Part 3

Community Management Issues in Smallholder Irrigation
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

1Consultant.
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 Vumilia).
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 Katili 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 (Mnzini). 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, Nyandarua, 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,
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 discuss 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, Katili 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 outfalls 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 at 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 (Hulsbosch 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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From Government to Farmer-Managed Smallholder Rice Schemes: The Unresolved Case of the Mwea Irrigation Scheme

Charity Kabutha and Clifford Mutero

Abstract

For years, large-scale rice schemes the world over have experienced centralized modes of management under which farmers have been passive participants in a sector meant to benefit them. The situation has however greatly changed in the last two decades due to a global wave of economic and political changes that has increased awareness of the farmers on their rights and the need for change. The farmers have subsequently made demands for inclusion and a greater say on matters related to the overall management of such operations. The Mwea rice irrigation scheme in Kenya, which operated under this kind of system for close to 50 years, is undergoing similar changes triggered by farmer demands for a greater say on the way the scheme is managed.

The Mwea irrigation scheme (MIS) is located just over 100 kilometers to the north of Nairobi, covers about 6,000 hectares and supports about 3,200 farm families. The British Government first established the scheme in 1953 but handed it over to the Government of Kenya in 1963 when Kenya got its independence. The Ministry of Agriculture ran the scheme until 1966 when it handed over the scheme to the National Irrigation Board (NIB) provided for by the Irrigation Act passed in 1967 (chapter 347 of the Laws of Kenya). In the same year, NIB took over the running of all national irrigation schemes in Kenya.

This study traces the history of the scheme and management under the NIB, areas of conflict between the farmers and the NIB, the new management of the scheme, its strengths and weaknesses and identification of opportunities to move ahead.

Introduction

Large-scale rice schemes the world over have been operated under centralized modes of management in which farmers have been passive participants in a sector meant to benefit them. The situation has however greatly changed in the last two decades during which a global wave of economic and political changes has increased awareness of the farmers of their rights.

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and the need for change. The farmers have subsequently made demands for inclusion and a greater say on matters related to overall management of the enterprises. The Mwea rice irrigation scheme in Kenya, operated under this kind of system for close to 50 years, is undergoing similar changes triggered by farmer demands for a greater say on the way the scheme is managed.

This study traces the history of the scheme and management under the NIB, areas of conflict between the farmers and the NIB, the new management of the scheme, its strengths and weaknesses and identification of opportunities to forge ahead. It also addresses challenges in areas such as scientific research and infrastructural management.

**History**

The Mwea irrigation scheme, located at the foothills of Mt. Kenya, is about 100 kilometers to the northeast of Nairobi. Although only 6,000 hectares are under irrigation, the entire scheme covers 12,000 hectares (30,000 acres3) and supports a population of over 50,000 organized in approximately 3,242 farm families living in 36 villages. The scheme is the largest rice scheme in Kenya. It is divided into five sections: Tebere and Mwea covering 3,285 and 3,110 acres, respectively, and Thiba, Wamumu and Karaba covering 3,019, 2,880 and 2,650 acres, respectively. Mwea and Tebere are the oldest and the largest while Karaba, located at the lowest end of the scheme, was the last to be developed in 1973. The scheme gets its water from two rivers, the Nyamindi and Thiba. Rice is grown as a mono-crop for only one season in a year. It uses the flooded-paddy irrigation method. The main varieties grown are Basmati 217/370, Sindano BW 196 and IR 2793.

The history of Mwea goes back to five decades, first developed in 1953 by the British colonial government. The scheme was developed using captive Mau Mau labor after the declaration of a state of emergency in October 1952 (Njihia 1984, 1, cited in Turner et al. 1997). Soon after independence, the scheme was handed over to the Ministry of Agriculture, which managed it until 1966 when the NIB was formed through an Act of Parliament (chap. 347). Because the Act vested sweeping powers on the NIB, farmers were unhappy as they lacked a say in the management of the scheme. It was this fact that, in part, led to the emergence, soon after independence, of farmers’ associations to represent their interests. Unlike other Kenyan farmer associations, such as the Kenya Planters’ Cooperative Union (KPCU), the Kenya Creameries Cooperative Union (KCC), etc., the rice-based associations failed to effectively influence the management of the scheme. Because of lack of an enabling environment and internal management problems, these associations were rather unstable for close to 40 years as described below.

The first association, the Mwea Irrigation License Tariff Cooperative Society, was formed in 1964 and later changed its name to Mwea-Tebere Cooperative Savings and Credit Society Limited. In 1967, a sister society was formed under the name, Mwea Farmers’ Cooperative Society. The management and membership of these two associations remained the same until 1981 when the two split and each established its own management. In 1983, the two societies joined and a banking section was formed under the name Mwea Amalgamated Rice Growers’

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31 acre=0.4049 hectare and 1 hectare=2.47 acres.
Cooperative Society Limited. In 1993, the giant society split again to form what is currently known as the Mwea Rice Growers’ Multipurpose Cooperative Society Limited and the Mwea Rice Growers’ Sacco Society Limited. Although the two operate under two different sets of management, they work closely and may soon be amalgamated because they believe that it was the NIB that kept them apart Mwea Rice Growers’ Cooperative.

There were quite a number of areas of conflict between the NIB and the farmers. The reasons for these were low producer prices, high cost of irrigation-related services, such as seeds, fertilizers and chemicals, a land tenure system that treated farmers as tenants and the absence of the voice of the farmers within the management. After a heightening of confrontations between the NIB and the farmers, the latter took over the running of the scheme in 1998. This study traces the historical events fomenting the radical changes and analyses the current management system, and its challenges and opportunities to forge ahead.

**Study Objectives**

The overall objective of this study was to document the management change that had occurred in the Mwea irrigation scheme, moving from government management to producer management. The study further explored potential implications of this change for continued productivity of the scheme.

**Study Methodology**

**The Process and Content**

The study methodology was both participatory and consultative. The choice of this approach was based on the conviction that local people and relevant stakeholders knew best about their own situation, needs, priorities and opportunities. The study specifically traced the history of the scheme, management under the NIB, the relationship between the NIB and the farmers, the factors that triggered the break and the new management.

**Stakeholders and Information Sources**

The main sources of information for this study included:

a. Existing literature on the scheme (surveys, reports, media)

b. Key stakeholders:
   1. the NIB management and the field managers
   2. the Central Committee of the MRGM and the technical staff
   3. rice farmers from three sections, Mwea, Karaba and Thiba, including women, men and young people, particularly young men
   4. rice millers: male and female
   5. rice merchants
The selection criteria for the sections to be consulted within the scheme took into account diversity and unique differences within the irrigation scheme. The age of the scheme and access to irrigation-related services, such as water, were key considerations. It was on this basis that Mwea, Thiba and Karaba were selected. Both Mwea and Thiba are well watered while Mwea is one of the oldest sections. Karaba is the most disadvantaged in terms of access to irrigation water but it was the last to be established.

Within the sections, discussions were held with mixed groups of men, women and young men. This was contrary to the original design that envisaged separate group discussions with men, women and young people. The rice farmers rejected this format because all information relating to this change was public information, and all individuals, irrespective of age and gender had a voice in this matter. Perhaps not so explicitly stated was the fact that they were suspicious of outsiders and the suggestion of working with different groups was seen as “divisive.” To the satisfaction of everybody, the suggested system worked out well.

Institutional-level consultations were held with the management teams within stakeholder organizations. The stakeholders included the Mwea Rice Multipurpose Cooperative Society, the Mwea Irrigation Agricultural Development and the Mwea Irrigation Scheme and the rice mill.

Each of the above sources provided information on the history of the scheme, the management, the relationship between the NIB and the farmers, areas of conflict, management by the rice producers, challenges faced by the new organization and the way forward.

Management of the Mwea Irrigation Scheme by NIB

The Irrigation Act and Regulations

The NIB, established in 1967 through an Act of Parliament, chapter 347 of Laws of Kenya (GoK 1967), managed the Mwea Irrigation Settlement Scheme up to the end of 1998 when the rice farmers took over its management. During the previous three decades, the NIB had used powers vested on it by the Act guided by regulations developed in 1977 (GoK 1977). Through the Act, the NIB was supposed to do the following:

- Conduct research and investigate into the establishment of national irrigation schemes.
- In conjunction with the Water Resources Authority, established under the Water Act, formulate, and be responsible for, the execution of policy in relation to national irrigation schemes.
- In consultation with the pro-tem Minister of Finance, raise funds for the development of national irrigation schemes.
- Coordinate and plan settlement on irrigation schemes.
- Design, construct, supervise and administer national irrigation schemes.
• Determine the number of settlers to be accommodated in a national irrigation scheme.

• Provide land in national irrigation schemes for public purposes.

• Promote marketing of crops and produce grown or produced on national irrigation schemes and liaise with organizations responsible for the marketing of agricultural produce.

• Provide, either by itself or by agreement with other persons, for processing of agricultural produce grown or produced in national irrigation schemes.

• Award scholarships or bursaries for the study of irrigation (in Kenya and elsewhere) or any other subject that the NIB considers to be of benefit to the NIB.

In addition, the NIB was mandated to impose a:

• cess on all or any agricultural produce grown in a national irrigation scheme

• cess on all or any agricultural produce processed in a national irrigation scheme

There was however a condition attached to this cess. The cess shall only be levied for the purpose of meeting the cost of services provided in the relevant scheme and for which services no other direct charges are available or payable. The cess levied in Mwea was in some cases used to subsidize other national irrigation schemes in the country, mainly Ahero and Perkerra. This transfer of rice profits from Mwea to other schemes was among the main sources of conflict that led eventually to the rift between the farmers and the government.

To support the NIB in the implementation of this Act, the Parliament developed regulations now contained in Legal Notice 68 of a Kenyan Legislation of 1977. These regulations are legally binding, and almost nonnegotiable. They were needed to help sustain the NIB that, as a parastatal, had to be financially self-sustaining and had to do this through recouping its overhead costs from the farmers. Some examples include the following:

• A licensee shall cultivate his holding to the satisfaction of the manager, and in accordance with the crop rotation laid down by the manager and shall comply with all instructions given by the manager relating to the cultivation and irrigation of his holding.

• As soon as each crop, other than paddy, has been harvested, the licensee shall deliver it, other than such portion as he may wish to retain for his consumption and that of his authorized dependants living with him, to the manager at a collecting station to be appointed by the manager, or shall otherwise dispose of it in accordance with the instructions of the manager.

• A licensee shall comply with all instructions given by the manager with regard to good husbandry, the branding, dipping, inoculating, herding, grazing or watering of stock, the production and use of manure and compost, the preservation of the
fertility of the soil, prevention of soil erosion, the planting, felling, stumping and clearing of trees and vegetation and the production of silage and hay.

- A licensee shall not hire, cause to be hired, or employ stock or machinery for cultural operations, other than stock and machinery owned by the manager, without prior written approval of the manager.

- The manager may allocate to a licensee a house to be occupied by him within the scheme or may permit a licensee to erect his own house.

- Any licensee who fails to comply with these regulations shall be guilty of an offence and could be liable to have his license terminated by the Minister on the recommendation of the manager (after confirmation by the committee) and the Minister’s decision will be final.

To enforce these rules, the NIB has put in place the necessary structures. For example, it maintained guards at strategic points within the scheme to screen the farmers to ensure that no rice was smuggled out of the scheme (farmers were officially allowed 12 bags of 75 kg per year for home consumption). These rules and regulations generated resentment and hostility between the NIB and the farmers.

**NIB Membership and Exclusion of Farmers**

The Irrigation Act treated farmers as passive recipients of strict instructions from the NIB. This is clearly reflected in the membership of the NIB that completely marginalized the real rice farmers as reflected below:

- The Director of Agriculture.

- One representative from each province in which a national irrigation scheme exists, appointed by the Minister and names suggested by the Provincial Agricultural Board.

- The Director of Water Development.

- Chairman of Water Resources Authority.

- Permanent Secretary to the Ministry of Finance.

- Permanent Secretary, Treasury.

- Permanent Secretary, Economic Planning.

- No more than three persons, appointed by the Minister who, in his opinion, have qualities of benefit to the NIB.

In practice, the NIB managed the scheme as reflected in its absolute role in the following:

- flooding the paddy fields
• rotavation (land preparation) of the fields using MIS tractors
• provision of seeds
• supervision of production of seeds by selected farmers
• provision of fertilizers and determining the amount and timing of application
• direct application of chemicals on the crop
• clearing of canals
• collection of rice after harvest and milling it
• marketing of the crop and determining the price and the dues for the farmers

The management of the scheme by the NIB was considered harsh by the farmers on account of the following reasons among others:

• Confiscation of land from the “tenants.” Once taken away, the land is said to have been corruptly given out to people external to the scheme.

• Harassment of farmers. Farmers reported various forms of harassment from the NIB. For example, farmers were required to spend 12 hours on their farms; for failure to do so, penalties were meted. After harvest, the NIB could take more than 10 days before collecting the paddy. During this period, the farmers would spend nights out providing security to the paddy. Any attempts by the farmers to retain more rice than was allowed by the NIB were harshly dealt with. There was the case of this female farmer who is said to have “hidden” 4 kilograms of paddy. Although she had a young baby, she is said to have spent days between police cells and the courts. The guards who undertook the unpleasant task of screening gum boots and thermos flasks for hidden paddy are said to have been, not just hostile, but also corrupt.

• Total disregard and disrespect from the field managers. The farmers described occasions when they would go to the NIB offices for official purposes but would be turned away in ways that were humiliating and embarrassing.

• The services provided by the NIB. These are said to have been unduly expensive and on many occasions inefficient. Information gleaned from NIB reports indicate that just about half the value of the rice crop went into the payment of these services. This is well illustrated in a 1995 socioeconomic survey4 carried out by NIB and JICA. The results of the survey indicated that, an average farmer obtained a total yield of 83.5 bags per 4-acre plot. Of these, 10.5 bags were consumed by the family and the remaining 73 sold to the NIB. From the expected income of KSh

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4Tsuruuchi and Waiyaki 1995.
75,150, the farmer finally received KSh 39,921 after deductions of KSh 31,420 (cost of materials) and KSh 8,501 for wage of hired labor.

The management of the scheme by NIB was considered not transparent. According to the farmers, it was not clear how deductions were determined, a situation that created suspicion between the parties.

**The Scheme and the Socioeconomic Situation of the Rice Producers**

The socioeconomic situation of the Mwea farmers did not improve during the entire period when the NIB managed the scheme. This is what the farmers said, was observed and also confirmed from a 1995 NIB/JICA socioeconomic survey that revealed that farmers never managed to meet their basic household needs from the rice proceeds.

**The NIB and the Scheme: Current Position**

The study team held discussions with NIB field managers on a variety of issues. At the time of the survey, there was little activity within the field-level organs of the NIB. These include MIS, the MIAD and the rice mill. This was, however, not unexpected since the farmers had assumed many of the roles previously held by the NIB. A meeting with the rice mill manager on 30 August 2000 confirmed the changed circumstances of the NIB in Mwea. He referred to the rice-mill-related activities as being dead at the time. Of the 120 workers 75 percent were being sent home on unpaid leave until further notice. Before the change, the rice mill had these 120 regular staff and a similar number of casual workers.

Discussing the history of Mwea and the events that had led to the takeover of the management of the scheme, the managers acknowledged the undemocratic mode of management that, although perhaps viewed as necessary at the beginning, failed to change with the times. A senior manager did however indicate that discussions on possible changes had been on within the NIB for quite sometime. For example, the NIB had considered, as early as the 1980s, a review of the Act to increase the role of the farmers in the management of the scheme. In support of this process, workshops had been held with stakeholders but no concrete actions had been taken.

The issue of assets, particularly the rice mill with a capacity of 15 tons per hour (4,000 bags per day) is still a thorny issue between the two groups. The rice mill was registered in 1967 as a private company. Currently, NIB holds 55 percent of the shares against 45 percent owned by the farmers. At this point in time, the farmer association is attempting to gain control of the rice mill. Their argument goes as follows. The NIB has managed this mill since 1967 and it is time to hand it over to the farmers. The farmers also argue that the NIB has not paid out dividends to them for a long time, thus making their cases stronger (the NIB admits that payment of dividends has not been regular). There is a clear stalemate on this issue since the NIB has no plans to just hand over this rice mill to the farmers. The NIB sees the following as the minimum conditions to be satisfied by the farmer group for the mill to be transferred:

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5The farmer group, currently using many small-capacity privately owned mills, is in dire need of a large mill with sorting and grading capacity. High-quality rice has a high market value.
• That the farmers pay off the 55 percent government shares. This is equivalent to KSh 500 million ($6.25 million). According to the NIB, the failure of the farmers to deliver the 1998 rice crop has resulted in a debt of KSh 300 million ($3.75 million). The NIB would therefore expect a total of KSh 800 million ($10 million) from the farmers.

• Alternatively, both the government and the farmers work out a framework that will allow the farmers to use the mill at commercial rates. The profits will then be proportionately shared between the NIB and the farmers.

In all these discussions, the managers gave no indication that the NIB was about to leave the scheme to the farmers. In fact, they saw as their core responsibility, continued provision of technical support in critical areas such as research, provision of certified seeds and water management and distribution, among others. These are areas they consider too specialized for the farmers to adequately manage. This is corroborated by the fact that the Ministry of Agriculture, according to the Daily Nation, 14 August 2000, was in the process of constituting a new NIB. This move was however suspended by a court of law because of a pending case filed by the farmers against the NIB and the Minister of Agriculture.

**Issues of Conflict between the NIB and the Farmers**

As indicated elsewhere, the relationship between the NIB and the farmers had a rough start and never really warmed up. The following are examples of areas of contention arising from NIB regulations governing rice production at Mwea.

**Land Tenure and Land Pressure**

Forty years since the settlement in Mwea, farmers are still tenants. The farmers argue against this status on two grounds. One, the farmers have been in the scheme long enough to graduate from tenants to landowners and two, this land was never government land. According to the early settlers, this land originally belonged to the nine clans of the Agikuyu people who live on the foothills of Mt. Kenya. The farmers therefore consider the move by the government illegal and with no basis. The lack of individual land title deeds for farmers’ plots has been among the most contentious issues in Mwea and was, to a large extent, the reason for some of the more violent riots between 1996 and 2000.

This whole issue was described in a media article in which the farmers sent an open letter to the Attorney General over what they perceived as the inhuman Irrigation Act. The farmers have strong views on the land issue; under the Act, the farmers remain settlers and have no estate under the Law of Succession Act through which their dependants can inherit (The People, Sunday, 24, September 2000). Past suggestions by the government to renew the current Land Leases in place of Title Deeds have met with resistance.

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6Because of difficulties in the relationship, joint ownership of the mill, with farmers owning more shares than the government, has not been considered.
Another land-related complaint was the practice of unilateral withdrawal of land leases by the NIB. The NIB withdrew such leases on the grounds of poor management of the land by the licensee. Such land was quickly given out to other people, not necessarily from Mwea. The farmers view such transfers with hostility. These actions were, however, covered by the Act and the Regulations and there was little the farmers could have done in the circumstances. In further discussions with the farmers on the matter of suboptimal husbandry, the farmers accepted that there were a few cases of this nature, but they explained that proceeds from rice were never enough to sustain families and farmers needed to engage in other activities to fill this gap.

Although against the regulations, the growing pressure on the land has forced farmers to open up new land bordering the Mwea scheme for rice production, and using the water system servicing the current scheme. The land pressure is explained by the fact that the four acres allocated to families at Mwea were at the time of inception of the scheme adequate because the families were small. The situation has however changed considerably over a span of 40 years. The family sizes have more than trebled, thus, overstretched the farm sizes. It is against this background that the farmers have established new rice fields, popularly known as jua kali. This name literally means “hot sun” and applies to local informal industries in which many Kenyans engage. What the farmers have done is illegal according to the regulations of the scheme. Expanding rice production is motivated by the high demand of rice in Kenya (Kenya is a net importer of rice).

As regards the above, it is worth noting that, Mwea, like much of the central province has, since the advent of multiparty politics, identified itself more with the opposition than with the ruling party. Opposition members of parliament have, therefore, supported farmers fully and used this opportunity to discredit the government.

Small, Poor and High-Price Housing

According to the regulations, no farmers were allowed to build their own houses without prior authority of the NIB. The regulation was very explicit on this matter; farmers were prohibited from constructing buildings or other works of any kind on the holding or elsewhere in the scheme without prior written consent. Therefore, the NIB assumed the responsibility for providing housing. The farmers have been unhappy on the scheme because the houses are too small and are of poor quality in addition to being overpriced. The houses have mud walls and tin roofs. On size, the NIB perhaps did not anticipate such an increase in family sizes since sons who reached 18 years were supposed to leave the scheme. The cost of each of these houses comes to KSh 12,972 ($160). This money was paid to the NIB by farmers in installments of KSh 432.40 per year for a period of 30 years.

Water Use Restricted to Rice Production

Irrigation water was restricted to rice production during the NIB regime even though rice is not a high-valued crop when compared to horticultural crops, such as tomato. The manager of the scheme had powers to destroy other crops if grown with water from the scheme. The regulation stated that the manager shall have the power to order the destruction of any crops planted in contravention of his instructions or of the provisions of these regulations. All costs incurred during the destruction would be recovered from the rice delivered by the respective farmer. In the latest petition to the Attorney General for repeal of the Act, this issue is highlighted.
The complaint is that the farmers are chained and tied up to rice farming all their lives as they devote their full personal time and attention in the cultivation of the crop ordered by the NIB.

Yet the manager of NIB at Mwea was well aware that horticultural production was taking place upstream of Mwea and was, in fact, collecting fees from those farmers who were pumping water from the NIB canals. Also, on a pilot-trial basis, the NIB had introduced a second crop of soybean, grown in the off-season and at one point it had expanded this program to 500 acres.

**Farmers’ Lack of Control over Their Product—Rice**

According to the regulation, families could only retain 12 bags of 75 kg of unprocessed paddy after harvest. This amount was expected to feed the family for a whole year. To ensure that the regulation was adhered to, the NIB engaged guards to screen the farmers as they left the fields. Contravention of this regulation saw many farmers in police cells. One woman from the Mwea section graphically narrated her ordeal in police cells for allegedly “smuggling” 4 kilograms of rice. As an illustration of farmers’ desperation, it can be stated that they smuggled rice for home consumption in gum boots and tea flasks on their way home from the farms.

**Regulation against Livestock Rearing**

Rearing of livestock in the rice scheme was prohibited. The regulation on this stated that a licensee shall not keep on his holding any stock other than those specified in his license; otherwise, the manager had authority to confiscate and sell such additional stock. This regulation was however not very aggressively pursued and herds of cattle and other small stock are a common sight in the area. This was also confirmed by a study carried out by Tsuruuchi and Waiyaki (1995), which established that more than half of the farmers kept cows, goats and chicken.

**Undermining the Family Unit—Boys over 18 to Leave the Scheme**

Although this regulation was never implemented, the farmers are still very incensed by the inclusion of this clause in the Act. They saw it as a way of undermining the culture and the family unit. In their culture, men are supposed to give their sons land and animals to help them start off their own families. Traditionally, these sons would inherit the family assets. This is however threatened by the current “tenant” status, which is not recognized by the Succession Act.

**Low Prices and Subsequent Poverty**

At the time of the radical takeover of the management of the scheme by the farmers, the price paid out to farmers for paddy stood at KSh 17.50 per kilogram. In 1998 (at the height of the conflict), the farmers had demanded an increase to KSh 20.00 per kilogram. Even as the NIB declined, there was one thing that the farmers knew. Their rice was worth more than what they were requesting and the real problem lay in paying the cost of a bloated NIB and subsidizing the running of two other national irrigation schemes, namely, Ahero and the Perkerra.


Farmers’ Takeover and the Situation at NIB

The Mwea Rice Growers’ Multipurpose Cooperative Society took over the management of the scheme in 1998 after many years of a strained relationship. This takeover was precipitated by many grievances as indicated above. However, at the core were the low price of rice and what farmers perceived as a high level of insensitivity by the NIB. The farmers reported that they were after an amicable solution to this stalemate. This was however not to be. A meeting held between the Ministry and the farmers in 1998 failed to resolve the issues. This final meeting is said to have been the 28 consultative meetings between the two parties on the subject.

Failure to reach a compromise provided the central province opposition parliamentarians an opportunity to castigate the government on insensitivity to the needs and suffering of the farmers. Acts of defiance that followed the stalemate between the government and the farmers therefore had the full backing of the local Member of Parliament and the central province opposition parties.

Consequent to this deadlock, the farmers refused to deliver the 1998 paddy crop to the collection centers traditionally used for that purpose (each section has a collection center). In addition, the farmers started destroying some of the infrastructure, such as the collection centers. During these scuffles, the police were called in, thus fuelling an already volatile situation. It was during one of these riots that two men from the scheme were shot dead by the police. The media covered these events comprehensively.

One question that lingers on is “why this pitch of ‘disobedience’ from farmers who had all these years lived with the NIB and the regulations?” To some degree, the environment was conducive. The decade had seen the introduction of multiparty politics and liberalization of many sectors including agriculture. Dissent was tolerated and for once, Kenyans could speak openly without fear of detention and harassment. This too was a period of free information flow and interaction. For example, through the joint GoK/JICA research project in Mwea, farmers were trained on how to experiment with new crops such as soybean. They also acquired skills on pricing systems and alternative market outlets. Those who produced soybean and sold the crop directly to buyers (not through NIB) made KSh 270 per kilogram against KSh 27 per kilogram when sold through the NIB.

Young people, born and bred in Mwea were a major source of change. Unlike the original settlers, the children had gone to school, acquired good education and some even had good jobs. For these young people, it was time for change in Mwea. They had lived in poverty and misery, and they wanted to bring an end to this.

In retrospect, young people tend to view the past as a bad dream. A young man of 23 years from Thiba proudly showed us new houses built by young men from the proceeds of the “jua kali” rice (building of houses and opening new land for rice was illegal during the tenure of the NIB). This young man narrated to us how, in 1998, he mobilized youth groups, personally commandeered an NIB lorry full of paddy and shared it out to Mwea residents. According to him, the days of slavery are over.
Management of the Scheme by the Mwea Rice Multipurpose Cooperative Society

About the Cooperative Society

The Mwea Rice Multipurpose Cooperative Society is a farmer association currently managing the irrigation scheme with, and on behalf of, the farmers. Its history goes back to 1964 when farmer associations started emerging. The associations had a difficult time holding their own as reflected in successive splits and mergers. Although the farmers we talked to attributed this instability to interference by the NIB and had high hopes of greater stability, there was evidence of other challenges in the form of poor management, accountability, etc.

The first association, registered in 1964, was the Mwea Irrigation License Tariff Cooperative Society. It changed its name to Mwea-Tebere Cooperative Savings and Credit Society Limited. In 1967, a sister society was formed under the name Mwea Farmers’ Cooperative Society. The management and membership of these two associations remained the same until 1981 when the two split and each established its own management. In 1983, the two societies amalgamated and a banking section was formed under the name Mwea Amalgamated Rice Growers’ Cooperative Society Limited. In 1993, the giant society split again to form what is currently the Mwea Rice Growers’ Multipurpose Cooperative Society Limited and the Mwea Rice Growers’ SACCO Society Limited. Although the two operate under two different sets of management, they work closely and may soon be amalgamated because they believe that it was the NIB that kept them fighting.

New Management of the Scheme

The current management of the Mwea Rice Growers’ Multipurpose Cooperative Society Limited has been in office 2 two years now. Its objective is to improve the economic, social and political welfare of the farmers. It considers as exemplary its performance during this 2-year period. According to the 1999/2000 Progress Report, the society highlights some of its successes during the 2 years it has been in office. For example, it states that between December and February 1999, the MRGM transported all the paddy from the fields to Mwariko in record time and at minimal cost, and land preparation, which started in March, was completed by August 1999, a feat the NIB never achieved during its lifetime in Mwea.

During this period, the society made efforts to keep afloat amid daunting technical, financial and infrastructural challenges. Its management appears a lot more democratic, the price of rice has moved to KSh 30 per kilogram and farmers have the freedom to sell their rice to the highest bidder (except a minimum of 40 bags that must be delivered to the society to meet the cost of services provided by the society).

Governance

The management consists of a central committee of nine members democratically elected by the farmers, staff members and unit leaders. These nine members represent the five sections of the scheme, i.e., Tebere, Mwea, Thiba, Wamumu and Karaba. To maintain an odd number of members for voting purposes, each of the four sections is represented by two members while one section is represented by one member (the section with one representative will, in the next round, have two members). The committee has however only one female member.
Reporting to the nine section leaders are 68 unit leaders distributed through the five sections. In terms of numbers, Tebere has 17 unit leaders, Mwea 17, Thiba 12, Wamumu 10 and Karaba 10. Out of these 68 unit leaders only 3 are women.

The unit leader is the frontline worker who links the farmers with both the management committee and the technical teams. They monitor views, needs and constraints for onward transmission to the section leader and finally to the society. As a backup, each section has a technical officer, employed by the society. It is important to note that a few of the technical staff are “defectors” from the NIB who have had years of experience in operating the canal system.

An Agricultural Subcommittee coordinated by the Scheme Manager handles technical issues. This subcommittee consists of Agricultural Officers and Irrigation Engineers.

According to the farmers interviewed, what they see as very different from the time of NIB is transparency in running the society. The farmers see this as central to the survival of the society. To ensure this transparency, farmers have put in place appropriate mechanisms. One such mechanism is a shadow management committee in each of the five sections that checks and evaluates the work of the official central committee. To demonstrate how seriously they view this matter, the farmers have, in the last 2 years, dismissed one committee for nonperformance.

On taking over, the society moved fast on relaxation of the regulations applied during the NIB tenure. For example, farmers, after delivering a minimum of 40 bags of paddy to the cooperative to meet the cost of services rendered by the society, can freely sell the rest directly to the millers for quick cash. The many barriers and policing of movement of rice are things of the past. A few farmers have also experimented with two crops a year although the results have not been encouraging. A new weed, similar to the water hyacinth has taken root in some canals within the Mwea section. Members of the technical staff attribute this to double cropping.

**Farmers’ Voice within the Society**

The farmers own the society and this is confirmed by the freedom with which they make demands on the technical teams at the society level. They also engage and fire members of the central committee if they fail to meet their own expectations. They are well informed and speak about the society with confidence. For example, they know about their assets such as the 20 tractors acquired by the society, have details on a new rice mill recently acquired and awaiting installation, know the cost of services provided to them by the society and are able to explain the financial difficulties of the society. The fact that the farmers have contributed to the acquisition of these assets confirms that they were not against deductions made by the NIB per se, but were against the lack of transparency in the entire process.

**Increased Incomes and Changing Lifestyles**

In 1998, when the Cooperative Society took over the running of the scheme, farmers were being paid KSh 17.50 per kilogram of paddy. Today, they get KSh 30 per kilogram. Other indirect gains are from the reduced cost of services provided by the cooperative. The aggregate result of these processes is increased incomes for the farmers. From discussions held with the farmers in three sections of the scheme (Mwea, Karaba and Wamumu) and with the millers in the Wang’uru town, the farmers have much higher incomes than earlier. This is said to have translated into a number of things. The farmers are now cleaner, better dressed, are able to
send their children to school and have embarked on improving their houses. One man from the Mwea section showed off a suit he had on and which he said was his first since settling in Mwea over three decades ago. He attributed his ability to buy such a suit to the change of management. For the women, they can now buy good clothes and shoes to prevent the cracking of their feet. Young men from the Wamumu section of the scheme who fully participated in the riots, showed us their new houses, which they had never dreamt of for two reasons; one, it was against the NIB regulations to build such houses and two, under NIB they would never have got enough money for such structures.

For the millers, this new change has transformed their livelihoods. In Wang’uru alone, there are more than 100 mills operating either independently or leased by the MRGM. The millers charge KSh 1 per kilogram of paddy milled and also retain the bran from the paddy. This bran is used in the manufacturing of animal feeds and fetches a good price for the millers. The millers admit that life has changed in Mwea and Wang’uru. According to the farmers who were interviewed in late 2000, virtually everybody is now able to generate some income for themselves, an aspect said to have reduced thuggery and insecurity to a minimum. However, by May 2001, there was less optimism in the new management by the MRGM as some farmers had not had their rice deliveries paid for two seasons.

**Challenges and Opportunities**

While certain things have worked well, the society knows that there are daunting technical and financial challenges ahead of them. The human capacity is overstretched and they have limited equipment and machinery, and virtually no capital for operations. Banks are also unwilling to advance the MRGM loans in view of uncertainties of the future of the scheme

*Human capacity.* The Cooperative Society has an extremely small workforce. According to one of the technical officers, the current team is a drop in the ocean when compared to the numbers during the NIB tenure. Each irrigation block/section has only one official and none of them has an office.

Certain key functions, such as water management and research, have not been established. The absence of systematic research, which is necessary to ensure regular supply of good seed, threatens the very foundation of the scheme. Plans for water distribution, particularly during water-shortage periods and plans for maintenance to allow equitable water distribution are necessary and need to be prepared by well-qualified staff members.

*Equipment.* During the time of the NIB, the scheme had enough machinery and equipment to handle the operations. After the takeover by the farmers, movable machinery, such as tractors and excavators, were transferred by the NIB to other national schemes. Research equipment is still at MIAD but out of reach of the society. These difficulties notwithstanding, it is encouraging to note what the society has been able to do on its own through the use of nontraditional approaches as discussed below.

**Subcontracting Services**

*Tractors.* The society has only 20 tractors of its own. Because these are clearly inadequate to rotavate (prepare the land) the 6,000 hectares, the society has contracted the services of independent contractors. The society pays for the services but deducts the cost from the
farmers’ proceeds. In the process of this struggle, the society has learned that it is cheaper and more efficient to farm out this service.

*Rice mills.* At the time of this survey (August 2000), the society had no functional rice mills of its own. For it to mill the rice delivered by the farmers, it leased rice mills from independent contractors. At peak time, it leased over 100 rice mills. This was, however, seen as a temporary measure while awaiting the installation of a 3-ton per hour rice mill it had just acquired. The society also revealed its plans to acquire more if the stalemate over the jointly owned rice mill was not quickly resolved. The society acknowledged that this was one service it was going to manage to maintain the high quality of rice. The current quality of rice is much lower than what the NIB produced. This automatically creates a marketing problem, particularly since imported rice of good quality is freely available at competitive prices in the local market.

**Production of Seeds**

This area is highly specialized. During the NIB tenure, a number of farmers were contracted to multiply seed for distribution to the rest of the farmers during the planting season. This ensured an uninterrupted supply of good-quality seed. When the society took over the running of the scheme, it employed the same seed-bulking farmers for the 1999 crop. These farmers opted to deliver their paddy seed to the MRGM due to the higher price offered. Now, however, the farmers are no longer producing seed leading to the nonavailability of good seed and lower-quality rice.

**Research**

This emerged as one of the weak areas. The society fully recognized this fact and was making efforts to address the matter. The acquisition of 20 acres, made freely available by farmers for field trials, is a demonstration of this commitment (the facilities at MIAD are however still held by NIB).

**Rice Milling**

The society has acquired a small mill with a capacity of 3 tons per hour although the minimum capacity needed is 15 tons per hour. The new mill was in the process of being installed during our interviews. At this time, the society was leasing rice mills from contractors. However, these mills had no capability to grade the rice, thus making it difficult to compete with imported rice in the local market.

**Working Capital**

Running the irrigation scheme is an expensive undertaking. The cooperative requires a minimum of KSh 300 million upfront to run the scheme. These funds are needed to meet the cost of fertilizer (KSh 70 million), land preparation (KSh 30 million), pest control and gunny bags (KSh 20 million) and payment to farmers close to KSh 150 million. In many ways, the new management is providing the services using a model close to that used by the NIB. What distinguishes it from the NIB management is its degree of transparency and the role of the farmers in the management of the operations.

The efforts by the society to get credit from commercial banks have not been successful and the society attributes this to interference by the government. They quote situations where
negotiations were almost concluded only to learn at the last moment that the deals had been terminated. In the midst of these financial difficulties, the society also has found some workable solutions. In 1999, it identified a rice buyer who paid KSh 200 million upfront, thus assisting the society to meet some of its financial needs.

**Human Health**

Malaria and intestinal schistosomiasis (bilharzia) (see paper by Mutero on health impact assessment) are common in the Mwea irrigation scheme. The NIB used to have a surveillance team to monitor and ensure that the two diseases did not attain epidemic proportions. This was partly achieved through the treatment of irrigation canals with molluscicides to kill carrier snails of bilharzia, and the provision of health credit facilities. Currently, there is no organized treatment of canals with anti-snail chemicals. Transmission of bilharzias might, therefore, rise again to the high levels common before the NIB instituted regular control measures.

**Discussions**

A change has occurred at the Mwea irrigation scheme. The NIB at Mwea is currently almost nonfunctional despite the capacity it commands in terms of technical expertise, facilities and political support. However, all signs indicate that the NIB has no plans to leave the scheme. For example, the Ministry is in the process of reconstituting a new NIB, but due to a pending suit between the Ministry and the farmers’ cooperative the court has temporarily halted this. Alongside the NIB is the farmer association, determined to make it despite many odds. The challenges are real. At the society level, the technical, financial and infrastructural challenges are daunting. There is a dire need for operating capital and the canals are in need of excavation, yet there is no equipment while a large-capacity rice mill is needed to produce quality rice.

This analysis clearly underlines the unfinished business at Mwea. There are issues to be resolved between the government and the farmers but, as it happens, the farmer cooperative urgently needs injection of capital to successfully keep the scheme functional.

**Conclusions and Recommendations**

**Conclusion**

After close to 40 years of a highly structured top-down management, radical changes have occurred at the Mwea rice irrigation scheme. The farmers took over the running of the scheme at the end of 1998 and have been running it since, albeit with difficulties. The management of the scheme is now by the Mwea Rice Growers’ Multipurpose Cooperative Society Limited through an elected management system. The Savings and Credit Cooperative (SACCO) has been integrated into the management and is currently responsible for sale of rice and payment of farmers’ dues. This new role was decided on by farmers when the MRGM had difficulties in timely payment of farmers’ dues.

There are divided assessments on the nature of this change. According to the farmers, this change is final and there is no going back. The use of the term “divorce” to illustrate this change is enough to conclude the position of the farmers. The government, while
acknowledging this change, still sees its role in the scheme and considers itself the de jure manager. In some ways, the government is right since it still controls assets essential to the operations of the scheme, e.g., the rice mill, the research facilities at MIAD and the paddy collection centers but, in fact, literally the keys to the main control structures of the system were handed over to the farmers’ group. A central issue is the Irrigation Act. This Act and the status of landownership are central to the meaningful takeover by the farmers and the government is aware that the farmers cannot change the Act on their own. The fact that the Ministry of Agriculture is in the process of reconstituting a new NIB for the scheme reinforces this position. Therefore, it is clear that while the farmers are functionally in charge of the scheme, the government still has a strong hold on the critical elements of the scheme.

Despite the challenges faced by the MRGM, some substantial positive changes have taken place. The management system is apparently more democratic and sensitive to the plight of farmers; prices paid to farmers have almost doubled; and opportunities for farmers and the people of Mwea have increased (farmers can sell the bulk of their paddy to independent rice millers, thus creating a new category of beneficiaries within the scheme). In addition, farmers have opened up new land for rice on their own initiative. The farmers interviewed have reported that, on the whole, the socioeconomic status of the entire area has improved.

While performance in certain areas is commendable, the cooperative society also faces some major challenges. Its technical team is inadequate, it badly needs operational capital and facilities for research and seed multiplication for research, it has limited milling capacity and it lacks critical machinery and equipment, such as excavators meant to keep the canals free of weed and silt. Innovation and flexibility have, however, helped the society in the face of these constraints. For example, the society has leased small rice mills from independent contractors and has contracted out services, such as rotavation, to supplement its 20-tractor capacity.

The split between the NIB and the farmers is far from complete and there is clearly unfinished business between the two parties. The farmers are still pressuring the Attorney General to review the Irrigation Act and there is the unresolved issue of the jointly owned rice mill and the idle infrastructure at the scheme (paddy collection centers, the MIAD research capacity). The society sees a clear link between this stalemate and its inability to get loans from banks. In the society’s view, the government is interfering with its operations.

In conclusion, it is apparent that dialogue and consultation between the government and the farmers are urgently required.

**Recommendations**

- Both the MRGM and the Ministry of Agriculture need to initiate meaningful dialogue to resolve pending issues, such as the review of the Irrigation Act. At the functional level, matters relating to joint assets, such as the rice mill and the paddy collection centers, among others, should be resolved.

- Review and appropriately strengthen the current capacity of the farmer cooperative society. While this should be preceded by a clear analysis of core functions and capacity requirements, visible gaps include equipment and machinery, operational capital and staffing.
The society needs to develop a strong operational system to improve the efficiency of the farmer cooperative. The society has embarked on certain aspects of this, such as computerization, but more needs to be done.

Strengthen the already initiated democratic process to ensure effective farmer representation and equity in terms of gender and other social characteristics.

**Researchable Areas**

**Technical**

A new weed that resembles the water hyacinth has taken root in some water canals in Thiba. Although not currently a threat, as a preventive measure, it is important to establish its nature and implications.

**Socioeconomic Changes**

Establish the level of socioeconomic change and subsequent changes at the household level. This will be in response to reports from farmers, rice merchants and millers that there has been an increase in disposable income for most people in the scheme.

**Organizational Systems**

Establish effective management systems within the society. Such systems should include computerization of their operations (the society is in the process of doing this), management capacity of the Central Management Committee and training needs of the technical staff, among others.

Research in this area should document the current systems and the basic minimum requirement to assist the society to embark on relevant developments.

**Acknowledgements**

The authors of this study acknowledge inputs and support from different individuals and groups. A number of groups are here identified for special mention. They include the rice farmers of Mwea, Thiba and Karaba, who without inhibition, narrated the story of the Mwea rice scheme and changes that have taken place during the last 40 years. The team also received support from the Management Committee of the Mwea Rice Growers’ Multipurpose Cooperative Society and the Mwea Irrigation Settlement Scheme team in the field. Both groups provided us with details on the history of the scheme and on the technical and operational sectors. A very relevant source of information comprised individual rice millers who took us round their mills and explained to us the changed environment and what it meant to the people of Mwea.

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Literature Cited


The Daily Nation. 2000. (14 October)


Health Impact Assessment of Increased Irrigation in the Tana River Basin, Kenya

Clifford M. Mutero

Summary of Health Impacts

I. Upper Tana

<table>
<thead>
<tr>
<th>Health Hazard</th>
<th>Community Risk Factors</th>
<th>Environmental Risk Factors</th>
<th>Institutional Risk Factors</th>
<th>Health Risk Associated with Increased Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>Important cause of morbidity among communities. Immune status low due to seasonal transmission.</td>
<td>Increase in potential mosquito breeding habitats expected with increase in irrigated agriculture. Increase in seasonal colonization of the breeding sites by mosquitoes. <em>Anopheles arabiensis</em> is the main vector of malaria and exploits varied habitats ranging in size from cattle hoof prints to rice fields.</td>
<td>Hospital facilities congested or difficult to access. No regular surveillance for malaria or its mosquito vectors. MOH and NGO-supported programs for insecticide-treated nets in some communities.</td>
<td>Increased malaria risk due to irrigation.</td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td>Exposure to parasites expected along edges of micro-dams or shallow wells among children having a swim and women doing laundry and fetching water.</td>
<td>Vector snails expected to rapidly colonize micro-dams including areas frequented for domestic purposes.</td>
<td>Curative. No surveillance and vector control at present.</td>
<td>Increased risk of infection with <em>S. mansoni</em>.</td>
</tr>
<tr>
<td>Human nutrition</td>
<td>An increase in farmers producing vegetables and fruits.</td>
<td>Local diet will improve if there is irrigated agriculture.</td>
<td>There will be a reduction in delivery of relief food by either the government or the NGOs.</td>
<td>Improved nutrition for Upper Tana communities.</td>
</tr>
<tr>
<td>Other hazards</td>
<td>Awareness of pesticides poor among communities.</td>
<td>Increased exposure to pesticides used in production of high-value crops.</td>
<td>Community health education programs inadequate.</td>
<td>Increased risk in agrochemical poisoning.</td>
</tr>
</tbody>
</table>

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II. Lower Tana

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<td>Leading cause of morbidity among communities in the Lower Tana area.</td>
<td>Increase in mosquito-breeding habitats expected in case of expanded irrigation. <em>Anopheles arabiensis</em> is an important vector of malaria along the Lower Tana area.</td>
<td>Hospital facilities congested or difficult to access. No regular surveillance for malaria or its mosquito vectors. MOH and NGO-supported programs for insecticide-treated nets in some communities.</td>
<td>Increased malaria risk.</td>
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<td>Schistosomiasis</td>
<td>Exposure to parasites expected in the increasing number of smallholder irrigation schemes.</td>
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<td>Curative. No surveillance and vector control at present. Management of two downstream irrigation schemes has collapsed.</td>
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<td>Increased risk in chronic and acute agrochemical poisoning.</td>
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**Introduction**

Agricultural policies, products and processes are major determinants of people’s health. More than two-thirds of the people in developing countries derive their livelihood from agriculture. Most working time is spent in agriculture, and most income on food. The health of most people is integrally linked with the agriculture sector, and agriculture dominates life in the rural areas (WHO 1986).

Agriculture involves transforming inputs, e.g., soils, solar radiation, rain, irrigation water, labor, agrochemicals and seeds through technologies and structures of work, into foods and other outputs. While agricultural policy makers may collaborate readily in the elimination of known, existing and clearly visible health risks that can slow agricultural growth, equal effort is often not directed at uncovering health risks implicit in existing and planned agricultural processes, which often negate the efforts of health and have negative feedback effects on agriculture.
Health and agricultural sectors need to work together to reinforce and support each other’s goals. At the local level, the two sectors should address themselves to the impact that agricultural processes have on the health of vulnerable groups in particular and the farming population as a whole. Both health and agriculture should concentrate on the equity-oriented components in agriculture. These tasks should be complemented by a clear definition of the contribution of the health sector to agriculture and of agriculture to the health sector.

In Kenya and many other African countries, only a small fraction of the irrigation potential has been developed (see Ngigi’s first paper). A considerable part of the area under irrigation is for rice production. The demand for rice on the continent is growing rapidly and the total area under its cultivation is likely to increase. Unfortunately, the flooding of agricultural land during rice cultivation has often resulted in increased health risks due to malaria and other vector and water-borne diseases (Lacey and Lacey 1990). In Kenya, research in an irrigated area has, for instance, shown a 70-fold increase in the number of malaria vectors biting people, compared to nearby nonirrigated areas (Surtees 1970). Species succession and peaks in vector densities related to the rice cultivation cycle are well-described phenomena.

**Objective**

This report presents a prospective health impact assessment (HIA) of increased smallholder irrigation in Kenya. The purpose of the assessment is to identify opportunities for improvement of human health and enhancement of household incomes through better agro-ecosystem management. Thus, an HIA provides the means by which inter-sectoral collaboration can be facilitated for the incorporation of health safeguards and mitigation of health impacts for water resources projects and other types of development (Bolton et al.1990; Birley 1995).

**Methodology**

The approach used in the present HIA was mainly qualitative, using secondary information from both published reports and key informants. A social-environmental model of health was used where the health, environmental and social impacts were interlinked. In this regard, reports and other materials compiled during the previous environmental assessment (EA) projects of the Tana river were found to be particularly useful in the absence of site visits. The latter were not feasible within the limited duration of the HIA, more so in view of a general lack of security in most of the study area.

The procedure for HIA consisted of the following four main steps (Birley 1995; Birley et al. 1997):

- **Identification of stakeholder communities.** Stakeholder communities refer to the different populations in the project area, mainly grouped according to their occupation, geographic location or ethnicity in the present HIA.

- **Identification of health hazards.** According to the HIA procedure, a health hazard is a potential source of harm. Health hazards can be conveniently discussed under
the following five categories: communicable diseases; noncommunicable diseases; malnutrition; injury; and psychosocial disorders.

- **Health risk assessment.** Health risk is a measure of the likelihood of a potential hazard affecting a particular group of people at a particular time and place. For the present project, assessment was limited to an indication as to whether there would be an increase or decrease of health risks if there was a substantial increase in smallholder irrigation along the Tana river basin. Health risks associated with increased irrigation were assessed on the basis of the following considerations: population risk factors; environmental risk factors and institutional risk factors.

- **Recommendations for risk management and mitigation measures.** Safeguards and mitigating measures can reduce the negative health impacts and optimize health opportunities if planned for in advance or incorporated in the project design. They include environmental management measures and the provision of certain basic health services.

**Stakeholder Communities**

**Indigenous Rural Populations**

For purposes of the HIA, the stakeholder communities in the proposed project area were arbitrarily grouped into Upper Tana and Lower Tana areas on the basis of geographic location. The site for the proposed Grand Falls/Mutonga Hydro Power Project (figures 1 to 3) represented the dividing line between the Upper and Lower Tana areas. The Upper Tana area crosses three districts: Embu, Tharaka Nithi and Mwingi. The population comprises several ethnic groups, including Embu, Meru, Mbeere, Tharaka and Kamba (Ominde 1974). Communities in the Upper Tana area practice mixed farming. The staple food crops include maize and millet and the most common cash crops are cotton, millet and green gram. Livestock forms an important component of the farming systems.

The larger part of the Lower Tana administratively falls under the Tana river and Garissa districts, with the Tana river itself acting as the boundary between the two. Major groups of people in the area include the Somali, Boran, Pokomo and Orma. The Tana river district is mainly occupied by the largely Orma pastoralists and Pokomo recession farmers while the rural population of Garissa is almost entirely Somali pastoralists. According to the previous EA report (Acropolis 1995), both arable and pastoral farming systems have evolved to make use of, and depend on, the natural flooding pattern of the river. Among the main economic activities, the Pokomo practice flood-recession farming for their staple crops while the Orma have evolved a transhumance system that links dry-season grazing in the floodplains with wet-season grazing in the hinterland. Despite being nomadic, the Somali pastoralist system depends on the river for stock water for up to 6 months of the year.

In the past, a number of irrigation schemes have been established on the Tana river. Two of the previous projects, Bura and Hola irrigation schemes were large scale but both collapsed for different reasons (JICA and Nippon Koei 1995). In the case of Hola, the Tana river changed its course in 1989, leaving the main inlet at Laini pumping station dry. The
Figure 1. Health facilities generally available in the Upper Tana and Lower Tana areas.
Figure 2. Endemicity of malaria in Kenya (after MOH 1998).
Figure 3. Prevalence of schistosomiasis in Kenya (after Highton, 1974).
cessation of irrigation at Hola since 1989 has affected the performance of the scheme and its tenants who have been unable to do any cultivation. Farmers who were previously dependent on the scheme for their livelihood have since become destitute without the means to feed and clothe themselves and their children or pay their children’s educational fees. The supply of relief food is a common feature of the area.

The Bura Irrigation Settlement Project was an ambitious scheme started in 1977 to create, among other things, employment and to contribute to foreign exchange earnings through cash crops, e.g., cotton. The scheme has since collapsed due to a host of problems including the breakdown of machinery and general mismanagement. As early as 1979, the World Bank recommended abandonment of the project since it was no longer considered economically or financially viable. The original government target to settle more than 5,000 families in 23 villages to cultivate cotton and maize on 6,700 hectares of land (i.e., 1.3 ha per tenant farmer for cotton) was never achieved (JICA and Nippon Koei 1995). Currently at Bura, the settler communities and their families live in abject poverty, suffering drought and famine. The total population of about 20,000 is composed of former herdsmen or farmers who had migrated to Bura for the promise of irrigated land.

**Secondary Communities**

Many development projects draw poor and unemployed immigrants from a wide hinterland. As they become squatters in the project area, they are especially vulnerable to the diseases resulting from poor living conditions. They retain links with their original homes and may carry diseases back home with them to dependents who, in turn, become vulnerable. Women immigrants are particularly at risk of specific hazards, such as domestic violence, while both men and women are at risk of sexually transmitted diseases including the acquired immune deficiency syndrome (AIDS).

**Assessment of Health Risk**

**Common Health Hazards**

Prior to the advent of AIDS, the most comprehensive account of health hazards in Kenya was perhaps that compiled by Vogel et al. (1974). At the time of that publication, substantial documentation already existed in relation to medical and epidemiological research in Kenya. Specific health problems discussed by the publication included communicable diseases, e.g., malaria, filariasis, meningitis and schistosomiasis; noncommunicable diseases, e.g., diabetes, cancer, malnutrition; injury, e.g., due to traffic accidents; and mental-health disorders.

The seven most common endemic communicable diseases in the Upper Tana and Lower Tana areas are shown below (table 1) ranked according to their relative occurrence during the 1990s (MoH 1996; JICA and Nippon Koei 1995; Campbell and Hodgson 1997).
Table 1. The seven most common* endemic communicable diseases along the Tana river basin.

<table>
<thead>
<tr>
<th>Upper Tana</th>
<th>Lower Tana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>Malaria</td>
</tr>
<tr>
<td>Upper respiratory tract infections</td>
<td>Upper respiratory tract infections</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>Diarrhea</td>
</tr>
<tr>
<td>Eye infections</td>
<td>Intestinal worms</td>
</tr>
<tr>
<td>Intestinal worms</td>
<td>Urinary tract infections</td>
</tr>
<tr>
<td>Urinary tract infections</td>
<td>Gonorrhea</td>
</tr>
<tr>
<td>Others</td>
<td>Schistosomiasis</td>
</tr>
</tbody>
</table>

* Excluding AIDS.

Up to now, malaria has been the leading cause of morbidity and attendance at outpatient health facilities not only in the study area but generally in most of Kenya (MoH 1996). More than 5 million cases of malaria are reported in the country annually. However, despite malaria being also an important cause of inpatient admissions at various hospitals, it is of interest to note that according to unpublished reports, hospitalization due to malaria was surpassed by that due to AIDS in 1998. Both malaria and AIDS infections are present in the project area.

The two communicable diseases likely to be most impacted on by an increase in smallholder irrigation are malaria and schistosomiasis. The following risk assessment places emphasis on those two hazards in addition to malnutrition and agrochemical poisoning.

**Health Services**

Operations under the Ministry of Health (MoH) in Kenya can be conveniently discussed under two broad categories: a) curative services and b) preventative and promotional services (Snow et al. 1998; GoK 1991). In most cases, these services are provided on an integrated and comprehensive basis.

As regards curative services, each of about 41 districts in Kenya has a general hospital located at the district or provincial headquarters. The average number of beds in a district hospital is 200. Provinces have at least one general hospital with 500 beds on average. Services of specialists in different medical disciplines are available at the provincial hospitals.

At the local, community or village levels basic or primary health care is provided at clinics (static or mobile), health centers and dispensaries. Most of these facilities belong to the central government, local government authorities and NGOs.

Preventive and health promotional services are mainly catered for under several Divisions of MoH including the Division of Vector-Borne Diseases (DVBD) that, as part of the Division of Communicable Disease Control, works alongside other MoH Divisions, including the Division of Environmental Health, the Division of Health Education and the Health Information Systems Department. The stated objectives of the DVBD are to coordinate control of vectors of diseases in general, coordinate control of disease reservoirs, coordinate and participate in research activities related to vector-borne and parasitic diseases in general, evaluate pesticides and rodenticides for public-health use, and assist in teaching at various institutions of MoH.
Figure 1 shows the distribution of government and mission health facilities that serve the populations resident along the Tana river basin (GoK 1991; Snow et al. 1998). The highest concentration of facilities is in the more densely populated areas of central Kenya. Hospital facilities in Garissa and the Tana river districts are comparatively much fewer being only found in the Garissa town, Hola and near the delta at Garsen. The long distances that residents of the two districts must travel to the nearest hospital pose a major constraint to the timely provision of adequate health services for the majority of the population. Health services provided by the MoH in Garissa, Tana river and, to a lesser extent, in Embu and Tharaka Nithi are of necessity heavily supplemented by those from NGOs. Table 2 shows the main NGOs involved in malaria control and provision of other community-based health care services along the Tana river (Snow et al. 1998).

Table 2. Organizations involved in malaria control and provision of other community-based health care (CBHC) along the Tana river.

<table>
<thead>
<tr>
<th>Area</th>
<th>District</th>
<th>NGO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Tana</td>
<td>Embu</td>
<td>African Medical Research Foundation (AMREF)</td>
</tr>
<tr>
<td>Tharaka Nithi</td>
<td></td>
<td>Chogoria PCEA Mission Hospital</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Christian Children’s Fund (CCF)</td>
</tr>
<tr>
<td>Lower Tana</td>
<td>Garissa</td>
<td>Medicins Sans Frontierie (MSF), Belgium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Action Nord-Sud</td>
</tr>
<tr>
<td>Tana river</td>
<td></td>
<td>Catholic Relief Services (CRS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>World Vision</td>
</tr>
</tbody>
</table>

**Malaria**

**Review of disease**

Malaria is endemic along the Tana river from Embu all the way to the Indian Ocean (figure 2) (MoH 1998). According to a recent classification of malaria endemicity (Snow et al. 1998), the Upper Tana area is characterized by unstable endemicity in the relatively higher and cooler areas, and low stable endemicity on lower ground. The Lower Tana area has stable endemic malaria all the way to the Kenyan coast.

In areas of unstable malaria, clinical manifestations of the disease appear seasonally during periods of peak transmission and people of all age groups may suffer severe attacks. The disease in such areas is characterized by intermittent transmission, which may be annual, biannual or variably epidemic. Districts with unstable malaria along the Tana include Embu, Tharaka Nithi and Mwingi.

Areas of stable malaria have intense perennial transmission of *Plasmodium* parasites. Severe infections are most common in children in the first 5 years of life and in women during pregnancy. The mortality rate is highest in children under 5 years of age. Partial immunity develops in communities in areas of stable malaria due to recurrent exposure to the parasite.
leading to protection against severe disease in the majority of older children and adults. Districts with stable malaria within the proposed project area include the Tana river, Garissa and Lamu.

**Community risk factors**

*Upper Tana communities.* Generally, the local population has low immunity to malaria due to the unstable characteristics of the disease. Employment and various commercial activities generated by an increase in smallholder irrigation will attract both immune and nonimmune immigrants. The former group is likely to constitute an asymptomatic reservoir of *Plasmodium* parasites acquired during previous stays in areas of high endemicity.

*Lower Tana communities.* Communities in Bura, Hola and further downstream in the delta area have higher immunity to malaria than those in the Upper Tana area, due to a more extensive prior exposure to the disease. Any expansion of smallholder irrigation will lead to renewed immigration into the areas by both immune and nonimmune populations.

**Environmental risk factors**

Variation in climatic conditions has a profound effect on the life of a mosquito and on the development of malaria parasites (Bruce-Chwatt 1985); hence its influence on the transmission of the disease and on its seasonal incidence. The most important climatic factors are rainfall, temperature and humidity.

Rainfall exerts its influence on malaria transmission mainly through the creation of aquatic habitats that are suitable for vector breeding. The *Anopheles gambiae* species complex is the main vector of malaria in most of East Africa (Gillies and De Meillon 1968). The species complex is represented at the delta of the Tana river by a mixture of *An. gambiae s.str.* and *An. arabiensis* while the latter is the main or only species upstream in parts of Lower Tana and in all of the Upper Tana area (Mutero et al. 1999; Mutero and Birley 1987). Generally, both *An. gambiae s.str.* and *An. arabiensis* breed in a great variety of types of water, the most striking being open sunlit pools. The origin of such pools is varied and may range from hoofprints around ponds and water holes to pools resulting from the overflow of rivers, or those left behind by receding rivers. Human activity is implicit in many of these sites, especially during the reclamation of seasonal swamps for cultivation. In this connection, rice fields constitute a prolific source of *gambiae*, particularly *An. arabiensis* (Mutero et al. 1999). A flooded or partly flooded rice field presents many different types of water whose characteristics are often difficult to describe with precision. In general, rice fields are most productive of mosquitoes about 2–3 weeks after transplantation of rice seedlings. Later on, when the rice is fully grown, breeding is at a lower level and confined mainly to the margins of the fields.

As regards the influence of other climatic factors, malaria parasites cease to develop in the mosquito when the temperature is below 16 °C. The best conditions for the development of plasmodia in the *Anopheles* and the transmission of the infection are when the mean temperature is within a range of 20–30 °C, while the mean relative humidity is at least 60 percent. A high relative humidity lengthens the life of the mosquito and enables it to live long enough to transmit the infection to several persons.

*Upper Tana area.* Climatic conditions in districts serving as a catchment for the Grand Falls reservoir area vary from the modified tropical climate of the Kenya highlands to the tropical
continental/semidesert climate of eastern Kenya (Ojany and Ogendo 1988). The highland climate is characterized by high rainfall with the long rains occurring between March and May and the short rains between October and December. The continental/semi-arid zone is drier, receiving less than 500 mm of annual rainfall. The mean annual minimum temperature in the modified highland climate is 15–20 °C while the mean annual maximum temperature is 25–30 °C. Temperatures in the semi-arid zone are higher. The range of temperature and humidity conditions is conducive to the breeding of *Anopheles arabiensis*, the main vector of malaria in the area, especially in the Mwea rice irrigation scheme (Mutero and Birley 1987; Rupuoda 1995). The population of *An. arabiensis* is likely to expand with expansion of irrigated agriculture in the Upper Tana. The climatic conditions in the area also favor transmission of malaria parasites for most of the year.

*Lower Tana area.* Both the Tana river and the Garissa districts have a mean annual minimum temperature of more than 25 °C and a mean annual maximum temperature higher than 30 °C. Malaria levels along the Tana river flood plain are among the highest in the country (figure 2). Even so, the prevalence of *P. falciparum* at Hola was 54 percent more than in the nonirrigated surrounding area (JICA and Nippon Koei 1995). A severe outbreak of cerebral malaria that caused serious child mortality in 1981–82, leading to increased desertion of the scheme, is indicative of the seriousness of the problem. Irrigation schemes introduced in areas of high-malaria endemicity have generally led to an expansion of the malaria-vector populations that, in turn, has led to an escalation of the malaria problem (Service 1984; Renshaw et al. 1998). For instance, irrigation in the Kano plain of western Kenya led to a 70-fold increase in the main malaria mosquito while both the Mwea and Hola/Bura irrigation schemes switched to perennial rather than to seasonal malaria transmission.

Despite the collapse of the Hola and Bura irrigation systems, the number of smallholder irrigation projects has increased (JICA and Nippon Koei 1994). This development is, to a large extent, attributable to the reduction of available pasture by the limitation of annual floods, resulting from the existence of several large dams upstream. The area upstream of Garissa is, for instance, host to a large number of displaced and refugee Somali and other pastoralists, some of whom have taken up irrigated farming. In the Ngao area towards the delta, farmers now utilize floodplain land formally providing dry-season pasture for a combination of rain-fed and small-scale irrigated farming. A considerable number of oxbow lakes previously surrounded by seasonal wetlands are now under crops.

In terms of vector populations and associated malaria transmission, smallholder irrigation systems can be just as notorious as the bigger schemes if water drainage is not properly managed. Even in the large rice irrigation schemes, mosquito breeding is most prolific among the many small pools that are created by footprints during rice transplanting. Assuming that the trend in smallholder irrigation is likely to grow, especially if there were more regular floods in the Tana, the vector-breeding habitat is also likely to expand, leading to a worsening of the current malarial situation.
Institutional risk factors

Both the MoH and NGOs operating in the Upper and Lower Tana areas are involved in the promotion of insecticide-impregnated bed nets for protection against mosquito bites and malaria. Community-based structures are mainly used to initiate grassroots organizations of full-cost recovery bed-net programs. Unfortunately, the failure rate of many such community programs is high mainly because the communities cannot afford either the nets or the chemicals with which they are treated. The MoH’s Division of Vector-Borne Diseases (DVBD), despite having stations at each of the sites with hospital facilities, is, to a large extent, inactive due to lack of funds for operations and vehicles. A further confounding factor for malaria is the now widespread resistance of malaria parasites to the commonly available curative drug, chloroquine. The cost of alternative drugs, e.g., Fansidar, is beyond the reach of most families.

Conclusion

An assessment based on community, environmental and institutional risk factors suggests that there will be an increase in the risk of malaria among communities living in both the Upper and the Lower Tana areas in the event of an expansion in smallholder irrigation for rice and other crops. The creation of mosquito-breeding habitats due to small-scale irrigation activities in the Upper Tana area will lead to an increase in malaria vector populations. Immigrants from malarious areas will provide a parasite reservoir that could result in malaria transmission taking place for most of the year. The vector habitat will similarly expand in the downstream area due to human activity, particularly related to trans-humanance and enhanced smallholder irrigation.

Schistosomiasis

Review of disease

The term schistosomiasis describes the pathological condition resulting from infection by flukes of the genus Schistosoma. Two species of the genus occur in Africa, namely S. haematobium and S. mansoni. Clinical signs for the two infections are blood in urine and blood in stools, respectively. S. haematobium has the highest prevalence along the Kenyan coast and in the downstream areas of the proposed Grand Falls/Mutonga project (Highton 1974) (figure 3). In 1956, when the irrigation scheme at Hola began, there were no snail vectors present on the scheme, owing to elevation of the scheme above the river and the absence of a suitable habitat for them (JICA and Nippon Koei 1995). A decade later, the prevalence of urinary schistosomiasis among Pokomo schoolchildren was 70 percent, rising by 1982 to 90 percent in Pokomo and Orma. The snail vectors for this disease in Hola and Bura areas include Bulinus nasutus.

S. mansoni, on the other hand, is absent from the coastal belt but is common in the more central areas of Kenya around Nairobi and the Upper Tana area. During the mid-1950s, an examination of 1,000 members of the indigenous population of the Embu/Kirinyaga areas failed to detect a single case of S. mansoni or S. haematobium (Highton 1974). A few years after the establishment of the Mwea rice irrigation scheme, surveys revealed a rapid increase in the prevalence of S. mansoni with up to 60 percent of schoolchildren having infections. The intermediate snail hosts for S. mansoni belong to the genus Biomphalaria, which has a wide
distribution in Kenya. However, *Biomphalaria* has not been reported from the coastal plain and its absence is substantiated by the lack of *S. mansoni* in the area.

**Community risk factors**

*Upper Tana area.* In this area, communities come into contact with infected water in the course of their routine activities e.g., washing, fishing and swimming. Immigrant workers, fisherfolk, farmers from nearby infected areas and hawkers of petty domestic merchandise can introduce the disease in their urine and excreta. It is likely that enhanced irrigation activities combined with washing and recreation on the edges of micro-dams would result in a rapid increase in the number of people infected with schistosomiasis. As discussed elsewhere in this report, a similar phenomenon has previously occurred at the Mwea rice irrigation scheme and downstream at Bura. Both these areas started with a relatively infection-free population.

*Lower Tana area.* Increased expansion of smallholder irrigation will lead to renewed immigration into various downstream sites by farm workers and petty business people. Some pastoralists will also convert to a more sedentary life, which will bring them into more frequent contact with water for irrigation. An established human reservoir of schistosomiasis infection already exists in the local population and will spread to more people.

**Environmental risk factors**

*Upper Tana area.* Development of water utilization projects for hydropower and irrigation schemes has, during the last few decades, provided ideal habitats for vector snails of intestinal schistosomiasis in the Tana river basin upstream of the proposed Grand Falls/Mutonga project. *S. mansoni* is, therefore, present in Upper Tana areas. In one of the main foci of *S. mansoni*, namely the Mwea rice irrigation scheme, control of vector snails has, in the past, involved the application of molluscidicides to the snail habitats, and proper maintenance of canals. Currently, the management of the irrigation scheme is in transition from the centrally managed structure of the government-owned National Irrigation Board (NIB), to community-run grassroots organizations. A decline in previous standards of snail control could lead to an increase in the snail populations in the scheme and, in turn, to an increased risk of their being washed downstream to other areas of the Tana river basin.

*Lower Tana area.* Snail vectors of urinary schistosomiasis are well established in Bura and Hola irrigation schemes (JICA and Nippon Koei 1995). They include *Bulinus globosus* and *B. nasutus*. The snails breed in poorly maintained irrigation channels. The collapsed state of both Bura and Hola schemes is potentially conducive to large increases in vector snail populations in the event of renewed irrigation activities. Snail populations flushed down from these areas by regular floods could easily end up as an addition to local colonies in the more recently established smallholder irrigation schemes further downstream.

**Institutional risk factors**

Both the Upper Tana and Lower Tana areas where schistosomiasis is a major health hazard have access to facilities that could play a role in schistosomiasis control, including hospitals and laboratories of the DVBD. The preventive role of the DVBD would be the most effective approach in the control of schistosomiasis compared to the curative approach of many hospitals
(Verhoef 1996). Unfortunately, operations of the DVBD are often hampered by lack of facilities and vehicles, and the fact that members of the staff are normally idle and demoralized.

**Conclusion**

The assessment concludes that there will be an increase in intestinal schistosomiasis in the Upper Tana and Lower Tana areas in case of increased irrigation activities.

**Human Nutrition**

**Review of disease**

Protein calorie malnutrition (PCM) is, in Kenya, one of the main public-health problems as it is in most tropical countries with a predominantly rural population (Blankhart 1974). The major types of PCM in Kenya are kwashiorkor and marasmus. Kwashiorkor refers to the disease of the child weaned too early on a low protein staple diet, usually maize. Kwashiorkor is caused by an unbalanced food intake with relative excess of carbohydrates and lack of proteins. Predisposing factors for kwashiorkor include infections such as measles, tuberculosis and enteritis. Marasmus, on the other hand, is due to a total lack of food, proteins as well as calories. It may affect the infant in its first 9 months of life if breast-feeding is inadequate. It occurs in older children when there is disease or shortage of food. However, to a large extent, it seems to be associated with unhygienic bottle-feeding often resulting in diarrhea.

**Community risk factors**

Famine is a perennial problem in some of the districts in both the reservoir and downstream areas including Mwingi, Garissa and Tana river district. Famine relief has been a feature of the Tana river district since the collapse of the Hola and Bura irrigation schemes about a decade ago (JICA and Nippon Koei 1995). Both marasmus and kwashiorkor are prevalent in the downstream districts. A survey conducted in the 1980s showed that 52 percent of the children in the Bura division were malnourished. Despite comparatively higher levels of nutrition in the reservoir area, the situation could change for the worse during resettlement of displaced communities.

**Environmental risk factors**

Part of the reservoir and all of the two main downstream districts are semiarid and prone to frequent severe droughts. The droughts seriously affect crop yields and animal communities. There is also a general lack of security, particularly in the Tana river and Garissa districts where bandit attacks are common.

**Institutional risk factors**

In the past, the Government of Kenya supplied relief food to the Tana river district, with assistance from the World Food Programme, CARE and Catholic Relief Services. A lack of adequate government resources combined with insecurity in the downstream area poses a big problem to the effective distribution of relief food.
Conclusion

The assessment concludes that increased irrigation will improve food production systems along the length of the Tana river basin and, in turn, maintain good nutrition among the resident communities.

Other Hazards

Review of disease

Other hazards associated with irrigation might include injury from irrigation equipment and agrochemical poisoning.

Community risk factors

An increase in irrigated crop production would result in increased movement of both secondary and primary communities in the Upper and Lower Tana areas. This movement would be mainly related to transportation of produce to various markets including Nairobi. The Kenyan public-transport system is prone to high accident rates and it is likely that many people will get involved in vehicle accidents.

Environmental risk factors

Expansion of irrigated agricultural production, particularly for vegetables, e.g., tomato, kale, etc., will lead to increased use of pesticides and, consequently, risk of death from accidental poisoning or when pesticides are used to commit suicide. In the Lower Tana area, agrochemical poisoning could be confounded by the washing down from the Upper Tana of additional persistent organic pollutants, e.g., organochlorine pesticides.

Institutional risk factors

Hospital facilities in both the Upper and Lower Tana areas are, like in many other places in Kenya, inadequate under the best of times. Any increases in the local population due to an influx of people into an area with expanded irrigation activities will lead to a further deterioration in the currently available health care, unless provision for additional services is made. As regards vehicle accidents, the prevailing poor road maintenance combined with unchecked corruption in the ranks of traffic police officers have all contributed to the existing poor road-safety record for Kenya.

Conclusion

The assessment concludes that there will be an increased risk of road accidents and other forms of injury in the event of a significant expansion in irrigated agriculture. Stress-related problems are also likely to be experienced among Lower Tana communities during months of water scarcity. The communities already blame upstream activities, e.g., the damming of the Tana for the disappearance of the regular annual floods and the subsequent economic deterioration of their areas (AIC 1995). By extension of this line of reasoning, expanded irrigation in the upper Tana area is likely to be blamed for downstream water shortages and is a potential source of conflict between the downstream and upstream communities.
Risk Management and Mitigation Measures

In selecting mitigation measures for a development project, higher priority should be given to interventions with a positive impact on the general health status than to disease-specific interventions (Konradse et al. 1997; Verhoef 1996). In the case of expansion in irrigation activities, general poverty is obviously among the more serious fundamental problems facing the stakeholder communities. Thus, a strengthening of production and marketing systems aimed at economic empowerment would rank high among measures for health improvement and the general well-being of the communities.

For malaria and schistosomiasis, a community-based health education program for promoting awareness about the diseases and available control options should be implemented at the start of expansion of irrigation activities in a given area. In the case of malaria, screening the eaves and windows of houses with mosquito-proof mesh wire could be a cost-effective method of reducing mosquito-person contact. Both the government and the NGOs should support communities in setting up sustainable systems for provision of insecticide-treated mosquito nets and antimalarial drugs. These measures are especially important if increased mortality is to be avoided among the high-risk groups including pregnant women, and children under 5 years. As regards schistosomiasis, swimming by children in infected water is considered to be the most important factor continuing or increasing disease transmission (Renshaw et al. 1998). It would be of benefit if villages along the Tana river were provided with snail-free bathing areas. These should be centrally sited, concrete-lined and protected from snail colonization. Latrine provision is also an essential element in the control of schistosomiasis. Therefore, there is a need for the promotion of improved and long-lasting latrines.

Conclusion

The present HIA shows that an increase in irrigation along the Tana river basin will enhance agricultural production systems and contribute to improved human nutrition and well-being among downstream communities. However, there will also be an increase in the risk of a number of communicable diseases including malaria and schistosomiasis. Safeguards against the negative impacts should be incorporated at the earliest opportunity to maximize their effectiveness.
Literature Cited


Integrated Pest Management (IPM) Issues in Irrigated Agriculture: Current Initiatives and Future Needs to Promote IPM Adoption by Smallholder Farmers in Eastern Africa

S. Sithanantham, A. A. Seif, J. Ssennyonga, C. Matoka and C. Mutero

Abstract

Irrigated agriculture is characterized by intensive land use and substantial use of external inputs. Intensive and year-round production of crops, particularly vegetables, under irrigation induces the continuous presence (and buildup) of pests and diseases, which often reach epidemic proportions. Growers, who are mostly smallholders, are prompted to increasingly depend on pesticides to protect their crops. This trend, if not corrected, will lead to environmental pollution, buildup of resistance in pests and diseases, destruction of beneficial arthropods, buildup of hitherto minor pests and unacceptable levels of pesticide residues in vegetable produce. Although pests and diseases are reckoned as major constraints to production of irrigated crops in Eastern Africa, there is a lack of quantitative data on the production losses they cause.

Against this background, this paper discusses the need and scope for promoting Integrated Pest Management (IPM) as a strategy for sustainable protection and production of irrigated crops. While the sustainability of irrigated agro-ecosystems is the base for developing strategies for sustainable irrigated crop production by smallholder farmers, available relevant research information within the region is scanty. The importance of multidisciplinary and collaborative research for evolving ecologically friendly pest management and related cropping practices in irrigated agro-ecosystems is highlighted in a case study of the Mwea rice irrigation scheme in Kirinyaga, Kenya. Also addressed in detail are IPM sectors for smallholders in irrigated agriculture: needs, training, adoption, examples of IPM measures for vegetables, and initiatives in the region. The experience gained from the joint initiative of the ongoing International Centre of Insect Physiology and Ecology (ICIPE) with national partners for the development of suitable models for IPM awareness-building among the farmers could be utilized for expanding the impact of IPM in irrigated agriculture. The potential for IPM as a useful component of regional initiatives is illustrated. The major theme areas suggested for a future IPM focus include a) choice of irrigation methods and regimes that favor cost-effective pest management, b) the choice of environmentally friendly pest and crop management options that favor the conservation of beneficial fauna and flora in the agro-ecosystem, and c) harmonizing policy and community issues with IPM awareness for catering to improvement in the farming systems and community health.

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Pests and IPM Issues in Irrigated Agriculture

Potential Role of Irrigation in Pest Problems

Intensive use of land and greater investment in external inputs are visualized as the major thrust in enhancing the profitability in irrigated agriculture. With improved access to irrigation, smallholder farmers tend to grow crops almost year-round, as a means of enhanced income generation. Such an overlap in crops enhances pests to continuously multiply, resulting in their greater severity. As a consequence, farmers either incur greater production losses or need to spend more for achieving adequate levels of pest control. Increased risks of crop losses or additional control costs should be taken into account in planning irrigated cropping systems.

Relative Importance of Common Pest Problems on Major Irrigated Crops

It is known that the common irrigated cropping systems, such as rice and vegetables, are prone to attack by a wide range of pests and diseases in Eastern Africa (table 1). Important pests include those living below the soil surface (e.g., termites, cutworms), foliage feeders (e.g., beetles, caterpillars), miners/borers (e.g., fruit borers, stem miners, leaf miners) and sucking pests (e.g., aphids, thrips, white flies, spider mites and bugs). Diseases of importance on these crops range from soil-borne pathogens (damping off, foot rot, wilts) to leaf diseases (blast, blight, rust) and those causing rotting of vegetative parts (stem rot, sheath rot) and reproductive parts (e.g., black rot, fruit rot). Nematodes often constitute an important biotic constraint to irrigated crop production.

Quantitative data on the extent of production losses caused by pests and diseases on these irrigated crops in Eastern Africa are scanty. However, a reasonable guesstimate of the commonly experienced losses in these crops due to pests and disease in the region would be 10 to 40 percent. It is important to assemble baseline information on the relative economic importance of the commonly occurring pests and diseases in the representative production ecologies of the region. Such information can be utilized in prioritizing the regional pest problems and in developing relevant options for their management.

IPM and Crosscutting Issues for Sustainability of Irrigated Agriculture

IPM is an approach that seeks to minimize and rationalize the use of chemical pesticides as well as promote the use of safer alternatives to pesticides (e.g., biocontrol, cultural practices). The goal for IPM is agro-ecosystem sustainability through the adoption of appropriate strategies that contribute to conservation of the biodiversity and activity of beneficial organisms in the farming system. Since intensive cultivation of crops is a feature of irrigated agriculture and external inputs often figure prominently in these cropping systems, IPM becomes more a need than an option in such systems. IPM seeks to ensure that we do not “destroy” the “beneficial insects” (e.g., predators, parasitoids), or “neglect” their role while adopting pest-control methods since they are “friends of the farmer” and help keep the pest populations under check. The extent to which IPM is appreciated/adopted by farmers will also influence the reduction in pesticide use (or misuse) in the ecosystem.
Table 1. List of common pest-disease problems on irrigated rice and vegetables in Kenya.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Pest/Disease</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Relative Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>Pest</td>
<td>Stem borer</td>
<td>Chilo partellus</td>
<td>**</td>
</tr>
<tr>
<td>-do-</td>
<td>Leaf hoppers</td>
<td>Cicadella spectra</td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>-do-</td>
<td>Case worm</td>
<td>Nymphula depunctalis</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>-do-</td>
<td>Stalk-eyed fly</td>
<td>Diopsis thoracica</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>Disease</td>
<td>Blast</td>
<td>Pyricularia oryzae</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>-do-</td>
<td>Sheath blight</td>
<td>Rhizoctonia solani</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>-do-</td>
<td>Sheath rot</td>
<td>Acrocynlindrium oryzae</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>-do-</td>
<td>Brown spot</td>
<td>Helminthosporium oryzae</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>-do-</td>
<td>Stem rot</td>
<td>H. sigmoideum</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>Onion</td>
<td>Pest</td>
<td>Thrips</td>
<td>Thrips tabaci</td>
<td>***</td>
</tr>
<tr>
<td>Tomato</td>
<td>-do-</td>
<td>Leaf miner</td>
<td>Liriomyza sp.</td>
<td>**</td>
</tr>
<tr>
<td>Tomato</td>
<td>-do-</td>
<td>African bollworm</td>
<td>Helicoverpa armigera</td>
<td>*</td>
</tr>
<tr>
<td>Tomato</td>
<td>-do-</td>
<td>Whitefly</td>
<td>Bemisia tabaci</td>
<td>*</td>
</tr>
<tr>
<td>Tomato</td>
<td>-do-</td>
<td>Spider mite</td>
<td>Tetranychus spp.</td>
<td>**</td>
</tr>
<tr>
<td>Cabbage/Kale</td>
<td>-do-</td>
<td>Diamondback Moth (DBM)</td>
<td>Plutella xylostella</td>
<td>***</td>
</tr>
<tr>
<td>Cabbage</td>
<td>-do-</td>
<td>Cabbage aphid</td>
<td>Brevicoryne brassicae</td>
<td>*</td>
</tr>
<tr>
<td>Tomato</td>
<td>Disease</td>
<td>Bacterial wilt</td>
<td>Ralstonia solanacearum</td>
<td>***</td>
</tr>
<tr>
<td>Tomato</td>
<td>-do-</td>
<td>Root-knot Nematodes</td>
<td>Meloidogyne spp.</td>
<td>***</td>
</tr>
<tr>
<td>Tomato</td>
<td>-do-</td>
<td>Early blight</td>
<td>Alternaria solani</td>
<td>*</td>
</tr>
<tr>
<td>Onion</td>
<td>-do-</td>
<td>Purple blotch</td>
<td>A. porri</td>
<td>**</td>
</tr>
<tr>
<td>Onion</td>
<td>-do-</td>
<td>Rust</td>
<td>Puccinia porri</td>
<td>*</td>
</tr>
<tr>
<td>Onion</td>
<td>-do-</td>
<td>Basal rot</td>
<td>Fusarium oxysporium f. sp. cepae</td>
<td>*</td>
</tr>
<tr>
<td>Cabbage/Kale</td>
<td>-do-</td>
<td>Black rot</td>
<td>Xanthomonas campestris pv. campestris</td>
<td>***</td>
</tr>
</tbody>
</table>

Note: *** = very important; **= important; * = less important.

**Interaction of Irrigation with Agro-Ecosystem Sustainability**

An important area of study is the effect of irrigation methods and the intensity/frequency of watering on the severity of pests/diseases. Drip irrigation is thought to be more desirable, as the risk of spread of soil-borne problem (e.g., nematodes, and wilts) is apparently less than with furrow and other forms of irrigation. Sprinkler irrigation may result in washing down of some pests (e.g., aphids, spider mites, thrips), but may enhance risks of some foliar diseases (due to leaf surface wetness favoring the germination of spores). Flooding (keeping water inundated) is known to suppress some soil pests (e.g., white grubs) and diseases (e.g., Fusarium wilt of tomato). Although there is no published information available in the region, the knowledge available elsewhere (table 2) could be useful in planning suitable adaptive research/verification trials.
Table 2. Examples of known effects of irrigation (methods and regimes) on pest/disease severity in crops from elsewhere.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Target Pest/Disease</th>
<th>Irrigation/ Treatment Studied</th>
<th>Country</th>
<th>Type of Effect Observed (+ = positive effect, - = negative effect, 0 = no effect)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple (Malus domestica; M. pumila)</td>
<td>Codling moth (Cydia pomonella)</td>
<td>Overhead watering</td>
<td>USA</td>
<td>Irrigation (+)</td>
<td>Knight 1998</td>
</tr>
<tr>
<td>Corn (Zea mays)</td>
<td>Corn earworm (Helicoverpa zea)</td>
<td>Furrow irrigation</td>
<td>USA</td>
<td>Larval parasitism by nematodes (+)</td>
<td>Cabanillas and Raulston 1996</td>
</tr>
<tr>
<td>Cotton (Gossypium hirsutum; G barbadense)</td>
<td>Whitefly (Bemisia tabaci)</td>
<td>Biweekly and weekly irrigation</td>
<td>USA</td>
<td>Weekly better than biweekly (+)</td>
<td>Flint et al. 1996</td>
</tr>
<tr>
<td>Groundnut (A. hypogaea)</td>
<td>Stem rot of peanut (Sclerotium rolfsii)</td>
<td>Irrigation</td>
<td>USA</td>
<td>Irrigation (-)</td>
<td>Davis et al. 1996</td>
</tr>
<tr>
<td>Potato (S. tuberosum)</td>
<td>Colorado potato beetle (Leptinotarsa decemlineata)</td>
<td>Leaf mulch and trickle irrigation</td>
<td>USA</td>
<td>Both treatments (+)</td>
<td>Stoner 1993</td>
</tr>
<tr>
<td>Rye grass (Lolium perenne)</td>
<td>Brown patch (Rhizoctonia solani), dollar spot (Sclerotinia homoeocarpa)</td>
<td>Daily irrigation and irrigation based on atmometer estimated ET</td>
<td>USA</td>
<td>Irrigation (-) for brown patch (-) for dollar spot</td>
<td>Jiang et al. 1998</td>
</tr>
<tr>
<td>Soybean (Glycine max)</td>
<td>Soybean looper (Trichophila sp.)</td>
<td>Irrigation</td>
<td>USA</td>
<td>Irrigation (0)</td>
<td>Lambert and Heatherly 1995</td>
</tr>
<tr>
<td>Tomato (Lycoopersicum Esculentum), Eggplant (Solanum melangena)</td>
<td>Thrips (Frankliniella occidentalis) and Aphids (Myzus persicae)</td>
<td>Ebb-and-flow irrigation</td>
<td>USA</td>
<td>Irrigation (-)</td>
<td>Latimer and Oetting 1994</td>
</tr>
<tr>
<td>Barley (Hordeum vulgare)</td>
<td>Termites (Termitidae)</td>
<td>Irrigating once or twice</td>
<td>India</td>
<td>Irrigation (+)</td>
<td>Bhanot and Verma 1990</td>
</tr>
<tr>
<td>Cabbage (Brassica oleracea var. capitata)</td>
<td>Diamond back moth (Plutella xylostella)</td>
<td>Sprinkler irrigation applied 5 minutes at dusk on alternate days over the first 3-4 weeks and everyday afterwards</td>
<td>Taiwan</td>
<td>Irrigation =</td>
<td>Talekar et al. 1986</td>
</tr>
<tr>
<td>Cucumber (Cucumis melo)</td>
<td>Thrips (Thrips tabaci)</td>
<td>Sprinkler irrigation and drip irrigation</td>
<td>Switzerland</td>
<td>Sprinkler was preferable for reducing the number of thrips</td>
<td>Bieri et al. 1989</td>
</tr>
<tr>
<td>Cucumber (C. melo)</td>
<td>Downy mildew (Pseudoperonospora cubenensis)</td>
<td>Drip irrigation every 3-4 days</td>
<td>Belgium</td>
<td>Irrigation (-)</td>
<td>Milevoj and Osvald 1994</td>
</tr>
<tr>
<td>Faba bean (Vicia faba)</td>
<td>Aphids (Aphis fabae and Erynia neaphidis)</td>
<td>Irrigation</td>
<td>UK</td>
<td>Irrigation (+)</td>
<td>Wilding et al. 1986</td>
</tr>
<tr>
<td>Groundnut (Arachis hypogaea)</td>
<td>Leafminer (Aproaerema modicella)</td>
<td>Increased level of irrigation</td>
<td>India</td>
<td>Increased level of irrigation (-)</td>
<td>Kasneniwar and Desinpande 1991</td>
</tr>
<tr>
<td>Groundnut (A. hypogaea)</td>
<td>Leafminer (A. modicella)</td>
<td>Overhead irrigation</td>
<td>India</td>
<td>Irrigation intensity (+)</td>
<td>Wheatley et al. 1989</td>
</tr>
<tr>
<td>Crop</td>
<td>Target Pest/Disease</td>
<td>Irrigation/ Treatment Studied</td>
<td>Country</td>
<td>Type of Effect Observed († = positive effect • = negative effect 0 = no effect)</td>
<td>Reference</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------</td>
<td>--------------------------------</td>
<td>---------</td>
<td>---------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Lentil (Lens culinaris)</td>
<td>Ascochyta blight</td>
<td>Irrigation</td>
<td>New Zealand</td>
<td>Irrigation (-)</td>
<td>Knight et al. 1989</td>
</tr>
<tr>
<td></td>
<td>(Ascochyta fabae)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lucerne (Trifolium alexandrianaum)</td>
<td>Leaf caterpillar</td>
<td>Flood irrigation</td>
<td>Arabia</td>
<td>Irrigation (+)</td>
<td>El-Sherif and Badr 1992</td>
</tr>
<tr>
<td></td>
<td>(Spodoptera littoralis)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peas (Pisum sativum)</td>
<td>Cutworms (Agrotis biconica and Mythimna separata)</td>
<td>Irrigation</td>
<td>India</td>
<td>Irrigation (+)</td>
<td>Prasad et al. 1987</td>
</tr>
<tr>
<td>Pepper (Capsicum annum)</td>
<td>Root rot of pepper (Phytophthora capsici)</td>
<td>Drip irrigation</td>
<td>Brazil</td>
<td>15 cm deep (+)</td>
<td>Café Filho and Duniway 1996</td>
</tr>
<tr>
<td>Potato (Solanum tuberosum)</td>
<td>(Tecia solaniwora and Pemamotyres vorax)</td>
<td>3 irrigation frequencies evaluated (5,6 and 8)</td>
<td>Venezuela</td>
<td>Irrigation at 6-day intervals (+)</td>
<td>Fernandez 1997</td>
</tr>
<tr>
<td>Rice (Oryza sativa)</td>
<td>Rice mealy bug (Brevensia rehi)</td>
<td>3 irrigation regimes compared: continuous ponding at a depth of 5 cm, irrigation to 5 cm of water at reproductive phase and irrigation to 5 cm each day after the disappearance of pond water</td>
<td>India</td>
<td>Continuous ponding at 5 cm (+)</td>
<td>Gropshan et al. 1987</td>
</tr>
<tr>
<td>Rice (O. sativa)</td>
<td>(Oryza matsumura)</td>
<td>Irrigation</td>
<td>China</td>
<td>Irrigation (+)</td>
<td>Yan et al. 1981</td>
</tr>
<tr>
<td>Sorghum (Sorghum vulgare)</td>
<td>Shootfly (Atherigona soccata)</td>
<td>Irrigation in post- rainy season</td>
<td>India</td>
<td>Irrigation (-)</td>
<td>Nwanze et al. 1996</td>
</tr>
<tr>
<td>Sugar beet (Beta vulgaris)</td>
<td>Root aphid (Pempligus fusciornia)</td>
<td>Intense irrigation</td>
<td>Belgium</td>
<td>Irrigation (+)</td>
<td>Ioannidis 1996</td>
</tr>
<tr>
<td>Sugar beet (B. vulgaris)</td>
<td>Caterpillars (Pemostya hyoscyami and Seropetalpeta ocellatella)</td>
<td>Irrigation</td>
<td>Egypt</td>
<td>Irrigation (+)</td>
<td>Mesbah et al. 1985</td>
</tr>
<tr>
<td>Sugarcane (Saccharum officinarum)</td>
<td>Stem borers (Chilo infuscattellus and Emmatocere depressella)</td>
<td>Timing irrigation at an interval of 10 days</td>
<td>India</td>
<td>10-day interval (+)</td>
<td>Mrig et al. 1995</td>
</tr>
<tr>
<td>Sugarcane (S. officinarum)</td>
<td>Stem borers (Scirophaga exemptis, C. infuscattellus)</td>
<td>Irrigation at an interval of 12-14 days and irrigation at a ratio equivalent to the soil water content</td>
<td>India</td>
<td>Both types of irrigation (-)</td>
<td>Singla and Dobra 1990</td>
</tr>
<tr>
<td>Sugarcane (S. officinarum)</td>
<td>Stalk borers (C. infuscattellus, Scale insects (Melanaspis glomerata) and Mealy bug (Sacchariucoccus sacchari)</td>
<td>Drip irrigation Traditional flood method</td>
<td>India</td>
<td>Increased irrigation intervals (+)</td>
<td>Parsana et al. 1994</td>
</tr>
<tr>
<td>Sunflower (Helianthus annus)</td>
<td>Severe Rutherford bug (Nysus vinitort)</td>
<td>Irrigation</td>
<td>Australia</td>
<td>Yield loss due to bugs (+)</td>
<td>Forrester and Saini 1982</td>
</tr>
</tbody>
</table>
IPM Linkages to Community and Environmental Concerns

The broad goal objective of IPM is the optimization of the entire crop/livestock system rather than maximization of returns. The definition of IPM, as the application of different pest-control tactics compatible so as to promote the health of crops, can be extended to cover the health of livestock, people or a combination of these, and in a manner that integrates the control tactics into local/or large human, agricultural and ecological systems on a sustainable basis. The realization of these objectives for IPM in irrigated agriculture in Africa will require two initiatives. The first is the development of reliable, practical and cost-effective tools, which farmers can use in pest and disease management. Simple but reliable guidelines need to be offered for pest monitoring such as those based on crop-development cycles in irrigated rice farming (Heong and Escalada 1997). The second task is to develop simple learning-by-doing tools to enable farmers to deal with the knowledge/management intensity of IPM. Successfully implemented approaches for farmers in integrated agriculture include farmers’ field schools (FFS) and farmer-to-farmer extension. These and other approaches should be available to the farmers in irrigated agriculture in East Africa.

Table 3. Examples of methodologies used in the study of nontarget effects of pest-control/irrigation practices adopted for cotton.

<table>
<thead>
<tr>
<th>Pest Control/ Irrigation Method</th>
<th>Target Pest Studied</th>
<th>Nontarget Group Studied</th>
<th>Method Adopted</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticide use</td>
<td>Helicoverpa armigera</td>
<td>Natural enemies</td>
<td>Predatory activity (secondary effects)</td>
<td>Hamburg and Guest 1997</td>
</tr>
<tr>
<td>Biological control using coccinellids</td>
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<td>–</td>
<td>Evaluation techniques (specificity assessment)</td>
<td>Obricky and Kring 1998</td>
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<td>Heliothis zea</td>
<td>Natural enemies</td>
<td>Enhancement of natural enemy effectiveness</td>
<td>Lewis and Nordlund 1985</td>
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<tr>
<td>Selective pesticides</td>
<td>–</td>
<td>Natural enemies</td>
<td>Nutritional restraints, endocrine events, physiological and behavioral strategies</td>
<td>Mullin and Croft 1985</td>
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<tr>
<td>Microbial insecticides</td>
<td>Various pests</td>
<td>Natural enemies</td>
<td>–</td>
<td>Falcon 1985</td>
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Understanding IPM Needs of Farmers

Aspects and Approaches to Understanding IPM Needs of Farmers

The task of understanding farmers’ IPM needs will entail understanding the end users’ production objectives, constraints, resources, and differing socioeconomic and agro-ecological situations.

Production objectives

Four major kinds of production objectives stand out as follows: a) food and food security, b) cash needs, c) health needs, and d) social needs (rituals, status, etc.). In sub-Saharan Africa, where external agencies tend to focus on irrigation in terms of food and food security, it is common that public policy and donors emphasize the production of cash crops to generate or save foreign exchange. This is the reason for cotton, sugarcane and rice to have dominated in irrigation projects. However, small-scale traditional irrigation systems focus on food production (Moris and Thom 1987). In recent years, small-scale farmers have undertaken horticultural production to earn cash income. As is shown elsewhere in this paper, crop protection programs in irrigated agriculture in general and pest and disease management in particular, focus on cash crops. Indeed, most discussions on IPM in irrigated agriculture in Africa are restricted to cotton, sugarcane and rice (Moris and Thom 1987). The new focus on smallholders will entail focus on IPM for cash and food crops under the region’s common irrigation systems.

Constraints

In the context of agriculture in eastern Africa, the most commonly identified constraints are: a) pests and diseases, b) poor soils, c) lack of planting materials, and d) socioeconomic bottlenecks (lack of labor capital, inputs, poor market and transportation infrastructure, weak extension, etc.). It is clearly recognized that pest/vector management should be considered only if crop or livestock losses due to the pest or the vector present significant production constraints relative to other factors that compete for investment (Kiss and Meerman 1991).

Resources

The most important resources include land, capital, labor, inputs, planting material and in the context of irrigation, water and engineering structures. Provision of these resources in irrigated agriculture is the single-most constraining factor in Africa. Montgomery’s (1983) comparative study rated the Mwia irrigation scheme in Kenya as the only example of a moderately successful irrigation scheme in Africa. To be able to keep up control, governments have appropriated to themselves the ownership of water resources and land under irrigation. Under these conditions farmers were, for the most part, tenants with insecure rights (Tiffen 1987). Pest control was, for the most part, carried out by the irrigation agencies using mostly chemical pesticides. Little has been done to integrate crop pest control into the management of vectors and vector-borne diseases. Furthermore, pest and disease control in traditional irrigation systems has not received attention from the private- and public-sector institutions. Part of the problem stems from the weak institutional bases and the lack of the critical mass of multidisciplinary human resources to develop policy, and plan and implement IPM in irrigated agriculture.
Differing socioeconomic and farming conditions

Farmers’ needs vary by socioeconomic strata, farming systems, culture, gender, mode of adaptation and other factors. Kiss and Meeran (1991) identify three broad classes of farmers and associated kinds of IPM needs in Africa: For subsistence farming, IPM should aim at increasing the level and reliability of production. For intensive farming relying on high levels of external inputs, IPM should seek to reduce costs, ecological disruptions and health hazards. For farmers in transitional systems (between subsistence and intensive-farming systems) IPM should aim at promoting yield increases without overusing pesticides. Farmers using chemical pesticides and other high external inputs intensely are often the first to turn to IPM strategies, since the approach offers economic incentives.

Farmers in indigenous irrigation systems approximate subsistence farmers while farmers engaged in irrigated horticulture may well fit the label “transitional.” Irrigated large-scale public agriculture, though not necessarily the tenant farmers in it, fit the conditions of intensive-farming systems. As indicated earlier, the pest/disease-management practices of farmers practicing indigenous irrigated agriculture (crop rotation, fallowing, use of resistant cultivars, bush burning, etc.) are the least known. The IPM needs of women and pastoralists under public-funded, medium- and large-scale irrigated systems seem to pose difficult challenges.

A clear understanding of the end users’ production systems, objectives, constraints, resources bases, and varying socioeconomic and farming systems described above will, therefore, be useful in visualizing the focus and adoption of IPM.

Understanding the IPM Needs of Smallholder Farmers in the Region

Assessing the IPM needs of smallholder farmers in irrigation-project areas can provide a basis for appropriate training and information-dissemination initiatives. As an illustration, the results from a recent four-country baseline survey (of about 60 vegetable farmers per country) in Kenya, Ethiopia, Uganda and Tanzania jointly undertaken by ICIPE and national partners is described in this section.

Farmers’ awareness of names of pests/diseases on vegetable crops

The survey results pointed out that there is a great gap in the farmers’ awareness of the pest problems in vegetable crops, more so among the crops grown for export. In general, it was observed that except for tomato, the majority of farmers in all the countries were not aware of even the name of any one pest occurring on seven other income-generating vegetable crops grown in the region for urban/export markets. The assessment of farmers’ awareness of the names of insect pests infesting the main crops in the four countries (table 4) indicated that there was considerable variation in the awareness of pest names between the farmers in the four countries. For instance, the proportion of farmers recognizing any insect pest by name was greater among the more commonly grown vegetables like tomato, cabbage and onion than among those grown for export such as French bean, okra, brinjal, capsicum and cucumber. Among the individual crops, the number of farmers who knew the names of pests on tomato by name were the highest in all the countries, while the overall proportion of farmers who knew the names of pests on okra was the least.
Table 4. Percent of farmers aware of names of pests in major vegetable crops, survey in four countries in eastern Africa, 1998-99.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Kenya (n=60)</th>
<th>Uganda (n=60)</th>
<th>Tanzania (n=40)</th>
<th>Ethiopia (n=30)</th>
<th>Overall (n=200)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>77</td>
<td>40</td>
<td>87</td>
<td>83</td>
<td>72</td>
</tr>
<tr>
<td>Cabbage</td>
<td>22</td>
<td>22</td>
<td>23</td>
<td>48</td>
<td>29</td>
</tr>
<tr>
<td>Onion</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>48</td>
<td>17</td>
</tr>
<tr>
<td>Capsicum/Chili</td>
<td>7</td>
<td>31</td>
<td>31</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>French bean</td>
<td>31</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Okra</td>
<td>0</td>
<td>7</td>
<td>13</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Brinjal/Egg plant</td>
<td>12</td>
<td>18</td>
<td>15</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Cucumber/Karela</td>
<td>13</td>
<td>2</td>
<td>33</td>
<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>

Source: ICIPE-IFAD-USAID-NARS IPM network project.

Farmers’ sources of advice/information on pesticide use

The survey also indicated that the predominant sources of advice/information to the farmers on pesticide use were agro-input shops or local pesticide stockists and, to some extent, their neighboring farmers. Some farmers depended on information from labels or technical handouts. By contrast, only a smaller proportion of farmers received advice from professional extensionists. Evidently, many farmers do not have adequate access to dependable and precise advice on choice of pesticides for use in relation to the pest problems on target crops. This assessment has helped in prioritizing the local-level strengthening of farmers’ access to technical information relating to appropriate and selective use of pesticides.

Farmers’ perceived constraints to pest control

The areas of information needs or constraints to pest control perceived by the participating farmers mainly relate to safe, rational and effective choice of pesticides. Second, they relate to their interest in more knowledge in identifying the different pests (and diseases). Enhancing their ability to correctly diagnose the pests was perceived as a critical way forward to enable them to select and use pesticides appropriately. Farmers also reckoned that they needed technical advice on safer alternatives to pesticide use as well. Apparently, the farmers recognized that pests are of great concern and that pesticide use was becoming more expensive. These concerns coupled with lack of adequate quality control on the pesticides sold in the market were among their perceived direct constraints.

Priority topics of IPM information/guidance needs of farmers

The farmers recognized the specific topics of IPM information they needed, based on the constraints they experienced. These needs included aspects of crop production as well as protection (figure 7). While crop management technologies appeared to be their priority, three major areas relating to crop protection (appropriate pesticides, correct method and dose of
application as well as capacity for correct identification of pests) were apparently next in priority. Such a listing of their IPM information needs is helpful in suitably planning to cater to the farmers’ perceived IPM information priorities.

Current and Potential IPM Awareness-Building Initiatives for Farmers

Increased access to supplementary irrigation has encouraged multitudes of smallholder farmers in eastern Africa to take up production of vegetables for urban and export markets since the potential for income generation is attractive. In Kenya alone, over 300,000 farm families produce vegetables for export as outgrowers (Ouko 1997). However, the range of information required by them on different aspects related to pest management, such as safe and selective use of pesticides, pesticide residues and waiting periods, needs-based pesticide use as well as alternative methods to substitute for pesticide use, calls for substantial strengthening of the local research-extension-farmer information flow systems. Based on earlier experience and consultation with stakeholders (Sithanantham et al. 1998a), a network program has been initiated under ICIPE’s leadership with NARES (National Agricultural Research and Extension System) partners in four countries in Eastern Africa—Kenya, Ethiopia, Tanzania and Uganda—for promoting pest-management awareness and attitudes among smallholder farmers growing income-generating vegetable crops (Sithanantham et al. 1998b).

The features being tested for developing locally sustainable pest-management information flow models include:

- group learning and exchange of experiences in pest management within and between farmer groups
- promoting farmers’ own cadre of trainers as “second-line extensionists”
- appropriate local modifications in FFS approach

The program involves baseline studies of farmer-groups’ needs and priorities in information on pest management. Stakeholder-participatory assessment of the scope of different pest-control options is also being undertaken. Preseason training to frontline extensionists and farmers’ cadre trainers (second-line extensionists) is being structured to cater to the following themes in successive seasons:

- capacity to correctly identify the common pests and distinguish them from beneficial insects like predators, parasitoids and pollinators
- awareness of safe and selective use of pesticides as well as standards for residues and consumer safety
- alternative options (to pesticide use) and how to evaluate and/or adopt them

Recent Initiatives in the Region by Different Institutions

Some more IPM projects have been undertaken on irrigated crops in the region by organizations including ICIPE, FAO/CABI and GTZ/IPM. The FAO IPM projects on cotton
and vegetables in Sudan offer substantial practical experience in utilizing the FFS approach for IPM awareness-building among smallholder farmers in Africa. Such initiatives may be visualized to help evolve locally sustainable models for empowering farmers with knowledge and confidence for adopting improved pest-management options as an integral part of the production of, and marketing strategies for, vegetable crops.

**Examples of Currently Recommended IPM Practices for Vegetables**

A list of currently recommended IPM practices is furnished below for the common vegetable crops grown in the region.

**Tomato**

- certified disease-free seed
- seed treatment with a fungicide and an insecticide
- resistant/tolerant varieties to major diseases and to root-knot nematodes
- incorporation into the soil of neem cake powder for the control of root-knot nematodes
- staking, pruning, mulching and wider spacing where late blight is a problem
- *B.t.* products for control of bollworms
- mineral oils for control of red spider mites
- trap crops for nematodes and whiteflies

**Cabbage/Kales**

- planting of varieties resistant to black rot
- certified disease-free seed (black rot)
- mulching and avoidance of overhead irrigation (black rot)
- *B.t.* products against DBM (do not use continuously)
- neem-based pesticides (DBM and aphids)
- intercropping with *cleome gynandra* or tomato (DBM)
- liming against club root disease of cabbage
- releases of *diadegma semiclausum* or *cotesia plutellae* where commercially available, for control of DBM
French bean

- seed treatment with imidacloprid + carboxin, oxycarboxin, captan or thiram for control of bean flies, aphids and damping-off diseases
- soil amendments for control of root rots
- incorporation of neem cake powder into the soil for the control of nematodes
- sprays of neem-based pesticides for the control of thrips
- use of bio-agents (e.g., *metarhizium anisopliae*) and bio-products (e.g., spinosad) for control of flower thrips
- avoidance of broad spectrum insecticides (to avoid killing of beneficial insects)
- use of mineral oils for control of red spider mites
- use of *B. t.* products for control of bollworms
- planting of varieties resistant/tolerant to rust

General measures

- crop rotation
- deep ploughing
- no mixed planting of young and old plants
- thorough weeding
- removal of crop debris from the field
- avoid field operations when wet
- do not plant new fields next to old crops
- mixed cropping

Examples of Indigenous Practices and Materials Used in Pest Control

Some of the practices and materials used by farmers for pest control in the region are listed below:

Local pesticides

- kerosene-soap solution (helps get rid of aphids, mites and thrips)
- soap solution (a good remedy against aphids and thrips)
• cow urine (for control of aphids, mites, thrips and fungal foliar diseases)
• cow manure (similar to cow urine)
• cow milk (against virus diseases)
• sodium bicarbonate (control of powdery mildew)
• corn/simsim/sunflower oil (treating food grain against storage pests)

**Indigenous crop-protection measures**

• hand-picking of caterpillars
• releasing fowl into fields to feed on caterpillars
• burning of field after harvest
• flooding of fields
• mixed cropping/interplanting
• shift cultivation
• hand weeding
• use of own seed selected from robust plants
• soil amendments with farmyard manure
• use of ash against storage pests

**Major Theme Areas Linked to IPM and Irrigated Agriculture**

**Interaction of Irrigation Methods and Regimes on Pest Severity and Management**

There is a need to undertake studies on the scope for beneficial options among irrigation methods and regimes that could minimize pest severity and consequently reduce pest-control costs. This research is crucial for promoting compatible and sustainable combinations of crop and water management. An example is the potential benefit of using sprinkler (wherever possible and if there are no other major drawbacks) so that pest severity could be reduced (e.g., aphids/caterpillars on kale/cabbage). Recent experiments in the Asian Vegetables Research and Development Center (AVRDC), Taiwan have shown the potential for utilizing irrigation regimes in minimizing the yield loss in onion due to thrips. There is a need to examine the direct and indirect effects of irrigation methods and intensities on crop health (pest and disease incidence levels), so that beneficial irrigation options could be adopted wherever possible. Mixing of pest-control products in irrigation water may also be given consideration, if it leads to a positive impact on pest control and/or ecosystem conservation.
**Assessment of Ecosystem Interactions in Irrigated Crop Production**

There is a need to relate the consequences and interactions of increased access to water as well as its efficient use in crop production with the agro-ecosystem components. For instance, flow irrigation with limited inundation (as in rice systems) can benefit by suppressing some pests like whitegrubs. However, furrow/channel irrigation passing through nematode-infested plots could inadvertently spread the problem. Access to irrigation is often associated with increased cropping intensity and fertilizer input. The extent to which the soil and habitat are intensively (often excessively) utilized and the impact of such crop-production practices on the sustainability of the ecosystem needs to be understood. Crops, which are common targets for a given pest, should be avoided in rotation, for example, the polyphagous pest—African bollworm (Helicoverpa armigera)—attacks tomato, capsicum, okra and French bean but does not attack some other vegetables like cabbage/kale and onion. Similarly, crops which cut off the buildup of soil nematodes (e.g., Tagetus, Crotalaria) should be encouraged as rotation crops in irrigated systems so as to promote soil health.

In irrigated crop production, there are perhaps three levels at which interactions between crop production practices and ecosystem components should be studied and, where necessary, harmonized. The first is at the level of choice of irrigation methods and/or regimes. While infrastructure and economic considerations may play a dominant role in their choice, options that benefit the ecosystem should be favored, wherever possible. On the other hand, the direct and indirect effect of the irrigation practices on the ecosystem components (at the multi-trophic level: soil-plant-pest-natural enemies) should be monitored and characterized. At the next level, whatever components/inputs go into the production (fertilizer, variety) and protection (preventive, curative) of the key target crops should also be studied for their effects on the other key components of the agro-ecosystem. At the final level, there is a need to consider individual farms in association with neighboring farms, so as to relate to the dynamics of the pestiferous as well as beneficial taxa both spatially and temporally. It is important that a multidisciplinary team involving irrigation experts, agronomists, plant protection (IPM) specialists, socioeconomists and extensionists should, together, plan and direct these studies.

**Role of Policy Issues in IPM Implementation**

Extensive reviews of the scope for IPM in the African agriculture have been produced in recent years (Kiss and Meerman 1991; Berger 1994; Zethner et al. 1989; Zethner 1995). Yudelman et al. (1998) have provided a futuristic vision on IPM in the context of global food production. The policy aspects need a holistic analysis and should be linked with overall strategies for improving the motivation among farmers to adopt IPM. Supportive policies that provide incentives for adopting organic and safer alternatives to pesticides, including appropriate crop rotation for minimizing pest problems, need to be explored. There is a great need for sensitizing policy makers on the importance of promoting IPM and the focus should be on the following:

1. Since irrigated agriculture is mostly characterized by intensive land use and external inputs, there is a need for policy guidelines that ensure sustainable use of natural resources. This will be important for sustainable income generation through irrigated agriculture.
2. In Eastern Africa, there is a need to sensitize national governments so as to recognize and declare IPM as a policy theme towards sustainable agriculture, especially in irrigated farming systems.

3. There is a need for a policy to link research initiatives for crop/pest management with management of vectors and vector-borne diseases of cattle and humans. This will minimize the practice of resorting to ecologically incompatible pesticide-based interventions and will help wean the farmers away from the “pesticide treadmill.”

4. There is a need to link the IPM policy with the human resources and institutional capability as the cornerstone of integrated community of health systems covering people, livestock, crops and the environment.

5. The research-extension linkages need to be reinforced with complementary initiatives for development of a wider menu of IPM options for key pests as well as for effective awareness-building programs to take IPM to the grassroots level.

**Case Study of the Mwea Irrigation Project**

**Survey of Pest Problems and Current Farmer Practices**

**Issues addressed**

A survey was undertaken to understand the IPM practices and issues in irrigated agriculture in the Mwea division, Kirinyaga district, Kenya. From within the five sections of the Mwea irrigation scheme and adjacent villages 50 farmers were randomly selected. Rice and vegetable crop producers were interviewed using a pretested structured questionnaire on farmers’ characteristics, (gender, education, etc.), type of farming systems (crops, land, tenure, etc.), pest management (knowledge of pests, diseases and associated problems), chemical pesticides and their use, knowledge of the nontarget effects of chemical pesticides and source of knowledge on pest management and indigenous pest/disease management practices. Data were analyzed using descriptive statistical procedures.

**Characteristics of households and farming systems**

The interviewed farmers (n=50) comprised men (72%) and women (28%), the majority (58%) being freeholders outside the scheme, and the rest (42%) being farmers inside the rice scheme. The majority of the farmers (57%) attained primary-level education, some (23%) had secondary- or tertiary-school education, while the rest (20%) had no formal education. Two rice varieties, namely, Basmati and BW were grown. The most prevalent vegetable crops were tomato (22%), kales (23%), soybean (10%) and French bean (7%). All farmers in the scheme are members of the cooperative society while farmers outside the scheme had no formal association to link them.
Knowledge of pests, diseases and associated losses

Knowledge of names and symptoms. There is a big gap between farmers’ knowledge of pests and diseases in relation to their damage symptoms. For example, whereas 57 percent of the farmers identified pests by name, only 35 percent identified their damage symptoms. The most frequently mentioned insect pests included leaf miner (30%), aphids (35%) and red spider mites (11%). Among the limited proportion (36%) that cited crop diseases by name only some (15%) had knowledge of their symptoms. Important diseases cited included late blight (8%), damping off (11%), bacterial wilt (7%), root rots (5%) and leaf spots (9%). In general, the majority of farmers were not able to recognize the symptoms of damage caused by pests and diseases.

Perceived losses due to pests and diseases. The perceived extent of losses due to pests and diseases varied greatly by crop. The majority of farmers (49%) estimated the extent of loss at less than 1/3 while 41 percent and 10 percent put it at 1/3–2/3 and over 2/3, respectively (figure 1).

Figure 1. Percentage of farmers estimating yield loss due to pests and diseases in different crops grown in Mwea, Kenya.
Chemical pesticide use

The large majority of the farmers (92%) used pesticides to control pests and diseases. The common insecticides used for pest control in rice included Furadan (18%) and Supersumithion (19%), while those used for vegetable crops were Selecron (15%), Ambush (16%), Karate (20%), Dimethoate (12%) and Polytrin (16%) (figure 2). Fungicides commonly used were Dithane (54%) and Green copper (32%). Knowledge of the quantity of pesticides used varied considerably by crop and season. Most farmers (56%) indicated that insecticides are applied more often during the dry season than in the wet season. About one-third of the number of farmers (31%) observed that more fungicides were applied during the dry season when diseases were more prevalent. Most vegetable farmers (59%) indicated that, in the dry season, they sprayed pesticides on a weekly basis. On the other hand, the majority of the rice farmers (64%) sprayed only once and 37 percent sprayed twice or several times.

Figure 2. Commercial pesticides commonly used by farmers in Mwea, Kenya.

Knowledge of adverse effects of pesticides

Farmers’ knowledge of pesticide residues varied greatly by crops grown and farming systems practiced. On average, 37 percent of the vegetable farmers had knowledge of pesticide residues. Almost a third of the farmers (31%) were aware of the “waiting period” to be observed between pesticide application and crop harvesting. By contrast, none of the rice growers were aware of the waiting period. Most of the vegetable producers (58%) indicated that harvesting was done usually 3–7 days after spraying and the rest harvested after 7 days.
The farmer’s knowledge of adverse effects of pesticides on beneficial insects appears to vary with the farming system and crops grown. The majority of the farmers outside the scheme (52%) and roughly one-fourth of the farmers in the scheme (26%) had knowledge of the adverse effects of pesticides on beneficial insects. Tomato farmers (63%) had the highest rate of awareness. The ratio was lowest (18%) for the Basmati rice growers. Among the commonly cited beneficial insects affected by pesticides were pollinators, i.e., bees (66%) and natural enemies such as the ladybird (22%). A large proportion of farmers (70%) specified that pesticides killed beneficial insects, rendered them inactive (9%), made them less reproductive (5%) and caused other effects (16%) (figure 3).

Figure 3. Percentage of farmers with knowledge of different effects of pesticides on beneficial

Knowledge of pesticide resistance

On average, 50 percent of the farmers had knowledge of pesticide resistance. Such knowledge was highest among tomato producers (77%), followed by kale growers (66%), French bean (60%) and other crops (40% or less). The pests that are resistant to pesticides, as commonly cited by farmers, were the red spider mite (32%), the leaf miner (15%), aphids (8%) and others (46%).

Supply of pesticides

Pesticides were supplied on credit to farmers in the irrigation schemes by their cooperative while outside farmers purchased them mainly from agro-vet stockists and brokers in the area.

Source of information on pesticides use

Information on pesticide use was obtained from local agro-vet stockists (26%), fellow farmers (19%), pesticide labels (22%) and extensionists (9%). On average, 67 percent of the farmers in the scheme had access to information on pesticide use while only 33 percent of the farmers outside the scheme had this information.
Farmers’ own pesticide alternatives

Several pesticide alternatives were being used for pest control to varying levels on vegetable crops and rice varieties. Some of the indigenous controls include the use of a mixture of tobacco and ash by farmers (8%) but their knowledge of the appropriate dosage of alternative controls was either inadequate or completely nonexistent. Furthermore, farmers’ group discussions during the survey confirmed that they needed guidance on appropriate alternatives and the correct dosage for achieving effective control of major pests. Plant extracts, such as those from neem and tobacco, were not commonly used. Unlike pesticides, they have to be prepared before use, a task which some farmers found to be onerous, e.g., 17 percent of the farmers indicated that the preparation of concoctions was labor-intensive; 25 percent observed that since the most appropriate and effective application rates were unknown, they could not be depended upon for effective pest control; on the other hand, 10 percent of the farmers associated the use of concoctions with backwardness (figure 4).

Figure 4. Percentage of farmers adopting indigenous pest control practices in Mwea, Kenya.
Use of different pest-control practices

An interesting feature was that the use of two or more pest-control components was higher among growers of vegetable crops than among growers of rice. The highest proportion of farmers adopting two or more components was among tomato producers (43%) followed by kale growers (18%) and the least among rice farmers (9% or less). For instance, 14 percent of the farmers combined pesticide controls with cultural practices while a mere 2 percent combined cultural practices with biological controls. Importantly, 43 percent of the farmers expressed disappointment at the increasingly declining pesticide effectiveness and because of this, they expressed a keenness to try other pest-control alternatives (figures 5 and 6).

Concluding remarks

The status of farmers’ knowledge and the use of different pest-management practices were found to differ sharply between the two farming systems, i.e., between rice systems and vegetable-multi-cropping systems. Rice farmers appear to have limited experience in using pesticides since the agency staff handled the pest-control operations up to the end of 1999. The knowledge of pests, diseases and associated problems of these farmers was lower than that of the farmers in the open (non-scheme) multi-crop agricultural systems. It is also evident that scheme farmers grew mainly one crop, rice, which has fewer pest problems. The intensity of pest control in vegetable-growing systems is high and several chemical pesticides are in use. It appears that pesticide-application regimes and intensity are high especially during the dry season. Vegetable farmers appear to have a higher extent of knowledge of the adverse effects of pesticides than rice farmers. It is impressive to find that farmers are articulate on the harmful effects of pesticides on beneficial insects and other organisms. However, restricting the use of pesticides seems to be limited to export crops, apparently in response to strict regulations imposed by importing countries.

The use of indigenous pest-control practices seems to be constrained by several factors, such as laboriousness, lack of appropriate dosage recommendations and even prejudice against them. Supportive research is required to evaluate the efficacy and cost efficiency of these practices. What is more important is to create awareness among the farmers that they need to consider alternative approaches due to the reported declining effectiveness of chemical pesticides. Therefore, there is a window of opportunity for IPM.

Farmers’ Needs for IPM Adoption and Potential Awareness-Building Options

Constraints

Some of the factors constraining farmers’ use of, and access to, IPM in irrigated agriculture in Mwea are listed below:

1. There is a lack of critical mass of human resources to plan and implement pest/vector/disease-management programs.

2. There is a lack of information on the IPM menu available to local extension workers, the private sector and farmers.
Figure 5. Percentage of farmers adopting some combination of different pest control practices in different crops in Mwea, Kenya.

Figure 6. Percentage of farmers adopting different combinations of pest control practices in Mwea, Kenya.
3. Consumers have not motivated farmers to shift to the safe use of pesticides.

4. Indigenous pest/vector controls have not been evaluated for their efficacy, cost-efficiency and appropriate dosage.

5. IPM concepts and approaches have not been disseminated to the end users.

6. Lack of policy for promoting IPM in general and irrigated agriculture in particular.

**Suggestions**

To overcome the constraints listed above, two main suggestions are given below:

- The development of an IPM focus program to tackle pest/vector and diseases in line with the agro-ecological mold described earlier in this paper should be initiated for irrigated agriculture.

- Research results from Mwea show that there are several windows of opportunity for IPM. The starting point is the farmers’ search for alternatives to chemical pesticides.

Information on the available improved IPM options/components should be made available to the farmers. The window of opportunity appears to be clear due to the high awareness level among farmers of the negative effects of chemical pesticides on beneficial insects. The finding that some consumers in the study area reject produce that appears to have chemical pesticide residues may be used as a basis to form catalytic consumer groups, which can lobby and exert pressure on farmers to use safe products in pest management.

**Conclusions and Themes for Future Focus**

**Conclusions from assessing the present situation**

Irrigated agriculture, characterized by intensive land use and crop production, is largely leaning to substantial use of external inputs. Overlapping seasons of planting and year-round cultivation of crops, often lead to greater buildup of pests both above and below ground. This, in turn, leads to increased costs of pest control or greater yield loss due to pests. Irrigated vegetable crops tend to fetch attractive prices in the market if they are free of blemish. Farmers often resort to unilateral (and indiscriminate) pesticide use in their effort to maximize the proportion of blemish-free produce at harvest. In the process, they unwittingly get into the “pesticide treadmill,” since the excessive use of pesticides often destroys the natural enemies of pests leading to a greater buildup of pests over time, even within the same crop season. Very often, enthusiastic farmers tend to “overuse” the “pesticide gun” and this results in a “U” turn, as the system cannot be sustained any longer. This situation presents both an urgent need and an excellent opportunity for utilizing IPM as the key for sustainable production of irrigated crops (figure 7). The scores of recent suicides by cotton farmers reported from India bring home the lesson for us in Africa, that IPM is important for sustainable crop production, and the guideline is “not to destroy the friends of farmers (beneficial insects)” in the ecosystem and not to favor unnatural buildup of pest organisms, while adopting different irrigation and pest-control practices.
Figure 7. Interlinkage of IPM with sustainable irrigated agriculture in sub-Saharan Africa.

**SPECIAL ATTRIBUTES OF IRRIGATED CROP MANAGEMENT**
- INTENSIVE INPUTS.
- YEAR-ROUND CULTIVATION.
- GREATER CROP VALUE.

**IRRIGATED CROP PROTECTION SCENARIO**
- HIGHER PEST-CONTROL INTENSITY.
- HIGHER PEST BUILDUP; INCREASED CONTROL COST.
- GREATER INTEREST BY FARMERS TO INVEST IN PEST CONTROL.

**HARMONIZE PEST CONTROL PRACTICES WITH AGROECOSYSTEM COMMUNITY-HEALTH AND CONSUMER CONCERNS**
- ENCOURAGE CROPPING AND PEST CONTROL PRACTICES THAT MINIMIZE NEED FOR PESTICIDE USE.
- ENSURE COMPLIANCE WITH IMPORTERS’ RESTRICTIONS ON PESTICIDE USE AND RESIDUE LEVELS.
- HARMONIZE CROP PROTECTION PRACTICES WITH COMMUNITY-HEALTH CONCERNS.

**INITIATIVES TO ENHANCE SUSTAINABLE CROP PROTECTION CUM PRODUCTION**
- RATIONALIZE USE OF CHEMICAL PESTICIDES.
- PROMOTE USE OF SAFER ALTERNATIVES TO PESTICIDES.
- BUILD UP FARMER AWARENESS ON BENEFITS OF, AND OPPORTUNITIES FOR, IPM.

**SELECT IPM OPTIONS ACCORDING TO FARMERS’ RESOURCE BASE AND FARMING OBJECTIVES**
- FOR SUBSISTENCE FARMERS:
  - INTERVENTION LIMITED TO SITUATIONS WHERE PESTS ARE PRIORITY CONSTRAINTS.
  - PEST-TOLERANT CULTIVARS AND CULTURAL PRACTICES.
- FOR TRANSITIONAL FARMERS:
  - FOCUS ON YIELD LEVELS ENHANCEMENT WITHOUT DEPENDING ON PESTICIDE USE.
  - UTILIZE SELECTIVE PESTICIDES AND APPLY ACCORDING TO NEEDS.
- FOR COMMERCIAL FARMERS:
  - FOCUS ON COST REDUCTION AS WELL AS CONCERN FOR HEALTH AND ENVIRONMENT.
  - RATIONALIZE PESTICIDE USE AND PROMOTE SAFER ALTERNATIVE OPTIONS.

**COMMON IPM OPTIONS AVAILABLE FOR USE IN IRRIGATED AGRICULTURE**
- MONITOR PESTS AND INTERVENE ONLY WHEN NEEDED.
- PLANT PEST-TOLERANT CROP VARIETIES (CULTIVARS).
- UTILIZE BIOCONTROL AGENTS/PRODUCTS.
- USE BOTANICALS (FOR EXAMPLE, NEEM).
- ADOPT BENEFICIAL CULTURAL PRACTICES.
- ENCOURAGE INDIGENOUS PEST-CONTROL TECHNOLOGIES.
Researchable themes of priority for sustainable irrigated crop production

IPM offers good scope as a component of sustainable management of natural resources in irrigated agriculture. While most papers in this System-Wide Initiative on Irrigation Management (SWIM) document focus on management of water, as related to socioeconomic and infrastructural issues, this paper focuses on complementarities between water use and pest control on irrigated crops, with focus on sustainability of the agro-ecosystem. In this section, we list priority research themes that could promote improved pest management options towards minimizing the pesticide burden on the soil-water systems in irrigated agriculture.

Promoting irrigation methods and regimes that minimize the severity of pest problems on target crops

Research on the effects of different irrigation methods and regimes on the extent of pest infestation in common target crops needs to be encouraged. This will help in advising agronomists/extensionists on the choice of options that can help minimize the intensity of pest-control interventions on irrigated crops.

Promoting the use of safer alternatives (IPM components) to chemical pesticides to minimize polluting the soil-water systems

Applied and adaptive research and demonstration of environmentally friendly pest-control options for key pests should be supported. This will be important for motivating farmers to shift away from the indiscriminate use of chemical pesticides. Among other benefits of the IPM approach is the minimizing of the pesticide burden on the soil-water system.

Developing holistic IPM-ICM-IAM impact assessment methodologies relevant to irrigated agricultural ecosystems

The multi-trophic impact of IPM and Integrated Crop Management (ICM) on linking soil-water-plant and beneficial or pestiferous flora/fauna should be more holistically evaluated/demonstrated in farming systems, based on irrigated agriculture. Improvements in methodologies and efforts to identify benchmark sites representing predominant irrigation systems for such research should be considered.

Integrating IPM with the management of cattle- and human-disease vectors

The indirect effects of IPM on the development of pesticide resistance among cattle-disease vectors (e.g., tsetse flies) and human-disease vectors (e.g., mosquitoes) in irrigation projects need to be monitored. The positive effect of IPM adoption in reducing the pesticide burden on the nontarget vector insects (in terms of resistance buildup) and on the soil-water system (in terms of pollution) should be verified and suitably demonstrated.

Recommendations for Regional Initiatives

Having recognized the critical role of the IPM approach to the sustainability of irrigated farming systems in the region, the following recommendations are made towards utilizing IPM research and knowledge on a continuing basis in irrigation project areas. These recommendations may be considered in the context of strengthening overall impacts in the region.
i. Build up and update a readily accessible “knowledge base” on important pest/disease constraints and the available/improved options for their management.

ii. Support “complementary” and “gap-filling” research that would help reduce the severity of pests, especially through “preventive” strategies.

iii. Encourage “adaptive” and “participatory” research towards minimizing the use of chemical pesticides by substituting safer alternatives for them.

iv. Monitor (and demonstrate) the benefits (both economic and environmental) of adopting IPM approach as a component of ICM in agro-ecosystem sustainability.

v. Provide “backup” and “underpinning” on the direct/indirect effects of irrigation methods and regimes on the pest severity and buildup in key crops.

vi. Contribute to IPM capacity-building among national research/extension personnel as part of IPM-ICM approach for sustainable irrigated agriculture.

*Table 5. Topics of IPM-ICM information identified as priority needs by vegetable farmers in four countries in eastern Africa, 1998–1999.*

<table>
<thead>
<tr>
<th>IPM Information Topics Needed</th>
<th>Number of Farmers Identifying the Need</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kenya (n=60)</td>
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<tr>
<td>Improved crop-management practices</td>
<td>35</td>
</tr>
<tr>
<td>Appropriate choice of pesticides</td>
<td>32</td>
</tr>
<tr>
<td>Correct identification of pests and their symptoms</td>
<td>28</td>
</tr>
<tr>
<td>Pesticide application method and dosage</td>
<td>17</td>
</tr>
<tr>
<td>Safe handling of pesticides</td>
<td>0</td>
</tr>
<tr>
<td>Improved supply of quality seeds</td>
<td>4</td>
</tr>
<tr>
<td>Dependable source of pesticides</td>
<td>0</td>
</tr>
<tr>
<td>Fertilizer application practices</td>
<td>5</td>
</tr>
<tr>
<td>Alternatives to chemical pesticides</td>
<td>3</td>
</tr>
<tr>
<td>Record keeping on pests and their control</td>
<td>1</td>
</tr>
<tr>
<td>Crop rotation practices</td>
<td>1</td>
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</tbody>
</table>

Source: ICIPE-IFAD-USAID-NARS IPM Project.
Table 6. Impact assessment of IPM trainers’ training in Kenya and Uganda (Farmers’ cadre and extensionists, 1988–1999).*

<table>
<thead>
<tr>
<th>Aspects Related to IPM</th>
<th>Percentage of Trainers with Awareness</th>
<th>Uganda</th>
<th>Kenya</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-training</td>
<td>Post-training</td>
</tr>
<tr>
<td>Knowledge of pests (insects, disease and weeds)</td>
<td></td>
<td>58</td>
<td>92</td>
</tr>
<tr>
<td>Knowledge of pest damage symptoms</td>
<td></td>
<td>42</td>
<td>67</td>
</tr>
<tr>
<td>Knowledge of pest life cycle</td>
<td></td>
<td>33</td>
<td>50</td>
</tr>
<tr>
<td>Knowledge of pre-harvest waiting periods</td>
<td></td>
<td>50</td>
<td>67</td>
</tr>
<tr>
<td>Knowledge on safety use of pesticides</td>
<td></td>
<td>58</td>
<td>67</td>
</tr>
<tr>
<td>Knowledge of safer pest control methods</td>
<td></td>
<td>42</td>
<td>58</td>
</tr>
<tr>
<td>Knowledge of beneficial insects</td>
<td></td>
<td>50</td>
<td>50.0</td>
</tr>
</tbody>
</table>

*Source: ICIPE-IFAD-USAID-NARS IPM Project.
Literature Cited


