Smallholder Management of Irrigation in Kenya

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Abstract

Indigenous smallholder irrigation still exists in Kenya. After a period of outside impulses and top-down inputs to smallholder-managed irrigation, the emphasis now is on participatory design and farmer-driven irrigation development. Cost-sharing and cost-recovery have been introduced and credit schemes developed. Smallholders manage half of the area under irrigation. Smallholder irrigation systems are characterized by small subplots of 0.25–1 acre, while the family is also engaged in rain-fed agriculture and livestock keeping. In smallholder horticultural schemes, the irrigated plots of various farmers are on the "main" farm and, therefore, not adjacent to other irrigated subplots. In rice schemes, irrigated subplots are concentrated in the lowlands, while other agricultural land and houses are on a higher elevation. Pump-fed schemes have not been sustainable. Gravity-fed schemes are sustainable and economically feasible if high-value cash crops are grown under intensive production systems. Participatory design has been achieved through step-by-step discussions of the issues before implementation. Operational (cash) requirements need to be clarified before farmers start with their implementation contributions. Farmers' involvement in design and in choice between systems was found to be feasible under conditions of cash contributions to the investment. A minimum of low-key follow-up support on a cost-recovery basis is recommended.

Introduction

Smallholder irrigation constitutes an important part of the total irrigation activities in Kenya. As in the coffee and tea production, smallholders have a major share in the irrigated produce of rice and vegetables. Smallholder irrigation has existed as an indigenous practice for several centuries. Scheltema and Osoro (1990) reported that smallholders manage about one-third of the total irrigated area. This share has now increased to one-half. At the same time, the area managed by the only irrigation parastatal (National Irrigation Board [NIB]) has decreased as farmers took over the largest scheme themselves (see paper by Kabutha and Mutero on Mwea). Other agency-managed schemes (Bura and Hola) along the Tana river stopped operating. Commercial irrigation shifted its emphasis from coffee to horticulture and floriculture, where it presently occupies 40 percent of the irrigated area.

Most of the indigenous smallholder irrigation schemes that have existed for centuries continue to date one way or another. For many years, the main impulse for change came to smallholder irrigation development from outside. The first one was from Arab influence along the coast and later impulses came from bureaucrats and projects from outside the farmer

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communities in a top-down approach. Thereafter, in a transition period, outside assistance was provided to promote farmer participation in irrigation development. Farmer-driven smallholder irrigation development emerged only recently. It is characterized by actions taken by individuals making use of small pump/engine systems, treadle pumps, and small gravity-fed drip systems (see paper by Sijali and Okumu).

Development of estate irrigation started in the colonial era with fodder production on ranches for livestock feeding in the dry season. After independence in 1964, most of these ranches were subdivided. Rice irrigation started under the colonial government and was continued after independence in centrally managed schemes. Sprinkler irrigation of coffee plantations and one large pineapple plantation started in the seventies and eighties. Large-scale sprinkler and drip irrigation of vegetables and flowers started in the late eighties and continued in the nineties.

Smallholder Management in a Historic Perspective

Indigenous Irrigation

Three major forms of indigenous smallholder irrigation were practiced:

1. Diversion systems with furrows
2. Diversion systems with flood flow
3. Water harvesting systems

1. Water was diverted from rivers and conveyed through earthen and rocky canals to the agricultural area where on-farm application was through wild flooding. This practice was found in the Taita hills and it was widely spread along the western escarpment of the Rift valley (Elgeo, Marakwet and west Pokot districts). These furrows started at the top of the escarpment, conveying water 1,500–2,000 m downward, to irrigate food crops at the foot of the escarpment in the Rift valley. These systems were elaborate and included temporary diversion weirs, and crossings of rivers and furrows of neighboring clans. Some are still operating or have been rehabilitated. In their original form they were labor-intensive due to the need for continuous repair of structures and the daily patrolling during the irrigation season. With a strong clan structure and in the absence of other reliable alternative sources of livelihood this has been a sustainable system for a long period of time.

   That irrigation is indigenous does not automatically mean that it is still feasible and sustainable as was reported, among others, by Klinken (1986). On the contrary, the weakening of the social structure has created a strain on the labor-intensive O&M, which tend to exceed present capabilities. Therefore, the production of irrigated food crops is often infeasible any more. In areas with easy access to markets, a transition has been made to irrigation of high-value cash crops (e.g., Ortum and Sigor in west Pokot). Deforestation in the catchment areas has decreased low flows during the dry season and it is this low flow that is used for

irrigation to benefit from the absence of rain-fed crops in the markets. Although investment in water-saving measures, such as lining of canals and implementation of permanent structures, is possible and has attracted donor funding, the question of economic viability was often avoided, by accepting minimum contributions from the farmers. Other alternatives for investment have to be considered as well, as irrigation of food crops is often not economically justifiable. When farmers cannot pay for future maintenance costs, the system should be considered unsustainable.

2. Indications of flood-flow diversion have been found at the bottom of the Rift valley in an area near the Baringo lake (Ol Arabel river).

3. Water harvesting for crop production was practiced, and still occurs in small depressions with natural overflows on the west side of the Turkana lake. The expansion of water harvesting, through the erection of bunds for water harvesting, has not been successful for the production of food crops. Studies in Baringo by Smith and Critchley (1983) and BPSAAP (1984) show that strip water harvesting for smallholders has not been successful but that possibilities exist for large-scale crop production. West of the Turkana lake 1-1.5 m high bunds were used in another program. With a low annual rainfall probability, most sites do not harvest water every year. The required discipline for strict maintenance of bunds and overflow sections by people who are predominantly nomadic in lifestyle is not appropriate. Subsequent heavy overland flows have often destroyed the water-harvesting infrastructures.

Impulses from Outside the Country

The first outside force was the Arab influence. The Arabs came from Oman and traded along the coast and settled there. They promoted the production of rice. Tidal fluctuations were used to irrigate rice in the mouth of the Lower Tana, where fresh river water raised during the high tide was diverted to rice plots along the river, that were surrounded by small dikes. In the late eighties, 600 hectares of rice were grown in seasonal lakes and along the riverbanks in the Tana delta. In the Vanga area in the Kwale district along the Umba river, water was diverted to scheme areas at some distance from the river. Even now, landownership is still with the descendants of the Arab settlers while the farmers are tenants. Changing flow regimes in the Umba river through deforestation in the Usambara mountains in Tanga Tanzania have resulted in scouring of the riverbed due to increased flood flows. It is not possible to divert water through simple temporarily constructed diversion structures, and the absence of clear landownership of the tenant farmers makes investments in permanent structures questionable.

The second outside impulse was the construction of the Ugandan railway, through Kenya, at the end of the last century. Laborers were contracted from the Indian subcontinent. During and after the railway construction, they started irrigation schemes for growing Asian vegetables, using their indigenous knowledge. In the Kibwesi and Mtito Andei areas springs and streams fed from the Chyulu range were diverted for use in a number of irrigation schemes. Specialization in Asian vegetables continues to date, although now it is in the hands of indigenous Kenyan farmers (e.g., schemes such as Mutitu, Kiboko and Vumillia).

The third outside impulse came during the Second World War when the colonial government required food for the British army. The government promoted the production of vegetables around Karatina in the Nyeri district and constructed some simple diversion structures (e.g., Ihwagi scheme) that are still in use. In addition, rice production was promoted in the Kano plains. The Uhuru floods, just after independence, destroyed most of these schemes. In the late fifties, the colonial government made use of Mau Mau detainees to develop irrigation schemes (e.g., Hola along Tana river, Mwea in Kirinyaga and Yatta furrow in the Thika district). The Tana river changed its course in the nineties and Hola was cut off from its water supply and irrigation activities were stalled. However, Mwea (see Kabutha and Mutero paper on Mwea) and Yatta furrows are still operational.

Top-Down Irrigation Development

Centrally managed schemes with tenant farmers. After independence in 1963, the Government of Kenya promoted rice production through centrally managed schemes with tenant farmers. New schemes were implemented in western Kenya, such as Ahero and west Kano in Kisumu and Bunjala in the Busia district. For the development of the Ahero scheme, land already under cultivation was confiscated and some of the original farmers returned as tenants. These schemes still exist but their organization is outdated because of the position of farmers as tenants. Also, the high service costs resulting from inefficient services by the central agency (water, land preparation, spraying, milling and selling) were untenable. Sprey (1984) posed the question whether tenants of the pump-fed centrally managed schemes could pay the real costs, which even then was impossible. Large areas suitable for tenant management systems became scarce. Eviction of smallholders for centrally managed schemes with tenant farmers was not feasible any more. An attempt to expand the gravity-fed Mwea scheme in the nineties failed for this very reason, although funding was already secured.

Settlement of pastoralists. In the seventies, irrigation schemes were constructed to settle pastoralists in Turkana, Garissa, Isiolo and Mandera. Indicative of the absence of any form of participation is the famous story of the FAO specialist who, with all good intentions, decided upon the location of a scheme by viewing the land from a small plane. Examples are Katilu and Morulem in the Turkana district, First Farm in the Garissa district, BP1 and Shantole in the Mandera district, and Merti and Malka Daka in the Isiolo district.

The gravity-fed schemes in Turkana are located along seasonal rivers with a high sediment load, which requires heavy labor input to excavate deposited silt in canals and to reconstruct temporary intakes. Most of these schemes have failed due to the relatively low additional benefits compared with rain-fed production (Asman et al. 1987) and the absence of effective farmer participation. The pump-fed schemes in Mandera, Garissa and Isiolo required continuous government assistance in O&M.

Some donors, such as NORAD in Turkana and several international NGOs joined in these activities and attempted to involve the potential farmer-pastoralists in the O&M from the start. The pastoralists' schemes were combined in a minor-irrigation program managed from Nakuru in the late seventies. Hogg (1983) has already reported on the Isiolo schemes. The Ewaso Ng'iro North river runs dry in some years due to deforestation and abstraction for irrigation in its catchment area (Aberdares and Laikipia; see Gichuki paper). Consequently, most schemes in Isiolo are abandoned.

Creation of an administrative presence in less-secure areas. Bura, a large-scale centrally managed scheme was implemented in the eighties with the objective, among others, of settling landless people mainly from central Kenya and of increasing agricultural production. In addition, it created an administrative presence in the lower Tana area, where security was, and remains, a major concern. Due to high operational costs, inefficient O&M of the pumping station and lower-than-expected yields, among others, the 6,000-hectare Bura scheme has never been in full operation and is now abandoned.

Technically motivated schemes. In the late seventies and early eighties, plans for irrigation development originated with the River Basin Authorities (Tana River Basin Authority in eastern Kenya, Lake Basin Authority around Lake Victoria and Kerio Valley Authority in northwestern Kenya) and the Ministry of Agriculture (Irrigation and Drainage Branch: [IDB]). The basis for scheme development was the physical opportunity for irrigation, such as availability of water, suitable soils and suitable topography. Technically oriented guidelines—MoALD 1986 and manuals MoALD 1984–1990—were developed. First, programs were designed and, later explained to the community in public meetings called by the chief. The chief is a government employee, with powers to arrest, impose a general fee, a fine, etc. Farmer participation was restricted to say "yes" at this public meeting. Moreover, a "yes" vote was in favor of the most obvious component: the creation of employment opportunities for casual labor during implementation.

Gravity-fed canal irrigation schemes. These schemes have been implemented mainly for rice production in the Nyanza province, for food production in the Rift valley province and food/horticultural production in the coast, central and eastern provinces.

Examples of *gravity-fed sprinkler-irrigation schemes* for horticultural production are Mitunguu and Kibirigwe. In the latter case, support from the administrative police was required during the topographic survey, as the farmers were afraid the government would confiscate their land. Although heavily supported for 3 years after implementation by the project, with extension and marketing, Kibirigwe is only 60 percent operational. The Mitunguu scheme, with 6 years of follow-up support in extension and FO, finally became fully operational.

Tana delta village rice-irrigation program. For the Lower Tana area, a special program was set up to promote pump-fed village rice-irrigation schemes. Participation of farmers was minimal. Rice production was less profitable in the schemes than by individuals outside the schemes, although outside production was limited to a few places along riverbanks and a seasonal lake. Moreover, the financial and technical management of pump systems was a heavy strain on the organizational capacities of the farmers. The river changed its course and traversed one scheme (Mnazini). Two others schemes, Wema and Hewani, were cut off from their pumping stations by a new canal for the Tana river rice scheme. In the end, none of the schemes of this program have survived, with the 1997–1998 El Niño floods breaking the camel's back.

Pump-fed irrigation with groups. In terms of development assistance, it is tempting to provide groups of farmers with a pump-fed irrigation system, especially if farmers have taken some initiative. For example, the formation of women's groups was encouraged to attract donor funds.

Other groups were producing vegetables with bucket irrigation. In the early eighties, altogether 40 such schemes were counted in the Nyanza province alone, all being now abandoned. The attractiveness of its quick and easy implementation and sometimes the focus on women's groups easily generated donor and political support. However, the management of a pump-fed system by a group is often beyond the capabilities of the farmer community. Fee collection for O&M of the pump and its prudent use are often difficult. Farmers can only make a profit, after reduction of costs for the pump and inputs, if they quickly adopt an intensive-production system. They have to achieve high yields and time their planting for marketing when demand is high. An individual farmer may achieve this, but to reach this production level as a group is very difficult. If some farmers are not able to contribute, others stop as well. All these irrigation schemes failed as a result of a top-down approach. Schemes failed even if they received the best in terms of farmer's preparation, training and follow-up. The few exceptions in Garissa have been achieved only after 15 years of assistance with crop extension, provision of fuel, and repair/maintenance of engines and pumps. Their location in the center of an arid area with a ready market for a wide range of produce has also contributed to their ultimate sustainability.

Individual pump-fed irrigation. Individual pump-fed irrigation with a small petrol or diesel engine has a better perspective than group-based schemes. A special manual for individual pump-fed irrigation was developed by MoALD (1990b).

New Approaches

Farmer Initiatives

In addition to the outside interventions described above, farmers started to develop their own schemes. A few representative but not exhaustive examples are given below:

Ranch furrows. After independence, most ranches were subdivided for smallholder settlement in the late sixties and early seventies. Some of these ranges had irrigation furrows, directly diverted from rivers, to produce fodder in the dry season through wild flooding. These furrows were transformed by smallholders for irrigation of crops. Initially, food crops (maize) were grown and, more recently, there has been a shift to horticultural crops (Laikipia, Nyeri districts).

Mountain furrows. Farmers in the foothills of Mt. Kenya (mountain or island scheme) and the Aberdares organized themselves to divert water from small streams. Furrows were excavated by manual labor in 1–2 day per week over a period of 1–3 years. The technical assistance consisted of a local extension worker with a line level, resulting in an average slope of 0.1 percent and furrow lengths up to 10 km (Embu, Nyeri, Meru, Nyandarwa, Kirinyaga, Nthii districts). In steep sloping areas, farmers take water from the earthen furrow through 1-inch pipes, which provide them with an almost equal flow, irrespective of the length of the pipe.

Rice schemes in the Kano plains. After the destruction of the rice schemes by the "independence floods" (see section under Impulses from Outside the Country, p.173) farmers used their experience to develop new schemes. Small streams, rivers and tail water from the

Ahero NIB scheme were diverted to impound water for rice production (Kano plain rice schemes, Kisumu district). The water supply was not secure and water distribution was organized on a first-come first-take basis. In addition, some diversion canals were eroded into drains by floods ("old" Gem-Rae).

Bucket irrigation along Lake Victoria shores. Small irrigation plots were established, predominantly by women's groups, and irrigated by buckets along the shores of Lake Victoria. Production and income are based on subplots cultivated by individuals. The labor-intensive method of irrigation restricts the cultivated area. The opportunity created through the allocation or hiring of a plot by the women's group brought about a strong commitment by the women. On an individual and customary basis, they would not have been allowed to keep the proceeds from their produce (Siaya, Homa Bay districts).

Participatory Design

In the late eighties, the Ministry of Agriculture realized the problems encountered in promoting smallholder irrigation development. New guidelines were developed first in draft form and, after testing, they were formalized by MoALD (1993). In the beginning, the engineers assumed that the farmers could not understand the design or the functions of the structures and explanation followed after implementation. Even engineers seldom considered design alternatives among themselves. Then a participatory planning method was developed, in which the farmer's participation was made manageable by distinguishing individual steps. The individual steps were:

- inventory
- agreement on surveys
- FO
- participatory layout of canals and drains
- O&M
- contribution to implementation
- implementation agreement

In the first step, the farmers show engineers the site of the scheme they had in mind and give information on the ideas they have about the scheme. The farmers are asked how they expect the water to reach their farms and how they want to be grouped in units or blocks. Alternative sites for diversion weirs may be visited. The agency staff prepares a document with terms of reference and cost estimates for the required surveys.

In the second step, the terms of reference and the estimated costs for a topo-survey are discussed with the farmers. Alternative sites for an intake, alignment of main canal and scheme area will be part of the topo survey. Where land has been used for grazing or other nonagricultural purposes a soil-suitability assessment is required. Consequently, the costs for a first soil assessment and its terms of reference will be included in the discussion. In case

the proposed irrigation site is already in use for agricultural production, observations and farmers' comments on the soil suitability may suffice. Possible contractors are proposed and proposals from at least three contractors will be invited. The received proposals will be evaluated with the existing committee and a contract awarded.

In the third step, the FO is dealt with in more detail. The need to collect cash contributions from the members requires a formal organization. Moreover, the future structure of the organization, based on blocks or zones with gender-balanced representation is to be discussed and agreed upon as early as possible. Often, some kind of organization already exists. A committee may have been elected with the sole purpose of attracting attention (funds and expertise) to the village; the educated villagers who reside in towns are often elected for this purpose. Sometimes, a more general organization exists and this committee automatically assumes the role of the irrigation committee. Moreover, during implementation the committee has to carry out a much more active role than during O&M. A pragmatic solution is to expand the existing committee with zonal or block representatives, who assist in mobilizing contributions from their area. The operational committee elected after implementation will be based on zonal representation, for which all farmers, including members of the old committee and representatives are eligible.

The fourth step is the scheme design. After the surveys have been carried out, the route(s) of provisional main and secondary canals and the position of structures are pegged out in the field, followed by the engineers and the farmers walking along this route and eventual discussions with the group. Amendments are made where needed and used to assign the preparation of a scheme design with possible alternatives.

The fifth step is to discuss the task of O&M with the farmers, translated into number of days and the amount in cash each farmer would contribute. If applicable, the cash requirements for O&M of pump, engine and pipes are included. In rice-growing schemes and more so in horticultural schemes, the input requirement is of importance. To make the scheme to become economically feasible, farmers need to intensify their production practices. The additional effort of labor and cash required, above what was needed for rain-fed agriculture, are to be largely compensated for by the profit generated from the sale of produce. The traditional attitude in rain-fed agriculture is characterized by risk aversion in anticipation of water shortages. Farmers have to adopt to a more intensive production system that requires an investment in certified seeds, manure, fertilizer and sometimes pesticides, while labor requirements will increase through gap-filling, timely weeding and crop-protection measures. At the end of this step, farmers have a more realistic picture of what kind of commitments they are required to make. The choice between alternative designs becomes then more apparent to the farmers.

In the sixth step, the farmers' contribution towards implementation in cash, labor and materials is discussed. This includes the estimated number of labor days required for excavation and collection of local materials, and the number of days per week farmers are willing to contribute, in which often market days are excluded. Initial cash contributions are required if farmers have chosen a design that requires cash contributions for O&M. This is to test their capability and organizational capacity in dealing with the financial consequences. Then they have to contribute the required cash during monthly meetings over a period of 6 months organized at the smallest unit. This will put a heavy strain on group cohesion, and coping mechanisms have to be developed, which are better tested prior to, rather than after,

construction. The minimum cash contribution is best set at twice the monthly cash contribution expected for the scheme when operational.

The final or seventh step is a written agreement between the farmers (committee) and the implementing agency. The farmers' contributions and time commitments as well as the obligations of the implementing agency are specified. Adherence to the agreed time schedule should be conditional and the agreement should be automatically canceled if delays occur beyond agreed periods. The contributions from a donor, if applicable, are specified in terms not only of materials and cash but also of technical assistance, costs of the number of visits, etc. Agreed meetings between the implementing agency and the committee or farmers' meetings should be adhered to, as otherwise the cost incurred has to be compensated for.

Development on Credit

In the early nineties, donor interest in smallholder irrigation in Kenya was lessening and it was foreseen that farmers had to make their own investments. Financial institutions were not interested in making loans for this sector. Agreements were tried out with the Cooperative Bank, Industrial and Commercial Development Corporation (ICDC) and Victoria Finance. However, the formal financial sector did not perceive smallholder irrigation loans, based on group guarantee, as their core task. Therefore, they did not give it the required attention. Moreover, lenders expected a security of 80–110 percent. As a result, all contracts performed poorly. In spite of these earlier disappointments, IFAD recently entered into a new contract with the Cooperative Bank and AfDB with the Agricultural Finance Cooperation (AFC) for their smallholder irrigation programs.

The informal banking sector is involved in short-term loans concentrated in larger rural towns and does not provide loans for agricultural purposes. To deal with this situation an informal credit organization called Smallholder Irrigation Scheme Development Organization was formed to provide loans on the basis of group guarantee as outlined by Scheltema and Mirero (1990). Loans were provided for irrigation activities, such as production inputs, small petrol pumps, and infrastructure of group schemes. The groups take responsibility for deciding on the supplier (inputs) or contractor and sign agreements. The Irrigation and Drainage Branch provides them with technical support, while agreements under credit provision have to be approved by the financial institute. Except for individual pump-loans secured through group guarantee both input loans and small-size scheme-infrastructure loans have performed well. However, the management performance has been variable and the organization has still to prove its value. Other organizations such as FPEAK (see Nggi's second paper) have recently started to provide credit for input loans based on an export production contract with one of its members.

Agency Support

The transition from handouts to development on a cost-sharing or cost-recovery basis meets most resistance from staff of government agencies and less from farmers. Engineers determined the design components and their construction standards were high. However, in the new participatory design approach, farmers are the ones to decide. For example, farmers chose between a river/gully crossing constructed from removable corrugated iron sheets or as a fixed piped crossing on pillars. The farmers' decision should be based on advice regarding advantages and disadvantages of various options provided by the engineer and by advice from other farmers during farmer-to-farmer visits. In addition, the decision-making process should also

consider the willingness of the farmers to participate in cash contribution. Without a cash contribution farmers will not fully own and utilize the scheme. Moreover, they would be excluded from discussions of the underlying business issues.

The position of the agency staff also changes drastically. Instead of distribution of the "goodies" the staff is now being challenged and called to task in addressing farmers' demands. The staff members are literally left empty-handed and have to find a new way of relating with farmers. Training is required on how to change the mode of operations and how to speak *with* farmers instead of *to* farmers. Engineers, with their technical background, are inclined to avoid chaos and to keep the situation under control. This is difficult to achieve in a farmer meeting where emotions play a role. To minimize chaos and to allow the engineers to conduct a meeting as effectively as possible the seventh-step approach as outlined in this section was adhered to. New developments, with a focus on designing for farmer's management have been emphasized in workshops already since Kortenhorts 1983, and further stressed by MoALD (1992, 1996); and Chancellor and Hide (1996). More recently, the emphasis shifted to strengthening the FOs' irrigation schemes (GoK-JICA 2000).

From the mid-nineties, the role of the government in implementation has diminished and the government started to concentrate on core tasks: to monitor, coordinate and supervise contractors. Activities such as surveys, design and construction were more and more contracted out. To contain expertise in the IDB a design team was formed, which could carry out a few designs but mainly supervise the design work of others. At first, the IDB did the contracting out countersigned by the farmers but, at a later stage, farmers became the clients in the contract. For supervision of the implementation, farmers may require technical assistance, which they can hire or request from the IDB. It is seen as a logical consequence that those who contribute in cash have an overruling say in the contracting procedure and the selection of the contractor. With farmers' supervision of the contractor, the problematic issue of handing over of the scheme after completion disappears, as it was theirs from the beginning.

Farmer-driven irrigation development is more recently promoted through small gravity-fed drip irrigation kits fed from a bucket or drum (see paper by Sijali and Okumu). Together with the use of small petrol- and diesel-driven pumping systems and the treadle pump, it provides individual smallholders with the potential for more profits than is possible through group irrigation.

Present Characteristics of Smallholder Irrigation

Today, smallholder irrigation consists mainly of group schemes with gravity-water supply, in which high-value cash crops (horticulture, floriculture) or rice crops are grown. Rice cultivation is restricted to the heavy clay soils (black-cotton soils), which are less suitable for the more profitable high-value crops. Production of food crops in irrigation schemes in pastoralist areas has declined or has been transformed to production of horticultural crops. Individually managed irrigation consists of only 10 percent of the smallholder area, the water supply is manual (bucket) and pump-fed (portable pumps) from open water sources, and the production concentrates on horticultural crops. The use of groundwater is an exception in smallholder irrigation. Boreholes and tube wells are used by commercial irrigators for the cultivation of fodder, flowers (roses) and horticulture.

The government sees political support for irrigation as a means of dealing effectively with food-security problems. However, the cost of irrigation schemes is prohibitive for the production of food crops such as maize. Irrigation is only economically viable if high-value cash crops are produced. With low levels of investments, rice production may be viable as well (for example, Kano plains in the Kisumu district). High-value crops may range from those that can be stored for short periods of time, such as onion, sweet potato and pepper to more perishable crops such as tomato, spinach and Asian vegetables. These crops are grown most profitably in the dry season to offset the larger supply by rain-fed producing areas. The income derived from the produce enables farmers to buy food. However, often only a small portion of the community has a plot in the scheme. To solve the problem of deficiency in food crop production, appropriate measures have to be taken to improve rain-fed food production.

Irrigated Horticulture

Smallholder irrigated horticulture is a highly diversified cropping system. A wide range of crops is grown in the irrigated plot with 2–3 crops per year. Moreover, the irrigated plot occupies only a (small) part of the farm on which rain-fed agriculture and livestock productions are practiced as well. Average smallholder farms range from around 1–2 acres in high potential areas (rainfall>800 mm/year) to 5–10 acres in low potential areas (semiarid). The irrigated plot size varies from 0.25 to 1 acre in most schemes. Labor requirements in horticulture and floriculture are high: a family of four laborers is required to cultivate half an acre. Labor requirements in person-days per acre per year are given by MoALD (1990a). They vary per crop under irrigation: French bean 525, cut-flowers 400, chili, okra, tomato, onion, carrot, cabbage, kale, cotton, brinjal and Irish potato 220–280, rice and sweet potato 175, coffee and banana 100, maize, millet, sorghum and bean 70.

The above-mentioned nationwide study showed a decreasing order of profitability: a) cut-flowers, b) tomato and kale, c) onion, brinjal and leaf vegetables, d) chili, French bean, cabbage and Asian vegetables, e) coffee, banana, sweet potato and okra, f) rice, g) cotton, Irish potato and millet, and h) local maize, cassava, sorghum, hybrid maize and bean. A large part of the brinjal, chili, French bean, Asian vegetables and coffee are exported while the other produce is consumed in Kenya. Irrigated produce is marketed in the dry season when the produce of rain-fed areas is minimal. Marketing studies by Caritec (1992) show an increasing demand for horticultural crops in the bigger towns due to an increasing population. Oversupply in the dry season is not expected to be a problem in the near future.

Farmers irrigate only a portion of their land, while the irrigated plots of the various farmers are nonadjacent. Reallocation of land to allow the formation of a more compact irrigation scheme is not acceptable to farmers. Land rights are very sensitive and farmers reject any possible infringement. This has negative repercussions on water efficiency in earthen canals as they have to be longer, and water losses are relatively high. In the new schemes, there is a tendency to pipe water by gravity. In such a case, the negative repercussion is not the loss of water but the larger investment of the longer pipeline required. An environmentally positive implication is the lower concentration of leached fertilizers (nitrogen) and pesticide residues in the groundwater, as this is spread over a wider area compared to a concentrated scheme.

Moreover, ample potential opportunities exist for integrated disease and pest management as a crop is grown on a small area in isolation from the same crop in fields further away. However, extension services have not yet emphasized the newly introduced integrated pest

management approach and farmers have not adopted the more complicated approach. The handling of chemicals used for disease and pest management in the field and their "storage" in the kitchen constitute a main concern (see paper by Sithanantham et al.).

Economic Feasibility

Feasibility studies of irrigation schemes tend to approach the economic viability of a scheme from the point of view of an average farmer. In these studies, the costs and the benefits for the scheme are compiled and divided over the total irrigated area to derive at an average profitability value per hectare. However, as the average farmer does not exist, the value of these studies is marginal. Farmers are "selected" on the basis of plot ownership in the command area and not on their farming capabilities. Therefore, a wide range of variation in the performance of irrigation farmers can be expected. In the age of cost-sharing, cost-recovery and farmers taking loans for scheme development, the variability in farmers' skills is relevant. It is important to estimate the profitability of a poorly performing farmer and his capability to address family cash requirements as well as cash needs for irrigation. This exercise is to ensure that his or her livelihood is not adversely affected by participation in the irrigation scheme and to prepare mitigating measures to offset nonpayment by a poor-performing farmer. The issue of the possible occurrence of poor performers has to be addressed in advance of the scheme development, by the farmers and, if applicable, by the credit institutes. Group credit schemes in which members guarantee the loans of each other, need to deal with members who cannot meet the loan repayments. One of the options is to shift the allocation of water temporarily from the poor performers to good performers in the same group.

Rehabilitation versus development of a new scheme. Farmers' participation in new schemes is relatively easy as all farmers have the same objective of getting access to water for irrigation. To achieve this, they are more willing to share the cost of implementation and the water charges. The greatest obstacle is in the improvement of existing schemes. These are often constructed by a small group of farmers who did not discus rules of O&M in advance. Those farmers closer to the water source tend to take more than their share. Those farmers, who contributed in the same way to the construction of the "furrow" but are further down (tail enders), do get proportionally less and sometimes no water at all. Farmers who have been "stealing" over a longer period do not like to give up their advantaged position. They are often not prepared to share water thus resulting in inequality and conflicts.

"Tail-to-mouth" and "economic bias" approaches in rehabilitation. In Kenya, rehabilitation is still approached as a one-time affair in which a scheme has to be upgraded in one operation. In Tanzania, the Traditional Irrigation Programme (TIP) has gone a step further and has developed a step-by-step approach for existing, traditional schemes. They have developed the "tail-to-mouth" and the "economic bias" concepts. In an existing scheme, first, farmers have to improve their on-farm irrigation ("tail") to enhance the efficient use of the little water they receive. Improvement is achieved through terracing and/or basin and furrow irrigation. In addition, under the "economic bias" concept, the farmers are to intensify the production on whatever small area they irrigate. They are encouraged to use manure, make nurseries, fill gaps after transplanting and to weed in time. The effect is increased production that is translated into cash income prior to the rehabilitation efforts. From these proceeds, farmers can value

further improvements and can contribute in cash to a next step of scheme improvement. The next step is governed by the answer to the question "what relative small investment (something farmers can now afford) will have the largest effect on production?" Often, a distribution structure or a gully crossing is selected. It is only as a last step that the most expensive structure, the offtake from a river or diversion weir (mouth) is tackled. This allows the farmers to make immediate use of the expensive structures as they have already optimized their on-farm production and internal distribution system.

High-potential versus low-potential areas. Often, there exists specific views on the priority of irrigation development in high-potential areas (high altitude, high rainfall and low evaporation) versus low-potential areas (low altitude, low rainfall and high evaporation). High potential areas are considered to be already well favored by nature and would require less support. However, farms may be small and intensification of the production would improve livelihoods in those areas. Moreover, farmers are already used to more intensive cropping systems and have experience with horticultural production during the rainy season.

Low-potential areas constitute a less-favorable environment and are considered more deserving for support. However, irrigation development in these areas is often more difficult than expected. Water development is more complex; gravity-fed irrigation requires huge investment in diversion weirs (e.g., wider, deeper and larger rivers with less suitable sites for weir construction) and longer supply canals (low head available). The farmers are less used to agriculture, in general, and to horticultural crops, in particular. Therefore, they would require more training and time to transform into intensive horticultural producers. Sources of input supply and markets tend to be further away and less accessible. Consequently, a longer period of follow-up in (horticultural) crop husbandry, on-farm water management and scheme organization is required. These costs need to be considered and incorporated in total project costs and in any feasibility assessment. Incorporation of these costs is also required when comparing smallholder irrigation development with other development options.

FO and Management

Registration

Farmers in each scheme are organized in a WUA registered with the Ministry of Water Resources by virtue of application for a water permit through the district Water Bailiff. Registration can also be as a self-help group with the Ministry of Social and Cultural Affairs, in order to open a bank account with the Ministry as a cosignatory.

Organization for Farmer Management

During construction as well as for O&M, the zonal or block organization is a viable concept. Mass organization of farmers for construction often puts a high strain on the organizational capacities of the committee. Registration is cumbersome and group responsibility is often low. Organizing work in smaller groups, where the members know each other better, reduces absenteeism and is easier to administer. Those not present on the assigned day can send a replacement for which they compensate in kind or in cash.

In operational schemes, the committee often consists of farmers at the head of the scheme and the situation of tail-end farmers is not "known" or dealt with in the scheme committee. Representation of the basic unit in the larger units is essential for a good management. Information tends to flow easier with block representatives, especially where they comprise both men and women. Moreover, the selection of officials is less politicized and more focused on the operations of the scheme if basic units send their delegates to a central committee. It is also easier to avoid election of absentee farmers or nonfarmers when the basic units are represented.

For social consistence, the optimum number of members for intensive, effective group performance is around 20–30. In micro-credit finance, the maximum group size used is 30. For example, in irrigation schemes along Yatta furrow with a membership below 30 the author observed no water distribution problems. However, in all schemes consisting of groups of over 30 members, the whole scheme or part of it was not operational. Conflicts in larger groups have a tendency not to be addressed, as the difference in the power of group members becomes an obstacle and requires outside intervention in order to be solved.

Marketing and Input Supply

The experience in Kenya is that the management of an irrigation scheme should be the responsibility of a separate organization that deals with the "water" aspects only. The few combinations of a WUA and a cooperative society dealing with input supply and marketing have all collapsed (Kibirigwe, Mitunguu, Katilu and Kwa Chai). The combination of managing O&M and depositing funds for major repairs in the future is already a task often beyond the capabilities of the FO. The "water" function and the "input marketing" function are not generally compatible. In the WUA, all farmers are "forced" to participate. Farmers are grouped together because their plots are close to each other and they are obliged to cooperate. They may be inclined to do so when it is the only way for them to obtain water. Input supply and marketing organizations need to be organized separately with voluntary membership. Not all farmers may be interested in input supply and marketing. Moreover, members from other schemes, rain-fed producers and individual pump-fed irrigators may want to join the input/marketing cooperative. With the functions combined in one organization, the funds for future repair and replacement were used to finance input supply and marketing, which reduced their cost-effectiveness. Finally, the funds were "lost" and the input and marketing activities stalled and the scheme was left without funds for major repairs and future replacement of the irrigation infrastructure. Therefore, the two functions are better separated in two different organizations open to different members.

All over the world, farmers complain about unfair farm-gate prices. However, studies in Kenya (Caritec 1992) on the profitability of middlemen showed a reasonably low profit margin in areas where sufficient competition between middlemen occurred. It was only in one area (Kibwesi) that two exporters/middlemen, dealing in this area, obtained a high profit margin, probably due to their relative monopolistic position. A major problem in making agreements between groups of farmers and middlemen or exporters is the unreliability of both partners. Where an agreed price is temporarily lower than the market price, individual farmers in the group will divert their produce to other buyers, leaving the contracted buyer with the problem of how to satisfy his (export) agreements. On the other hand, nonpayment for produce, obtained by middlemen and exporters, does occur as well.

Farmers tend to diversify their production; they produce various crops for the local market and often select one crop for the export market. However, high market prices of tomato over a period of time tempted farmers to produce them continuously (Kibirigwe). As a result, for some years thereafter, soil-borne diseases made the area unsuitable for tomato and potato.

Design for Farmer Management

A series of manuals were prepared to facilitate farmer management of irrigation schemes. Manually operated structures with moveable parts were avoided to reduce the need for operational staff and maintenance works. This lowered the requirements for the level of scheme management. Instead of moveable gates, orifice-side weir combinations were introduced to prevent flood flows entering the scheme. Proportional division boxes were used to allow distribution of water within the scheme without the use of moveable gates. In a range of manuals for senior staff this concept was incorporated among other features, (MoALD 1989–1994; and Scheltema 1993).

Water Permits

The allocation of water permits is based on Water Catchment Boards in which government agencies are represented. Representation of WUAs or commercial water users is not yet dealt with. Water abstraction is presently not charged and consequently operational funds to administer water permits are virtually nonexistent. An abstraction fee was imposed in 1994, but revoked shortly after invoices were sent out. Water was charged per volume of water abstraction per category of water users (drinking water, irrigation water and industrial water). District water bailiffs deal with the management of water permits. Checking of offtakes directly from rivers is only carried out in extremely dry years when the Ministry of National Resources and Environment may revoke all permits for irrigation water use. But there is no incentive for farmers to use water efficiently without charges per volume of water abstracted and effective control of amounts diverted. At present, in most canal irrigation schemes, allocation is per time period (hours) and not per volume. In schemes with long earthen canals the tail enders may get half the amount of water or even less in the same time period as farmers close to the intake, at the head of the scheme, get. Charging for water abstraction would promote discussions within the scheme on allocation of water among members.

According to the Water Act, separate water allocations are made for flood flow and low flows. Scheme design is based on flood flow, to allow sufficient water to be conveyed into the scheme. The assumption is that water will be used only for supplementary irrigation. This is not the reality and farmers use water most economically when producing high-value cash crops during the dry season. Supplementary irrigation at the end of the main rainy season is a confusing concept. On paper, it appears feasible, but in reality it seldom works. Maintenance is often not carried out until the need for irrigation arises, which is only in years when the rains subside early. At such times, the time required for maintenance is too long and irrigation water comes too late or not all.

Gender Issues

In horticultural crop production, at least half the fieldwork is done by women, and in rice production it is even more so (Hulsebosch 1990, 1992). Hence, within the cultural context, it makes sense to discuss scheme implementation or rehabilitation with women. Intensification

of production in particular has to be discussed with women. Sometimes, women have a special plot on the farm that they use for food production and the men deal with cash crops. Women-headed households constitute a large number of farmer families, and include those headed by widows, unmarried women, and where the husbands work outside the farm community. Often, the latter amount to one-third or one-half of the households in the area. As men tend to discuss issues among themselves, often the relevant information does not reach the women. Therefore, gender-balanced representation from the lowest level of block or group to higher levels (scheme committee) is appropriate. The position of treasurer is often allocated to women, as men trust them to handle money better than themselves.

Follow-Up on Implemented Schemes

Participation of farmers can be quite successful if they are trained in administration, organization and technical matters related to scheme O&M. It is unfortunate when trained committees are replaced by untrained ones. Therefore, in the more complex piped gravity-fed sprinkler irrigation schemes it is appropriate to have some kind of follow-up. The donors and, certainly, credit organizations need a guarantee that schemes stay operational during the repayment period of the loan, with some options for loan rescheduling. For example, a credit organization cannot approve a loan for a portable pump unless the borrower shows proof of an insurance against fire and theft. It is in the same line that complex gravity-fed irrigation schemes should acquire a follow-up contract for technical, organizational and financial/administrative issues stipulating regular reporting to the annual farmers' meeting. Specifically for this purpose an NGO, Water Users' Support Organization (WASO), was formed, which provides these services on a cost-recovery basis (Kariuki and Scheltema 1996). However, at present the WASO deals only with supplies of drinking water to the community and not yet with irrigation schemes.

Lessons Learned

Options for irrigation development should not only be technically and economically feasible but suitable for farmer management as well. Repeating past mistakes would be disappointing. Therefore, additional attention should be given to the causes of earlier failures.

1. *Farmers' participation as clients in the design and scheme construction is not only possible* but is found to be a prerequisite for the sustainability of irrigation schemes. It requires a modified approach to irrigation system design involving clearly defined steps, in which the full support and retraining of engineers are essential.

2. *O&M and scheme organization* require an agreement on follow-up services to ensure optimal utilization of the investments by farmers, donors and credit organizations.

3. *Involvement of women as members of the WUA is essential.* Membership should be open for women from both male-headed and female-headed households.

4. *Intensification of the production* requires cooperation between men and women at household level. High labor demands require men to increase their labor input and

women to be consulted on the use of revenue generated, before they will allocate more attention within their already overburdened daily schedule.

5. *Individual smallholder irrigation has not yet realized its potential.* The adoption rate of treadle pumps, small drum-fed drip systems and small petrol-driven pumps shows a remarkable potential for improving the economic benefits of farmers.

6. *Rehabilitating schemes with large discrepancies* in water distribution among their members is difficult and time-consuming.

7. *Irrigation development may assist in addressing food security issues indirectly, but it should not necessarily be considered the only or even the most appropriate measure.* Rice production in low-cost schemes obviously contributes to food security in the country, but improving rain-fed agriculture is often more cost-effective and probably has greater scope for increasing food production.

8. *Pump-fed schemes managed by groups of farmers have not been sustainable.* Although construction is easier compared to gravity-fed schemes, financial demands and organizational requirements are much higher. Neither women's groups nor mixed groups have managed to successfully sustain pump-fed operations in Kenya. Most schemes have failed even before the pump needed replacement at the end of its life span. Farmers have only been able to collect sufficient fees and to use these fees for O&M when follow-up support was provided for at least 10 years. On the other hand, individually owned pumps are growing in popularity, particularly in high-value crop production in the dry season.

9. *Combining O&M with the organization of input supply and marketing of horticultural crops should be discouraged.* It is advisable to have one organization to address the issue of water, which requires a "forced" cooperation among water users. Input supply and marketing should be cooperation by choice in which farmers organize themselves because of their common interest.

Future Perspective

Farmers' cooperation in group-based schemes is sometimes a necessity to make large investments in irrigation infrastructure viable. However, farmers' cooperation and the management of an FO result in a large number of problems that have to be dealt with adequately.

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