www.water-alternatives.org
Volume 4 | Issue 2
Barron, J. and Noel, S. 2011. Valuing soft components in agricultural water management interventions in meso-scale watersheds: A review and synthesis.
Water Alternatives 4(2): 145-154

Valuing Soft Components in Agricultural Water Management Interventions in Meso-Scale Watersheds: A Review and Synthesis

Jennie Barron
Stockholm Environment Institute, University of York, UK; and Stockholm Resilience Centre, Stockholm University, Sweden; jennie.barron@sei.se

Stacey Noel
Stockholm Environment Institute, University of Dar es Salaam, Tanzania; stacey.noel@sei.se

ABSTRACT: Meso-scale watershed management (1-10,000 km^2) is receiving growing attention as the spatial scale where policy in integrated water resource management (IWRM) goes into operational mode. This is also where aggregated field-level agricultural water management (AWM) interventions may result in externalities. But there is little synthesised 'lessons learned' on the costs and benefits of interventions at this scale. Here we synthesise selected cases and meta-analyses on the investment cost in 'soft components' accompanying AWM interventions. The focus is on meso-scale watersheds in Asia, sub-Saharan Africa and Latin America. We found very few cases with benefit-to-cost evaluation at full project level, or separate costing of hard and soft components. The synthesis suggests higher development success rates in communities with an initial level of social capital, where projects were implemented with cost- and knowledge-sharing between involved stakeholders, and where one or more 'agents of change' were present to facilitate leadership and communications. There is a need to monitor and evaluate both the external and the internal gains and losses in a more systematic manner to help development agents and other investors to ensure wiser and more effective investments in AWM interventions and watershed management.

KEYWORDS: Meso-scale watersheds, agricultural water management, investment, cost benefit, social capital

INTRODUCTION

Rain-fed agroecological landscapes currently provide food and livelihoods for the predominantly rural population countries in sub-Saharan Africa, Asia, and parts of Latin America. This is also where poverty and undernourishment are at their highest, with over 60% of rural inhabitants in sub-Saharan Africa existing on less than US$1.25 per day (IFAD, 2010) and 30% of sub-Saharan Africa's population undernourished (FAO, 2010). Improving agricultural water management (AWM) in smallholder farming systems can provide a first step solution to secure crop production, thus enabling other much-needed investments in, for example, nutrients, weeding, timely operations, and post-harvest processing, to further improve yield levels and productivity. Here, we use a broad definition of AWMs, which can span from soil and water conservation measures to smallholder irrigation interventions, and a mix of soil and water interventions in between that aims to enhance crop water availability within existing, or through additional, crop seasons. However, there are principal challenges: despite various successful AWMs as shown by research and commercial farmers, adoption and adaptation have so far been less than successful, in particular among smallholder poverty-affected and least productive farmers. Secondly, the aggregated effects on landscape water and land 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 in addition to the technical requirements of water and soil management. Clearly, AWMs need to be biophysically and technically appropriate and economically viable for the smallholder farmer. But there is also a growing awareness of the need to focus on the social and human settings, including formal/informal social organisations, governance and empowerment. Ultimately, it is farmers who enable adoption and adaptation of AWMs. It is also the local people who will have to cope with potential adaptive management as farming and landscapes transform, especially to deal with the emerging externalities, on water and land resources as well as on social and equity issues.

In the next 30-50 years, more water will need to be allocated to food production (e.g. Comprehensive Assessment, 2007), thus demanding higher production and productivity from smallholder farmers whilst requirements are maintained or grow also for other sectors of water users, including support of ecosystem services and society. When accounting for total rainfall available per capita (Rockström et al., 2009) it is found that, already, water stress is emerging in a range of climate zones, not just in arid environments. 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 (Christensen et al., 2007) and its impacts on crop production (e.g. Lobell et al., 2008). Thus, AWMs to increase on-farm productivity constitute one step to adapt to increased uncertainty. At the same time, it is important to ensure that potential water and land trade-offs in the landscape are explicit and accounted for, so that the increase in on-farm water management does not undermine surrounding landscape ecosystem services, or downstream development of water resources. The necessity of human and social capital to implement AWMs as well as deal with the continuous management and governance of land and water resources at the meso-scale (1-10,000 km^2; FAO, 2006) is less explicit, and even less well-assessed for investment needs and actual costs. This paper aims to give a first overview of investment in 'soft components'[1] aiming to build on, and strengthen, social and human capital in meso-scale AWM interventions which target rural smallholder farming communities in the developing context. Firstly, it will identify which soft components are related to successful interventions and development indicators in meso-scale AWM interventions. Secondly, it will report on actual costs of soft components in AWM interventions aiming at meso-scale adoption and adaptation. The objective is to develop evidence of costs associated with the 'soft' components of interventions. This will aid investors to account for more successful development action when addressing the full complexity of AWM interventions and accompanying biophysical and social-human impacts.

MATERIAL AND METHODS

In this paper we use different source material from scientific peer-reviewed papers, technical reports and working papers, and personal communication. A detailed description of the meta-analyses and cases is available in Barron et al., 2008. We define the spatial scale as 1-10,000 km^2 for meso-scale watersheds as this is the scale where biophysical impacts, in particular water quantity and quality, can be controlled by and impacts experienced by local stakeholders, following FAO's (2006) definition. In the Indian cases of watershed management and interventions, the watersheds tend to be at the lower range – often in the order of 0.5 to 50 km^2 – to coincide with local communities. However, the current operationalisation of Integrated Water Resource Management (IWRM) principles in various sub-Saharan countries tend to be for Water Users Associations for water resource management purposes at

[1] 'Soft' components are defined in relation to physical infrastructure or 'hardware', which includes: "physical construction/excavation, structures, facilities, equipment and materials, such as dam, canal, irrigation road, sluice, water-gate, construction materials, etc" (Inocencio et al., 2005). Any project component that is not hardware is considered a soft component.

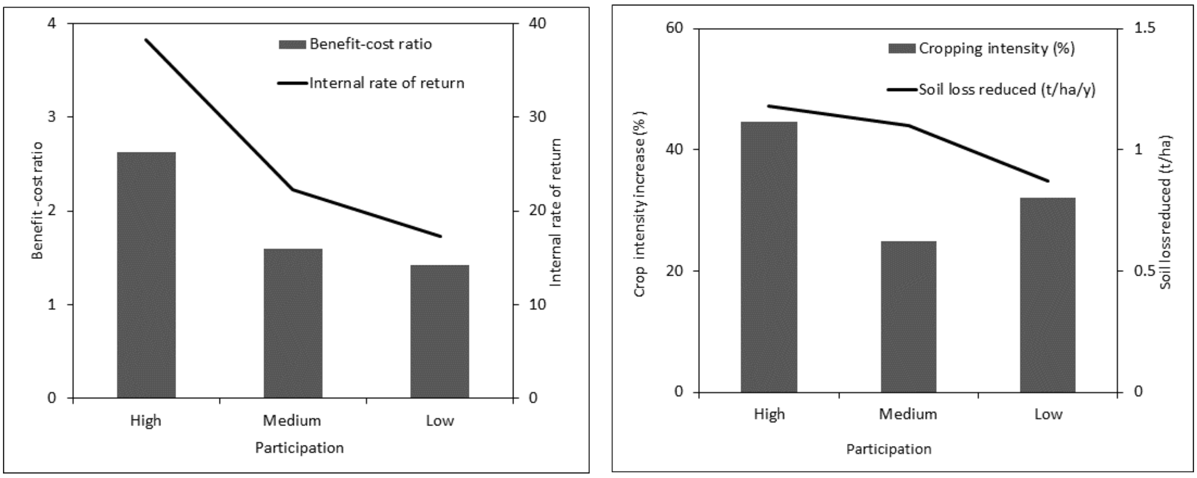
higher spatial scales, ranging up to 500 km^2 in drier areas.[2] For hydrological impact purposes, it is still justified to address the scale up to 10,000 km^2, albeit that most cases will be less than 1000 km^2.

RESULTS

The 'soft component' in projects with AWM interventions and watershed management

Adoption and adaptation 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., 2006; Joshi et al., 2008). In addition, change in smallholder farmers' use of meso-scale land and water resources may have impacts both in socioeconomic and biophysical terms at the local level and downstream. Often, AWM interventions have multiple goals in the development context, which mixes socio-economic and environmental sustainability targets. Successful AWM interventions as well as other development actions tend to have commonalities, such as existing social capital and human capital, to build upon. 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), Krishna and Uphoff (2002) and Noble et al. (2006), and further discussed by Barron et al. (2008) for additional cases. The most consistent study by Joshi et al. (2008) found internal rates of return and benefit-cost ratio being higher in watersheds classified as having high rates of participation than for watersheds classed as having low levels of participation (figure 1a). Also, the environmental impact indicators of increased crop intensity (% area increase) and reduced soil loss (tons per hectare per year) were correlated to levels of participation, with higher positive gains in watersheds with high participation (figure 1b).

Figure 1. Indicators of efficiency (a: left) and sustainability (b: right) of high, medium and low community participation in meta-analysis of Indian watershed management



Source: Data after Joshi et al., 2008.

To enhance success in adoption and adaptation, many interventions seek to further strengthen the social and human capital through various actions. These soft components of intervention projects or programmes do have some generic features according to the meta-analyses found here. Examples of these soft component features include:

[2] Authors' personal reflections from experiences in six sub-Saharan countries.

- *Agent of change:* An important feature is the presence of an agent of change, or leadership able to mediate the development interventions in a community or location. The agent of change can be local or external, but the role is consistent in terms of the agent acting as a translator between local communities or individuals and external stakeholders. This 'agent of change' (or 'broker', 'key leader', 'champion' or 'facilitator') is also identified as an important feature in social network analyses for improved natural resource governance and management (e.g. Olsson et al., 2006).
- *Knowledge building and empowerment:* Knowledge systems and capacity building were also common features introduced in successful AWM adoption. As Joshi et al. (2008) report, a first step can be to learn about the local environment or introduce new AWM interventions. Project components to empower and enable local decisions were also shown to enhance benefit-cost ratios in the meta-analysis of watershed programmes in various parts of India.
- *Building a consortium that includes government-civil society partnerships:* The cases involved bringing a new consortium of actors together around a common development agenda. The key actors were the local community and local public institutions, with a selection of additional inputs from donors, researchers, NGOs, and others. Of note is the absence of private-sector entities; it appears that in these cases, the returns were not sufficiently attractive and/or the risks were too great to elicit the involvement of the local business community.

These results are similar to those found in more recent quantitative cases in South Asia. Krishna (2001) analysed the performance for different sets of rural watershed development activities across 60 villages in Rajasthan, India, and found that high social capital, combined with the presence of capable new (typically young) leaders, was associated with highest performance in the development activities studied. Another study (Janssens, 2010) looked at 1991 households across 102 villages in Bihar, India, and found that a women's empowerment project which strengthened social capital through the formation of women's groups had a significant 'spillover' effect, benefitting non-participating households, often at lower-caste and lower-income levels. The 'spillover' effect created higher levels of trust in community members and contributing more to community projects than households in villages without an empowerment project. According to Khwaja (2009), improved project design can overcome pre-existing social capital deficiencies; based on work in northern Pakistan relating to various irrigation initiatives, suggested elements for improvement include some commonalities with the points made above: support to develop leadership, involvement of local communities in decision making, and emulating NGOs. It should be noted that the case studies and the meta-analyses are largely drawn from the South Asia context. There is a large knowledge gap for generic characteristics for other socio-cultural settings, although similar conclusions have been presented by the Africa Highlands Initiative (AHI) participatory watershed approaches (Stroud and Khandelwal, 2006; German et al., 2007). In a recent review of approaches for natural resources management in watershed development (Stroud and Khandelwal, 2006), it was 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 five key factors lead to sustainable natural (land, water, forest) management: (i) policy setting; (ii) payback of investment; (iii) local capacity and empowering; (iv) multiple livelihood interventions/income generating options; and (v) research and development to work in collaboration. However, the review of the AHI experience is more qualitative than quantitative, and thus it is difficult to compare it with other more systematic analyses by Joshi et al. (2005, 2008) and Kerr (2002).

Despite knowing the importance of soft components in AWM and watershed implementation, the costs of these components in watershed projects are not easily obtained. In table 1, 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 percentages can be expected, but the evidence from comprehensive meta-analyses is currently weak. Only case studies can be referred to for support here (e.g. Barron et al., 2008).

Table 1. 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 (Muñoz, 2008)	←	US$65-360 / trained person	→		Extension projects
Kusa, Kenya (Sandström et al., 2005)	←	US$5 /cap (for 20,000 inhabitants in a watershed)	→		Mostly soft components: extension, commu-nity mobilisation
IFAD (2000)	US$93 / trained person				Case
IDE case Nepal (Mikhail, 2008)	←	US$195-226 per 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 Rehabilitation: 25% of total cost	Meta-analysis

In-situ AWM: water for improved infiltration and better crop water availability is largely from within the field where the crop is located. Typical technologies include soil water conservation measures, pitting and ridging terracing;

Ex-situ AWM: water is collected externally to the field, which benefits from improved water availability. An example is run-off rainwater harvesting, sometimes with storage components.

Benefit-cost estimates of AWM interventions at farm to meso-scale watersheds

The issue of cost-effectiveness, i.e. how much benefit for each dollar invested, is important to any investor, whether a farmer, government, or external funder. Here we discuss some emerging issues concerning benefit-cost 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-Saharan Africa and South Asia. Overall, we found very few consistent and comprehensive analyses of benefit-cost ratios of watershed interventions and watershed management in the literature. This was also stated by the World Bank (2007), albeit referring to the internal evaluation of watershed interventions.

The inconsistency in benefit-cost analyses is partly because 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 on private or community land). Other direct and indirect benefits are rarely estimated in economic terms, such as the gains in natural and social capital in a watershed due to individual and collective actions taken in AWMs.

Project implementation aiming to increase adoption of AWMs is associated with a greater range of prices per hectare under interventions than what is implied in the benefit-cost estimates per hectare for farmers. 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 in 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 watershed intervention, the existing capacity of the community and partner institutions has a high impact on costs. Communities do not have the same pre-existing institutional infrastructure or social and human capital. In the reviewed literature, most analyses of projects with AWM and watershed management components did not report costs and benefits for internal watershed trade-offs between different land-use beneficiaries, or shifts in wealth due to AWM interventions in the involved and/or excluded communities. Equally poor was the reporting of externalities: How did the water flows change (or not) due to watershed interventions? Were there any other changes, social and/or natural that emerged due to the watershed intervention upstream? This lack of data was also highlighted by the World Bank (2007) evaluation. Often, the costs and benefits were evaluated at the end of the project. Lasting effects and/or changes due to the project implementation are often not revisited or accounted for. There was 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., 2005, 2008; Noble et al., 2006[3]), it emerged 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 around US$400/ha and upwards for in-situ smallholder interventions (table 2). Conventional cost estimates from meta-analyses of large-scale successful irrigation interventions are, on average, US$2500/ha for South Asia and US$5000/ha for sub-Saharan Africa (Inocencio et al., 2005). This can be explained partly 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.

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 run-off flows, etc). Two concerns are raised here about these benefit-cost estimates: the discount rate and the estimated value of labour in predominantly smallholder subsistence farming systems. The first issue is that the discount rate needs to be varied to reflect the uncertainty of investment that many smallholder farmers face. 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; Tenge et al., 2005). As many AWMs and other farm improvements involve labour intensification, it is important to reflect the diverse labour costs to get an accurate idea on investment potential (see Barron et al., 2008 for further details).

[3] 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 these 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.

Table 2. Comparing per hectare investment costs for watershed-level interventions projects with AWM components (including soft and hard components).[4]

	In-situ AWMs	*Ex-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., 2008)	←	B/C=2.00 average B/C=1.70 median	→		Meta-analysis $EIRR_{av}$=27 ($EIRR_{med}$=25)
India (Kerr, 2002)	←	US$56-185/ha watershed	→		Meta-analysis
The Commission for Africa (Lankford, 2005)			B/C=1.7-3.3	US$5000-US$20,000/ha (new) US$1000+/ha ('seed' projects)	A cost framework for irrigation investment in Africa
WB Large irrigation Sub-Sahara Africa (Inocencio et al., 2005)				US$4790/ha (new) US$1970/ha (rehabilitation)	Meta-analysis success projects EIRR=22-23
WB Large irrigation South Asia (Inocencio et al., 2005)				US$2526/ha (new) US$898/ha (rehabilitation)	Meta-analysis success projects

The meta-analyses from Indian watershed interventions (Kerr, 2000; Joshi et al., 2005, 2008) are evidently developed from a range of source materials. It has been suggested that early documented cases tended to represent 'successes' rather than failures. There is therefore no guarantee that the overall results are a 'true sample', but more likely a representation of the available sample. An easy test would be to run statistics for the meta-analysis on a subsample of the cases, dividing into early versus later cases, and study the biases as compared to overall results.

CONCLUSIONS AND EMERGING ISSUES

High recognition of soft components but little valuation

From the synthesis of meta-analyses and through additional cases, we confirm the importance of social and human capital in AWM interventions at the meso-scale watershed. The level of social capital in a community is not only an entry point but also a key building block for successful adoption and adaptation of AWM interventions at the farm and watershed level. The preconditions 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. Evidence summarised here demonstrates 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

[4] B/C is benefit-cost ratio. EIRR is economic internal rate of return, expressed as a percentage.

emerged in several cases as an important feature of successful intervention. And although not thoroughly studied here, these targets are often similar for other development interventions, such as in environmental conservation, biodiversity protection, or climate adaptation of local rural livelihoods.

Despite recognition of the importance of soft components for AWM interventions in the meso-scale, the cases as well as the meta-analyses on watershed interventions had poor benefit-cost evaluations. 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. We believe this is a gap in project management. There is a need for rigour in the monitoring and evaluation of preconditions as well as evaluation of both intended and unintended impacts on the coupled socioecological system that the AWM interventions intend to change in watersheds. 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 benefit-cost analyses; and
- the difficulties in assessing even conventional benefit-cost analyses with multi-stakeholder contributions, as is often the case in watershed management (e.g. Kerr, 2002; Kerr et al., 2007).

Emerging issues

Overall, we conclude that there is little systematic evidence and quantification on the success (and failures) of watershed-level interventions. The only systematic quantitative analyses that could be identified were for the Indian watershed interventions described by Kerr (2002) and Joshi et al. (2005, 2008). No similar quantitative meta-analyses for watershed interventions could be found for sub-Saharan Africa or Latin America.

Equally, as there is a knowledge gap on return of investment in projects of AWM interventions and watershed management, there is a need to evaluate watershed interventions beyond the watershed where implementation occurs to ascertain the extent of external as well as internal benefits and costs. Conventional economic benefit-cost analyses poorly account for emerging effects on natural, human, and social capital within and beyond the meso-scale watershed. This was also concluded in the World Bank review of watershed interventions during 1990-2004 (World Bank, 2007). 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? What impact was attained in poverty alleviation?

Thus, there are some basic lessons learned concerning how to do watershed management in natural resources management and how it may be seen as successful in terms of increased yields of farmers and potentially reduced erosion. The soft component is throughout recognised as a key cornerstone together with the existing social and human capital in the targeted watershed. But there is little synthesised evidence on past AWM interventions taken to scale or watershed management interventions for increased agricultural productivity available, and how it affects off-farm land as well as downstream locations. The attained impact on poverty alleviation is equally poorly documented. The environmental impact assessment has consistently been poorly documented in the cases found. Equally, the emerging costs and benefits, which include the soft components as well as extended analyses on wealth and assets of natural and social capital changes, need to be addressed in future AWM and watershed interventions in order to meet goals on both equity and sustainability in communities involved and beyond the targeted watershed. More consistent monitoring and evaluation of both soft and hard system indicators could help investors in AWM development to better direct efforts and design more effective actions, with potential to fast-track development actions considerably.

ACKNOWLEDGEMENTS

We acknowledge the Bill & Melinda Gates Foundation for providing financial support for the initial study underlying this paper. The findings and conclusions contained within are those of the authors and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation. Additional support was contributed by FORMAS research council in Sweden. We also thank representatives of IWMI, IFPRI, FAO and the Bill & Melinda Gates Foundation for comments and valuable input.

REFERENCES

Barron, J.; Noel, S.; Malesu, M.; Oduor, A.; Shone, G. and Rockström, J. 2008. Agricultural water management in smallholder farming systems: The value of soft components in meso-scale interventions. SEI Project Report. Stockholm: Stockholm Environment Institute.

Christensen, J.H.; Hewitson, B.; Busuioc, A.; Chen, A.; Gao, X.; Held, I.; Jones, R.; Kolli, R.K.; Kwon, W.-T.; Laprise, R.; Magaña Rueda, V.; Mearns, L.; Menéndez, C.G.; Räisänen, J.; Rinke, A.; Sarr, A. and Whetton, P. 2007. Regional climate projections. In Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K.B.; Tignor, M. and Miller, H.L. (Eds), *Climate change 2007: The physical science basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, USA: Cambridge University Press.

Comprehensive Assessment. 2007. *Water for food, water for life: A comprehensive assessment of water management in agriculture.* Comprehensive Assessment of Water Management in Agriculture. Colombo: International Water Management Institute; London: Earthscan.

FAO (Food and Agriculture Organization of the United Nations). 2006. *The new generation of watershed management programmes and projects.* FAO Forestry Paper 150. Rome: FAO.

FAO. 2010. *The state of food insecurity in the world: Addressing food insecurity in protracted crises.* Rome: FAO.

Fox, P.; Rockström, J. and Barron, J. 2005. Risk analysis and economic viability of water harvesting for supplemental irrigation in semi-arid Burkina Faso and Kenya. *Agricultural Systems* 83(3): 231-250.

German, L.; Mansoor, H.; Alemu, G.; Mazengia, W.; Amede, T. and Stroud, A. 2007. Participatory integrated watershed management: Evolution of concepts and methods in an ecoregional program of eastern African highlands. *Agricultural Systems* 94(2): 189-204.

IFAD (International Fund for Agricultural Development). 2000. *Report and recommendation of the President to the Executive Board on a proposed loan to the Republic of Madagascar for the upper Mandrare Basin development project.* Rome: IFAD.

IFAD. 2010. *Rural poverty report 2011: New realities, new challenges: new opportunities for tomorrow's generation.* Rome: IFAD.

Inocencio, A.; Kikuchi, M.; Merrey, D.; Tonosaki, M; Maruyama, A.; de Jong, I.; Sally, H. and Penning de Vries, F.T.P. 2005. Lessons from irrigation investments experiences: Cost-reducing and performance-enhancing options for sub-Sahara Africa. Report No. 6 of series *Investments in agricultural water management in sub-Sahara Africa: Diagnosis of trends and opportunities*. Colombo: African Development Bank/ International Water Management Institute.

Janssens, W. 2010. Women's empowerment and social capital in Indian villages. *World Development* 38(7): 974-988.

Joshi, P.K.; Jha, A.K.; Wani, S.P.; Joshi, L. and Shiyani, R.L. 2005. *Meta-analysis to assess impact of watershed program and people's participation.* Comprehensive Assessment Research Report No. 8. Colombo: Comprehensive Assessment Secretariat.

Joshi, P.K.; Jha, A.K.; Wani, S.P.; Sreedevi, T.K. and Shaheen, F.A. 2008. *Impact of watershed program and conditions for success: A meta-analysis approach.* Global Theme on Agroecosystems. Report No. 46. Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Kerr, J.M. 2002. *Watershed development projects in India: An evaluation.* Research Report No. 127. Washington, DC: International Food Policy Research Institute.

Kerr, J.; Milne, G.; Chhotray, V.; Bauman, P. and James, A.J. 2007. Managing watershed externalities in India: Theory and practice. *Environment, Development and Sustainability* 9(3): 263-281.

Khwaja, A.I. 2009. Can good projects succeed in bad communities? *Journal of Public Economics* 93(7-8): 899-916.

Krishna, A. 2001. Moving from the stock of social capital to the flow of benefits: The role of agency. *World Development* 29(6): 925-43.

Krishna, A. and Uphoff, N. 2002. Mapping and measuring social capital through assessment of collective action to conserve and develop watersheds in India. In Grootaert, C. and van Bastelaer, T. (Eds), *The role of social capital in development: An empirical assessment,* pp. 85-124. New York: Cambridge University Press.

Lankford, B. 2005. *Rural infrastructure to contribute to African agricultural development: The case of irrigation.* Report for The Commission for Africa. Norwich: University of East Anglia.

Lobell, D.B.; Burke, M.B.; Tebaldi, C.; Mastrandrea, M.D.; Falcon, W.P. and Naylor, R. 2008. Prioritizing climate change adaptation needs for food security in 2030. *Science* 319: 607-610.

Mikhail, M. 2008. Personal communication. By email. 15 February 2008.

Muñoz, G. 2008. Personal communication. By email. 20 February 2008.

Noble, A.D.; Bossio, D.A.; Penning de Vries, F.W.T.; Pretty, J. and Thiyagarajan, T.M. 2006. *Intensifying agricultural sustainability: An analysis of impacts and drivers in the development of* '*bright spots*'*.* Comprehensive Assessment Research Report No. 13. Colombo: Comprehensive Assessment Secretariat.

Olsson, P.; Gunderson, L.H.; Carpenter, S.R.; Ryan, P.; Lebel, L.; Folke, C. and Holling, C.S. 2006. Shooting the rapids: Navigating transitions to adaptive governance of social-ecological systems. *Ecology and Society* 11(1): 18.

Rockström, J.; Falkenmark, M.; Karlberg, L.; Hoff, H.; Rost, S. and Gerten, D. 2009. Future water availability for global food production: The potential of green water for increasing resilience to global change. *Water Resources Research* 45(W00A12): 1-16.

Sandström, K.; M'Imanyara, K.M. and Torkelsson-Zetterquist, Å. 2005. *Evaluation of the Kusa Project.* Reference No. 2000-3103. Stockholm: Swedish International Development Agency.

Stroud, A. and Khandelwal, R. 2006. '*State of the art*' *of approaches, strategies and methods for improving natural resources management and livelihoods.* African Highlands Initiative Working Paper No. 6. Kampala: African Highlands Initiative.

Tenge, A.J.; De Graaff, J. and Hella, J.P. 2005. Financial efficiency of major soil and water conservation measures in West Usambara highlands, Tanzania. *Applied Geography* 25(4): 348-366.

World Bank. 2007. *Watershed management approaches, policies and operations: Lessons for scaling up*. Energy, Transport and Water Department, Water-For-Food Team. Washington, DC: World Bank.