SEI Project Report

Agricultural water management in smallholder farming systems: the value of soft components in mesoscale interventions

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2008

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Project funded by the Bill and Melinda Gates Foundation

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EXECUTIVE SUMMARY

Agricultural water management (AWM) is generally perceived as a key step towards improving low yielding smallholder farming systems in sub-Sahara Africa, South Asia and Latin America. However, efforts to address improved AWMs at the mesoscale watershed is often more complex than improving AWM at the farm scale. In this review, we study examples of mesoscale watershed interventions, to identify values of the associated soft components. Firstly, what are the emerging commonalities in watershed interventions for AWMs concerning the social and institutional settings? Secondly, are there any methodologies in watershed interventions that may be particularly successful, and thirdly, what are the costs associated with watershed interventions including /excluding social capital investments? The ten cases and the World Bank projects review represent a range of agro-ecosystems in the developing world, whereas the meta-analyses are based on India watershed experiences.

The reviewed material shows that there is a high consensus that key characteristics for successful watershed interventions in AWMs has fairly high initial social capital and a fairly high investment in consensus building and capacity building (including awareness raising) in formal and informal stakeholder organisations. Enabling policies as well as multiple livelihood approaches rather than a single sector AWM approach also emerge as common characteristics from successful cases and meta-analyses. The cases suggested that an external agent of change (providing new knowledge a/o mediating) was often needed to incite the intervention.

The reviewed cases are fairly consistent in the proposed methodologies for building local engagement. They all built on highly participatory methodologies, mostly using a 'common interest approach' where local stakeholders and stewards of the land and water resources are engaged in learning groups with a common theme. Often these groups were formed on existing social structures, and facilitated and strengthened through external support.

The cost-benefits and rates of return on mesoscale watershed interventions for AWM were poorly documented in general, including in the reviewed material. Although most interventions are justified by the aim to alleviate poverty (improve the livelihood of beneficiaries), these data are poorly reported. Nor are the consequences on the land and water resources of the subject area, or areas external to the intervention site, well monitored and addressed.

To conclude, there appears to be little consistent monitoring of gains and losses of AWM interventions in mesoscale watershed management both concerning social changes (soft components) as well as environmental changes within and beyond the watershed subject to interventions. To translate these gains and losses also into monetary values will contribute towards the potential weighing of project investments and environmental management in the future.

Photo: Maimbo Malesu/ Alex Oduor

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INTRODUCTION

In the developing world, poverty and hunger alleviation is still the dominant issue among rural communities. Rainfed agro-ecological landscapes currently provide food and livelihoods for the predominantly rural population. This is also where poverty and under-nourishment is at its highest, estimated at approximately 70% of rural inhabitants. Agricultural water management (AWM) in conventional smallholder farming systems can provide a win-win solution in the provision of opportunities to secure crop production, thus enabling other much-needed investments in, for example, nutrients, weeding and timely operations. However, the emerging effects on landscape water resources induced by many farmers changing their field-scale water management strategies are unpredictable and context specific. It is increasingly being realised that to ensure successful and sustainable adoption of new AWM approaches, a range of different issues must be addressed. Clearly, AWMs need to be biophysically and technically appropriate and economically viable. There is also an increasing awareness of the need to focus on the formal and informal institutional setting, which ultimately define the governance of water and land at the local scale. The complementary support to institutions and community mobilisation at the mesoscale of small catchments is equally important to gain successful adoption of new AWMs. Thirdly, the emerging externalities, both on water and land resources not subject to AWM interventions needs, as well as social and equity issues, must be addressed: who benefits and who loses?

This paper aims to give a first overview of 'soft components' in mesoscale interventions in AWM strategies targeting rural smallholder farming communities in sub-Saharan Africa, Latin America and South Asia. Specifically, it will address lessons learned in the case context (i.e., who initiated the process, what were the initial investments, how did the out-scaling gain momentum, etc.). Secondly, this paper will present examples of methodologies for community mobilization and AWM technology/practice adoption. Finally, a few issues concerning cost and benefits of mesoscale AWM interventions will be discussed. The analysis was carried out as a desk study on existing literature and documentation and through selected consultations in the water and land management development sector in sub-Saharan Africa.

Photo: Stacey Noel

2 BACKGROUND

2.1 AWMS TO UPGRADE RAINFED FARMING

For decades the AWM focus has been either on the farmers' field (soil and water conservation) or on the greater sub-basin/basin scale for irrigation development. The mesoscale1 has largely been left out, particularly in sub-Saharan Africa. This omission is understandable given that water resource management at the mesoscale entails management of intermittent blue (runoff) flows that flow through the landscape in a short period of time (as compared to stable runoff in rivers and groundwater at the larger basin scale). At the mesoscale, the focus is on managing storm surface runoff in water harvesting systems or into the soils ('green water'), instead of diverting stable river flow for storage in dams. The Comprehensive Assessment (2007) clearly showed that the challenge of meeting growing food demand will hinge on the ability to upgrade rainfed agriculture, particularly in areas with high incidence of poverty, and in areas with high variation in rainfall such as the sub-humid and semi-arid environments of Africa, Asia and Latin America. In these dry areas, rainfed agriculture currently has low yield production and low water productivity (as m^3 water per ton biomass) due particularly to the frequent occurrence of dry-spells, but also due to soil nutrient conditions and overall management in crop production systems.

The significant and wide knowledgebase on soil and water conservation strategies (SWC) provides a first step towards the improved *in situ* water management techniques of AWMs. These initiatives have often resulted in successful erosion control, but have not adequately addressed crop water availability during dry-spells, which affect final yield levels of smallholder farmers. The only way to manage dry-spells in rainfed agriculture is through investments in field-scale water and addition of micro-irrigation components in rainfed systems. Improving and securing crop water will provide the needed 'window of opportunity' to secure further investments in the crop system, such as fertilizers, pest and weed management, as well as farm diversification in crops and livestock. However, the incentive to invest in improved AWMs may not necessarily emerge from the farmer or local community. Often, new approaches in AWM are facilitated through agents of change (donor, local government/extension, NGO or proactive individuals in a community).

Future demands will require that more water be allocated to food production, thus increasing pressure on accessible water resources in the landscape. Already, water stress is emerging in a range of climate zones, not just arid environments, when accounting for total rainfall available per capita (Rockström *et al*., forthcoming). Climate change may exacerbate or decrease current water stress indicators for many developing tropical and sub-tropical regions, but there is a high degree of uncertainty associated with climate predictions. Thus, AWMs to increase on-farm productivity are one step to adapt to increased uncertainty. At the same time, it is important to ensure that potential water trade-offs in the landscape are understood, so that the increase in on-farm water management does not undermine surrounding landscape productivities, or down stream located developments of water resources.

2.2 THE AGRO-HYDROLOGICAL MESOSCALE: POLICY GOES INTO PRACTICE

The incentives of policy, legislation and markets are often at a much higher spatial scale than where the actual implementation of AWMs occurs in the farmers' field (Fig.2.1). Three issues merge at the mesoscale:

- Administrative directives, policies and drivers of change concerning water, land and agriculture (including livestock) are to be operationalised at a local level;
- The biophysical features of water resource management moving from plot to mesoscale

1 The mesoscale is defined as beyond the farmers' field but below the basin catchment; it can be described as the community, village or sub-catchment level. Regarding size, it typically encompasses 1 – 10,000 km2.

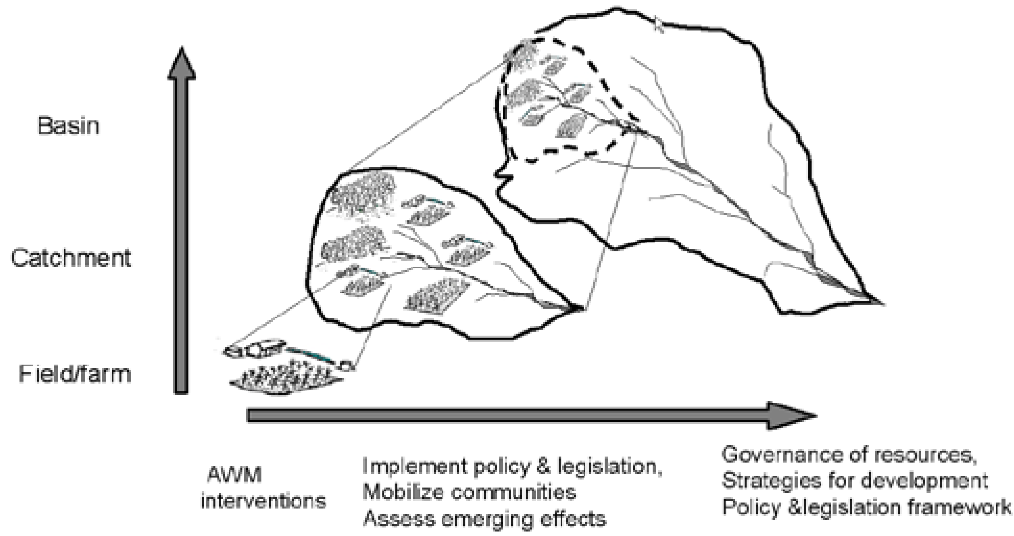

Figure 2.1: Water management in different spatial scales

is particularly challenging as the green water (predominant at plot scale) turns into blue (at the catchment scale), and the dominant hydrological flow paths can be difficult to predict. For example, at the farmer field scale, up to 30% of seasonal rainfall can be lost as surface runoff, whereas at the outlet of the catchment typically 10-20% of seasonal rainfall is stable blue flow. This results in the inability to aggregate the changed water flows through spatial scale, whereas water quality can be summed through the spatial scales; and

- Negative and positive externalities emerge when the implementation of 'top down' policies and legislation, and the aggregated hydrological effect of 'bottom-up' AWMs at field scale, are poorly aligned. These are of two types: (i) the upstream-downstream potential trade-offs (where upstream land use affects water quality and quantity downstream), and (ii) the within watershed trade-offs (when on-farm water management affects off-farm land use productivity).

Thus, the watershed management moves beyond the AWM implementation at individual farms and communities, to safeguard sustainability in greater spatial and temporal scales of water and land resources

Photo: Maimbo Malesu/ Alex Oduor

3 SOCIAL AND INSTITUTIONAL SETTING FOR AWM INTERVENTIONS: META-ANALYSES AND SYNTHESISING CASES

3.1 WATERSHED MANAGEMENT AND STAKEHOLDER PARTICIPATION: META-ANALYSES

The need to incorporate participation in watershed management approaches has been increasingly recognized in the last few decades, largely due to the failure of centrally-planned projects that introduced AWMs technologies and techniques using subsidies and coercive measures (Johnson *et al.* 2001). Two meta-analyses of watershed management development projects in India, and a recent review of watershed intervention projects funded by the World Bank (World Bank, 2007) offer evidence of the importance of participation in achieving successful outcomes.

The first study, by Joshi *et al.* (2005), undertook a meta-analysis of 311 Indian case studies. The project included all types of watershed programs and implementing agencies (central and state government, World Bank, European Economic Community and bilateral donors). The cases covered a wide range of ecological and agricultural conditions in terms of location, size, rainfall and regional prosperity. Each study was assessed on three elements:

- investment efficiency: proxied by benefit-cost ratio and the internal rate of return;
- equity: measured by additional employment generation in agriculture; and
- sustainability: indicators were (i) increased water storage capacity; (ii) increased cropping intensity; (iii) reduced runoff; and (iv) reduced soil loss.

An ordinal scale (high, medium, low) was used to score participation.

The study found that the watershed programs met the objectives: the mean cost-benefit ratio was 2.14 and the mean internal rate of return 22%; mean additional annual employment of 181 person days/ha/year (for watershed projects including multiple activities, the figure was 900 person days/ha/year); soil loss savings of 0.82 tons per ha per year, average of 13% reduction in surface runoff, and on average increase in irrigated area of 34% and average increase in cropping intensity of 64%. However, projects with higher levels of participation outperformed projects with medium or low participation (Figure 3.1). The authors

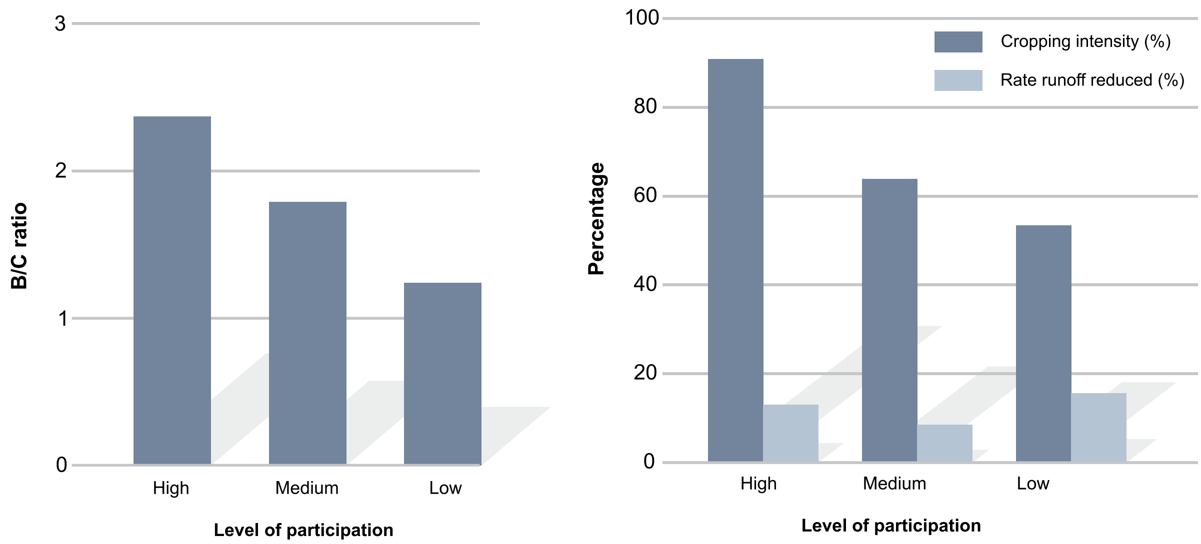

Figure 3.1: Indicators of efficiency (left) and sustainability (right) of high, medium and low community participation in India watershed management

Source: data after Joshi *et al.* 2005

concluded that the '*evidence reveals that people's participation was the key determinant in the success of the watershed development programs*.'

Interestingly, the study also found that benefits were noticeably higher in low-income regions (benefit-cost ratio of 2.46) than in high-income areas (1.98). Similarly, annual employment in low income regions was 175 person days/ha/year versus 132 in high income areas.

A second meta-analysis was performed by Kerr (2002) and considered 76 villages in Maharashtra and 10 in Andhra Pradesh, including villages with and without watershed projects; villages with projects included those administered by government focusing mostly on technical interventions, by NGOs with an emphasis on social organization, and by collaboration between the two that attempted to combine the two approaches. To ascertain project success, the analysis utilized the following performance criteria:

- soil erosion;
- measures taken to arrest soil erosion;
- groundwater recharge;
- soil moisture retention;
- agricultural profits;
- productivity of non-arable lands; and
- household welfare

The analysis looked at before and after conditions in project villages, utilizing data on performance indicators from a 1997 IFPRI/National Centre for Agricultural Economics and Policy (NCAP) survey, supplemented by additional fieldwork to collect quantitative and qualitative data at the plot, household and village level in 13 of the Maharashtra villages and 16 of the Andhra Pradesh villages (village-level data was also collected in the other 57 Maharashtra villages).

The study aimed at answering three questions: (i) which projects were most successful in terms of raising agricultural productivity, improving natural resource management and reducing poverty; (ii) what approaches enabled project to succeed; and (iii) what non-project factors contributed to success? The general finding was that 'the participatory projects performed better than their technocratic, top-down counterparts. However, participation combined with sound technical input performed best of all.' The author concluded the reason for the success of participatory approaches hinged on the complex and location-specific livelihood systems in the study villages, which required high levels of flexibility. It was also noted that both NGO and collaborative (NGO/government) projects typically chose villages that had previously demonstrated the capacity for collective action. Finally, the conclusions also flag the fact that the collaborative project villages had all been part of previous watershed projects, and therefore experienced NGOs had been operating in the villages for several years; thus the issue of scaling-up would be dependent on the presence of a network of strong, capable NGOs, which likely will not exist in the numbers needed.

The presence of an external actor to catalyze collective action on watershed management also seems to be a critical factor. Hinchcliffe *et al.* (1999) found that even when users could realize gains from cooperative management, the collective action needed to achieve it rarely emerged on its own. It appears that the institutional setting at the local level, both formal and informal, is often not sufficiently developed to give rise to mesoscale water management, offering an explanation why these approaches have not spontaneously spread more widely despite the benefits to local communities. This result may particularly hold true in communities with heterogeneous populations, where the capacity for collective action is especially constrained.

In a recent review of lessons learned in World Bank funded watershed project interventions 1990-2004, similar conclusions were made (World Bank, 2007). The review recognises the shift in development paradigm in the early 1990s when watershed interventions began to address issues beyond water resources. Poverty alleviation, natural resource conservation and productivity increase were also included into the watershed management and development agendas. The report concludes that interventions had been focussing in the mesoscale (up to 62 km^2) and at that scale it was possible to bring different stakeholders together. However, due to consistent lack of monitoring of hydrological impacts and inadequate modelling, the review could not find evidence that the upstream interventions at mesoscale watershed had significant impact on water flow a/o quality downstream at a higher spatial scale. But projects did often have a locally improved effect as in reduced erosion within the selected watershed. Nor did the review give solid evidence that the interventions in the projects reduced poverty, although projects achieved income increasing targets. The most successful projects were those undertaken in highly degraded watersheds, and when interventions were perceived as investments with short return periods. A diverse set of technologies for stakeholders to select from was also identified as a reason for successful adoption. Another factor for success was the anchoring of the intervention activities in local institutions, to ensure custody of the watershed interventions beyond the project period. Local stakeholder involvement in problem definition, research and outreach was identified as a cornerstone in successful projects, and to enable equity in participatory processes the review recognises the value of human capacity building at different levels.

3.2 WATERSHED MANAGEMENT AND STAKEHOLDER PARTICIPATION: SELECTED CASES

To investigate the dimensions of social and institutional setting in watershed (mesoscale) AWM interventions, a number of cases were identified through literature searches. The cases were used if the case description provided sufficient understanding of the initial context of the social and institutional setting as well as the process of AWM introduction. The cases were not always intended to be on a watershed scale, but may have had effects that potentially could apply to a corresponding watershed-level intervention.

Biophysical and social characteristics of cases

The different cases presented here include a wide range of social and environmental settings (Figure 3.2; Table 3.1). All cases were set in rural areas with potential high degree of poverty among communities; however, data on poverty was not always available in the case descriptions. Different rainfall regimes were represented, spanning from the tropical semi-arid in Burkina Faso to the humid tropics of the Philippines. The key water-related issues in the sub-humid and semi-arid

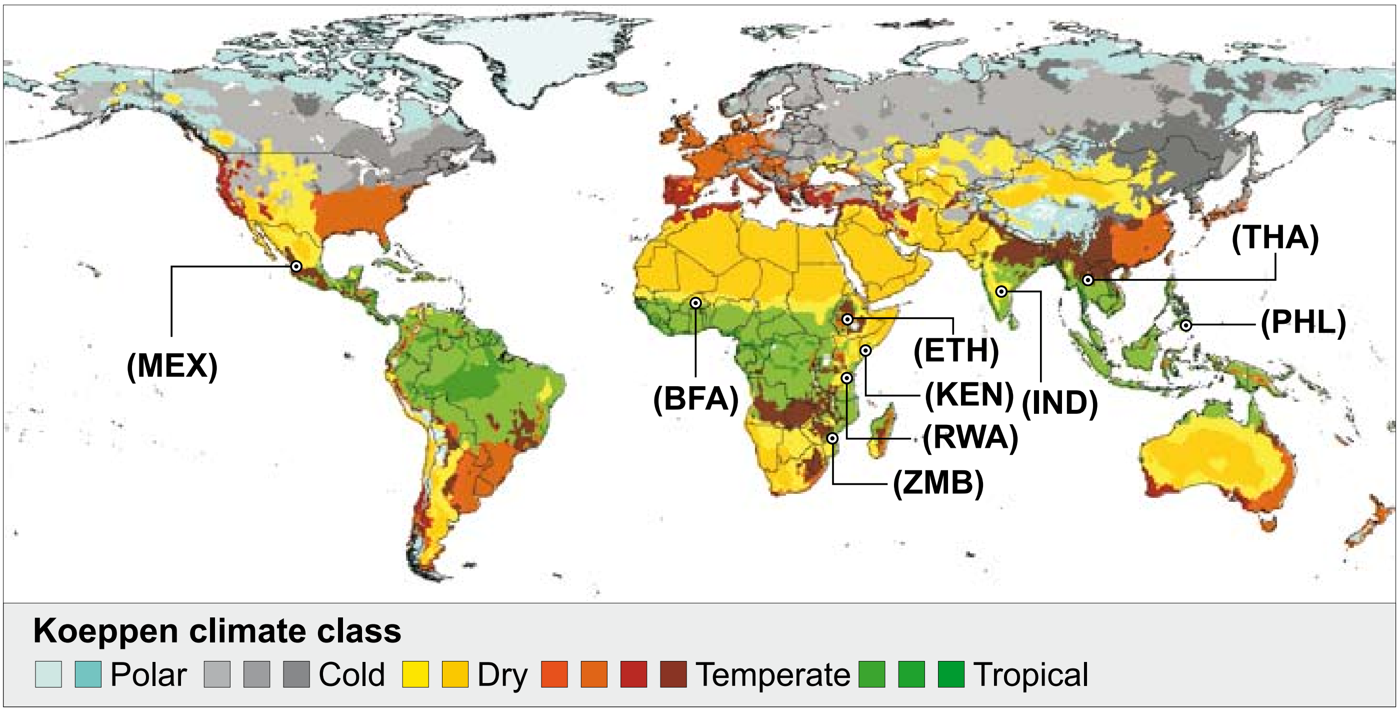

Figure 3.2: Locations of cases in the review of social and institutional context for AWM interventions at the mesoscale

Table 3.1: Biophysical and farming system characteristics of cases

Location	Climate regime	Area	Farming system	Water issue	Reference
Yatenga Province BURKINA FASO	Tropical semi-arid (600-700 mm y^{-1})		Smallholder subsistence rainfed	Low yields, dryspells, erosion, degardation	Kaboré & Reij, 2004
Wulinchiti ETHIOPIA	Tropical semi-arid (800 mm y^{-1})		Smallholder subsistence, rainfed	Dry spells/floods low yields	Shone, pers com.
Adarsha Andhra Pradesh INDIA	Tropical semi-arid (780 mm y^{-1})	4.3 km^2 (1.4 ha /household)	Smallholder subsistence, rainfed	Erosion Dryspells Lowering groundwater	Sreedevi *et al*., 2004
Powerguda, Andhra Pradesh, INDIA	Tropical semi-arid (1100 mm y^{-1})	4.2 km^2 (53% agric. land)	Smallholder subsistence, rainfed	Erosion, water logging, lowering groundwater	D'Silva *et al*..2004
Lare Division Nakuru District KENYA	Tropical semi-arid (850 mm y^{-1})		Smallholder subsistence, rainfed	Dry spells, low yields	Malesu *et al*., 2006
Kusa KENYA	Tropical sub-humid (1100 mm y^{-1})	NA	Smallholder subsistence, rainfed	Erosion, low yields,	Sandstrom *et al*., 2005;
Trojes de Paul MEXICO	Tropical semi-arid (630 mm y^{-1})	30 km^2	Smallholder rainfed, irrgated	Low yields, dryspells, closed basin	Scott and Silva-Ochoa, 2001
Nyanza, Bugesera & Ruhango Districts, RWANDA	Tropical humid (1150 mm y^{-1})	22,000 ha	Smallholder subsistence, rainfed & irrigated	Low yields, dryspells, degradation	Malesu & Oduor, 2007
Manupali Bukidnon PHILIPPINES	Tropical humid (1800mm y^{-1})			Erosion deforestation	Catacutan & Duque, 2006
Various provinces, ZAMBIA	Temperate/tropical sub-humid	15% of smallholder farmers	Smallholder subsistence, rainfed	Low yields, land degradation, loss of draught power	Malesu & Oduor

cases were irregular rainfall, i.e. the occurrence of intra-seasonal dry spells, and droughts and floods. Also, soil degradation in the form of soil erosion losses, crusting and reduced soil fertility was mentioned. In the humid site, the predominant water-related concern was erosion associated with too much water on steep sloping land (Philippines case). In all cases, the wider livelihood issue of poverty was mentioned as one motivation (together with water-related agricultural issues) for initial involvement in the specific community. More detailed descriptions of the cases can be found in Appendix I.

Commonalities of social and institutional issues emerging in cases

Despite the great biophysical and social diversity that the cases represent, some commonalities emerge on the soft components in mesoscale water management interventions (Table 3.2). The soft component issues related to what is pre-existing, to what is on-going during the project intervention, and what happens after the project ends.

Pre-conditions: most cases had a relatively high level of internal social capital, in the form of community organisation. These community groups differed from case to case: some were determined by age and/or gender (youth, women), while others were determined by interest (e.g. farmers groups, irrigation communities, churches, etc).

Mobilisation for implementing AWMs: all the reviewed cases mentioned the strengthening and involvement of existing community organization as a key to successful implementing AWMs on private and/or common lands in the watershed. Key individuals (sometimes 'champions') in the communities often played a central role to initiate contact and/or act as links between the larger community and external facilitators.

External agent of change: most of the cases had external agents of change who introduced new knowledge systems, capacity building and funding to facilitate adoption of AWMs. Only one case (Trojes de Paul, Mexico) was described as being initiated by the local community. In most cases, the external agents provided two key inputs: new knowledge and funding to facilitate implementation and build capacity.

Other factors: another commonality among several of the case studies was the organisation of the external (donor, NGOs, extension, research) and local agents. To increase efficiency and build institutional and human capacity, a consortium was often formed whilst the project was on-going.

Although the initial aim of this study was to identify issues on soft components and institutional settings, there were additional commonalities that emerged from the selected cases:

Problem description: in the cases identified here, the initial problem description concerning water-land resources was not necessarily identified by local stakeholders.

Multiple livelihood approach: in several cases, interventions did not solely focus on one AWM technology, but often involved a range of technologies aimed both at individual farms as well as common land. In addition, several of the projects purposely had taken a livelihood approach mixing technologies for a range of crop improvements and addressing household and livestock issues.

Monitoring and evaluation: the implementation of AWMs was not monitored and evaluated for long-term impacts on natural or social capital. Thus, there is little knowledge on how sustainable these mesoscale interventions were for the involved communities, or how effective they were to address the initial issues on erosion, dry-spells and low yields. There is very little information on how livelihoods improved or poverty was reduced in quantitative terms.

Cost-effectiveness: the cases rarely discussed the economic returns of investments, and consequently there is little information on investment cost-effectiveness.

Public institutions - community partnership: it is notable that all the cases are examples in which new consortium of actors are brought together on a common development agenda. These key actors are the local community and the local public institutions, with a selection of additional inputs from donor, researchers NGOs and possibly others. Also of note is the absence of private sector entities to address the identified entry problems of water management at the watershed scale: it appears that in these cases the returns were not sufficiently attractive and/or the risks too great to elicit the involvement of the local business community.

Photo: Maimbo Malesu/ Alex Oduor

Table 3.2: Social and institutional summaries for cases with AWM interventions

Case study name	AWM promoted	Social capital	Mobilisation for AWMs	Funds/ Investment	Other factors
Yatenga Province BURKINA FASO	*In situ* AWMs	local community groups (farmers)	Pro-active individuals NGOs experimenting with SWC Informal: intra-village farmers information sharing	Internal: labour External: funding for exchanges, transport of mtrs	
Wulinchiti ETHIOPIA			local community groups (CIG)	External: piloting finds &expertise Local:extension	Multiple livelihood interventions
Adarsha Andrha Pradesh INDIA	*In situ* AWMs Storage	local leadership, local community groups (women , young)	local community groups (water) Individual leaders Farmer-to-farmer	Internal: own investment on private land,	Multiple livelihood interventions Consortium of partners in AWM intervention
Powerguda, Andrha Pradesh, INDIA	*In situ* AWMs	Community groups, esp. women groups Initial high social capital	local community groups (CIGs, forest, water) Local government	Internal: External : ICRISAT, WB, VSS, IFAD	Fast economic return of AWMs Multiple livelihood interventions
Lare Division Nakuru District KENYA	Storage, irrigation, *in situ* AWMS		Local community initiative/ willingness to adopt new techniques Pro-active individuals	External: local and international NGO, govt	
Kusa KENYA	*In situ* AWMs Irrigation storage	local community groups Groups networks	Community groups (CIGs) networks: Pro-active individuals	Internal: labour, raising micro credit scheme External: provided by ext donor, gvt	Multiple livelihood interventions
Nyanza, Bugesera & Ruhango Districts, RWANDA	Off stream storage, *in situ* AWMs, supplementary irrigation	National policy support, Local leadership, local community groups	CIGs, Farmer Cooperatives, Govt parastatals	Internal: Labour. External: MINAGRI, RADA, ICRAF	Integrated WRM; Partners in AWM interventions
Trojes de Paul MEXICO	On-stream storage, irrigation	local community groups (farmers) Initial high social capital	Community involved in resource mobilization for reservoir construction	Internal: labour External (provided by central government)	Long tradition of communal management and collective action land communally titled
Manupali Bukidnon PHILIPPINES	*In situ* AWMs	Enabling policy Initial high social capital	Community groups for NRM	LGU initiator External: by USAID, ICRAF, HPI &local gvt	Wider NRM Strong focus on particip, awareness & capacity building
ZAMBIA	*In situ* AWMs	Enabling policy	Farmers groups, farmers union	Internal: Extension service, Farmers union External: Bilateral partners	Institutional support key stakeholders

4 EXAMPLES OF METHODOLOGIES FOR PARTICIPATORY MESO-SCALE INTERVENTIONS

4.1 COMMON INTEREST GROUPS

The Common Interest Groups (CIG) approach involves creating action-oriented self-help groups based around a particular AWM package or other livelihood activity, with water issues typically serving as the entry point into the community. The CIG methodology centers on an external facilitator, for example an NGO, providing the impetus for group formation. The facilitators' role is foremost to enable the CIG to develop their own learning around a specific technology or issue and assist in the introduction of expertise to the group and help arrange training or field visits. As the CIG is thoroughly driven by the members' own willingness to participate and to develop around a certain theme, the group will only survive as long as members have an interest and feel 'ownership' of the idea.. The necessary training is provided, with community members then advancing the process as they create new groups relevant to their particular location. Although the initial CIG often focuses on a specific AWM, additional groups can spontaneously form by the community around other livelihood activities or local concerns based on residents' priorities and needs. In this way, the participants of each CIG have a vested interest in their group, in some cases even paying membership fees. The introduction of CIGs into a community has proven efficient in working with different age, gender and income groups.

In implementation of this approach in Wulinchiti, Ethiopia, the entry point was the construction of rainwater harvesting structure. To accomplish this, specialists from national and regional governments provided practical training, including the formulation of a constitution for groups. The group, with assistance from external expertise, constructed household partially-underground tanks for roof water harvesting and farm-level underground spherical tanks for harvesting runoff water. Other CIGs were formed on homestead improvement and poultry production, reflecting other community needs. Similarly, for a CIG project in Kusa, Kenya, the CIG on rainwater harvesting tanks proved the most popular, but other groups formed around other livelihood activities such as keeping of dairy goats, poultry, fruit trees, cassava, making of mats, and community interests such as AIDS/HIV and health awareness. The fact that many residents were members of more than one group was also effective in developing community capacity through a network effect.

4.2 THE LANDCARE APPROACH

The Landcare approach is in principal community groups which has the aim to prtect and enhance the land resources. In Australia, where it was initiated in the mid 1980s , the Landcare network consists of more than 4000 community groups which partner individuals, private enterprise and public institutions in diverse ecological settings such as rural, urban, wildlife and coastal habitats (Yol *et al*., 2006). The movement has spread to the Philippines and South Africa, and there are also pilot groups in Malawi and Uganda. Its aim is to empower local stewards of the land (farmers and other landusers and owners) to be effective managers of their own natural resources. Consequently in the Landcare case the objective of creating the groups is to promote the adoption of conservation techniques to address a specific stakeholder-identified environmental issue. The improved management, or technologies, to address the common issue can either be on individual land or on common land, and the effort can be either by individuals or as a community. The Landcare methodology works through the consortium actors of farmers, local government units and technical service providers and involves three elements: the provision of appropriate technologies, institutional building, and partnership building. Each actor has a specific role: farmers share knowledge and expertise, the government provides policy support and funding for training and projects, and the technical services providers (e.g., NGOs, private companies, research institutes) provide information about sustainable farming and facilitate the groups. The consortium thus functions as an effective point of entry for extension dissemination, stakeholder engagements in NRMs and community networking (including labour sharing, joint investments, etc).

As in the CIG approach, the entry point can be around AWM, but any other natural resource issue can be equally or more relevant to the local community: in implementation of the approach in the Manupali watershed in the Philippines, soil conservation and agroforestry practices were the focus of the groups (Catacutan and Duque, 2006). In the same case, local farmers were also empowered to be effective managers of their natural resources, engaging in community-wide activities such as river rehabilitation and NRM-based livelihood and marketing activities

Two features of the Landcare movement are noteworthy: it builds strongly on the local communities' own vision and initiative, and its actions are endorsed by the local/regional/national public institutions, often through considerable economic support as in Australia (Stroud and Khandewal, 2006; Youl *et al*., 2006).

4.3 PRADAN/SPS APPROACH IN INRM

Professional Assistance for Development Action (PRADAN) and *Samaj Pragati Sahayog* (SPS), Indian NGOs working in watershed development, both employ an approach that centres on stakeholder input and community mobilisation. Both organisations also make equitable distribution of intervention gains a key goal in their projects.

PRADAN uses an Integrated Natural Resource Management (INRM) (PRADAN 2008a).This approach involves a series of steps focused on community engagement and capacity building to develop villages' ability to manage their natural capital. A key component in INRM is the Gram Sabha, a village-level governing body that includes all the residents of a village over the age of 18. As outlined by PRADAN, the INRM process includes the following sequenced activities:

- **selection of target villages** based on poverty indices, accomplished through the Gram Sabha;
- **concept seeding**, consisting of interaction between community members at the hamlet level and interacting with the Gram Sabha to develop a programme plan, with the Gram Sabha in turn aggregating the hamlet-level plans into a village-level plan;
- formation of a **Programme Execution Committee**, which manages the programme at the village level and formation of **hamlet-level associations**; and
- **development of a resource management**, which proceeds from baseline data collection; resource mapping; ownership mapping; problem identification; option generation; and activity plan and proposed land map use.

In common with the Landcare and CIG approaches, PRADAN also uses self-help groups (with a special emphasis on women's groups) beyond the INRM process described above (PRADAN 2008b). In some cases, the organization uses self-help groups as its entry point into the community, from which it can then expand into additional livelihood enhancement activities, further capacity building and enhancement of collective action capabilities through the development of networks, in a similar vein as what was achieved in the CIG cases outlined above.

SPS's approach is similar, utilizing both agricultural interventions and catalyzing social capital in its project communities (www.samprag.org; M. Shah, *pers. comm.*). In common with PRADAN, SPS strives to empower local communities, which it believes is an important goal in and of itself, as well as serving as a lever for development. SPS employs a Dryland Agricultural Programme that utilizes rainwater harvesting and introduces seed varieties adapted to the local environment, which is then supplemented with women's self-help groups to develop community micro-finance capabilities. The organisation also builds consortiums, partnering with local government and *panchayat raj* institutions as well as existing civil society entities, a theme also found in the cases reviewed above. SPS particularly focuses on developing capacity in local NGO/voluntary organisations, a technique pursued to ensure both long-term sustainability and out-scaling of its work.

5 ECONOMIC ESTIMATES OF AWM INTERVENTIONS AT THE Mesoscale

The issue of cost-effectiveness, i.e., how much benefit for each dollar invested, is of great importance to any investor, whether a farmer, government or external funder. In this section we discuss some emerging issues concerning cost-benefit analyses in relation to watershed interventions, in particular those relevant to the context of watershed management and promotion of different AWM systems for poverty alleviation in rural sub-Sahara Africa and South Asia. Overall, there is very little consistent and comprehensive analysis of benefit-cost rations of watershed interventions and watershed management (World Bank, 2007). This is partly due to the fact that costs of interventions are often split between different stakeholders (individual farmers, local and national government bodies, external donors, NGOs national research bodies and even the private sector). Secondly, the benefits are often estimated as direct yield improvements (as the interventions often refer to AWMs). Other direct and indirect benefits are rarely estimated on an economic basis, such as for example the gains in natural and social capital in a watershed due to individual and collective actions taken in AWMs (see Appendix 3 for a list of potential costs and benefits at farm and watershed level associated with AWM interventions). In the following section we list some meta-analysis data on watershed interventions, as well as provide a brief discussion on the benefit-cost of the soft components in watershed interventions.

5.1. COST-BENEFIT ANALYSES IN PROJECTS PROMOTING AWMS AT FARM AND WATERSHED LEVELS

There are abundant case studies on benefits and costs of different AWMS at plot/farm level. These are usually conventional in their economic approach, not accounting for indirect external changes through the changed AWM at the plot scale (for example, changed sediment transport, altered surface runoff flows, etc.). Two concerns are raised here about these benefit-cost estimates: the discount rate and the estimating value of labour in smallholder predominantly subsistence farming systems. The first issue is that the discount rate needs to be varied to reflect the uncertainty for investment that many smallholder farmers face (see Appendix 2). Failing to vary the discount rate may otherwise give a false representation of the investment context of the farmer. Secondly, labour may or may not be valued depending on time of season as well as the local possibility of wage employment on a temporary and/or permanent basis (see for example, Fox *et al*. 2005 and Tenge *et al*. 2005). As many AWMS and other farm improvements involve labour intensification, it is important to reflect the diverse labour cost to have an accurate idea on investment potential (see Appendix 2 for a more detailed discussion).

Project implementation aiming to increase adoption of AWMs is associated with a greater range of prices per ha under interventions than what is implied in the cost-benefit estimates per ha for farmers (see Appendix 2 for further discussion). This is because projects are associated with both 'hard components', (i.e., the investment in physical capital) and 'soft components' (institutional and capacity building; investment into social and human capital). Costs associated with hard and soft components are highly context-specific, and thus values derived from a large number of studies are needed to estimate 'average' values of different components.

The hardware costs of a project will be affected by the type of AWM technology implemented and the assigned value of labour. In participatory projects of AWM interventions with communities and farmers/land managers, where all stakeholders share the costs, labour is often supplied by the local community and farmers. Thus, this cost cannot be readily extracted in project budgets, nor is it easily available for costing of projects.

On the soft component side of a project, the existing capacity of the community and partner institutions has high impact on costs. Communities do not have the same pre-existing institutional infrastructure or social and human capital. Some important elements of social capital for successful projects have been identified through meta-analyses of AWM interventions and watershed management by Joshi *et al*. (2005), Kerr (2002) and Noble *et al*. (2006), and other case-based studies of watershed management and AWMs (see also section 2.3 and 3). Post-conflict states and communities with high levels of heterogeneity would most likely fall into the low capacity category, whereas countries with long cultural and/or political traditions of participatory governance would be in the high capacity category.

In the reviewed cases and literature, most analyses of projects with AWM and watershed management components do not report costs and benefits for internal watershed tradeoffs between different landusers, nor shifts in wealth due to AWM interventions in the involved communities. Equally poor is the reporting of externalities: how did the water flows change (or not change) due to watershed interventions? Were there any other changes,-social and /or natural that emerged due to the watershed intervention upstreams? This lack of data was also highlighted by a World Bank (2007) evaluation of over 50 watershed interventions in its portfolio. Often the costs and benefits are evaluated at the end of the project. Lasting effects and/or changes due to the project implementation are often not revisited, nor accounted for. .There is also a large gap in values incorporating changes in both natural and social capital for watershed management, as well as consistent methodologies to do systematic estimations of these changes.

When comparing costs from meta-analyses of watershed interventions (Kerr 2002; Joshi *et al*.,

Table 5.1: Comparing per hectare investment costs for watershed level interventions projects with AWM components (including soft and hard components)

	In situ AWMs	*In situ* AWMs	Small–scale irrigation	Large-scale irrigation	Comments
'Bright spots' (Noble *et al.*, 2006)	US$ 356/ha		US$ 490/ha (in SSA)		Meta-analysis developing countries
India (Joshi *et al.*, 2005)	<-------- B/C=2.14 average/1.84 median -------->				Meta-analysis $EIRR_{av}$=22 ($EIRR_{med}$=16)
India (Kerr, 2002)	<------------- US$56-185/ha watershed ----------->				Meta-analysis
The Commission for Africa (Lankford, 2005)			B/C=1.7-3.3	US$5,000-20,000/ha (new) US$1,000+/ha ('seed' projects)	A cost framework for irrigation investment in Africa
WB Large irrigation Sub-Sahara Africa (Inocencio *et al.*, 2005)				US$ 4,790/ha (new) US$ 1,970/ha (rehab)	Meta-analysis success projects EIRR=22-23
WB Large irrigation South Asia (Inocencio *et al.*, 2005)				US$ 2,526/ha (new) US$ 898/ha (rehab)	Meta-analysis success projects

2005; Noble *et al*., 2006[2]), it emerges that the per hectare investment is considerably higher in large-scale irrigation projects than what can be found in smaller-scale interventions for successful projects. Conventional cost estimates from meta-analyses of AWM interventions are on the order of US$400/ha and upwards for *in situ* smallholder interventions (Table 5.1). Conventional cost estimates from meta-analyses of large-scale successful irrigation interventions are on average US$2,500/ha for South Asia and US$5,000/ha for sub-Sahara Africa (Inocencio *et al*., 2005). This can partly be explained by the high share of costs on hardware for large-scale irrigation. But there are too few cases to draw any clear conclusions from this comparison.

5.2. THE 'SOFT COMPONENT' IN PROJECTS WITH AWM PROMOTION AND WATERSHED MANAGEMENT

Adoption of new AWM technologies among farmers, communities or in a watershed depends on a range of social, cultural, gender and institutional pre-conditions as well as technological suitability and economic returns (Noble *et al*., 2005; Joshi *et al*., 2005; and this study, section 3). Successful projects tend to have some commonalities such as existing social capital to build upon (community groups, common interest groups etc.), key individuals or leaders who are willing to mediate the development interventions in the community and an enabling institutional context (see section 3.2). Thus, the

Table 5.2: Cost of soft components of selected case studies and meta-analyses of watershed-level AWM interventions

	In situ AWMs	*Ex situ* AWMS	Small irrigation	Large irrigation	Type
FAO cases (Munoz, personal com.)	<------------ US$65-360 / trained person ------------>				Extension projects
Kusa, Kenya (Sandstrom *et al*.,)	<--- US$5 /cap (for 20 000 inhab. in watershed) --->				Mostly soft components: extension , community mobilization
IFAD, (2000)	US$93 / trained person				Case
IDE case NEPAL (Mikhail, personal com.)	<------------- US$195 - 226 /household ------------->				Multiple use systems
WB Large irrigation Sub-Sahara Africa (Inocencio *et al*., 2005)				New: 38% of total cost Rehab: 34% of total cost	Meta-analysis
WB Large irrigation South Asia (Inocencio *et al*., 2005)				New: 15% of total cost Rehab: 25% of total cost	Meta-analysis

2 The meta analysis of Noble *et al*. (2006) uses all types of agricultural (crop system) improvements, not specifically agricultural water management strategies. However, many of theses interventions were AWMs, and others (including tree planting) are used in watershed interventions. Thus, we consider the meta-analysis of Noble *et al*. (2006) still valid for the purpose of providing cost at the farm scale.

soft component of strengthening the social capital at both individual and community level is a key for sustainable project implementation[3].

Despite knowing the importance of soft components in AWM and watershed implementation, soft component costs in watershed projects are not easily obtained. In Table 5.2 some costs of predominantly soft component projects and the share of soft components are summarised. Clearly, the cost of soft components can be as high as 40% of total project costs in large-scale irrigation projects. For projects promoting AWMs at a smaller scale (*in situ* and *ex situ* technologies, small-scale irrigation), similar figures can be expected, but the evidence from comprehensive meta-analyses is currently weak. Only case studies can be referred to for support here.

It is even more difficult to relate soft component project costs to success rates, in terms of how social capital was enhanced through the soft component investments. Cost-benefit analyses are conventionally not carried out in these types of AWM-watershed projects, similar to emerging externalities and off-site costs and benefits discussed in 2.2 and 3.2).

Photo: Maimbo Malesu/ Alex Oduor

3 An example is the goal of empowerment for communities in some watershed management areas. As noted above, for some NGOs empowerment is an end goal: a necessary objective to give communities and individuals the confidence and self-esteem to take control of their lives and their futures. While 'community empowerment' can be difficult to quantify in M&E, measures of human and social capital accumulation can offer a partial indication of empowerment.

6 CONCLUSIONS AND EMERGING ISSUES

6.1 DISCUSSION OF OUTCOMES

Through the synthesis of meta-analyses and through additional cases, this study shows the importance of social capital in AWM interventions at the mesoscale. The level of social capital in a community is not only an entry point but also a key building block for successful AWM interventions at the farm and watershed level. The pre-conditions in terms of community cohesion and existing community organisation strongly affect the viability of AWM interventions. Successful outcomes, in terms of adoption and long-term sustainability of practices, are higher where there is an initial high level of social capital. The cases as well as meta–analyses demonstrate that successful projects had high participatory involvement, with communities playing a key role in the decision regarding which AWM technologies to implement. Cost-sharing between all stakeholders also emerged in several cases as an important feature for successful intervention. Similar conclusions have been driving the Africa Highlands Initiative (AHI) participatory watershed approaches (Stroud and Khandelwal, 2006; German *et al*, 2007).

A feature in several cases was to complement AWM technology interventions with other crop system improvements for nutrient and pest and weed management and post-harvest processing. Micro credit schemes and/or small loan facilities were occasionally part of AWM technologies introduced. Additional interventions addressing other livelihood issues were often included, such as improving water supply and sanitation and health issues. The different AWMs and other interventions implemented could often be described as a mix of short (immediate private benefit) and long (slow return, sometimes with community rather than private benefit) types.

It is noteworthy that the initial problem definition for AWM intervention did not necessarily emerge at the farmer or community scale targeted. Often, external factors realised at a higher institutional level, drove the problem definition (e.g., land quality issues such as erosion and degradation, or rural development agendas). As a consequence, there was often an external 'agent of change' that provided new knowledge and funding to initiate the process of adoption and adaptation of new AWMs at the community level.

In a recent review of approaches for natural resource management in watershed development (Stroud and Khandelwal, 2006), it is recognised that although different external development and research agents may enter the watershed management from different schools of discipline (hydrology, agriculture, conservation, forestry), the implementation of actions to create synergies between resource management and development are merging. They conclude that 5 key factors lead to sustainable natural (land, water, forest) management:

- Policy setting should be inclusive and able to cope with multiple interests;
- Investments must pay: especially to individuals the returns need to be short term;
- Actions need to build local capacity (empower) and address equity in the process;
- Often, economies need to be diversified to enable entering into monetary markets as well as increase livelihood support net; and
- Research and development implementation need to work in better collaboration to enhance synergies in outputs.

The specific methodologies needed to mobilise a community differ depending on the initial level of community social capital, the problems addressed and the external agents of change. The common feature is that the intervention builds on the initial community organisation and creates a strong anchoring, i.e. ownership of the water-related resource issue among community and individuals. It is also common to let communities participate in the development and prioritisation of actions, in order to ensure sustainability after the project concludes. Thus, an important feature of social learning is to enable the local stakeholders to build knowledge about their land and water resources.

Equally, it merges from the cases that there is often a strong partnership created ('platform') for stakeholders to negotiate and exchange knowledge. The partnership often included the local community and local public institutions. In a number of cases, a watershed management plan, or action plan was seen as a key development product for parties to unite around (World Bank, 2007; German et a, 2007; Catacutan and Duque, 2006) or one case , a very specific goal (Wester *et al*, 2001).

Despite recognition of the importance of AWM interventions in the mesoscale with participatory approaches, the cases as well as the meta-analyses on watershed interventions had poor benefit-to-cost evaluation. This was the case at the full project level as well as at individual costing of hard and soft components, respectively. Similar conclusions were also drawn by a World Bank (2007) review of 48 watershed development projects. Clearly, the omission of estimated investment returns at the watershed scale is due to many factors. We suggest that the main reasons for this are:

- the difficulties in monitoring and evaluating watershed intervention success;
- the poor capturing of gains and losses in social and natural capital through conventional cost-benefit analyses; and
- the difficulties to assess even conventional cost-benefits with multi-stakeholder contributions, as is often the case in watershed management (e.g., Kerr, 2002).

6.2 EMERGING ISSUES

The watershed-level interventions lack systematic analyses and quantification of success (and failures). The only systematic analyses that could be identified were for the India watershed interventions described by Kerr (2002) and Joshi *et al*. (2005). No similar quantitative analyses for watershed interventions could be identified for sub-Sahara Africa.

Equally, as there is a gap on return of investment in projects, there is a need to evaluate watershed

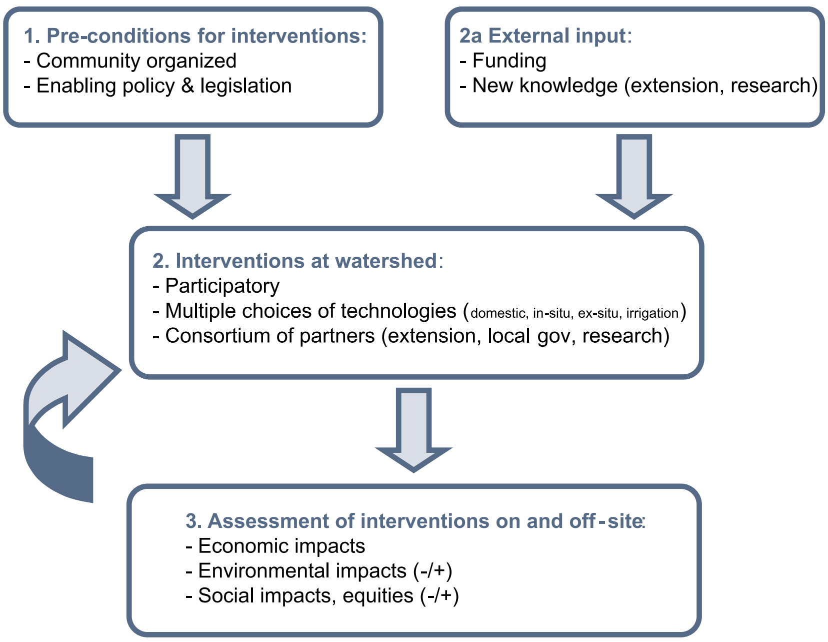

Figure 6.1: Principal summary of social-institutional components in the AWM interventions


Photo: Maimbo Malesu/ Alex Oduor


Photo: Gedion Shone

interventions beyond the watershed where implementation occurs, in order to ascertain the extent of external as well as internal gains and losses. Conventional economic cost-benefit analyses cannot account for emerging effects on natural and social capital within and beyond the mesoscale watershed. This was also concluded in the World Bank review of watershed interventions during 1990-2004 (World Bank, 2007, p.58 -59). There is great need to develop methodologies to estimate asset changes in parallel with better monitoring of intervention effects. These changes are primarily related to water flows and land resources, with respect to both quality and quantity, but analyses should also include social changes induced by the watershed interventions relating to income strata and gender: who gains and who may lose?.

The water flows should ideally be monitored and valued both for within-watershed use (on- and off-farm changes due to AWM interventions) as well as external effects (upstream-downstream). Ultimately, shifts of water resources to individual farms to increase yields (and livelihoods) can affect common pool resources, which often support livelihoods of the poorest and most vulnerable in the community (Hope, 2007; Kerr, 2002a; Johnson et al., 2001).

We conclude that there are some basic lessons learned concerning how to do watershed management in natural resource management and how it may be seen as successful (increased farmers yield, reduced erosion). The soft component is throughout recognised as a key corner stone together with the existing social capital in the targeted watershed. But there is very little synthesized evidence on past watershed management interventions for increased agricultural productivity available, and how it affects off-farm land as well as downstream locations. The environmental impact assessment has been largely ignored in the documentation. Equally, the emerging cost and benefits, which includes the soft components as well as extended analyses wealth and assets of natural and social capital changes needs to be addressed in future watershed interventions, in order to meet goals on both equity and sustainability in communities involved and beyond the targeted watershed.

ACKNOWLEDGEMENTS

This study is a component of the IWMI-led project entitled 'Agricultural water management strategy scoping study.' Support was provided by the Bill and Melinda Gates Foundation. We thank representatives of IWMI, IFPRI, FAO, IDE and the Bill and Melinda Gates Foundation for comments and valuable input to this paper. We also thank SPS and PRADAN for insights into AWM philosophy and methodology during discussions in Delhi and field visits to Raigarh in April 2008.

Photo: Stacey Noel

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APPENDIX 1: Case Descriptions

LATIN AMERICA

Trojes de Paul, Mexico

Trojes de Paul is an *ejido* which lies within in the Lerma-Chapala basin in west-central Mexico. The Lerma-Chapala, which covers approximately 55,000 km^2 spread across five states, is a closed basin: total water depletion in the basin on average exceeds supply by 10% (Wester *et al*. 2001). A 1.3 million m^3 reservoir was built in Tropes de Paul in 1968 through a process driven by considerable community resource mobilization: influential community members secured the support of the agriculture and water ministry and Trojes residents supplied significant contributions in terms of both labour and materials. Not surprisingly, the *ejido* gained a strong sense of ownership in the reservoir, which was demonstrated when residents took exception to the government's staging of an inauguration ceremony and accompanying placement of an official plaque at the completion of the reservoir construction. This suggests there is a strong community identity and significant levels of social capital in the *ejido* which stretches back decades.

The village's water users group manages labour mobilization needed to keep canals clear, the start of irrigation, and a distribution schedule that includes seasonal changes to allow tail- and head-end irrigators alternate first access to irrigation water. The group also sets fines and other sanctions for over-irrigation and were discussing the implementation of irrigation service fees at the time the fieldwork was undertaken (1999). Under the Trojes system, water is not allocated per user but rather distributed equitably per unit of land, a system all users seem to accept with researchers finding little infighting amongst users during fieldwork. Under the system, each individual user decides when to complete irrigation of their own field and pass water on to the next user in the system. Even during a drought in summer 1999, the system held, with each user applying his/her fixed amount of water to whatever percentage of their land area they had chosen to irrigate.

An analysis of gross value of production both by area and by water during the 1999 fieldwork showed that the *ejido* compared very favourably to other nearby farmer-managed irrigation schemes and larger irrigation districts; crop per drop analysis also showed good physical productivity in comparison with global data on similar crops. The case study authors concluded that 'the relatively high productivity of Trojes must be understood in the context of social relations', citing the community mobilization to secure the reservoir as instrumental in consolidating a strong and independent water users organisation.

ASIA

Kotha Powerguda, Andhra Pradesh, India

The village of Kotha (New) Powerguda, located in the district of Adilabad in Andhra Pradesh, was born in 1995 when 30 families decided to leave the village of Powerguda (now called Old Powerguda or Powerguda-O) due to social conflict. The new village lacked drinking water, road access and electricity, and was almost devoid of employment opportunities and villagers survived by working as labourers on nearby farms or towns and gathering food from the forest. In January 2000, however, an ITDA project funded by IFAD undertook a participatory rapid appraisal in the village in advance of a soil and moisture conservation project to be implemented in the village. The ITDA researchers encountered a community of 32 families (most of them living in poverty) and unused to outsiders but one that had a long cultural tradition of village-level participation in governance.

After baseline surveys and discussions with residents, an intervention plan was developed. At the community level, this included staggered contour trenches, a drain diversion into an irrigation tank, gully control structures, graded bunds, and percolation and masonry structures of 200-1,000 m^3 for water storage. At the farm level, 30 new technologies were to be tested, including broad-bed and furrow, landform for drainage, tropicultor, and improved crop strains. In addition, interventions in nutrient management and integrated pest management were also set to be introduced.

During the timeframe 2000 to 2003, ITDA spent Rs 3.1 million (excluding staff time) in the village, which is Rs 20,945 per capita or 3 ½ years of family income in 2003. The majority of the investment – Rs 2.3 million - went into watershed development, with the rest going toward agricultural development, income-generating activities and the building of social networks. Residents also contributed through investments in their personal property (houses and farms) and in human capital (education and health). Investments in agribusiness were also made, with an oil extracting machine purchased by ITDA for the village. The village also channelled an Rs 30,000 payment for environmental services from the World Bank into a tree nursery.

As a result of the watershed investment, ICRISAT estimates that approximately 20% of seasonal runoff was captured in storage structures, which raised groundwater availability in four wells in the village by 2 m as well as providing a source of irrigation water. Crop yields went up dramatically - gains averaged 14.3% per acre per year - and cropping patterns changed, due to both the water availability and the other interventions. Average family income rose to Rs 27,821 in 2002-2003, from a baseline of Rs 15,677 prior to the start of the project; 95% of household income was from the agriculture sector.

The funds invested in social capital were particularly instrumental. Women's self-help groups (SGHs) were set up and received technical as well as organizational training, enabling them to serve as the contractors for building some of the storage structures; the SGHs received government contracts and were able on average to save 18% of the total expenditure in their group accounts, thus offering the chance to leverage these savings for bank loans with favourable interest rates. A forest protection committee (Vana Samarakshana Samithi – VSS) was also created, with the goal of promoting public investment in the forest and managing the new nursery business. Additional local governance structures include the watershed committee and the panchayat, the three-tier local government. In a 2003 study on social capital in forest protection and watershed development, Powerguda ranked first out of three villages in the district, with a score of 5.5 on a scale on 6.

Adarhsa Watershed, Kothapally, Andhra Pradesh, India

The village of Kothapally, located in Ranga Reddy district in the state of Andhra Pradesh, has a population of 1,492. Almost all households in the village are engaged in cultivation, and the average plot per household is 1.4 ha. Prior to the ICRISAT project described below, over 80% of land was under rainfed agriculture and the village had no water harvesting structures. These factors led ICRISAT to a watershed project meet with villagers, who expressed an interest in participating due to recurrent droughts and declining land productivity.

ICRISAT introduced a farmer participatory consortium model for natural resource management in the village, which combined staff from universities and research organizations, NGOs and development workers, policymakers and farmers. Interventions included water storage structures, gully control structures, mini percolation pits, and a 500-m diversion duns and field bunding on 38 ha. At the plot level, farmers implemented broad-bed and furrow landform and contour planting and use of tropicultor for planting. Additional measures were also introduced: integrated pest management, nutrient management, vermiculture, and village-level Helicoverpa Nuclear Polyhedrosis Virus (HNPV) production.

Building on initial enthusiasm, community members worked as equal members of the consortium, volunteering to abide by rules set collectively. The project worked through a watershed committee (which counted the Panchayat chief as an officer) and existing youth and women's groups in the village, both of which were receptive to innovation. User groups were formed for each water storage structure, which are responsible for desiltation and other maintenance. Project activities were sequenced so that interventions to provide immediate, tangible benefits at the plot scale occurred before community-level interventions; in this way, farmers' reluctance to institute soil and water conservation techniques were overcome and the capacity for collective action was built. Short-term benefits to individuals were also carefully balanced with long-term community benefits in terms of watershed management. Landless households and women's groups received training in agribusinesses such as the production of pesticides and biofertilizers.

Yield increases were realized (250 kg more pigeonpea and 50 kg more maize per ha using broad-bed furrow on medium-depth soils than from flat landform). Runoff was significantly reduced in the watershed: 45% less than the untreated area in high rainfall year and 29% less than the untreated area in a sub-normal rainfall year. Soil loss measured during a sub-normal rainfall year was also reduced: 1/3 less than the untreated watershed. Over a three-year period, the mean average rise of groundwater was 415 cm, and due to the additional recharge 200 ha in post-kharif season and 100 ha in post-rabi crops (primarily vegetables) were irrigated. In terms of household income, households within the watershed had an average crop income of Rs 12,700 whereas the figure for households outside the watershed (located in villages in close proximity to the watershed villages and thus considered to have similar socioeconomic and biophysical characteristics) was Rs 9,500. Similarly, average income including livestock and non-farm sources for watershed households was Rs 37,420 compared to Rs 29,140 for non-watershed households.

Manupali Watershed, Lantapan, Bukidnon, Philippines

The Manupali watershed is located in the southern Philippines. From the 1980s, a number of externally-funded development and research programs took place in Lantapan, thus raising levels of social capital in the area. A program of natural resource management was begun in 1996, which created a Natural Resources Management Council (NRMC); the NRMC was quite comprehensive in terms of its community representation: groups drawn from included farmers, churches, business, youth, academe and tribal sectors. With funding from local government, the NRMC received capacity training to build its technical and planning skills; participatory and consensus-building workshops were also held.

Then, in 1998 the Landcare approach was introduced to the area. Landcare revolves around the formation of community groups for mobilization to achieve the adoption of agroforestry and conservation techniques and includes three basic tenets: provision of appropriate technologies, institution building and partnership building. In Lantapan, Landcare focused on disseminating techniques to control erosion and environmental degradation, using farmer-to-farmer learning and also linking Landcare groups from different areas for knowledge sharing. External agencies worked in coordination with the watershed management and development plan, with ICRAF introducing agroforestry and conservation techniques and the Heifer Project International co-implementing a livestock dispersal project with local government.

The effectiveness of the overall approach is demonstrated by the dramatic uptake of natural vegetative strips and agroforestry practices, with the number of farmers using these techniques growing from 277 in 1998 to over 900 by mid-2003.

SUB-SAHARA AFRICA

Yatenga, Burkina Faso

The province of Yatenga lies in the Nord Region of Burkina Faso. During the 1970s, it suffered an environmental crisis, as its population doubled over 1930s level, leaving it with an average population density of 100 person/km^2. Over the same period of 40 years, the region experienced increases in cultivated land over soils marginal to agriculture and in erosion, along with decreases in soil fertility, agricultural production, and fallow.

Extension services were also lacking in Yatenga in the 1970s: unable to offer suitable technologies to help poor farmers overcome the environmental degradation. Two projects – a large-scale mechanized soil and conservation effort in the early 1960s and the introduction of graded earth bunds in 1977 – failed due to farmer resistance: in both cases the farmers did not undertake maintenance and in some case deliberately destroyed project works. Following these unsuccessful attempts to introduce new methods, others moved forward in different directions: individual farmers sought to improve on traditional planting pits, called zaï, while NGO staff worked at introducing contour stone bunds. The two techniques had the right characteristics for successful uptake – simple to implement and efficient in increasing yields

– and, when applied together, turned out to be very successful in rehabilitating the poor state of agricultural land in Yatenga.

The reintroduction of an enhanced version of the zaï in the 1980s was spearheaded by an individual farmer, Yacouba Sawadogo, who may have been introduced to the concept during an Oxfam-funded study visit to Mali. This increased use of the improved zaï came to the notice of the Oxfam agroforestry project, who began to promote the technology and spread awareness of it to other NGOs as well as to government agencies. Around the same timeframe, another farmer also began successfully experimenting with the use of zaï. Both farmers developed mechanisms for further spreading their knowledge: Sawadogo started an association to promote the use of zaï and organized an annual zaï market in which users from 100 villages gather to exchange ideas, and the other farmer created a zaï school. Farmers use the techniques they learned to reclaim degraded land providing all the labour on their own; because fields could be rehabilitated progressively, households could treat as much land as they had the labour available for. The use of this technique therefore offered greater flexibility over SWC projects that required machinery and collective action for treating blocks of land.

Of particular note is that the only external assistance needed to support the land rehabilitation effort was the public funding invested in the study visits. Thus, in effect, these two farmers created a private extension service, which succeeded where the parallel public services, which focused on cotton and suffered from a lack of funds, failed. Eventually, the enhanced zaï concept spread even further: an IFAD-funded project sent thirteen farmers from the Illela district of Niger to Yatenga in 1989, and by 1992 the knowledge of how to rehabilitate degraded land through the use of zaï (called tassa in the local tongue of the district) was so widely known that there existed an active market for degraded land in Illela.

The introduction of the contour stone bunds succeeded for much the same reason as the zaï technological advance: as the information spread – in this case, not initially by individual farmers but by NGOs - farmers found they could implement the technique on their own, again providing the labour needed; the only external funding required was for transportation of the stones.

Regarding yield increases achieved through the use of zaï alone or in tandem with stone bunds, there has been no study in Yatenga, where the technology was reborn. Research has found average yield increases ranging from 38 for white sorghum grown in other regions of Burkina Faso to 310 kg/ha in Niger. When the zaï technique is paired with manure or inorganic fertilizer, the gains increase: in Illela, yields rose to an average of 388 kg/ha for cereals when manure was added, versus the 125 kg/ha averaged previously, and with the addition of a dose of inorganic fertilizer they further increased by 640 kg/ha. Similarly, trials in Mali found that over two seasons with zaï and manure combined yields rose by 719 kg/ha on average.

In terms of livelihood improvements, farmers in the northern Central Plateau of Burkina Faso reported that the use of the enhanced zaï had improved household food security, creating small surpluses in high rainfall years that could provide during poor rainfall years; findings were similar in Niger. These surpluses also permitted asset investment, with farmers in the northern Central Plateau stating they were keeping larger numbers of livestock. This increase was also facilitated by the increase of available fodder, with the livestock in turn providing manure to further increase yields. Improved water availability at the village level, thought to be the result of SWC techniques4, also made increased livestock numbers feasible, and added further gender benefits when wells and boreholes stopped running dry at the end of the rainy seasons, thus saving time in water fetching duties for the female members of the household.

Kusa, Nyando District, Kenya

Kusa is in Nyando District and sits on the shores of Lake Victoria. At the time the project was initiated,

4 Kaboré and Reij (2004) report that 'a spectacular improvement of water availability' has occurred in villages with a long-term history of SWC techniques, but not in those with little or no SWC. This suggests to the authors that the water increases are not due to increased rainfall in the 1990s but to the varying levels of SWC employed.

the community was in crisis, with high rates of poverty, severe land degradation, and the loss of its main livelihood source, fishing. In addition, AIDS had decimated the community, wiping out a large percentage of the population of working age and creating many children-headed poor households. The community was fortunate to have during this period a group of professionals who had returned to Kusa following their retirement and had joined forces with resident Kusa fishers to lobby for external support to address the situation.

Thus, Kusa came to the notice of the Swedish development agency Sida, which was looking for a site to pilot a project for poverty reduction and environmental improvement that could be replicated in the Lake Victoria region. The Kusa Pilot Project, implemented by Sida's Regional Land Management Unit (RELMA), began in early 1999 with intensive participatory consultations with residents; the initial phase included study tours, community-level democracy training, human resources and institutional development, and interventions in water, agriculture and the environment, in order to engage the community and build support for the project early.

The main thrust of the project was to create an institutional web; to achieve this, the project fostered Common Interest Groups (CIGs), which were centered around livelihood activities (dairy goats, poultry, livestock, water tank). CIG meetings served an important role in providing a forum for sharing ideas, and the project final evaluation found that the community felt the CIGs were empowering, by helping community members, and especially females, to gain bargaining power in their commercial relations. The CIGs also strengthened the community's social capital as they included members of different clans. Other project capacity building activities involving the CIGs included study tours and exchange visits around the lakes to facilitate the exchange of knowledge. Training initiatives were also undertaken, with group members trained as artisans, such as tank constructors, paravets, health workers, and model farmers.

The project estimated that 1,500 households had one or more members who participated in project activities, out of the 2,255 households in Kusa. In total, project management estimated it had reached 20,000 people (though this figure may be high), at a cost of US$8.40 per capita. The final evaluation of the project noted that with the deletion of some of the experimental activities (such as a 'think tank' designed to meet Sida's needs for learning), the project could be implemented for approximately US$5.00 per person. However, it must be noted that the project's final evaluation, completed in January 2005, recommended that the sustainability of project activities be judged in three years time, to see whether the CIGs had continued without external support. This has not yet been undertaken, so the success of the project cannot be accurately judged at this point.

Lare Division, Nakuru District, Kenya

Lare Division, located in the Nukuru District in Kenya's Rift Valley, comprises 134 km^2; rainfall averages 600-1,000 mm per annum. The area's soils are mostly volcanic, generally fragile loam to sandy loam, and thus vulnerable to erosion. Crops cultivated include wheat, peas, beans and vegetables, and dairy cows are also raised; typical farm sizes are 4 to 10 hectares. The area has been plagued by deforestation due to settlement patterns and has experienced water and food insecurity, possibly as a result of the clearing of forests. Water scarcity has been acute, with 70% of the population affected.

Rainwater harvesting has been successfully adopted in Lare. In addition to rooftop harvesting systems for domestic water, community members also use earth dams, built with local materials, and excavated ponds. Advocacy efforts from NGOs were important to uptake, and effective collaboration between government agencies, research institutions and the private sector were also instrumental. Significant extension, excursions and other training were conducted by local and international NGOs: a Lare household studied had been exposed to rainwater harvesting techniques through training at two separate centers, excursions and visits to Machakos and western Kenya, and personal visits to his residence by extension and development agents. Through these activities and the community's openness to new technologies and practices, the uptake of water harvesting in Lare has been dramatic: in 1998, only 409 households used the technique, but by the end of 1999, over 1,000 did so and by 2004, the number of households using water harvesting exceeded 4,000. In-situ rainwater harvesting is also practiced: pitting and runoff farming.

Wulinchiti, Ethiopia

Wulinchiti area is located in the Rift Valley, 125 East of Addis Ababa. The area is known to suffer from low and highly inconsistent rainfall. Since it is located along the escarpment of the Rift Valley, it also suffers from flooding from upstream. The inhabitants of the area suffered both contrasting extremes. In 2001, the Regional Land Management Unit (RELMA)5, organized a study tours to Kenya and Tanzania for farmers and extension workers from this area. From among the many land management interventions they saw, the participants identified rainwater harvesting as the most important technology for them. The group requested to be trained in rainwater harvesting for domestic use and for home gardening. RELMA responded positively and in collaboration with the Extension Department of the Federal Government of Ethiopia planned and conducted training. The training was based on an approach of organizing farmers into Common Interest Groups (CIG). The objective of this was to make the training as part and parcel of creating action-oriented self-help groups.

Using Subject Matter Specialists that were previously trained by RELMA from the National and the Oromia Regional Bureaus of Agriculture, the training in rainwater harvesting for domestic use and homestead gardening was advertised and interested farmers formed a group. Two other groups, one homestead improvement and a second on poultry production were also formed. The practical training included formulation of constitutions for each of the groups, which outlined the organizational set-up, bylaws and procedures. This was then followed by each group practically executing the activity. Two types of tanks were constructed during the training using soil cement blocks, which are cheap as compared to any other form of construction material. At the homestead, partially underground tanks for roof water harvesting were erected while at the farm level underground spherical tanks were made to harvest runoff water, which would then be pumped or hand lifted for supplementary irrigation. The training also included drip irrigation, vegetable preservation by drying and homestead improvement and hygiene. Each group formulated its own bylaws and was encouraged to start saving and credit schemes.

Ethiopia is well known as a drought-prone land and the Government had a keen interest in rainwater harvesting. The RWH group in the small village in Wulinchiti became famous as they transformed their areas and started to grow fruit trees and vegetables in an-otherwise harsh environment. The group was later identified as a national model for promoting rainwater harvesting and was used to train farmers far beyond their region.

A post-mortem visit after five years revealed that the common interest group that was established during the RELMA training is still operational, although the number of members has not increased substantially. Since the rainy season in the area is short and erratic (2.5-3 months), members were able to grow short seasoned varieties of crops; growing maize and sorghum was a gamble. The most interesting technical development by the farmers was the utilization of the stored water: they use the harvested water to prolong the rainy season. They do this by preparing a nursery to grow seedlings of cash crops such as onions and hot paper two months ahead of the rainy season. By the time the rains start, the seedlings are ready to be transplanted to the field. This way they have effectively prolonged the growing season by two more months, which is a breakthrough.

By so doing, most of the members have substantially increased their income, changed their grass thatched houses into tin-roofed bigger houses, and some have purchased motor bicycles. Although the agricultural extension system has not taken up the technology, some NGOs are actively helping in spreading the adoption. A substantial number of farmers are benefiting from the technology.

Comment: The extension approach based on CIG did not spread beyond the surrounding villages. To mention some of the factors contributing to the failure for the uptake are:

5 RELMA was a regional project sponsored by Sida (Swedish International Development Agency), housed in Nairobi, Kenya covering 6 countries of Eastern Africa, Eritrea, Ethiopia, Kenya, Uganda, Tanzania and Zambia. .

- The fact that the approach was introduced only at the field level and not promoted at the Regional and/or National levels. The input and impact was so small: one training in one village with limited number of SMS to make significance;
- Lack of flexibility and centralized government extension system; and
- Lack of continued support to pilot the activity until is had reached a scale of significance.

Assessment of water harvesting potential for upscaling agroforestry in Rwanda

Maimbo M. Malesu, Alex R. Oduor, Meshack Nyabenge & Douglas Nyolei

Background

In 2005, ICRAF and UNEP developed a tool for mapping rainwater harvesting (RWH) potential to assist policy makers in crafting decisions on viable areas for developing technologies that can utilize both blue and green water. This tool became useful when the Government of Rwanda requested the World Agroforestry Centre (ICRAF), to address and advice on the imbalance of agricultural activities which is currently biased at the valley bottoms whilst the upstream areas get denuded through deforestation. In March 2007, ICRAF signed an MoU with the Rwandese Ministry of Agriculture and Animal Resources (MINAGRI), to utilize the mapping tool in developing a national masterplan on RWH for agroforestry development. Through MINAGRI, the Government of Rwanda funded a nine month RWH project to the tune of approximately one million US dollars.

Methodology/activities

The ICRAF Water Management Team carried out pre-feasibility studies and consultations with representatives from MINAGRI and Rwanda Agricultural Development Authority (RADA). Having agreed on the broad project areas to cover Bugesera, Nyanza and Ruhango districts, GIS was undertaken to produce rainfall, digital elevation models and vegetation cover base maps. These helped in the identification of suitable areas for establishing the Best Practices-Scaling Up Sites in addition to ground truthing in collaboration with the local and communities leaders. Insitu and runoff water harvesting potentials were computed using GIS and relevant formulas. With this database, ICRAF was able to design *in situ* and runoff based water harvesting agroforestry systems. Following a training needs assessment, ICRAF used the designs to build capacity for MINAGRI, RADA and the farming community in the implementation of the project.

Results

- Nine best practices sites with total farming population of 16,200 inhabitants were identified from Bugesera, Ruhango and Nyanza districts.
- Rainwater harvesting potentials were determined for National, Provincial and plot scales. Rwanda has a very high potential for RWH with 8.3 km^3 harvestable from insitu rainwater and 6.0 km^3 harvestable from runoff water (See tables below).
- ICRAF designed a RWH system that utilizes a 120m^3 reservoir with conveyance mechanisms to irrigate half acre plots of vegetables, mangoes and pawpaws.
- Farmers were organized into operational Common Interest Groups to address and implement the production of mangoes, pawpaws and vegetables. The long term measure is to organize these groups into farmer field schools that would eventually graduate to form cooperatives.
- Six technicians, 36 artisans and 26 agricultural extension officers were trained. 14 underground tanks, 65 ponds with accompanying rope-and-washer pumps were constructed. In addition, 200 conservation agriculture plots were established.

Conclusions

Following the interest generated from the introduction of RWH for agroforestry interventions, the government of Rwanda is working on a 40 million dollar proposal to upscale RWH to cover the whole country.

Studies needs to be done on cost benefit analysis which will inform future project planners on aspects to consider for upscaling of the best practices. For sustainability of the project, it is important to train staff at regional and national levels based on the Training Needs Assessment report provided by ICRAF.

Conservation Farming in Zambia: A Case Study underpinning its Success in Zambia

Maimbo M. Malesu & Alex R. Oduor

Introduction

This case study summarizes the success in the promotion of Conservation farming in Zambia. It highlights the underlying challenges within the smallholder farming sector that led to the development of CF. The case also reports on the role of key stakeholders in facilitating scaling up of the conservation farming in the country.

Conservation Farming is an integrated form of agriculture that conserves soil, moisture, fertilizer, seeds, energy, time and money. It leads to enhanced environmental conservation and sustained agricultural production. CF eliminates conventional practices such as burning of crops residues, tillage using the mould-board plough and maize monoculture.

Conservation farmers use conservation tillage methods to establish their crops and grow legumes in rotation with their other crops. The legumes fix nitrogen, improve soil fertility, break soil pans and are an excellent source of protein for the family. Conservation farmers recognize the value of trees on cropland for producing fodder, timber, fruit, medicines and fuel wood.

Background of the Case Study

The Republic of Zambia is a landlocked country in Southern Africa. The country is divided into three main Agro-ecological zones I, II and III according to the amount of rainfall received. Zones I and II are often affected by mild to severe droughts that lead to unpredictable and mostly very low crop yields. The low yields from these zones cause significant detrimental effect in the food security of the country as a whole as the commodity has to be found else where to supplement the shortfall. Worse still, the areas affected are mostly in rural settings where the inhabitants have almost no financial strength to buy food throughout the year. Figure 1 shows the four provinces where conservation farming is practice by over 120,000 small scale farmers.

Despite efforts to strengthen agriculture sector, subsistence farming has experienced numerous challenges that impelled the Government of Zambia and other stakeholders in the sector to scrutinize conventional farming practices and seek alternative farming methods that would turn around negative impacts on production and environmental sustainability. The important challenges identified include:

- Declining yields and productivity
- Chronic and transitory food insecurity and inadequate nutrition
- Excessive dependency on food aid
- Land degradation including soil fertility loss, soil erosion
- Migration of farming communities, encroachment of virgin woodland and deforestation
- Uneven distribution of rainfall especially in agro-ecological zone I and II.
- Inadequate animal draught power after loss of cattle due to corridor disease

Over the years, Conservation Farming has been introduced and encouraged in Zambia, mostly through the Ministry of Agriculture and Cooperatives. This method of farming aims at mitigating inadequate rainwater resources and is adapted as part of integrated watershed management process.

Detrimental conventional farming practices

Smallholder farmers in Zambia have a long history practicing hazardous conventional farming techniques which have impacted negatively on productivity and the environment in general. The three most common ones include burning of crop residues at the end of the growing season, tillage using mould board plough and hand hoe and maize monocropping.

Burning Crop Residues Farmers suppose that burning crop residues gets rid of pests and diseases, especially the larger grain borers which are known to destroy of crops. Farmers also argue that crop residues clog the plough making land preparation cumbersome and time consuming. In the Eastern province of Zambia, farmers primarily burn crop residues to hunt rats, a nutritious and delicious relish. However, crop residues protect the soil from sheet erosion, improve water infiltration and reduce soil temperatures especially during the hot dry season. Termites and other soil fauna incorporate crop residues in the soil maintaining its structure and fertility.

Tillage Using the Ox-drawn Mould-Board Plough Because the ox-drawn mould-board plough works best in moist soils, farmers have to wait for the onset of rains around mid November to prepare their land for planting. According to the Conservation Farming Unit in Zambia (CFU), ploughing 18 days after first planting rains, results in 25% loss of yield. Thirty percent of seasonal rainfall and 50% of applied nutrients are also lost as storm flow. This has been exacerbated by the loss of draught animals which occurred in the early 1990s due to tick-borne disease outbreaks. Repeated use of the mould-board plough results in the creation of a hardpan at 30cm below the soil surface. This hardpan impedes infiltration and inhibits rooting of crops. The hand hoe pan also creates a hardpan.

Maize Monoculture, Dry spells and the Threat of Climate Change Maize monoculture or the planting of maize in one field year after year, combined with the use of acidifying fertilizers and conventional tillage, is a widespread recipe for disaster in Zambia. This practice results in increasing acidity, declining soil fertility, oxidation of organic matter, development of hardpans, declining water holding capacity and plummeting maize yields. This has increased vulnerability to effects of climate.

Key reason for success

The noticeable contributing factors to the success of conservation farming in Zambia comprise favorable government policies, support by bilateral partners and institutional support by CF specialized institutions and the Zambia National Farmers Union.

Favorable Government Policies:

- In 1999, the Ministry of Agriculture and Cooperatives (MACO) adopted CA as the main message within the agricultural extension system.

- MACO implemented the Land Management and Conservation Farming programme

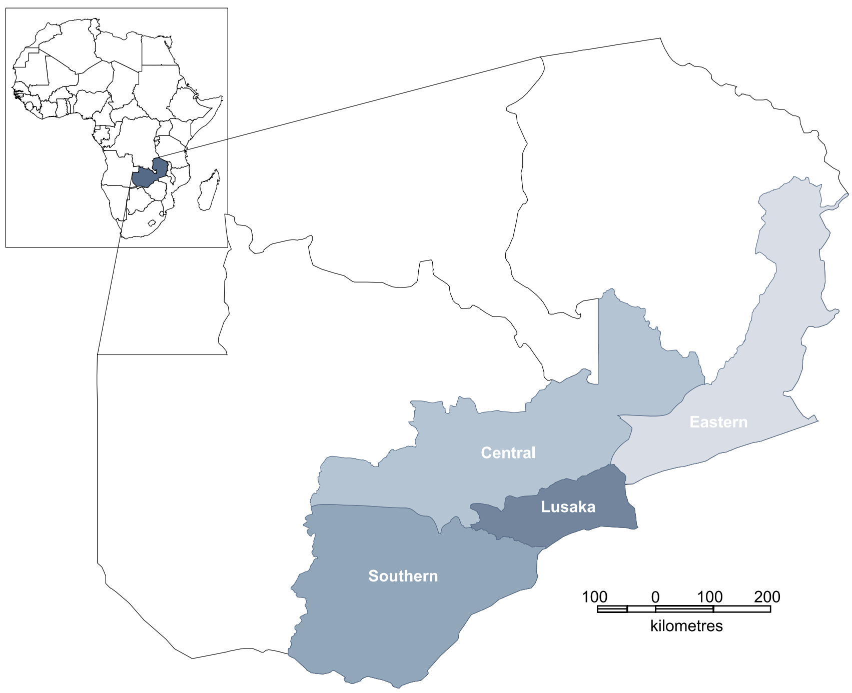

Figure 1Map of Zambia Showing Main Conservation Farming Provinces

1999-2002. The programme trained over 350 extension staff working in the targeted provinces.

- Support by the Golden Valley Agricultural Research Trust - GART

Up scaling Projects by Bilateral Partners:

- The Swedish Government via Swedish International Development Agency – Sida, supported the LM&CF programme and Agricultural Support Program (ASP). These programmes piloted CF in the Southern, Eastern, Central and Lusaka provinces covering at least 75,000 farm families per annum.

- As early as 1996 The Norwegian Government initiated support to the Conservation Farming Unit - CFU, an NGO that championed hand hoe based CF in under the umbrella of Zambia National Farmers Union.

Institutional support key stakeholders

- Support by the Zambia National Farmer's Union and its Conservation Farming unit

- Support from private sector such as CLUSA working with DUNAVANT for cotton farmers, the GTZ and HODI (Formally Harvest Help UK).

Results from Golden Valley Research Trust (GART)

Golden Valley Agricultural Research Trust (GART) undertook research on various trials in conservation farming between year 2000 and 2004 which involved the effect of tillage on maize, pigeon peas and cotton production. The results are depicted as follows

As shown in Table 1, deep ripping and basin planting has the ability to increase water harvesting, rainwater infiltration and thus water use efficiency. This is more so with the Magoye ripper which has performed better than the Palabana ripper. Compared to ploughing using conventional methods, conservation tillage methods result in three-fold increase in maize yield.

Direct ripping is the most suitable for maize. However, ripping 25 – 30 cm is suited for cotton and pigeon peas (Table 2). It ensured improved water infiltration and adequate water storage. This enabled roots to grow deeper with large volumes and eventually produce better crop yields. Roots of pigeon peas and cotton grow relatively deeper than maize and eventually produce better crop yields. In addition, their potential is fully exploited in an environment of deep tillage.

Conclusion

In conclusion Langmead (2003), observed that conservation farming practice increases yields by around 78 percent which is significantly greater than in normal farming practice. In addition, Conservation Farming traps soil moisture to improve water availability. Keeping crop residue on the surface traps water in the soil and provides a shade. The shade reduces water evaporation. In addition, crop residue slows runoff and increases the opportunity for water to soak into the soil. Further infiltration occurs owing to macro pore channels created by earthworms and old plant

Table 1Tillage and Fertilizer Effect on the yield of Maize at Magoye 2000/2001 season

Tillage System	Fertilizer (ka/ha)	No Fertilizer (ka/ha)	Increase in Yield (%)
Holey Ground	2875	612	369
Ploughing	2958	2010	47
Deep ripping (Palabana Subsoiler)	3250	756	308
Shallow ripping (Magoye ripper)	2567	531	383

Source: GART year book 2001

roots. Continuous no till can often result in as much as 2 more additional inches of water available to plants in summer.

Today in Zambia over 120,000 farmers have already benefited from the adoption of CF. By 2011 it is aimed at increasing adoption to 250,000 families or about 30% of Zambia's small-scale farming community. The benefits of CF and CA are proven and offer farmers the opportunity to:

- Dramatically increase their yields, diversify their production base and engage in economic activity.
- Regenerate their soils and sustain adequate levels of production in all but the worst droughts.
- Liberate themselves from dependency on food aid and excessive use of costly external inputs.
- Practice sedentary agriculture on a sustainable basis.

References & further reading

CF Handbook for Ox Farmers in Agro-Region I & IIa - CFU

CF Handbook for Hoe Farmers in Agro-Region l & lla - CFU

CF Handbook for Hoe Farmers in Agro-Region lll - CFU

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Langmead P. (2003). The Land Management & Conservation Farming Program (LM&CF) A Cost-Benefit Analysis

Table 2 Crop yields in tones / hectare under different Tillage Systems at Magoye (2002 – 2003 season)

Tillage System	Maize	Pigeon Peas	Cotton
Direct planting	0.97	0.93	0.86
Planting Basins (CFU)	1.11	0.97	0.93
Ploughing	1.14	1.29	0.79
Ripping (25-30 cm)	1.03	1.51	1.07
Ripping/ ridging	1.28	1.23	0.83
Direct ripping (15cm)	1.32	1.11	1.02

Source: GART 2003 Year Book

APPENDIX 2: Estimating costs and benefits at a farm level

2.1 There is a wealth of case studies estimating costs and benefits of agricultural water management (AWM) systems, ranging from *in situ* systems to small-scale irrigation. The assumptions are first that individual farmers will not invest in a technology that does not yield financial returns, and secondly, that these returns need to be immediate, preferably within one or two seasons, for the technology to be of interest to the smallholder farmers targeted.

2.2 However, an analysis of individual farmer/household financial returns is only one component of estimating total benefits at a higher spatial scale. Clearly the effects of altered AWMs on fields do not only affect the crop yields, but also potentially land and water resources in other locations in the landscape. This becomes more evident the higher the rate of adoption of the AWM. For example, a positive externality from farmers' adoption of erosion control measures is a decrease in sediment loads to downstream areas. An example of a negative effect can come in some instances from planting trees or from digging small wells, which ultimately lower groundwater tables. Thus, ***conventional farm-level cost-benefit analyses do not account for changes in natural assets and wealth, nor for costs and benefits that emerge outside the fields from the implementation of the new AWMs.***

2.3 Conventional cost-benefit analyses assume that labour has an opportunity cost. But in communities where there are limited opportunities for paid labour, the opportunity cost can be set near or at zero. On the other hand, if labour is required when the farmer is otherwise engaged, for example in crop management, the shift of labour may actually incur a cost at another part of the household. Including ***a range of labour costs in the analysis for a specific AWM*** is therefore important for obtaining accurate estimates.

2.4 The discount rate reflects the uncertainty of future income flows. For many smallholder farmers, the discount rate is very high (i.e. in the range of 20%), reflecting more immediate vulnerability which necessitates a short-term focus. ***Thus, cost-***

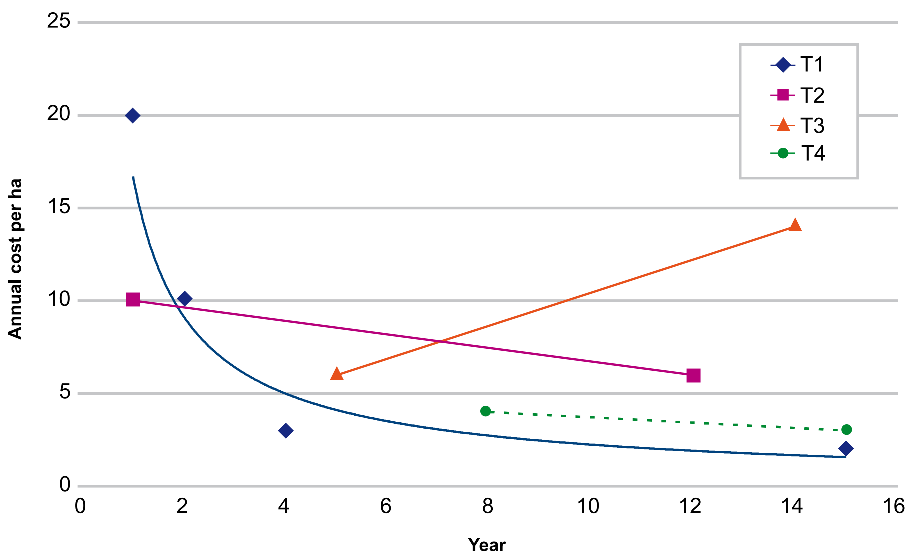

Figure 2.1: Potential cost per hectare for agricultural water management technologies in a given context.

T1-T4 represents different technologies with associated costs. T1 may be a high investment, but with decreasing annual maintenance (such as a well, or pond), whereas T2 may represent a conservation tillage system with relatively high annual maintenance (oxen and tools). T3 and T4 represent new technologies being introduced in the area, where T3 shows a situation when the technology package input gets more expensive (ex, increased diesel/petrol price, less accessible supplies as in herbicide/pesticide).

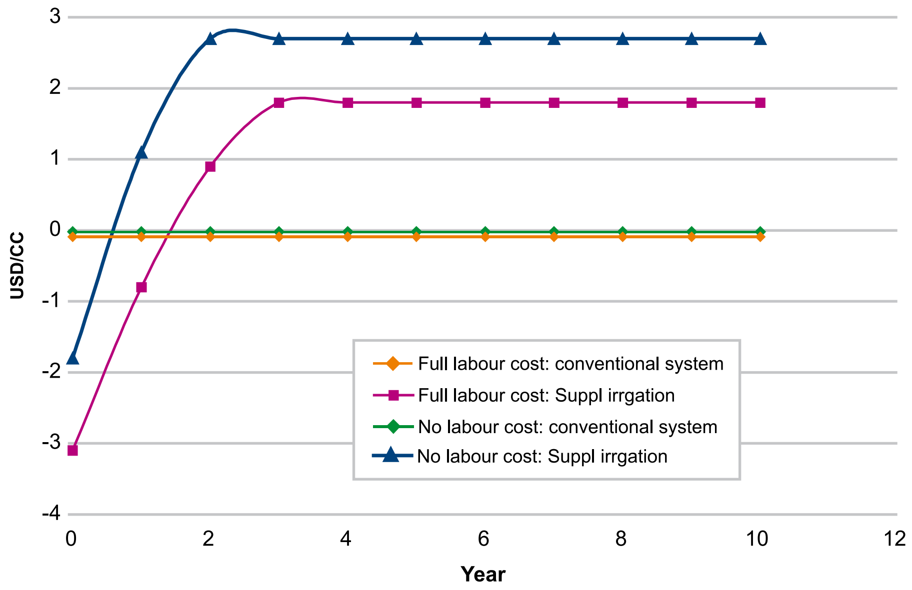

Figure 2.2a: Profit analysis on one hectare of land relative to household grain self-sufficiency for conventional and supplemental irrigation (*ex situ*) system in semi-arid Burkina Faso.

The value of one (1) on y-axis indicates household self-sufficiency in cereals (equal to US$236 per year). Two labour cost scenarios are presented for conventional and supplemental irrigation system. In both cases the conventional system fails to meet household food self-sufficiency, whereas the supplemental irrigation makes profit after year 2 independent on labour cost scenario (data after Fox *et al*., 2005).

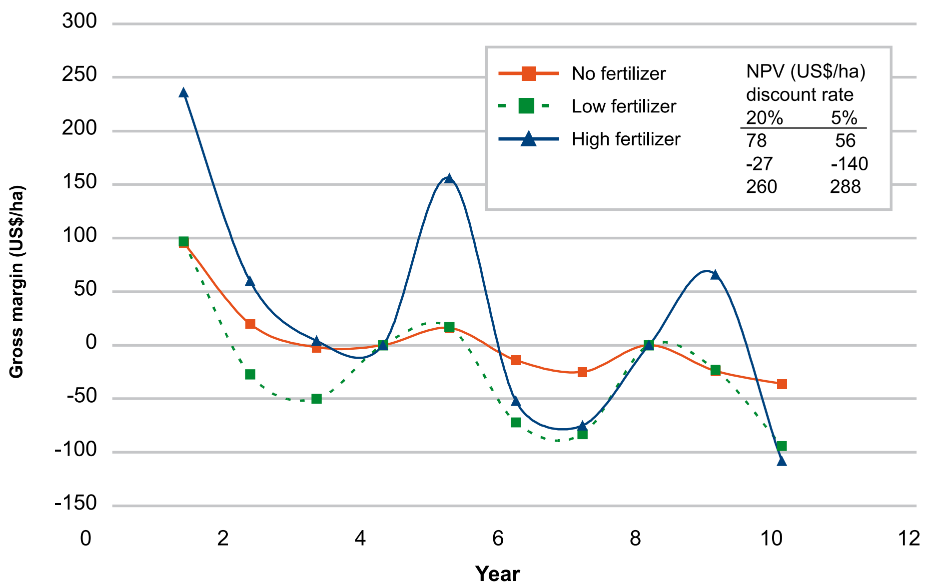

Figure 2.2b: Gross margin (US$ per hectare) for a ridging system (an *in situ* AWM) with no, low and high fertilizer and a maize crop.

Note the negative trend especially for ridging without and with low fertilizer. Inserted in the Figure is the Net Present Value (NPV) estimated for different discount rates (data after Ellis-Jones & Tengberg, 2000)

benefit analyses performed at farm levels should utilize a range of discount rate assumptions to incorporate the potential risk scenarios facing the investor in AWMs.

2.5 The theoretical assumptions in technology can be perceived as follows (Fig 2.1): when a new technology is introduced, it is associated with relatively high cost, as there is limited knowledge, supply and access to the technology. As time passes and adoption rates rise, the cost per item (for example, a pump, a ripper for conservation tillage, drip irrigation kits) decreases. These principal cost developments do not account for externalities, changes in other inputs to realise water potential, or changes in natural or social capital and wealth.

2.6 However, ***water management alone at plot scale does not necessarily increase yields, but often must be complemented with other inputs, which affect the cost-benefit analysis.*** In particular, fertilizers are needed to realise the potential benefits of additional water. Increased access to water may enable a shift in crops (from cereal to high value vegetables and fruit), in turn potentially requiring a higher input of labour. Examples of cost-benefit and development over time at farm level can be seen for supplemental irrigation in two locations and for *in situ* AWMs at three locations in sub-Sahara Africa (Fig 2.2a and b).

Photo: Maimbo Malesu/ Alex Oduor

APPENDIX 3: Example of social and natural capital changes at different scales due to AWM interventions at farm and mesoscale level

Scale	Type of capital	Direct	Indirect
Farm	Natural	Increased on-farm biomass production/ productivity Less sediment loss Less surface runoff	Winner/losers from externalities on other farm interventions
Farm	Social Human	More income Livelihood improvements Household resilience	Equity effects/gender Serve as part of community capacity
Watershed	Natural	Altered water flows: surface and groundwater Altered water quality: nutrients, pesticides, sediments	Effects on non-farmland (forest, grazing, waterways, wetlands) Biodiversity
Watershed	Social Human	Strengthen community knowledge & learning in resource base Empowerment	Equity effects/gender

A range of cost and benefits of watershed interventions are not included in conventional economic analyses

Only red highlights are usually addressed in cost-benefit analyses

Notably the WB (2007) assessing 40+ projects could not find comprehensive assessment on water flow effects in the landscape due to interventions by farmers and/or communities, Also, there were very little data on sustainability of intervention beyond project interventions, and also on achieved poverty alleviation.

There are a full range of environmental and social issues to be incorporated into regular monitor and evaluation of AWM interventions at farm and mesoscale.

These can either emerge as externalities, i.e. effects downstream or internally, as effects on off-farm land.

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