Water, agriculture and rural livelihoods

The livelihoods perspective

This report follows a "livelihoods approach" to development. A livelihood may be defined as the sum of ways in which households obtain the things necessary for life, both in good years and in bad. These necessities include food, water, shelter, clothing and health care (with education often included too). Pertinent activities can include crop

Table 1 Shifting towards a livelihoods-based approach in rural water development

Capital	Issue	Production-based Approach	Livelihood-based Approach
Physical	Infrastructure for rainfed and irrigation systems	Rainfed and irrigation livelihood zones improved to increase agricultural production.	Improves decision-making ability through better rainfed and irrigation livelihood zones. Removes risk and uncertainty including maintenance and management of natural capital stocks.
Social	Community approach needed to raising or managing other forms of capital of crucial importance in irrigation management	Communities mobilized to establish (WUAs) to improve agricultural water management.	Identifies poorest households and strengthens participation in, and influence on, community management systems. Creates safety nets within communities to ensure the poor have access to water. Improves rights to land and water and establishes right to access by poor households within communities.
Natural	Land and water availability	Develops new, and enhances existing, water resources using physical and social assets.	Enhanced through training in catchment protection and maintaining natural environment.
Financial	Cash, credit, savings, animals	Develops individual or community-based tariffs and charges mechanisms for water uses.	Secured through access to small-scale credit.
Human	Labour, knowledge (through education, experience)	Trains people in agricultural water management and promotes gender equity.	Knowledge of demand, responsive approaches, community self-assessment of needs, participatory monitoring, gender mainstreaming.

Source: WWAP (2006).

and livestock production, fishing, hunting, gathering, bartering, and other endeavours and income-generating activities (including off-farm work). Livelihoods vary significantly within a country, from rural to urban areas, and across countries. The household is taken as the unit of reference because it is by far the most important institution through which populations anywhere organize production, sharing income and consumption (FAO, 2006a).

A livelihoods approach can be distinguished from a production-based approach in that it makes the household the centre of the analysis, taking an integrated view of the importance of all its assets or forms of capital (physical, financial, human, natural and social). Table 1 shows how a livelihoods approach is applied to these different forms of capital in contrast to the more traditional production-based approach.

Box 1 Describing livelihood capitals and how they can be improved

Human capital

Human capital is about knowledge and skills. Many farmers and their families have adequate knowledge and skills for operating within a given level of technology and given their resource constraints. Efforts to intensify or diversify production require investments in new knowledge and skills. Farmers and households need to enhance their human capital, but many poor households do not have sufficient resources for making such an investment. In such cases, assistance might be provided by a public extension service or a private firm with an interest in boosting agricultural productivity. With regard to water in agriculture, important enhancements in human capital include knowledge of methods for improving water management in both rainfed and irrigated areas. Such methods might involve small changes in existing techniques, or the use of new equipment, crop varieties, and complementary inputs.

Natural capital

Natural capital is about natural resources, mainly land and water. Many poor households rely on the environment for key inputs in their production and consumption activities. Water is perhaps the most important of these inputs. All households require water for consumption. Farming households also require water for producing crops and raising livestock. Households also depend on the quality of soils and rangeland, and many households gather fuelwood and fodder from areas within walking distance of their homes. Rainfall is important in maintaining the quality of rangeland and other common areas. In arid areas with a substantial population density, the demands placed on natural capital can exceed the sustainable supply. Severe degradation of natural resources can reduce the livelihood status of households that depend on them for production or consumption.

Physical capital

Physical capital is about infrastructure. Typically, investments in irrigation enhance physical capital. New or refurbished irrigation systems add to the physical capital of households and communities. So do investments in other forms of infrastructure. Inadequate physical capital can constrain household production for consumption or sale. Physical depreciation owing to inadequate maintenance has caused the decline of many irrigation schemes. The likelihood of maintaining physical capital is strongly related to the other four types of capital available in a given community. Wealthier communities, and those with greater social cohesion, might have greater success in maintaining irrigation infrastructure. Human capital is also help-

ful in understanding the need for maintenance and the methods required to perform necessary tasks. Natural capital might refer to the quality of the setting in which the irrigation infrastructure is placed. Settings prone to rapid siltation or structural degradation might be associated with more rapid decline of irrigation infrastructure.

Financial capital

Many poor households have inadequate financial capital. This limits their ability to pay for water and the costs of operating and maintaining an irrigation system. Inadequate finance can also prevent households from investing in new methods of crop production and irrigation. In addition, many households are risk averse because they have limited financial ability to respond to unexpected shortfalls in income. Limited finance also prevents farmers from accessing all of the complementary inputs required to maximize the productivity of land and water resources. Farmers with access to affordable credit can purchase inputs. However, in many areas, the risk of a shortfall in production prevents farmers from using that option. This is particularly important in rainfed areas where crop yields can vary substantially with annual rainfall, and where insurances can play an important role.

Social capital

Social capital is about solidarity and community action. Many small-scale irrigation schemes are operated by community associations. These associations, and farm villages more generally, represent a form of social capital that provides value to individual households. For example, a village or community can assist individual households in times of financial stress. Social capital is also helpful in organizing the operation and maintenance of a community irrigation scheme and bringing workers together to perform necessary tasks. Inadequate social capital can leave households more vulnerable to unexpected shortfalls in crop yields. Strong social capital helps in allocating water resources among farm households in ways that are acceptable to community members and beneficial to the community as a whole.

In the case of physical capital, the approach gives prominence to improving decision-making in the households and removing uncertainty through better management rather than simply to improving irrigation systems on their own. In the case of social capital, it emphasizes the importance of including poor households in the decision-making processes and the importance of ensuring access to water rights for the poor, rather than simply setting up water users associations (WUAs) to improve water management. In the case of natural capital, the livelihoods approach complements the building of new water resources by enhanced training in catchment protection. Similarly, for financial capital, this approach seeks to develop small-scale credit programmes, and for human capital, it emphasizes the importance of community self-assessment of needs, participatory monitoring and gender mainstreaming. Box 1 describes in detail the different livelihood capitals and their relation to water and agriculture.

Livelihood strategies and outcomes at the household level depend to a large degree on the amounts and qualities of these assets owned or controlled by the household. Land and water endowments can be viewed as elements of natural capital, while human capital includes the amount and quality of labour available. The optimal combination of investments in the five forms

of capital might be viewed as a necessary condition for achieving sustainable rural development (Pender *et al.*, 2004).

Many households in rural areas, and in particular in SSA, have very little physical and financial capital. Their key assets include a small amount of land and their labour. They might also possess a fair amount of "social capital" in the form of kinship and community relationships. While acknowledging the important role of social capital in smallholder households, it remains elusive and difficult to measure. Hence, this study focuses on physical, natural and human forms of capital, which are better documented and measured. In particular, it examines ways in which improvements in agricultural water use can enhance the incremental productivity of land and labour. It also analyses how investing in physical capital, such as building new irrigation schemes and improving water harvesting methods in rainfed areas, can enhance rural livelihoods.

Most people's livelihoods can be characterized by a predominant activity, which is then supplemented by several other activities. In most communities in developing countries, farming-based activities are the principal source of livelihood, and households complement them with other food and income-earning activities.

The adoption of a livelihoods approach (moving away from a top-down engineering-focused approach towards a more holistic, household-centred one) is now widely seen as critical to ensuring success in any future water sector interventions in agricultural development. In Chapters 3 and 4, this report designs its programmes of interventions on the basis of different livelihood zones of SSA, thus placing the livelihoods of farming households at the centre of the proposed strategy.

Rural livelihoods in transition

New dynamics related to rural livelihoods

The rural poor are usually marginalized smallholders who depend partly on subsistence production (mostly not sufficient to sustain their livelihoods) and partly on cash income from selling surplus, from wage labour (mostly not sufficient and not reliable either), and, increasingly, from remittances. They are also the landless people, relying on seasonal jobs as farm workers and on informal non-farm income sources (IFAD, forthcoming). Their poverty is usually characterized by a lack of various assets or resources:

- They are often short of land in terms of farm size, quality and security of access.
- They lack access to clean and safe drinking-water.
- They are often short of family labour (owing to migration or HIV/AIDS) and, therefore, suffer from seasonal labour bottlenecks.

Their lack of assets prevents them from accessing the financial resources they need in order to increase their productivity, and they typically live in remote areas with scarce access to markets and services. All these constraints make them highly vulnerable to shocks, in particular those related to climate variability, health risks, natural hazards, and market fluctuations. Accordingly, their strategies are to avoid risks by diversifying their economic activities, by engaging in low-external-input / low-capital-investment technologies and by investing in social relations to maintain a social safety network. Low-risk livelihood strategies necessarily yield low returns and represent a severe constraint on poverty reduction. These characteristics are not new, but they continue to be relevant for the majority of rural poor.

The new dynamics of rural livelihoods – the new rurality – result predominantly from globalization and deregulation, which create new opportuni-

ties but also new threats and limitations. New opportunities for rural smallholders result from access to external markets ("niche markets") with increasing demand for new agricultural products, such as fruits, vegetables, nuts, flowers, fish, shrimps and spices. However, these new opportunities are limited, leading to strong competition for limited market chances. New limitations and risks for rural livelihoods result from increasing competition caused by flooding of domestic markets with world market commodities, resulting in high levels of unemployment (especially in SSA) and limited domestic demand for basic agricultural products. In addition, agricultural and rural service systems (inputs, financial services, and information) are absent or not accessible for poor people as private service providers do not exist to fill the gap left by the abolishment of public services. In some countries, replacement of customary land law by individual tradable property rights tends to increase the risk to poor smallholders of losing their access to land. In addition, environmental degradation and the increasing frequency of natural hazards tend to reduce the assets of the rural poor and so make them more vulnerable.

As opportunities and limitations/risks are not equally spread among rural smallholders, there are winners and losers. The winners can usually be found in central locations in proximity to dynamic markets and among resource-rich rural households that can mobilize additional assets. The losers are those in remote places and those with limited resources. Migration has become a predominant survival strategy for the rural poor. As a consequence, rural livelihood systems in many parts of the developing world have become highly diversified and highly mobile, multilocal livelihood systems. Thus, poor rural families are no longer real smallholder farm households. A consequence of this is the feminization of the rural economy and of agriculture in particular. In many cases, women have to secure the survival of children and aged family members (Vargas-Lundius, 2007).

This pattern has important implications for efforts to promote development based exclusively on agricultural productivity. Young people tend to have limited skills and interest in farming as it is only one – and usually not the preferred – livelihood option. While there is limited long-term investment into farming, people are flexible and tend to take up any income opportunity in farming if it is promising. Despite the diversification of rural livelihoods and increasing urbanization, at least half of the poor people are expected to remain in rural areas by 2035, and a significant number of them will depend on smallholder farming as their main source of livelihood (IFAD, 2001).

Implications for rural water strategies

These "new poverty" patterns have implications for identifying and targeting the rural poor. While high shares of subsistence production and of irregular remittances from migrants may complicate attempts to establish the poverty status by absolute income levels (such as US$1/day), it might be more relevant to identify poor households by their vulnerability or food-insecurity level. Furthermore, any rural water development strategy will have to deal with multilocal diversified livelihood systems with limited capacities for agricultural investment, a predominance of risk-avoiding strategies (IFAD, 2005), female-headed households, high workloads, and rural people's limited ties to their land. Such characteristics and trends have both methodological and strategic implications.

In methodological terms, the complexity of the new rural reality reinforces the need for a livelihoods approach to development. In terms of water, this "means a fundamental shift beyond considering water as a resource for food production to focusing on people and the role water plays in their livelihood strategies" (WWAP, 2006); and implies de facto a multiple-use perspective (Molden, 2007). Any water intervention needs targeting not only according to farming systems but also according to socio-economic catego-

ries. Identifying different categories of farmers and rural workers according to the level of their integration into the local economies is necessary in order to ensure the effectiveness of interventions. In addition, other context-related criteria – according to the stage of food self-sufficiency / food security, the share of income from agriculture, and gender – are also relevant.

In strategic terms, these characteristics of the rural poor require that particular attention be given to low capital investment and low external input technologies, taking the limited financial assets of poor households and the weaknesses of rural service systems into account. Building on existing local knowledge and avoiding the introduction of unnecessarily sophisticated farm management systems contribute to a better uptake of technologies and takes into account the part-time nature of many farm activities and the widespread absence of functioning agricultural extension systems. Such interventions and investments should be considered in complement, and not in opposition, to the more conventional large-scale investments in surface water storage and irrigation, which remain a valid option where they can be justified on the basis of market opportunities.

The provision of water for small productive activities, such as home gardens, fruit trees and small off-season vegetable plots, helps in addressing land and labour bottlenecks, in particular of female-headed households in multilocal livelihood systems. Focusing on women (and the elderly who stay in the village) and taking their specific assets, constraints and coping strategies into account is of paramount importance in ensuring the success of water interventions. In short, agricultural water interventions should no longer be based on the assumption of specialized or increasingly specializing irrigation farm units managed by full-time professional farmers, but be prepared to assist in overcoming water bottlenecks in manifold context-specific ways.

Increasing agricultural productivity and impact on rural households

Agricultural production relies on a set of basic inputs (labour, land, water, seeds, fertilizers, chemicals, animal power, machinery, etc.). The productivity of any one of these inputs varies with the availability of one or more of the other inputs. For example, fertilizer is less productive where water is limiting, just as land and water are minimally productive where fertilizer is limiting. Optimal intensification requires that farmers have affordable access to the suite of inputs required to generate desirable crop yields. Improvements in agricultural productivity can provide a pathway out of poverty for rural households in several ways:

- For poor households that own land, increases in crop and livestock yields will generate greater output and higher incomes per unit of land and labour.
- For households that do not own land but provide farm labour, improvements in yields will increase the incremental productivity of labour, thus stimulating the demand for farm labour and raising farm wages.
- For households that do not own land or provide farm labour, improvements in yields will generate greater aggregate output, thus increasing the local supply of agricultural products, with consequent reductions in prices.
- Higher agricultural incomes and higher net incomes in non-agricultural households that are net food purchasers will generate greater demand for food and other goods and services that might be provided by local farmers and other non-farm residents.
- Improvements in crop yields made possible by enhancing water management will increase the incremental productivity of complementary inputs, such as labour, fertilizer, chemicals, animal health services, animal traction, and

machinery. Greater demand for these inputs might stimulate economic activity that benefits households providing non-farm labour.
- Improvements in the yields of crops and livestock might also stimulate labour demand in local processing and marketing activities, particularly in areas near urban centres.

The relative importance of these potential implications of improvements in agricultural productivity will vary among regions with differences in resource endowments, demographic characteristics, marketing opportunities, and labour supply and demand. However, in most cases, the impacts should be such that poor households gain opportunities to improve their livelihoods by generating greater output per unit of owned land and labour, or by earning greater wages for the labour they provide to others. Over time, higher net income will enable poor households to generate savings and invest these funds either in farm-related activities or in efforts to increase the potential return from non-farm and non-rural endeavours.

Water: access, control and management

This section focuses on the role of water in improving agricultural productivity for the following reasons:

- Water is an essential input in crop and livestock production.
- Water scarcity is a feature of many rural livelihood realities.
- The lack of adequate water is linked to poverty – households facing water shortages are more likely to be poor or fall into poverty than households not facing such shortages.
- Actions to address the problem of rural poverty by improving water availability make economic and social sense.

The importance of water as a key input in agriculture and its central role in the panoply of assets, resources and institutional arrangements that farmers need in order to sustain production has already been mentioned. This section elaborates further on this role, on how closely a lack of adequate water is tied to rural poverty, and on the ways in which investments in water have to fit in with investments in other aspects of agricultural production.

Rural and agricultural water use can be analysed in terms of three main components: access, control, and management. Access describes the degree to which a household can obtain water from rainfall (in rainfed conditions), surface water sources, groundwater, surface or subsurface return flows from agriculture, or wastewater from urban or peri-urban areas. Control describes how well a household can move water from a source to the location at which the water is applied. Elements within the control component might include farmer-operated canals and ditches, small pipelines, and sharing arrangements with other farmers. Management describes farm-level decisions and practices regarding the application of water for crop and livestock needs. In the case of crops, farmers must determine the timing and amounts of irrigation deliveries, and the methods used for applying water on farm fields. Decisions regarding crop and livestock water management are influenced by a farmer's human capital, the type of irrigation equipment available (if any), and information describing crop and livestock water requirements.

Although water-scarce areas do not represent a large share of the world's population in absolute terms, semi-arid areas and dry subhumid climates such as savannahs and steppe ecosystems are hosts to many malnourishment hotspots in which rainfed agriculture is the primary source of food, and where water scarcity limits crop growth (Molden, 2007). While few would disagree with

this general correlation, the policy implications are less clear concerning the issue of whether an increase in water supply will necessarily lead to increases in output and reductions in poverty. Water is often not the only limiting factor in production. Public agencies planning to intervene by developing irrigation or improving agricultural practices in rainfed areas must also consider the availability of affordable complementary inputs, access to markets, and institutional arrangements that promote farm-level investments in land and water resources. Furthermore, great attention has to be paid to the form in which access to water is increased. There is no "one size fits all" strategy that can be recommended, and each "livelihood condition" must be considered individually and in its historical and cultural context. This is at the heart of the approach developed in this report.

The debate about irrigation and poverty reduction

Irrigation can contribute to poverty reduction primarily by enhancing the productivity of labour and land (Smith, 2004), leading to higher incomes, higher wages, and lower food prices. Hussain and Hanjra (2004) describe three pathways through which irrigation affects poverty: the microlevel, mesolevel, and macrolevel. At the microlevel, irrigation enhances returns to the physical, human and social capital of poor households. It enables farmers to achieve higher yields and earn larger revenues from crop production. Higher net revenues can be invested in productive inputs or used to diversify farm and non-farm activities. The accumulation of net revenues over time can enable poor households to implement measures that reduce their vulnerability to shocks, and possibly to escape from chronic poverty.

The mesolevel impacts include new opportunities for landless labourers to work on irrigated farms or to earn higher wages on rainfed farms. If the availability of irrigation water increases the incremental productivity of labour, the demand for farm workers will increase, all else being equal. The consequent rise in wages will be determined by the amount of idle labour available locally and the degree to which farm workers migrate in search of job opportunities. Mesolevel impacts also include the reduction in local food prices that might occur when irrigation enables farmers to generate greater output per unit of land and per season. Increases in the demand for locally produced non-agricultural goods and services also can generate employment opportunities and stimulate local economic activity (Mellor and Johnston, 1984).

The macrolevel effects occur through interactions in national and international markets. Improvements in agricultural productivity made possible by irrigation can stimulate aggregate economic growth. Such growth can be helpful in reducing poverty and hunger if appropriate policies and investments are implemented by state and national governments. Improvements in productivity and reductions in the average cost of producing crop and livestock products can also provide new opportunities for gaining benefits through international trade.

Similarly, Lipton, Litchfield and Faurès (2003) have described the direct and indirect ways in which irrigation reduces poverty. Direct effects include: higher yields and increased diversity of cropping made possible by irrigation; higher wages from enhanced employment opportunities; and lower food prices. Indirect effects include: stimulation of activity in input and output markets; impacts on non-rural labour and product markets; and reduction over time in the variability of output and economic activities. This stabilization effect of irrigation generates substantial benefits across economic sectors, when operating in a supportive policy environment that ensures that

farmers have affordable and timely access to key inputs, and that they receive adequate prices for their output.

Such evidence as there is on the poverty reduction benefits of irrigation comes largely from Asian countries with high population densities and favourable natural resources conditions. Several studies (Hussain, 2007a) have examined poverty incidence in selected Asian countries in settings "with and without" irrigation. In every case, poverty incidence was higher in the non-irrigated setting. The estimated poverty headcounts reported in the studies range from 17 to 64 percent in irrigated settings, and from 23 to 77 percent in non-irrigated settings, which suggests some correlation between the two.

Perhaps the best-known case of irrigation contributing to poverty reduction is the green revolution implemented in India, Pakistan and elsewhere in Asia in the 1960s and 1970s with the goals of increasing food production by promoting rapid increases in agricultural productivity. Irrigation was a key component of the green revolution package of inputs, which also included higher-yielding varieties of rice and wheat, and affordable access to fertilizer, pesticides and energy. Aggregate cereal production increased substantially, improving rural incomes and enabling millions of urban and rural people of Asia to obtain affordable food supplies (Mellor, 1998). While much poverty remains in Asia, the gains in aggregate production and the notable reductions in poverty could not have been achieved without substantial investments in irrigation (Hussain, 2007b).

In terms of poverty reduction, the impact of irrigation will depend on how successfully the poor can share in the benefits of the water that is made available. Typically, poverty incidence is higher at lower reaches of canal systems, where farmers have less secure access to irrigation water (Hussain, 2007a). This is particularly the case in areas where good-quality groundwater is not available as a substitute for canal water supplies in lower reaches, and where farmers have limited opportunities for generating income in non-farm activities. The unequal distribution of land and wealth along some canal systems limits the poverty-reducing impacts of investments in irrigation (Hussain, 2007a, 2007b).

The main conclusion to be drawn from these experiences is that there is a role for irrigation in improving agricultural productivity and in reducing poverty, but it has to be carried out in a more strategic way, with a more in-depth assessment of the costs and benefits, both direct and indirect. It is also essential to have meaningful local participation in the design and operation of the schemes and to provide other supporting interventions (especially access to input and output markets and the promotion of higher value crops) as appropriate (Magistro *et al.*, 2007). Again, there will be significant differences between livelihood zones and agro-ecological zones in what is the right way forward, and a move from a top-down to a bottom-up livelihoods-based paradigm will be key to success in this area. Should a "green revolution" happen in SSA, it is likely to differ considerably from the first one in Asia, given the significant differences in resource endowments, demographics, lack of appropriate technologies, public perspectives regarding government support for intensive agriculture, and the completely different economic context at both local and international level.

The critical role of institutional reforms

Actions needed to reduce rural poverty from a water-based interventions perspective also need to be examined from the perspective of institutional reforms. A shift away from a top-down to a bottom-up approach to investment and policy reforms is widely recognized as essential. At the

same time, the public sector cannot be responsible for all the required interventions; some element of private and public partnership will be necessary. In improving access to market, advantage must be taken of the increased opportunities created by new markets, in which the private sector is investing heavily, and which offer smallholders the possibility to have secured sales of high-value products, in some cases through contract farming, with support from the buyers in the form of credit and inputs. Investments in water supply systems can also benefit from public–private partnerships in which community-based or private market-driven schemes are developed through local initiatives.

Some important elements of institutional reforms in irrigation (Kemper and Sadoff, 2003) include:

- better alignment of irrigation and drainage institutions, and transfer of responsibilities for operation, maintenance and management of irrigation and drainage systems to organized local user groups;
- cost-sharing for infrastructure improvement, accompanied with improved financial mechanisms for farmers;
- introduction, where appropriate, of systems of water rights and volumetric delivery for greater efficiency in water use;
- re-dimensioning of irrigation systems where they are not financially or environmentally viable (here, public participation of stakeholders is critical).

It is also necessary to recognize that the benefits of infrastructure investment in water provision cannot be measured in narrow economic terms alone, and that impacts of programmes on poverty, as well as on public expenditures in the form of food aid, must be taken into account. This has implications for the criteria applied in selecting investment projects and programmes. It also implies that projects may be considered socially beneficial even where individuals cannot afford to pay the full cost of the services provided to them. In such cases, incentive-compatible subsidy schemes have to be designed and implemented, again with the support of local communities.

Agriculture and rural poverty in sub-saharan africa

Performance of agriculture in the region

While the overall picture is that of an agriculture that does not manage to keep pace with population growth, not all recent developments in agriculture in SSA have been negative. As macroeconomic conditions have improved since the mid-1990s, agricultural growth has also increased from 2.3 percent a year in the 1980s to 3.8 percent between 2001 and 2005 (World Bank, 2007a). Where this growth has occurred, there have been some declines in poverty. However, population growth has absorbed much of the gain, reducing per capita agricultural growth to 1.5 percent, which has not been enough to prevent an increase in the number of the rural poor. They rose from slightly more than 200 million in 1993 to about 240 million by 2002. Hence, there is a need to accelerate the rate of growth in agriculture, which is feasible but which will require commitments, skills and resources.

Part of the explanation for poor agricultural performances in the region is the specificity of the agro-ecological features of African countries, which leaves them less able to take advantage of international technology transfers, the small size of many of the countries, which prevents them from capturing economies of scale in research and development, and prevailing low population density. New varieties of maize, wheat, rice and other crops have been developed and planted in Africa (Maredia, Byerlee and Pee, 2000; Gabre-Madhin and Haggblade, 2004), but poor quality

soils, inadequate use of fertilizer, and unreliable rainfall have limited yields (Eswaran *et al.*, 1997; Sanchez, 2002; Holmén, 2005a).

Other factors have militated against improved yields. With population growth, family farms have been divided up repeatedly among members of new generations, with the result that average farm sizes of many poor households have declined substantially (Jayne *et al.*, 2003). As a result, many poor households have less than 1 ha of land – an area too small to generate sufficient food or income to sustain a household throughout the year.

An important factor that is responsible for the relatively poor performance of SSA agriculture is poor access to reliable services providing inputs and knowledge. Many African farmers do not have access to affordable credit, and they cannot purchase and apply key inputs in a timely fashion (Kelly, Adesina and Gordon, 2003). In some areas, farmers lack the knowledge and access to extension service support to implement optimal crop management practices, with consequent reductions in crop yields (Baïdu-Forson, 1999; Haefele *et al.*, 2001; Wopereis-Pura *et al.*, 2002; Poussin *et al.*, 2003).

Finally, there has been low investment in infrastructure in the sector. (Hayami, 2001; Holmén, 2005b; Larsson, 2005). While a greater provision of infrastructure is necessary, it is not sufficient by itself. It has to be accompanied by greater use of inputs and better access to markets. Within the range of new opportunities, probably the greatest market potential pertains to domestic and regional markets for food staples including cereals, roots and tubers, pulses, oil crops, and livestock products (Diao *et al.*, 2007).

The experience with irrigation schemes has not been a particularly positive one in the region, although it has been improving. Of the 7.1 million ha under full or partial irrigation (i.e. about 3 percent of cultivated area in SSA and 20 percent of the area that is considered as potentially irrigable) only 5.3 million ha have systems that are operational. Previous schemes have had a poor record in terms of high costs of construction and operation, environmental damage, and low increases in productivity for farmers.

However, more recent investments in both large-scale and small-scale systems have performed better. In particular, where they are community-based or private-market-driven by smallholders with low-cost technology, small-scale operations have shown good appropriation by farmers. In some cases, these successful interventions take the form of improved management of water in areas that would still be defined as rainfed (including all schemes that improve and control access to water, such as water harvesting or very small-scale water management at the farm level). In many cases, an important factor for success has been the simultaneous promotion of links to markets for farmers in areas where irrigation is promoted, and the use of a decentralized approach to selecting the method of intervention.

In summary, SSA has made some progress in increasing agricultural output but the rate of progress has not been enough to reduce rural poverty. The combination of a challenging set of initial conditions (geography, soils, and rainfall variability) and a history of inadequate investments in natural and physical assets has limited the pace of agricultural development in Africa, specifically, and economic development more generally (Brown and Lall, 2006). Policies and programmes designed to improve agricultural productivity must acknowledge the many issues that limit crop yields and farm-level income. Efforts to address only one issue will not be successful.

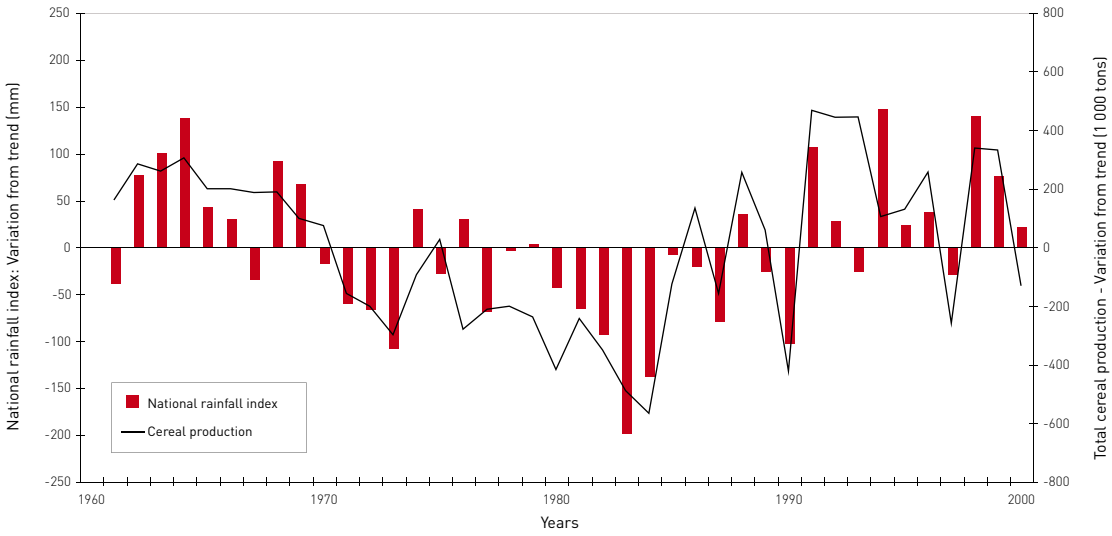
Adopting a broader approach to water control in agriculture

Much of the debate on the future of agriculture in SSA focuses on irrigated and rainfed agriculture. With slightly more than 3 percent of its cultivated land under irrigation, the region shows one of the lowest degrees of investment in irrigation among developing regions, and recent surveys do not show any sign of change, the annual increase in irrigation being slightly more than 1 percent in the period 1995–2005 (FAO, 2006a). The reasons for such situation are numerous and complex, and range from relatively low population density to lack of market access and incentives for agricultural intensification, to low quality soils, unfavourable topography, and inadequate policy environments.

These conditions seriously limit the economic feasibility of irrigation development projects, and recent studies have demonstrated that, on average, the cost of irrigation development in the region is substantially higher than in Asia (Inocencio *et al.*, 2007). While there is considerable scope for further development of irrigation in the region, it is now admitted that a much closer analysis of opportunities and markets is needed in order to ensure the success and sustainability of future irrigation investments (World Bank, 2007a), and that these investments must be accompanied by substantial policy and institutional changes.

As a result of this unfavourable situation, agriculture in large parts of the region remains highly dependent on climate. Figure 1 shows how cereal production in a semi-arid country (Burkina Faso) is extremely dependent on the seasonal variability of rainfall. Such a situation, which is common in several SSA countries, has induced planners to look for alternative ways of addressing the issue of climate dependency of rainfed agriculture in the region. Recently, the Comprehensive Assessment of Water Management in Agriculture (Molden, 2007) has suggested considering a "continuum" of water management practices, from purely rainfed to fully irrigated agriculture. Chapter 4 describes a range of such water management options in more detail and examines their potential range of application.

Figure 1 **Burkina Faso: rainfall and cereal production, 1960–2000**



Source: Molden (2007).

While broadening the scope of water control options offers a much wider choice, it should be clear that there is a direct relation between the level of water control and the cost of these different options. Therefore, the selection of the most appropriate water management options will involve a relatively complex cost–benefit analysis where benefits in terms of increased resilience of farming practices to climate shocks will probably be as important as those resulting from direct increases in production.

Key challenges and issues for the region: a long-term perspective

It is important to recognize the scale of the challenge and the broader issues involved. The population of SSA is expected to increase from 700 million in 2007 to 1 100 million in 2030 and 1 500 million in 2050, while daily food consumption per person is projected to increase from the current 2 200 kcal to 2 600 kcal in 2030 and 2 800 kcal in 2050 (FAO, 2006b). Hence, the region will require substantial increases in food supply in order to support the doubling of population by 2050 and the nearly threefold increase in calories consumed. Without such increases, undernourishment and poverty will increase. Projections indicate that the problem is likely to be particularly severe in countries such as Benin, Burkina Faso, Burundi, Niger and Uganda (Alexandratos, 2005).

The consumption of agricultural commodities in SSA is currently increasing at about 3.2 percent per year, while production increases at 3.0 percent per year, resulting in a net increase in imports of agricultural commodities. Consumption is projected to increase by 2.8 percent annually through to 2030, and by 2.0 percent from 2030 to 2050, while production is projected to increase by 2.7 percent and 1.9 percent in these periods, respectively (FAO, 2006b). The resulting gap may be partly filled by imports but, given the limited capacity of the rural poor to buy food, their situation could worsen as a result of the growing gap between production and consumption.

Increases in agricultural yields are believed to be possible in SSA. Alexandratos (2005) has built scenarios in which yields in 2050 are twice those in 2000. However, this will require significant investment in infrastructure, research, etc. However, if the alternative of not making such investments is likely to be large expenditures on food aid in the future, then the attractiveness of investment in agriculture is considerably enhanced.

In the long term, climate change may well represent an additional challenge to African agriculture. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) presents the state of knowledge on climate change and its impact on different sectors. While the level of uncertainty about possible impacts remains high, recent studies indicate potentially large negative impacts on agriculture in developing regions (Easterling *et al.*, 2007). Projections based on agro-ecological zoning indicate that, in most scenarios, arid and dry semi-arid areas in Africa will expand by about 5–8 percent as a result of climate change by 2080 (Shah, Fisher and van Velthuizen, 2008), and most models predict a decrease in good agricultural land in the region. Many SSA countries already showing a high prevalence of undernourishment are expected to see their cereal production potential reduced, while others will see this potential increase. However, the overall net balance in cereal production potential is expected to be negative in SSA, and negative impacts are expected on overall agricultural gross domestic product (GDP) for the region,

Increased climate variability and droughts may also affect livestock production, and there are risks that temperature increases combined with decreases in precipitation in some regions, including Southern Africa, will lead to increased losses

of cattle. Furthermore, the combined increase in heat stress and lower precipitation holds the risk of increased water requirement for cattle in marginal areas, with possible expansion of water grazing around watering points. Potential impacts of climate change on inland fisheries and aquaculture include stress caused by increased temperature and oxygen demand, uncertainty about future water supply, possible negative impact of extreme weather events, and increased frequency of diseases (Easterling *et al.*, 2007).

In summary, temperature increase, associated with increased variability in precipitation and higher frequency of extreme events, is likely to affect agriculture, in particular in low-latitude regions. Smallholders and subsistence farmers in SSA countries, together with pastoralists and fishers, show extremely low resilience to shocks, and their adaptive capacity is generally constrained by their low level of livelihood assets. Therefore, they are most vulnerable to possible climate change and, in particular, to extreme events.

Adaptation by smallholders in SSA calls for increased resilience to shocks and reduced vulnerability. Financial and insurance mechanisms can play an important role in increasing farmers' resilience. However, for smallholders who consume most of their production, they can only provide limited support. Resilience building, in particular in drought-prone areas, implies increased buffering capacity through better management of soil moisture, and a combination of surface water and groundwater storage.

Bioenergy has been advocated as a possible new business opportunity for growth in rural tropical areas, an opportunity for countries to reduce their dependency on energy supply, and a climate-change mitigation opportunity. Little is known about the biophysical and socio-economic impacts of biofuel, and several questions remain. Besides the question of the net impact on greenhouse gas emission, concerns have been raised about the implications for smallholder farmers in developing countries. Future bioenergy-related policies will need to be designed carefully if they are to serve the rural poor and smallholder farmers, and they will need to be integrated with food security policies in order to avoid conflicting situations. In particular, such policies will need to guarantee adequate protection for the poor and positive implications for the food insecure, and develop safeguards to ensure overall environmental sustainability. Therefore, opportunities exist for rural producers, in particular in humid tropics, but the political environment in which bioenergy development takes place will dictate its impact on the rural poor.