13 Challenges of Adoption and Adaptation of Land and Water Management Options in Smallholder Agriculture: Synthesis of Lessons and Experiences

B. Shiferaw,[1]* J. Okello[2] and V. Ratna Reddy[3]*****

[1] *International Crops Research Institute for the Semi-Arid Tropics, PO Box 36063,*
Nairobi 00623, Kenya; [2] *Department of Agricultural Economics,*
University of Nairobi, PO Box 29053, Nairobi 00625, Kenya;
[3] *Centre for Economics and Soil Studies (CESS), Nizamia Observatory Campus,*
Begumpet, Hyderabad 500 016, Andhra Pradesh, India;
*emails: *b.shiferaw@cgiar.org; **okelloju@msu.edu; ***vratnareddy@cess.ac.in*

Introduction

Conservation and management of land and water resources for sustainable intensification of agriculture and poverty reduction in many developing regions has remained one of the most challenging policy issues for a long time. The increasing degradation of agroecosystems gradually deprives the poor of key productive resources and affects communities whose livelihoods heavily rely on utilization of these resources. Degradation of land and water resources gradually diminishes the capacity of individual farmers and communities to undertake critical investments needed to reverse the situation. This in turn reduces opportunities for addressing nutritional and other necessities and depletes the ability to buffer shocks, thereby increasing vulnerability of livelihoods. The potential nexus between worsening poverty and degradation of natural resources also raises fundamental questions on strategies for poverty reduction, equitable distribution of income and intergenerational equity. These challenges are highest in many developing regions representing the intersection of hotspots of widespread poverty and fragile ecosystems (e.g. arid and semi-arid areas, highland regions) (Pender and Hazell, 2000; IFAD, 2001; Shiferaw and Bantilan, 2004).

In recognition of these challenges, governments, donors and development partners in many developing countries have devoted substantial resources to develop and promote soil and water conservation practices and technologies for sustainable intensification of agriculture. These technologies are generally very diverse and vary from one region to another but include a mix of indigenous and introduced structural (or mechanical) and agronomic practices for combating soil erosion and nutrient depletion, improving water conservation, and enhancing soil and water productivity. Some examples include structural methods for soil conservation such as soil and stone bunding and terracing; agronomic practices for soil and water conservation and management such as minimum tillage, organic and inorganic fertilizers, grass strips and

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agroforestry techniques; and water-harvesting options such as tied-ridges, planting basins, check-dams, ponds, tanks and wells used in many rainfed systems (Wani *et al*., 2006; Chapters 1 and 9, this volume). The structural methods have been promoted through donor-funded projects (e.g. food for work programmes) in many parts of Africa and Asia, primarily for arresting soil erosion and productivity decline. Agronomic methods and agroforestry technologies, in particular alley cropping, aim to reduce soil erosion while also enhancing soil organic matter and have been shown to replenish soil nitrogen through nitrogen inputs. Water-harvesting technologies provide farmers with the opportunity to plant early and help reduce reliance on unpredictable rains (Baidu-Forson, 1999).

Despite the increasing efforts made and the growing policy interest, spontaneous and widespread adoption and adaptation of technologies and innovations for sustainable management of land and water resources by smallholder farmers outside of intensively supported project locations has generally been limited (Fujisaka 1994; Pender and Kerr, 1998; Barrett *et al*., 2002). Smallholder farmers and resource users continue to face difficulties in adoption and adaptation of soil and water conservation technologies. The diagnosis of these changes and lessons from different examples show that several factors have indeed contributed to the continuing challenges facing smallholder farmers in adoption and adaptation of sustainable land and water management interventions – ranging from the poor performance of the technologies themselves to policy and institutional deficiencies at different levels (Joshi *et al*., 2005).

In an effort to address these problems, the basic paradigm and approach to soil and water conservation has itself evolved over time. In recent years more holistic and landscape-wide approaches that go beyond resource conservation towards improved land husbandry and water management for beneficial conservation have been promoted (Wani *et al*., 2006). Taking a broader view, this chapter reviews African and Asian experiences in promoting soil and water conservation and sustainable land management technologies. It synthesizes lessons from various case studies and offers new insights on approaches and strategies that accelerate widespread adoption and adaptation of such interventions.

The chapter is organized as follows. The next section provides a brief description of the evolution of approaches to soil and water conservation in agriculture. The third section provides a broad conceptual framework for analyses of investment opportunities and challenges to smallholder farmers in adoption and adaptation of natural resource management (NRM) interventions. The fourth section builds on the conceptual framework and presents a review of factors that condition the adoption and adaptation of sustainable land and water management interventions. The fifth section presents the conclusions and implications for policy and future research.

Evolution of Approaches for Sustainable Land and Water Management

Concern with land and water degradation in smallholder agriculture is not a new issue. It has been around for a long time and farmers are involved in a constant struggle to adopt and adapt mitigation and conservation strategies under changing climatic and socio-economic conditions. Many countries have also tried to complement farmers' efforts by developing and promoting strategies that reduce the problem of soil erosion (and nutrient depletion) and that counter on-site productivity decline associated with degradation of agricultural land. In some cases, soil erosion and deforestation of hilly slopes also imposed significant off-site effects (e.g. siltation of dams and waterways), thereby adding another justification for government intervention. But the strategies adopted and technological solutions to the problem of land degradation varied over time and space. In many sloping areas with undulating topographies, the traditional emphasis has been on arresting soil erosion and reducing run-off. In semi-arid regions where rainfall is either unreliable or insufficient, the focus has been on technological solutions for capturing and utilizing surface and groundwater.

As indicated above, stimulating widespread adoption and adaptation of land and water management innovations has seen limited success, especially in marginal and vulnerable environments with limited socio-economic infrastructure. In an effort to redress the problem and improve actual livelihood and environmental outcomes, the approach to soil and water conservation has evolved through several phases. These different approaches may be grouped into three major types: top-down interventions, populist or farmer-first, and neo-liberal approaches. Most of the early soil and water conservation approaches focused on top-down interventions, mainly using structural methods for arresting the physical process of soil erosion (Wani *et al*., 2006). This approach is also characterized by lack of farmer participation in technology design and use of command-and-control type policies for implementation of externally developed structural measures. In the pre-independence era, colonial governments, following concerns with the rapid rate of land degradation in marginal areas (i.e. the reserves), instituted policies that aimed at checking the rate of soil and water degradation. These policies included forced adoption of soil erosion control, planting of trees on hillsides, and protection of water/river catchments. However, the policies were largely driven by fear of future consequences of inaction. Similar top-down approaches also continued in several countries (especially in Africa) until the mid-1980s (e.g. see Shiferaw and Holden, 1998; Pandey, 2001). As we show later, the command-and-control approach has imposed its own challenges on the farmers' ability to innovate and adopt and adapt improved land and water management practices.

Based on the experiences gained from the failed command-and-control policies, a new paradigm – referred to as 'populist' – that upturned the process and made the farmer central to programme design and implementation of soil and water conservation activities has emerged. This view appeared in the late 1980s and was marked by the publication of *Farmer First* – a book that embodies many of the ideas behind the 'populist' approach (Chambers *et al*., 1989). This approach stressed small-scale and bottom-up participatory interventions, often using indigenous technologies (Reij, 1991) and largely rejected the traditional transfer of technology model in the process of technology development and extension. The difficulties of implementing such farmer-led participatory approaches has prompted some researchers to reject this model in favour of a broader approach, in which farmer innovation is driven by the economic, institutional and policy environment. The neo-liberal approach advocates the need to understand the present structure of incentives that prevents resource users from adopting and adapting existing land and water management technologies. This approach recognizes the appropriate roles for farmer innovation but brings to the centre stage the critical role of markets, policies and institutions to stimulate and induce farmer innovation, adoption and adaptation of suitable options. The critical importance of making conservation attractive and economically rewarding to farmers through productive technologies and improved access to markets is regarded as the driving force for igniting farmer investments in sustainable land and water management options.

The growing understanding and recognition of the public goods characteristics of soil and water conservation and the non-technical factors that condition individual technology choice and adaptation has also prompted strategies that address institutional and organizational constraints and internalize local externalities to induce proper action at the community and landscape level (Shiferaw *et al*., 2006). An example of this is the integrated watershed management (IWM) approach, which aims to improve both private and communal livelihood benefits from wide-ranging technological and institutional interventions. The concept of IWM goes beyond traditional integrated technical interventions for soil and water conservation to include proper institutional arrangements for collective action and market-related innovations that support and diversify livelihoods. This concept ties together the biophysical notion of a watershed as a hydrological landscape unit with that of community and institutional factors that regulate local demand and determine the viability and sustainability of such interventions. Integration of the biophysical concept of a watershed and the social concept of a community helps to design appropriate technical interventions while also strengthening local institutions for collective action to internalize undesirable externalities and stimulate joint investments to address community-wide resource management problems (Wani *et al*., 2003, 2006; Shiferaw *et al*., 2006).

In the last few years, the approach for soil and water conservation in agriculture has also slowly moved towards the concept of sustainable land (and water) management, at both farm and landscape level. There is no single definition for sustainable land (and water) management but Hurni (2000) suggests that it implies ‘a system of technologies and/or planning that aims to integrate ecological and socio-economic and political principles in the management of land for agricultural and other purposes to achieve intra- and inter-generational equity’. The broadening of the concept shows the complexity of the challenges and the need for broadening of desired partnerships and the disciplinary analyses required for stimulating and promoting options for sustainable land and water management. The following section builds on this broader concept of sustainable land (and water) management and develops an integral conceptual framework for analyses of challenges for adoption and adaptation of beneficial conservation methods and practices.

Conceptual Framework

Smallholder farmers in many developing regions are dual economic agents engaging simultaneously in the production and consumption of the same commodities and investments in improving productivity and sustainability of natural resources. Hence, smallholder farmers are often referred to as farm-households. This means that smallholder decisions for land and water management in agriculture are likely to be influenced by several interrelated factors on both the production and consumption side. This is especially the case when smallholder farmers operate under imperfect information and market conditions that prevent them from pursuing a purely profit-maximizing principle in their production and investment decisions. Based on the prevailing approaches discussed above, in this section a broader conceptual framework for analyses of factors that condition farm-household decisions for adoption and adaptation of NRM interventions is presented.

The farm-household, pursuing certain feasible livelihood strategies, is the ultimate decision maker on how and when to utilize natural resources in agricultural production or to undertake certain productivity-enhancing investments to attain preferred objectives. Understanding the investment decisions of the resource users and the most important factors that drive such decisions will allow designing effective strategies for upscaling promising options for sustainable land and water management. In the context of multiple outcomes and pathways that are possible, this would also provide insights on how policy makers, analysts and development practitioners motivate and tailor farmer resource use, production and investment strategies towards win–win pathways that reduce poverty and enhance future production possibilities. This requires a more holistic conceptual framework (as depicted in Fig. 13.1) that captures the intertemporal investment decision problems across alternative livelihood options (crops, livestock and non-farm diversification) and on-farm natural resource investment possibilities that resource users face at each period and the consequences of these livelihood strategies on the quality of the resource base. The pattern of change in the quality of the natural resource base, household assets and livelihoods would then determine the evolution of the ‘development pathway’ and incentives for future natural resource investments in subsequent periods (Shiferaw and Bantilan, 2004).

This conceptual framework builds upon the farmer-first and sustainable livelihoods principle (Chambers, 1987) by incorporating important elements from the theory of farm-household behaviour under market imperfections (de Janvry *et al.*, 1991), the economics of rural organization (Hoff *et al.*, 1993) and the role of economic policies (Heath and Binswanger, 1996), and institutions and institutional change (North, 1990). The conceptual framework clearly recognizes and places household investment decisions in the context of the evolving global, national and local policies and institutional changes that shape production and investment opportunities available to smallholder farmers. This is consistent with the broader evolving interdisciplinary and dynamic perspective required for technology design and development efforts targeting poverty reduction and sustainable NRM in agriculture.

In making their production and investment decisions in each period, smallholder farmers attempt to maximize their livelihood benefits

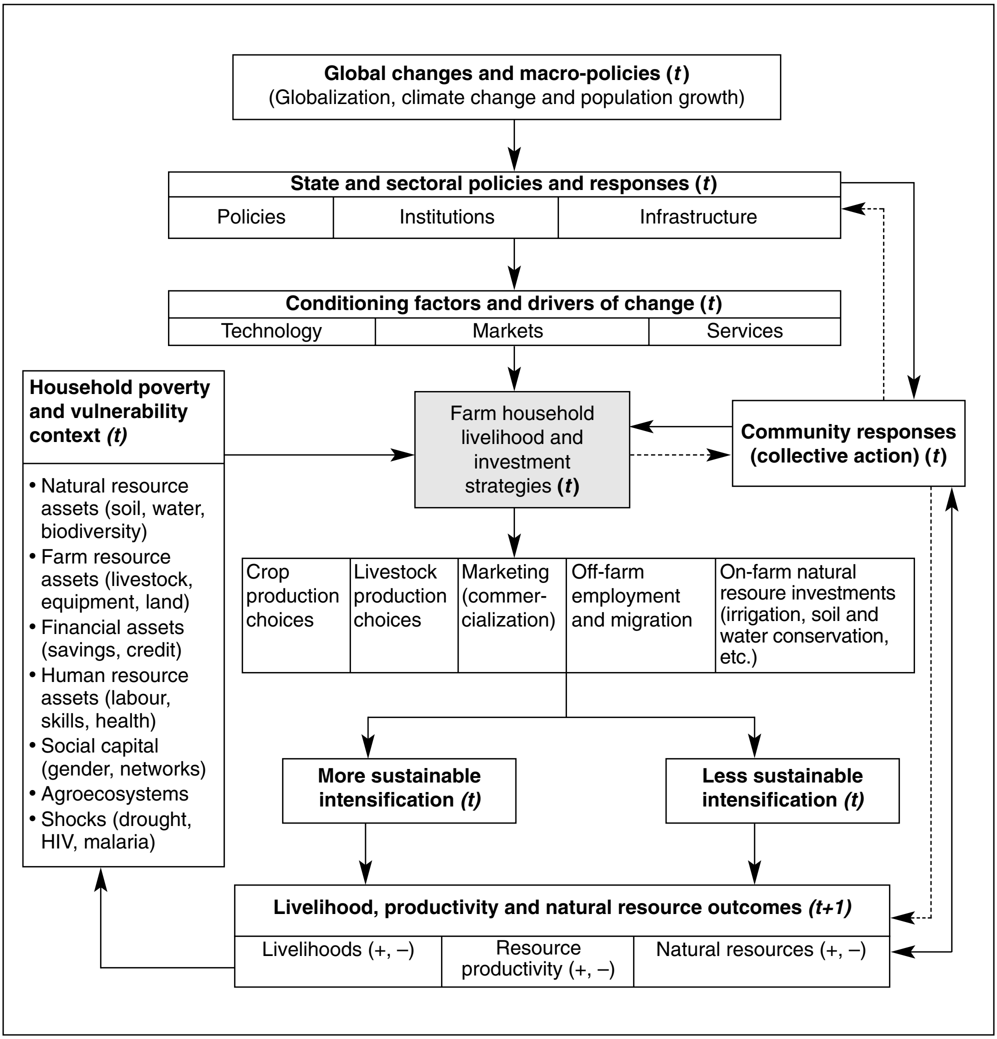

Fig. 13.1. Factors conditioning smallholder natural resource investments and development pathways.

over a period of time based on existing resource assets and expected shocks that jointly determine the vulnerability context. These decisions are also conditioned and mediated by the prevailing socio-economic and policy environment, including subnational and subsectoral policy changes and responses to shifts in global and macro-policies, transmitted to the local level through policy reforms, institutional changes and infrastructural investments, which in turn determine relative input–output prices and access to new technologies and markets at the local level (Shiferaw and Bantilan, 2004). The extent to which global and national policies are transmitted to the local level depends on trade policies and the extent to which input and output markets are integrated. In some situations (e.g. watershed management), collective action by the community may further enhance and supplement individual production and investment possibilities (Sreedevi *et al.*, 2006; Wani *et al.*, 2006).

The diversity of household assets and the prevailing biophysical and socio-economic environment therefore jointly determine the livelihood options and investment strategies available to farmers. Access to markets (including output, credit, input markets), appropriate technologies, and the input and output prices define the production feasibility set and determine the livelihood and investment strategies. While the endowment of family resources and assets determines the initial production and investment capabilities, the socio-economic and policy environment shapes the resource use patterns and the ability to relax initial constraints through trade and market participation (Fig. 13.1).

The framework shows that when more profitable resource-conserving or -improving technologies are available, and capital and institutional constraints are not limiting, farm-households may undertake productivity-enhancing resource investments. Enabling policies (e.g. secure rights to land and water), access to markets and institutional arrangements (e.g. credit services and extension systems) create incentives to invest in options that expand future production and consumption possibilities. Such resource-improving and productivity-enhancing investments provide opportunities for intensification of agriculture and diversification of livelihood strategies that will help combat resource degradation. This will in turn determine the livelihood and natural resource outcomes in the next period (*t+1*). In a dynamic sense, improved level of well-being and natural resource conditions will in turn enhance the stock of livelihood assets available for production, consumption and investment decisions in the subsequent periods. This shows how the interplay of good technology and conducive socio-economic conditions enable some households to pursue a more sustainable intensification strategy that will also help them escape poverty.

Nevertheless, these conditions are often lacking for many smallholder farmers in less-favourable regions with poor market access and suffering from high levels of resource degradation. In the absence of enabling policy and institutional environments that encourage technological innovation, smallholder farmers lack the economic rationale to adopt and adapt interventions for sustainable land and water management. In such situations, increasing subsistence demand and land degradation further undermine the ability to manage the resource base. The interface of lack of viable technological options and adverse biophysical, policy and institutional environments may force smallholder farmers in marginal areas to practise more exploitative and unsustainable livelihood strategies. There may also be several such trajectories leading to less sustainable intensification pathways, indicating extractive resource use patterns (Shiferaw and Bantilan, 2004). In this case, the synergistic effects of poverty and resource degradation lead to worsening conditions of the poor, potentially leading to a downward spiral (Scherr, 2000). Breaking this spiral is a complex challenge requiring innovative strategies that stimulate technical innovation and enabling policy and institutional arrangements, including targeted subsidies for investments, that generate positive public benefits (e.g. poverty reduction and sustainability). Based on a review of examples from Africa and Asia, these specific factors are discussed in the following section.

Determinants of Farmer Conservation Investments

Farmers adopt and adapt new practices and technologies only when the switch from the old to new methods offers additional gains in terms of either higher net returns or lower risks, or both. This means that smallholder farmers are likely to adopt NRM interventions only when the additional benefits from such investments outweigh the added costs (Lee, 2005). Investment in soil and water conservation is often just one of the many investment options available to farmers. Farmers can therefore defer undertaking such conservation investments until the gains from such investments are perceived to be at least equal to the next best investment opportunities available to them (Kerr and Sanghi, 1993). In other words, farmers in developing regions implicitly compare the expected costs and benefits and then invest in options that offer highest net returns (in terms of either income or reduced risk). In some cases, the highest (but short-term) net returns might be realized from foregoing soil and water conservation. Where private costs of adopting and adapting conservation interventions outweigh the benefits, voluntary adoption will be greatly hampered unless society is willing to internalize some of the costs and offer subsidies to farmers.

The literature identifies a number of factors that condition the adoption and adaptation of soil and water management intervention in smallholder agriculture across Asia and Africa. In many cases, farmers reject some interventions for lack of additional benefits (incentive problem). In other cases, farmers also find themselves highly constrained to adopt and adapt otherwise profitable (or economically attractive) interventions due to poverty, imperfect information, market, policy, institutional and other limiting factors. These constraints further limit the economic gains from investments in some NRM interventions and make it unattractive for farmers to adopt and adapt them on their farms. These factors can be broadly categorized into incentive and market factors, poverty and capacity factors, policy and institutional factors, participation and information factors, and environmental factors. These are discussed in turn below.

Markets and incentives

The fundamental economic incentives (related to relative profitability and risk reduction gains) for farmers to adopt NRM interventions are often affected by prevailing relative input and output prices, interest rate, and access to labour and output markets.

Relative output and input prices

Studies that examine the effect of commodity prices on land and water management find mixed effects of price changes on conservation investments. An increase in the price of agricultural commodities may often mask the effect of land degradation and make agricultural production using erosive practices attractive to farmers. In other cases, an increase in commodity prices may make certain NRM interventions profitable or attractive to farmers. Accordingly, some studies find a positive relation between increase in commodity price and adoption of conservation technologies (e.g. Shiferaw and Holden, 2000; Lee, 2005). Shiferaw and Holden (2000) showed that when conservation offers short-term productivity gains, an increase in commodity prices enhances the adoption of soil and water conservation technologies among highland smallholder farmers in Ethiopia. They also found that when conservation does not provide such complementary economic benefits, an increase in the price of an erosive crop would encourage smallholders to expand or intensify the production of such crops without investment in conservation. The same effects can be observed when governments provide price support and other subsidies for certain crops that would distort the incentives faced by resource users. The case in point is the commodity price support to irrigated crops, e.g. rice (*Oryza sativa*) and wheat (*Triticum aestivum*), that discourages farmers in semi-arid areas to cultivate sorghum (*Sorghum bicolor*) and other water-efficient dryland crops. This indicates that policies introduced with good intentions for attaining food security could lead to extensive land degradation and depletion of groundwater resources by encouraging dryland farmers to abandon traditional crops in favour of more erosive or water-intensive irrigated crops (Shiferaw *et al*., 2003). The overall effect of commodity price changes therefore depends on the likely impact of the associated agricultural practice for the particular product and how this affects the relative prices and profitability of conservation investments.

Looking at the input prices, a major determinant of adoption of conservation practices is the price that farmers have to pay to have the technology in place, i.e. the cost of adopting a conservation technology. These costs often raise the cost of production and reduce the profitability of the technology or even make it unaffordable to farmers to invest in such interventions. One obvious example is how an increase in the price of fertilizer may reduce the profitability of its use while also making the input increasingly unaffordable to small producers. This is particularly the case in Africa where countries have removed fertilizer subsidies and poor infrastructure often raises the price of imported fertilizers. As expected, studies that investigate this question find an inverse relationship (Pattanayak and Mercer, 1997). That is, the higher the price of inputs that constitute the conservation practices, the higher the costs and the lower the profitability of the technologies. The majority of these studies investigate how the cost of land and water management interventions (e.g. hedgerow cropping, terracing, minimum tillage, no tillage, etc.) and agricultural water-harvesting techniques affect adoption of such technologies (Pattanayak and Mercer, 1997; Baidu-Forson, 1999). In some cases the cost of conservation may not show directly in terms of actual cash outlays but in terms of indirect short-term effects on production or risk management. But if farmers are able to recognize such indirect costs, they will be factored into their consideration of investment strategies.

Market access and off-farm employment opportunities

Market access for agricultural products often facilitates commercialization of production and adoption of commercial inputs like fertilizer, pesticides and the like. When farmers clearly perceive the future costs of current land degradation and when policy and institutional mechanisms support changes in behaviour, improved market access can be the driving force for sustainable intensification of agriculture. But this is not always the case – there are situations where market access for certain products may end up encouraging less sustainable practices. Hence, the overall effect of improved market access on investments in land and water management is not always positive. The positive role of market access in promoting land and water conservation is best demonstrated by the often-cited example of Machakos district in Kenya (Tiffen *et al.*, 1994; Barbier, 2000). The district suffered serious soil erosion problems in the 1930s due to failed colonial government soil conservation policies. By the mid-1980s, the district had not only brought soil erosion largely under control but also realized increased per capita income, even after a sixfold population growth during the period. This tremendous success has been in part attributed to good access to markets for local produce, which was facilitated by proximity to Nairobi. This has accelerated commercialization of agriculture, which raised the profitability of farmer investments, raised incomes and facilitated adoption and maintenance of conservation practices in this largely semi-arid area.

Using large-scale survey data from Uganda, Pender *et al.* (2004) used alternative indicators (physical distance to all-weather road, distance to nearest market, etc.) of market access to examine how these affect crop production and soil erosion. They found that physical distance to the nearest market was not significantly correlated with production or erosion levels, but distance to nearest all-weather road had a negative effect on production and soil erosion.

However, market access is constrained in many rural areas by the poor transport and communication infrastructure, leading to high transaction costs in accessing markets. The associated high transaction costs and limited market opportunities in turn affect adoption of sustainable land and water management options (Pender and Kerr, 1998). Such market failure caused by high transaction costs is especially endemic in marginal areas where basic market infrastructure and supporting institutions are lacking or underdeveloped (Poulton *et al.*, 2006). Pender and Kerr (1998), for example, examined the role of output market failure on adoption of soil and water conservation in the semi-arid areas of India. Their findings suggest that market failure in both input and output markets affects the profitability of investments in such technologies and hence constrains adoption. Since market failure often affects households differently depending on their resource endowments, this study explained why technology choice and conservation investments may actually vary from farmer to farmer.

The effect of market access or performance on farmer conservation choice and investments may also vary depending on the dimensions of the affected market. When labour markets are missing or imperfect, the empirical evidence shows that households endowed with more family labour will have an advantage to adopt labour-intensive methods. When credit markets are imperfect, wealthier households with higher liquidity will have an advantage to invest in practices that require cash outlays upfront (Pender and Kerr, 1998).

An interesting relationship is the effect of off-farm and non-farm employment on adoption and adaptation of sustainable land and water management interventions. The empirical findings are mixed (Reardon *et al.*, 1994; Pender and Kerr, 1998; Holden *et al.*, 2004). In the case of parts of the Ethiopian highlands where on-farm returns to family labour are low, Holden *et al.* (2004) showed that increased availability of opportunities for off-farm employment will have a positive effect on household welfare but a negative tradeoff with reduced soil and water conservation investments. Kerr and Sanghi (1993) found reduced soil and water conservation investments around large Indian cities with active off-farm labour markets compared with more remote areas. Reardon and Vosti (1997) found similar results in their study of adoption of sustainable soil management technologies in Rwanda, Burundi and Burkina Faso. Two reasons are offered in the literature for the negative outcomes. First, under some situations, household workers face higher opportunity costs and prefer to allocate family labour into off-farm activities, where it fetches higher returns than on-farm soil and water conservation. Second, off-farm employment often directly overlaps with slack-season conservation activities and reduces the labour available for adoption and maintenance of conservation practices.

Therefore, opportunities for off-farm employment, when they exist, not only affect the decision to adopt conservation technologies but also the degree of adoption as well as the maintenance of conservation structures once they are in place (Shiferaw and Holden, 2000; Pender *et al.*, 2004). Shiferaw and Holden (2000) found a negative relationship between off-farm income and maintenance of implemented conservation structures. They found that, given the higher returns to off-farm labour, households with unconstrained access to non-farm employment are likely to conserve less land than their counterparts.

Other authors, however, argue that there exists a positive relationship between off-farm employment and adoption of conservation technologies (Tiffen *et al.*, 1994; Scherr, 2000). These studies review empirical examples across sub-Saharan Africa that show how income from off-farm employment under certain enabling conditions can be used to fund essential soil and water conservation investments and contribute to reducing the problem of land degradation. Off-farm employment and migration opportunities may also ease the pressure on land and reduce the intensity of resource use in densely populated areas.

The emerging picture from the above discussion is that market access, especially off-farm employment, should not necessarily be bad for land and water conservation. It would seem that the direction of the effect will depend on the opportunity cost of labour, the policy and institutional environment, and how important agricultural income is for people's livelihoods. Where returns to family labour in agriculture are high due to better market opportunities and supportive policies that encourage farmer conservation, market access is likely to induce adoption of strategies for sustainable intensification.

Poverty, asset endowments and scarcity

There has been a growing concern about the potential linkages between poverty and land degradation, some positing a nexus that locks poor people under a low-level equilibrium that perpetuates poverty and environmental degradation (Reardon and Vosti, 1995; Holden *et al.*, 1998; Scherr, 2000). Several studies across the developing world have shown that under conditions of imperfect credit and insurance markets, asset endowments and wealth will have a significant influence on the ability of smallholder farmers to adopt and adapt certain conservation practices. This section reviews the empirical regularities and relations between poverty and sustainability investments.

Farmer capacity to invest in conservation

As discussed earlier, credit, insurance and labour markets in rural areas of many developing countries tend to be either missing or highly imperfect. This means that households who lack in cash capital, labour, essential skills or in their ability to manage risks will face constraints, especially when these resources are needed for adoption and adaptation of sustainability investments. This indicates that the smallholder farmer better endowed with such family resources will have greater capacity to undertake certain conservation investments that require more of these resources. For example, education and human capital endowments affect adoption and adaptation of such practices through several directions. First, it enhances the likelihood of farmers perceiving land degradation as a problem. Second, it increases the likelihood of farmers to receive and process information about a technology that can solve the problem by increasing their managerial ability. On the other hand, higher levels of education under certain conditions may raise the opportunity cost of family labour in agriculture and direct its allocation into other activities that offer higher returns (e.g. migration and non-agricultural wage employment).

Another important factor for farmer investment is operating capital or access to credit. This is particularly important for certain capital-intensive investments that require heavy investments upfront (e.g. irrigation, terracing, tree planting and fertilizer use). While credit is generally found to have a significant effect in stimulating farmer investments for land and water management, it may at times conflict with the adoption of indigenous soil and water conservation practices. Holden and Shiferaw (2004) tested the effect of access to input credit (seed and fertilizer inputs) on adoption of sustainable soil and water management strategies in Ethiopia. They observed that increased access to input credit for fertilizer may reduce farmer conservation investments in terms of traditional soil and water conservation works on farmers' fields. This can, however, be tackled through cross-compliance policies that require farmers using subsidized inputs that may cause such tradeoffs to comply with certain minimal on-farm conservation requirements.

Land and water scarcity

The effect of population pressure on incentives for sustainable resource management has been contested for a long time. Diverging theories exist on how population growth and the relative scarcity of agricultural land may affect incentives for land and water management (Boserup, 1965; Cleaver and Schreiber, 1994). These theories will not be reviewed here but empirical evidence provides support to both Malthusian and Boserupian type responses. However, the empirical regularities seem to suggest that, other things being equal, scarcity of land and water would stimulate farmer innovation and investment patterns in conservation practices or methods that augment and enhance the productivity of these resources (Templeton and Scherr, 1999; Scherr, 2000; Mazzucato *et al.*, 2001; Shiferaw and Bantilan, 2004). Lack of proper policy and institutional arrangements and informational asymmetries may, however, prevent farmers from pursuing strategies that save or conserve scarce resources, as is often observed in overexploitation and depletion of common pool resources (groundwater, grazing lands, lake fish, etc.). Similarly, poverty and lack of credit arrangements also prevent farmers from adopting fertilizer and improved seeds, the necessary land-augmenting investments needed as farm size and/or soil fertility decline due to population growth and land degradation.

Risk

Another important factor conditioning adoption and adaptation of conservation technologies is risk. Smallholder farmers are generally risk averse and face constant difficulties in buffering various risks triggered by health, climatic and socio-economic shocks. Hence, land and water management technologies that increase variability or uncertainty of the income stream tend to be shunned by farmers. Such risks can arise from greater odds of crop failure or could be caused by insecure property rights. Whereas soil and water conservation generally tends to reduce production risks, there may be circumstances in which some proposed interventions may actually increase risks (Shiferaw and Holden, 1998; Mazzucato *et al.*, 2001). For example, some water-harvesting technologies can exacerbate flooding problems and cause loss of crop income. A study in Ethiopia found that soil and stone bunds caused pest infestation (or even flooding) that reduced crop yields for farmers (Shiferaw and Holden, 1998), or such technologies may not necessarily increase returns to land and labour in the short term (Shiferaw and Holden, 2001).

In addition to the above risks associated with conservation itself, exogenous risks can also dampen farmers' motivation to adopt conservation technologies. Unless conservation counteracts the problem, the increased risks of crop failure due to weather variability and pest and disease outbreaks can also discourage farmer investments. But substantial empirical evidence shows that when farmers perceive the risk-reducing benefits of conservation investments, they will be willing to increase expenditure as part of their strategy to cope with and adapt to drought and climatic shocks (e.g. water harvesting and irrigation in many semi-arid areas of India and Africa). This shows the need for farmers to recognize the risk-reducing benefits of land and water management interventions, which could serve as an additional incentive to stimulate greater adoption of such practices.

Time preferences

Most resource management investments require heavy initial investments (either in cash or in kind) but deliver benefits many years in the future. At the same time, land and watershed degradation often impose long-term economic and environmental effects. For example, the short on-site productivity effects of soil erosion are often small but impose greater long-term consequences unless action is taken immediately. However, most resource-poor farmers have short planning horizons and face difficulties in adopting a long view (Holden *et al*., 1998). This is particularly the case when the cost of borrowing is high (e.g. high rates of interest) and capital markets in rural areas are largely imperfect. This raises the subjective rate of discount for poor farmers contemplating certain investments and discourages adoption of technologies that may not offer immediate benefits but improve livelihoods only in the long haul. This is demonstrated in Fig. 13.2.

Let us assume alternative income streams from adoption of different resource management investments (e.g. corresponding to Options 1 to 4 in Fig. 13.2). For simplicity, the current resource-degrading practice is shown under the status quo (Option 1), whereby incomes constantly fall over time. Under the next best available conservation option (Option 2), incomes also decline but more slowly than the current farmer practice. As is typical for many conservation investments, the net income in the first few years to period *t* is lower than the status quo but higher thereafter. The question is whether poor farmers afford to internalize these initial losses in order to gain higher incomes in the future. Evidence shows that if the farmer is just faced with these two alternatives, the resource-conserving available technology (Option 2) is unlikely to be adopted (Holden *et al*., 1998). The main reason is that poor farmers will find it difficult to sustain initial income losses even when adoption may improve future income to compensate initial losses. Unless subsidized, farmers

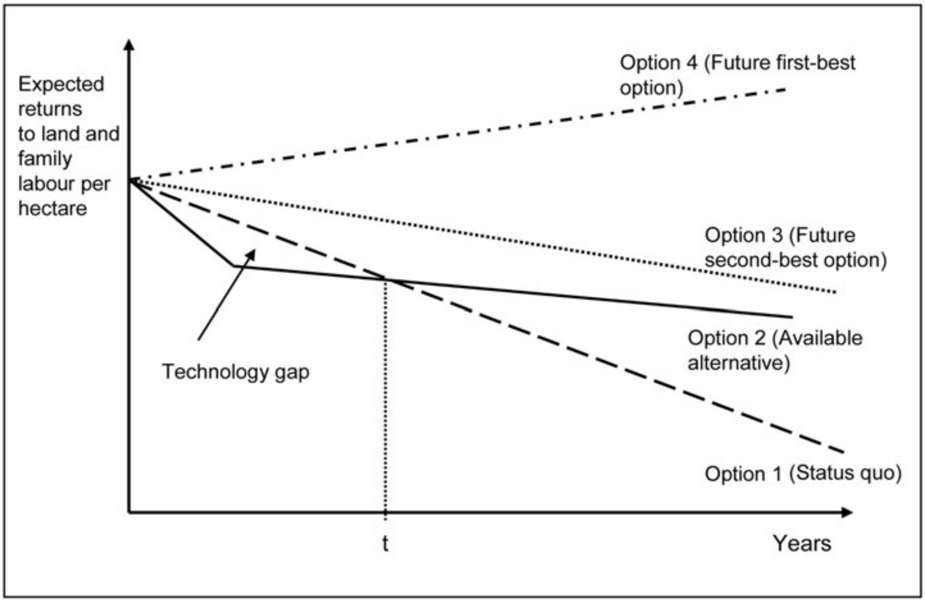

Fig. 13.2. Challenges in the design and development of pro-poor natural resource management technologies.

with a positive discount rate may not be interested in such options.

Alternatively, if the farmers have access to technological options depicted under Options 3 and 4, there will not be such tradeoffs between current and future income. If farmers are not constrained by other factors, one would expect widespread adoption and adaptation of such technologies. One major challenge is that many of the currently available land and water management technologies often cause temporal income tradeoffs and may not be similar to those depicted under Options 3 and 4.

Policy and institutional factors

There has been an increasing recognition of the role that policy and institutions play in sustainable management of natural resources and the environment (Heath and Binswanger, 1996; Barbier, 2000; Pandey, 2001; Reddy, 2005; Shiferaw *et al.*, 2006). The effect of markets and prices on adoption of land and water management interventions has been discussed above. In this section, the effects of other agricultural and sector policies and institutions on adoption and adaptation of sustainability investments are examined.

Agricultural policies

One of the important policy issues is the interest of some governments to provide certain agricultural input and investment subsidies to improve productivity and reduce reliance on rainfed agriculture. Unlike some Asian countries (such as India), many African countries have done away with such subsidies, but there is an ongoing debate to reintroduce some targeted subsidies (e.g. for fertilizer, seeds and irrigation). The effect of agricultural policies on conservation investments can best be examined by looking at public support for irrigation water and infrastructure. In India, as in many Asian countries, water for smallholder irrigation is free while the electricity used for pumping groundwater is highly subsidized (Shiferaw *et al.*, 2003; Reddy, 2005). These subsidies provide distorted signals to farmers and landholders and displace efforts to invest in soil erosion control and conservation of available water (Shiferaw and Bantilan, 2004; Reddy, 2005). In addition, irrigation subsidies cause farmers to shift cropping patterns to water-intensive crops, which should not be promoted in semi-arid areas. Subsidies can also temporarily raise the returns to conservation practices and create an impression that farmers are investing in the new management practices only for them to resort to old practices once the subsidies are withdrawn. The upshot is that while subsidies could be justified under some conditions where market or institutional failures prevent socially desirable conservation, there is a need for careful appraisal of the equity and sustainability implications of policies that affect smallholder resource use and management decisions.

Institutions for collective action and property rights

The institutional factors conditioning the adoption of conservation technologies mainly relate to the prevailing system of property rights, i.e. the right of access and security of rights to land, water and other natural resources. Understandably, farmers lack economic incentives to invest their time or money if they cannot capture the full benefits of their investments. This condition may prevail when farmers have insecure rights to land (e.g. non-transferable usufruct rights) or when the natural resource is governed by an open access property regime. In addition, farmers are not likely to invest in sustainable resource management of rented private property if the length-of-use right does not allow them to recoup their investments (Ahuja, 1998; Barrett *et al.*, 2002; Shiferaw and Bantilan, 2004).

Incomplete property rights and the associated public goods externalities (high costs of exclusion and non-rivalry) can also discourage private conservation investments. This is typical in investments characterized by externalities such as flood control in community watersheds. In some cases the externality may flow in both directions (reciprocal externality) or in one direction. In such cases, the interdependence of resource users and resources (as in watershed programmes) will require collective action and cooperation to achieve socially desirable levels of conservation investments. Promotion of certain interventions that affect several users within a given landscape and provide public goods benefits may therefore require new kinds of policies and institutional arrangements to induce and sustain collective action.

Evidence also shows that collective action (which embodies social capital) can play a significant role in the adoption and adaptation of technologies for conservation and management of contested resources (Wani *et al.*, 2006). Ahuja (1998), Gebremedhin *et al.* (2003) and Pender *et al.* (2004) have examined the effects of collective action (especially membership of a farmer group/association) on adoption of conservation technologies in Côte d'Ivoire, northern Ethiopia and Uganda, respectively. Their results show that collective action can enhance adoption of conservation practices by helping farmers address market failures and information constraints.

The impact of collective action on adoption of land and water management practices is greater when a larger proportion of the community has a shared vision and common interest in maintaining and improving the existing natural resources. Such interests may be similar irrespective of the asset ownership (e.g. landholding) but tend to occur when asset productivities are linked with resource conditions and are influenced by socio-economic and cultural backgrounds of the communities. For instance, evidence from India indicates that the degree of homogeneity in socio-economic and cultural conditions of the community determines the success of community-based lift-irrigation schemes (Deshpande and Reddy, 1990). Other studies have also shown that equity in economic and social structure of the community facilitates collective action (e.g. see Tang, 1992; Bardhan, 1995) because they reduce the transaction costs of mobilizing and organizing the community to undertake joint investments.

Collective action and property rights are also interlinked, although causality is difficult to establish. Property rights can induce and stimulate collective action, especially when property rights guarantee equity in distribution of costs and benefits. In the absence of equitable benefit and cost sharing, strategies that rely on collective action tend to hurt the poor and may not be effective in stimulating adoption and adaptation of conservation technologies. The high transaction costs involved in addressing the equity issues in property rights deter the required changes, thus allowing the persistence of inefficient property rights regimes (Libecap, 2002).

The success of land and water management interventions also depends on the degree to which the user communities are involved through local collective action in the design and implementation of the programmes. In India, studies observe that the programmes implemented by non-governmental organizations often outperform those implemented by the government, mainly because the former ensure active and sustained participation of the community (Vaidyanathan, 1991, 1999; Farrington *et al.*, 1999). Integration of the interests and knowledge of the local community into watershed management programmes also tends to be lacking in government-implemented programmes because government line departments typically centralize the management of such programmes and adopt a top-down bureaucratic approach. In addition, many government-run programmes in the past ignored the importance of integrating other enterprise and economic activities into watershed management programmes and, if they did, it tended to take a top-down uncoordinated approach.

Gender issues

Along with men, women play an important role in improving land and water productivity and conservation of natural resources. In many cases, women are major stakeholders in sustainable NRM, mainly because they represent the main users and immediate direct beneficiaries from improved availability of water, fodder, fuel-wood and other livelihood resources. Successful land and water management interventions that result in increased availability of livelihood resources for domestic use directly benefit women by reducing the time they spend searching for water, fuel-wood and similar resources. While equitable participation of women in land and water management programmes is critical, improvements in resource conditions could release some of the time for investment in land and water management. Available studies also indicate that women often show clear resolve and dedication for resource improvement and tend to be more spiritual in dealing with natural resources, perhaps making them better managers (Mikkelsen, 2005). Integrating the unique interests of women and their active participation at all stages in the process of land and water management can therefore help in improving the effectiveness and sustainability of such interventions (d'Souza, 1998; Pangare, 1998).

The specific needs of women can be addressed more effectively when they participate in decision making and in implementation of the programmes. However, women are often left out of decision making because they rarely own or control resources. In many watershed management projects, women provide hired labour for installation of selected interventions but are not involved in decision making (Sreedevi and Wani, 2007). Pangare (1998), for instance, suggests that women rarely receive the benefits (in terms of access and control) from the resources they help to create and conserve because of social and cultural inhibitions. Future interventions for sustainable land and water management would need to explicitly address the needs of both men and women resource users and seek equitable sharing of benefits (Sreedevi and Wani, 2007).

Information asymmetry and farmer participation

Farmer participation in the design of conservation technologies and availability of information about the potential benefits and risks associated with new methods has an important role to play in influencing farmers' attitudes and perceptions. Many past interventions that followed the top-down non-participatory approach have failed (Reij 1991; Tiffen *et al.*, 1994). A number of factors have contributed to the success of participatory conservation technologies designed using bottom-up approaches. First, such technologies take into account the unique socio-economic characteristics of target farmers, allowing them to adapt to their specific circumstances. Second, farmers are able to test, try or experiment with and adopt various practices at their own pace and preferred sequence. This process of farmer innovation and adaptive experimentation leads to a high degree of compatibility with local situations and farming systems. Third, participatory approaches allow farmers to gradually adapt the technology to changing market and agroclimatic conditions (Bunch, 1989).

The information and perception issues are also important as some types of land degradation may not be directly visible to farmers, especially when external variability in growing conditions makes it difficult for farmers to attribute such changes to declining resource quality. Farmers will adopt technologies only if they perceive soil and water degradation as a major problem that affects their livelihood (Fujisaka, 1994; Baidu-Forson, 1999; Cramb *et al.*, 1999). Along with participatory technology design, education and awareness about new options and the process of resource degradation or depletion (e.g. levels of soil fertility or groundwater depletion) are critical in stimulating awareness and action by individual resource users and communities.

Biophysical environment

Finally, the profitability of natural resource investments will ultimately depend on the agroecological and biophysical conditions. Factors like the natural fertility of soils, topography, climate and the length of the growing period influence the success of research investments and the type of technologies needed to sustain livelihoods and conserve the resource base. For example, meta-analysis of watershed development impacts in India identified rainfall and water availability as major determinants of the success of community watershed programmes. Cost–benefit ratios were found to be largely positive in medium rainfall (701–900 mm) and low-income regions (Joshi *et al.*, 2005). This indicates that in drought-prone semi-arid areas with infertile soils and erratic rainfall patterns, risk considerations imply emphasis on water management to reduce vulnerabilities to drought and to increase crop yields. In such areas suffering from moisture stress and seasonal drought, water conservation provides an important entry point; hence, the need to focus on enhancing *in-situ* conservation and productivity of water. Technologies for water harvesting and supplementary irrigation provide higher incentives for farmers to adopt other complementary inputs. This is mainly because the quick gains in terms of reduced risk of drought and increased productivity of other purchased inputs (e.g. fertilizer) enhance the expected returns from such investments. Similarly, in higher rainfall areas, soil and water conservation may emphasize mitigating soil erosion through cost-effective methods, which reduce overland flow and improve safe drainage of excess water. Even in such areas, the excess water may derive some benefits for supplementary irrigation during the post-rainy season or for domestic and livestock use.

The heterogeneity of the biophysical system in both dry and wet areas therefore suggests the need for careful consideration of local conditions in designing conservation options. The challenge is how to balance applied research needed to adapt to micro-niches with the need for strategic knowledge on cross-cutting issues that will have wider relevance and application.

Conclusions and Policy Implications

This chapter reviewed the challenges that diverse stakeholders and smallholder farmers face in tackling the long-standing problem of land degradation and sustainable management of agroecosystems. Review of the wide literature shows that resource-poor farmers, especially in marginal and rainfed regions, continue to face complex challenges in adopting and adapting alternative management practices and innovations for mitigating this problem. In an effort to address this challenge, the approach to soil and water conservation itself has evolved over several phases, latest perspectives encouraging the need to ensure farmer participation and consideration of market, policy and institutional factors that shape farmers' incentives. The need for farmer participation and innovation is justified by the fact that most soil and water management problems tend to be site and even farm specific. This calls for the need to provide farmers with a set of options to fit specific niches depending on specific constraints rather than a wholesale 'one-size-fits-all' type approach that promotes a single technological package in all areas.

The review also indicates that adoption and adaptation of land and water management innovations is constrained by failure to link conservation with livelihoods, extreme poverty and imperfect factor markets, inadequate property rights systems, and weak organizational and institutional arrangements at different levels. The best way to ensure adoption of innovations for sustainable land and water management is to develop them iteratively, in collaboration with the target group. This can be done through linking formal research with indigenous innovation processes of local resource users and communities. Effective soil and water conservation interventions are characterized by a process of joint innovation that ensures farmer experimentation and adaptation of new technologies and management practices and careful consideration of market, policy and institutional factors that condition and shape farmer conservation decisions.

Linking farmers to better markets for their produce and inputs like fertilizer and credit generally makes a positive contribution in raising the returns to land and labour in agriculture. When complemented with proper policies and institutional mechanisms to induce the process of farmer innovation and adoption of conservation practices, market access can be a useful driving force towards sustainable intensification of smallholder agriculture in both rainfed and irrigated areas. Given that investment poverty and lack of farmer capacity can be a major limiting factor for certain sustainability-enhancing investments, access to investment credit at farmer-affordable rates and availability of pro-poor options for beneficial conservation (i.e. offer short-term livelihood benefits) will be an important step in solving some of the long-standing constraints.

In addition, experience has shown that projects should act as 'toolboxes', giving essential support to resource users to devise complementary solutions based on available options, rather than imposing exogenous practices and technologies. If investments in the resource provide a worthwhile return and when enabling policy and institutional arrangements empower individual resource users and communities, smallholder farmers often try to protect their land and water resources from degradation. The major challenges for future land and water management will be in addressing the externalities and institutional failures that prevent joint investments for management of agricultural landscapes and watersheds. This will require new kinds of institutional mechanisms for empowering communities through local collective action that would ensure broad participation and equitable distributions of the gains from joint conservation investments.

Finally, some of the key lessons for the future include: (i) future land and water conservation projects should be flexible enough to respond to land users' innovations and inputs; (ii) land and water conservation interventions should favour approaches that provide a number of different technologies and management practices, which individual resource users can choose, test, adapt and adopt or discard as they see fit; (iii) resource-poor farmers are unlikely to adopt interventions that do not provide short-term economic gains, especially when credit markets and property rights are imperfect to permit investments with long payback periods; (iv) adoption requires a conducive institutional and policy environment and good linkages with product and factor markets to enhance the returns to beneficial conservation investments; and (v) integrated and landscape-wide interventions require community participation and collective action to coordinate and regulate resource use and investment decisions.

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