CHAPTER 5

Development Potential, Market Demand, and Investment Opportunities

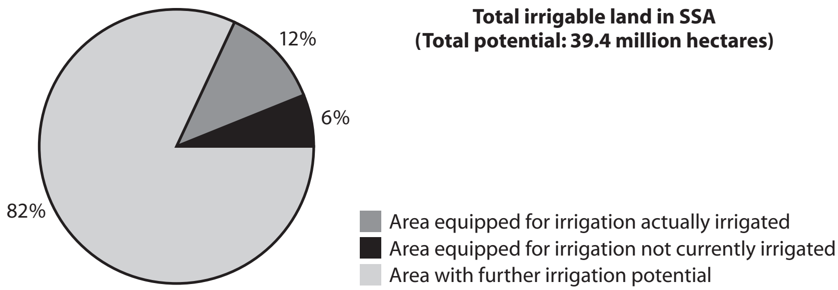
5.1 Physical Potential for Agricultural Water Development

According to FAO (2005a), the total physical potential for irrigation in sub-Saharan Africa is estimated at 39.4 million hectares (Summary Table 1). As mentioned (section 1.3 above), approximately 18 percent—or 7.1 million hectares—of this has already been developed. The remaining physical potential for new irrigation is therefore approximately 32.4 million hectares.[1]

Not all of this will be suitable for development, mainly for economic reasons. Almost one-third of the potential is concentrated in two very humid countries, Angola and the Democratic Republic of the Congo—although the humidity of these countries does not necessarily mean that they do not need irrigation or other forms of water management (the already large areas of wetlands cultivation and flood recession planting in Angola are testament to this). The remaining potential in the other countries of the region is therefore on the order of 23 million hectares (Summary Table 1). This is not evenly distributed: some countries, notably Madagascar, Mauritius, Somalia, South Africa, and Sudan, have

1. This includes the potential for 'water harvesting', which, as discussed in section 2.1, is considered to be water development for small- and micro-scale irrigation.

Figure 5.1 Irrigation Potential in Sub-Saharan Africa



Source: FAO, 2005a.

already developed more than 60 percent of their potential for irrigation (Summary Table 1).[2]

Current water abstractions in the region as a whole are low—but a growing number of countries risk becoming water scarce. Current abstractions for all purposes amount to only 2.2 percent of the total renewable resource (Summary Table 3 and Map 5). Abstractions for agriculture (mostly irrigation) are less than 2 percent of the total renewable water resource (section 2.1 above and Summary Table 2). If the full irrigation potential of 39.4 million hectares was to be developed the demand for agriculture would increase from 2 percent to only 12 percent of the total renewable water resource.[3] Even if an annual growth in demand for urban and industrial water supplies of 5 percent was to be factored in, total abstractions for all purposes for the region as a whole would still only reach 13 percent of renewable resources by 2030 (Summary Table 3). However, the region-wide average of water availability masks considerable variation between countries. If all the irrigable area were developed by 2030, renewable water resource availability would vary from a massive 114,000 m^3 of available water per person per year (Democratic Republic of Congo) to a minimal 68 m^3 per person per year (South Africa). If all the area were developed, 19 of the 48 countries in the

2. As opposed to 'other forms' of water management in the AQUASTAT terminology (other countries may use more than 60 percent of their potential if these other forms of water management are taken into account).

3. This assumes that development and utilization of the remaining 32.4 million hectares would consume an additional 630 billion m^3/year (at an average of 16,000 m^3/ha/year). From Summary Table 2 the Total Renewable Water Resource for the region is 5,450 billion m^3/year. Thus at full development the demand for agriculture would amount to 630/5,450*100 = 11.6 percent of the total.

region would risk falling below 1,000 m^3 per person per year, which is usually considered to be the threshold of water scarcity.

Surface water resources are often concentrated in a seasonal window and can be extremely variable. In the upper Zambezi, for example, some 80–90 percent of water resources occur as stream flow in the wet season between December and May while in the six months from June to November stream flow is either rapidly falling or extremely low or nonexistent. Rice farmers on run-of-river irrigation schemes in Tanzania, for example, often complain of water shortages between and within seasons, with dramatic variations in the areas that can be fully irrigated from year to year (Box 5.1). Climate change is likely to aggravate the situation.

In an increasing number of river basins, there is also competition between different users. Despite the overall 'abundance' of water implied by the low rates of abstraction, cases are emerging of competition between users. This can lead to shortages, friction, sub-optimal production and environmental degradation (Box 5.2). In some cases the problem is institutional—a lack of a regulatory framework, water rights, and organizations to cooperate over water resource allocation and management.

In many cases, however, the problem is not absolute water scarcity but a lack of infrastructure to regulate supplies for use in dry seasons and dry years. Most sub-Saharan Africa countries have low levels of water

Box 5.1

Run-of-the-River Improvements Are Not Enough for Rice Development in Tanzania

Farmers at run-of-river rice schemes developed under the Participatory Irrigation Development Project (PIDP) in Tanzania complained that one of their main constraints was irrigation water. Government and farmers had just invested more than $1,000/ha to improve the diversion and distribution of irrigation water, but this had not improved water availability or reliability. In some years, only one-quarter of the command area could be irrigated, and it was too risky for farmers to invest in inputs, so that even in a year of adequate irrigation supplies, average paddy yields (3.3 t/ha) remained below potential. Farmers are now pressing for dams to regulate flow to the schemes.

Source: IFAD, 2007.

Box 5.2

Competing Demands for Water in Tanzania

The Great Ruaha River is the lifeline of the Ruaha National Park and its ecosystem. It also drives the Mtera and Kidatu hydropower stations that provide 85 percent Tanzania's power supply. However, upstream irrigation development in the Usangu plains competes for Ruaha water.

Smallholder irrigation systems in Usangu were developed by smallholder farmers from the 1940s, mostly for wet season irrigation of rice. As Tanzania's demand for rice increased, a number of large-scale parastatal rice farms were also developed. Water shortages in the Ruaha began to occur and in 1993 the river dried up in the Ruaha National Park. Flows for hydropower generation were also reduced, which resulted in electricity cuts in Dar es Salaam. Upstream irrigation development was blamed for the shortages.

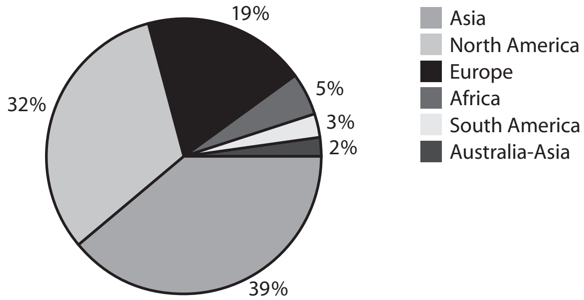
The river basin authority then had to arbitrate between the competing water demands of agriculture, power, the environment, and tourism, although research by Sokoine University, the University of East Anglia, and IWMI indicates that electricity shortages were primarily the result of poor management of the hydropower dams rather than upstream irrigation extractions. There is considerable scope for increasing upstream water-use efficiencies, but options for improved water management in the plains wetlands also need to be considered.

Source: Lankford, 2004; Fox, 2004.

storage infrastructure: only 5 percent of the world's dams are located in sub-Saharan Africa (see Figure 5.2 and World Bank, 2005c). The implication is that in many countries development of the physical potential for irrigation will have to be accompanied by the construction of new storage to cope with seasonal variability and local water scarcity.

The potential for further groundwater irrigation could also be important—particularly for private individual irrigators. In most of the region, the transmission of the underlying geology tends to be too low to furnish reliable quantities of water for irrigation on any scale. There are notable exceptions, for example in the *karstic* aquifers of the Zambian Copperbelt, and there are limited reserves of renewable groundwater in most countries, which are extensively used by individual private irrigators mainly for gardens. Despite the localized nature of these resources, there could be substantial scope for expansion of this type of irriga-

Figure 5.2 Breakdown of Dams by Geographical Zone



Source: World Registry of Dams.

tion (Giordano, 2005).[4] In Zimbabwe, for example, where smallholders are already exploiting shallow groundwater with low-cost technology in the *dambo* wetland areas, renewable groundwater resources could potentially irrigate a further 80,000 hectares—an area equal to about one-quarter of the official estimates of remaining irrigable land. At the Office du Niger, irrigation of paddy in the wet season results in groundwater replenishment that is lifted by individually-operated groundwater pumps for dry-season irrigation when water deliveries by the Office are in short supply. Similar opportunities are likely to exist in many other rice growing areas.

In-field rainwater management could become as important as the other alternatives, particularly for the production of non-rice cereals. The FAO estimates of potential exclude in-field rainwater management for dryland crops. Although it is thought that the total area currently under this type of agricultural water management is small compared with the area under irrigation, in-field rainwater management could in theory be practiced on all cultivable land that is not already developed for agricultural water management. In practice, however, physical, agro-ecological, and market constraints will limit such development. Assuming that it was possible to develop in-field rainwater management for dryland crops on only 25 percent of the land currently cultivated, the indicative physical potential would amount to approximately 46 million hectares.[5]

4. For the present report, however, it is assumed that the indicative potential for new irrigation discussed above includes groundwater potential.

5. This is based on the assumption that such development would take place mainly in the dry sub-humid zone and partly in the semi-arid zone and is the equivalent of 25 percent/100*182.7 million hectares.

5.2 Current Region-Wide Development Proposals

Recent reviews of Africa's development status have highlighted the trend of underinvestment in agricultural water and the need for concerted and immediate efforts to reverse this trend. In 2005 the Commission for Africa recommended doubling the area under "irrigation" in sub-Saharan Africa by 2010. CAADP (see section 4.2 above) was recently revised to call for investment in improved water control on an even larger incremental area of 15.9 million hectares by 2030. Of this, 6.6 million hectares would be expanded irrigation schemes as well as water-managed wetlands and valley bottom systems, 2.1 million hectares would be rehabilitated large irrigation schemes, and 7.2 million hectares would be in new "water harvesting and soil and water conservation" interventions (Table 5.1).[6] This implies a rate of increase in the water-managed area (excluding irrigation rehabilitation and water harvesting and soil and water conservation) of approximately 260,000 hectares annually, more than three times the current rate of increase (section 1.3 above and FAO, 2005a). As discussed above in section 4.2, NEPAD, with FAO assistance, is currently reassessing actual national

Table 5.1 CAADP Program for Investment in Agricultural Water to 2030

	Area of investment by type ('000 ha)					
Region	*New large-scale irrigation schemes*	*Rehabilitation of large-scale irrigation schemes*	*New small-scale irrigation schemes*	*Wetlands and inland valley bottoms*	*Water harvesting/ soil and water conservation*	*Total*
Sudano-Sahelian	208	1,200	516	729	1,684	4,337
Gulf of Guinea	68	110	350	1,061	2,109	3,698
Central	40	99	163	281	169	752
Eastern	110	143	411	914	1,570	3,147
Southern	208	485	533	443	1,566	3,235
Islands	39	77	332	200	100	748
Total	673	2,114	2,305	3,628	7,198	15,917

Source: AfDB/FAO, 2005.

6. In this context, 'soil and water conservation' is interpreted to mean 'in-field rainwater management'.

potential for increasing the equipped area by developing National Medium Term Investment Programs, and will reassess the original targets by building up from this base.

5.3 Market Demand and Economics of Investment

Market Demand

Demand for basic staples and other foods will increase strongly. While sub-Saharan Africa is currently self-sufficient in most of its major staples and imports less than 5 percent of its needs for food other than rice and wheat—the only food crops for which irrigation is currently important (see section 2.2)[7]—domestic food markets are expected to double in volume by 2015, with some increase in demand for superior foods as incomes rise. At current levels of productivity and rates of growth, net imports of wheat and rice are expected to reach 40 million tonnes by 2030 (Table 5.2), while imports of maize and vegetable oils are also expected to increase substantially. Overall, on a region-wide basis, cereals self-sufficiency is expected to decline marginally from 82 percent in 1997/99 to 81 percent in 2030 (FAO, 2003a:68).

There will be some growth in world demand for sugar and cotton, but while cotton prices may rise, sugar prices are likely to remain volatile. Irrigated industrial crops, especially sugar and cotton, will continue to supply domestic and export markets (Table 5.3). Growth in domestic demand will continue to expand and cotton export prices could rise strongly if US and EU protection and subsidies are reduced under the Doha Round (FAO, 2006; Diao et al., 2003). However, the combined impact of the EU sugar policy reform and an increase in global demand (partly driven by demand for ethanol) could increase prices for sugar, but with increased volatility.

Horticulture demand will continue to grow. There are substantial growth prospects for irrigated horticulture because the range of potential products is vast (over 80 different commodities in the 'vegetables and fruits' UN trade classification) and sub-Saharan Africa's current share of world trade in these products is small (Diao et al., 2003:61). There are many high-value niches to explore for exports, although the market is highly competitive and risky. However, low wage rates are

7. Food imports are predominantly wheat, rice, and vegetable oil. Cereals imports currently total 24 million tonnes, of which 21 million tonmes are from commercial imports and the remaining 3 million tonnes from food aid.

Table 5.2 Projected Regional Net Trade in Cereals in 2030 (tonnes)[a]

Crop	*Central*	*Eastern*	*Gulf of Guinea*	*Islands and others*	*South Africa*	*Southern*	*Sudano-Sahelian*	*Total Sub-Saharan Africa*
Wheat	(4,373,200)	(3,646,700)	(6,249,900)	(664,500)	(500,000)	(1,388,700)	(4,311,700)	(21,134,700)
Rice	(2,329,100)	(1,212,900)	(7,848,200)	(912,400)	(1,078,000)	(400,200)	(4,233,900)	(18,014,700)
Maize	(1,475,900)	(1,749,000)	(268,000)	(339,600)	1,000,000	(1,926,800)	(830,000)	(5,589,300)
Barley	(380,700)	(270,300)	(253,500)	(48,400)	(300,000)	(71,800)	(130,300)	(1,455,000)
Millet	(200)	(2,400)	7,100	(300)	0	300	(70,000)	(65,500)
Sorghum	(76,900)	(126,400)	0	(3,000)	2,800	(40,400)	(85,000)	(328,900)
Other	(16,500)	(33,200)	(56,200)	(14,500)	(10,800)	(79,900)	(174,300)	(385,400)
Total	(8,652,500)	(7,040,900)	(14,668,700)	(1,982,700)	(886,000)	(3,907,500)	(9,835,200)	(46,973,500)

a. The regions shown are those adopted by FAO (2005a). See Map 1 for the groupings.

Source: FAO, 2003a cited in FAO, 2006.

Table 5.3 Projected Water-Managed Production in 2030 ('000 tonnes)

Crop	*Baseline 1998*	*Projected 2030*	*Increase (%)*
Sugarcane	32,411	80,807	149
Wheat	1,697	2,281	34
Rice	3,800	10,097	166
Fruit	3,975	2,784	(30)
Vegetables	6,239	11,688	87
Potatoes	1,583	425	(73)
Citrus	1,681	850	(49)
Cotton	413	1,079	161
Groundnut	491	838	71
Bananas	351	469	34
Sorghum	750	1,564	109
Tobacco	18	13	(28)
Tea	21	65	210
Barley	41	18	(56)
Sunflower	28	0	(100)
Soybean	23	25	9
Pulses	184	253	38
Maize	830	978	18
Coconut	9	65	622
Coffee	4	17	325

Source: FAO, 2006.

likely to preserve the region's comparative advantage and exports could grow fast. The large domestic market, which absorbs most horticultural production, will also expand steadily.

Demand for fodder will increase—but from a small base. Fodder production is expected to account for only 4.7 percent of total crop output by 2030 (FAO, 2006 and section 2.4 above), of which only a small proportion is likely to be irrigated. Although fattening and intensive stall-fed systems for milk and meat can be highly profitable where demand for meat and dairy products is firm, and although the projected increase in demand for these commodities is higher than other developing regions and the world as a whole, the increase will be from a relatively small base. Nevertheless, some increase in irrigated production of feed barley, maize, alfalfa, and other green fodder crops is likely.

Box 5.3

Why Economic Viability Is Imperative for Agricultural Water Investments

First, investment that results in an economic return less than the opportunity cost of capital can only lead to an increase in a country's debt burden that will act as a brake on all sectors of the economy, constraining economic growth and poverty reduction. Economic viability is an essential condition for an investment to contribute to economic growth. The corollary is that investment in non-viable projects is a sure way to limit development.

Second, a policy of investment in non-viable projects often results in agricultural water development at any cost. Annual maintenance costs are usually directly proportional to the initial capital cost, therefore development at any cost often translates into annual maintenance costs that cannot be supported by the users. Unless public funding is then made available, maintenance is deferred to the point that the investment will no longer function without new investment in rehabilitation. By definition, this is not sustainable development.

And third, economic efficiency (or maximizing the net benefit of an investment to the economy) is one of the guiding principles of IWRM.

Source: Current study.

Whether this growing demand creates opportunities for viable investment depends on economics. Strong market demand for cereals and the benefit of natural protection and low labor rates indicate some potential to displace imports, particularly for rice and, in the more temperate zones, perhaps for wheat. However, although sub-Saharan African countries may have more leeway to apply domestic support under the Doha Round, there is no indication that real prices of cereals will improve (FAO, 2006; Diao et al., 2003). It is thus unlikely that the economic viability of cereals under irrigation will change much in the foreseeable future. Rice-based schemes and those where other cereals are produced with higher value crops are likely to prove more viable than non-rice cereal monocrop schemes. At the average capital cost of recent well-designed projects (i.e., $6,000 per hectare), and current productivity levels, new irrigation development is unlikely to be viable for growing non-rice cereal crops. Thus growth in irrigated cereal production is likely to be mainly rice, and to a lesser extent wheat (Table 5.1).[8] Other crops (such as cotton, sugar, and horticulture) and certain investments (such as irrigation improvement and run-of-river schemes) will be more viable, even at moderate levels of productivity, although this will be highly specific to sites and market opportunities.

Nevertheless, the benefits of agricultural water investment are often underestimated. Project appraisal techniques have in the past failed to capture the full benefits of agricultural water investment, particularly the benefits induced by the multiplier effect (see section 3.5 above). Where these benefits can be quantified and valued the return to agricultural water investment may be much higher than previously thought. Although no comparable study is available for sub-Saharan Africa, a study on Pakistan found that while the on-site productivity of irrigation water was \$0.04/m^3, this increased to \$0.24/m^3 when other local benefits were factored in, and to \$0.48/m^3—12 times the on-site benefits—when all quantifiable national-level economic and social benefits were accounted for (IWMI, 2005h; World Bank, 2005a:149).

Also, the economics of investment can improve if investments are multi-functional. Multi-functional projects can sometimes bring otherwise unviable rates of return to agricultural water investment up to acceptable levels. There are often opportunities to invest in irrigation development that, on their own, would be judged unviable, but when combined, for example, with small to medium hydropower generation could result in an acceptable economic rate of return (World Bank, 2005f: 9). The association of irrigation with livestock (Box 5.4) or fisheries is another example of potentially mutually reinforcing economics (IWMI-ILRI, 2005e).

Some storage investments will be justified economically, but past skepticism needs to be overcome. Development of the physical potential on any significant scale will require the construction of new storage, it will thus be necessary to overcome the prevailing skepticism regarding the viability of such investments and their associated social and environmental costs. In fact, the thousands of privately financed irrigation dams in Southern Africa (and even publicly financed dams such as those constructed under the Mara Region Farmers' Initiative Project in Tanzania [IFAD, 2007]) are proof that such investment, if soundly and cost-effectively designed, can be viable and sustainable. Furthermore, the World Commission on

8. The projected imports of 18 million tonnes of rice in 2030 (Table 5.2) could be met from an additional 6 million hectares of new irrigation single cropped at an average yield of 3 t/ha.

Box 5.4

Taking Account of Livestock in Agricultural Water Investments

Crops and livestock are closely linked components of irrigated production systems, and both can be potentially fast growing and profitable enterprises where rapid urban growth generates demand. Growth in associated irrigated crop and livestock production is most likely in countries and areas with large animal populations and good access to urban markets.

To exploit possible complementarities between agricultural water development and livestock production, planners should work with stakeholders to assess ex ante the likely impact of irrigation development and correlated changes in land use on livestock keepers. Taking account of livestock in this way will minimize costs to livestock keepers of lost access to land and water resources and passageways, and mitigate any social tension or risk of impoverishment. In most cases it will also allow complementary investment and management that can improve livestock productivity—access to watering points, land and paths zoned for livestock, and encourage the adoption of cropping patterns that have significant quality residue for use as animal feed or the development of zero-grazing systems based on irrigated crops and residues. Beyond the irrigation scheme itself, it may be possible to integrate management of upland catchment areas with downstream agricultural water service, which may involve investments and management to ensure that upstream pastoral systems remain profitable while conserving soil and water resources.

Source: IWMI-ILRI, 2005e.

Dams (Annex 10) has also acknowledged that dams can make an important contribution to human development and that negative externalities can be minimized or mitigated with careful planning.

5.4 Possible Investment Opportunities

There are significant opportunities for development and a wide range of water management investments are possible. As discussed, the theoretical potential for new irrigation, including groundwater irrigation, amounts to approximately 32 million hectares—almost five times the area currently developed. In addition, the prospect of bringing back into production the 2 million hectares of land that is equipped for irrigation but currently unused presents an opportunity to benefit from significant sunk costs. Improving water control on the 2 million hectares of land under 'other forms of water management' in wetlands and flood recession areas also presents a similar opportunity for relatively low-cost investment. Finally there is the potential for improving in-field rainwater management on existing dryland crop areas, which currently extend to more than 176 million hectares (Summary Table 1). There is thus a very wide range of opportunities for investment in agricultural water development, from rehabilitation and expansion of existing irrigation schemes, to the development of new irrigation from surface and groundwater resources, improved water control in cultivated wetlands and flood recession planting areas, to improved in-field rainwater management for dryland crops. There may also be opportunities for investment in watershed management to conserve catchments and stabilize or enhance flows for irrigation.

Development of new irrigation could take several forms and benefit many people. New irrigation development could consist of a wide range of technologies, ranging from individually operated micro-scale irrigation (e.g., using treadle pumps at very low cost) through to large scale. In many cases the development of small areas by individual smallholder irrigators using micro-irrigation technologies will be appropriate. Small- to medium-scale communally managed schemes also have potential, although where these conveyance structures are needed, they may require some public investment support. Large-scale irrigation would probably only be developed in cases where economies of scale and specific market links can be exploited (e.g., for industrial crops such as sugarcane).

Some development is likely to require new storage, which again might range from micro-scale water harvesting systems to large dams, providing opportunities to exploit synergies between irrigation and other uses (e.g., domestic and livestock water supplies, fisheries, or hydropower). Other development is also likely to involve complementary investment in associated watersheds.

New irrigation is likely to be used for a range of crops from rice to horticulture or other high-value crops. The range of costs is very great, depending on the water management technology employed (see Tables 3.1, 3.3, and 4.1). At an assumed average holding size of 0.75 hectares per household, investment in 32 million hectares of new irrigation development could directly benefit some 43 million irrigator households (or approximately 237 million people) plus a further 10–20 million households that would engage in increased opportunities for agricultural wage labor (Table 5.4).[9]

The revival of equipped but currently unused areas could also benefit many people. A mix of interventions is likely to be required to bring back

Table 5.4 Indicative Summary of Opportunities to Invest in Agricultural Water Development

Type of opportunity	*Theoretical potential (million ha)*	*Possible crops*	*Potential direct beneficiaries (million households)*[a]	*Indicative cost ($/ha)*[b]	*Scope for investment (million dollars)*
New irrigation	32	Rice, sugar, cotton, dry beans, fodder, horticulture, other high-value crops	58	6,000	192,000
Irrigation rehabilitation[c]	2	Rice, sugar, cotton, dry beans, fodder, horticulture, other high-value crops	4	3,500	7,000
Improved water control in wetlands and flood recession areas	2	Rice and non-rice cereals, cotton, dry beans, fodder	4	2,000	4,000
Improved in-field rainwater management for dryland crops[d]	46	Barley, maize, wheat, cotton, teff, dry beans, coffee, fodder	20	250	11,500
Totals	82		86		214,500

a. Assumes an average of 0.75 ha/household on irrigated land, wetlands, and flood recession areas and 2.5 ha/household on dryland areas. Also that direct beneficiaries increase by 25–50 percent on irrigated land, wetlands, and flood recession areas and by 10 percent on dryland areas, as a result of increased agricultural wage employment resulting from investment.

b. Includes both software and hardware where applicable.

c. Likely to be an underestimate because some of the 5 million hectares currently under irrigation could be in need of rehabilitation.

d. Assumes only 25 percent of current cultivated area will be developed.

Source: Current study.

9. This assumes that for every household benefiting directly from irrigation an additional 0.25–0.50 households would benefit from incremental wage employment.

into production the 2 million hectares of land that is equipped for irrigation but currently not used. This land is located in large-, medium- and small-scale schemes and will require interventions such as rehabilitation and upgrading of physical works, changes in the institutional set-up, and improved water management and crop husbandry. At an average cost of $3,500/ha for recent well-designed rehabilitation projects, these investments could prove economically viable. However, these schemes would involve similar O&M costs to those for new irrigation schemes, and the cropping pattern would have to be sufficiently high value to cover those costs and provide an incentive income to farmers. Again, at an assumed average holding size of 0.75 hectares per household, investment in these schemes could directly benefit some 2.7 million households (or 15 million people) plus a further 0.7–1.3 million households engaging in increased agricultural wage employment.

There is potential for improving water control in wetlands and flood recession areas. Improving water control on the 2 million hectares of land under 'other forms of water management' in wetlands and flood recession planting areas might involve the development of flood protection and drainage systems, or even irrigation systems. However, in many cases the development of small areas by individual smallholder irrigators, using micro-irrigation technologies (such as treadle pumps) will be appropriate. Such investments are likely to involve lower capital and O&M costs than new or rehabilitated irrigation schemes and may be justified by the production of lower-value crops. Cropping patterns could include rice and other cereals, cotton, dry beans, fodder and, in a number of cases, horticulture. Average land holding could be similar to that for new irrigation and the total numbers of direct beneficiaries could be of a similar order to those from investment in the rehabilitation or upgrading of existing, but unused, irrigation schemes—perhaps a total of 4 million households region-wide.

Solving the problem of low productivity on existing irrigated land presents a major investment opportunity. As discussed in section 2.3, irrigated production in sub-Saharan Africa is characterized by low productivity, constrained by unreliable water supplies, poor water management, low input use, and poor crop husbandry, as well as poor access to input and output markets. Apart from unreliable water supplies, the constraints highlighted are mainly institutional and require investment in software rather than hardware. This opportunity would therefore involve only a fraction of the cost of physical works suggested in Table 5.4 and represents a first class investment opportunity.

Finally, improving in-field rainwater management for dryland crops clearly presents a further major opportunity. Improving in-field rainwater management is an attractive possibility because of the vast areas that might be involved, so that even a small yield increase could have a large production impact. For example, the area currently planted to dryland maize is 24 million hectares (FAO, 2005a). An incremental yield of just 250 kg/ha on this area would be 6 million tonnes—i.e., more than the total projected imports of maize in 2030. In addition, the poverty reduction impact would be immediate because dryland farming is the production system of the poor. Improvements could involve a range of interventions, although all would have the common objective of increasing the effectiveness of rainfall for dryland crops.

As discussed, various technologies have been successfully demonstrated in the region but, apart from one or two cases (e.g. the *tassa* in Niger and conservation tillage in Zambia) adoption has been poor. The constraints to wider adoption by smallholders are likely to be similar to those that are thought to currently limit productivity on irrigated land—i.e., a lack of farmer empowerment to access input and output markets, poor agricultural support services (including extension and credit), and a lack of supply chains for implements and equipment. The theoretical potential is 174 million hectares. For the present purpose it has been assumed that 25 percent of the currently cultivated area, or 46 million hectares, might eventually be developed. Success is likely to be greater in the higher potential agro-ecological zones, particularly in the dry sub-humid zone, but the experience from Niger suggests that good results can also be achieved in the semi-arid zone. Although the possible impact of this development on overall runoff, streamflow, and ecosystems has not been quantified, it is unlikely that this would be significant.

5.5 Choices Facing Governments at the Country Level

At the country level, there are many constraints to developing the physical and economic potential identified. These constraints and some examples are typically economic (the identified projects are not economically viable), financial (investment costs are too high for available finance), institutional (the institutional model is unlikely to deliver good water service or will not prove financially and socially sustainable), environmental (irrigation is viable but the regulatory framework cannot control adverse environmental impacts), capacity-related (local capacity to implement projects efficiently is weak), and poverty related (poor farmers cannot invest in profitable agricultural water technology to improve productivity because they are resource poor and risk averse). These many possible constraints operate in every country in different degrees.

For each country situation, institutional and investment responses need to be devised to allow the potential to be realized despite the constraints. Essentially, choices will be required that reflect the development priorities and absorptive capacity of each country. The general principles that can guide governments in preparing strategies for agricultural water use were discussed above in section 5.4. In each country adapting these principles to the specific opportunities and constraints that exist will require a painstaking iterative process.