Policies and institutions to enhance the impact of irrigation development in mixed crop–livestock systems

Berhanu Gebremedhin and D. Peden
International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia

Abstract

Improvement in access to water serves as a powerful tool to increase income, diversify livelihoods and reduce vulnerability, since irrigation water creates options for extended production across the year, increases yields and outputs, and creates employment opportunities. In the mixed crop–livestock systems, irrigation can increase livestock feed supply through increased crop residues of food–feed crops, thus relieving the pressure on grazing lands and improving livestock productivity. In sub-Saharan Africa (SSA), inadequate growth in food production and increasing water scarcity pose serious challenges to future agricultural and economic development. Water for food has been identified as a critical challenge for society in the 21st century. The challenges arising due to increasing water scarcity can be addressed through two strategies: supply management (policies and actions to locate, develop, and exploit new sources of water for irrigation, household and industrial uses) and demand management (incentives and mechanisms that promote efficient use and conservation of water). Irrigation water development in Ethiopia during the imperial and military regimes focused on the development of large-scale irrigation schemes. This trend was reversed by the current government, which emphasised the development of small-scale schemes. However, the history of irrigation development has been characterised by emphasis on technical and engineering aspects, with inadequate attention accorded to policy, institutional and socio-economic factors. The lessons from the experience of irrigation development in SSA in general, and Ethiopia in particular, show that:

- a pluralistic approach to water development (which includes carefully selected and managed large-scale schemes, and farmer managed small-scale projects)
- provision of supportive legal framework and secure water rights
- development of local management and leadership capacity and
- active involvement of beneficiaries in design, implementation and management of schemes could enhance the impact of irrigation on farm household income, natural resources management, and the local and national economies.

Project engineers should continuously interact with agronomists, economists and other social scientists from the beginning to prepare a comprehensive *ex ante* assessment of irrigation projects. Moreover, policy and institutional interventions to enhance the impact of irrigation also need to be based on the objective of enhancing the contribution of irrigation to

sustainable livelihoods of rural people. This could be done by enhancing the contribution of irrigation to household asset building by strengthening market access, promoting high-value crops, and improving systems for providing extension and technical support to smallholder irrigation. The best place to start perhaps is to ensure access to farm inputs and markets.

Introduction

Water plays a critical role in the sustainable livelihoods of rural people. Improvement in access to water serves as a powerful tool to diversify livelihoods and reduce vulnerability for small producers, since irrigation water creates options for extended production across the year, increases yields and outputs, and creates employment opportunities. Increased household income may be spent locally thus helping to stimulate the rural economy. Participation in water users associations (WUA) widens social networks and empowers people, thus facilitating the creation of social capital.

In mixed crop–livestock systems, irrigation can increase livestock feed supply through increased crop residues of food–feed crops, thus relieving the pressure on grazing lands. Irrigation can also increase the productivity of the grazing lands themselves if water is used for producing feed directly, thus perhaps allowing crop residues to return to the soil to maintain soil fertility. Livestock are important assets and sources of cash income of the rural people, especially the rural poor. Improved feed availability increases the productivity of livestock, thus improving household income.

During the 20th century, human population tripled and water use increased six-fold, mostly for agricultural use. Agricultural productivity has also risen sharply in recent decades due to higher yielding varieties, increased fertiliser use, and major investments in water resources infrastructure. Investment in many billions of dollars in irrigation infrastructure has been the key component of the Green Revolution.

Agriculture today accounts for most of the water withdrawals,[1] and accounts for about 80% or more of water withdrawals in developing countries (Cai et al. 2001). As populations continue to grow further, the demand for agricultural water will increase and irrigation will be required to provide increasing share of total food production to meet the growing food demand (Rosegrant and Ringler 1998).

In SSA, inadequate growth in food production and increasing water scarcity pose serious challenges to future agricultural and economic development. Moreover, semi-arid and arid areas are home to about one-sixth of the world's population. Inadequate water is the principal cause of poverty in these areas. Water demand for domestic and industrial uses is also projected to grow even faster than agricultural water demand, especially in developing countries (Shiklomanov 1998; Rosegrant et al. 1999). Accordingly, water for food has been identified as a critical challenge for society in the 21st century.

However, water scarcity is not necessarily caused by inadequate rainfall, but by lack of conservation, and sustainable management and use of the available water. Even in the

1. A distinction can be drawn between water withdrawal and water consumption. Water withdrawal refers to water removed from a source, some of which may be returned to it and reused. Water consumption refers to the water withdrawn from the source and actually consumed or lost to seepage, contamination, or a 'sink' where it cannot be economically reused.

so-called dry regions, rainwater is available in abundance. For example, the International Water Management Institute (IWMI) estimates that the total renewable water resources in SSA are about 4000 km^3 per year. However, most of it evaporates or flows into saline sinks before it is put into beneficial use, mainly due to the difficulty posed by the nature of rainfall. The rain is very poorly distributed in both spatial and temporal terms. The critical challenge is, therefore, how to deal with the poor distribution of rainwater leading to short periods of too much water and flooding, and long periods of too little water. There is a need for the development, adaptation and application of innovative technologies and management strategies for more efficient conservation and use of rainwater, surface and groundwater.

The challenges arising due to increasing water scarcity can be addressed through two strategies: supply management (policies and actions to locate, develop and exploit new sources of water for irrigation, household and industrial uses) and demand management (incentives and mechanisms that promote efficient use and conservation of water).[2]

In Ethiopia, despite an estimated potential of 1–3.5 million hectares[3] of irrigable land, only about 5–10% is currently estimated to be under irrigation. Modern water development in Ethiopia started during the imperial regime in the 1950s, with large-scale irrigation schemes and hydro-electric power projects. The large-scale irrigation projects were intended to supply agricultural raw materials for the agro-processing sector and for export. These large-scale projects were nationalised in 1975 by the military regime, and handed over to the Ministry of State Farms. The focus of both the imperial and military regimes was on large-scale irrigation projects.

Unlike its predecessors, the Government of the Ethiopian Peoples' Revolutionary Democratic Front (EPRDF), since it assumed power in 1991, has given strong emphasis for small-scale irrigation development in the country. However, the history of irrigation development in Ethiopia has been characterised as one that considered irrigation development mainly as a technical or engineering issue. Policy, institutional and social factors were not accorded due consideration in the design, implementation and operation of irrigation projects. This paper intends to present and discuss important policy and institutional issues that need to be considered in research and capacity building for water resource development in Ethiopia.

Irrigation development in Ethiopia

There are various estimates of the irrigation potential in Ethiopia. These estimates range from 1.0 to 3.5 million hectares of irrigable land, of which between 160–190 thousand hectares (5–10%) is estimated to be currently irrigated. About 65 thousand hectares is estimated to be under traditional irrigation (MoWR 1997). Per capita irrigated area is also

2. Policies and actions that affect the quantity and quality of water at the entry point to the distribution system are classified as supply management, while actions that influence the use or management of water after this point are considered as demand management (UNDTC 1991; World Bank 1994)
3. The wider range of estimated irrigation potential indicates the lack of precise estimate of irrigable areas in the country.

estimated at about 35 m^2, compared with the world average of 450 m^2. About 352 thousand hectares of land is said to be irrigable using small-scale irrigation schemes.

Modern water development schemes are recent phenomena in Ethiopia. The imperial government in the 1950s took the first initiative in water resource development. Large-scale water development projects both for agricultural purposes and power generation were constructed at the end of the 1950s. These developments were concentrated in the Awash Valley as part of the agro-industrial enterprises development initiative. Water resource development at that time gradually expanded to the Rift Valley and the Wabi Shebele basin. The government's focus of water resource development was on large-scale and high technology water projects. At the beginning of the 1970s, about 100 thousand hectares of land was estimated to be under modern irrigation in Ethiopia, about 50% of which was located in the Awash Valley (Wetterhall 1972). During the imperial regime, the main objective of irrigation was to provide industrial crops to the growing agro-industries in the country, many of which were controlled by foreign interests, and to increase export earnings. Main crops grown were sugarcane, cotton, sesame, fruits and vegetables. Management and operational problems that resulted in salinity and water logging problems are said to have put thousands of irrigated land out of production in the Awash Valley in the 1980s after less than five years of cultivation (Mahmud 1997).

All large-scale irrigation schemes that were constructed during the imperial regime were nationalised by the military government in 1975, and handed over to the Ministry of State Farms. Most of the landlord based small-scale irrigation schemes were also handed over to producer co-operatives. The military government, like the imperial regime, was keen to develop large-scale water projects and its focus was on commercial farming. High technology water development schemes were managed by the nationalised agro-industrial and agricultural enterprises. However, little attention was given to small-scale and traditional irrigation schemes constructed and managed by smallholder farmers.

It was only during the second half of the 1980s, after the devastating famine of 1984/85 that the Derg regime started to show interest in small-scale water development schemes (MOA 1986; Tahal Consulting Engineers 1988). This interest was signalled by the establishment of the Irrigation Development Department (IDD) within the Ministry of Agriculture (MOA) in 1984, a department that was entrusted with the task of developing small-scale irrigation projects that would benefit smallholder farmers. However, IDD's performance was slow, only 35 small-scale projects were constructed between 1984 and 1991, of which about one-third were improved traditional irrigation schemes (MOA 1993). Moreover, small-scale irrigation development was considered as 'infrastructure development' and grouped with rural roads and similar construction teams, and largely staffed with engineering personnel.

Like the imperial regime, the military government's focus was on commercial farming and smallholder beneficiaries were excluded. Despite the long success of farmer-managed traditional[4] irrigation systems, the military regime destroyed this tradition by confiscating

4. In Ethiopia, there are four different types of small-scale irrigation systems used by farmers: diversion systems (diverting natural river flow), spate systems (systems that make use of occasional flood flows), spring systems (that use flows from springs) and storage systems (that store water behind dams), and lift systems (which extract water from rivers, irrigation canals reservoirs and wells). Diversion systems are probably the most common forms of small-scale irrigation systems in Ethiopia, although there may be regional variations.

them and handing them over to producers' co-operatives. The lessons from the experiences and failures of irrigation development during the imperial and military regimes indicate that a pluralistic approach to water development and active involvement of beneficiaries in the design and implementation of water development projects, and management of operational schemes could have benefited smallholders better and contributed to the national food production.

The focus on large-scale irrigation development and the neglect of small-scale schemes was reversed when the Ethiopian Peoples' Revolutionary Democratic Front (EPRDF) took power in 1991. The EPRDF government put the development of small-scale irrigation schemes and improvement of farmer-managed traditional schemes at the forefront of its water development policy. Moreover, with the creation of the Ministry of Water Resources (MoWR), there is now a unified public agency for water resources development.

In 1994, IDD was dissolved while the government's interest in small-scale irrigation remained very high, as manifested by the creation of the Regional Commissions for Sustainable Agriculture and Environmental Rehabilitation (Co-SAERs) in a number of regions. The primary mandate of the Co-SAERs has been to promote small-scale irrigation for the benefit of smallholders. However, like IDD the focus of the Co-SAERs also remained rather technical-oriented, with inadequate attention accorded to policy, socio-economic and institutional issues. However, there have been significant improvements in beneficiary participation compared with during the military regime.

In sum, irrigation development planning in Ethiopia has been beset by the emphasis on the agronomic, engineering and technical aspects of water projects, with little consideration to issues of management, beneficiary participation, availability of institutional support services such as credit, extension and input supply, and marketing. The experience of irrigation water development in the last five decades in Ethiopia suggest that several measures need to be taken to support farmer-managed small-scale irrigation projects in Ethiopia. These include enhancing and improving the efficiency of the traditional irrigation systems such as:

- improving the durability of headworks
- making simple, cheap and environmentally friendly irrigation technologies such as hand pumps and shallow tube wells available
- improving market access by building roads, price support and improving product quality
- developing appropriate extension and credit services, and input supply system and
- enhancing beneficiary participation in governance (establishment of working rules and responsibilities) and management (running the day-to-day operation of projects).

The impact of irrigation development during the last decade appears to be mixed. Based on a survey of 50 communities, 500 plots and more than 2000 plots in the highlands of Tigray in 1998/99, irrigation was found to increase the intensity of input use, especially labour, oxen, improved seeds and fertiliser (Pender and Berhanu 2002). Use of manure or compost was about 50% more likely on irrigated plots than on rainfed plots, controlling for other factors. By promoting increase in use of such inputs, irrigation contributes to increased crop production. The predicted average impact of irrigation, based on the predicted impacts of irrigation on use of inputs, was an 18% increase in crop production relative to rainfed field plots. However, the impact of irrigation on the productivity of land management practices (i.e. the effect of irrigation controlling for use of inputs and practices) was statistically insignificant. Thus the main impact of irrigation on crop production is through promoting increased intensity of farming, rather than through increased productivity of farming practices.

Similarly, in the Amhara highlands of Ethiopia, irrigation was associated with increased intensification through greater use of fertility-improving technologies (fertiliser and manure), and other purchased inputs (improved seed and pesticides), labour and draft power (Benin et al. 2002). However, the impact of irrigation on the productivity of farming practices, controlling for other factors was insignificant. The reason why irrigation failed to improve the productivity of farming practices in both the highlands of Amhara and Tigray deserves further and careful research on the technical, institutional, governance and managerial aspects of irrigation. Such an investigation could provide important guidance for policy and institutional intervention to enhance the impact of irrigation on productivity, income and the natural resource base.

Policy and institutional research issues

A comprehensive irrigation development strategy should take into account the technical requirements (e.g. equipment, spare parts, operation and maintenance), policy issues (e.g. incentives, pricing, cost recovery), and institutional issues (e.g. farmer participation and organisations, extension and credit services, marketing, governance and management of water resource). Sectoral policies affecting water development should be harmonised. There is a need to determine the appropriate mix and role of government and non-government agencies, the private sector, communities and individuals in the effort to develop, control and manage water resources. Institutional mechanisms need to be put in place to minimise transaction costs and resolve conflicts.

In many developing countries, the success of irrigation systems is highly affected by policy, institutional and social factors much more than technical issues (Beets 1990). Hence, in this section we present and discuss important policy and institutional issues of irrigation development that need to be considered in irrigation development strategies in Ethiopia.

Demand and supply management for irrigation water

To meet the challenges of increasing water scarcity, both more vigorous demand management accompanied by comprehensive water policy reform to make better use of existing supplies, and supply management involving the development and exploitation of new water supplies will be required (Rosegrant and Perez 1997). The level of economic development and the degree of water scarcity will determine the appropriate mix of supply and demand management. At the current level of development and degree of water scarcity, most SSA countries will likely be primarily concerned with water supply augmentation. However, demand management should not be ignored. With economic growth and development, the competition for water increases thus raising the value of water, and the benefit from and the role of demand management increases significantly.

Effective water demand management saves water in existing uses, increases the economic efficiency of water use, improves water quality, and promotes environmentally sustainable water use. With economic growth, a large share of water to meet new demand must come from water saved from existing uses through comprehensive reform of water policy. However, water reforms are challenged by the long-standing practices, and cultural and religious beliefs that have treated water as a free good, and by entrenched interests that benefit from the existing system of subsidies and administered allocation of water (Rosegrant and Perez 1997).

As water scarcity increases, the supply of impounded or diverted water becomes inelastic. As economies grow the demand for water delivery increases rapidly and the competition for water among the different uses increases. Externality problems that were not important with adequate water supply become increasingly important. All these factors raise the value of water and the benefits from efficient allocation of water, thus possibly shifting the likely balance of effort from supply management to demand management (Randal 1981).

Policy instruments potentially applicable for water demand management include (Bhatia et al. 1995):

1. enabling conditions, i.e. measures that modify the institutional and legal environment of water delivery and use, including reform of water distribution systems and water laws, assignment of water rights, and organisation and operation of water user associations
2. market-based incentives intended to directly influence the behaviour of water users through incentive systems to conserve on water use. These may include pricing reform, subsidy reduction, and development of water markets
3. non-market instruments, such as restriction quotas, license requirements, and pollution controls
4. direct intervention including public conservation programmes, maintenance and repair programmes, and infrastructure development.

Empirical evidence shows that farmers are price responsive in their use of irrigation water, by use of less water on a given crop, adoption of water-conserving irrigation technology, shifting of water application to more water efficient crops, and change in crop mix to higher-valued crops (Gardner 1983; Rosegrant et al. 1995). The choice between market, and non-market and administrative methods should be largely a function of which approach is more cost-effective. Research is needed to determine which approach has a relative advantage in specific country situations.

Large vs. small-scale irrigation

Failures of large-scale irrigation projects in Africa abound. Construction costs as high as US$ 40 thousand per hectare and estimated negative rates of return have been documented (Rosegrant and Perez 1997). The high costs and negative rates of returns have been primarily due to design and technical flaws, management failures, and political difficulties (Rosegrant and Perez 1997). Inability of ministry and agency headquarters to respond in time to field level problems, excessive centralisation of management taken away from farmers, poor training and skill levels, uncontrolled overhead costs and rent-seeking are some of the other reasons for the failure of large-scale irrigation schemes.

However, irrigation development in Africa has also documented successful large-scale schemes. For example, efficient management, relatively low-cost infrastructure, low operating costs, good technical design, availability of agronomically suitable crops and cropping systems were cited as factors for success of large-scale irrigation systems in Cameroon (Brown and Nooter 1992).

Since the 1980s, the widespread failures in large-scale irrigation systems have been used to advocate future investment strategies based on small-scale irrigation systems. However, failures and successes in both large- and small-scale systems have been observed in Africa. Scale as such seems to be less important than the extent to which control is operated by the farmers, and where systems are managed bureaucratically, the extent to which quality of management is maintained and equitable distribution of income among farmers is achieved. (Rosegrant and Perez 1997). Hence, it is not so much the size of the irrigation system that determines its success, but a host of institutional, physical and technical factors. Large-scale irrigation should be carefully assessed as a possibility for specific locations.

In general, small-scale systems may have advantages over large-scale systems. These advantages include that small-scale technology can be based on farmers existing knowledge; local technical, managerial and entrepreneurial skills can be used; migration or resettlement of labour is not usually required; planning can be more flexible; social infrastructure requirements are reduced; and external input requirements are lower (Underhill 1990). However, these advantages may not be realised if the mode of implementation is not right.

Hence, a pluralistic strategy of irrigation water development needs to be pursued in Africa. Large-scale projects need not be abandoned provided that they are carefully designed and implemented; they have no significant environmental problems; participation of beneficiaries in planning, operation and management is ensured; and they ensure benefits to the surrounding population. However, there appears to be a consensus that small-scale and user-based schemes have higher advantages, are less costly and more sustainable.

Direct vs. indirect investment strategies

Public investment strategies for the development of farmer-controlled small-scale irrigation schemes, including the improvement of traditional schemes, can be categorised as direct and indirect investment strategies (Coward 1986). In direct investment strategy, government agencies are directly involved, using their own budget and staff, in the design, construction, and operation of new or improved irrigation facilities on the traditional irrigation systems. These new or improved irrigation schemes will then be solely government-controlled or co-managed with the communities. In the indirect investment strategy, government agencies get involved through the provision to farmers of grants, loans and technical expertise, to implement irrigation development on works owned and controlled by individual users or group of users.

Experiences in South-East Asia indicate that the indirect approach may be superior, since it leaves ownership and management of the system with traditional groups or individuals, and often leads to complementary investment of local resources. Available evidence in Africa also indicates that the indirect approach may be a preferable option to assist farmer-controlled irrigation. In Nigeria, the successful *fadama* development programme had several characteristics of the indirect investment approach. The availability of small inexpensive petroleum pumps in the markets in Nigeria in the early 1980s enabled farmers to replace their traditional water lifting devices. Following the success of the small pumps, the government launched a National Fadama Development Project (NFDP).

Hence, high priority may need to be given to indirect investments for expansion of farmer-controlled small-scale projects, especially in areas where potential for rainfed agriculture is poor and risky. Initial grants or loans to establish economically sustainable technologies, for example, for purchasing a small tube well, may be reasonable given the absence or weakness of credit markets in much of Africa. Expansion of small-scale farmer-controlled irrigation would have the additional benefit of developing farmer experience not only with respect to the technological skills of operation, but also with respect to the economic, social and institutional aspects of implementation. However, research is needed to determine the strengths and weaknesses of the indirect investment approaches in the specific country situation in Africa and to identify the cost-effective way of implementing it.

Farmer vs. government-controlled irrigation schemes

There is much evidence that farmer-controlled small-scale irrigation has better performance than government-controlled small-scale systems. The substantial farmer-controlled small-scale irrigation sector that exists in many countries in Africa, often without government support, indicates that these systems are economically viable. Areas under farmer-controlled small-scale irrigation systems have grown rapidly over the past decades, and account for large and growing share of irrigated area in SSA (Rosegrant and Perez 1997).

Water users associations or co-operatives, or private individuals manage the small-scale farmer-controlled systems. Some of the factors that contributed to the relative success of farmer-controlled small-scale irrigation systems include:

- use of simple and low-cost technology such as small pumps
- active involvement of farmers in project design and implementation
- availability of supporting infrastructure to permit access to inputs and markets to sell surplus production and

- generation of high and timely cash returns to farmers (Brown and Nooter 1992).

Farmer-controlled schemes can be group or individual-owned. Individual schemes are owned and managed by individual owners. Private schemes are mainly small schemes that make use usually of pumps and tube wells and are operated by the owners. Technology is simple and management is less complicated. Some argue that private irrigation has good potential in Africa and governments need to provide the necessary policy environment for the expansion of private irrigation schemes.

In Asia, it is widely documented that private pump irrigation from ground and surface water bodies is far more productive and profitable relative to public irrigation systems (Kolavalli and Chicoine 1989; Dahwan 1990; Shah 1993). Several researchers have also shown that private small-scale pump irrigation (from ground and surface water sources) is much more productive than canal irrigation and is more financially viable and self-governing.

However, pump irrigation, the most adapted private irrigation, is suitable only in areas with sufficient ground water or along the banks of rivers or lakes. Unrestricted expansion of private irrigation will also lead to the depletion of aquifers. Therefore, the scope of private irrigation may be limited. Moreover, there are schemes that are better managed and operated communally. In this case, group ownership and management becomes essential.

When irrigation schemes are collectively owned, schemes that balance all costs and benefits for all people in a watershed and which provide secure water rights to beneficiaries are most likely to gain long-term support. However, since water is vital for livelihoods, water rights are the results of the interaction of state law, project regulations, religious laws and values, and local institutions and norms (Meinzen-Dick and Bakke 2000). Formal laws may not always coincide with peoples' own perceptions of water rights and the ways in which water has been managed at the local level, since property rights are only as strong as the institutions that back them up (Meinzen-Dick and Bakke 2000). Local institutions are important in translating water rights in actual access and use, since local institutions affect the implementation and enforcement of rules. In some case local institutions can modify formal laws. Hence, attention needs to be given to the mediating institutions that translate water rights (from whatever source) into actual access to water. Research is needed to understand the extent to which formal statutory laws regarding water rights are translated into practice and the role of mediating local institutions.

Poverty and irrigation

When resources become scarcer, the poor and vulnerable in society are hard hit and suffer most. Increased competition for water in agriculture and non-agricultural uses in developing countries reduces the access to water for the rural poor, especially rural women. Increased water scarcity also may lead to frequent conflict, loss of life and generally to the marginalisation of the poor and powerless in terms of access to water.

Irrigation development may benefit the poor by raising labour productivity, promoting the production of high-value crops, and the generation of farm and non-farm employment opportunities, especially when increased production stimulates the local economy through backward and forward linkages (i.e. water systems can be used as 'growth centres' where services, markets and employment are also stimulated). However, there does not seem to exist a consensus on the impact of irrigation on poverty alleviation, in the absence of targeted interventions aimed at benefiting the poor. The International Rice Research Institute (IRRI)-led research in six villages in Madha Pradesh, India, found that incidence, depth and severity of poverty were substantially lower in villages where there were irrigation compared with rainfed villages (Janaiah et al. 2000), while similar studies in Myanmar concluded that recent expansion of irrigation infrastructure in the 1990s has not increased household income due to farmers' inability to cope up with the economic and technical demands of the new rice-based technologies (Gracia et al. 2000). Hence, targeted measures to ensure that poor people are reached and gain from irrigation investments need to be on the agenda at the earliest stages of scheme development. For example, water allocation based on land size may reinforce the existing inequities in land distribution in the distribution of water and water-created wealth. Irrigation may induce land transactions as resource poor farmers may lease their land out. This may exacerbate income distribution further.

Some research results also indicate that plot location in relation to the irrigation scheme (head, middle and tail) may have implication for poverty alleviation. Moreover, irrigation usually induces changes in crop choice and poor farmers usually grow low value crops. Hence, targeted interventions to make inputs available to the poor are one option to enhance the impact of irrigation in poverty alleviation. Representation in the water users association (WUA) of the poor and women is one way to ensure that the interests of these people are considered in irrigation water decision-making. A pro-poor approach to irrigation development requires a good understanding of the relationship between water and poverty and the causes of poverty, so that strategic poverty reducing interventions can be identified.

Gender and irrigation

While playing a crucial role in many water and food related issues, women still tend to be underrepresented in the decision-making fora. Gender issues in irrigation water development need to be looked at three levels: farm/field level, association level, and leadership level (van Koppen et al. 2002). At the farm level, gender performance of irrigation projects need to address whether or not there are systematic gender-based differences categorically engrained to water rights, irrigated land and associated obligations. At the water users association[5] level, irrigation projects need to ensure that systematic gender-based differences in the participation in these associations do not exit. At the leadership level, irrigation schemes need to make sure that there are no systematic gender-based exclusions from leadership positions of irrigation management. It is important to note that the systematic gender bias at the field, water users association and leadership levels may not necessarily be the result of formal laws or institutions. Informal

5. Water users associations create formal and informal forums through which collective management of irrigation schemes are implemented.

institutions based on local culture and religion could be important sources of systematic gender bias. Social science research is required to identify systematic gender-based exclusions or biases in irrigation schemes, and devise appropriate strategies to ensure equitable representation and distribution of benefits.

Land use and management for better rainwater conservation

Rainfed agriculture produces the highest proportion (over 60%) of food crops in the world. Including livestock production, the contribution of rainfed agriculture to food and commodity production is very high. Moreover, rainwater is the only source of agricultural water for many rural poor.

Research results estimate that in many farming systems, more than 70% of the direct rain falling on crop fields is lost as non-productive evaporation or flows into sinks before plants use it. Hence, in rainfed agriculture wastage of rainwater is probably an important cause of low yields or complete crop failure more than absolute shortage of cumulative seasonal rainfall. For example, adoption of improved water conservation technologies in the Great Plains of the USA have contributed to about 45% increase in average wheat yields, compared with the contributions of improved varieties (30%) and fertiliser practices (5%).

The necessary technologies for overcoming loss of water in rainfed agriculture are soil and water conservation practices. The principal requirement is the improvement of infiltration, water holding capacity, and water uptake by plants. Conserving water on fields for better use by crops results in win–win benefits converting erosion-causing runoff into plant available soil water, and non-productive evaporation into productive transpiration.

Impact of land use and management for improved water conservation may have beneficial effects for both upstream and downstream users. Upstream users may benefit due to higher availability of water, which would otherwise be wasted as runoff. Downstream users would be benefiting through the reduction of floods, sedimentation and a more smooth flow of water throughout the year. Streams and springs may be better recharged if water is conserved upstream, but this needs research to be confirmed.

Appropriate strategies need to be identified for dealing with climatic variability and droughts, and identify the land use and management practices to reduce land-use related degradation of surface water. Additional research is also needed to identify policy, institutional and socio-economic factors that promote improved household and community land use practices for better conservation of rainwater on fields.

Collective action and water users associations/ organisations

Identification of factors that facilitate the establishment and effectiveness of collective action for irrigation development would help identify where collective action can easily be established and be effective, and where concerted effort is needed for the establishment and effectiveness of collective action. Key research issues regarding collective action for irrigation management include how people organise themselves with respect to water, what consistent and detectable influences of policies and other instruments can be deployed to modify stakeholder behaviour, and how experience in participatory research and extension and common property management be used to facilitate local organisations for water management. The best starting point perhaps is to learn from the success of traditional irrigation systems, especially from the institutional and legal aspect of water administration and management. Understanding the evolution, development and functioning of traditional water users associations should provide important insights as to how to organise and develop modern irrigation associations.

International experience with farmer irrigation management suggests that, for a successful community management of irrigation schemes, the economic and financial costs of sustainable self-management must be a small proportion of improved income, the transaction cost of the organisation must be low, and irrigation must be central to the improvement of livelihoods for a significant number of members. Developing local leadership skills for irrigation management also appears to be a key factor for successful collective irrigation management.

Conclusions and implications

Improved access to agricultural water supply plays critical role in the sustainable livelihoods of rural people, since it increases yields and outputs, facilitates diversification, reduces vulnerability and creates employment opportunities. In mixed crop–livestock systems, irrigation increases feed supply through increased crop residues of food–feed crops, which may reduce the pressure on grazing lands. Improved livestock productivity through better availability of feeds has the potential to increase household income.

With population growth, the demand for agricultural water increases and competitions with non-agricultural use intensifies. In SSA, inadequate growth in food production and increasing water scarcity pose serious challenges to agricultural and economic development in the 21st century, thus increasing the need for more efficient utilisation of water and the development of new supply sources. Both water demand and supply management will be increasingly required to mitigate the effects of water scarcity, although currently SSA countries may need to focus more on supply management.

In Ethiopia, despite an estimated potential of irrigable land ranging from 1–3.5 million hectares, only about 5–10% is estimated to be currently irrigated. Irrigation water development in Ethiopia during the imperial and military regimes focused on the development of large-scale irrigation schemes. The current government reversed this trend. However, the history of irrigation development has been characterised by emphasis on technical and engineering aspects, with inadequate attention accorded to policy, institutional and socio-economic factors.

The lessons from the experience of irrigation development in SSA in general, and in Ethiopia in particular, show that:

- a pluralistic approach to water development (which includes carefully selected and managed large-scale schemes, and farmer-managed small-scale projects)
- provision of supportive legal framework and secure water rights
- development of local management and leadership capacity and
- active involvement of beneficiaries in design, implementation and management of schemes could enhance the impact of irrigation on farm household income, natural resources management, and the local and national economies.

Project engineers should continuously interact with agronomists, economists and other social scientists right from the beginning to prepare a comprehensive *ex ante* evaluation of irrigation projects.

Moreover, policy and institutional interventions to enhance the impact of irrigation also need to be based on the objective of enhancing the wealth-creating potential of small-holder irrigated farming by strengthening market access, promoting high-value crops, and improving systems for providing extension and technical support to small-holder irrigation. The best place to start perhaps is to ensure access to farm inputs and produce markets. A wider menu of irrigation technologies need to be available for farmers to choose from, so that farmers would respond more flexibly to irrigation development opportunities.

Although public agencies may need to be directly involved in investing in selected large-scale projects, high priority needs to be given to indirect investment strategy through the provision to farmers of grants, loans and technical assistance for the development of small-scale farmer managed irrigation schemes. Such an indirect investment strategy empowers farmers by providing ownership and management of the system, and leads to complementary investment of local resources.

There does not seem to be a consensus on the impact of irrigation on poverty alleviation in the absence of targeted interventions aimed at ensuring that the poor are reached and gain from irrigation development. For example, allocation of water rights based on land size may exacerbate existing inequities in income distribution. Hence, when the objective is poverty alleviation, targeted measures to ensure that the poor and vulnerable benefit needs to be incorporated at the earlier stages of scheme development.

Gender issues are also important in irrigation water development, since often women get underrepresented in the decision-making fora. Gender issues in irrigation development need to be considered at three levels:

- field level, to ensure the allocation of water and land rights, and associated responsibilities do not involve systematic gender-based differences;
- water users association level, to ensure that there are no gender-based exclusions from participation; and
- leadership level, to ensure that equal opportunities exist for leadership positions.

In rainfed agriculture, lack of conservation and efficient use of rainwater is probably more important than absolute shortage of water in determining crop yields or total crop failure. Conserving water on fields through changes in land use and management results in a win–win benefits by converting runoff into plant available soil moisture, which would otherwise result in soil erosion or possible flooding, and non-productive evaporation into productive plant transpiration.

Understanding the factors that facilitate farmer organisations to manage irrigation water, and its effectiveness would help devise strategies to facilitate the development and effectiveness of local organisation for water management. The best starting point perhaps is to learn from the evolution, development, operation and success of traditional water users associations, to gain insights for the development of modern water management organisations.

Secure land rights are critical for farmers to invest in irrigation technologies and maintenance. Moreover, land allocation around irrigation schemes is an issue that deserves careful analysis, since it will have direct effect on income distribution. Perhaps, such land allocation programmes may need to be based on the determination of minimum land size for profitable farming. In cases where irrigation development displaces local people, compensation and resettlement provisions need to be part of the scheme development planning right from the early stages.

References

Beets W.C. 1990. *Raising and sustaining productivity of smallholders farming systems*. AgBe Publishing, Alkmaar, The Netherlands. 738 pp.

Benin S., Pender J. and Ehui S. 2002. Policies for sustainable development in the highlands of Amhara Region: Overview of research findings. Paper presented at the conference on natural resource degradation and environmental protection in the Amhara Regional National State, Bahir Dar, Ethiopia, 24–26 July 2002.

Bhatia R., Cestti R. and Winpenny J. 1995. *Water conservation and reallocation: Best practice cases in improving economic efficiency and environmental quality*. A World Bank–Overseas Development Institute joint study. The World Bank, Washington, DC, USA.

Brown E.P. and Nooter S. 1992. *Successful small-scale irrigation in the Sahel*. World Bank Technical Paper 171. The World Bank, Washington, DC, USA.

Cai X., Ringler C. and Rosegrant M. 2001. *Does efficiency of water management matter? Physical and economic efficiency of water use in the river basin*. Environment and Production Technology Division Discussion Paper 72. IFPRI (International Food Policy Research Institute), Washington, DC, USA.

Coward E.W. 1986. Direct and indirect alternatives for irrigation investment and the creation of property. In: Easter K.W. (ed), *Irrigation investment, technology and management strategies for development*. Westview Press, Boulder, Colorado, USA.

Dahwan B.D. 1990. *Studies in minor irrigation: With special reference to ground water*. Commonwealth Publishers, New Delhi, India.

Gardner B.D. 1983. Water pricing and rent seeking in California Agriculture. In: Anderson T.L. (ed), *Water rights, scarce resource allocation, bureaucracy, and the environment*. Pacific Studies in Public Policy. Pacific Institute for Public Policy Research, Ballinger, Cambridge, Massachusetts, USA.

Gracia Y.T., Garcia A.G. and Hossain M. 2000. Income distribution and poverty in irrigated and rainfed ecosystems: The Myanmar case. *Economic and Political Weekly* (December 30):4670–4676.

Hoeck W.V.D. 2001. *Water and rural livelihoods*. 2020 Focus 9 (Overcoming water scarcity and quality constraints). Brief 5 of 14. IFPRI (International Food Policy Research Institute), Washington, DC, USA.

Janiah A., Bose M.L., and Agrawal A.G. 2000. Income distribution and poverty in irrigated and rained ecosystems: Village studies in Chhattishgarh. *Economic and Political Weekly* (December 30): 4664–4669. Kolavalli S. and Chicoine D.L. 1989. Ground water markets in Gujarati, India. *Water Resources Development* 5(1).

van Koppen B., Parthasathy R. and Safiliou C. 2002. *Poverty dimensions of irrigation management transfer in large-scale canal irrigation in Andra Pradesh and Gujarat*. IWMI Research Report 61. IWMI (International Water Management Institute), Colombo, Sri Lanka.

Mahmud Omer. 1997. Environment and water resource development in Ethiopia. Paper presented at Conference on Environment and Development in Ethiopia, Debre Zeit, Ethiopia, 12–15 June 1997. (Unpublished).

Meinzen-Dick R. and Bakke M. 2000. *Water rights and multiple water uses—Framework and application to Kirindi Oya Irrigation, Sri Lanka*. Environment and Production Technology Division Discussion Paper 59. IFPRI (International Food Policy Research Institute), Washington, DC, USA.

MOA (Ministry of Agriculture). 1986. *Strategies for small-scale irrigation development* (in Amharic). Irrigation Development Department, MOA, Addis Ababa, Ethiopia.

MOA (Ministry of Agriculture). 1993. *Information regarding activities of small-scale irrigation* (in Amharic). Irrigation Development Department, MOA, Addis Ababa, Ethiopia.

MoWR (Ministry of Water Resources). 1997. *The process and framework of policy and strategy development: A summary report*. MoWR, Addis Ababa, Ethiopia.

Morris J. and Thom D.J. 1990. *Irrigation development in Africa: Lessons from experience*. Westview Press, Boulder, Colorado, USA.

Pender J. and Berhanu Gebremedhin. 2002. Impacts of policies and technologies in dryland agriculture: Evidence from northern Ethiopia. Paper presented at the symposium on challenges and strategies of dryland agriculture into the new millennium. Annual meeting of the American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America, 13 November 2002, Indianapolis, USA.

Randal A. 1981. Property entitlements and pricing policies for a maturing water economy. *Australian Journal of Agricultural Economics* 25(3):192–220.

Rosegrant M.W. and Perez. N.D. 1997. *Water resources development in Africa: Review and synthesis of issues, potentials, and strategies for the future*. Environment and Production Technology Division Discussion Paper 28. IFPRI (International Food Policy Research Institute), Washington, DC, USA.

Rosegrant M.W. and Ringler C. 1998. Impact on food security and rural development of transferring water out of agriculture. *Water Policy* 1(6):567–586.

Rosegrant M.W., Gazmuri Scheleyer R. and Yadav S. 1995. Water policy for efficient agricultural diversification: Market-based approaches. *Food Policy* 20(3):203–223.

Rosegrant M.W., Ringler C. and Gerpacio R.V. 1999. Water and land resources and global food supply. In: Peters G.H. and von Braun J. (eds), *Food security, diversification, and resource management: Refocusing the role of agriculture? Proceedings of the 23rd international conference of Agricultural Economics, held in Sacramento, California, 10–16 August 1997*. Ashgate, Oxford, USA.

Shah T. 1993. *Water markets and irrigation development: Political economy and practical policy*. Oxford University Press, Bombay, India.

Shiklomanov I.A. 1998. World Water Resources: A new appraisal and assessment for the 21st Century. IHP report. UNESCO (United Nations Educational, Scientific and Cultural Organization), Paris, France.

Tahal Consulting Engineers. 1988. Traditional organizational forms in small-scale irrigation schemes in Ethiopia (prepared for Ministry of Agriculture, Addis Ababa, Ethiopia). Tahal Consulting Engineers, Tel Aviv, Israel.

Underhill H.W. 1990. Small-scale irrigation in Africa in the context of rural development. Crafield Press, Bedford, UK.

UNDTC (United Nations Department of Technical Cooperation). 1991. Demand management: A strategy for the implementation of the Mar del Plata action plan for the 1990s. UNDTC, New York, USA.

Wetterhall H. 1972. *Government and land in Ethiopia*. Ministry of Land Reform and Administration, Addis Ababa, Ethiopia. (Unpublished report).

World Bank. 1994. A strategy for managing water in the Middle East and North Africa. The World Bank, Washington, DC, USA.