the luck of finding an employer who supported me throughout. Frank Rijsberman, then director of the International Water Management Institute (IWMI), and Chris Scott, then director of IWMI-India, made this dissertation possible by providing me with the time and space to concentrate on my work. Also, I received support from Tushar Shah, Madar Samad, David Molden, Deborah Bossio and Mark Giordano, and many other colleagues from IWMI headquarters, who kept showing an interest in my work. In India, the IWMI office became almost like a bunch of friends. Chris and Stephanie, Jeroen, Trent, Ranjitha, Gayathri, Roja, Mattia, Manthri, Anju, Shirish, Preeti, Narayan, Rama, Jean-Phillipe, Navanita, Judith, Murli, Partha, Urmila, Liaqath, Qadir, Sekhar and the many IWMI-interns, especially Johan, Prisca, Petra, Stefan and Daan, thank you for your contributions, for being such nice colleagues and for showing so much interest in my work. Finally, I have had the great pleasure of working with some of India's most renowned NGOs. Thank you Pradeep and Chennaiswamy from SAMUHA and all staff from the SAMUHA Tavaregera office, Marcella D'Souza and Sandeep from WOTR and all staff from the WOTR Ahmadnagar office, Neelima Khetan and Shalendra Tiwari from Seva Mandir, and all staff from the Seva Mandir Udaipur office, Naveneetha Reddy from VSS and Ramchendru and Ravindra from WASSAN. Also, I have benefited from discussions with Vijay James, Vasudha Pangare, Suhas Wani, Bekele Shiferaw, Priya Deshingkar and Kanchan Chopra and from my participation in the EEE programme on Ecological Economics, organized by Karl Göran Mäler and Partha Dasgupta. Finally, a special thanks to my research assistants, Pradhumn Jagtap, Bhim Raj Suthar and Srinivas Rao, who have done a great job in collecting data and assisting me in the field.

Returning back to the Netherlands after three years in India, I spent almost a year at the University of Tilburg to finish my work. The Environmental Economics department provided a warm and welcoming environment, thanks to my supervisors and to Cees Withagen, Jack Smulders, Corrado di Maria, Edwin van der Werff and Cathy Wick. Thanks also to Jenny Ligthart, Eline van der Heyden, Emilia Lazarova, Judith Lammers and all the PhD students who accepted me as one of their own.

After finishing the main part of my dissertation, I started working at the Institute for Environmental Studies of the Vrije Universiteit Amsterdam, where I currently still work. My new colleagues were really welcoming and showed, again, great interest in my work. Thank you Pieter, Dave, Vincent, Roy, Sliman, Laurens, Onno, Frans, Marjan, Julia, Kyla, Sebastiaan, Luke, Marije, Kim and others for being such nice colleagues. I look forward to the projects we will be working on together in the time to come!

Throughout the whole process, my family and friends have been there to support me and bring me back to daily life. Thank you, Anke, Catelijne, Carmen, Hildegard, Myrtille, Simone, Marga, Jerre and Delphine, Gregor and Wencke, Martine, and, in India, Gayathri, Roja, George and Vera, Manesha and Adit, Vicky and Vincent, Mattia and Marie-Eve, Karin and Rolf, Ian and Emma, Jos and Peter, Rashmi, Bhavani, Vidya and many others for being there. The importance of my family I have acknowledged before. Thanking them seems an understatement of the importance of their role. Still, I would like to acknowledge the dear support of my brother, Hans, and of my family in-law. Finally, one very special person deserves explicit mention, although she and this dissertation were born around the same time. Berber has patiently waited for her mother to finish, and is now ready to play. Hopefully, one day she will start her own journey and discover her own new lands. For the years to come, however, I hope we can spend a lot of time together enjoying the shore.

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1. Introduction

The main question of this dissertation is whether individual agents can be expected to voluntarily contribute to the provision of a semi-public good. The characteristic of a public good being that a) consumption is non-rival and b) individuals cannot be excluded from enjoying the benefits of provision, individual agents have an incentive to under invest and free ride on the contributions by others (Starrett 2003). This reduces welfare, as each agent contributes less than the socially optimal amount. Although semi-public goods differ from pure public goods in that there is rivalry in consumption, without control of free rider behaviour an optimal level of semi-public good provision is still unlikely to be reached.

Traditionally, economists assumed that to ensure an optimal level of semi-public good provision, government coordination, or even provision, was required. The literature on common property resource management suggests however that under certain conditions groups of individuals, or communities, can effectively control free rider behaviour as well (Ostrom et al. 2002, Baland and Platteau 1996). Community management has an advantage over government management in that the costs to control free rider behaviour are usually lower (Bowles 2005). Besides, by decentralizing semi-public good provision to the community level, local requirements and needs are often also better addressed. Communities do not necessarily take care of all their members however, and decentralizing semi-public good provision might result in the social exclusion of certain groups (Bowles and Gintis 2002). Also, community management is not always possible as it requires that certain conditions are met (Ostrom 1990). If these conditions are not satisfied, government coordination might still be needed to ensure that a socially optimal level of semi-public goods provision is reached.

This dissertation analyzes whether households in India's semi-arid regions are likely to voluntarily cooperate in the maintenance of soil and water conservation (SWC) investments. SWC investments have important public good externalities in that upstream investments generally affect users downstream. Typically, SWC investments consist of small dams, earthen bunds, trenches and village ponds with the aim to reduce the speed of surface water run off and allow for more of the rainfall to be locally absorbed. Although some of the benefits of SWC are private (for example, increased soil moisture or reduced soil erosion on private land) an important part of the benefits of SWC tends to be shared (for example, recharged groundwater aquifers and better quality common land).

The government of India, together with a large number of non-governmental organizations (NGO's), heavily subsidizes SWC investment under the program of participatory watershed development (WSD). To optimize returns, investments are planned at the scale of the micro-watershed (500-1000 ha) and implemented at the village scale. The main objective of the WSD program is to increase agricultural productivity and alleviate poverty. The WSD program is one of the main programs for rural development in India's semi-arid regions with an annual budget of approximately USD 500 million USD (GOI 2000). Households contribute 0-25% of the investment costs in voluntary labour, but with project wages above the market wage investments are effectively subsidized for over 100% (Kerr et al. 2002, Shah 2005).

To stimulate household cooperation in SWC management, the WSD program also invests in community organization and local institution building, and has villagers participate in project planning and implementation from the start. Although several studies have indicated that community participation increases WSD project effectiveness (Kerr et al. 2002, Ratna Reddy et al. 2004), the longer-term impacts on community SWC management have hardly been addressed. There are indications however that SWC maintenance is lacking (Kerr et al. 2002, ODI et al. 2002) but whether this is caused by over subsidization, poor project implementation or lack of incentives for voluntary cooperation has not yet been assessed systematically. Since without maintenance, SWC investments are not effective because agricultural productivity is not structurally improved, it seems important to better understand the factors that determine the households' willingness to voluntarily contribute to the maintenance of semi-public SWC.

The question whether households can be expected to voluntarily contribute to SWC maintenance seems relevant to more than those interested in India's WSD program alone. Globally, local communities are being made responsible for the management of roads, irrigation and sanitation infrastructure, water supply and schools (for an overview see for example Mansuri and Rao 2004). Community-based projects have become one of the fastest growing mechanisms of development assistance, the Worldbank's portfolio alone being estimates at USD 7 billion (Mansuri and Rao 2004). Evidence of whether communities are successful in managing semi-public structures is scarce, however, and little is known as to how the effectiveness of community-based approaches might be improved (Khwaja 2004, Mansuri and Rao 2004).

This dissertation aims to analyze the incentives for voluntary cooperation in semi-public good provision and to assess whether investments in community organization are likely to improve project effectiveness in the long run. In the next paragraph I review some of the literature on common property resource management to explore the conditions for successful community resource management. In the remaining part of the chapter I define the objectives and research hypothesis of this dissertation.

1.1 A short review of the literature

The literature on common property resource management distinguishes four factors that help determine whether communities are likely to successfully manage collective and semi-public goods (Ostrom 1990, Baland and Platteau 1996,Wade 1988, Agarwal 2001) i) resource system characteristics, ii) the external environment, iii) user group characteristics and iv) institutional arrangements. In the following, I will shortly address each factor, reviewing the literature and elaborating its meaning for the analysis of community-based SWC.

The first factor, resource system characteristics, determines the extent to which communities can successfully assign and enforce informal user rights. If the boundaries of the collective resource exceed the boundaries of the community, the community cannot internalize all externalities and free rider behaviour is more difficult to control. For example, if the boundaries of an aquifer correspond to the village boundaries the village can decide on a set of rules to manage its use. However, if a neighbouring village also has access to the aquifer, management already becomes more complicated and free rider behaviour is less easily controlled (Dasgupta 1982). Resource system characteristics also affect resource management in influencing the costs of control. For example, grass cutting is easier to monitor than groundwater extraction. If the costs of monitoring and control are high, then community resource management is less likely to be successful since informal user rights cannot be effectively enforced (Baland and Platteau 1996).

In the case of SWC, the boundaries of the resource system tend to exceed the community boundaries. Whereas investments in soil conservation have important on-site benefits, investments in rainwater harvesting generate most of their impact downstream. In fact, to include all externalities, water-related investments should ideally be planned at the basin scale (McKinney et al. 1999, Shah and Raju 2001) To facilitate implementation most water related projects are however planned and implemented at a lower scale. The WSD program is no exception, planning interventions at the level of the micro-watershed (500-1000 ha) as this corresponds most closely to the administrative boundaries of the village. Although several studies discuss the problems of having the boundaries of the hydrological system exceed the boundaries of the management unit (Swallow et al. 2001, Rhoades 1998), few studies actually quantify the externalities involved. Shah and Raju (2001) suggest that the downstream externalities of watershed development are substantial and Batchelor et al. (2003) actually quantify the hydrological effects. However, to the author's knowledge there are no studies evaluating the welfare impacts of WSD at the basin scale.

Summarizing, the characteristics of SWC investments and the targeting of village communities for WSD planning and implementation are likely to affect the management of SWC in two important ways. First, since the impact of WSD exceeds the boundaries of the village, communities might not have an incentive to cooperate at the village-level as free rider behaviour cannot be controlled. Second, since the downstream externalities are not accounted for in WSD planning, it is unclear whether WSD is welfare enhancing at the basin scale. For the success of community resource management this last element might not be important, but it does determine whether community-based SWC management is socially efficient or not. Hence, in this dissertation both aspects will need to be addressed.

The second factor, the external environment, is important in determining the household's incentive to contribute to semi-public good provision and in defining the institutional environment in which community resource management takes place. In the literature on farm household decision-making the influence of the external environment on household decision–making is well explored (see for example Ray 1999, Bardhan and Udry 1999). In particular, the literature on 'less favoured regions' suggests that an environment like that of India's semi-arid regions is likely to keep households trapped in a low-welfare equilibrium since both the agro-ecological and the socio-economic conditions for agricultural production are poor (Barrett and Swallow 2006, Fan and Hazell 1999). Poor soil quality and high water scarcity keep agricultural productivity low (Ryan and Spencer 2001, Scherr 2000) and due to the poor production potential, few public investments in rural infrastructure and services are made (Fan et al. 2000).

With regard to the incentives for investing in SWC, the literature suggests that households are reluctant because the benefit-cost ratio of SWC investment is relatively low (Barbier 1990, Heerink et al. 2001, Pender and Kerr 1998, Shiferaw and Holden 2000). Especially in India's semi-arid regions, low farm gate prices, uncertain revenues and increasing opportunity costs of labour make investments in rainfed agriculture rather unattractive, especially when compared to investments in groundwater irrigation and agricultural intensification (Walker and Ryan 1990). Also, with over 30% of the households in India's semi-arid regions being classified as poor (Ryan and Spencer 2001), farm households tend to go for short-term benefits instead of investing in the productivity of the resource base (Bardhan and Udry 1999).

Clearly, government subsidization of WSD implementation has substantially lowered SWC investment costs, but to maintain SWC households need an incentive to contribute as well. If the returns to agriculture are very low or if the amount of rainwater that can be harvested is negligible, the incentives for households to cooperate in SWC maintenance are likely to be low as well. Kerr et al. (2002) suggest that investments on plots with access to irrigation are better maintained than investments on dryland plots and that maintenance is less in projects with high subsidization. Generally, the literature on common property resource management has paid relatively little attention to the influence of external factors for community resource management success (Agarwal 2001). Except when underlining the importance of an enabling institutional environment (see for example Ostrom 1990, Poteete and Ostrom 2005, Wade 1988) the analysis tends to concentrate on internal, community-related factors instead. In this dissertation, specific attention will be paid to the relative importance of external factors in explaining community resource management success.

The third factor, user group characteristics, is important for community management since it determines the extent to which community members interact and whether the benefits of cooperation are distributed in a fair and equal way. Several studies have analyzed the way user group characteristics influence how communities manage collective resources. For example, Henrich et al (2004) show how individuals from societies depending on collective activities are more cooperative than those from societies in which the family is the key decision making unit. Alesina and La Ferrara (2000) suggest that heterogeneous communities are less cooperative than homogeneous communities possibly because homogeneous communities share a set of social norms and trust that facilitate cooperative action which heterogeneous communities lack.

In the case of WSD in rural India, caste heterogeneity is likely to be an important determinant of community cooperation. The caste system is typical for India[1] and consists of a hierarchical system of social rules that defines social interaction and, to a certain extent, the household's occupation and thus, economic status. Although formally caste membership plays no role in resource governance, especially in rural areas it is one of the most determining factors for community interaction and development (see for example Das et al. 2004). In fact, Dumont (1970) argues in his famous book on the caste system in India that village communities do not exist. Since it is along caste lines that households interact, social norms, behavioural rules, networks and trust are mostly built along caste lines and not at the village scale. Still, WSD projects are targeted at village communities and basically assume that households are willing to cooperate at the village scale. Whether households are indeed willing to do so is likely to depend at least partly on village heterogeneity and the extent to which households daily interact at the village level.

Socio-economic inequality also affects community resource management, although the direction in which is unclear. Baland and Platteau (1999) indicate that the impact of inequality on community resource management is ambiguous. High inequality might reduce voluntary cooperation, but it can also induce the few households that have access to resource benefits to privately provide the semi-public good. How inequality affects WSD projects has not really been assessed. Although several studies address the impact of inequality on project implementation (see for example Kerr 2002, Joy and Paranjape 2004, Kumar 2002) its impact on long term SWC management remains largely unclear. Hence, in this dissertation both the influence of socio-economic inequality and caste heterogeneity on community SWC management will need to be addressed.

The fourth and last factor, community level institutional arrangements, play a role in facilitating voluntary cooperation by controlling free rider behaviour and coordinating the use of semi-public goods.

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[1] Neighbouring countries like Pakistan, Nepal and Bangladesh have some elements of the caste system.

The analysis of existing community resource management arrangements has shown that a wide range of informal mechanisms exists (Baland and Platteau 1996, Meinzen-Dick et al. 2002, Ostrom et al. 2002, Bardhan 1993, 2000). However, in newly established community-based projects institutional arrangements to coordinate the use of collective resources might not be in place. Still, most of the literature on common property resource management focuses on cases where institutional arrangements for local resource management exist.

To improve the effectiveness of WSD it would seem more useful to concentrate on examples where, with no existing institutional arrangements, free rider behaviour is still effectively controlled. For this, the literature on international environmental agreements seems to provide an interesting example. Like in newly established community-based development projects, international environmental agreements lack an external authority to control free rider behaviour. Hence, whether participants can be expected to contribute to public good provision depends on whether the conditions for voluntary cooperation are being met. The literature suggests that in order to reach a socially efficient level of semi-public good provision, a stable coalition of cooperative participants has to exist (Finus 2001, 2003, Carraro and Marchiori 2002, Barrett 2003). For this to be the case, three conditions have to be met: (i) cooperation should be profitable, (ii) there should be consensus with regard to the common goal, and (iii) the implicit agreement to cooperate should be self-enforcing (Finus 2003). The profitability requirement has been widely elaborated in the literature on common property resource management, but the self-enforcement and consensus requirement are much less addressed. Hence, for the analysis in this dissertation it seems important to pay specific attention to these requirements. Also, since consensus and commitment building are important elements of community-based projects, this gives ground for the hypothesis that community involvement in project planning and implementation could help facilitate community resource management in the long run.

Overall, partly due to the case-study nature of most of the literature, a systematic assessment of the relative importance of the different conditions influencing community resource management lacks (Agarwal 2001). This complicates the inference of more general lessons that could help facilitate the implementation of community-based projects and increase the effectiveness of project implementation in the long run. This dissertation aims to fill this gap by undertaking a comprehensive analysis of the different factors involved.

1.2 Objective, research hypothesis and methodology

The main objectives of this dissertation are a) to analyze the conditions under which rural communities in India's semi-arid regions are likely to voluntarily cooperate in the provision of a semi-pubic good, i.e. SWC maintenance and b) to assess whether community-based WSD is likely to be welfare enhancing at the basin scale.

To analyze these objectives I defined the following four research questions:

i) Are households likely to voluntarily cooperate in SWC maintenance, given the semi-public nature of SWC investments and given the context of agricultural production in India's semi-arid watersheds;

ii) Do investments in community organization improve community resource management, i.e. SWC maintenance in the long-run;

iii) How do community characteristics influence voluntary cooperation and what is the relative importance of this effect, and;

iv) How important are the downstream externalities of participatory WSD and how do they influence the welfare impact of WSD at the basin scale.

Roughly, each question will be addressed in a separate chapter. Before addressing the four research questions, chapter 2 will first set the stage. To better understand the WSD program and the specific problems WSD projects need to tackle, the chapter introduces the process of WSD planning and implementation and the wider context in which SWC investments are made. In describing the problems WSD projects encounter, the four conditions for community resource management success will be further explored. Also, the chapter will further elaborate the potential benefits of SWC investment and the specific types of investment made. Although the range of SWC undertaken is actually quite large, the analysis in this dissertation will focus on water related SWC investments, i.e. investments that promote rainwater harvesting, groundwater recharge and the construction of small dams and water storage ponds. The chapter ends with an introduction of the study sites.

Chapter 3 concentrates on the first research question, i.e. whether households are likely to voluntary contribute to the maintenance of a semi-public good. Using the basic framework of non-cooperative game theory, the model analyses individual decision-making when outcomes do not only depend on individual choices but on the actions of others as well (Folmer and De Zeeuw 1999). The strategic interdependence of multi-person decision-making is what complicates the management of semi-public resources. If individuals do not cooperate, a socially efficient outcome is unlikely to be reached. Using a formal model to analyze the conditions under which a socially efficient outcome becomes possible allows for a better understanding of the actual mechanisms involved.

The analysis specifically focuses on the self-enforcement condition, i.e. whether a stable coalition of cooperative households is likely to be reached. Special attention is paid to how changes in the external environment influence coalition stability. In particular, the analysis elaborates the influence of emerging labour markets. Whereas initially in most of India's semi-arid watersheds few 'outside' options existed, with the improvement of rural infrastructure and transport services temporary out-migration starkly increased (Deshingkar and Start 2003). The influence of emerging labour markets on community cooperation has received little attention so far. Most WSD projects still assume low opportunity costs of labour and are not aware that emerging labour markets might affect SWC maintenance in the long run.

The results suggest that only if the coalition has a strong strategic advantage a socially efficient level of SWC provision is likely to be reached. If the strategic advantage of the coalition is less, an initially cooperative group of households is unlikely to continue cooperation in the long run. This can be explained by the fact that without a strategic advantage, the individual benefits of free riding are larger than the individual benefits of cooperating, and with free mobility between coalition and fringe households are unlikely to stay in the coalition long. Whereas the availability of an outside option generally reduces the level of SWC provided, it can also increase the strategic position of the coalition and thus increase cooperation in the long run. Interestingly, the external environment does not only influence community cooperation, but the extent to which households cooperate also influences the impact that the external environment has. Generally, a higher external wage rate lowers the incentive for community cooperation, but when households are intrinsically cooperative the benchmark wage rate has to be higher to motivate households to migrate out. The explanation for this is that in cooperative villages the returns to agriculture are higher because a socially efficient level of SWC investment has been made.

Chapter 4 addresses the second research question, whether investments in community organization affect SWC maintenance in the long run. To analyze the long-term impact of community-based interventions, I collected data from 800 households in 22 villages in 4 meso-scale watersheds in semi-arid India. Watersheds were selected on the basis of WSD treatment, average rainfall and market integration. To control for the effect of project placement on project outcomes, study villages were selected on the basis of their location in the meso-watershed. Since upstream villages are more often treated than downstream villages, by controlling for location I tried to control for project placement effects. Since I did not have access to time series data, I asked households about their intention to contribute to SWC in the long run. Considering that investments in community organization are expected to influence the household's commitment to contribute, taking the household's intention as a proxy for long-term maintenance seems appropriate to assess impacts in the long run. The characteristics of the watershed were used to analyze the influence of the external environment, i.e. the impact of market integration and relative aridity on project results. Besides, income inequality was taken as an indicator for user group characteristics and used to assess its impact on household cooperation at the village scale.

In line with the literature on WSD, the results indicate that participatory approaches are more effective in the short run. If WSD project implementation is participatory, more investments in SWC are made. The effect of participatory WSD on long term SWC maintenance is however less clear. Investments in community organization do not seem to directly impact the household's intention to contribute to SWC maintenance, but indirectly participatory approaches do have a positive effect. By increasing the critical mass of households with SWC investment, the household's commitment to SWC maintenance is increased. Besides, the household's intention to contribute to SWC maintenance is influenced by household and village characteristics and the external environment in which WSD investments take place.

In chapter 5 I address the third research question, the importance of community characteristics for voluntary cooperation at the village scale. In fact, the popularity of community-based approaches stems largely from the expectation that communities are intrinsically cooperative and will facilitate investment maintenance in the long run. This expectation is based however on the assumption that communities have control over a stock of social capital that facilitates social interaction and helps control free rider behaviour at the village scale. However, the availability of social capital is likely to depend on community characteristics, like village heterogeneity and the extent to which households frequently interact (see for example Dasgupta 2002, Miguel and Gugerty 2005). To analyze the relative importance of community characteristics in determining the likelihood of voluntary cooperation, I conducted field experiments to measure village levels of trust. Trust is supposed to be an important element of social capital, as it facilitates social interaction and pro-social behaviour at the community scale. Because survey questions have been indicated to measure reciprocity instead of trust (Glaeser et al. 2000), using an experimental approach seemed most appropriate (Carpenter et al. 2004). The advantage of inviting actual farm-households to participate in the experiments is that participants have been shown to use their experiences from everyday life to solve the problems they encounter in the experiment (Henrich et al. 2004). Hence, using 'real people' instead of college students is expected to improve the quality of results. To analyze the relative importance of social capital for community resource management I combined the experimental results with the household survey data. This not only allowed for an integrated analysis of the different factors influencing household behaviour, it made it possible to pay attention to the 'generalizability' of the experimental results as well.

Results indicate that trust is higher in homogeneous communities and that it is a significant determinant of the household's willingness to contribute to SWC maintenance in the long run. Individual trusting behaviour is not a significant factor, but average trust levels at the village scale are. This is in line with the literature on social capital, which defines social capital at the community scale. In terms of impact, village levels of trust are about equally important as other variables in fostering participation in community resource management. Hence, targeting homogeneous communities is likely to improve project effectiveness, but it does not guarantee project success.

In chapter 6 I divert attention from community resource management to focus on the impacts of WSD at the basin scale. Although several evaluations have shown that WSD can improve welfare at the village scale, at the scale of the basin the welfare impacts of WSD remain unclear. With data from the Krishna river basin in southern India, I assess the impact of a reduction in surface water flow on users downstream.

For the analysis, I assume that up and downstream regions share a fixed amount of surface water and that between up and downstream users no flow of groundwater exists. Under these circumstances, WSD in India's semi-arid regions is likely to effectively re-allocate water from down to upstream regions. Two factors are expected to determine basin-scale welfare impacts. First, using water upstream reduces the transpiration losses associated with storing water in large irrigation reservoirs. Second, re-allocating water might decrease water use efficiency because in upstream regions the conditions for agricultural production tend to be worse. In assessing the welfare impacts of WSD, the trade-offs between these two factors will need to be assessed.

Using an economic optimization model, I simulate how changes in water allocation affect the agricultural value produced. For five different investment levels I evaluate WSD costs and benefits and assess whether benefits are sufficient to pay back costs. I then use a Monte Carlo simulation to assess the robustness of the results. The results indicate that the downstream externalities of WSD can be substantial and that the benefits of WSD are on average insufficient to pay back investment costs. SWC maintenance increases the probability of WSD having a positive welfare impact with 10-20% but even in the most optimistic scenario, and under the conditions mentioned, the probability that WSD is welfare enhancing is less than 50%. Still, WSD in semi-arid regions might be socially desirable if WSD would substantially reduce poverty upstream. Several studies have shown the impact of WSD on poverty alleviation to be disappointing however. Hence, in semi-arid regions, with no flow of groundwater between up and downstream users, WSD does not seem to be a very effective strategy to improve welfare at the basin scale. The effects of reduced soil erosion and reforestation have not been considered however, and especially in higher rainfall and mountainous watersheds it seems important to account for these factors as well.

Chapter 7 recapitulates the outcomes of the different chapters and discusses whether households are likely to voluntary cooperate in SWC maintenance and if WSD projects can be expected to improve welfare at the basin scale. The chapter concludes that in the context of India's semi-arid regions, the likelihood of households voluntarily cooperating in SWC maintenance seems relatively small. Besides, the likelihood that WSD is welfare enhancing under the conditions prevailing in the areas studied is relatively low This is not to say that community-based WSD can not be welfare enhancing, but that the likelihood of community-based WSD structurally changing the outlook for India's semi-arid regions is relatively small.

For the analysis I collaborated with several of India's leading non-governmental organizations (NGO) to collect data in the field. Besides, I collaborated with hydrologists and remote sensing specialists from the International Water Management Institute in Hyderabad, India to evaluate impacts at the basin scale. Because several of the chapters in this dissertation are also co-authored, in the rest of this dissertation I will refer to the author as 'we'. Clearly, all errors and omissions are mine.

2. Participatory watershed development

2.1 Introduction

The watershed development (WSD) program is one of the main programs for rural development in India's semi-arid regions. Although the program started as a program to generate employment in times of drought, over time attention shifted to more structural investments to increase agricultural productivity and alleviate poverty. Poor soil quality and water scarcity being regarded as important production constraints (Ryan and Spencer 2001), investments in SWC are supposed to structurally improve the agricultural production potential and increase agricultural productivity in the long run. Whereas in some regions interventions concentrate on the restoration of degraded lands, in other regions WSD projects focus on groundwater recharge and rainwater harvesting. Most projects are a mixture, however, of interventions combining investments in soil conservation, rainwater harvesting and the restoration of (degraded) common lands.

Agricultural productivity is low in India's semi-arid regions, not only because of poor resource endowment but because of a lack of infrastructure and agricultural services as well (Walker and Ryan 1990). Agricultural productivity has always been relatively low in these regions, due to high climatic uncertainty, poor soils and high water scarcity. However, as public investments in agricultural production concentrated on the more high-potential regions downstream the gap in agricultural productivity increased. For example, the Green Revolution (1967-1978) largely bypassed India's semi-arid regions, whereas in better-endowed regions substantial investments in canal irrigation, rural infrastructure and improved production techniques were made. Hence, in 1970 the value produced per hectare in high-potential regions was on average 60% higher than that in semi-arid regions but by 1994 the difference had gone up to 78% (Fan et al. 2000).

To reduce the gap in agricultural productivity, the WSD program tries to improve the agricultural production potential of semi-arid regions. Investments in SWC are supposed to reduce soil erosion, improve soil moisture and increase the availability of stored (ground) water resources for irrigation in periods of drought (Oweis et al. 1999). Analysts have argued that to improve agricultural productivity, besides investments in SWC, investments in improved production techniques and rural infrastructure are required as well (Rosegrant et al. 2002, Fan and Hazell 1999).

Although other government programs are making investments in rural infrastructure and improved production techniques, the WSD program mainly concentrates on SWC. WSD projects do sometimes invest in micro-credit provision and product diversification, but generally do not have the means or intent to change the wider context in which agricultural production takes place.

The extensive literature on WSD in India has shown that well-implemented WSD programs can significantly enhance the productivity of agriculture.[1] Investments in soil conservation improve soil moisture and, thus, the yields of rainfed crops and investments in water conservation have been shown to increase groundwater levels and the area under irrigation. Besides, WSD interventions reduce soil erosion and improve the quality of common (forest) land. Most evaluations of WSD projects are case studies however and the influence of the external environment is often not addressed. Agronomic studies have established however that SWC investments in less arid environments are more effective than in arid environments because with high aridity the amount of rainfall that can be harvested is relatively low. Similarly, SWC investments on soils with a higher soil moisture retention capacity (i.e. black soils) are more effective since relatively more water can be stored (Wani et al. 2002, 2003).

A study that does systematically evaluate the benefits of WSD interventions is the study by Kerr et al. (2002). With data from 86 villages in two states (Maharastra and Andhra Pradesh) the study compares the impact of participatory and non-participatory project interventions on soil erosion, irrigation development, rainfed agriculture and the rehabilitation of degraded lands. The results indicate that investments in SWC significantly improve the productivity of agriculture and that participatory approaches are more effective than interventions that implement SWC investments from the top-down. In fact, the study was so influential that from 2000-2001 onwards[2] government initiated WSD project became participatory as well (see GOI 2000 for example). Although the results of Kerr et al. (2002) clearly indicate that participatory approaches are more effective, the longer- term effects remain unclear. Besides, the study only considers impacts at the village level and, thus, does not assess the welfare implications of WDS at the basin scale.

This dissertation attempts to evaluate the long- term effects of WSD and the impact of WSD at the basin scale. The purpose of this chapter is to elaborate how WSD projects are implemented and to describe the wider context in which SWC investments are made. In the next section, we describe the WSD program and the process of project planning and implementation. In the third section we review the conditions for successful community resource management to determine what the main problems for long-term voluntary cooperation in SWC maintenance are likely to be. The fourth

[1] See for example Boersema 2001, Kerr et al. 2002, Wani et al. 2003, Ratna Reddy et al. 2004, Chandrakanth et al. 2004, Sharma et al. 2005, Honoré 2002, Joshi et al. 2004, 2005.

[2] Although the study was published in 2002, the research was undertaken in 1997 and outcomes were presented and widely shared before 2002.

and last section of this chapter introduces the project sites. Introducing these sites not only provides the background for analysis in two of the seven chapters of this dissertation, it is expected to help visualize the conditions for voluntary cooperation in India's semi-arid regions too.

2.2 Participatory watershed development

There are roughly two ways in which WSD projects intent to improve agricultural productivity i) by increasing the yields of rainfed crops and ii) by increasing (or maintaining) the area under (groundwater) irrigation. SWC investments with a focus on rainfed agriculture concentrate on measures to improve soil moisture and reduce soil erosion. SWC investments with a focus on irrigated agriculture concentrate on rainwater harvesting and groundwater recharge. Although most SWC measures contribute to both, some SWC measures (i.e. bunding, terracing etc.) generate more soil-related benefits whereas other SWC investments (water storage reservoirs, small dams etc) generate more water-related benefits. Whether WSD projects emphasize soil or water conservation usually depends on the characteristics of the watershed: in steeply-sloped watersheds, SWC investments often concentrate on soil conservation whereas in watersheds with high levels of groundwater depletion investments focus more often on groundwater recharge. In this dissertation, we concentrate on investments emphasizing water conservation as in our study sites water conservation is the main WSD benefit perceived.

In fact, the WSD emphasize on water conservation is relatively recent, since, traditionally, agriculture in India‘s semi-arid regions used to be rainfed, with some seasonal sources of irrigation like shallow groundwater wells and small surface water reservoirs. Only with the development of deep groundwater irrigation did continuous irrigation become an option. Because access to continuous irrigation allows for the production of high value, water intensive crops, farm households massively invested in deep groundwater irrigation (see also Shah et al. 2003). This caused groundwater levels to steeply declined and the demand for groundwater recharge to grow.

SWC investments range from bunding, drainage line treatment and reforestation to investments in small dams, gully plugs and groundwater recharge ponds. To optimize investments it is important that the downstream externalities associated with SWC are adequately addressed. This requires both technical SWC expertise and knowledge of the local context and hydro-ecological environment in which investments take place. Although initially most WSD projects were planned by external experts and implemented from the top-down, informational asymmetries between the implementing agent and the local beneficiaries caused the effectiveness of this approach to be relatively low. The success of more participatory approaches indicated that including communities in project planning and implementation helps to address these informational constraints (see also Stalker Prokopy 2005). In fact, the most successful WSD projects are those that combine community participation with technical expertise (Kerr et al. 2002).

To ensure the long-term effectiveness of SWC investments it is important that investments are maintained. In some cases, this will be mostly a private effort of a farmer redoing the bunding on his land. In most cases it requires, however, that other households contribute as well. Depending on the biophysical context, cooperation might be required between households sharing an aquifer or a small dam, between up and downstream households sharing a drainage line or the entire village when investments include, for example, a surface water reservoir or common land.

To involve local communities, WSD interventions generally start with the establishment of a watershed committee. Although for government-financed WSD projects the establishment of a watershed committee is mandatory (GOI 2000)[3], the extent to which communities participate in project planning and implementation differs a lot (Joshi et al. 2004). Whereas in some projects the watershed committee merely approves the investment plan, in other projects the watershed committee is made largely responsible for project planning and implementation. Case study analysis suggests that, for a well-functioning watershed committee, substantial investments in community organization need to be made prior to its establishment (Joy and Paranjape 2004, Farrington et al. 1999). For example, the community has to be made aware of what the WSD program seeks to accomplish and what the role of the watershed committee in the planning and implementation of investments will be.

If the watershed committee is to formulate a plan that represents all interests, its members should ideally be elected in a democratic way. This in turn requires that poor and marginal households are stimulated to participate in village decision-making. Generally, if participation by marginal households in village decision-making is not actively supported, village decision-making is taken over by the local elite. The poor usually have less influence in village decision-making and, hence, participatory approaches are often incapable of controlling rent-seeking behaviour by the local elite (Bardhan and Mookerjee 2005, Galasso and Ravallion 2005). This is likely to reduce the long-term effectiveness of WSD as it impedes consensus regarding the WSD plan. Hence, investments in local awareness, empowerment and the election and establishment of a representative and well-functioning watershed committee are required to ensure effective community participation in the long run (Joy and Paranjape 2004). Non-governmental organizations involved in WSD implementation usually spend more time and resources on community organization than governmental organizations. Generally, attention for community organization increases the time needed for project implementation from 1-2 years up to 2-4 years. Since governmental organizations generally do not have the facilities to spend 2-4 years on project implementation, often non-governmental organizations receive government

[3] In the most recent government WSD guidelines (the 'Hariyali guidelines; Government of India, 2003) the village council (the Panchayat Ray Institution) is given a more prominent role. However, as in the study sites WSD was implemented before 2003, we do not consider the role of the village council in WSD planning and implementation.

funding to implement WSD. Few professional, highly committed NGOs exist, however, and there are many cases of NGOs implementing WSD projects without technical expertise or of NGOs being established for the cause of receiving government funding alone. In this dissertation, we only consider professional NGOs and do not address the wide range of semi-professional, and even corrupt, NGOs that are out there in semi-arid India to implement WSD projects as well.

With regard to the costs of WSD investment, as mentioned before, households contribute to 0-25% of the total costs in voluntary labour. With project wages above the market wage and with high unemployment, investments are effectively subsidized for over 100% (Kerr et al. 2002, Shah 2005). Households and communities have real costs however in having part of their land taken out of production. Also, they are supposed to maintain SWC investments in the long run. For investments on private land, households have to bear the full costs of SWC maintenance, but for collective structures or investments on common land in some cases a maintenance fund exists. If a maintenance fund has been established, it is managed by the watershed committee and only covers the material costs of SWC maintenance.

With respect to the benefits of WSD, several benefits arise. First, there is the employment benefit associated with project implementation. Villagers can get a good income from WSD implementation as they are paid a wage above the market wage. This often leads to local rent-seeking behaviour, influential households securing employment benefits for their kin. Second, households benefit from possible SWC investments on their land. The on-site, private benefits of SWC are mostly improvements in soil moisture and soil fertility and depend on the slope, size and quality of the land (Barbier 1990, Heerink et al. 2001, Pender and Kerr 1998). Third, households benefit if they have access to the collective benefits of SWC. The most important collective benefits of WSD are recharged groundwater aquifers and improved biomass availability on common lands. Households with livestock benefit from improved biomass availability (Puskur et al. 2004). Generally, households with access to irrigation and land located near drainage lines benefit most (Farrington et al. 1999, Bouma and Scott 2006). As these are often the households that are already better off, the impact of WSD on poverty alleviation tends to be small.

An unequal distribution of WSD benefits not only reduces the impact on poverty, it might affect long-term project effectiveness as well. Although in this dissertation no specific attention will be paid to the distribution of WSD benefits, the analysis will address the impact of inequality on the effectiveness of the WSD approach. Apart from a qualitative assessment of the functioning of local watershed committees, the analysis will not elaborate the organizational aspects of WSD implementation. Many case studies regarding the pro's and con's of the different approaches to WSD implementation already exist, and the analysis in this dissertation will concentrate on the importance of the external environment and community and household characteristics for project effectiveness instead.

2.3 The incentives for SWC maintenance in semi-arid India

In the following, to get a better picture of the challenges faced by the WSD program we will review the four conditions for successful community resource management and elaborate where in this dissertation the different elements will be addressed.

2.3.1 Resource system characteristics

In the preceding chapter we introduced some of the externalities associated with SWC investment but we did not elaborate how land and water user rights are defined. Generally, most of the land in semi-arid India is privately owned. In some watersheds, part of the land is government land, either owned by the forest department or the village council. Few user rights regarding the use of common lands usually exist. In some watersheds, villagers monitor and enforce some limited grazing rights. Hence, government lands are often heavily degraded, as they tend to be open for all. Water rights also tend to be poorly assigned (Bruns and Meinzen-Dick 2000, Aggarwal 1995). Under the riparian system of property rights, the right to use (ground) water is linked to the ownership of land, but since the boundaries of most water systems exceed individual land entitlements, the appropriation externalities associated with water use tend to be large. Only with regard to the extraction of water from canal irrigation systems and surface water reservoirs are explicit rules sometimes defined (Wade 1988, Mosse 2003). However, since most surface water reservoirs are used for groundwater percolation these rules are often no longer in use.

Assigning individual user rights to collective groundwater resources is notoriously difficult as the boundaries of groundwater aquifers are often unclear and the quantity of groundwater available is largely unknown. As the information costs of establishing groundwater user rights would be very high, it is unlikely that communities can successfully assign and enforce individual water user rights at the community scale. For common lands, the assignment of user rights is more straightforward, but here the problem arises that the government usually owns these lands. Hence, communities are reluctant to improve common property resource management, as they cannot be sure to reap the benefits in the long run.

The lack of clear user rights regarding the use of common land and (ground) water is clearly not conducive for SWC management. However, it does not necessarily impede voluntarily cooperation (see for example Aggarwal 2000). By making households that benefit from semi-public SWC structures contribute proportionally to the costs of maintenance, free rider behaviour might still be controlled.

Although this dissertation will not elaborate whether and how individual maintenance responsibilities might be assigned, the analysis is likely to provide some clues as to how this might be done. For example, the analysis in chapters 4 and 5 is expected to generate insight into the factors determining SWC contributions and the analysis in chapter 6 evaluates the relative importance of downstream externalities.

2.3.2 The external environment

The socio-economic environment for agricultural production in India's semi-arid regions is generally characterized by poor infrastructure, poor access to agricultural services and little use of improved production techniques (Walker and Ryan 1990, Fan and Hazell 1999). These factors are likely to influence SWC maintenance as they determine the benefits that can be gained. For example, poor market access increases the transaction costs of agricultural marketing and high transaction costs generally cause farm-households to rationally settle for the production of low-return subsistence crops (De Janvy et al. 1991, Omamo 1998). Similarly, lack of access to improved production techniques, agricultural inputs and improved seeds generally reduces the value of agricultural production, thus lowering the incentive for households to invest.

Poor infrastructure and underdeveloped markets can however also reduce the availability of so-called 'outside options'. This is expected to make farm-households more likely to contribute to SWC maintenance as it reduces the opportunity costs of labour. With the development of rural transport services, even in remote areas the availability of outside options has increased (Deshingkar and Start 2003). Whether and how this is likely to have influenced the long-term effectiveness of WSD will be addressed in chapter 3. The impact of poor market access is addressed in chapter 4.

The external context is not only important in determining the costs and benefits of cooperation, it is important in determining the institutional environment for community-based resource management as well. Formally, the village council, or Panchayat Raj institution (PRI), is responsible for resource management at the village scale. However, since PRIs usually do not have the capacity or resources to manage natural resources effectively, WSD programs have focused on local communities instead[4]. By creating a watershed committee, existing political and institutional complexities can be avoided and resources can be earmarked for local resource conservation alone. However, the fact that the watershed committee has no formal responsibilities or entitlements might impede the management of SWC structures as well. In this dissertation we do not pay much attention to the broader institutional environment but instead concentrate on the conditions for voluntary cooperation.

2.3.3 User group characteristics

User group characteristics are important as they help determine the level of social interaction that takes place. If households frequently interact this creates a set of social norms, preferences and expectations that help facilitate cooperation in the long run (Gächter and Fehr 1999, Sethi and Somanathan 2003, Fehr and Gächter 2000, Sigmund et al. 2002).

[4] Clearly, with the new Hariyali guidelines (GOI 2003), which emphasize the role of the village council in WSD management, this changed. However, as PRIs are hardly capacitated to take up their

Socio-cultural or socio-economic factors can, however, also complicate social interaction. In the Indian context, caste heterogeneity and socio-economic inequality are, for example, likely to play a role. In the literature on WSD effectiveness, the importance of caste heterogeneity has hardly been addressed[5]. The impact of socio-economic inequality has received some attention, local elites dominating collective decision-making more often in unequal villages, reducing consensus and commitment regarding the WSD investment plan (Farrington et al. 1999). As the literature on voluntary cooperation indicates, consensus is crucial to control free rider behaviour when external enforcement mechanisms lack (Ostrom et al.1992, Finus 2003). This has led for example Kerr (2002) to argue that to improve WSD effectiveness interventions might need to be targeted at homogeneous communities. Whether this can be expected to improve WSD effectiveness depends on the relative importance of village heterogeneity as compared to other factors. Khwaja (2004) suggests for example that better project implementation is more important than socio-economic homogeneity, and that well-implemented projects can succeed in making even heterogeneous communities voluntarily cooperate in the long run. In chapter 4 we analyze the relative importance of income inequality at the village scale. In chapter 5 the relative importance of caste heterogeneity for voluntary cooperation will be addressed.

2.3.4 Institutional arrangements

With regard to the institutional arrangements for SWC in semi-arid India, Mosse (2003) indicates that in some regions traditional arrangements did exist. Local warlords, kings and priests invested in water storage and conservation and local communities contributed by giving part of their harvest and voluntary labour in return (Mosse 2003). Increased population pressure, the formalization of natural resource management to government agencies and the development of deep groundwater irrigation caused traditional arrangements to become dysfunctional and dissolve (Jodha 1996). Still, Banerjee and Iyer (2005) convincingly show how long discarded institutions might significantly influence current resource use. Long abolished land tenure systems can still explain differences in agricultural productivity and socio-economic development between regions. Although the shift from surface to groundwater irrigation seems to have structurally changed the way water resources are used still regions with a tradition of voluntary cooperation in reservoir maintenance or temple restoration might have an advantage over regions that do not. In the analysis of chapter 4 these factors will be controlled for in the watersheds fixed effects, because information about the historical background of the study sites unfortunately lacks.

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responsibility in WSD management, community cooperation remains crucial to maintain SWC.

[5] Kerr (2002b) does mention the role and importance of village homogeneity in discussing the success of Sukhomajri watershed, India's most famous example of successful WSD.

Since in most watersheds no explicit institutional arrangements to coordinate SWC maintenance exist, the coordination of resource use and control of free rider behaviour is expected to largely depend on whether communities can meet the self-enforcement requirement and whether interventions succeed to reach consensus regarding the WSD investment plan. Although this dissertation will not analyze the process of consensus building or the specific impact of the different investments in community organization, the analysis in chapter 4 will describe some of the investments in community organization and the impact investments in local institution building seem to have. The self-enforcement requirement is the subject matter of chapter 3.

2.4 The project sites

The empirical analysis in this dissertation makes use of data collected for the project "Livestock-Environment Interactions in Watersheds". This study, undertaken by IWMI-India and partners[6], focused on livestock production *vis-à-vis* the use and availability of natural resources in semi-arid watersheds. Study sites were defined at the scale of the meso-watershed (5,000-10,000 ha), each project site comprising 10-26 villages of which 4-6 villages were selected for further analysis. In each watershed, the LEAD study team and the author of this dissertation collected agro-ecological, hydrological, village-level and household-level data. To address some of the specific questions of this dissertation, the LEAD study team allowed for some extra questions to be added to the household questionnaire. The relevant parts of the questionnaire can be found in annex B.

[6] The LEAD partners are the NGOs Seva Mandir (Rajasthan), WOTR (Maharastra), Wassan (Andhra Pradesh), SAMUHA (Karnataka) and Sampark (Madhya Pradesh). The study was financed by the Swiss Development Cooperation (SDC) and the Food and Agriculture Organization (FAO) and was undertaken between 2002-2005.

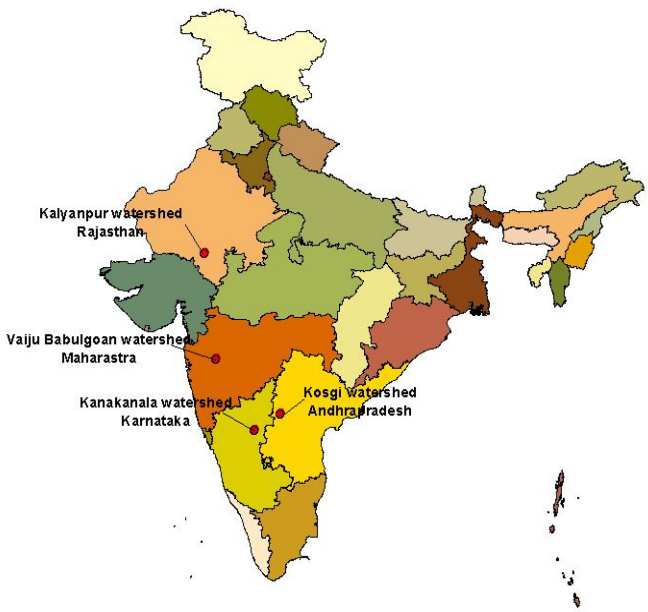

Figure 2.1 Location of the study sites.

Roughly, the study sites were selected on the basis of their natural resource endowment and socio-economic context[7]. Table 2.1 shows the categorization of the watersheds, using rainfall as proxy for resource endowment and market access as a proxy for socio-economic embeddedness.

Table 2.1 Categorization of the study sites.

	Very Low Rainfall <500 mm	Low rainfall <700mm
Remote watersheds	Kanakanala watershed, Karnataka	Kalyanpur watershed, Rajasthan
Integrated Watersheds	Vaiju Babulgaon watershed, Maharastra	Kosgi watershed, Andhra Pradesh

To account for possible up-down stream externalities, the LEAD study explicitly selected villages from the upper, middle and lower region of the meso-scale watershed. Also, the selection of study villages included villages that had undergone WSD treatment and villages that had not. In two of the watersheds we could even distinguish between villages that had been treated by the government or by an NGO.

[7] In fact, five study sites were selected by the LEAD study team, but since the fifth site (Ladki Nadi watershed, Madhya Pradesh) showed considerable overlap with Kalyanpur watershed, Rajasthan, I did not include this watershed in the analysis of this dissertation.

Table 2.2 presents data on the number of villages and WSD treatment in the four watersheds.

Table 2.2 Investments in soil and water conservation per watershed.

Watershed	Implementing agent	Study villages	Treated villages	Watershed area (ha)	Area treated	Costs per ha treated area (USD/ha)
Kosgi	DPAP* (GO)	4	3	3,460	58%	80
Kanakanala	SAMUHA (NGO)	6	3	13,064	48%	60
Kalyanpur	DPAP (GO) and Seva Mandir (NGO)	7	6	7,488	27%	125
V.Babulgaon	DPAP (GO) and WOTR (NGO)	5	3	4,876	24%	155

Source: IWMI (2005). *DPAP=Drought Prone Areas Program, GO= governmental organization, NGO= non-governmental organization

Since exact data on treatment costs and area treated were hard to come by, the figures presented are only indicative of WSD treatment in the four study sites. The size of the different watersheds varies because size is defined on the basis of the hydrological boundaries of the 'area from which all water flows to a common drain' (i.e. the definition of a watershed).

In the following we will introduce the study sites and elaborate the differences in resource endowment and market access that exist between the study sites. Also, we describe the WSD interventions undertaken and the perceived impacts this has had. The information used is mostly based on field visits and village meetings, although household survey data and secondary data are used for the description of the study sites too.

2.4.1 Resource endowment and the agro-ecological context

Table 2.3 presents a summary overview of the parameters indicative of the relative resource endowment of the different watersheds.

Table 2.3 Rainfall, aridity and slope in the study sites.

	Kosgi	Kanakanala	Kalyanpur	V.Babulgaon
Average rainfall/year	739 mm	499 mm	584mm	430 mm
Aridity (P/Pet)[a]	0.5	0.31	0.39	0.32
5 % slope/total	0	17%	49%	42%

Source: IWMI (2005) [a]P/PET= precipitation/potential evapotranspiration

The average amount of rainfall is indicative of water scarcity, but aridity is a better indicator as it reflects the rate of water 'lost' to transpiration too. If the aridity parameter is high, a larger share of rainfall can effectively be used.

In Kalyanpur, Vaiju Babulgaon and Kanakanala watershed, most of the steeply sloped lands are government lands. Most of this land is highly degraded due to deforestation and over-grazing: Government control is poor and community monitoring and control lack (Puskur et al. 2004). In Kosgi watershed there is no common land since due to high population pressure all common land has been divided into private parcels and is being used as agricultural land.

Soil quality and depth are highly variable within each watershed. Under low rainfall conditions, black soils are generally more productive than red soils because of their high soil moisture retention capacity. In each watershed both red and black soils exist, but since no soil maps were available the distribution of soil type, depth and fertility could not be assessed. Generally, soil depth and quality are lower in the upper regions of the watershed, especially when slopes are steep. Although investments in soil conservation can improve soil quality, degraded soils take a long time to recover and especially in the upper regions of the study watershed soils are often so degraded that agricultural productivity is extremely low.

Agricultural productivity clearly does not only depend on natural resource endowment, it depends on the investments in the agricultural resource base as well. Investments in land levelling, for example, increase agricultural productivity by changing the initially negative condition of having steeply sloped land. Similarly, in the highly uncertain climatic conditions of India's semi-arid regions, investments in irrigation access not only increase crop yields but reduce the risk of crop loss as well. Three types of irrigation broadly exist: i) canal irrigation from small surface water reservoirs, ii) supplemental irrigation from shallow groundwater wells, and iii) tubewell irrigation from deep groundwater aquifers. In the project sites, surface water irrigation is only an option in Kalyanpur watershed.

Generally, tubewell irrigation is preferred over open well irrigation as it supplies a more continuous flow of water. However, the investment costs of tubewell irrigation are high and depending on the hydrogeology of the watershed the risk of failure are substantial. Once farm households start investing in tubewell irrigation, the shallow open wells used for seasonal irrigation often fall dry. This is what actually happened in Kosgi watershed, where groundwater levels have dropped to 300 ft. In Kalyanpur and Vaiju Babulgaon watershed the number of tubewells is relatively low and has not affected water levels in open wells. In Kanakanala watershed, investments in tubewell irrigation recently increased, but the number of tubewells is still very low.

Although in all watersheds, traditionally, some investments in SWC were made, Vaiju Babulgaon has the highest percentage of households investing in SWC. In Kosgi watershed, partly because the watershed is flat, prior to the WSD program very little investments in SWC were made. In Kanakanala and Kalyanpur watershed few farmers indicated they had invested in SWC prior to the WSD program.

Table 2.4 Population density, landholding size and irrigation access.

	Kosgi	Kanakanala	Kalyanpur	V.Babulgaon
Total no. of households	4242	2643	1711	1298
Population density (hh/non-sloped land)	1.23	0.24	0.45	0.47
Average landholding size (acres)	3.18	8.89	2.64	5.40
% irrigated area of total	30%	1-5%	10-20%	10-15%
% HH with access to irrigation	72%	24%	80%	95%

Source: IWMI (2004, 2005). Hh=households

Table 2.4 gives an impression of the differences in irrigation access and population density between the watersheds. Generally, the higher the population density the more households need to investment in agricultural intensification to increase the productivity of their (small) plot. This is especially notable in Kosgi watershed. Average landholding size is however even lower in Kalyanpur, which can be explained by the fact that a relatively large amount of land in this watershed is government owned. Irrigation access is best in Vajiu Babulgaon, where most households have access to seasonal, open wells. Within the watersheds, irrigation access varies. For example, in Kanakanala watershed no household in upstream Idlapur can get access to irrigation because the water table is too deep, whereas in downstream Garjanal even poor households invest in tubewell irrigation. Similarly, in Kosgi watershed some villages have no access to irrigation whereas in other villages some households have several tubewells. In Kalyanpur, downstream villages have access to surface water irrigation, but in the upper region villages have no access to irrigation at all.

Figure 2.2 presents rainfall pattern in the different study sites. The rainfall pattern is important as it largely determines the agricultural production season. There are three seasons, Kharif (monsoon), Rabi (post-monsoon) and summer. Depending on the local rainfall pattern, the Kharif season starts around June/July with the harvest in Oktober/November. Rabi season starts around November/December with harvest somewhere in February/March. The summer season is from March till the monsoon begins, usually at the end of June. Generally, in Kharif , provided the rains are good, most farmers grow a crop. In Rabi, farmers with access to irrigation will grow a crop, but for rainfed farmers this will depend on whether it was a good monsoon. Farm households with poor quality land, i.e. a low soil moisture retention capacity, might not be able to grow a second crop. In summer, only households with access to deep groundwater irrigation can cultivate any crops. Farmers without irrigation usually migrate.

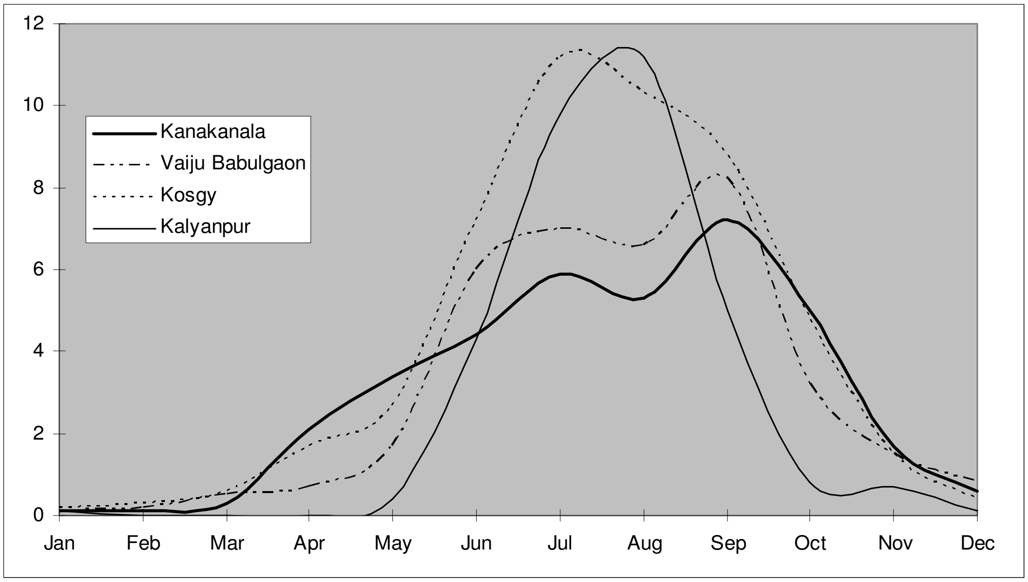

Figure 2.2 Rainfall patterns in the study sites (days/month).

Figure 2 indicates that Kosgi and Kalyanpur have a clear peak in days with rainfall, whereas in Kanakanala and Vaiju Babulgaon rainfall is more evenly spread. Because a peak in rainfall generally causes more surface water run-off this might be an indication that WSD in Kosgi and Kalyanpur generates higher returns. Although in the analysis we do not account for the peak run off flow, we do account for relative aridity as a dummy variable, the value of which is zero for Kosgi and Kalyanpur and one for the other two.

2.4.2 Market access and the socio-economic environment

With regard to the influence of market access on agricultural production and SWC investments in the study sites, Kalyanpur and Kanakanala watershed can be characterized as mostly subsistence economies, whereas the well-integrated watersheds Kosgi and Vaiju Babulgaon are largely cash based. In Kosgi, the share of the subsistence crop sorghum decreased over the last 10-15 years to 30%, whereas in Kanakanala more than 60% of the area is still cultivated with sorghum (Bouma and Scott 2006). In Vaiju Babulgaon many traditional subsistence crops are still grown, but this is mostly for its fodder production. Most households in Vaiju Babulgaon earn a good income from dairy production and the marginal value of fodder is high.

Market access, or lack thereof, not only affects crop choice, it also has a strong influence on the composition of household income. In Kosgi and Vaiju Babulgaon a larger share of income is derived from non-agricultural sources. Although farm-households in Kanakanala and Kalyanpur watershed also migrate temporarily for additional income, in the two integrated watersheds non-agricultural income sources play a more structural role. This might influence the opportunity costs of labour and hence the willingness of households to cooperate in SWC maintenance.

Also, farm households in Kosgi and Vaiju Babulgaon use more externally purchased inputs and high yielding varieties than in the other two watersheds. This is both related to the better availability of these inputs and the fact that when farmers earn cash they have cash to spend on inputs as well. In Kanakanala and Kalyapur, farmers hardly use any agricultural inputs at all.

Local governments have an important role to play in providing agricultural services and extension services, especially when agricultural markets fail. Only in Vaiju Babulgaon watershed, however, do agricultural extension services exist. Government investments in infrastructure and services are notably higher in the more market-integrated watersheds, i.e Kosgi and Vajiu Babulgaon. Infrastructure is basic in all four watersheds, but whereas in Vaiju Babulgaon and Kosgi a relative large share of the households owns bicycles or motorbikes, in Kanakanala and Kalyanpur watershed mobility is much less. Both Vaiju Babulgaon and Kosgi watershed are located within 2 hours from a major urban center (Ahmadnagar respectively Mahbubnagar). Bus transportation services to the main urban centers are available in all four watersheds.

The socio-cultural differences between the study sites are large. As Table 2.5 shows, Kalyanpur and Vaiju Babugaon are relatively homogeneous watersheds in terms of caste membership, but Kosgi and Kanakanala watershed are relatively caste divers.

Table 2.5 Caste composition in the study sites.

	Kosgi	Kanakanala	Kalyanpur	V.Babulgaon
Other caste	16%	15%	5%	81%
Backward caste	68%	69%	0	9%
Scheduled caste	17%	5%	2%	9%
Tribal population	0	12%	94%	1%

Kalyanpur is a so-called tribal watershed, with a population consisting mostly of the aboriginal population of India. Tribals generally have a low socio-economic status and tribal regions are usually the most neglected regions of India. In Kalyanpur watershed, the best lands are generally owned by non-tribals and a relatively large proportion of the land, former forestland, is still government owned. In Vaiju Babulgaon watershed, on the other hand, most of the population belongs to the ruling Marathi caste. This caste has a high socio-economic status and has been the ruling class of Maharastra for a long time. In Kosgi and Kanakanala watershed the population is more diverse. This has resulted in serious caste related conflicts in Kosgi, but in Kanakanala watershed the effect of caste heterogeneity seems low. It is important to note that although case heterogeneity might be high at the scale of the watershed, at the scale of the village it is often (much) less. This is actually a specific attribute of the caste system that certain castes are not allowed to mix.

2.4.3 WSD implementation in the study sites

In Kosgi implementation was undertaken by the government and finished in 2001. Investments concentrated on ground and surface water recharge and horticulture development. During project implementation little time was allocated to stakeholder involvement and few families benefited from the WSD program. Overall, investments concentrated on groundwater recharge and few investments in rainfed agriculture were made. Also, the quality of investments was low. Of the four villages selected for the study, three were treated.

In Kanakanala, the NGO SAMUHA is implementing WSD. Of the villages selected for the study, watershed work is ongoing in two villages and treatment in three other villages was finished in 2001. In one village, no watershed work has taken place. Overall, investments focus on increased soil moisture and biomass, erosion reduction, and improved access to supplemental irrigation. Implementation has been participatory and some investments in local institution and capacity building have been made. Although, due to the size of the watershed, investments per hectare are relatively low, the quality of investments is high and most villagers have benefited in one way or the other. For investments on private lands, households contribute 25% of the costs with voluntary labour and for investments on common lands 10%.

In Kalyanpur, the NGO Seva Mandir has implemented WSD in three of the selected villages, whereas in three other villages the government invested in WSD. Investments were finalized in 2001-2002 and focused on soil moisture and biomass improvement, reduction of soil erosion and improved access to supplemental irrigation. In the Seva Mandir villages substantial investments in institution and capacity building were made, but government implementation was non-participatory and top down. In one village, no WSD treatment took place. For investments by Seva Mandir, households contributed 15% with voluntary labour, for investments on common land the community contributed 10% voluntary labour. In case of government WSD investment contributions were 10% and 5% respectively.

In Vaiju Babulgaon, the NGO Watershed Organisation Trust (WOTR) finished WSD implementation in two out of the five selected villages in 2002. In one other village government investments were made. Government investments were non-participatory and badly implemented, but investments by WOTR were thus that one of the two villages is considered a model site. Households contributed 16% to the costs for both investments on private and common land. In the remaining two villages no structural investments in WSD were undertaken, although under drought relief some investments did take place.

In terms of impacts, in Kosgi, farmers indicated that investments increased groundwater levels. Farmers with no access to irrigation did not benefit from the WSD program since no measures were taken to increase soil moisture on their lands.

In Kanakanala's Phase 1 villages (where WSD implementation finished in 2001), crop yields reportedly increased by 30-50% (Samuha 2003). In Phase II villages, investments are still ongoing, but farmers say that received benefits from the investments upstream.

In Vaiju Babulgaon, crop yields in the villages with NGO implementation increased for both dryland and irrigated crops. Whether these crop yields increased because of increased soil moisture or higher use of agricultural inputs is not clear since both fertilizer and pesticide use increased considerably over the same period of time. Also, WSD allowed farmers to shift to higher value crops, like vegetables and fruit, as the irrigated area increased from 8% of the total cropped area to 21% (WOTR 2003). In the village with government WSD, no impacts were reported.

In Kalyanpur watershed, NGO investments were said to have increased groundwater levels, reduced soil erosion and increased the availability of biomass on common lands. Both households with and without access to irrigation benefited, but households with land downstream benefited most. In government implemented WSD programs impacts were perceived to be less.

Due to the poor availability and quality of hydrological data we could not quantitatively assess the importance of up-down stream externalities in the different watersheds. Also, we could not assess whether the reported impacts were real. The information from village meetings and household interviews indicates however that positive externalities exist at the meso-watershed scale. Downstream villagers indicated to have benefited from the SWC investments upstream. Finally, in all four watersheds, respondents suggested that due to the extended drought the impact of WSD had been relatively low. In all four watersheds, rainfall was below normal for the last three years (i.e. 2000-2002) and several respondents confided that results from the WSD program were yet to be seen.

3. Voluntary cooperation in the provision of a semi-public good*

3.1 Introduction

The literature on community resource management has credibly established that communities are capable of managing collective and semi-public resources in a socially efficient way (Ostrom 1990, Bowles and Gintis 2002). However, most of the literature concentrates on traditional cases of community resource management, where, over time, communities established behavioural rules and internal sanctioning mechanisms to control free rider behaviour and coordinate use. In newly established community based projects such mechanisms might not be in place. Also, external enforcement mechanisms are generally lacking since community-based approaches effectively decentralize local resource management to the village scale. The question is whether under these circumstances sustained voluntary cooperation is likely, i.e whether households are likely to voluntarily maintain the semi-public good.

The literature on international environmental agreements suggests that sustained voluntary cooperation is possible, even when no sanctioning mechanisms, institutional arrangements or behavioural rules exist. Like community-based projects, international agreements lack mechanisms to control free rider behaviour and cooperation depends on the incentives of individual participants to contribute to the public good. The literature on international environmental agreements suggests that for sustained voluntary cooperation three conditions have to be met: (i) the agreement should be profitable (ii) it should be reached by consensus, and (iii) the agreement should be self-enforcing (Finus 2003). The profitability requirement has been widely elaborated in the literature on common property resource management, but the self-enforcement and consensus requirement have received much less attention so far. Hence, applying the framework of the literature on international environmental agreements to the case of community-based resource management might lead to new insights regarding the importance of consensus and self-enforcement for ensuring voluntary cooperation in the long run.

The importance of cooperation being profitable has been well explored in the literature on community resource management. Basically, individuals need an incentive to cooperate, and if cooperation is not profitable this incentive lacks (Ostrom 1990).

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* This chapter is based on Bouma, J.A., D.P. van Soest and A.J. de Zeeuw (2007).

The consensus requirement is related to the process of agreement formulation. For an agreement to be kept it is important that the signatories agree about how the objectives are defined and in what way the objectives should be attained (Finus 2001). Ostrom et al. (1992) mention the importance of consensus for voluntary cooperation, indicating that consensus increases the commitment of individual agents to contribute to the joint plan. Applying the consensus principle to the case of community-based SWC suggests that WSD projects should make sure that the entire community agrees with the objectives of WSD and is committed to contribute to these objectives in the long run. This is exactly what participatory approaches try to do. By involving communities in project planning and implementation, households become more supportive of the investments undertaken and are expected to become more committed to contribute to SWC maintenance in the long run (Mansuri and Rao 2004). It is important to note, however, that in the case of community-based SWC special efforts are made to create consensus regarding the WSD investment plan, but that the maintenance of SWC investments is not explicitly discussed. Households are simply expected to voluntarily contribute to SWC maintenance and project implementers hardly invest in creating consensus regarding the maintenance plan.

The self-enforcement condition requires that the collective agreement is formulated in such a way that signatories have an incentive to contribute. In the case of community-based SWC, 'signatories' would be the participating households. By decentralizing long-term maintenance to local communities, we basically expect these households to implicitly form a coalition to cooperate in SWC management and maximize the welfare of the group. The question we focus on in this chapter is whether a group of initially cooperative households can be expected to maintain a socially efficient level of SWC. This largely depends on the stable size of the coalition (Barrett 2003, Carraro and Marchiori 2002, Finus 2003). For a coalition to be stable those in the coalition should have no reason to leave (internal stability) and those outside the coalition should have no reason to join (external stability). This is only the case if either coalition membership is fixed, or if the net benefits of cooperation and of non-cooperation are the same. Clearly, in the case of participatory WSD coalition membership is not fixed. Hence, for the coalition to be stable the benefits of cooperation and non-cooperation need to be the same.

With respect to the interaction between the coalition of cooperative households and the non-cooperative households, or the fringe, the standard assumption of non-cooperative coalition theory is that agents choose their contributions simultaneously (the Nash-Cournot assumption). Hence, coalition members jointly decide the effort level of the group and, at the same time, non-participating households individually choose their effort level. An alternative assumption (the Stackelberg assumption) is that the coalition chooses first, taking into account the best-response by non-participants. Because of the strategic advantage of being the first mover, the size of the coalition tends to be larger under Stackelberg than under Nash-Cournot (Finus 2003).

In our model we assume the coalition behaves according to Stackelberg and, hence, to have a strategic advantage. The rationale for this assumption is that households in the coalition can communicate about a joint strategy. Ostrom et al (1992) indicate that communication increases commitment to cooperate, which gives coalition members an advantage over non-cooperative households that act alone.

To analyze the conditions for coalition stability we develop a simple model in which households divide their time between agricultural production and investment in a public good, SWC. Investing in SWC increases the (public) amount of water available for agricultural production, but reduces the (private) availability of agricultural labour. We assume agents are symmetric and that the benefits of SWC investments are equally shared. Because the benefits of SWC investment are shared, households have an incentive to free ride on the contributions of others. Households committed to SWC provision form a coalition to maximize returns for the group. Whether a social optimum level of SWC provision can be reached depends on coalition stability.

To evaluate how changes in the external environment affect coalition stability we analyze the impact of emerging labour markets. Although, traditionally, off-farm employment opportunities were hardly available in India's semi-arid regions, with the development of rural transport services farm households have started to migrate for part of the year (Deshingkar and Start 2003). This might have affected the incentives for voluntary cooperation, but its impact of WSD effectiveness has been widely ignored. One reason for this could be that the WSD program started as an employment generation program and project-implementing agents still assume the opportunity costs of labour to be very low. Another reason might be that project implementers generally view migration as a sign of distress (Chopra and Gulati 2001) whereas households mostly migrate during summer season when few crops are grown.

Hence, we elaborate a model with and without external labour markets to evaluate the impact of emerging labour markets on the provision of a local public good[1]. For both models we compare the outcomes of having a coalition of cooperative households with the social optimum outcome and the non-cooperative outcome. We derive three main results. First, the relationship between the external environment and community cooperation goes both ways. Emerging labour markets influence the incentives for village cooperation, but village cooperation also influences the impact emerging labour markets have. Second, a coalition of cooperative households is unlikely to maintain a socially optimal level of public good provision. With full mobility between coalition and fringe it is not possible to fulfil the self-enforcement condition at a conservation level above the non-cooperative solution, unless the strategic advantage of the coalition is such that all households join the coalition.

[1] Tarui (2007) also pays attention to influence of outside options on common property resource management but he does not consider the role of emerging labour markets.

Third, the availability of an outside option tends to lower the level of water conservation, but might also enforce the strategic position of the coalition and, thus, improve SWC.

The chapter is organized as follows. In the next section we present the model. In section three we solve the model for the case of no labour market. We derive the Nash equilibrium and the social optimum level of SWC and compare this with the investments provided by a stable coalition of cooperative households. In section four we do the same for the case with a labour market. The conclusions ensue.

3.2 The role of SWC for agricultural production

Households maintain resource conservation structures to increase the amount of water available for their crops. Because of the public good externalities associated with water conservation, water availability depends on the efforts of the entire community. Denoting the water conservation effort of individual household i by l_{wi}, the amount of water available for agricultural production is a function of collective investment in water conservation $\left(\sum_{i=1}^{N} l_{wi}\right)$:

$$W = \sigma R\left(\sum_{i=1}^{N} l_{wi}\right), \text{ with } 0 \leq \left(\sum_{i=1}^{N} l_{wi}\right)\sigma < 1, \qquad (1)$$

where R is annual rainfall and σ is a parameter reflecting the share of rainfall that can maximally be captured (which depends on, for example, the hydro-geological characteristics of the watershed).[2] Water is accessible by multiple users from the same village, N. We assume the share each user can appropriate is equal to $1/N$, so that the amount of water an individual household can appropriate is equal to $w_i = W/N$.[3]

Agricultural output of household i is produced using water (w_i) and labour allocated to cultivation, (l_{ci}), according to the following Cobb-Douglas production function:

$$y_i = l_{ci}^{\alpha} w_i^{\beta} \text{ with } \alpha + \beta < 1. \qquad (2)$$

We can now determine the Nash equilibrium water conservation levels. We consider two cases; one where labour markets are missing, and one where households are able to trade labour at a given wage rate, ω.

[2] For simplicity, we assume farm households treat water as a flow resource. This might seem like a strong assumption, but in practice households tend to neglect the sustainability issues associated with the maintenance of water stocks.

[3] This implies that water is a pure public good, and also that we do not account for unequal access to water resources. Allowing for heterogeneity in impact does not affect the Nash equilibrium and social optimum effort levels of our model.

3.3 No labour markets

Starting from the assumption of no labour market, households can decide how much labour to allocate to agricultural production l_{ci}, and how much to resource conservation l_{wi}. The total amount of labour of household *i* is fixed, and each household faces the following time constraint:

$$\bar{l} = l_{wi} + l_{ci} \tag{3}$$

3.3.1 The social optimum and Nash equilibrium

Using *P* to denote the agricultural output price, revenues of household *i* are equal to:

$$\max \pi_i = c l_{ci}^{\alpha} \left(\sum_{i=1}^{N} l_{wi} \right)^{\beta}, \text{ with } c = P\left(\frac{\sigma R}{N}\right)^{\beta}. \tag{4}$$

With no coordination between households to invest in resource conservation, each household maximizes individual profits, taking the water conservation decisions of all other households $\left(L_{W-i} = \sum_{j \neq i} l_{wj}\right)$ as given.

The first-order conditions yield:

$$\alpha L_W = \beta l_{ci} \text{ with } L_W = \sum_{i=1}^{N} l_{wi}. \tag{5}$$

Hence, the relative productivity of labour in agricultural production α and water conservation β determines the way labour is divided. The individual households' best response function for every possible level of water conservation efforts by all other households is:

$$l_{wi} = \frac{\beta \bar{l} - \alpha L_{W-i}}{\beta + \alpha} \tag{6}$$

The symmetric Nash equilibrium water conservation effort level becomes:

$$l_{wi}^{Nash} = \left(\frac{\beta}{\beta + \alpha N}\right)\bar{l} \tag{7}$$

Note $\partial l_{wi}^{Nash} / \partial N < 0$; individuals have less incentive to contribute as the village gets larger.

Individual welfare is:

$$\pi_i^{Nash} = c\left(\frac{\alpha N \bar{l}}{\beta + \alpha N}\right)^{\alpha}\left(\frac{\beta N \bar{l}}{\beta + \alpha N}\right)^{\beta} \tag{8}$$

Welfare would increase if households would coordinate their efforts. By maximizing village production the social optimum level of water conservation can be derived:

$$\max\ \Pi^{S} = c\sum_{i=1}^{N} l_{ci}^{\alpha}(\sum_{i=1}^{N} l_{wi})^{\beta} \tag{9}$$

The first order conditions now result in:

$$\alpha L_W = N\beta l_{ci} \tag{10}$$

and an individual conservation effort level of:

$$l_{wi}^{S} = (\frac{\beta}{\alpha+\beta})\bar{l} \tag{11}$$

Upon comparing the socially optimal and Nash-equilibrium allocation of labour it is evident that water conservation is under-supplied in the Nash equilibrium as $\frac{\beta}{\beta+\alpha N} \langle \frac{\beta}{\alpha+\beta}$ (for all N>1). Individual welfare under the social optimum scenario is:

$$\pi_i^{S} = c\left(\frac{\alpha\bar{l}}{\beta+\alpha}\right)^{\alpha}\left(\frac{\beta N\bar{l}}{\beta+\alpha}\right)^{\beta} \tag{12}$$

This is higher than individual welfare under Nash, if N>1.

3.3.2 Coalition formation and stability

Now, consider the case where a coalition of villagers aims to maximize the income of the coalition. This is basically a two-stage problem, where households first decide whether to join the coalition or not, and second what the effort level of the coalition should be. Typically, these problems are solved through backward induction. First the level of conservation effort is determined, given the size of the coalition, and second the number of signatories is derived. In accordance with the Stackelberg assumption we assume that once the coalition is formed, coalition members strategically choose the level of water conservation investment based on the expected behaviour of non-member households. Although we start from the assumption of no labour markets, in section 3.4 we extent the analysis to the case with outside employment opportunities. First, let us derive the best response of non-cooperating households. Assume a non-cooperating fringe of *n*, hence a coalition of size *N-n*. Using superscripts *C* and *D* to denote coalition members and non-members, the objective function of non-members reads as:

$$\max \pi_i^{D} = c l_{ci}^{D^{\alpha}}(L_W^{C} + L_W^{D})^{\beta}, \quad \text{where } L_W^{C} = \sum_{n+1}^{N} l_{wi}^{C},\ \ L_W^{D} = \sum_{1}^{n} l_{wi}^{D},\ \text{i=1,2,....,N} \tag{13}$$

or labor input in water conservation by the Coalition and by Defectors, respectively.

The equilibrium best response function of non-coalition members is:

$$l_{wi}^{D} = \left(\frac{\beta \bar{l} - \alpha L_{W}^{C}}{\beta + \alpha n} \right) \tag{14}$$

Note that when the coalition reduces conservation effort by one unit, there is a less than proportionate increase in conservation effort by the defectors.

In turn, the Coalition maximizes payoff given the fringe's best response:

$$\text{Max } \Pi^{C} = c \sum_{n+1}^{N} l_{ci}^{C^{\alpha}} \left(\sum_{n+1}^{N} l_{wi}^{C} + L_{W}^{D} \right)^{\beta} \tag{15}$$

Substituting (14), we get the following expression:

$$\text{Max } \Pi^{C} = c \sum_{n+1}^{N} l_{ci}^{C^{\alpha}} \left(\frac{\beta}{\beta + \alpha n} \sum_{n+1}^{N} l_{wi}^{C} + \frac{n \beta \bar{l}}{\beta + \alpha n} \right)^{\beta} \tag{16}$$

Solving (16), the optimal labour allocation for each coalition member becomes:

$$l_{wi}^{C} = \left(\frac{\beta (N-n) \bar{l} - \alpha n \bar{l}}{(\alpha + \beta)(N-n)} \right), \text{ and } l_{ci}^{C} = \frac{\alpha N \bar{l}}{(\alpha + \beta)(N-n)} \tag{17}$$

Consequently, the amount of labour defectors put into water conservation and agricultural production is:

$$l_{wi}^{D} = \frac{(\alpha + \beta)(\beta + \alpha n)\bar{l} - \alpha \beta N \bar{l}}{(\alpha + \beta)(\beta + \alpha n)}, \text{ and } l_{ci}^{D} = \frac{\alpha \beta N \bar{l}}{(\alpha + \beta)(\beta + \alpha n)} \tag{18}$$

Applying the non-negativity constraints to (17) and (18) shows that

$$\frac{\beta}{\alpha + \beta} N - \frac{\beta}{\alpha} \leq n \leq \frac{\beta}{\alpha + \beta} N \tag{19}$$

If n exceeds $\frac{\beta}{\alpha + \beta} N$ the coalition will allocate all its labour to agricultural production and conservation input is determined by $\frac{n \beta \bar{l}}{\beta + \alpha n}$. If n is lower than $\frac{\beta}{\alpha + \beta} N - \frac{\beta}{\alpha}$ the fringe will allocate all its labour to agricultural production and conservation effort will be determined by (11)[4].

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[4] With total conservation effort: (N-n)(β/β+α) $\bar{l}$. Basically, the coalition maximizes welfare for its members and hence follows the socially optimal strategy for N-n.

What do these results mean? It basically means that only for a certain coalition size and for $\beta > \alpha$ both the coalition and the fringe contribute to soil and water conservation. If the number of free-riders exceeds $\frac{\beta}{\alpha+\beta}N$, the coalition stops contributing and the aggregate level of conservation investment is lower than with no coalition, since $\frac{n\beta\bar{l}}{\beta+\alpha n} < \frac{N\beta\bar{l}}{\beta+\alpha N}$. If the number of free-riders is less than $\frac{\beta}{\alpha+\beta}N - \frac{\beta}{\alpha}$, the fringe stops contributing. Whether the resulting level of water conservation is higher than the level without a coalition depends on whether $(N-n)\frac{\beta}{\beta+\alpha}\bar{l} > N\frac{\beta}{\beta+\alpha N}\bar{l}$. This is the case if $n < \frac{\alpha N(N-1)}{\beta+\alpha N}$ which is fulfilled if $\frac{\beta}{\alpha+\beta}N - \frac{\beta}{\alpha} < \frac{\alpha N(N-1)}{\beta+\alpha N}$ holds. Since this holds for every N, the total level of water conservation is higher than the level provided under Nash when the number of free-riders is less than $\frac{\beta}{\alpha+\beta}N - \frac{\beta}{\alpha}$.

The question is whether these results hold if there is full mobility between coalition and fringe. With full mobility between coalition and fringe, the stable solution in the interval $\frac{\beta}{\alpha+\beta}N - \frac{\beta}{\alpha} \le n \le \frac{\beta}{\alpha+\beta}N$ is the solution for which $\pi^C(N-n) \ge \pi^D(n+1)$ (internal stability) and $\pi^D(n) \ge \pi^C(N-n+1)$ (external stability) hold. Substituting the profit functions:

$$\pi^C = c\left(\frac{\alpha N\bar{l}}{(\alpha+\beta)(N-n)}\right)^{\alpha}\left(\frac{\beta^2 N\bar{l}}{(\alpha+\beta)(\beta+\alpha n)}\right)^{\beta} \tag{20}$$

and

$$\pi^D = c\left(\frac{\alpha\beta N\bar{l}}{(\beta+\alpha n)(\alpha+\beta)}\right)^{\alpha}\left(\frac{\beta^2 N\bar{l}}{(\alpha+\beta)(\beta+\alpha n)}\right)^{\beta} \tag{21}$$

indicates that if $\frac{\beta}{\alpha+\beta}N - 1 \le n$, internal stability results.

Note that for $n = \frac{\beta}{\alpha+\beta}N - \frac{\beta}{\alpha+\beta}$, $l_{wi}^{C} = \frac{\beta}{\beta+\alpha N}\bar{l} = l_{wi}^{Nash}$. This means that the only possible stable coalition size results in water conservation levels that are close to those in the non-cooperative Nash solution. Hence, with free mobility between coalition and fringe, the only possible stable coalition is the coalition where effort levels for the coalition and defectors are the same and equal or close to the Nash levels.

3.4 With labour markets

Introducing a labour market, the individual households' time constraint becomes

$$\bar{l} = l_{ci} + l_{wi} + l_{mi} \tag{22}$$

where l_{mi} denotes off-farm labour activities undertaken by household *i*.

3.4.1 The social optimum and Nash equilibrium

Given the presence of a labour market, the objective function has to be rewritten to allow households to allocate their labour off-farm and earn a fixed wage rate ω.

$$\max \pi_i = c l_{ci}^{\alpha} \left(\sum_{i=1}^{N} l_{wi}\right)^{\beta} + \omega(l_{mi}) \tag{23}$$

This results in the following first order conditions:

$$\alpha L_W = \beta l_{ci} \text{ with } \alpha c \left(\frac{\beta}{\alpha}\right)^{1-\alpha} L_W^{\alpha+\beta-1} = \omega \tag{24}$$

Hence, by introducing a labour market the shadow price of labour becomes equivalent to the wage rate. The Nash equilibrium labour input in water conservation is:

$$l_{wi}^{Nash} = \frac{1}{N}\left[\frac{\alpha c}{\omega}\left(\frac{\beta}{\alpha}\right)^{1-\alpha}\right]^{\frac{1}{1-\alpha-\beta}} \tag{25}$$

In contrast, the socially optimal labour input for water conservation becomes:

$$l_{wi}^{S} = \frac{1}{N}\left[\frac{\alpha c}{\omega}\left(\frac{\beta N}{\alpha}\right)^{1-\alpha}\right]^{\frac{1}{1-\alpha-\beta}}. \tag{26}$$

Equations (25) and (26) show us that by introducing a labour market the level of water conservation is no longer determined by the relative productivity of water as compared to labour, but by the relative benefits of any of these activities in comparison to the external wage rate. If external wages exceed a certain threshold, farm households move labour out of agriculture (and hence water conservation) until the opportunity costs of on and off farm labour are the same[5]. The comparatative statics show that with an external wage rate the effectiveness of water conservation investment starts playing a role. The higher rainfall (R), the absorptive capacity of the watershed (σ) and agricultural prices (P), the more labour is allocated to water conservation (note that $c = P\left(\frac{\sigma R}{N}\right)^{\beta}$).

[5] Note that households will never completely move out of agriculture according to this model, regardless of the off-farm wage rate.

If we define $\tilde{w}$ as the threshold value where wages are such that household investments in SWC are the same with or without a labour market, using (7) and (25) we get the following expression:

$$\tilde{w}^{Nash} = \alpha c\left(\frac{\beta}{\alpha}\right)^{1-\alpha}\left(\frac{\beta+\alpha N}{N\beta\bar{l}}\right)^{1-\alpha-\beta} \tag{27}$$

If households do not cooperate, external wages exceeding $\alpha c\left(\frac{\beta}{\alpha}\right)^{1-\alpha}\left(\frac{\beta+\alpha N}{N\beta\bar{l}}\right)^{1-\alpha-\beta}$ result in a Nash labour input in water conservation that is lower than that without a labour market. For wages below the threshold value, Nash input in water conservation is in both situations the same.

When households cooperate, the threshold wage changes. Using (11) and (26), the threshold wage with village cooperation becomes:

$$\tilde{w}^{S} = \alpha c\left(\frac{\beta N}{\alpha}\right)^{1-\alpha}\left(\frac{\alpha+\beta}{N\beta\bar{l}}\right)^{1-\alpha-\beta} \tag{28}$$

If we compare (27) and (28), since $N^{1-\alpha} > \left(\frac{\beta+\alpha N}{\beta+\alpha}\right)^{1-\alpha-\beta}$, the threshold wage with village cooperation is higher than the threshold wage with no cooperation. This can be explained by the fact that the productivity of on-farm labour is higher when villagers cooperate. It is an interesting result, as it shows that the relationship between the external environment and village cooperation goes both ways: the external environment influences village cooperation, but the extent to which villages are cooperative also determines the impact external factors have.

3.4.2 Coalition formation and stability

With a labour market and sufficiently high wages, the Defectors' first order conditions are:

$$\alpha(L_W^D + L_W^C) = \beta l_{ci}^D \text{ and } \alpha c\left(\frac{\beta}{\alpha}\right)^{1-\alpha}(L_W^D + L_W^C)^{\alpha+\beta-1} = \omega \tag{29}$$

Hence, the total amount of water conservation equals:

$$L_W^D + L_W^C = \left[\frac{\alpha c}{w}\left(\frac{\beta}{\alpha}\right)^{1-\alpha}\right]^{\frac{1}{1-\alpha-\beta}} \tag{30}$$

and the Defector's best response is:

$$l_{wi}^{D} = \frac{1}{n}\left(\left[\frac{\alpha c}{w}\left(\frac{\beta}{\alpha}\right)^{1-\alpha}\right]^{\frac{1}{1-\alpha-\beta}} - L_W^C\right) \quad (31)$$

Since every increase in effort by the coalition is now completely offset by a decrease in conservation effort by the fringe, the coalition does not contribute to water conservation if wages are sufficiently high, or $w \geq \tilde{w}(n)$. Defectors undertake all investments in water conservation, but with free mobility between coalition and fringe they are likely to also join the coalition. This reduces the number of defectors, thus increasing the opportunity costs of water conservation and, hence, the threshold wage. Once $w = \tilde{w}(n)$, the level of water conservation becomes:

$$L_W = \left(\frac{n\beta\bar{l}}{\beta + \alpha n}\right) \quad (32)$$

If more households leave the fringe, or *n'<n,* the level of water conservation becomes $\left(\frac{n'\beta\bar{l}}{\beta + \alpha n'}\right)$. Now, the coalition can do two things. It can either continue to do nothing or it can start contributing to water conservation. If it chooses to do nothing, the level of water conservation becomes $\left(\frac{n'\beta\bar{l}}{\beta + \alpha n'}\right)$. However, if the coalition would contribute just enough to maintain the old level of water conservation $\left(\frac{n\beta\bar{l}}{\beta + \alpha n}\right)$, the welfare of the coalition is increased. In fact, the coalition would like to contribute more[6], but since any contribution exceeding the difference between $\left(\frac{n\beta\bar{l}}{\beta + \alpha n}\right)$ and $\left(\frac{n'\beta\bar{l}}{\beta + \alpha n'}\right)$ results in an equal decrease in water conservation effort by the fringe, this is not an optimal strategy. Hence, total investment by the coalition becomes:

$$L_W^C = \left(\frac{n\beta\bar{l}}{\beta + \alpha n}\right) - \left(\frac{n'\beta\bar{l}}{\beta + \alpha n'}\right) \quad (33)$$

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[6] Given the behaviour of the fringe, the first order conditions of the coalition are equal to (17) for N-n. Hence, the coalition would like to internalize the externalities of water conservation for its members, and invest more in water conservation than (33).

The coalitions' input in agricultural production and off-farm labour is:

$$l_{ci}^{C} = \left(\frac{\alpha n\bar{l}}{\beta + \alpha n}\right),\ 0 < l_{mi}^{C} < \left(\frac{\beta\bar{l}}{\beta + \alpha n}\right) \tag{34}$$

Defectors do not work on the labour market, but spend their remaining time on agricultural production:

$$l_{ci}^{D} = \left(\frac{\alpha n\bar{l}}{\beta + \alpha n}\right),\ l_{mi}^{D} = 0 \tag{35}$$

Since for all $0<n<N$

$$\frac{1}{N-n}\left[\left(\frac{n\beta\bar{l}}{\beta + \alpha n}\right) - \left(\frac{n'\beta\bar{l}}{\beta + \alpha n'}\right)\right] < \left(\frac{\beta\bar{l}}{\beta + \alpha n}\right) \tag{36}$$

the fringe has an incentive to join the coalition until no defectors remain.

Once the grand coalition has been reached, the coalition starts investing the socially optimal amount of water conservation as there are no more free-riders to neutralize this effect. Hence, ultimately the emergence of a labour market positively influences the level of water conservation as it increases the strategic power of the coalition. This is in accordance with Finus (2001, 2003), who claims that when the slope of the best reply function is –1, the stable coalition under the Stackelberg assumption is the coalition with size N.

3.5 Discussion

The conditions for voluntary cooperation in semi-public good provision have received relatively little attention in the literature on community resource management. This chapter has analyzed the conditions under which a coalition of initially cooperative households is likely to voluntarily maintain a socially optimal level of semi-public SWC investment. The analysis suggests that it is unlikely that a socially optimal level of SWC investment is maintained, unless all households join the coalition and a grand coalition is reached.

The emergence of a labour market negatively influences the level of semi-public SWC provision, unless it strengthens the strategic position of the coalition. If the coalition has a strong strategic advantage it can credibly threaten not to contribute to SWC. This leaves defectors no other option than to either unilaterally provide all SWC investments or to join the coalition as well. Since the benefits of joining the coalition are always greater than the benefits of free riding, no free riders remain.

It is important to note that outcomes are radically different if the coalition does not behave according to Stackelberg. Under the Nash-Cournot assumption, the stable coalition is of size one and water conservation effort is close to Nash. Hence, the question is whether it is realistic to assume the coalition has a strategic advantage. Finus (2001) argues it is not, but he associates the strategic position of the coalition with the coalition having an informational advantage. Clearly, a signatory leaving the coalition is unlikely to lose the informational advantage of being a former coalition member. However, if we picture the coalition as having a strategic advantage because coalition members can communicate and agree upon a joint strategy whereas defectors act alone, it seems realistic to assume that the coalition behaves according to Stackelberg, and not Nash-Cournot.

Using a model developed in the literature on international environmental agreements to explain community resource management has proven useful, as it has highlighted the importance of consensus and self-enforcement for sustained voluntary cooperation. Overall, results indicate that explicit attention for the role of emerging labour markets and strategic coalition formation is important to improve the effectiveness of community-based approaches, like participatory WSD.

4. The effectiveness of participatory watershed development*

4.1 Introduction

Participatory WSD has become a good example of the so–called community-based approaches that have become one of the fastest growing mechanisms for channelling development assistance (Mansuri and Rao, 2004). The popularity of the approach stems from the claim that involving communities in project design and implementation improves investment targeting, increases government responsiveness, empowers the poor and strengthens community governance. However, evidence of the extent to which community-based approaches live up to these expectations is scarce: Mansuri and Rao (2004) detect a general dearth of well–designed evaluations with few cases proving a causal link between the participatory intervention and project outcomes. With respect to participatory WSD in India, a major evaluation was undertaken by Kerr et al. (2002). This study found participatory approaches to be more effective than the earlier top–down approaches, attributing success mainly to its responsiveness to local requirements and needs and to the time and resources committed to community organization.

The main objective of this chapter is to assess the extent to which participatory approaches are also more effective in the long run. Whereas most studies focus on the short–term effectiveness of participatory WSD, there are indications that its long–run impact is much smaller. ODI et al. (2002) conclude from a qualitative study of several WSD projects that maintenance of SWC is poor because institutions for community governance fail to manage resources in a sustainable way. Kerr et al. (2002) argue that poor maintenance can be attributed to poor investment targeting and over–subsidization. If households receive SWC structures they do not really want, these structures are unlikely to be maintained in the long run. Although over-subsidization might definitely be a factor, we would expect participatory implementation to partly compensate this effect. Better investment targeting is likely to increase the incentives for SWC maintenance and investments in consensus building can be expected to improve cooperation as well (Ostrom et al. 1992, Finus 2003).

* This chapter is partly based on Bouma, J.A., D.P. van Soest and E.H. Bulte (2007).

To what extent investments in community organization actually result in better investment targeting[1] and stronger conservation management at the village scale, is however an open question. We address this question by analyzing the impact of participatory WSD on the intention of households to contribute to SWC in the long run while controlling for household characteristics and factors such as market access, income inequality and resource scarcity. This allows us to identify conditions under which WSD efforts are more likely to succeed. The methodology used is a cross–sectional analysis of data from 682 randomly selected households in four meso–scale watersheds[2]. To distinguish between short– and long–term impacts, we study the effect of interventions on – stated – actual household investments in SWC, and on the intention of households to contribute to the operation and maintenance of SWC structures in the future. Whereas our analysis of actual household SWC investments confirms that participatory approaches are more effective than top–down approaches in the short run, our analysis of household intentions indicates that investments in community organization do not increase the sustainability of WSD in the long run. However, as participatory implementation does increase the critical mass of households with SWC investment, participatory WSD indirectly does affect SWC maintenance in a positive way.

To get an understanding of the impact of participatory WSD at the village scale we then extend the analysis with an in-depth study of several of the study villages. We specifically focus on the role of maintenance funds and the distribution of WSD benefits. Maintenance funds are a recent addition to participatory WSD projects and little about their effectiveness is known. Because the statistical analysis indicates that the availability of a maintenance fund has a significant, negative impact on the household's commitment to voluntarily contribute to SWC, it seems relevant to study their functioning at the village scale. Although the sample is not representative of WSD projects in general, by including two known success stories and one apparent failure we try to get insight into the range of effects. In the next section we present the conceptual framework. In the third and fourth section we present the approach and results of the household level analysis assessing the impact of participatory WSD on SWC maintenance. In the fifth section we present the results of the qualitative village case study analysis and in the sixth section we conclude.

4.2 Conceptual framework

Extensive research has shown that SWC can increase the productivity of dryland agriculture and improve the sustainability of resource use (e.g. Wani et al. 2002, Honoré 2002). However, a recurring concern is that farm households are reluctant to invest in SWC (e.g. Barbier 1990, Heerink et al. 2001, Pender and Kerr 1998).

[1] Kerr et al. (2002) suggest that the negative impact of subsidization on SWC maintenance seems less pronounced in participatory projects.

[2] Although in the four study sites a total of 803 households were surveyed, due to missing data we could only include data from 682 households in the analysis.

There are two explanations for why this may be the case. First, the private benefit–cost ratio of SWC tends to be low, especially when compared to investments in (groundwater) irrigation and agricultural intensification (Walker and Ryan, 1990). Low farm gate prices, uncertain revenues and increasing opportunity costs of labour due to improved off farm employment opportunities tend to make investment in rain-fed agriculture rather unattractive.

Second, investments in SWC have important public good externalities that give individual households an incentive to free ride (Baland and Platteau 1996 and 1997). Depending on the type of investment, the size of the externality varies. For example, in situ investments in soil conservation tend to have fewer externalities than investments in water harvesting, because with water harvesting more of the benefits of conservation are shared. In the presence of significant externalities, investment decisions depend on the expected behaviour of others. If people trust others to reciprocate SWC investment, or if a local authority exists to control free rider behaviour, the likelihood of collective investments increases. Since in most dryland watersheds no organizations exist to coordinate SWC, investments in community organization are needed to facilitate local cooperation and to enhance local commitment and trust.

To address the low benefit-cost ratio of SWC investments, and to stimulate poor households to take up conservation measures on their plots, interventions in WSD heavily subsidize SWC investment. Depending on the program, households contribute voluntary labour but in most cases investments are effectively subsidized by over 100% (Kerr et al. 2002). An important reason for the over–subsidization of WSD investments is the fact that in most regions the WSD program did not start as a project aimed at increasing the productivity of dryland agriculture, but as a program to offer employment in times of drought (Shah 2005). Although the focus shifted over time, subsidy rates remained high.

To stimulate local cooperation, project implementers make substantial investments in community organization. There are several reasons why such investments are expected to increase the sustainability of WSD. First, investments in community organization increase the effectiveness of participation and create consensus regarding the WSD investment plan. This is important for better-targeted investments and for reaching a socially acceptable distribution of project benefits. Second, investments in community organization are supposed to strengthen local institutions and hence community governance. At the most basic level, this implies the establishment of a watershed committee, but investments in local capacity building, empowerment and communication might also enhance community governance in the long run (Joy and Paranjape 2004). Evidence of the extent to which investments in community organization have indeed improved the sustainability of WSD is sketchy. In the short term, investments in community organization seem to have improved effectiveness through better–targeted investments and a better distribution of project effects (Kerr et al. 2002, Farrington et al. 1999, Joshi et al. 2004 and 2005).

In the longer term, however, the impact of investments in community organization is less clear and it is difficult to assess whether lack of SWC maintenance is caused by over–subsidization, lack of investment in community organization or because of external effects. This is what this study attempts to contribute: to assess (i) whether investments in community organization have improved the sustainability of SWC in India's semi–arid watersheds, and (ii) whether any effects can be attributed to SWC subsidization, investments in community organization or external factors.

With regard to the importance of external factors, from the literature on farm-household decision making and local resource management, the impact of contextual factors such as resource scarcity, market access and inequality is well known (e.g. Ray 1999, Bardhan and Udry 1999, Agarwal 2001, Wade 1988, Ostrom 1990, Baland and Platteau 1996). The incentive to invest in SWC, or, for that matter, to cooperate in semi-public good provision, largely depends on the net benefit the household expects to make. With regard to the impact of resource scarcity, Kadekodi and Chopra (1999) argue that the relationship between resource scarcity and cooperation is non–linear. Users do not cooperate if resources are very scarce, but may decide to cooperate if the resource base is rehabilitated and the expected benefits of cooperation increase.

Similarly, increased market integration is expected to have an ambiguous impact on local resource management. An increased value of resource use associated with market integration affects the conditions for local management positively, but the increase in "exit options" and volatility of income may affect resource management in a negative way (Kurian et al. 2002). The impact of inequality on community resource management is also ambiguous (Baland and Platteau 1999, Mansuri and Rao 2004). If the distribution of resource access is highly unequal, resource conservation might improve as those with access have higher individual benefits. But high inequality can also affect community resource management negatively, in reducing the incentive to cooperate and decreasing the transparency of village decision-making.

4.3 Methodology and data collection

To analyze the impact of investments in community organization on the sustainability of participatory watershed development, we use household survey data from 682 randomly selected, landowning households in four meso–scale watersheds. In each site, we selected 4–6 villages on the basis of their location in the meso–watershed. From the selected villages, 20% of the households were randomly drawn to participate in the survey. Of the total of 22 villages selected for the household survey, some had been treated by a NGO, some had been treated by a governmental organization (GO) and some had not been treated at all. Overall, NGOs invested much more in community organization, participatory planning and implementation than GOs. In fact, the NGOs represented include some of the most successful examples of WSD in India. In the following, when we mention participatory we refer to the NGO approach.

The selection of villages for WSD treatment is based on the location of the village in the meso–watershed. As treatment of the upper catchment of the watershed tends to benefit downstream villages, WSD programs target upstream villages first. Since geographical location is something we can control for, project selection of upstream villages does not necessarily bias our results (Ravallion and Wodon 1998). However, upstream villages might also be poorer than downstream villages, which could constitute another WSD selection criterion, or there could be other project placement criteria that bias results in an unobservable way (Baker 2000).

To detect a potential selection bias we conducted several tests. First, assuming average income to be a reasonable indicator for the level of economic development and poverty, we performed a t-test to see whether treatment was in any way correlated with average income. The lowest p–value being 0.79, there seem to be no significant differences in average income between treatments and sites. Second, we estimated the probability of a village having received NGO, GO or no treatment, i.e. propensity score matching, using village level indicators such as village homogeneity, average income, location and inequality. Except for location, none of the factors were significant. Hence, we can safely assume that project placement does not significantly affect our results, except for effects associated with the geographical location of the village in the meso–watershed for which we added a separate control. In Table 4.1, we present the distribution of sample household in terms of received WSD treatment and location in the watershed.

Table 4.1 Representation of households in terms of WSD treatment & location.

	Not treated	GO treated	NGO treated
Number of sample villages	7	7	8
Number of sample households	234	320	249
Location in watershed (% of households)	Up 0% Middle 68% Down 32%	Up 37% Middle 63% Down 0%	Up 54% Middle 0% Down 46%

Source: IWMI (2004)

4.4 Analytical approach and results

To empirically test the impact of participatory WSD on household contributions to SWC, we specify two models. In the first model the regressand is a binominal variable that reflects whether the household has *actually* invested in SWC or not[3]. This is a stated variable, based on whether the household indicated that investments in SWC were made at the plot level. Since most households only invested in SWC on one of their plots we conduct the analysis at the household -level. For households that invested in several plots we only included the largest plot.

[3] Unfortunately, we did not have data about the size or type of the investments.

Our main interest is whether outside intervention influences the probability of household SWC investment. We tested the following model:

$$SW_i = \text{constant} + C\beta_1 + I\beta_2 + X_i\beta_3 + V\beta_4 + \varepsilon_i \qquad (4.1)$$

where SW_i is a discrete measure of household investment in SWC, *C* is a vector of contextual variables, *I* is a vector of variables measuring the type of intervention, X_i a vector of household level control variables including income per capita, land holding, access to irrigation, land quality and the households' influence in village decision making and *V* a vector of community characteristics.

Our intervention variables, *I*, capture the nature of the agent implementing WSD. In Kanakanala an NGO initiated watershed investments, in Kosgi a GO, and in Vaiju Babulgaon and Kalyanpur a GO treated some villages whereas other villages were treated by an NGO. In all four sites at least one of the selected villages was not treated at all.[4] As mentioned before, NGO's spent more on community organization, but they often spent more on physical SWC investments as well. In the first model, we cannot separate these two effects since data on investment costs per household or village lack. In the second model we attempt to separate these two effects by using direct and indirect intervention effects.[5]

In the second model the regressand is a binominal variable that expresses whether the household has the *intention* to contribute to SWC in the future. Again, this is a stated variable. Since different answers were possible, we defined two regressands: In the first, all positive answers (use less water, operation and maintenance (O&M) of structures on own plot, O&M collective structures etc.) are grouped into one category ('Planned contribution All'), in the second definition only the answers specifying O&M activities were taken as a positive answer ('Planned contribution only O&M').[6] The two definitions allowed for extra robustness tests, which showed minimal differences between the two definitions (see table 4.6).

$$\begin{aligned} Plancontribution_i = \text{constant} + C\beta_1 + I\beta_2 + PI\beta_3 + X_i\beta_4 + V\beta_5 + \\ M\beta_6 + \varepsilon_i \end{aligned} \qquad (4.2)$$

[4] Villages in the process of treatment have been included under the 'not treated' category.
[5] Since NGO's do not offer higher subsidies (they often offer lower subsidies) we do not expect higher investments to result in extra distortions. Instead, we expect higher investment cost to translate into higher quality investment and better coverage of households in the area treated. This has actually been confirmed in village meetings and household interviews.
[6] See also question 48 in the household questionnaire, Annex B.

The model basically uses the same set of control variables as the *SW* model, except that to test for the indirect effect of more households having invested in SWC we used the predicted SW from the first model and calculated the average predicted SW at the village scale (*PI*). Also, we added a variable representing the existence of a maintenance fund (*M*)[7].

We expect participatory WSD interventions to influence the households' intention to contribute to sustained SWC in two ways. First, we expect participatory WSD interventions to directly influence the households' intention to contribute through investments in community organization. This is captured by the relevant coefficient on vector *I*. Second, we expect an indirect effect, as WSD interventions are likely to increase the number of households with investments in SWC. We expect this to have a positive impact on the households' intention to contribute because the more households invest in SWC the greater the critical mass of households that are likely to contribute to SWC in the future as well. This indirect effect, which is basically the effect of effective subsidization, is captured by the coefficient on *PI*. *M* is a vector of dummy variables representing whether the village has a functional maintenance fund or not. Table 4.2 presents summary statistics for X_i, or the vector of control variables.

Table 4.2 Summary statistics

	Kosgi	Kanakanala	Kalyanpur	V.Babulgoan
No. of observations	153	181	174	178
HH with investments in SWC	30%	35%	36%	61%
HH that *intent* to contribute to SWC-All	17%	12%	59%	93%
HH that *intent* to contribute to SWC-O&M	13%	11%	52%	79%
No.of household members	6.6 (2.6)	6.7 (2.5)	6.6 (2.2)	5.6 (2.3)
Average income per capita (Rs)	2,818 (3,752	2,526 (1,825)	1,800 (1,677)	10,661 (8,170)
Gini coefficient income	.41 (.07)	.35 (.06)	.38 (.08)	.36 (.04)
Average landholding (acres)	3.18 (5.14)	8.89 (7.75)	2.64 (4.31)	5.40 (7.84)
HH with access to irrigation (%)	72%	24%	80%	95%
HH with black soil in relevant plot (%)	33%	17%	21%	31%
HH Influence on village decision-making (%)	23%	39%	18%	47%
HH is member of village majority case (%)	68%	69%	98%	81%

Source: IWMI 2004 (standard deviations in parentheses).

[7] Village maintenance funds were established by several NGO's to finance the maintenance of collective structures on the long run. The watershed committee generally manages this fund. Of the 22 villages included in the sample, 3 villages have a functioning maintenance fund. Household interviews and village meetings showed that most households in villages with a maintenance fund believe the fund will maintain all investments, including investments on private land.

The figures presented in table 4.2 show that average income is four times higher in Vaiju Babulgaon watershed vis-à-vis the other watersheds. This can be explained by the fact that the overall level of socio-economic development is higher in Vaiju Baulgaon as compared to the other watersheds. Besides, most households gain a substantial income from dairy production and have at least one household member with a stable non-farm income source. To control for differences in the level of socio-economic development, we include the variable 'average village income' in the regression analysis.

Differences in household income are especially large in Kosgi watershed, which is reflected in the high Gini coefficient for income.[8] Although we would have preferred to include a Gini coefficient representing inequality in irrigation access, due to the fact that data were collected in a drought year, data reflecting the irrigated area were distorted and could not be used. Hence, access to irrigation is defined as a dummy representing whether a household has access to surface water (a village tank), deep groundwater (a tube well) or shallow groundwater (open well) irrigation through the ownership of pumps, wells or land located near the irrigation canal.

Land holding size is relatively large in Kanakanala because population pressure is low. In Kalyanpur, average landholding size is smallest since more than 50% of the watershed has a slope of over 5%. Land quality, mainly determined by soil type and slope, is heterogeneous in all four watersheds. For the analysis, we used only land quality information regarding the plot where investments in SWC were made. Because of the poor quality of slope data, these were not included. The household's perceived influence on village decision-making is a dummy variable, which measures whether the household feels capable to influence village decision-making or not. With this variable we expect to measure the households' position in village decision-making and its impact on the choices the household makes[9]. The number of household members is relatively equal, except for Vaiju Babulgaon. We include a variable reflecting whether the household is a member of the village majority caste group since this might affect the household's commitment to cooperate as well. For more information about the household survey data and the variables used we would like to refer to Annex A and B.

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[8] To control for the potential endogeneity of household income, we included the predicted value of household income (with the explanatory variables Kosgi, Kanakanala, Kalyanpur, average village income, household membership of majority caste group, number of household members and household access to black soil. R2= 0.40). However, since this did not change the results, we report the stated variable in table 4.3 and 4.5.

[9] Although we expected the type of intervention to influence the household perceived ability to influence decision-making, we could not properly determine whether this was the case as the explanatory power of the model was very low (R2= 0.08). Still, the type of intervention had no significant impact, so we do not need to use the predicted value to control for potential endogeneity problems and can use the stated variable instead.

Table 4.3 presents the results of the first model. Since in both cases the regressand is a discrete variable we use Probit analysis[10].

Table 4.3 The impact of WSD interventions on household SWC investment

	Household SWC investment	
	Coefficient (S.E.)	Marginal effects
Average village income (Rs '000)	0.06* (0.03)	0.02
Market access #	0.02 (0.18)	
Very low rainfall region #	–0.39* (0.21)	–0.15
NGO investment WSD #	0.67 *** (0.18)	0.26
GO investment WSD #	–0.06 (0.17)	
Downstream location in watershed #	–0.35 ** (0.17)	–0.13
Upstream location in watershed #	0.23 (0.18)	
Land holding size (acres)	0.04 *** (0.01)	0.01
Household has access to irrigation #	0.29 ** (0.14)	0.11
Income per capita (Rs '000)	0.01 (0.01)	
Gini coeff. income capita	– 4.44*** (0.94)	–1.7
Black soil #	0.32 *** (0.12)	0.13
No.of household members	0.00 (0.02)	
Household is member village majority caste #	–0.17 (0.14)	
Household can influence decision making #	0.06 (0.11)	
Constant	0.72 (0.43)	
No.of observations	682	
Log Likelihood	–404.3	
Wald Chi2 (df)	105.5 (15)	
Pseudo R2	0.13	

The outcomes presented are the result of a Probit analysis. *10% significant ** 5% significant *** 1% significant. Robust standard errors are presented between brackets. #= dummy variable

[10] In the absence of specific knowledge about the distribution of data there exist no general criterion to determine whether Probit is the most suitable method to use (Greene 2003). However, since the outcomes of Logit and Probit were quite similar we chose Probit for an easier interpretation of results.

The regression analysis confirms the results of earlier studies that participatory approaches are more effective: The probability of households investing in SWC increases with 26% in watersheds subjected to participatory intervention. Government intervention, in contrast, does not have a significant effect. Households with larger landholdings, access to irrigation and with black soil are more inclined to invest in SWC than households with smaller, dryland plots and red or other soils. This confirms the finding that small landowners are less willing to invest because the fixed costs of land loss to SWC investment are relatively high. Also it confirms that households with black soil are more likely to invest since the soil moisture retention capacity of their soil is relatively high (Wani et al. 2002, 2003).

Village income inequality has a negative impact on household SWC investment. This might be an indication of rent seeking behaviour by the local elite. The significant, positive effect of average village income could either indicate that average income levels are important for household SWC investment, or that the specific characteristics of Vaiju Babulgaon watershed are conducive for household investment in SWC.

The predictive accuracy of the model is relatively low. Whereas the model estimates the probability of overall household SWC investment with 98% accuracy, for individual households the accuracy is only 68%. An explanation for the low predictive accuracy could be that data on household specific factors, like slope and location in the micro-watershed, are missing. Hence, whereas on average the model is accurate in predicting household participation, the variation at household level cannot be explained.

Table 4.4 Hit and miss table of the predictive accuracy SWC investment model

	SWC=1	SWC=0	Total
Probability > 0.5	139	69	208
Probability < 0.5	152	337	489
Total	291	406	697

Now that we have confirmed the result that participatory approaches are more effective in the short run, we turn to our key question, whether participatory approaches are more effective in the long run. In table 4.5 we present our main results.

Table 4.5 The impact of WSD interventions on future SWC contributions

	Planned contribution All		Planned contribution O&M	
	Coeffic (SD)	Marginal effect	Coeffic (SD)	Marginal effect
Average income village (Rs '000)	0.51 *** (0.10)	0.20	0.32 *** (0.07)	0.12
Market access #	– 1.23 *** (0.25)	–0.46	– 1.07 *** (0.23)	–0.39
Very low rainfall #	– 2.04 *** (0.48)	–0.69	– 1.41 *** (0.35)	–0.51
NGO investment WSD #	1.38 (0.89)		0.47 (0.66)	
GO investment WSD #	– 0.64 *** (0.24)	–0.25	– 0.67 *** (0.21)	–0.25
Downstream location in watershed #	– 0.37 (0.54)		– 0.16 (0.43)	
Upstream location in watershed #	1.03 *** (0.33)	0.38	0.45 * (0.25)	0.18
Land holding size (acres)	0.04 (0.04)		0.02 (0.02)	
HH access to irrigation #	1.23 *** (0.37)	0.46	1.00 *** (0.25)	0.35
Income per capita (Rs '000)	0.04 * (0.02)	0.02	0.01 (0.02)	
Gini coeff. Income per capita	– 7.74 (5.35)		– 1.15 (3.88)	
Black soil #	0.77 ** (0.39)	0.29	0.29 (0.26)	
Predicted probability of HH investment in SW (%)	– 4.85 (3.31)		– 3.13 (2.02)	
Average predicted SW investment in village (%)	0.41 (1.98)		3.12 * (1.87)	1.20
No.of household members	0.04 (0.03)		– 0.00 (0.03)	
Household is member village majority caste #	– 0.16 (0.26)		– 0.03 (0.18)	
Availability of maintenance fund #	– 0.73 ** (0.31)	–0.28	– 0.81 *** (0.28)	–0.27
HH capability to influence decision making #	0.41 *** (0.16)	0.16	0.31 ** (0.13)	0.12
Constant	2.07 (2.68)		– 0.96 (1.99)	
# Observations	682		682	
Log Likelihood	–277.2		–330.95	
Wald Chi2 (df)	269.8 (18)		228.22 (18)	
Pseudo R2	0.41		0 .31	

The outcomes presented are the results of a Probit analysis. *10% significant ** 5% significant *** 1% significant. Robust standard errors are presented between brackets. #=dummy variable

Table 4.5 shows some interesting results. First, external factors become highly significant once households have to finance investments in SWC themselves: Market access and aridity both have a significant, negative effect. The negative impact of high aridity suggests that high resource scarcity reduces the incentive for resource conservation, possibly because the benefits of investment are relatively low. The significant, negative effect of market integration seems to indicate that with the development of a cash economy, the opportunity costs of labour start to play a more prominent role. Since more market-integrated watersheds tend to have better access to labour markets, the incentive for households to maintain SWC in these watersheds could be attenuated.

Second, household access to conservation benefits (i.e. irrigation, black soil) increases the probability of households significantly contributing to resource conservation. This is in accordance with the results of Kerr et al. (2002), who show that households with access to irrigation invest structurally more in operation and maintenance. Similarly, influential households are more likely to contribute to long-term SWC, possibly because they had more influence on where WSD investments were made.

The most striking and interesting result, however, is that investments in community organization, i.e. implementation by an NGO, have no significant impact on the household's intention to contribute to SWC in the long run. This result is robust for the alternative definition of the regressand (i.e. including only planned contributions to O&M). Interestingly, implementation by a GO does have a significant, negative impact. This seems to indicate that if households cannot actively participate in WSD planning and implementation they do not feel responsible for the maintenance of these structures in the long run. This is in line with the theoretical analysis of chapter three. With no consensus regarding the WSD investment plan, households are unlikely to voluntarily cooperate in the long run. Although we would also expect a positive sign for NGO implementation, the fact that this impact is insignificant could also be an indication that investments in community organization failed to create consensus at the village scale.

Indirectly, NGO approaches do influence household intentions possitively. By increasing the critical mass of households with investments in SWC the intention to contribute increases. This only holds for the alternative definition of the regressand; more investments in SWC do not improve the incentive to reduce water use or contribute to SWC in other ways. The availability of a maintenance fund negatively affects the household's intention to contribute to future SWC, probably because households believe the fund takes full responsibility for SWC maintenance.[11]

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[11] Results are also robust for estimation with a fixed effect model, where contextual variables are replaced by watershed scale fixed effects.

With respect to the predictive accuracy of the model, the model predicts long-term household participation accurately at 93% (Planned contribution- All) respectively 91% (Planned contribution- only O&M). For individual households, accuracy is also relatively good at 85% respectively 82%.

*Table 4.6 Hit and miss table of predictive accuracy future SWC model**

Classified	PLANOM=1	PLANOM=0	Total
Probability> 0.5	265 (221)	34 (55)	299
Probability < 0.5	73 (72)	325 (349)	398
Total	338 (293)	359 (404)	697

*Figures between brackets reflect the predictive accuracy of 'Planned contribution- only O&M'.

The results indicate that whereas participatory approaches might increase the critical mass of households willing to contribute to SWC, investments in community organization do not seem to have much effect. The establishment of a maintenance fund further decreases household commitment to contribute to SWC. However, if maintenance is successfully taken over by village level institutions, outsourcing might improve the sustainability of participatory WSD. Whether this seems to be the case will be the subject of the next paragraph.

4.5 The impact of participatory WSD at the community scale

To analyse the impact of participatory WSD on community resource management we selected 6 villages for further case study analysis. Due to logistical problems, we could not select any villages in Kanakanala watershed, but in the remaining three watersheds we selected two villages of similar size and location but of a different treatment type. To focus on well-implemented participatory projects, we selected two known success stories, Bicchiwara and Vaiju Babulgaon. In each village, 20 of the households that participated in the household survey[12] were further interviewed about the investments made in SWC, the operation and maintenance of these investments and community resource management. Interviews and village meetings took place between October-December 2004 and were performed by local research assistants on the basis of core questions and structured questionnaires.

The main aim of the case study analysis is to get better insight into how investments in community organization influence community resource management, in particular the functioning of local watershed committees and maintenance funds. Table 4.7 presents the characteristics of the case study villages[13].

[12] In most villages, except for Dagawadi and V.Babulgaon, this constituted for all the households that had participated in the household survey.
[13] In the same six villages we conducted trust game experiments, the results of which are presented in chapter 5.

Table 4.7 Characteristics of the case study villages

Watershed	Village	HH	Location	WSD treatment	O&M fund	Caste composition
V.Babulgaon	Dagawadi	223	Up	GO treated	No	Homogeneous
	V.Babulgaon	264	Up	NGO treated	Yes	Homogeneous
Kalyanpur	Bicchiwara	243	Up/Middle	NGO treated	Yes	Homogeneous
	Karji	115	Up/Middle	GO treated	Yes	Heterogeneous
Kosgi	Sampally	164	Middle/Down	GO treated	No	Heterogeneous
	Kadampally	187	Middle/Down	Not treated	No	Heterogeneous

With regard to the functioning of the watershed committee, in the NGO villages substantial investments were made in community organization. In both villages, investments in community organization started prior to the establishment of the watershed committee. After a substantial period of awareness raising and training, watershed committee members were elected democratically. Once the watershed committee was established, meetings were open for everybody to attend. Committee members received training to ensure accountability and most villagers knew what decisions the watershed committee had made. In both NGO villages, the project-implementing agent also created a maintenance fund. The watershed committee manages this fund to finance the material costs of collective SWC structures.[14]

In the WSD projects implemented by the government, few investments in community organization were made. The project-implementing agent basically selected the watershed committee members, who were often members of the local elite. Sometimes, low-caste households or women were also included in the watershed committee, but when interviewed they indicated to have had no influence on project outcomes at all.[15] Watershed committee meetings were not open to attend and most villagers were not aware of the decisions that had been made. Whereas in the GO villages the watershed committee stopped functioning after project implementation, in the NGO villages it continued to work. The main function of the remaining committees was the management of the maintenance fund. In Karji, the GO village with a maintenance fund, people did not know who managed the fund. In all three villages with a maintenance fund, respondents complained that the allocation of funds was not transparent and that rules regarding fund management were not clear.

[14] The establishment of a maintenance fund is no common practice. We explicitly selected cases with a maintenance fund to analyze whether the existence of a maintenance fund seems to ensure the maintenance of SWC structures in the long run.
[15] In some cases, members did not even know they were officially a member of the watershed committee.

In general, there seemed to be quite some mistrust regarding the watershed committee. An important reason for the mistrust seemed to be that respondents felt the benefits of WSD had not been equally distributed, and that in the allocation of SWC subsidies the watershed committee had played an important role. This might also provide an explanation for why investments in community organization do not seem to influence the household's intention to contribute to SWC maintenance. If villagers feel that the watershed committee does not represent the interests of the entire village, consensus regarding the WSD investment plan is likely to be low. In geographically and/or social-economic heterogeneous communities, households complained more about an unequal distribution of benefits than in homogeneous communities. For example, in Rajasthan, the geography of the area greatly determines the distribution of benefits. According to several respondents, members of the watershed committee assured investments benefited their households most. Even in the most participatory projects, capture by local elites could not be avoided, however.

Elite-dominated village decision-making might also explain why in the preceding analysis economic inequality, as measured by the Gini coefficient, had a significant negative effect on actual household SWC investment but did not significantly affect the household's intention to contribute to future SWC. With higher inequality, local elites are more likely to capture part of the project funds, but this does not necessarily influence the incentives of households to contribute to SWC in the long run.

When we asked respondents whether they thought collective structures were properly maintained, respondents from NGO initiated interventions more often replied that maintenance was satisfactorily than those from GO villages[16]. However, the difference was only marginal, as figure 4.1 shows.

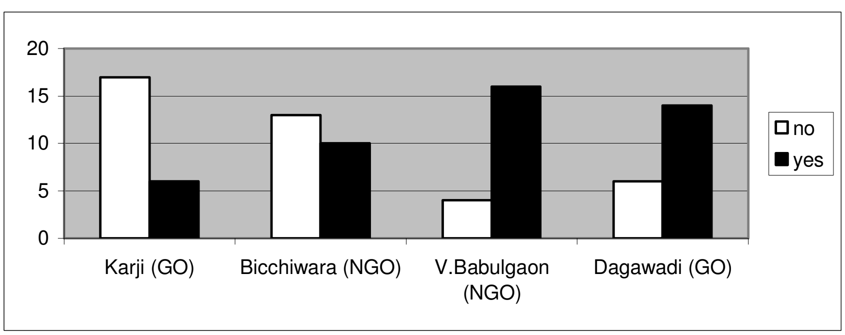

Figure 4.1 Perceived maintenance of collective SWC structures

[16] In Sampally village no collective SWC investments were undertaken.

An important reason for the higher satisfaction levels in participatory projects seemed to be the higher quality of investment. For example, in Sampally (GO), respondents mentioned that no collective investments were made as contractors, together with the local elite, pocketed the money. In Dagawadi and Karji village (both GO), respondents said that structures had already fallen apart because of the poor quality of the material used. On the other hand, in Bicchiwara and Vaiju Babulgaon (both NGO), most structures were still functional and respondents were more satisfied. Hence, participation seems to have a positive influence on the quality of project implementation. This is in accordance with Galasso and Ravallion (2005) who suggest that community based approaches might reduce rent-seeking behaviour of government officials and project implementers through local monitoring and control.

Turning to the impact of participatory watershed development on community resource management, impacts were perceived to be very small. Although in some villages (i.e. Vaiju Babulgaon and Bicchiwara) the watershed committee established rules to ban the drilling of new tubewells, respondents complained that rules were abolished as soon as the project implementers left the stage. Also, there was a lack of clarity with regard to the maintenance of collective structures and the rules and responsibilities regarding the use of the maintenance fund.

In Bicchiwara and Karji, respondents did perceive participatory WSD to have positively influenced resource management, but this was largely because the implementing NGO still plays an active coordinating role.

4.6 Conclusions

We have examined whether investments in community organization increase the sustainability of WSD interventions in India's semi-arid watersheds. While participatory approaches are associated with more effective WSD project implementation, we find that interventions have no direct impact on the intention of households to contribute to SWC maintenance. Indirectly, participatory WSD does influence SWC maintenance positively by increasing the critical mass of households with SWC. However, this seems to be the result of effective subsidization rather than of investments in community organization.

The main impact of participatory WSD seems to be that more funds reach the target group: this not only causes the indirect effect of having a larger critical mass of households with SWC investments, it results in higher quality SWC investments as well. This is important for the sustainability of participatory WSD for the simple reason that structures are less likely to fall apart. The positive impact of having a larger critical mass of households with SWC investment is in line with the analysis in chapter 3. A larger group of cooperative household's increases the likelihood that a socially efficient level of semi-public SWC investments is maintained in the long run.

The investments in community organization that characterize participatory approaches were not found to have much effect. First, household commitment to SWC maintenance did not improve with investments in community organization. However, since GO implementation was shown to have a significant, negative impact, investments in community organization seem to at least help neutralize the over-subsidization effect. Besides, the case study analysis indicated that investments in community organization might not have succeeded in creating consensus regarding the WSD investment plan. This could help explain why investments in community organization had no significant impact on the intention to cooperate in SWC maintenance in the long run.

Second, local rent-seeking behaviour could, even in the most participatory projects, not be controlled. Higher income inequality caused fewer households to invest in SWC, which seems to reflect local rent-seeking behaviour, i.e. the capture of WSD benefits by the local elite. This result was confirmed in the case study analysis where even in the most successful examples of WSD implementation respondents complained members of the watershed committee had disproportionately benefited themselves.

Third, even in the most participatory projects, the watershed committee did not gain much authority and its role in community resource management was perceived to be small.

The establishment of a maintenance fund did not seem to safeguard the long-term maintenance of SWC. Respondents indicated that funds were used rather arbitrary and that no rules regarding fund allocation and contributions did exist. Although further analysis would be required to evaluate the role of maintenance funds, since the household analysis indicated that the existence of a maintenance fund erodes household commitment to contribute voluntarily, the existence of a maintenance fund might end up worsening the situation if not managed in an effective way.

Finally, the analysis indicated that higher aridity and better market access negatively influence the household's intention to contribute to SWC maintenance. This might be explained by the fact that higher aridity reduces SWC benefits and better market access increases SWC costs, i.e. the opportunity costs of labour. Since in semi-arid India even remote watersheds are becoming more integrated in the market economy, this could actually be an indication that it might be difficult to structurally improve the effectiveness of WSD in the long run.

5. Social capital and community resource management*

5.1 Introduction

In the previous chapter we analyzed whether investments in community organization can improve the effectiveness of WSD in the long run. However, involving communities in project planning is already expected to enhance voluntary cooperation as communities are expected to control a stock of social capital that facilitates local cooperation and collective action in the long run (Bowles and Gintis 2002, Gächter et al. 2004). While the exact definition of social capital is subject to debate, most analysts treat it as a characteristic of communities, and describe it in terms of trust, norms and networks that enable collective action (e.g. Putnam 1993, Fukuyama 1995, Woolcock and Narayan 2000, Bowles and Gintis 2002).[1] Social norms influence people's preferences and constraints, lower transaction costs (as they preclude the necessity to write contracts that capture all contingencies), and facilitate the exchange of information (Bowles 2005). Most empirical work – be it based on cross section analysis or case studies – suggests a positive relationship between social capital, the quality of governance and economic development (e.g. Putnam 1993, Knack and Keefer 1997, Knack 2002, Pretty and Ward 2001). This is likely to explain the popularity of community-based approaches, which make use of the existing stock of social norms and expectations to facilitate voluntary cooperation and community resource management.

In this chapter, we focus on the role of trust for voluntary cooperation. We interpret trust as 'the expectation that arises within a community of regular, honest and cooperative behaviour based on commonly shared norms on the part of other members of that society' (Fukuyama 1995), a causal definition that allows for empirical interpretation (Durlauf 2002). We believe attention for the role of social capital in voluntary cooperation is important as improved understanding of the importance of trust enables NGOs and government agencies implementing community-based development projects to tailor their efforts in areas where the returns to investment are largest.

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* This chapter is based on Bouma, J.A., D.P. van Soest and E.H. Bulte (2007).

[1] An alternative approach is to view social capital as an individual's social characteristics and skills (Glaeser et al. 2002) with individuals deciding whether to invest in social capital or not.

The main objective of our analysis is to analyze i) how trust is correlated with socio–cultural community characteristics, and ii) how social capital affects community resource management. To measure trust, we use data from experiments we conducted in three of the project sites (Kosgi, Kalyanpur and Vaiju Babulgaon). Based on actual behaviour of the respondents, rather than stated beliefs[1], in these trust game experiments we construct a measure of social capital, based on 'trust.' We then relate experimental play and the measure of social capital to real behaviour in terms of voluntary contributions to SWC – something that few other studies have done (Gächter et al. 2004, Cramb 2005).

Since in caste heterogeneous villages social interaction is expected to take place along caste lines (Dumont 1970), the availability of social capital in heterogeneous communities is expected to be less. In fact, caste heterogeneity might be a good proxy for the availability of social capital. Hence, we compare the effectiveness of using trust as an indicator for social capital and using caste homogeneity. The advantage of using caste homogeneity is that it is easily observable, which would reduce data collection costs.

With respect to the experimental proxy of social capital, a key hypothesis is that "social capital" identified in the experiment generalizes to other behaviours and contexts – higher levels of trust in the experiment are expected to translate into higher propensities to invest in SWC. Falk (2004) demonstrates that social preferences identified in experiments indeed spill over to other domains such as voluntary contributions to charities. Interestingly, List (2005) finds that this is not true for domains where participants feel the pressure of the market. While agents display social preferences in laboratory settings, the same individuals' behaviour in the marketplace is best described as self–interested, and the main reason for deviating from self–interest in List's study is concern about one's reputation. Since we are interested in individual contributions to a semi-public good, we expect that the experimental results will spill over, i.e. that trusting behaviour in the experiment translates into a higher propensity to contribute to future SWC.

The main objectives and findings of the analysis are as follows. First, we find that the household's trusting behaviour is not directly determined by socio-cultural community characteristics, but rather by the social position the individual has. For example, participants that belong to the majority caste group are more trusting, whereas participants that depend on outside sources of income trust less. Second, social capital is a significant determinant of the household's intention to contribute to future SWC, social capital being proxied as the average trust level at the village scale.

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[1] Empirical work has been plagued by problems that emerge when one attempts to measure social capital. For example, using trust as an indicator, analysts typically resorted to survey questions to assess whether respondents feel that other people can be trusted or not. The potential divergence, between stated versus actual preferences and beliefs, has been elaborated elsewhere and is a potential concern for trust surveys.

Interestingly, the individuals trusting behaviour is not significantly correlated with SWC investment. So, while we are unable to predict individual behaviour in real life from experimental play, we do find a significant correlation between aggregate play and individual behaviour. This suggests that the trust game may be used to measure social capital, provided social capital is interpreted as a community characteristic. Third, we find that caste homogeneity is a significant determinant of voluntary cooperation, its explanatory power being comparable to that of the average level of trust. This suggests that the easily observable indicator of caste homogeneity can be used as a proxy for social capital.

The chapter is organized as follows. In the next section we summarize the literature on the use of experimental methods to measure social capital, and outline the trust game. In section three we present key results from the experiment and analyze the determinants of trust. In section four we analyze the role of social capital for community resource management and in section five we conclude.

5.2 Measuring social capital using field experiments

Economists have successfully studied individual behaviour using experimental games. By having participants perform simple tasks or play simple games in the controlled environment of a laboratory, the factors influencing individual behaviour can be carefully assessed. More recently, economists and others have also started to conduct experiments in 'the field'. A good example is the work by Henrich et al. (2004), who conducted experiments in 15 small-scale societies all over the world with 'real' people instead of the students who usually participate in experimental games. They concluded that 'experimental play often mirrors patterns of interaction found in everyday life' (Henrich et al. 2004: 10–11) and that people use their experiences in everyday life to solve the problems they encounter in the experiment. For example, individuals from societies depending on collective activities are more cooperative than those from societies in which the family is the key decision making unit. Hence, using 'real' people instead of students seems to significantly influence results.

Cardenas and Carpenter (2005) confirm this result, showing that the outcomes of experiments conducted with students differ significantly from those conducted with non-students. Similarly, Harrison and List (2004) conclude that the outcomes of field experiments differ fundamentally from lab experiments, but their conclusion is based on a much wider range of differences than the difference in subject population alone.

In fact, Harrison and List (2004) distinguish four types of experiments, i) conventional lab experiment, ii) artefactual lab experiment (same as i) but with 'real' people), iii) framed field experiment (same as ii) but with field context in either the commodity task or information set that subjects can use) and iv) natural field experiment (when subjects do not know they are participating in an experiment). Following their taxonomy, the experiment we use to measure the availability of trust at the village scale is an example of an artefactual lab experiment.

Hence, although we conducted the experiment with Indian farmers, the experimental transactions were kept abstract, and were not translated to reflect actual situations from daily life. The advantage of this approach is that the interpretation of the experiment can be better controlled; the possible disadvantage that participants might not associate the experiment with situations from daily life.[2] However, post–game evaluations revealed that subjects understood the game, and that they did compare the game to situations from daily life. For example, in Kadampally participants compared the game to helping a friend (with the expectation that help is reciprocated) and in Bicchiwara a participant said the game showed that there are good and bad people, good people being individuals who adhere to the social norm of returning what is being sent and bad people neglecting this norm. Hence, we expect that the experimental results will spill over to actual behaviour 'in the field'.

The game we conducted is the so-called trust game (Berg et al. 1995). In this game, there are two participants, investor i and trustee j, who play the game anonymously. Investor i receives an amount of money $\overline{S} > 0$ from the experimenter, and can "invest" any amount $0 \leq S_i \leq \overline{S}$ by sending it to trustee j. The experimenter triples the amount sent, so the trustee receives $3S_i$. Next, the trustee can send back any amount R_j between 0 and the received amount $3S_i$ ($0 \leq R_j \leq 3S_i$). The sum of payoffs to the investor and the trustee is maximized if the investor sends the total endowment $\overline{S}$ to the trustee, so that the aggregate payoff is $3\overline{S}$. However, in the absence of sufficient trust that a share of the surplus will be returned, the investor sends nothing.

One of the controversies in this field is about what trust games actually measure. For example, Cox (2004) focuses on altruism and reciprocity, Bohnet and Zeckhauser (2004) consider fear of trust betrayal, and results by Johansson–Stenman et al. (2005), Karlan (2005) and Schechter (2006) suggest that trust games measure both trust and risk preferences (e.g., a propensity to gamble).[3] While confounding altruism and trust might not be such a problem, given that both are elements of social capital, it is evident that confusing risk preferences and trust could invalidate the results. This however seems unlikely since there is no reason to believe that risk will

[2] Levitt and List (2006) argue human decisions are not only influenced by monetary payoffs but also by (i) the nature and extent to which one's behaviour is scrutinized (by the experimenter or otherwise), (ii) the context and process by which a decision is embedded, and (iii) self selection of the participants. We argue that (i) and (iii) are unlikely to bias our results because our experiment was double blind (participants were informed about this so experimental scrutiny should not play a role) and because selection was by means of random design. Nevertheless, the context of the experiment may affect behaviour as compared to behaviour outside the lab and, like other studies, we cannot control for this.

[3] Johanson–Stenman and colleagues find that the amount sent in trust games is a function of the stake size, Karlan finds that investors who send high shares are the same people who are more likely to default on loans in real life and Schechter finds that omitting risk aversion as a regressor might significantly affect the coefficients of explanatory variables such as gender and wealth.

vary systematically over the villages considered. Still, in what follows we try to control for characteristics that are indicative of risk.

Experimental data were gathered during February 2005 in the villages presented in chapter 4, table 4.8. Unfortunately, we had to discard all data from Dagawadi since participants turned out to be family related, which became obvious because in the Trust Game all participants sent the maximum amount. The same households that participated in the household survey were invited, some 100 in total (20 per village), to send one member to participate in the experiment in which they played with households from their own village.

The experiment closely followed the trust game instructions of Barr (2003) and Burks et al. (2000). The English version is in Appendix C, but instructions were translated into the three local languages (Marathi, Telugu and Merwari). The experimenter read out the instructions in all villages, and was assisted by local assistants who had received extensive instructions and training beforehand. Transactions were performed with coded envelopes, and the experimenter was the only one with access to the codes. The experimenter herself did not interact with the participants during play, so that interaction was double blind. To ensure random selection and transparency, participants drew numbers from a box to select their (anonymous) partner. The investor's investment fund ($\overline{S}$) was Rs 50 (US$1.15), roughly equivalent to one day's wage. To induce participants not to communicate during the experiment, those who did communicate did not receive another Rs 50 after the experiment finished. This incentive proved to be effective as no communication occurred during the actual experiment.

Because of the low level of education of the respondents (33% was illiterate), instructing the participants posed a challenge. Instructions needed to be read out aloud but also acted out, and were hence time consuming; it took between 2 and 3 hours to explain the game, and another 3 hours to (i) test each participant's understanding of the game[4], and (ii) actually implement the game itself.

To make sure that the participants remained concentrated, we decided to separate the instructions from the actual implementation of the experiment: The instructions were provided on one day, and the test and the experiment itself took place on the next. This implied a loss of control, as respondents were able to discuss strategies. Such group discussions took place in two villages: Kadampally and Bicchawara. This did not compromise our approach to measuring trust, because agents in the experiment were anonymous and any agreements were not enforceable. Potential agreements are cheap talk, and agents will only respect the joint strategy in case of sufficient trust – which is exactly what we intend to measure.

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[4] We allowed all participants to complete the game (to prevent uproar as the stakes – in local real income– were significant), but the data from seven participants are not used in the analysis as these respondents failed to answer the test questions correctly.

But, since it is known that communication can affect the outcomes of play (Ostrom 2006, Ledyard 1995), we do control for ex ante group discussions by including a dummy variable (with value one for Kadampally and Bicchawara, and zero for the other three villages) in the regression analysis below.

In the instructions, participants were given a generic explanation of the game without announcing what role a particular participant was going to play. The experiment was set up such that each subject played both the role of the investor as well as that of the trustee, in line with the experiment conducted by Burks et al. (2000). Participants were not informed about this on beforehand. By letting participants play both roles, the number of observations was doubled. Besides, information was gained about each subject's characteristics since we could use a subject's play as a trustee to explain his/her decisions as an investor (and vice versa).

Previous research suggests that having participants play both roles, but without informing them about this on beforehand, should not affect the participants' *trust* decision as compared to their actions when playing just one role (Burks et al. 2000). However, the same study also finds that the role reversal significantly reduces reciprocity. Since our results are consistent with those of Burks et al., we base the social capital measure only on the trust decision, and not on 'trustworthiness.'

Finally, the fact that people's behaviour may be influenced by contextual variables as well as household and village characteristics, posed some methodological difficulties. To determine the magnitude of social capital effects from individual data requires that the impact of contextual variables on behaviour is properly addressed. While ideally this requires including village dummies as well as group averages of the variables used to control for household characteristics (Durlauf 2002), this was not possible due to the small size of our database (5 villages only) and multicollinearity problems. Instead, we control for contextual variables by including a watershed dummy and by including group averages for key characteristics like household income.

5.3 Trust and its determinants

Table 5.1 presents a comparison of the results of the original trust game (Berg et al. 1995), the trust game played by Barr (2003) with Zimbabwean farmers, and the Indian results. We have also added the results obtained by Burks et al. (2000) as this study also used the 'double–role' playing strategy.

Table 5.1 Comparison of trust game results.

	Single role			Double role	
	Berg et al. (1995)	Burks et al. (2000)	Barr (2003)	Burks et al. (2000)	This study
Subjects	US students	US students	Zimbab.farmers	US students	Indian farmers
Number of playing pairs	32	22	141	46	92
Initial endowment	US$ 10.00	US$ 10.00	Zimb$ 20.00 [1]	US$ 10.00	Rs 50.00[2]
Relative value initial endowment	Two hour's wage	Two hour's wage	Half day's wage	Two hour's wage	Full day's wage
Proportion of 'investors' investing zero	0.06	0.14	0.09	0.06	0.13
Mean investment by investor (S_i)	0.52	0.65	0.43	0.62	0.49
Mean return on investment for investor *i* (R_j/S_i)	0.89	1.31	1.28	0.78	0.87

[1] Zimb$ 20.00 = US$ 0.80. [2]Rs. 50 = US$ 1.15.

In an overview of trust games conducted all over the world, Cardenas and Carpenter (2005) find that on average, participants sent 0.51 of their initial endowment, with a mean return on investment of 75%. However, amongst non-student populations the return on investment is 85%, which corresponds nicely with our result.[5]

Substantial variation underlies the average numbers, and investments in the villages where pre–game discussions took place are somewhat higher than in other villages. However, amounts sent in Kadampally and Bichiwara are not significantly higher than amounts sent in Karji, and the multivariate regressions below indicate that pre–game discussions are not a significant variable. This gives some credence to the notion that such discussions are to a large extent cheap talk.

Table 5.2 Means and standard deviations of investor and trustee behaviour

	Kadampally	Sampally	Bicchiwara	Karji	V.Babulgaon
Investor's share of endowment sent (S_i)	0.61 (0.23)	0.35 (0.23)	0.66 (0.37)	0.52 (0.36)	0.33 (0.22)
Trustee's share returned of amount received ($R_j/3S_i$)	0.25 (0.20)	0.29 (0.18)	0.32 (0.27)	0.27 (0.21)	0.32 (0.19)

Standard deviations in parenthesis.

With respect to trustee behaviour, the share returned is very similar in all five villages. Closer inspection revealed little correlation between investments and the share returned across villages (for the entire sample the correlation coefficient is 0.15).

[5] Cardenas and Carpenter (2005) give an overview of 28 trust game experiments, 12 of which are conducted with non-students. The average amount sent by non-students is 48% of the initial endowment. Although a significant number of the experiments are conducted with non-student populations, few experiments link outcomes to actual household behaviour.

Indeed, consistent with Burks et al. (2000), we find that "role reversal" seems to have compressed (and possibly biased) trustworthiness. For this reason we will focus on trust as a proxy for social capital in what follows, and only use the data on returner behaviour as a control variable in the trust regression.[6]

To analyze the determinants of the amount sent by the investor we estimate a regression equation using interval regression since participants were confined in their decision making to Rs10 notes (Greene 2003). We use the following specification:

$$S_{ik} = \text{constant} + \beta_1 X_{ik} + \beta_2 G_{ik} + \beta_3 C_k + \varepsilon_{ik}, \qquad (5.1)$$

where i indexes investors in village k. X_{ik} is a vector of investor characteristics (caste group membership,[7] dependency on agriculture, income per capita, landholding per capita, literacy, access to irrigation, soil quality, sex of participant, family size, age class dummies, and the perceived ability to influence decision making at the village level – see appendix A for details), G_{ik} is a vector of game specific events, and C_k is a vector of contextual variables (watershed fixed effects, average income in the village). Finally, ε_{ik} is the error term. Since per capita income is potentially endogenously determined, we also try to instrument for per capita income in an additional IV regression analysis.[8] These results serve as a robustness check.

The elements of the vector G_{ik} were inspired by prior research of Barr (2003). She found that the amount sent by the investor was a positive function of expected trustworthiness, or the behaviour of the *average* trustee. Expected trustworthiness can be measured in two ways. The participant may have a notion of the average trustworthiness in the village, or she may base her expectations on her own personal behaviour (introspection). Therefore G_{ik} contains expected trustworthiness or average share returned, as well as own behaviour as a trustee. Finally, we control for pre–game communication. Summary statistics of the explanatory variables are provided in Table 5.3.

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[6] In future research it may be interesting to also base a social capital proxy on trustworthiness as measured in the Trust Game. Our results, and those of Burks et al., suggests that it is best then to not ask respondents to play roles as both investor and receiver.

[7] We include case membership as a control variable because social interaction tends to take place along caste lines, which may affect trust game decisions.

[8] The results of the Wu test indicated that income per capita is not endogeneous, but for completeness we also present the IV results.

Table 5.3 Summary statistics

Watershed Village	Kosgi Kadampally	Sampally	Kalyanpur Bicchiwara	Karji	V.Babulgaon V.Babulgaon
Total number of households	187	164	243	115	264
Number of participants	20	19	19	21	20
% participants that are a member of the majority caste group #	70%	47%	100%	86%	90%
% female participants#	15%	26%	37%	24%	25%
% participants not dependent on agriculture#	10%	32%	21%	14%	10%
% illiterate participants#	45%	47%	32%	29%	10%
% participants older than 50	55%	26%	11%	17%	35%
% participants between 20 and 50 years old	45%	63%	74%	57%	45%
Village homogeneity (% participants from same caste)	70%	47%	100%	86%	90%
Income per capita (Rs '000)	3.47	5.24	2.12	2.93	9.27
	(2.08)	(9.99)	(2.50)	(1.04)	(8.57)
Landholding per capita (acres)	0.77	1.09	0.29	1.15	1.30
	(0.80)	(1.69)	(0.19)	(2.30)	(0.75)
Number of household members	7.80	6.26	7.16	7.43	6.60
	(3.12)	(2.26)	(1.61)	(1.43)	(2.89)
% HH with investments in SW #	44%	33%	37%	66%	80%
% HH that intend to contribute to maintenance#	30%	21%	26%	33%	85%
% HH with access to irrigation #	67%	87%	53%	57%	100%
% HH with black soil #	39%	33%	5%	0	40%
% HH able to influence decision–making #	25%	42%	42%	10%	50%

IWMI (2004) Standard deviations in parenthesis. # =dummy variable

Table 5.4 presents the results of the interval regression explaining trust. Column (1) presents the results of a comprehensive set of explanatory variables, column (2) is a more parsimonious specification, and column (3) presents the 2nd stage results of an IV regression to control for a potential endogeneity of income. Since in Vaiju Babulgaon watershed only one village is represented, to economize on degrees of freedom we included just one watershed dummy for Kalyanpur. We chose Kalyanpur since socio-culturally this watershed is the most different from the other two watersheds. Changing the watershed dummies does not significantly affect results.[9]

[9] Neither Kosgi nor Kalyanpur is significant in the trust regressions when we include average income as control variable. If we omit average income as control variable both watershed dummies are significant, suggesting that income is one of the main relevant differences between the watersheds.

Table 5.4 Determinants of the amount sent by individual i (S_i)

	(1)Standard	(2)Standard	(3)IV
Constant	36.36*	37.27**	27.86
	(19.37)	(18.06)	(18.24)
Kalyanpur#	5.28	4.47	– 1.74
	(6.82)	(5.81)	(6.98)
Average income village (Rs '000)	– 2.01	– 2.03*	– 4.48**
	(1.56)	(1.15)	(1.81)
Share returned by individual *i* (%)	22.03***	19.93***	23.69***
	(8.01)	(7.11)	(6.86)
Average share returned in the village (%)	– 90.06	– 71.91	– 30.27
	(82.12)	(79.15)	(80.91)
Pre–game discussion #	5.66	5.49	1.12
	(4.78)	(4.06)	(4.71)
Participant is member majority caste#	11.07***	12.61***	19.12***
	(4.34)	(3.63)	(4.84)
Income per capita (Rs '000)	0.53**	0.59**	
	(0.26)	(0.23)	
Predicted per capita income[10] (Rs'000)			1.56**
			(0.70)
Landholding per capita (acres)	– 3.83***	– 3.41***	– 2.77***
	(1.26)	(0.92)	(1.25)
Access to irrigation #	9.69**	8.58**	9.75**
	(4.00)	(4.07)	(3.96)
Dependency on agriculture #	– 13.19***	– 13.40***	– 11.30***
	(4.60)	(4.47)	(4.42)
Participant is literate#	5.02		
	(3.96)		
Participant is female#	0.77		
	(4.44)		
Influence decision making#	0.74		
	(3.33)		
Number of household members	– 0.23		
	(0.71)		
Black soil #	1.45		
	(4.08)		
Participant is older than 50 #	3.19		
	(5.50)		
Participant's age is between 20 and 50 #	4.45		
	(4.80)		
No. of observations	84	84	85
Log likelihood	–128.49	–130.07	–131.18
Wald chi2 (df)	102.7 (17)	69.43 (10)	76.03(10)
Pseudo R2	0.15	0.14	0.14

The outcomes presented are the result of an interval analysis. Robust standard errors in brackets.

[10] Predicted income per capita calculated using OLS regression. Explanatory variables: Kosgi, Kalyanpur, household head is older than 50, household head is between 20 and 50, household head is literate, household is member majority caste, household has access to fertile land R^2=0.30, F (8, 83) =4.49.

The results for the three specifications are rather similar. First, in both the interval and IV analyses we find that, contrary to Barr (2003), the average share returned is not significantly correlated with the amount sent. In Barr's study, both the average share returned and its variance were higher, possibly because that experiment was not double blind (as ours was). Alternatively, participants in a non–repeated trust game may base their expectations on their own behaviour (and have an imperfect understanding of the average behaviour of the group). This is what our analysis indicates; a 10-percentage point increase in share returned by the participant translates into about a 2 rupees increase in the amount sent (or 4% of the initial endowment).

We also find that agents tend to send more money (i) when they are member of a majority caste (so that they are more likely to interact with a member of their own caste), (ii) when they have access to irrigation and (iii) when they have higher per capita income. The result that being a member of a majority caste positively affects the amount sent supports the finding that caste homogeneity positively affects trusting behaviour.[11] The result that higher per capita income positively influences the amount sent might be an indication of risk aversion (Schechter 2006) and is robust for the instrumentation of income. The result that having access to (groundwater) irrigation is associated with more trusting behaviour is perhaps caused by the fact that groundwater stocks are a shared resource. Following the logic of Henrich et al. (2004), farmers may be more cooperative because they depend on choices of others in the community and take these experiences to the experiment.

Controlling for income we also find (iv) that people who own relatively large areas of land are less likely to send large amounts to their fellow villagers and that (v) participants who work outside the village sent less. This last result is another indication that the households position in the village matters, and that participants who depend less on collective resources trust less. Interestingly, we find that pre–game group discussions do not significantly impact the amount sent – suggesting that such discussions are indeed cheap talk.[12]As robustness check to see if these results may be contaminated by risk preferences (as opposed to trust or altruism) we have also ran these regressions without the richest village in the sample, V. Babulgaon. We found that none of the results were affected.

The explanatory power of the model is rather low (the pseudo–R^2 is 14% for most specifications), which may be indicative of omitted variables. For example, the 'fundamental differences in religion, culture and institutions' on which trust levels are also said to depend (e.g. Fukuyama 1995, Willinger et al. 2003) are not explicitly accounted for in the analysis, except for the watershed dummy for Kalyanpur.

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[11] When we include village level homogeneity instead of the watershed dummy, homogeneity is not significant. Hence, it is the households position in the village that determines individual trusting behaviour, not homogeneity as such..

[12] However, if instead of average income we include another watershed dummy, Kosgi, then strategy does become positively significant together with the dummy for Kalyanpur watershed.

5.4 Social capital and resource management

In this section we analyze whether the results of the trust game are useful in explaining behaviour of participants in terms of voluntary provision and maintenance of SWC investments. Based on the analysis of trust we define an indicator of social capital based on an aggregate measure of trust (the average amount sent). In addition, since conducting economic experiments and household surveys is expensive and time–consuming, the question naturally arises whether directly observable village characteristics would not perform equally well in serving as a proxy for social capital. Hence, we test whether our measure of social homogeneity, or the percentage of participants in a village that belongs to the majority caste, explains participation in community resource management as well as trust.

How does social capital affect the incentives of people to contribute to SWC? To address this issue, we again consider both investments in SWC (*SW*), and efforts to uphold and maintain existing conservation infrastructure (operations and maintenance, *OM*). For our purposes there exists a crucial difference between these activities. *SW* activities are subsidized by NGOs or government agencies, and are therefore privately rational to undertake. In contrast, the costs of *OM* efforts are fully borne by households, and reflect voluntary contributions to a good with private and public benefits. Hence, we hypothesize that social capital is important for household participation in *OM*, but that it may not play a role for household investment in subsidized activities *SW*.

For both the *SW* and *OM* models we use the following specification:

$$Z_{ik} = \text{constant} + \beta_1 S_k + \beta_2 X_{ik} + \beta_3 C_k + \varepsilon_{ik}, \qquad (5.2)$$

where i indexes households in village k. Z_{ik} is measured as either SW_{ik} or OM_{ik}, S_k is a vector of social capital indicators at the village scale (average trust or social homogeneity), X_{ik} a vector of individual household characteristics (own amount sent in the Trust Game, caste group membership, income per capita, landholding per capita, household access to irrigation, soil quality, number of household members, dependency on agriculture and the household's perceived influence on decision making) and C_k captures context variables (average income in the village, the dummy variable for an NGO established maintenance fund and watershed dummy).[13] To deal with the endogeneity of own amount sent, S_i, with respect to income and other variables we instrument for that variable in Tables 5.5 and 5.6, using the results from the 3rd column of Table 5.4 as the first stage. Moreover, in Table 5.5 we instrument for income because of the potential for reverse causality between this variable and ongoing SW efforts (note that this is not relevant for Table 5.6 because the intention to invest in OM cannot affect current incomes). The *SW* results are provided in Table 5.5.

[13] Note that we do not include all the participant variables that we included in Table 4 to explain *SW* and *OM* (e.g., sex, age class, literate). This is because such variables may be relevant for individual play in the Trust Game but not for household decisions regarding soil and water management.

Table 5.5 Household investment in soil and water conservation

	Trust Game results as proxy for social capital				Observable as proxy	
	(1) Probit	(1) Marginal effects	(2) IV	(2) Marginal Effects	(3) IV	(3) Marginal effects
Constant	– 2.48		– 2.99		– 2.85*	
	(1.54)		(1.96)		(1.49)	
Kalyanpur#	0.78*	0.28	0.81*	0.30	0.76	
	(0.43)		(0.49)		(0.72)	
Average income village (Rs ‘000)	0.20		0.25		0.23	
	(0.14)		(0.23)		(0.21)	
Amount sent by participant (Rs)	– 0.01					
	(0.01)					
Predicted amount sent by participant[a] (Rs)			0.00		0.00	
			(0.03)		(0.03)	
Average amount sent in village (Rs)	0.02		0.00			
	(0.04)		(0.05)			
Village homogeneity (%)					0.11	
					(1.53)	
Household is member majority caste#	– 0.12		0.06		0.07	
	(0.43)		(0.79)		(0.79)	
Income per capita (Rs ‘000)	0.16**	0.06				
	(0.07)					
Predicted per capita income[b] (Rs ‘000)			0.09		0.09	
			(0.10)		(0.10)	
Dependency n agriculture #	– 0.26		0.13		0.14	
	(0.42)		(0.57)		(0.57)	
Landholding per capita (acres)	0.24		0.40		0.40	
	(0.26)		(0.31)		(0.31)	
Access to irrigation #	– 0.59		– 0.75		– 0.75	
	(0.37)		(0.49)		(0.49)	
Black soil #	– 0.13		– 0.14		– 0.14	
	(0.41)		(0.41)		(0.41)	
Number of household members	0.13**	0.05	0.16**	0.06	0.16**	0.06
	(0.07)		(0.08)		(0.08)	
Influence decision making#	0.07		0.00		0.00	
	(0.34)		(0.34)		(0.34)	
No. of observations	92		85		85	
Log likelihood	– 49.14		– 46.55		– 46.55	
Wald chi2 (df)	19.27 (12)		19.44 (12)		19.44 (12)	
Pseudo R2	0.22		0.21		0.21	

The outcomes presented are the result of a Probit analysis [a] Derived from IV estimation of trust; see Table 4, column (2). *10% significant ** 5% significant *** 1% significant. # = dummy variable. Robust standard errors presented in brackets.

Columns (1) – (2) report the results where we use the Trust Game data as a proxy for social capital. Column (1) presents the regular probit results and in column (2) we present IV estimates. In column (3) we use "village homogeneity" as an alternative proxy for social capital (the correlation with "average amount sent" being $\rho = 0.45$).

Consistent with intuition we find that social capital, regardless of whether we proxy it by trust or social homogeneity, is not a significant determinant for household SWC investment when such investments are subsidized. Households undertake such efforts regardless of the level social capital as proxied by the average amount sent in the experiment. Regarding other regressors, the three specifications yield similar results with respect to family size – not surprisingly we find a positive association between the number of household members and SW efforts. The Probit regression indicates that the only other significant variable is per capita income, the coefficient of which is significant and positive. Possibly this reflects that the hourly wage of subsidized labour typically exceeds wages paid on local labour markets so that community members compete for such jobs (with richer households better able to secure such positions). However, this result is not robust. When we instrument for income it disappears.

None of the variables reflecting personal stakes in SW investments are found to be significant, as reflected by the lack of significance of the variables access to irrigation, fertile soils, and the household having non–agricultural sources of income too. Most importantly, note that individual behaviour in the Trust Game – or own amount sent – is not significantly associated with subsidized soil and water conservation efforts. This is true regardless of whether we instrument for it, or not.

Turning to our main results, Table 5.6 documents how social capital impacts on the intention to maintain community resource infrastructure when labour is not subsidized. Again, we test specifications using two different proxies for social capital: trust (columns 1–2) and social homogeneity (column 3).

Table 5.6 Household contribution to SWC maintenance

	Trust Game results as proxy for social capital (Robust SE)				Observable as proxy (Robust SE)	
	(1) Probit	(1) Marginal effects	(2) IV	(2) Marginal effects	(3) IV	(3) Marginal effects
Constant	–16.29*** (3.52)		–16.20*** (4.03)		–10.90*** (2.84)	
Kalyanpur#	2.75*** (0.68)	0.83	2.34*** (0.78)	0.75	– 0.55 (0.80)	
Average income village (Rs ‘000)	1.35*** (0.31)	0.54	1.29*** (0.39)	0.51	0.40 (0.26)	
Amount sent by participant (Rs)	0.00 (0.01)					
Predicted amount sent by participant[a] (Rs)			0.02 (0.04)		0.02 (0.04)	
Average amount sent in village (Rs)	0.27*** (0.08)	0.11	0.26*** (0.08)	0.10		
Village homogeneity (%)					8.18*** (2.65)	3.23
Maintenance fund #	– 1.99*** (0.72)	– 0.66	–1.75** (0.83)	– 0.60	– 1.82** (0.85)	–0.62
Household is member majority caste#	1.16* (0.65)	0.40	1.14 (0.75)		1.14 (0.75)	
Income per capita (Rs ‘000)	0.12*** (0.04)	0.05	0.14** (0.06)	0.05	0.14** (0.06)	0.05
Dependency on agriculture #	0.33 (0.51)		0.58 (0.74)		0.58 (0.74)	
Landholding per capita (acres)	– 0.22 (0.17)		– 0.24 (0.27)		– 0.24 (0.27)	
Access to irrigation #	0.65* (0.40)	0.25	0.94* (0.53)	0.34	0.94* (0.53)	0.34
Black soil #	0.86* (0.48)	0.33	0.77 (0.49)		0.77 (0.49)	
Number of household members	0.02 (0.08)		– 0.03 (0.08)		– 0.03 (0.08)	
Influence decision making#	1.52*** (0.45)	0.55	1.52*** (0.49)	0.55	1.52*** (0.49)	0.55
No. of observations	92		84		84	
Log likelihood	– 32.38		– 28.04		– 28.04	
Wald chi2 (df)	45.07(13)		36.34 (13)		36.34 (13)	
Pseudo R2	0.49		0.51		0.51	

The outcomes presented are the result of a Probit analysis [a]Derived from IV estimation of trust; see Table 4, column (2). *10% significant ** 5% significant *** 1% significant. # indicates a dummy variable. Robust standard errors between brackets.

Consistent with Gächter et al. (2004) we now find that social capital ("average amount sent") has a significant and positive impact on the provision of the public good. This is true both in the Probit and IV regression.[14] Our interpretation is that in villages with high levels of trust, agents can expect that their investment efforts are 'rewarded' by voluntary contributions of their peers, so that they are more likely to contribute to SWC themselves.

The village homogeneity variable in column (3) is significant and positive. The coefficients and significance levels of the other variables, as well as the share of the variance explained, are largely the same as in Column (2). This suggests that the easily observable homogeneity variable might act as a substitute for our Trust Game based social capital proxy.

Both the Probit and IV Probit estimates reveal that OM efforts are positively correlated with (i) average income in the region, (ii) own income, (iii) the extent to which households feel they can influence village decision–making, (iv) whether or not the household belongs to a majority caste, (v) access to irrigation and (vi) soil type. The positive impact of the household belonging to the village majority caste group and household access to black soil are not robust for the instrumentation of trust. The robust results are in accordance with the analysis of chapter 4, which also showed irrigation access and the households perceived ability to influence decision making to affect the households' intention to contribute in a significant way. Also consistent with the results from chapter 4 is that the establishment of a maintenance fund significantly crowds out the incentive for voluntary participation of villagers.

Interestingly, we don't find a significant correlation between "amount sent by participant" in the Trust Game and investments in soil and water conservation – neither in the Probit, nor in the IV regressions. So, while average behaviour in the trust game is associated with conservation efforts, suggesting that the Trust Game may be used to measure social capital, we also find that the play in the game is a bad predictor of individual behaviour in the field.[15]

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[14] This result is robust for clustering of standard errors at the village level. The same holds for the results in table 5.5

[15] We also ran a few regressions using average trustworthiness as measured in the Trust Game as a regressor to proxy for social capital. Surprisingly, we find that average trustworthiness – arguably an alternative proxy for social capital – is *negatively* associated with the provision of the public good. We did not expect such an effect, and consider it an anomaly, possibly reflecting that our measure of trustworthiness is contaminated by our empirical strategy of role reversal without informing the respondents about this prior to the game. However, it is perhaps important to note that Barr's study also finds puzzling results for trustworthiness. Barr (2003, p.628) speculates that the different results for trust and trustworthiness are caused by "asymmetries" in the game. The trust game implies looking forwards, considering future rewards, and thinking about all fellow villagers. This is perhaps not unlike real projects in the community. In contrast, the trustworthiness game implies looking backwards – they react to the action of one specific villager. As such this might be expected to be less informative about investment choices in a public good situation. Nevertheless, the awkward

Whether the impact of trust and social homogeneity on the probability of household contribution to soil and water conservation is high or low is open for debate. The marginal effects of the relevant variables indicate that trust or social homogeneity is about equally important as some of the other variables: the availability of a maintenance fund, the households access to irrigation, and the perceived influence on decision making affect the probability of household contribution with, respectively, -60, +34 and +55%. To achieve a roughly similar increase in the probability of households investing in OM (i.e. 50%) the average amount sent in the Trust Game should increase with 5 Rs., or 10% of the initial endowment.

5.5 Conclusions

We have undertaken an experimental study to uncover the interlinkages between social capital, community characteristics, and the provision of a local public good, i.e. investments in SWC maintenance. Our results indicate that social capital is an important determinant of the households' intention to contribute to SWC maintenance, both when proxied by village average trust levels and when proxied by caste homogeneity. In terms of economic significance, or impact, we find that social capital is about equally important as other variables in fostering participation in community-based resource management.

We find that individual trusting behaviour is determined mostly by the individual's own characteristics. Participants base their expectation regarding the amount returned mostly on their own behaviour. Being a member of the village majority caste group and being employed outside the village significantly influence the household's expectation as well. Especially this last result is interesting as it suggests that increased migration might not only increase the opportunity costs of labour but reduce village trust levels too. Results further indicate that in caste homogeneous villages the likelihood of sustained resource conservation is larger that in heterogeneous villages. This could be an indication that targeting homogeneous communities might improve the sustainability of community-based projects. However, given the fact that the household's perceived influence in village decision-making is also an important indicator for explaining the household's intention to voluntarily cooperate in the long run, better project interventions might be able to improve project effectiveness as well.

We believe results are not only relevant for analysts of social capital and common pool management. The results also add to the emerging literature on the 'generalizability' of experimental results to other behaviours and contexts. Whereas individual behaviour in the game does not seem 'generalizable' to actual behaviour in the field, the average, village level of trust does significantly predict individual behaviour.

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trustworthiness result could be important in light of the remark by Glaeser et al. (2000: 811) and Karlan (2005) that currently most social capital surveys might measure trustworthiness (rather than trust). We conclude that this is an interesting area for future research.

This suggests the trust game may be used to measure social capital, provided social capital is interpreted as a community characteristic. Whether this could solve some of the empirical problems associated with measuring social capital is an interesting topic for further research.

6. The downstream externalities of watershed development in India

6.1 Introduction

Several studies have shown that watershed development (WSD) can significantly enhance welfare at the village scale.[1] There are few studies, however, that also account for the possible welfare impacts of WSD downstream. Hydrological analysis has shown that WSD reduces the downstream flow of surface water by allowing more of the rainfall to be locally absorbed (Madsen 1988, Ramireddygari et al. 2000, Burt 2002, Batchelor et al. 2003). Under high rainfall conditions this might benefit downstream users by reducing the risk of flooding. However, under conditions of water scarcity it can also cause severe water stress downstream. Batchelor et al. (2003) argue that in the case of India's semi-arid regions this last example is actually the case. Capturing rainfall upstream reduces water levels in downstream irrigation reservoirs, which negatively impacts agricultural production downstream. Whether the upstream gains of WSD are sufficient to compensate for potential downstream losses remains unclear. Although it is generally agreed that the downstream effects of water related investments should be accounted for (Shah and Raju 2001, McKinney et al. 1999) few studies have actually estimated welfare impacts at the basin scale (exceptions are Chakravorty and Umetsu 2003 and Rosegrant et al. 2000).

This chapter attempts to assess the downstream externalities of WSD in India's semi-arid regions. Historically, water was relatively abundant in India's downstream regions since upstream few investments in irrigation infrastructure were made. Hence, most of the rainwater from upper catchment areas was captured in large irrigation reservoirs downstream. The reason investments in irrigation infrastructure concentrated on downstream regions is that downstream the conditions for agricultural production are generally better (Molden et al. 2001): water can be captured from a larger catchment area, the land is flatter, soils are more fertile and climatic conditions are better too. In fact, the better conditions for agricultural production and large public investments resulted in agricultural productivity being on average 78% higher in downstream irrigated regions than in the dryland regions upstream (Fan et al. 2000).

[1] See for example Kerr et al. 2002, Farrington et al. 1999, Joshi et al. 2005, Joy and Paranjape 2004, Boersema 2001, Chandrakanth et al. 2004, Ratna Reddy et al. 2004.

One of the objectives of the WSD program has been to reduce the gap in agricultural productivity by capturing and using more of the run-off upstream. Over the last decades, however, water scarcity in several of India's river basins strongly increased, resulting in dropping water levels in downstream reservoirs (Amarasinghe et al. 2004, Biggs et al. 2007). Climatic variability partly explains the drop in reservoir levels, but the development of upstream groundwater irrigation seems to be an important factor as well (Bouwer et al. 2006, Biggs 2005). Prior to the 1980s, upstream regions could only irrigate from small surface water tanks, but with the development of groundwater irrigation the total irrigated area increased (Shah et al. 2003). This caused a reduction in the flow of surface water to downstream reservoirs since more of the surface runoff became locally absorbed and recharged to groundwater. Also, it caused a drop in groundwater levels, which resulted in an increased demand for WSD in upstream regions in order to recharge groundwater aquifers at a faster rate. The result is that in the canal irrigated systems that were earlier relatively water abundant farmers have to leave their land un-irrigated (Gaur et al. 2007). Although at the basin-scale, runoff reduction has often been attributed primarily to upstream surface irrigation projects, the WSD program increased the trend in reduced reservoir inflow by creating more water storage capacity upstream and by recharging groundwater aquifers at a faster rate.

To evaluate the welfare impacts of WSD at the basin level there are two factors that need to be taken into account. The first is that by using water 'where it falls'[1], and recharging it to soil and groundwater, storage losses can be avoided. Storing water in large-scale irrigation reservoirs causes approximately 20% of the water to be lost to evaporation.[2] Under conditions of high water scarcity this is a significant inefficiency, which can be avoided by using the water upstream. Second, re-allocating water from down- to upstream regions might lower water productivity. As mentioned before, agricultural productivity is generally higher in downstream regions and by re-allocating water from down to upstream regions the productivity of water might actually come down. This would basically result in less 'crop per drop' or a lower efficiency of water use at the basin scale.

To analyze these trade-offs and assess the impact of WSD at the basin scale we use a simple model in which up and downstream users share a fixed amount of water. Investments in WSD reduce the availability of water downstream, and the welfare impact of WSD is equal to the change in agricultural value produced. For the estimation of costs and benefits, we use hydrological, land use, water use and crop data from the Krishna basin in Southern India.[3]

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[1] To use water 'where it falls' is the slogan the influential Center for Science and Environment (CSE) uses to promote rainwater harvesting and watershed development.

[2] Oral communication, Anju Gaur, project leader IWMI Krishna basin project.

[3] Data are taken from the IWMI-Krishna Basin study, which looks at water allocation in the Krishna basin. For more information contact dr. Luna Bharati: L.bharati@cgiar.org

The Krishna basin is a good example of a river basin where water scarcity strongly increased since the 1960s (Biggs et al. 2007). Also, in the upper catchment areas of the Krishna basin substantial WSD investments are being undertaken, the downstream impacts of which have not yet been addressed. We concentrate the analysis on the allocation of irrigation water, and do not consider other potential WSD effects. For example, WSD might reduce soil erosion which not only provides the basis for improved soil quality but which can also reduce the costs of reservoir siltation downstream. For lack of data we cannot consider these effects. However, since in the sub-basin considered the landscape is relatively flat we expect the relative importance of this effect to be rather small. WSD investments might also improve the productivity of rainfed agriculture by increasing soil moisture in rainfed plots. Since we only have data about the impact of SWC investments in terms of the additional water storage capacity created, we unfortunately cannot consider this potential impact here.

The results of the analysis suggest that the likely welfare effect of WSD is negative, since under all scenarios WSD benefits are insufficient to pay back investment costs. This might not be problematic if WSD succeeds in reducing poverty at the basin scale. Several studies have shown the impact of WSD on poverty alleviation to be disappointing however (Farrington et al. 1999) and the effectiveness of WSD for poverty alleviation is generally considered low (Fan et al. 2000). Upstream benefits do exceed downstream losses but only when the water productivity of upstream agricultural production is relatively high. When the shadow price of water upstream is lower, upstream benefits are not sufficient to compensate losses downstream. In the sub-basin considered, upstream water productivity is relatively high. In most, more remote, watersheds the value of agricultural water use is, however, likely to be much lower and, under these circumstances, WSD is unlikely to have a positive welfare effect. More research is required however to include the impacts of WSD on soil erosion and rainfed agriculture and to consider welfare impacts when a flow of groundwater between up and downstream users exists.

The structure of this chapter is as follows. In the next paragraph we introduce the Krishna basin and elaborate how WSD investments affect users downstream. In the third part we evaluate the welfare impacts. For this purpose, we formulate an economic model to optimize crop water use at the basin scale. In the fourth part we test the robustness of results with a Monte Carlo simulation and in the last part we discuss the wider welfare implications and conclude.

6.2 The impact of watershed development at the basin scale

The Krishna basin is one of India's major river basins located in the Southern peninsula and spread over three states. Water is scarce in the basin and only a small amount of water still reaches the sea (Biggs et al. 2007). In one of the sub-basins of the Krishna, the Musi sub-basin, substantial WSD investments have been made. The city of Hyderabad is located in the sub-basin, with approximately 6.5 million inhabitants the fifth largest city of India.

WSD investments upstream of the city of Hyderabad caused water levels in two of the cities drinking water reservoirs to drop. To compensate for the reduced supply of drinking water from the two reservoirs, the city of Hyderabad started pumping extra water from the Nagarjuna Sagar irrigation reservoir, 120 km downstream. Although the extra water extracted from the Nagarjuna Sagar irrigation reservoir accounts for less than 1% of the total water volume stored, due to high water scarcity any reduction in reservoir storage is likely to cause a loss of irrigated area downstream (Van Rooyen et al. 2005).

Watershed development, especially the establishment of check dams and groundwater recharge structures, decreases inflows to reservoirs by capturing overland flow. The surface water retained by the check dams recharges the groundwater, which encourages farmers to either establish or continue groundwater irrigation and switch from rainfed to irrigated crops. Due to a lack of soil moisture stress, irrigated crops have higher rates of ET than rainfed crops, so the total amount of water evaporated from the upstream watershed increases. Groundwater in the upper Musi is not closely connected to groundwater in the mainstream Krishna River, due to both the distance of the upper Musi from the Krishna and the low hydraulic conductivity of the hard-rock aquifers in the region. Hence, any benefits in terms of recharged groundwater aquifers do not reach the users downstream.

The case of WSD investment in the Musi sub-basin presents a unique opportunity to evaluate the costs and benefits of WSD at the basin scale. Data are available regarding both WSD investments and the flow of surface water to the reservoirs downstream. Usually, multi-year, hydrological data are not available and no linkage between upstream investments and downstream impacts can be made. Besides, we have data from the IWMI Krishna basin project to estimate the changes in cropping patterns resulting from the reallocation of water at the basin scale.

However, the case also has a serious disadvantage in not being very representative for WSD. Most WSD projects are undertaken in remote areas with poor market access, whereas the farm households in the Musi-sub-basin are located near Hyderabad city with good infrastructure and market opportunities. As a consequence, the percentage of high value crops like vegetables, fruits and spices is relatively high, which is likely to positively influence the estimation of WSD benefits. In the discussion of results we will pay specific attention to this bias and discuss potential impacts.

In the analysis, we will not pay attention to the urban costs associated with WSD. The value of drinking water being much higher than that of irrigation water (Saleth and Dinar 2001), accounting for urban costs is likely to strongly influence the results. Since in most cases WSD projects are not located upstream of major drinking water reservoirs, accounting for urban costs would make the analysis even less representative.

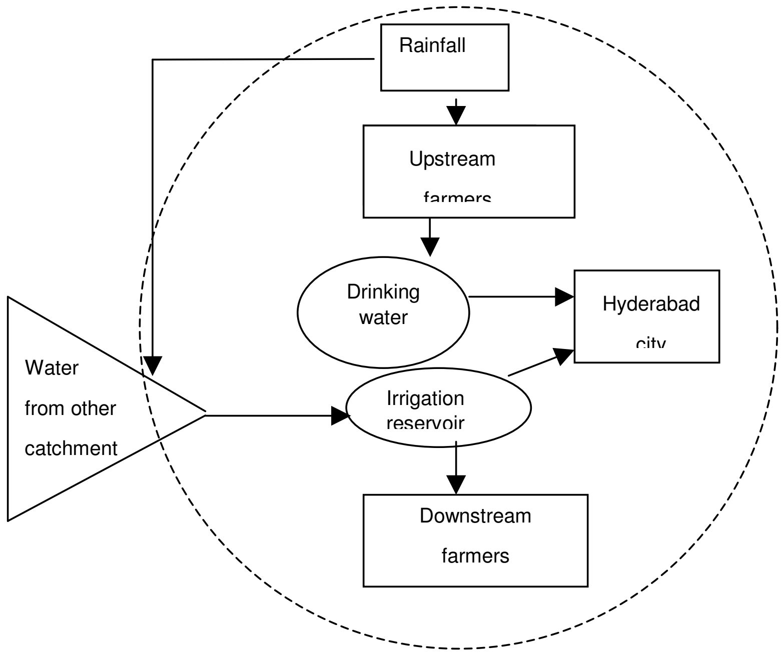

Figure 6.1 Schematic representation of water flows in the Musi basin

Between 1975 and 2002, the annual inflow of water to Hyderabad's two drinking water reservoirs decreased by a total of 17 million cubic meters (MCM) (Biggs 2005). (Biggs 2005). Between 1970 and 1985 an average rainfall of 600-700 mm rainfall was sufficient to fill up the reservoirs, but in the period 1985-2003 this changed to a minimum rainfall level of 800-900 mm (Biggs 2005).[4] Interestingly, government data on WSD investment in the catchment area of the two reservoirs indicate that between 2000 and 2005 in the most conservative estimate (i.e. assuming structures fill up once a year) an additional 15 MCM of water storage was created upstream.[5]

Although the reduction in inflow started prior to the WSD investments, WSD is expected to have deepened and extended the reduction of inflow by recharging depleted groundwater aquifers at a faster rate. This is confirmed by several studies in the region. For example, Ratna Reddy (2005) shows that in villages with no WSD the irrigated area seriously declined due to groundwater depletion. Another case study in the same region shows that WSD increases groundwater recharge by 25-70 % (Chandrakanth et al. 2004). We do not expect upstream groundwater recharge to benefit downstream users because in the hard rock conditions prevailing in the Musi subbasin no lateral flow of groundwater between up and downstream regions is known to exist (Biggs 2005).

[4] Average rainfall is approximately 800 mm per year.

[5] The district statistical office provided data on the costs, number of structures, and storage volume created. The total volume of storage created in the catchment was determined by multiplying the

In sum, WSD in the Musi sub-basin increased upstream water availability by 15 MCM per year and decreased downstream water availability by 12 MCM (i.e. minus the 20% transpiration loss due to reservoir storage). To estimate the welfare implications of this re-allocation of water, in the next paragraph we elaborate an economic model to simulate the impact on cropping patterns and to evaluate the costs and benefits of WSD at the basin scale.

6.3 Evaluating basin-scale costs and benefits

To evaluate the costs and benefits of WSD in the Musi- sub-basin we need to know what an additional liter of irrigation water is worth. If the total value of the increase in irrigated area upstream exceeds the value of the loss in irrigated area downstream, upstream users can compensate downstream users and welfare might improve. Whether the total impact on welfare is positive however also depends on whether total benefits are sufficient to pay back investment costs. If costs exceed benefits, the investment is unlikely to be economically efficient and welfare would increase if the money is otherwise spent. If investments however improve the distribution of welfare, welfare might still improve even when benefits are insufficient to compensate costs. The second welfare theorem states that when resource endowments are not equally distributed, redistribution can improve welfare if resources are re-allocated from individuals with higher utility levels to individuals with lower utility levels. Hence, if WSD succeeds in reducing upstream poverty (without causing increased poverty downstream) total welfare might increase, even if costs exceed benefits. In this chapter we concentrate the analysis on the efficiency of water use, but in the discussion of results we will pay attention to the distributional impacts of WSD as well.

Since markets for water are missing in the Krishna basin we need to infer the value of irrigation water from the agricultural value produced. Agro-economic models generally show water to be a crucial determinant of agricultural production (Cai et al. 2001). More water increases agricultural yields and better access to irrigation water generally allows for the production of more water intensive, higher value crops. In line with Rosegrant et al. (2000), one of the few other studies that evaluate the welfare impacts of water re-allocation at the basin scale, we use the producer surplus method to assess the value of irrigation water.

The producer surplus method estimates the change in producer's surplus resulting from a change in resource use, assuming that, apart from water, all other production factors are accounted for in the production costs. Using the producer surplus method has an advantage over, for example, a consumer surplus or willingness to pay approach, in that data are more readily available. Crop prices, costs and land use data can be collected from secondary sources, whereas willingness-to-pay figures or water consumption figures are much harder to collect.

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mandal (= administrative unit) -level statistics by the fraction of the mandal in the catchment. Data were only available for the period 2000-2005.

However, using the producer surplus method has one important drawback as it basically assumes that markets are functioning perfectly and that except for water, no other missing markets exist. Especially in India's rural regions, this is hardly the case (Walker and Ryan 1990, Bardhan and Udry 1999). By focusing the analysis on semi-commercial crops like vegetables, rice, cotton and oilseeds we try to avoid some of the problems associated with missing markets. Also, in the discussion of results we pay explicit attention to the limitations of the analysis and to how the assumption of well functioning markets might bias our results. Still, further analysis is needed to better include market imperfections and to assess how this might influence the results.

To estimate how changes in water allocation affect cropping patterns, and hence producer surplus, we develop an economic model. We assume there is a social planner who wants to maximize basin welfare based on the following production function:

$$\text{Max } \Pi = \sum_{i=1}^{3} \sum_{j=u,d} p_{ij} A_{ij} e_{ij}^{\alpha_j} h_{ij}^{1-\alpha_j} - \beta_j h_{ij}^{\gamma_j} \quad \text{with } 0 \le \alpha \le 1 \text{ and } \gamma > 1 \qquad (6.1)$$

and with i=1,2,3 for the different crops, j= u,d for location in the sub-basin (up and downstream), p for net prices, e for crop water use, h for crop land use, A is a technical coefficient reflecting crop productivity, α the water intensity of agricultural production and $\beta_j h_{ij}^{\gamma_j}$ a cost function reflecting increasing production costs per ha.

The direct costs of production are already included in p, but cultivating an extra ha is expected to generate extra costs since during harvesting season there are additional costs in terms of peak labour demand. Since labour markets and production costs differ between up and downstream regions, the cost function $\beta_j h_{ij}^{\gamma_j}$ differs between the two regions as well.

The water intensity of agricultural production α is also location specific. In fact, the water intensity of agricultural production also differs per crop, but with crop specific water intensity variables the model becomes analytically unsolvable. Hence, we assume the same water intensity for all crops at one location. This might somewhat bias the outcomes of the analysis, but since we calibrate the model using actual cropping patterns we do not expect this assumption to affect outcomes much. However, we will pay explicit attention to the potential impact of this assumption in the discussion of results.

The main constraint the social planner faces is that total crop water demand should not exceed supply (E_j):

$$E_j - \sum e_{ij} = 0 . \qquad (6.2)$$

Clearly, if WSD investments are undertaken E_u increases and E_d is reduced. By comparing outcomes with and without WSD investment the impact of WSD on basin welfare can be assessed.

We use the assumption of a social planner because in the context of India's river basin management water is allocated from the top down: Water markets do not exist and the allocation of irrigation water is largely controlled by the state. An exception is the investments that are undertaken in upstream groundwater irrigation, which are largely private and lack state coordination and control. However, given that without government WSD investments the area irrigated with groundwater would strongly decrease, we might consider the re-allocation of water to upstream users through WSD investment partly state controlled as well.

Although cropping patterns are decided individually, for most crops the state offers minimum support prices and effectively most of India's agricultural production is state planned. We consider three crop groups, two of which, rice and oilseeds/pulses, are largely state controlled. For the third crop group we consider, high value, high water intensity crops like vegetables, spices and fruit, no state support prices exist. In this case the assumption of a constant demand function, i.e. fixed prices regardless of the amount supplied, is rather strong, but for lack of data we cannot assess what the actual demand function would be.

The social planner maximizes welfare by setting marginal benefits equal to marginal costs. To get an explicit function for the shadow price of water μ, we use (1) and (2) to form the Langrarian function of which the first order conditions are:

$$\frac{\partial L}{\partial e_{ij}} = p_{ij} A_{ij} \alpha_j e_{ij}^{\alpha_j - 1} h_{ij}^{1-\alpha_j} - \mu_j = 0 . \tag{6.3}$$

$$\frac{\partial L}{\partial h_{ij}} = p_{ij} A_{ij} e_{ij}^{\alpha_j} (1 - \alpha_j) h_{ij}^{-\alpha_j} - \beta_j \gamma_j h_{ij}^{\gamma_j - 1} = 0 . \tag{6.4}$$

$$\frac{\partial L}{\partial \mu_j} = E_j - \sum e_{ij} = 0 . \tag{6.5}$$

Solving (3) for h_{ij} we get

$$h_{ij} = \left(\frac{\mu_j}{p_{ij} A_{ij} \alpha_j} \right)^{\frac{1}{1-\alpha_j}} e_{ij} . \tag{6.6}$$

Substituting (6) into (4) we get the following expression for crop water demand e_i

$$e_{ij} = \mu_j^{\frac{1-\gamma_j-\alpha_j}{(1-\alpha_j)(\gamma_j-1)}} \left(\frac{1-\alpha_j}{\beta_j \gamma_j} \right)^{\frac{1}{\gamma_j - 1}} \alpha_j^{\frac{\gamma_j+\alpha_j-1}{(1-\alpha_j)(\gamma_j-1)}} p_{ij} A_{ij}^{\frac{\gamma_j}{(1-\alpha_j)(\gamma_j-1)}} . \tag{6.7}$$

Using (5) and (7) we get an expression for the shadow price of water μ

$$\mu_j = E_j^{\frac{(1-\alpha_j)(\gamma_j-1)}{1-\gamma_j-\alpha_j}} \alpha_j \left(\frac{\beta_j \gamma_j}{1-\alpha_j} \right)^{\frac{1-\alpha_j}{1-\gamma_j-\alpha_j}} W_j^{\frac{(1-\alpha_j)(1-\gamma_j)}{1-\gamma_j-\alpha_j}} \quad , \qquad \text{with} \tag{6.8}$$

$$W_j = (p_{1j}A_{1j})^{\frac{\gamma_j}{(1-\alpha_j)(\gamma_j-1)}} + (p_{2j}A_{2j})^{\frac{\gamma_j}{(1-\alpha_j)(\gamma_j-1)}} + (p_{3j}A_{3j})^{\frac{\gamma_j}{(1-\alpha_j)(\gamma_j-1)}} .$$

From which it follows that

$$e_{ij} = \frac{E_j}{W_j} (p_{ij}A_{ij})^{\frac{\gamma_j}{(1-\alpha_j)(\gamma_j-1)}} \quad \text{and} \tag{6.9}$$

$$h_{ij} = \left(\frac{E_j}{W_j} \right)^{\frac{\gamma_j}{1-\gamma_j-\alpha_j}} \left(\frac{\beta_j \gamma_j}{1-\alpha_j} \right)^{\frac{1}{1-\gamma_j-\alpha_j}} (p_{ij}A_{ij})^{\frac{1}{(1-\alpha_j)(\gamma_j-1)}} . \qquad \text{(6.10}$$

Hence, the optimal allocation of land and water depends on the total amount of water *E* and relative crop water productivity *W*, the marginal costs of cultivation *β* and *γ* in relation to the water intensity of cultivation *α* and the value of crop production *p* together with crop productivity *A*. Depending on the value of *β, γ* and α the social planner decides how much land is cultivated with a certain amount of water.

If the marginal costs of cultivating an additional ha of irrigated land are high, the amount of water used per ha of land will be higher than when the marginal costs are low. To estimate the value of the technical parameter *A* for the different crop types we use data from the Krishna basin regarding crop water use and crop yields. Since $Q_{ij}/h_{ij} = A_{ij}(e_{ij}/h_{ij}^j)^{\alpha}$ we can estimate A and α with data on Q_{ij}/h_{ij} , crop yield per ha, and e_{ij}/h_{ij}^j , crop water use per ha.

Although data linking crop water use to crop yield are very difficult to come by, we managed to collect some indicative data for both variables. We collected data for three data points: a) maximum yield and the optimal crop water requirement, b) actual yield and actual crop water use and c) rainfed yield and crop water use under rainfed conditions, i.e. without irrigation. We used the data regarding actual crop water use, together with data on actual cropping patterns, to estimate E, the total availability of water up and downstream.

Table 6.1 Total water availability and actual crop water use

	Actual land use (ha)	Actual water use (m3/ha)	Total water (E) (MCM)
Upstream			
Paddy	10585	6500	261
Vegetables, fruit, spices, cotton	26712	4860	
Oilseeds, maize and pulses	19443	3200	
Downstream			
Paddy	251255	7350	4028
Cotton, vegetables, fruit, spices	274625	5000	
Oilseeds, maize and pulses	218513	3700	

Source: Government of India/www.indiastat.com and District statistical handbook 2000-2001

In line with the actual cropping patterns in the Krishna basin we use vegetables as the reference crop for high value crops in the upstream region and cotton as the reference crop downstream. For the third crop group we use oilseeds as the reference crop.

Optimal crop water requirements are calculated on the basis of the FAO Penman-Monteith equation, which uses information about local climatic conditions to estimate potential crop water use, where soil moisture does not limit evapotranspiration (see also Allen et al. 1998). Assuming that all other production requirements are met, supplying crops with the optimal crop water requirement results in the maximum yield. Clearly, in India's semi-arid regions it is hardly the case that all other production requirements are met. Hence, we took the highest yields we encountered in the region to reflect the maximum yield. The data on actual crop water use and crop water use under rainfed conditions were taken from two studies using remote sensing data to estimate agricultural water use in the Krishna Basin (Bouwer et al. 2007, Biggs and Turral 2007). Data regarding crop water requirements of rainfed rice were taken from a study by Bouman and Tuong (2000) in central India. In the annex of this chapter we present the indicative figures used and the sources of these data.

In table 6.2 we present the empirical estimates for A and α together with the figures we used in the analysis.

Table 6.2 Estimates for the technical coefficiencts A and α

	Actual	Scenario 1	Scenario 2
Upstream			
a1 (paddy)	.77		
a2 (vegetables)	.85	.79	.75
a3 (oilseeds)	.74		
A1 (paddy)	2.7	2.6	2.8
A2 (vegetables)	10.1	3.4	3.6
A3 (oilseeds)	1.7	1.9	2
Downstream			
a1 (paddy)	.79		
a2 (cotton)	.72	.77	.75
a3 (oilseeds)	.79		
A1 (paddy)	2.6	2.8	2.8
A2 (cotton)	0.6	1.6	1.6
A3 (oilseeds)	1.4	1.9	1.9

As mentioned before, we unfortunately could not estimate the model with crop specific water intensity parameters and had to assume some average value for the three crop groups together. This also affected the value of the crop specific technical coefficient A. Clearly, different estimates of the location specific, average value of α were possible. Hence, we estimated two scenarios, one in which the water intensity of agricultural production is higher upstream (scenario 1) and one where it is the same for the up and downstream region (scenario 2).

As the figures in table 6.2 show, the estimates of the average water intensity of agricultural production over estimate the water intensity of upstream production (except for vegetable production) and underestimate the water intensity of downstream production (except for cotton). The impact this has on the outcomes of the model will be later discussed.

We first calibrated the model using actual cropping patterns. We minimized the difference between the estimated and the actual cropping patterns, letting the model determine the values of β and γ. Table 6.3 presents the results.

Table 6.3 Key parameters of the two scenarios

	Scenario 1		Scenario 2	
	Up	*Down*	*Up*	*Down*
Shadow price water (μ) (Rs./liter)	0.85	0.73	0.61	0.60
Increasing costs of peak labor demand (γ)	1.54	1.66	1.55	1.67
Cost factor land (β)	4.73	0.19	3.77	0.16

As the figures in table 6.3 show, the shadow price of water in scenario 1 is higher upstream than downstream whereas in scenario 2 the shadow price is in both regions the same. This reflects the higher water intensity of upstream production in scenario 1. We estimate the model with the Excel based Solver model, an optimization model. Since the model we want to estimate is non-linear, the outcomes of the Solver model are sensitive to the initial values used. As initial values we used the values presented in tables 6.2 and 6.3. However, in the last section of this chapter we undertake a sensitivity analysis of these figures as well.

Before we can estimate the impact of changes in water availability on cropping patterns we need information about p, or the net prices of the different crops. Information about farm harvest prices and production costs is generally hard to come by. Although the government of India publishes some statistics on crop prices and the costs of inputs, data often concern different years or regions, which makes them hard to compare. Based on the information we could find regarding farm harvest prices and production costs, we used the following indicative figures for our analysis. As the variance of these figures is likely to be large, we pay explicit attention to the sensitivity of these figures in the last section.

Table 6.4 *Prices, costs and net prices per crop (Rs./kg)*

	Farm harvest prices	Production costs*	Net prices
Upstream			
Rice	5	2.5	2.5
Vegetables	4.5	2.5	2
Oilseeds	12	8.5	3.5
Downstream			
Rice	5	2.5	2.5
Cotton	20	15.5	4.5
Oilseeds	12	8.5	3.5

Source: Government of India, www.indiastat.com *Production costs include costs of (family) labour.

In table 6.5 we present the baseline scenario, or the outcome of the calibrated model.

Table 6.5 *Simulated versus actual cropping patterns*

	Actual	Scenario 1	Scenario 2
Upstream			
Paddy	10585	12659	12955
Vegetables, fruit, spices, cotton	26712	19562	19835
Oilseeds, maize and pulses	19443	13380	13741
Downstream			
Paddy	251255	251255	251246
Cotton, vegetables, fruit, spices	274625	274625	274632
Oilseeds, maize and pulses	218513	218513	218516

As the results in table 6.5 show, the model estimates downstream cropping patterns perfectly, but underestimates upstream vegetable and oilseed production and overestimates upstream production of rice. The reason for this result is that the model underestimates the water productivity of vegetable crops and overestimates the water productivity of rice, as mentioned in the explanation of table 6.2.

To assess the impact of water re-allocation in the sub-basin, we compare total welfare with and without watershed investments for five different investment levels. We define the investment levels on the basis of current WSD investments, average investment costs per ha and the total harvestable amount of rainwater. Actual WSD investments in the Musi sub-basin increased upstream water availability with 15 MCM at a cost of 8 million USD.[6] Since the total watershed area is 80,000 ha, this translates into an average investment cost of USD 100 per ha.

To define the potential for additional WSD investments, the question is what the maximally harvestable amount of runoff would be. Most of the rain in semi-arid areas infiltrates into the soil profile and is subsequently evaporated to the atmosphere, resulting in relatively low runoff coefficients. For the watersheds draining to the drinking water reservoirs of the upper Musi (Figure 6.1), annual runoff was an average of 9.3% of annual precipitation (1981-1990) with a range of 1.6%-15%. Runoff to the reservoirs fell to 7.5% of rainfall by 1994-2003. Assuming that roughly half of the approximately 9% of rainfall can be successfully recharged and is useful to irrigated agriculture, the maximally harvestable amount from the upstream reservoirs would be 75 MCM. [7] If we assume that costs increase linearly with the amount of water harvested, harvesting 75 MCM would cost approximately 500 USD per ha. Considering that WSD projects generally do not invest more than 150-200 USD per ha (see table 4.2) it seems more realistic to assume a maximum investment of 16 million USD, with a maximum harvest of 30 MCM. If we take this to represent the 100% WSD investment level, an investment of 20% would correspond to an increase in upstream water availability of 6 MCM (and a loss downstream of 4.8 MCM) at a cost of 3.2 million USD. Using these figures to estimate the impact of changes in water availability, table 6.6 presents the results.

[6] The district statistical office provided the data on WSD investment costs.
[7] The total amount of rainfall being 1690 MCM, or the equivalent of average rainfall (800 mm) times the size of the total catchment area (211.100 ha).

Table 6.6 Cropping pattern changes (in ha) resulting from WSD investments

Scenario 1	20%	40%	60%	80%	100%
Upstream					
Rice	+173	+344	+513	+681	+848
Vegetables	+267	+531	+793	+1053	+1311
Oilseeds	+182	+363	+543	+720	+896
Downstream					
Rice	-161	-322	-483	-644	-805
Cotton	-176	-352	-528	-704	-880
Oilseeds	-140	-280	-420	-560	-700

Scenario 2	20%	40%	60%	80%	100%
Upstream					
Rice	+172	+257	+342	+426	+511
Vegetables	+263	+394	+524	+653	+782
Oilseeds	+182	+273	+363	+452	+542
Downstream					
Rice	-159	-238	-317	-397	-476
Vegetables	-173	-260	-347	-434	-520
Oilseeds	-138	-207	-276	-345	-414

As the results show, the impact of WSD is larger in scenario 1 than in scenario 2. This follows from both the higher water intensity of agricultural production (α is 0.79 respectively 0.77 as compared to 0.75 in scenario 2) and the fact that the shadow price of water is significantly higher in scenario 1.

Crop water use in the different scenarios is quite similar to actual crop water use for cotton, but for rice it is much less and for vegetables and oilseeds it is significantly more. In estimating the model, we actually defined a minimum crop water requirement to reflect crop water use under rainfed conditions when supplementary irrigation is supposed to be nil. Although for oilseeds, vegetables and cotton the estimated crop water use is a bit higher than actual water use, for rice it is actually quite close to the amount of water supplied under rainfed conditions, i.e. half the actual water use. Again, this seems to be the result of assuming average water intensity for all three crops.

The annual benefits of WSD are derived by deducting the total producer surplus generated under the base scenario (no WSD investment) from the value generated under the different WSD scenarios. Table 6.7 presents the results.

Table 6.7 Annual benefits of WSD (in million USD)

	Scenario 1	Scenario 2
	Annual benefits	Annual Benefits
20%	0.04	0.02
40%	0.08	0.04
60%	0.11	0.06
80%	0.15	0.08
100%	0.19	0.10

In line with the results from table 6.6, the impact of WSD on basin welfare is almost twice as high under scenario 1. Interestingly, for both scenarios, benefits upstream are sufficient to compensate downstream losses. That is to say, the efficiency gains of avoiding the transpiration losses of water storage are larger than the efficiency losses of having a lower water efficiency of irrigation water use.

In order to compare WSD benefits with WSD investment costs, we have to calculate the net present value of WSD benefits. To do this we first need to make an assumption about the expected lifetime of WSD investments. With no maintenance, we assume that the expected lifetime of investments is 10 years. When investments are maintained, we expect the lifetime of WSD investments to increase to 25 years. We evaluate both a scenario with and without investment maintenance. We assume maintenance is undertaken every 5 years at 5 % of the investment cost.

Second, we need to make an assumption about the discount rate. Since the capital costs of WSD reflect a real financial expenditure, we use a discount rate of 5%. However, we also calculate the net present value at a 0% discount rate. With respect to the costs of WSD, different figures might apply. If we consider total government expenditure, a 10% increase in watershed investment increases costs with 1.6 million USD. If we consider the fact that the WSD program started as an employment program, i.e. low opportunity costs of labour, it would seem more appropriate to only account for material costs[8]. In that case a 10% increase in WSD investment increases costs with 0.64 million USD.[9]

Figure 6.2 and 6.3 present the net present value of scenario 1, with and without investment maintenance. As the figures show, even when investments are maintained and no discount rate is applied, WSD benefits are not sufficient to pay back WSD investment costs.

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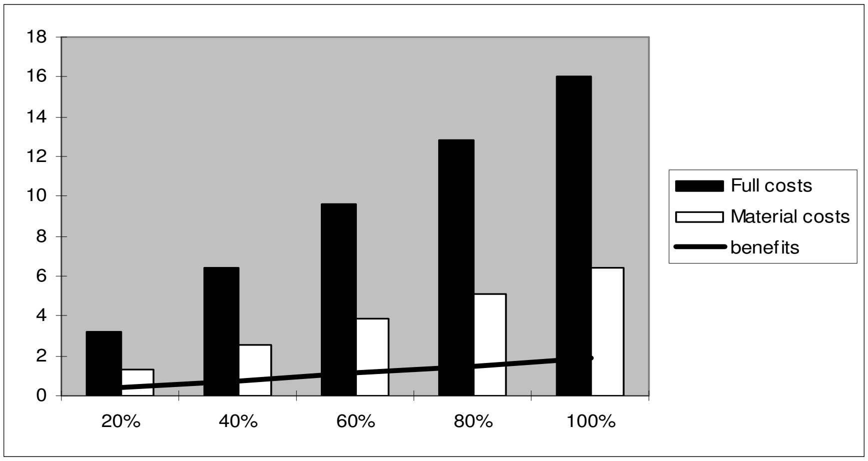
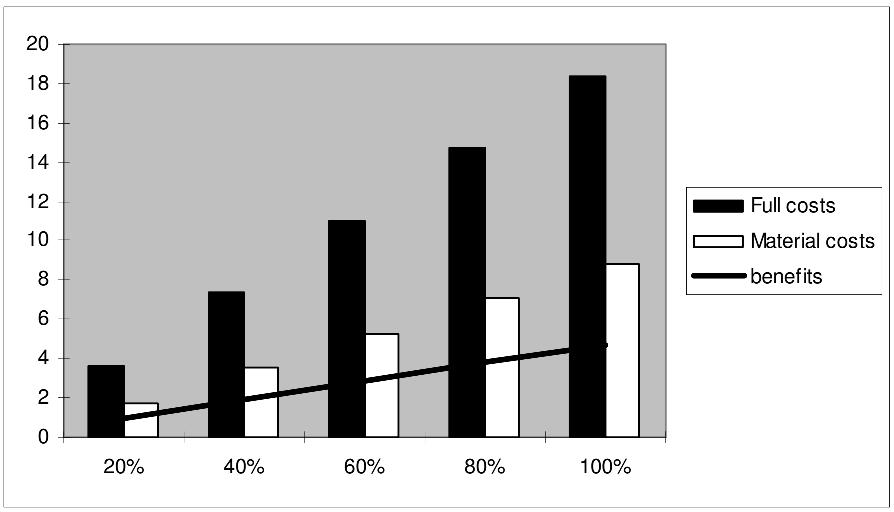
[8] This might seem to be contradicting our earlier statement regarding increasing labor costs. However, there is a clear issue of seasonality here. WSD investments are generally undertaken in the dry season, when unemployment is high. In the harvesting season however labor is generally scarce.
[9] Figure of 40% material costs taken from Mehrotra (2005)



* Lifetime investments 10 years, 0% discount rate

Figure 6.2 Net present value of costs and benefits scenario 1 - no maintenance



* Lifetime investments 25 years, 0% discount rate

Figure 6.3 Net present value of costs and benefits scenario 1 - with maintenance

Before discussing these results and their possible implications for the WSD investment program, in the next paragraph we first analyze their sensitivity.

6.4 The robustness of results

At several points in the preceding analysis we reported that data were only indicative since we had few data points and the data we had were of varying quality. To test whether the use of alternative figures would significantly alter the results, we perform a Monte Carlo simulation using a random sample of 75-125% of the data earlier used. Except for α, γ and E all other parameters were left to vary. Assuming data are uniformly distributed, with the Excel-based McSimSolver programme we estimated the model, for each WSD investment level, 5000 times (Barreto and Howland 2006).

We then use these simulations to calculate the standard deviation of the two scenarios in order to estimate the probability that watershed development would have a positive welfare impact, i.e. that WSD benefits would be sufficient to compensate costs. Table 6.8 presents the one sided p-values for scenario 1 and 2.

Table 6.8 Probability that benefits ≥ full investment or material costs.

	Without maintenance				**With maintenance**			
	Scenario 1		*Scenario 2*		*Scenario 1*		*Scenario 2*	
	Full costs	Material costs	Full costs	Material costs	Full costs	Material costs	Full costs	Material costs
20%	12%	36%	8%	31%	33%	44%	27%	41%
40%	1%	23%	0	15%	18%	39%	11%	31%
60%	0	13%	0	6%	9%	35%	3%	24%
80%	0	7%	0	2%	3%	29%	1%	16%
100%	0	3%	0	0	1%	25%	0	11%

The reported probabilities are one-sided P-values

The results indicate that for most scenarios there is a probability that WSD generates a positive welfare impact, but that this probability is less than 50%. The probability decreases at higher investment levels and is, obviously, smaller when accounting for full investment costs. When we only allow prices to vary, and keep A and β fixed, the probability that WSD is welfare enhancing becomes less[10]. Overall, SWC maintenance increases the probability that WSD improves basin welfare with 10-20 %.

In line with the empirical estimates for α and A we only evaluated scenarios for which the shadow price of water is higher upstream or the same. When upstream farmers are not in the position to produce high value crops the shadow price of upstream water is however likely to be lower. Since in most semi-arid watersheds this is actually the case, we re-calculated scenario 2 with higher values for downstream A, γ and β resulting in a shadow price of downstream water of 0.90 rs/liter (as compared to a shadow price of 0.60 rs/liter for users upstream). The results show that in this case upstream benefits are no longer sufficient to compensate downstream losses. Hence, if the shadow price of water downstream is significantly higher, the efficiency gains of avoiding storage losses are no longer sufficient to compensate the loss in water use efficiency at the basin scale.

Estimating the model with crop specific water intensity variables α might improve the results. At present, the model underestimates the water productivity of vegetable production, which reduces total WSD benefits upstream. Hence, using crop specific water intensity factors might slightly change the outcome in favour of WSD.

[10] We also tested whether our conclusions hold if α is for example 0.5. Although again several specifications are possible, the specification with values for A, β and γ similar to the values in scenario 1 and 2 resulted in a much lower shadow prices for water (μ=0.04 upstream and μ =0.05 downstream) and, hence, a much lower impact of WSD. Still, upstream benefits are sufficient to compensate downstream losses, but they are nowhere close to paying back investments costs.

However, given that in most semi-arid watersheds upstream farmers hardly produce any vegetable crops, it does not change the general expectation that WSD is unlikely to be welfare enhancing at the basin scale. Still, further research seems required to test the effect of different scenarios and cropping patterns on the results.

6.5 Discussion

The idea to re-allocate water from the relatively water abundant regions downstream to the dryland regions upstream seemed like a good idea. Water scarcity being regarded as the main production constraint in most upstream, semi-arid regions, the idea to capture water 'where it falls' appealed to many, not in the least because the costs seemed relatively low. Although the benefits proved attractive, the externalities to downstream users were largely ignored. This chapter suggests that the downstream externalities of watershed development are substantial and that WSD benefits are on average insufficient to payback investment costs.

If WSD interventions succeed to ensure SWC maintenance, the probability that WSD is welfare enhancing increases with approximately 10-20%. However, even when SWC structures are maintained the probability that WSD generates a positive welfare impact is less than 50%. Besides, the question is whether it is realistic to assume that SWC investments are maintained. The analysis in the previous chapters indicated that the likelihood of sustained SWC maintenance seems relatively low.

Results are likely to worsen if we account for the market distortions that keep farm households from actually maximizing the value of their crops. Especially in upstream regions, infrastructure and market services tend to be poor as public investments in infrastructure and agricultural services traditionally focused on the higher productivity regions downstream. Hence, more semi-subsistence crops are produced and the value of agricultural production tends to be low. The analysis indicated that if the shadow price of water is downstream higher, upstream benefits are no longer sufficient to compensate losses downstream.

If we account for the urban costs of WSD the likelihood that WSD has a positive welfare impact becomes even less. In the case of Hyderabad city, due to WSD investments the annual costs of urban water supply increased with almost 5 million USD[11]. If instead of using the actual costs of water supply, which are likely to reflect potentially large inefficiencies, we use consumer willingness to pay figures[12] to estimate the increase in costs, the annual loss from diverting water from urban to agricultural use would still be 2 million USD. Clearly, no watershed development program can generate sufficient benefits to compensate such a loss.

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[11] The extra costs of pumping water from the Nagarjuna Sagar reservoir are 14.5 Rs./m3.

[12] Saleth and Dinar (2001) estimated consumer willingness to pay figures for Hyderabad in 1997.

Under these circumstances, re-allocating water from down to upstream regions only makes sense if watershed development significantly contributes to poverty alleviation or if it enhances welfare in another way. Looking at the wider welfare impacts of WSD, investments in the Musi sub-basin were mainly targeted at groundwater recharge, but might have benefited soil conservation as well. Since we lack data on the impacts of soil conservation, we cannot assess the importance of this effect. However, the sub-basin being relatively flat, we don't expect the benefits in terms of reduced soil erosion or siltation to be substantial. Some investments were made in reforestation, but only for 7% of the total WSD budget. Again, we know little about the number of trees planted or the broader welfare impact this investment might have had. In terms of water conservation the longer term impact seems to be small: hydrological studies in the region indicate that WSD does not improve long term groundwater levels since all water harvested tends to be used (Batchelor et al. 2003).

With respect to the impact on poverty alleviation, several studies have shown the impact of WSD on poverty alleviation to be relatively small. Investments mainly benefit farmers with access to irrigation and good quality land, something poor households tend not to have (Bouma and Scott 2006, Farrington et al. 1999, Kerr 2002). In fact, Fan et al. (2000) conclude that investments in watershed development are not effective to alleviate poverty and that investing in roads, education, agricultural R&D and extension services is likely to have a much larger effect. The poor usually depend more on rainfed agriculture and agricultural labour and although they do benefit from the employment generated during project implementation, this is a relatively short-term effect. An improvement in the returns to rainfed agriculture might have a more structural impact on the poor. Besides, it might reduce the downstream externalities of WSD, as less rainfall would be captured upstream.

Although this dissertation has not addressed the feasibility of improving rainfed crop productivity, the analysis does give some indications that such a strategy is unlikely to work. The returns to rainfed crops are generally lower than the returns to irrigated agriculture. This reduces the incentive to invest in SWC and increases the probability that investments are not maintained. Besides, to improve the yields of rainfed crops, analysts have indicated that investments in market access and agricultural extension services are required as well (Rosegrant et al. 2000). Also, the risks of crop loss are relatively high in rainfed agriculture. Stimulating poor households to invest in rainfed agriculture under conditions of increasing climate variability is unlikely to reduce poverty much.

Annex to chapter 6

Table 6.9 Crop yield and crop water use data

			Data Source
	Maximum		
	Yield (kg/ha)	*ET (m3/ha)*	
Upstream			
Rice	3200	9360	Yield data from Government of India, (different sources) at www.indiastat.com ET calculated using the FAO Penman-Monteith equation (Allen et al 1998)
Vegetables	20000	7700	
Oilseeds	1000	5520	
Downstream			
Rice	3600	8920	
Cotton	400	7850	
Oilseeds	1200	5300	
	Actual		
	Yield (kg/ha)	*ET (m3/ha)*	
Upstream			
Rice	2550	6500	Yield data from Government of India, (different sources) at www.indiastat.com. ET data for oilseeds from Biggs and Turral (2007) and for rice, cotton, veg. from Brouwer et al (2007)
Vegetables	13500	4860	
Oilseeds	750	3590	
Downstream			
Rice	3250	7350	
Cotton	322	7090	
Oilseeds	1000	3590	
	Rainfed		
	Yield (kg/ha)	*ET (m3/ha)*	
Upstream			
Rice	2000	5000	Yield data calculated on the basis of crop yield factors from Biggs and Turral (2007). ET data for rice from Bouman and Tuong (2000) and for the other crops from Biggs and Turral (2007)
Vegetables	10000	3200	
Oilseeds	530	2260	
Downstream			
Rice	2200	5000	
Cotton	200	3150	
Oilseeds	580	2260	

7. Discussion and Synthesis

To transform India's semi-arid, upper catchment areas, the WSD program has tried to reduce poverty and improve agricultural productivity by investing in SWC at the village scale. In this endeavour, local communities played an important role. They actively participated in investment planning and implementation and were supposed to engage in voluntary cooperation to maintain SWC structures in the long run. This dissertation has taken a closer look at the extent to which communities can be expected to voluntarily engage in long term SWC. Also, it has analyzed whether planning and implementing projects at the scale of communities might also have adverse impacts in causing welfare losses downstream. Together these two factors are an important indication of whether community-based WSD can be considered an effective strategy to reduce poverty and increase agricultural productivity in India's semi-arid regions.

Overall, the analysis in this dissertation suggests that community-based WSD is unlikely to transform India's semi-arid regions in the long run. Although under favourable conditions households might voluntary cooperate in SWC maintenance, for the average household in the average village the incentive to contribute seems low. Involving communities in project planning and implementation does positively influence project effectiveness, but mainly by increasing the critical mass of households with SWC. Investments in community organization do not seem to significantly influence the household's commitment to voluntary contribute to SWC maintenance, possibly because community investments do not always succeed in creating consensus regarding the WSD investment plan.

Generally speaking, WSD seems most likely to structurally improve agricultural productivity in regions, and for households, that are already relatively well off. This implies a trade-off between the WSD objectives of poverty alleviation and improved agricultural productivity since SWC investments in poor regions and for poor households are less likely to be effective, whereas these are the regions, and the households, that require public investments most. Another trade-off that arises is between the welfare of upstream regions and the welfare of regions downstream. In water scarce river basins, WSD effectively re-allocates water from high potential regions downstream to the lower potential watersheds upstream. Although under some circumstances upstream benefits are sufficient to compensate downstream losses, benefits are on average insufficient to pay back investment costs.

In the introduction of this dissertation I formulated four research questions to analyze whether communities can be expected to maintain semi-public SWC structures in the long run. In the following, I will address each of these questions to synthesize the conclusions and discuss the main results.

The first question concerned the likelihood that households voluntarily contribute to SWC maintenance, given the semi-public nature of SWC investments and given the context of agricultural production in India's semi-arid watersheds. The analysis in chapter 3 suggested that whether a coalition of households is likely to maintain a socially efficient level of SWC investments depends on whether it has a strategic advantage as compared to non-cooperative households. If the coalition does not have a strategic advantage, and coalition membership is not fixed, initially cooperative households will leave the coalition and a socially efficient level of SWC provision is unlikely to be reached. Household commitment might reduce mobility between coalition and fringe but as it cannot increase coalition stability this does not improve the maintenance of SWC structures in the long run. If the coalition has a strong strategic advantage it can credibly threaten defectors to stay in the coalition or to have their welfare strongly reduced. Under these circumstances the entire community will join the coalition and a socially optimum level of SWC investment can be attained.

With regard to the costs and benefits of cooperation, the analysis indicated that emerging labour markets tend to increase the opportunity costs of labour and, hence, to reduce voluntary contributions to the public good. Interestingly, the emergence of a labour market not only affects community cooperation, community cooperation also determines the impact emerging labour markets have. In intrinsically cooperative communities, the external wage rate needs to be higher to reduce water conservation levels than in communities that do not cooperate much. This can be explained by the fact that in cooperative communities the value of agricultural production is higher as more water is harvested for collective use. The impact of emerging labour markets on community cooperation is not necessarily negative. If it enforces the strategic position of the coalition, it can actually increase the level of SWC provided. Hence, it seems important to pay more attention to the influence of emerging labour markets on community resource management to improve the effectiveness of WSD.

The influence of the external environment on community resource management was addressed in chapter 4. The analysis accounted for region, village and household specific factors, like market access, aridity, location in the watershed and soil type, and tried to assess the relative importance of these factors in determining the household's intention to contribute to SWC. The results indicate that the poorer the conditions for agricultural production, the lower the contribution of individual households to SWC. At the aggregate scale, low rainfall and poor quality soils reduce the incentive to invest in SWC and at the household level, households with no access to irrigation and good quality land benefit less. Hence, paradoxically, the regions and households that require subsidized SWC investment most are least inclined to maintain these structures in the long run.

With respect to the wider socio-economic context, poor market access was expected to reduce the incentive for voluntary cooperation due to its impact on market transaction costs. However, the analysis in chapter 4 suggests that poor market access affects voluntary cooperation positively. This seems to be an indication that the incentive to invest in SWC is not so much influenced by poor market access in terms of agricultural input and output markets as it is by the opportunity costs of labour. In accordance with the analysis in chapter 3, better access to labour markets reduces the incentive of households to invest in SWC. Whether poor access to agricultural input and output markets is indeed less important for the safeguarding of SWC investment maintenance remains to be seen. The household's access to irrigation, an indication that the household can grow high value cash crops, does have a strong, positive impact, and so does average income at the village scale. Hence, further analysis seems required to assess the extent to which investments in infrastructure and agricultural input and output markets might improve the conditions for SWC maintenance, for example by separating labour market from in- and output market effects.

The second question concerned the issue whether investments in community organization can improve SWC maintenance in the long run. The analysis in chapter 4 indicates that the results are mixed. Investments in community organization do not significantly influence the household's intention to contribute to SWC maintenance. However, community involvement in WSD project planning and implementation does increase the critical mass of households with investments in SWC. A greater critical mass of households with SWC investment positively influences the household's intention to contribute to SWC maintenance, possibly because it increases the size of the coalition, as the analysis in chapter 3 would suggest.

Besides, the household's intention to contribute is positively affected by the household's perceived influence in village decision-making. Although the analysis does not provide evidence of investments in community organization positively affecting village decision-making, case study analysis indicates that investments in awareness raising and empowerment have a positive effect (Joy and Paranjape 2004, Honoré 2002). Also, non-participatory approaches affect the household's intention to contribute negatively. Hence, if households cannot participate in investment planning and implementation they are unlikely to contribute to the maintenance of these investments in the long run.

The case study analysis in chapter 4 indicated that active involvement of villagers in project planning and implementation has a positive impact on investment targeting and the monitoring of project implementation. More money seems to reach the target group resulting in more and better quality SWC investments. This positively influences the effectiveness of WSD for the simple reason that SWC structures are less likely to fall apart. Even the most participatory projects, however, cannot ensure that benefits are equally shared. The analysis indicates that village level inequality does not affect the household's intention to contribute to SWC maintenance.

However, an unequal distribution of project benefits might also be an indication that investments in community organization did not succeed in creating consensus regarding the WSD investment plan. This could help explain why investments in community organization have no significant impact on the household's intention to contribute to SWC maintenance. Further research seems required however to analyse this effect, linking information about specific community organization investments to the level of consensus and distribution of project benefits at the village scale.

Finally, the establishment of a village maintenance fund negatively affects the household's intention to contribute to SWC maintenance. Since the case study analysis suggests that the existence of a maintenance fund does not seem to improve SWC maintenance, the establishment of a maintenance funds might end up worsening the situation if funds are not managed well. More research seems required however to evaluate the functioning of maintenance funds and their long term impact on SWC.

The relative importance of social capital for voluntary cooperation was the subject matter of chapter 5. The analysis suggested that the availability of social capital at the village scale is a significant determinant of the household's intention to contribute to SWC. Using trust as a measure of social capital, higher trust levels positively influence household commitment to SWC maintenance. Interestingly, the intention to cooperate is influenced not by the household's own expectation, or trust, regarding the contribution of other households but rather by average trust levels at the village scale. This is in accordance with the definition of social capital as a community characteristic, and implies that community characteristics are indeed important to facilitate cooperative behaviour at the village scale.

Whether participants trust other participants to reciprocate pro-social behaviour does not directly depend on community characteristics, but rather on the household's social position in the group. For example, participants that belong to the village's majority caste group were shown to be more trusting, whereas participants that depend on outside sources of income trust less. This last result is especially interesting as it indicates that emerging labour markets might not only increase the opportunity costs of labour, but could erode village trust levels as well.

When using caste homogeneity as a proxy for the availability of social capital, voluntary cooperation is shown to be higher in homogeneous villages. Hence, targeting homogeneous villages might improve project effectiveness in the long run. The relative importance of social capital for voluntary cooperation is comparable to that of other factors. This not only underlines the importance of social capital, it also indicates that targeting homogeneous villages is not the only road to success. Improving the effectiveness of investments in community organization or reducing the negative impact of a village level maintenance fund might help increase voluntary cooperation as well. Besides, in heterogeneous communities explicit control mechanisms to facilitate cooperation might be developed, although the feasibility of this option has not been assessed.

The fourth research question concerned the possibly adverse impacts of WSD at the basin scale. The analysis in chapter 6 indicated that the downstream externalities of WSD are substantial. Although in the specific example of the case study region upstream gains were sufficient to compensate downstream losses, on average WSD benefits do not seem sufficient to pay back investment costs. Still, watershed development might be socially desirable if it substantially reduces poverty upstream. Several studies have shown the impact of WSD on poverty alleviation to be disappointing, however, and WSD does not seem an effective strategy to improve welfare at the basin scale.

One possible exemption is a scenario where WSD interventions succeed to ensure SWC maintenance in the long run. In this case, there is a 40% probability, at low investment levels, that benefits are sufficient to pay back investment costs. The question is, however, whether such a scenario seems realistic. First, in the case study evaluated the value of upstream production is relatively high. Most WSD projects are however targeted at more remote regions where the transaction costs of agricultural marketing are such that farm households rationally decide to cultivate low value, semi-subsistence crops. Hence, the economic value of agricultural production in upstream regions is often lower than in the case study evaluated in chapter 6, and upstream benefits are less likely to be sufficient to compensate losses downstream.

Second, in line with the overarching research question of this dissertation, the question is whether households can be expected to voluntarily cooperate in the provision of a semi-public good. Overall, the likelihood that households in semi-arid watersheds will voluntarily maintain SWC investments seems relatively low. With no mechanisms to control free riding behaviour, the incentive to defect is high and especially in arid watersheds with poor soils and little access to irrigation, the expected benefits are low. Increased migration and the emergence of labour markets are likely to worsen the incentives for voluntary cooperation, as this increases the opportunity costs of labour and lowers trust levels at the village scale. In highly committed, homogeneous villages with relatively high-income levels and good access to irrigation and fertile land, voluntary cooperation for SWC maintenance might work. However, if conditions are less favourable, the establishment of explicit contribution mechanisms seems required to ensure SWC maintenance in the long run.

Analyzing the conditions for successful community resource management has helped in understanding the factors that determine the effectiveness of WSD. Emerging labour markets, contextual factors and community and household characteristics were all shown significant, whereas the existing literature mostly concentrated on intervention-related factors instead. Although the type of project implementation was shown to play an important role, for long term project effectiveness contextual factors seem to matter more. Further analysis seems required to analyze how the welfare impacts of WSD can be improved. In this analysis, specific attention should be paid to the allocation of water user rights and rainfed agriculture. Besides, the role of external agents in facilitating effective WSD management could be further explored.

With respect to community-based approaches in general, the main lesson seems to be that community involvement in project planning and implementation is crucial to ensure project effectiveness. For sustained community resource management it is also necessary, however, that the conditions for voluntary cooperation are met. The analysis in this dissertation has stressed the importance of consensus and self-enforcement for sustained voluntary cooperation. Besides, the importance of household incentives for voluntary cooperation has been underlined. If cooperation has no particular advantage or if households cannot expect other households to cooperate too, decentralizing resource management to local communities is unlikely to be successful in the long run.

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Nederlandse samenvatting

Dit proefschrift richt zich op de vraag of je van individuele huishoudens kunt verwachten dat ze vrijwillig samenwerken om zorg te dragen voor het beheer en de voorziening van een semi-publiek goed. Publieke goederen zijn gedefinieerd als goederen waarbij 1) het moeilijk is anderen van gebruik buiten te sluiten en 2) gebruik niet rivaliserend is. Bij semi-publieke goederen is het gebruik wel rivaliserend, wat feitelijk impliceert dat gebruik van het goed niet zonder consequenties voor anderen is. De vrije toegankelijkheid van semi-publieke en collectieve goederen en hulpbronnen bemoeilijkt het beheer aangezien individuen geneigd zijn af te wachten totdat iemand anders de noodzakelijke investeringen maakt. Dit gedrag wordt 'free-riding' genoemd, aangezien men feitelijk gratis meelift op de investeringen van anderen. Als iedereen wil meeliften op de investeringen van anderen komt de voorziening van het semi-publieke goed in gevaar. Zelfs als er grote waarde wordt gehecht aan het beschikbaar zijn van het semi-publieke goed geldt dat als meelift gedrag niet in toom kan worden gehouden het niveau waarop semi-publieke goederen beschikbaar zijn zal liggen onder het maatschappelijk optimale niveau.

Gedurende een lange tijd zijn economen ervan uit gegaan dat semi-publieke goederen alleen door een overheid kunnen worden beheerd. Daarbij werd gepropageerd dat het toewijzen van individuele eigendomsrechten, waarmee het buitensluiten van gebruik door anderen mogelijk wordt, de meest efficiënte oplossing zou zijn. Dat groepen individuen of gemeenschappen zelf in staat zouden zijn om semi-publieke goederen te beheren werd lange tijd niet mogelijk geacht. De empirisch gebaseerde literatuur ten aanzien van 'common property resource management' heeft echter overtuigend aangetoond dat onder bepaalde omstandigheden gemeenschappen prima in staat zijn zelf zorg te dragen voor de voorziening en het beheer van semi-publieke en collectieve goederen en hulpbronnen. Het decentraliseren van het beheer van semi-publieke goederen naar lokale gemeenschappen bleek bovendien een aantal voordelen te hebben. Allereerst zijn op decentraal niveau de kosten van het in toom houden van meelift gedrag over het algemeen lager dan op centraal niveau. Daarbij is gedecentraliseerd beheer beter in staat in te spelen op de behoeften en wensen van gebruikers en kunnen investeringen optimaal aan de lokale context worden aangepast. Decentralisatie heeft echter ook een paar nadelen. Zo is de toegankelijkheid van het semi-publieke goed niet perse gewaarborgd en ontbreekt coördinatie op een hoger schaalniveau. Dit laatste kan bijvoorbeeld problemen opleveren als het gebruik van het semi-publieke goed en/of de collectieve hulpbron ook effect heeft op niet-lokale gebruikers.

Concreet richt dit proefschrift zich op de vraag of het reëel is te verwachten dat huishoudens in semi-aride gebieden in India vrijwillig publieke investeringen in bodem- en water conservering zullen onderhouden. Bodem- en water conserveringsmaatregelen hebben belangrijke semi-publiek eigenschappen aangezien een belangrijk deel van de baten wordt gedeeld. Met name investeringen gericht op waterconservering (kleine reservoirs, dammen, putten etc.) hebben grotendeels gedeelde baten aangezien de belangrijkste opbrengst, grondwater, vrij toegankelijk is. In het geval van bodembeschermingsmaatregelen (greppels, aarde- en stenen wallen, etc) is een groter gedeelte van de baten privaat, maar ook hier is sprake van aanzienlijke publieke baten. Mede door het deels publieke karakter van bodem-en waterconserveringsinvesteringen heeft de Indiase overheid, tezamen met een groot aantal non-gouvernmentele organisaties, fors in bodem-en waterconservering geïnvesteerd. Arme gronden, periodieke droogte en waterschaarste worden algemeen gezien als belangrijke reden voor de lage agrarische productiviteit van India's semi-aride gebieden en investeringen in bodem-en waterconservering worden verwacht structureel bij te dragen aan een hogere agrarische produktiviteit. Het investeringsprogramma wordt ook wel het 'watershed development' programma genoemd vanwege de aandacht voor de benedenstroomse effecten van investeringen op een deel van het afwateringsgebied. Met een jaarlijkse investeringsomvang van ongeveer 500 miljoen dollar (in 2000) een van de belangrijkste rurale ontwikkelingsprogramma's voor India's semi-aride gebieden.

De vraag of van lokale gemeenschappen in India's semi-aride gebieden verwacht kan worden dat zij de semi-publieke investeringen in bodem-en waterconservering op de lange termijn vrijwillig zullen onderhouden is niet alleen relevant voor betrokkenen bij het Indiase 'watershed development' programma, het is tevens relevant voor het bredere ontwikkelingsbeleid. Lokale gemeenschappen worden in toenemende mate geacht semi-publieke investeringen zoals wegen, scholen en irrigatie-infrastructuur te onderhouden en steeds meer programma's decentraliseren het beheer van semi-publieke goederen en collectieve hulpbronnen naar het gemeenschapsniveau. Het portfolio van de Wereldbank met gemeenschapsgerichte projecten alleen al wordt geschat op 7 miljard dollar, terwijl het onduidelijk is of a) de huidige benadering wel werkt en b) op welke wijze de effectiviteit van de benadering kan worden vergroot.

Om beter inzicht te krijgen in de voorwaarden voor effectief beheer van semi-publieke goederen op gemeenschapsniveau, en om de effectiviteit van de gemeenschapsgerichte benadering te kunnen vergroten, maakt dit proefschrift gebruik van de literatuur over vrijwillige samenwerking, gemeenschappelijk beheer van publieke en collectieve goederen en hulpbronnen, sociaal kapitaal en gemeenschapsgerichte projectimplementatie. Aan de hand van vier onderzoeksvragen tracht het proefschrift de volgende twee hoofdvragen te beantwoorden: a) onder welke voorwaarden kan verwacht worden dat lokale gemeenschappen in India's semi-aride gebieden vrijwillig bijdragen aan het onderhoud van semi-publieke bodem-en waterconserveringsmaatregelen en b) wat zijn de welvaartseffecten van bovenstroomse investeringen in bodem-en waterconservering op stroomgebiedsniveau.

Na een inleidend hoofdstuk over het 'watershed development' programma en de karakteristieken van bodem- en waterconservering in India's semi-aride gebieden worden in vier hoofdstukken de volgende vier onderzoeksvragen opgepakt:

1. Kan je van huishoudens in India's semi-aride gebieden verwachten dat ze vrijwillig samenwerken in het onderhoud van bodem- en waterconserveringsinvesteringen, gegeven de context van agrarische produktie in India's semi-aride gebieden en gegeven het semi-publieke karakter van bodem-en waterconserveringsmaatregelen?

2. Wat is het effect van investeringen in participatie, gemeenschapszin en lokale organisatie op het lange termijn onderhoud van bodem-en waterconservering investeringen?

3. Hoe beïnvloeden gemeenschapskarakteristieken vrijwillige samenwerking en wat is het relatieve belang van dit effect?

4.Hoe belangrijk zijn de benedenstroomse effecten van bovenstroomse investeringen in bodem- en waterconservering en wat is, in Indiaas semi-aride gebieden, het welvaartseffect van bodem- en waterconserveringsmaatregelen op stroomgebiedsniveau?

De eerste onderzoeksvraag, of van huishoudens verwacht kan worden dat zij vrijwillig bijdragen aan het onderhoud van een semi-publiek goed, wordt uitgewerkt in een speltheoretisch kader, waarbij huishoudens de keuze hebben tussen samenwerken of niet. Huishoudens baseren hun beslissing op de verwachte baten van samenwerking. Indien de baten van samenwerken lager zijn dan die van meeliften, werken huishoudens niet samen en zijn de investeringen in bodem-en waterconservering laag. Indien het echter lukt een strategische coalitie van coöperatieve huishoudens te vormen kan samenwerken wel een aantrekkelijke optie worden en nemen de verwachte investeringen in bodem- en water conservering toe. Of dit ook leidt tot lange termijn onderhoud hangt af van de stabiliteit van de coalitie, of de mate waarin huishoudens een prikkel hebben om samen te blijven werken op termijn. Zonder mechanismen om meeliftgedrag te voorkomen is de enige reden waarom huishoudens zouden willen blijven samenwerken dat de baten van samenwerken die van meeliften overtreffen. Dit is alleen het geval als het strategisch voordeel van de coalitie dusdanig is dat alle huishoudens deel van de coalitie willen uitmaken. In dat geval werkt iedereen samen en wordt een sociaal optimale hoeveelheid investeringen in bodem-en waterconservering gemaakt. Uitgaande van het gegeven dat de coalitie een strategisch voordeel heeft doordat over een gemeenschappelijke strategie kan worden gecommuniceerd, blijkt onder bepaalde condities langdurige, vrijwillige samenwerking mogelijk.

In het hoofdstuk wordt specifiek aandacht besteed aan het belang van zich ontwikkelende arbeidsmarkten, aangezien dit in de context van bodem-en waterconservering in India's semi-aride gebieden van belang wordt geacht. Zoals verwacht neemt in het geval van een zich ontwikkelende arbeidsmarkt de prikkel om in bodem-en waterconservering te investeren af aangezien dit de kosten van arbeid verhoogt.

Onder bepaalde voorwaarden kan het echter ook de strategische positie van de coalitie versterken waarmee de rol van zich ontwikkelende arbeidsmarkten voor bodem- en waterconservering niet perse negatief is. Aandacht voor het effect van arbeidsmarktontwikkeling op het beheer van gemeenschappelijke goederen en hulpbronnen is voor gemeenschapsgerichte projecten lijkt derhalve van groot belang.

De tweede onderzoeksvraag, over het lange termijn effect van investeringen in participatie en gemeenschapszin, is geanalyseerd met behulp van gegevens over 683 huishoudens uit 22 dorpen verspreid over 4 stroomgebieden. Specifiek richt de analyse zich op het onderscheid tussen projectinterventies door de centrale overheid, die over het algemeen niet participatief zijn, projectinterventies door non-gouvernementele organisaties, die over het algemeen wel participatief zijn, en dorpen waar geen interventies hebben plaatsgevonden. De belangrijkste vraag van het hoofdstuk is of investeringen in participatie en lokaal beheer de effectiviteit van de interventie op de korte en lange termijn verbeteren. De indicator voor korte termijn effectiviteit is het aantal huishoudens met investeringen in bodem- en waterconservering. De indicator op lange termijn is het aantal huishoudens dat aangeeft van plan te zijn in de toekomst bij te dragen aan bodem-en waterconservering. In overeenstemming met de bestaande literatuur blijken participatieve benaderingen inderdaad effectiever op de korte termijn te zijn, maar op de lange termijn is er geen significant effect. Wel geven huishoudens in overheidsgeïmplementeerde projecten aan niet van plan te zijn in de toekomst bij te dragen aan bodem-en waterconservering. Aangezien een grotere kritische massa van huishoudens met bodem- en waterconserveringsinvesteringen bovendien van positieve invloed is op de motivatie om op de lange termijn bij te dragen heeft een participatieve benadering indirect wel een positief effect.

Naast een analyse op het niveau van de huishoudens, wordt in het hoofdstuk aandacht besteed aan het effect van participatieve benaderingen op het gemeenschapsniveau. Zo werkt betrokkenheid van lokale gebruikers positief door op de kwaliteit van de genomen investeringen en is men in participatieve projecten over het algemeen meer tevreden over hoe de baten van projectimplementatie zijn verdeeld. Zelfs in de meest participatieve projecten is de verdeling van baten echter ongelijk, wat deels samenhangt met geografische karakteristieken maar deels ook met het gedrag van de lokale elite. Tenslotte lijkt de werking van zogenaamde onderhoudsfondsen grotendeels averechts: indien er een onderhoudsfonds beschikbaar is willen huishoudens zelf geen investeringen meer doen, terwijl de fondsen zelf nauwelijks voor onderhoud blijken te worden gebruikt.

De derde onderzoeksvraag, over de rol en het belang van gemeenschapskarakteristieken, is opgepakt met behulp van een experimenteel economische benadering. In zes van de 22 onderzoeksdorpen zijn 20 representanten van de eerder geselecteerde huishoudens uitgenodigd voor een spel. De bedoelding van het spel was om te meten in hoeverre spelers elkaar vertrouwen en wat dit zegt over de mate waarin men bereid is om bij te dragen aan het onderhoud van bodem- en waterconserveringsinvesteringen of niet.

Interessant genoeg blijkt er een duidelijke samenhang te zijn tussen de resultaten van het spel en de antwoorden in de huishoud vragenlijst. Individueel vertrouwen is niet significant, maar het gemiddelde niveau van vertrouwen op gemeenschapsniveau wel. Dit kan gezien worden als indicator voor het beschikbaar zijn van sociaal kapitaal, of het niveau van vertrouwen en de gedeelde normen en waarden op gemeenschapsniveau. In gemeenschappen waar mensen elkaar vertrouwen wordt meer samengewerkt dan in gemeenschappen waar dit niet het geval is, en de analyse laat zien dat in heterogene gemeenschappen vertrouwen lager, en samenwerking minder, is.

Het relatieve belang van vertrouwen voor de bereidheid om bij te dragen aan bodem- en waterconservering op de lange termijn is in dezelfde orde van grootte als het al dan niet toegang hebben tot irrigatie, de mate waarin men meent de besluitvorming op gemeenschapsniveau te kunnen beïnvloeden en het al dan niet aanwezig zijn van een onderhoudsfonds. Dit betekent dat sociaal kapitaal een belangrijke verklarende variabele is voor het begrip waarom bepaalde gemeenschappen wel samenwerken en andere niet. Tegelijkertijd geeft het ook aan dat dit niet betekent dat investeringen zich alleen op homogene gemeenschappen zouden moeten richten. De belangrijkste les van het hoofdstuk is dat het belangrijk is rekening te houden met sociale factoren en gemeenschapskarakteristieken indien het beheer van semi-publieke goederen en collectieve hulpbronnen wordt gedecentraliseerd naar gemeenschapsniveau.

De vierde onderzoeksvraag betreft de welvaartseffecten van bodem- en waterconservering op stroomgebiedsniveau. Alhoewel verschillende studies hebben aangetoond dat investeringen in bodem-en waterconservering over het algemeen leiden tot een welvaartsverbetering in het gebied waar de investeringen zijn gemaakt, is het onduidelijk wat de effecten op benedenstroomse gebieden zijn. Zeker indien boven – en benedenstroomse gebieden, naast een stroom van oppervlakte water, niet ook via een stroom grondwater met elkaar verbonden zijn, lijkt bovenstroomse waterconservering te leiden tot een reallocatie van water op stroomgebiedsniveau. De benedenstroomse welvaartseffecten van een dergelijke water reallocatie moeten in de beschouwing worden meegenomen wanneer de welvaartsimpact van ‘watershed development’ wordt bepaald. Dit is tot nu toe nog niet gebeurd.

In het bepalen van het welvaartseffect van ‘watershed development’op stroomgebiedsniveau spelen twee factoren een belangrijke rol: 1) het opslaan van water in benedenstroomse irrigatiereservoirs leidt, door verdamping, tot een verlies van 20% en 2) door betere en plattere landbouwgronden en een minder aride klimaat is de produktiviteit van landbouw benedenstrooms hoger. Het uiteindelijke welvaartseffect van bovenstroomse investeringen in waterconservering hangt af van de balans tussen deze twee factoren. Om de balans te bepalen gebruiken we een economisch model. Het model maximaliseert de opbrengsten uit landbouw voor beide gebieden, op basis van de hoeveelheid beschikbaar water en land. De uitkomsten suggereren dat de kosten op stroomgebiedsniveau niet opwegen tegen de lokale baten bovenstrooms.

Uit de gevoeligheidsanalyse blijkt dat alleen als investeringen worden onderhouden er een kleine kans bestaat dat 'watershed development' de welvaart vergroot op stroomgebiedsniveau. Houden we echter rekening met het feit dat in de meeste waterconservering investeringsgebieden de waarde van agrarische produktie veel lager is dan in het onderzochte gebied dan wordt de kans op een positief effect verwaarloosbaar klein.

Aangezien 'watershed development' projecten er meestal ook niet in slagen om de armoede te verlagen in het interventiegebied, lijkt het vanuit maatschappelijk oogpunt niet wenselijk te investeren in bovenstroomse waterconservering indien dit de beschikbaarheid van water benedenstrooms verlaagt. 'Watershed development' projecten hebben echter ook vaak welvaartseffecten in termen van bodemconservering en verminderd overstromingsgevaar en verzilting benedenstrooms. Dergelijke effecten zijn in de studie niet meegenomen, maar kunnen wel van invloed zijn op het uiteindelijke resultaat.

De conclusie van het proefschrift is dat alhoewel onder bepaalde omstandigheden huishoudens vrijwillig zullen bijdragen aan het onderhoud van bodem-en waterconserveringsinvesteringen op de lange termijn, de prikkel voor het gemiddelde huishouden in het gemiddelde dorp in India's semi-aride gebieden vrij klein wordt geacht. Relatief gegoede huishoudens, met toegang tot irrigatie, een duidelijke stem in dorpsbesluitvorming en goeie kwaliteit land, die deel uitmaken van de meerderheidsgroep in een homogeen dorp, en die zijn gelegen in een gebied met weinig alternatieve inkomstenbronnen maar voldoende regenval, zijn wellicht tot lange termijn vrijwillige samenwerking bereid. Echter, de marginale huishoudens in aride gebieden die publieke investeringen in bodem-en waterconservering het meest nodig hebben zijn het minst geneigd deze te onderhouden op de lange termijn. Dit levert een interessante paradox. Door interventies te richten op de meest marginale huishoudens neemt de duurzaamheid van de investeringen af, maar alleen als 'watershed development' erin slaagt de armoede te verlagen kunnen de baten van meer water bovenstrooms opwegen tegen het verlies aan water benedenstrooms. Indien huishoudens de investeringen niet onderhouden biedt dit echter geen structurele oplossing van het probleem, en een revisie van het 'watershed development' programma lijkt gewenst om de effectivietit te verbeteren op de lange termijn.

De les met betrekking tot gemeenschapsgerichte project interventies is dat niet simpelweg kan worden aangenomen dat huishoudens langdurig samenwerken in het beheer van een semi-publiek goed. Zelfs als de baten van samenwerking groot zijn is het niet gezegd dat dit samenwerking bevorderd op de lange termijn. Door intervenies te richten op homogene gemeenschappen en door aandacht te besteden aan consensus-vorming, betrokkenheid en het versterken van strategische coalities van samenwerkende huishoudens op gemeenschapsniveau kan de kans op lange termijn succes wel worden vergroot. Uiteindelijk hangt veel echter af van de context waarbinnen gemeenschapsgerichte initiatieven plaatsvinden, en is externe ondersteuning in het beheer van de semi-publieke goederen in veel gevallen waarschijnlijk gewenst.

Annex A Summary overview of the empirical variables of chapters 4 and 5

Variables from the LEAD household survey, IWMI (2004)	
a) Household investment in soil and water conservation (SW)	Dummy variable, 1 = household has invested in soil and water conservation (question 20, Annex B)
b) Household contribution to soil and water conservation maintenance (OM)	Dummy variable, 1 = household is planning to continue contributing to conservation (question 48, Annex B)
c) Maintenance fund	Dummy variable, 1 = existence of a village SW maintenance fund (for material costs)
d) Participant is member majority caste	Dummy variable, 1 = participant is member of the village's majority caste group
e) Village homogeneity	% of households belonging to the majority caste
f) Number of household members	Number of household members
g) Income per capita	Total household income in Indian Rs '000, divided by number of household members
h) Average income village	Village average of g)
i) Landholding per capita	Total ha of land owned by the household, divided by number of household members.
j) Access to irrigation	Dummy variable, 1 = household has access to open well, tube well or canal irrigation
k) Black soil	Dummy variable, 1 = household owns land with black soil
l) Influence decision making	Dummy variable, 1 = household feels capable of influencing village decision–making (question 61, Annex B)

Variables from the trust game experiment (see also Annex C)	
m) Amount sent by individual *i* (S_i)	Actual amount sent by individual *i* to individual *j* (0–50 Indian Rs)
n) Average amount sent	Village average of m)
o) Share returned by individual j (R_j)	Share of amount received that is returned ($R_j/3S_i$)
p) Average share returned in the village	Village average of o)
q) Pre–game discussion	Dummy variable, 1 = pre–game discussions
r) Participant is older than 50	Dummy variable
s) Participant is between 20 and 50 years old	Dummy variable
t) Dependency on agriculture	Dummy variable, 1 = participant depends on non–farm income
u) Literate	Dummy variable, 1 = participant is literate
v) Female	Dummy variable

Annex B Selection of relevant parts of the household questionnaire

<u>Book 1: General Household characteristics</u>

1. Village name:_______________________
2. Name of hamlet: ______________________
3. Location in watershed (Upper, middle, lower): ___________________
   (0=lower, 1=middle, 2=upper)
4. Treated / untreated: _____________________ *(0=untreated, 1= treated)*
5. Household no.: ___________________________
6. Respondent:_______________________
(1=husband, 2=wife, 3=son, 4=daughter, 5=other)
Full name of respondent: ______________________
Sex of respondent: _____________________________
Age of respondent: _____________________________
Religion/Community/Caste:____________________

13. Household characteristics:

		NO	**YES**
13.1	Does the household own any land?		
13.2	Does the household lease any land?		
13.3	Does the household own large ruminants?		
13.4	Does the household own small ruminants?		
13.5	Does the household own a tractor?		
13.6	Does the household own/share a tubewell?		
13.7	Does the household own/share an open well?		
13.8	Does the household have access to tank irrigation?		
13.9	Does the household own a bicycle?		
13.10	Does the household own a motorbike?		
13.11	Does the household own a radio?		
13.12	Does the household own a Television?		
13.13	Does the household have connections in the city?		

(0= no, 1=yes)

Book 2: Land use, ownership and investments in soil and water conservation

20. Land use, ownership and investments in soil and water conservation

	Plot 1	**Plot 2**	**Plot 3**	**Plot 4**
Land areas (acres)				
Ownership status *(1=owned, 2=leased in, 3=leased out, 4=other)*				
Distance from homestead *(specify units)*				
Area irrigated *(acres)*				
Area irrigated with groundwater *(acres)*				
Area irrigated with nala water *(acres)*				
Area irrigated with tank water *(acres)*				
Area irrigated with purchased water *(acres)*				
Whether protective irrigation? *(1=yes or 2=no)*				
Topography *(1=steep slopes, 2=moderate slopes, 3=slight slope, 4=flat)*				
Soil type *(1=red, 2=black, 3=other (specify))*				
Soil fertility *(1=good,2= medium,3= bad)*				
Soil erosion *(1=non-detectable, 2=slight/moderate, 3=severe)*				
Investments in SWC *(0=none, 1=bunds, 2=gully plugs, 3=farm pond, 4=boulder checks, 5=combination, 6=other (specify))*				
Investments in irrigation systems *(0=none, 1=lift, 2=hand pump, 3=tubewell, 4=drip, 5=other (specify))*				
Location near nala ? *(1=yes/0=no)*				
Location near check dam? *(1=yes/0=no)*				
Location near tank? *(1=yes/0=no)*				
Tenure arrangement if land leased in/out				
Rental share (%) 0=own land				

Tenure arrangement*: 0=own land 1=share cropping 2=fixed rent after harvest 3=fixed rent before harvesting 4=mortgaged 5=other*

Book 4: Household income

36. Average household income over the different cropping seasons

	Kharif	**Rabi**	**Summer**
Average income from food crop production			
Average income from cash crop production			
Average income from livestock production			
Average income from wage labour in watershed			
Average income from wage labour outside watershed			
Average income from migration			
How many days in a year do you migrate?			
How many days in a year do other family members migrate?			
Average income from other sources (specify)……………………			
Need to purchase cereals for HH consumption?0=no, 1=yes			

Book 5: Local Resource Management

44. Has the household been actively involved in watershed rehabilitation?

0=no 1=yes, member of VWC 2=yes, participation in meetings 3=yes, other means 4=yes, passively

45. Have you, or members of your family, participated in the food for work program last year or received other drought assistance? If yes, what?

0=No assistance 1=Food for work,less than 2 weeks 2=Food for work, more than two weeks 3=fodder for livestock 4=food for household 5=water tanker 6=combination 7=other _________specify

46. How has the household contributed to soil and water conservation?

0= none 1=voluntary labour 2=private investments on own land 3=contribution to overall costs (cash or kind) 4=plantation on own land 5=changed cropping pattern 6=changed livestock production 7=other ____________(specify)

47. How much have you approximately contributed over the last 5 years?

_______________*(any value, but be specific if it is in Rs. or labor days)*

48. How are you planning to continue contributing to soil and water conservation?

0=not 1=don't know 2=use less water 3=more stall feeding 4=OandM of SandW on own land 5=contribute in cash/kind to OandM of SandW on common land 6=OandM of check dams and water tanks 7=contribute to watchmen costs 8=combination 9=other________________ (specify)

49. What constraints do you face in contributing to soil and water conservation?

0=no constraints 1=don't know 2=others contribute less 3=effect unclear 4=labour costs are high 5=lack of organization 6=other ____________(specify)

50. To which extent do you consider yourself interested in the rehabilitation of the watershed?

1=not interested at all 2. not very interested 3. somewhat interested 4. fairly interested 5. very interested

51. To which extent do you consider the current state of common lands (pasture, forest, waste lands) in the watershed degraded?

1= very degraded 2= fairly degraded 3= somewhat degraded 4= not very degraded 5= not degraded at all

52. What do you think are the main reasons for the degradation of common and grazing lands?

0=not degraded 1=overgrazing 2=deforestation 3=overpopulation 4=destruction by some people 5=negligence by the government, 6=Conflicts in the community, 7= lack of rules and regulations 8=other

53. What needs to be done to reduce degradation?

0=don't know 1=reduce no. of livestock 2=new rules and regulations 3=fencing 4=higher penalties for breaking rules 5=more watchmen 6=reforestation/ban grazing 7=other

54. To which extent do you think water stocks in the watershed are being depleted?

1=almost depleted 2=considerable depletion 3=seasonal depletion 4=irregular scarcity problems 5=not problems with water availability at all

55. What do you think are the main reasons for the depletion of water resources in the watershed?

0=No depletion 1=too many bore wells 2=natural reasons like bad monsoon 3=overpopulation 4=over use by some people 5=negligence by the government, 6= conflicts in the community, 7=lack of water storage and conservation 8= other (specify)

56. What needs to be done to reduce water resource depletion?

0=don't know 1=increased water storage and conservation 2=rules and regulations 3= ban on bore wells 4=ban on certain crops 5= reforestation 6=other (specify)

57. Household benefits of watershed rehabilitation

Main benefit from watershed rehabilitation	
Secondary benefit from watershed rehabilitation	

0= no benefit 1= employment 2= water in tubewell 3= water in open well 4= soil moisture 5=better availability of drinking water 6= biomass/fodder 7= less soil erosion 8=other

58. Has everybody benefited equally from watershed rehabilitation, or have some benefited more?

0= don't know 1= others benefited more 2= others benefited less 3= everybody benefited equally 4= other (specify)

59. Who gained most benefits from watershed rehabilitation?

0=everybody gained equally 1=landowners near nala 2= landowners down stream 3= landowners with tubewell/open well 4= livestock producers 5= wage labourers 6= others ________________(specify)

60. Do you regularly attend meetings of the local panchayat, watershed committee or other village organizations?

0=no 1= yes, the panchayat 2= yes, water user organization 3= yes, watershed committee 4= yes, joint forestry committee 5= yes, other _____________(specify)

61. To which extent can you influence the decisions made?

0=not at all 1=sometimes, depends on issue 3=I can influence decision making 4=other ________________(specify)

62. To what extent do you feel the village representatives (sarpanch, watershed committee, water users etc) are working in your interest?

0=don't know, 1=not at all, 2=to a certain extent, 3=in most cases, yes, 4= yes, they are improving the welfare of all

Any remarks with regard to the questionnaire/any other information that might be useful but that has not been asked?

Thank you very much for participating in this questionnaire, and once we have analyzed your answers we will come back to share the results.

Annex C Protocol of the field experiments

Day 1: Instruction day

Welcome to all of you. Today we will give instructions about a game you will play tomorrow. In the game you may earn some money. There are no winners and losers in the game, but how much you earn will depend on how you play the game. Today, you will not earn any money. However, only the people that attend the full session today are allowed to play for real money tomorrow. The objective of the game is purely research and the money for the game comes from Europe, from a Dutch university. Seva Mandir/WOTR has no role in this event, they are only facilitating.

Before I explain the game to you, I would like to introduce the research team. My name is Jetske Bouma. I come from Holland and I work at the International Water Management Institute in Hyderabad. My translator you all know, his name is Pradhumn Jagtap and he has been doing research for me in this area for the last 3 months. My other two assistants are Bhim Raj Suthar and Srinivas Rao. They also form part of the research team, and are based in Rajasthan and Andhra Pradesh.

Now I would like to explain the game to you. Tomorrow, this group will be divided into two groups. In the one group, everybody will be assigned the role of PLAYER 1 in the other group everybody will be assigned the role of PLAYER 2. You will play the game with somebody from the other group. So, if you are assigned the role of PLAYER 1 you will play with somebody in the other group who has been assigned the role of PLAYER 2. If you are PLAYER 2, you will play the game with somebody in the other group who has been assigned the role of PLAYER 1. To make sure you do not know with whom you play the game, the person you play the game with will be in another room. So tomorrow, one group will stay in this hall, another group will go to another room. You will not learn who the person is with whom you play the game and the other person will not learn your identity either. Nobody will know with whom you play the game.

To both players we give Rs 50. Now suppose you are assigned the role of PLAYER 1. That means you have to start the game and decide how much of the Rs 50 you send to the person in the other room. All the money you send to the person in the other room, we will triple. All the money you keep is for yourself. So, if you send Rs 10, the person in the other group receives Rs 30 and you keep Rs 40.

If you send Rs 20, the person in the other group receives Rs 60, and you keep Rs 30

If you send Rs 30, the person in the other group receives Rs 90, and you keep Rs 20

If you send Rs 40, the person in the other group receives Rs 120, and you keep Rs 10

If you send Rs 50, the person in the other group receives Rs 150, and you keep Rs 0

You also have the option to send nothing and keep the Rs 50 to yourself. The person in the other group then receives nothing. (all on the blackboard)

Now, the second part of the game starts. Suppose you are PLAYER 2. That means you receive money that has been sent to you by somebody in the other group. You have to decide how much of this money you want to send back to PLAYER 1.

Suppose Player 1 has sent you 10 Rs. That amount is tripled, and so you receive Rs 30. Of these Rs 30 you can send back 0, 10, 20 or 30 Rs.

Suppose Player 1 has sent you 20 RS. That means that you receive Rs 60. Of these RS 60 you can send back 0,10,20…60 Rs.

Suppose Player 1 has sent you 30 Rs. That means that you receive Rs 90. Of these Rs 90 you can send back 0, 10, 20….90 Rs.

Suppose PLAYER 1 has sent you 40 Rs. That means you receive Rs 120. Of these Rs 120 you can send back 0, 10, 20…120 Rs.

Suppose PLAYER 1 has sent you 50 Rs. That means that you receive Rs 150. Of these Rs 150, you can send back 0, 10,20….150 Rs.

PLAYER 1 can also decide to send you nothing, which means you cannot send anything back.

Your total earnings if you are assigned the role of PLAYER 1 then equals the amount of money you started out with (Rs 50), minus the amount of money you decided to send to PLAYER 2, plus the amount of money PLAYER 2 decided to send back to you.

Your total earnings if your are assigned the role of PLAYER 2 equals the amount you started out with (Rs 50), plus the amount of money you received from PLAYER 1, minus the amount of money you decided to send to PLAYER 1.

If PLAYER 1 sends nothing, PLAYER 2 is not able to send anything back, so from the game both players earn Rs 50.

If PLAYER 1 sends 10 Rs and PLAYER 2 sends Rs 10 back, PLAYER 1 earns Rs 50 and PLAYER 2 Rs 70 ETC. (all on the blackboard)

To make sure you understand the game, we will now show with paper money how the game is played.

(On one side of the room PLAYER 1 and on the other side of the room PLAYER 2. Both receive an envelope, PLAYER 1 a colored envelope, PLAYER 2 a brown envelope. Both players show there is Rs 50 inside. PLAYER 1 takes money from the colored envelope and gives the rest to the experimenter. The experimenter walks to the middle, takes it out of the envelope, triples it and puts it in a different envelope. This envelope he brings to PLAYER 2. PLAYER 2 opens the envelope and takes out what he wants to keep for himself. The experimenter collects the colored envelope with the remaining money. The experimenter takes it out of the envelope, puts it in the original envelope and gives it back to PLAYER 1. PLAYER 1 and PLAYER 2 now both show how much money they have). REPEAT 6 times for the options PLAYER 1 has (0,10,20,30,40,50)

Tomorrow we will test each of you individually to see whether you understand the game. Only if you understand the game are you allowed to play. If you have any doubts, please clear them now.

This is the end of the instruction day. Tomorrow we will play for real money. Please come your self and come on time. If you don't come yourself, the person you sent will not be allowed to play the game. Only if you come yourself and if you are on time, are you allowed to play the game.

Day 2: Implementation of the game

WELCOME to all of you. Today we will play the game. We would like you to take the game seriously and we would like to ask you not to talk to other participants during the entire event. Today we will play for real money. You might earn a substantial amount of money, but it is also possible that you do not. There are no winners and losers in this game but how much you earn, will depend on how you play the game. To make sure none of you goes home empty handed, we will give each one of you Rs 50 at the end of the game. This is additional to what you earn in the game. However, if during the game you talk to other participants or do not follow the rules in any other way, we will not pay the Rs 50 at the end.

To you refresh your memory, I will now recapture the instructions we gave yesterday. This group will be divided into two groups. Some of you will stay in this room, some of you will go to another room. The game you play will be with somebody from the other group (in the other room). You will not learn whom the other person is with whom you play the game, and neither will the other person know that he/she has played the game with you.

All participants, no matter what role they play, receive Rs 50.If you are assigned the role of PLAYER 1, you start the game by deciding how much money you send to PLAYER 2.

You leave the amount that you want to send to PLAYER 2 in the coloured envelope, and you take out the amount you want to keep yourself. We collect the envelope and triple the money we find inside. This amount we give to PLAYER 2. If you are assigned the role of PLAYER 2, you now receive the coloured envelope; with inside the money somebody has sent you from the other room. You take out of the coloured envelope the money you want to keep. The money you leave inside the coloured envelope will go back to PLAYER 1. We collect the envelope and bring it back to PLAYER 1.

Now I would like you to come forward and pick a piece of carton from this box. It is either marked orange or green. My assistants will ask you to show the carton to them, so that they can register it. Please do not show to the other participants what number or letter you have. Those of you with a letter on the carton will form the red group, those of you with a number are the green group. The people who draw an orange card will stay here, those who draw a green card will go to another room. Are there any questions or doubts? If not, I would like to ask you one by one to come forward and draw a carton.

Instructions 1: Orange (Green) group

Welcome to the orange (Green) group. I am the facilitator of this group and I request you to follow my instructions. Please do not communicate during the game. Anybody who does communicate during the game will be punished by not receiving Rs 50 at the end.

First, we want you to pick a carton from this box (orange (green) box 1). On the carton there is a letter (number). We will ask you to show us this letter (number), so that we can register it. Please don't show your letter (number) to any of the other participants: it is your personal letter (number).

Now, all the orange (green) people have been assigned to play the role of PLAYER 1. We will again explain to you what this means. We will give you two envelopes. One envelope is brown and unmarked. It is empty and you can use it for the money you want to keep for yourself. So, all money that you put in the brown envelope you keep for certain. The second envelope is orange (green) and is marked with a letter (number). The mark on the envelope matches with your personal letter (number) on the carton. When we give you the orange (green) envelope, please check if it has your personal letter (number) or not.

The orange (green) envelope contains Rs 50 and this is the money you may send to PLAYER 2. Any amount you decide to send to PLAYER 2 we will triple. So,

If you leave Rs 10 in the orange(green) envelope, PLAYER 2 will receive Rs 30, and you keep Rs 40.

If you leave Rs 20 in the orange(green) envelope, PLAYER 2 will receive Rs 60, and you keep Rs 30.

If you leave Rs 30 in the orange(green) envelope, PLAYER 2 will receive Rs 90, and you keep Rs 20.

If you leave Rs 40 in the orange(green) envelope, PLAYER 2 will receive Rs 120 and you keep Rs 10.

If you sent Rs 50 in the orange(green) envelope, PLAYER 2 will receive Rs 150, and you keep Rs 0.

If you decide to send nothing, PLAYER 2 receives nothing and cannot send anything back.

PLAYER 2 might decide to send money back to you. The money you earn at the end of the game is the money you have kept to yourself plus the money PLAYER 2 has sent back to you.

For example, if you send Rs 10 and PLAYER 2 sends back Rs 20, you earn Rs 40 + Rs 20= Rs 60.

For example, if you send Rs 40 and PLAYER 2 sends back Rs 60 you earn Rs 10 + Rs 60 = Rs 70.

For example, if you send Rs 40 and PLAYER 2 sends back nothing you earn Rs 10 + Rs 0 = Rs 10.

As promised, we add Rs 50 to the amount of money you earn in the game IF you do not talk to other participants during the event.

We will now ask you one by one to come forward and draw a carton from the orange (green) box. Show us the carton and check if the orange (green) envelope we give you has the same letter (number) on it. Then, take out of the orange (green) envelope the money you want to keep for yourself. This money you put in the brown envelope, your personal 'wallet'. Don't show others the money you have in the brown envelope, this is your personal money. The money you leave in the orange (green) envelope will be tripled by us and sent to the person in the other group. If you are done, give the closed orange (green) envelope to my assistant. Before we start the game, my assistant and me will ask each of you individually a few questions to check your understanding of the game. Only if you understand the game you will be allowed to participate. Before my assistant and me check your understanding, are there any questions?

Then I would like you to come forward one by one so that we can ask you some questions. (While asking the questions, write the examples down on paper)

If, out of the Rs 50 in the orange (green) envelope you decide to send Rs30 to PLAYER 2, how much do you have left yourself [Answer: Rs 20]

- If you sent Rs 30 to PLAYER 2, how much does PLAYER 2 receive? [Answer: Rs 90}

- If PLAYER 2 receives Rs 90, what is the maximum amount of money he/she can send back to you? And what is the minimum amount? [Rs90, or Rs0]

- Suppose that you sent PLAYER 2 Rs 30 and that PLAYER 2 decides to send Rs 50 back to you. What are your total earnings? [You: Rs 20 + Rs 50 = Rs 70].

Now, we will start the game. If you have any questions during the game, please raise your hand and we will come to you. Are there any questions now? If not, let us start the game.

Instructions 2: Orange (green) group

So, we have now completed the first part of the game. In fact, the participants in the other room also played the role of PLAYER 1. That means that now you will play the role of PLAYER 2.

As PLAYER 2 you will receive a green (orange) envelope from somebody in the other group. In this envelope you will find the money somebody from the other group has sent you. You have to decide how much of this money you want to send back to that person in the other group. The money you take out of the green (orange) envelope you keep for yourself. The money you leave in the green (orange) envelope will go back to the person who sent you the money from the other group.

To decide which envelope you receive, we will ask you to pick a carton from this box (orange (green) box 2). On this carton a number (letter) is written. This number (letter) belongs to somebody in the other group. The money you receive will be from that person. Any amount you decide to send back, will go to the same person in the other group. This will most probably not be the same person you sent money to in the first part of this game: it will be a different person.

Now, we will ask you one by one to come forward and pick a piece of carton from the box. You have to give this carton to us and we will give you the corresponding envelope. Please open the green (orange) envelope and take out the amount of money that you wish to keep for yourself. This money you put in your own brown envelope. The money you want to send back you leave in the green (orange) envelope. If you are finished, give the closed green (orange) envelope back to my assistant.

We will give the green (orange) envelope back to the person to whom it belongs in the other group. At the same time, we collect the orange (green) envelopes you sent, from the persons who received it in the other group. We then give you back your own orange (green) envelope. The money you find inside is yours.

Are there any questions? If not, let us continue with the game.

Instructions 3

The game is now finished and the money you hold is yours. Please do not tell other people how much money you have earned, this is personal information you should keep to yourself.

Thank you!