The role and responsibilities of engineers and agriculturalists in reducing vector-borne disease hazards

by A. Kandiah

Health components should be integrated into the overall planning, development and management phases of irrigation projects.

The expansion of irrigated agriculture through appropriate development and the management of natural resources is recognized as a most important strategy to increase food production in countries where the human population exceeds (or will shortly exceed) the low-input supporting capacity of their land resources.

During the past two decades, increased outbreaks of water-borne diseases such as malaria and schistosomiasis associated with irrigation development, have been a focus for international concern. Analysis of the situation has revealed that most of the health-related problems could have been mitigated or eliminated, had environmental and public health considerations been an integral part of the planning, design and operation of irrigation projects.

In the past (and in some countries at present), agricultural and irrigation development projects have been planned, implemented and operated by technical specialists, normally agriculturalists and engineers, who worked mainly within their specialities. Social, cultural or public health data were rarely considered in the planning, design or operation.

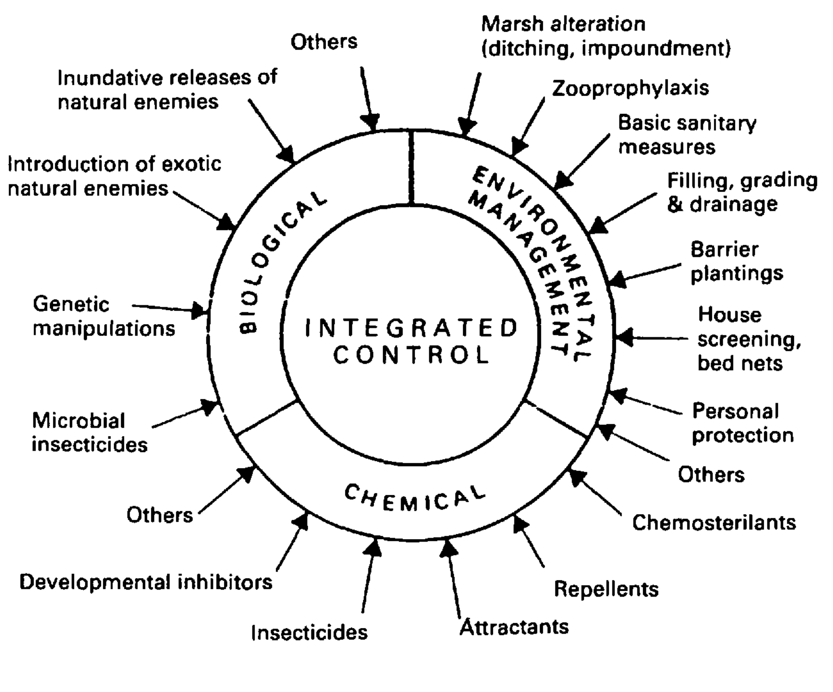
In the context of the present world food situation, we cannot afford to make mistakes in our agricultural and irrigation development efforts, particularly mistakes that threaten long-term productivity, or environmental and human health. The problems are not insurmountable; they can be solved, provided appropriate strategies and policies are followed. One of the important strategies relating to the prevention of water-borne diseases in irrigation schemes is the adoption of environmental management measures for disease vector control. In this strategy, agriculturalists and engineers can play a vital role. As lead players of agricultural and water development teams, they can bring into the system appropriate measures to combat water-borne diseases. This paper discusses the role agriculturalists and engineers can play in controlling water-borne diseases in agricultural and irrigation development projects.

Environmental factors

Environmental management for vector control refers to the modification and/or manipulation of environmental factors, or their interaction with man with a view to preventing or minimizing vector propagation and reducing man-vector pathogen contact.

Environmental modification consists of any physical change that is permanent or long-lasting, such as canal lining, drainage and land levelling, while environmental manipulation refers to any planned recurrent activity aimed at producing temporary conditions unfavourable for vector breeding, such as the regulation of water levels in reservoirs, canal flushing and intermittent irrigation. Modifications and/or manipulations of the environment in relation to human habitation or behaviour is also considered a component of environmental management, which refers to actions such as the siting of settlements away from vector breeding sites and the mosquito-proofing of houses. The components of environmental management in the overall picture of integrated mosquito control are illustrated in Figure 1.

Most engineering and agronomic practices fit well within the environmental modification and manipulation components of environmental management. It is interesting to note that measures aimed at improving irrigation system performance from the agricultural point of view, also alleviate the vector-borne disease



(Adapted from Axtell, R.C., Priciples of integrated pest management (IPM) in relation to mosquito control, Mosquito News 39, pp709-18, 1979.)


I. Self/WHO

Clean and well-maintained canals discourage snails and reduce the risk of schistosomiasis infection.

hazard. It is vital to appreciate that good maintenance of irrigation schemes has both production and health benefits. Hence the implementation of environmental management measures for vector control through the 'agriculture sector' should be relatively easy *if* the 'two-sided' benefits of such measures are well-understood by engineers and agriculturalists alike.

Water storage

Storage reservoirs are often a component of irrigation scheme environments. These might consist of large storage reservoirs associated with hydro-power and water regulation schemes, or relatively small structures such as night storage reservoirs, balancing reservoirs, or fish ponds.

Because of their proximity to the community, the small reservoirs can have a marked impact on the incidence of vector-borne diseases as compared to the large ones. The introduction and operation of small reservoirs therefore calls for the particular application of appropriate management techniques. An especially important aspect is that of maintenance. A satisfactory storage structure, if allowed to deteriorate, may create a serious health hazard. Engineering measures relevant for vector control in the case of small reservoirs include the appropriate design of dikes and dams, excessive seepage prevention and facilities to drain the storage when required.

Bank slope is an important parameter in relation to the growth of marginal vegetation which may form an ideal breeding ground for mosquitoes and snails. A relatively steep bank is therefore an advantage, but slope stability and erosion problems should be taken into account in designs.

Larger reservoirs, generally at the head of main canals and controlled by head gates and sluices, may also present serious problems. The more constant water level and the low water velocities on the margins provide an environment well-suited to snails and the breeding of mosquitoes. The adoption of flushing procedures (to strand eggs and larvae), steeper slopes of banks protected with rip-rap, and the provision of screens to intake structures, are means recommended for vector control.

Water conveyance

Open canal systems are the most common means of water conveyance in many irrigation schemes. Canal design is a major factor in controlling the breeding of snails through a design providing a sufficiently high flow-velocity to detach the snails and a smooth boundary to reduce their ability to colonize the banks. In Japan, replacing earth canals with concrete lined ones in the schistosomiasis endemic rice-growing area of Kofu proved to be very successful in eradicating the disease. Canal lining also benefits mosquito control measures by reducing seepage, water table build-up, and the growth of aquatic and semi-aquatic vegetation on the margins of irrigation schemes.

Drainage

The importance of drainage in agriculture has at last been realized but only at the cost of losing millions of hectares of good agricultural lands due to water-table rise and salinity and/or alkalinity. The importance of an appropriate and effective drainage system is substantiated not only from the point of view of agricultural production, but also from the standpoint of disease vector control.

Lack of an appropriate drainage system often results in waterlogging in the tail-end of a system and in low-lying areas, and is likely to create an environment conducive to vector multiplication. Equally bad is an inappropriately designed and ineffective drainage system. Drainage canals of large cross-sections and gentle slopes result in low water-velocities, giving rise to conditions of sediment deposition and weed growth. These can be further aggravated by fertilizer runoff from the fields, providing an environment ideally suited to many disease vectors. Standards of design and construction are major factors in effective drainage, but equally important is the maintenance of the drains. A well-designed and maintained drainage system with a free-flowing hydraulic regime will prevent the build-up of vectors not only in the drainage system alone but in the whole project area.

Water control structures

Water control structures are installed in water supply and drainage canals in order to control, measure and divert water flow as required by the irrigation scheme. These structures include silt traps, drops, sluices, siphons, turnouts, intakes, offtakes, gates and many others. Each has a modifying effect on flow and a potential for maintaining a residual aquatic environment when the rest of the irrigation system is dry. This may then provide a micro-habitat for vector production, or for sustaining a vector population between natural or artificial wet seasons.

Attempts have been made to design water control structures that will freely drain the residual water when flow in the canal system is stopped. At the Mushandike Irrigation Scheme in Zimbabwe, field-level experiments are being conducted on the introduction of a modified drop structure that is free draining, and on a new type of canal offtake structure to reduce the multiplication of vectors. The free-draining drop structure with its suitably designed energy dissipators, does not have the sump which is common in most drop structures. Thus standing water downstream of the drop is avoided in the modified design, resulting in a potential for control of mosquito breeding. Similarly, the offtake structure that is being experimented with at Mashandike overcomes many problems associated with traditional offtake structures by allowing a free flow of water over the weir and not reducing the flow velocity upstream of the structure. As for any irrigation or drainage network, maintenance of these structures is an important factor on which the ability to control both water and vector depends.

Many on-farm management practices, which fall within the area of competence of agriculturalists and farmers, can contribute to a significant reduction in vector multiplication without sacrificing yield or productivity. These will mainly be environmental manipulations as they are temporary in nature but very effective in controlling vector breeding.

Water regime manipulations

Water application to crops can be effected by many methods. Some common irrigation methods are: basin; furrow; sprinkler; and micro. The type of irrigation method finally selected will depend on the crop, field slope, soil, tillage and farming practices, capital investment, farmers' skills and many other factors. Each system has a characteristic field-water regime and hence has a definite influence on vector multiplication. Basin irrigation with continuous flooding has a high risk of mosquito breeding and snail infestation. With temporary flooding there are no direct implications of vector breeding but during the rainy season water may be present for a longer time and create a vector habitat. Similarly for furrow irrigation, if land levelling is poor, water may stagnate in the field and cause problems. In the cases of sprinkler and micro irrigation there are no vector breeding implications at all.

Rice is predominantly irrigated by the basin irrigation method and the field is kept under standing water most of the time. The most usual method of rice production by surface flooding and soil saturation provides an ideal environment for many vector mosquito larvae and for the snail intermediate host of schistosomiasis.

Although continuous flooding is a common practice of rice irrigation, the rice plant does not require such a water regime for its growth and the production of rice grains. In fact, rice can be grown successfully under non-flooded conditions and even under sprinkler irrigation. But growing rice under non-flooded conditions requires an improved design of the delivery system, better water scheduling and greater skill from the farmer. Alternate wetting and drying appears to be a possibility which can be adapted to most existing irrigation systems with minimum structural changes and which has a potential to control the breeding of mosquitoes.

In the Yellow River Basin in Henan Province, alternate wetting and drying was successfully introduced as a means of controlling the breeding of Japanese encephalitis mosquito in rice fields. Fifteen days after transplanting, the rice fields were irrigated with a shallow layer of water so that it disappeared within 24 to 48 hours after irrigation. The irrigation interval varied between three to five days depending on the stage of growth of the rice plant.

Intermittent irrigation of rice as a widely applicable and standard method of rice irrigation, however, has not yet been accepted by most rice scientists and farmers. The topic was discussed in detail at an IRRI/PEEM collaborative meeting held in Los Banos, Philippines in 1987. The recommendation of the meeting on this subject is presented below.

The effectiveness of alternative methods of manipulating on-field water regimes to eliminate or minimize breeding sites and reduce vector populations needs to be determined, and their impact on rice yields assessed for various soil types in different rice-production systems. They are essential for devising water management methods that effectively control vector-borne diseases without reducing rice yield. Such evaluations should deal with intermittent irrigation as well as other irrigation practices.

Rice varieties that will permit the use of intermittent irrigation or periodic drainage should be developed. The role of water control infrastructure and management, including rice-field levelling, needs to be determined for the irrigation system as a whole and for the farm level. The socio-economic implications of adopting the most promising methods also require assessment.

Other on-farm practices

Several other on-farm management practices such as crop rotation, tillage, pesticide application and integrated pest management, can be important in the control of vector-borne diseases in irrigation projects. Agriculturalists and farmers can thus play a lead role in introducing practices which reduce vector multiplication without significant loss to agricultural production. For example in rice irrigation schemes, the introduction of upland, non-rice crops instead of the double cropping of rice is likely to reduce vector breeding in endemic rice monocrop areas. Integrated pest management, as opposed to chemical pest control, has been found to be advantageous not only in combatting agricultural pests but also in vector control.

Recent studies by IRRI (1988) have shown that neem cake, an additive with fertilizer used in rice fields, can be effective as a repellent to female mosquitoes searching for an appropriate location to deposit their eggs and it also kills the larvae. Further research is needed to confirm these effects, but the potential benefits are evident.

Many more agronomic practices have been identified and are being investigated. In all cases, the impact of such practices on individual farmers and the community requires evaluation.

Project improvements

A number of water resources development projects in the past have failed to meet their objectives, and produced far too many adverse impacts, because of improper planning. Most of these projects were planned with narrow objectives in mind and without consideration for the many important associated factors such as environment, health and social impacts. Engineers and agriculturalists can play an important role in planning, bringing to the notice of the planners, politicians and funding agencies, the need to adopt a holistic approach in the planning process. They can contribute significantly by drafting comprehensive terms of reference for the planning studies at the various stages of the planning phase, namely at the reconnaissance, pre-feasibility and feasibility stages.

The implementation of the physical works form an important phase in the development of irrigation schemes. This follows a feasibility study, project appraisal, and selection and provision of funds for implementation.

A recurring tragedy of development is that environmental considerations cease at the planning or assessment stage. In the past, there have been projects for which comprehensive feasibility reports and preliminary designs, including environmental health components, were prepared, but the environmental aspects were only partially considered, if not completely ignored, during final design and implementation for reasons of economy.

The difficulty with many environmental, health or social interventions is that they are not easily quantifiable in terms of tangible benefits or economic value. Consequently, they are the first to be dropped to improve the economic viability of a project, and hence the final design often fails to show any environmental management component. The project is constructed as per the final design, and specifications are rarely evaluated during or after construction against the recommendations made at the planning stage. This is particularly so in complex development projects where many plans are made and the most recent ones supercede older ones.

Project construction is often supervised by engineers and economists and the environmental supervision of construction is sadly lacking in many parts of the world. This situation can change only when the engineer takes the responsibility to see that the final design incorporates all environmental management measures recommended at the planning phase, and the construction is undertaken without any omissions. The engineer can also play a crucial role in checking the specifications of construction that might influence the project environment in relation to vector-borne diseases.

Management

Many irrigation schemes have also fallen short of their expectations because of poor management. A considerable amount of research and development effort has gone into improving the management of irrigation schemes, and several guidelines are available in this area. Most guidelines focus on operation and maintenance functions for increasing crop yields, water-use efficiency, farmer income, and the economic efficiency of the schemes. Again, little attention is paid to the potential for vector-borne disease control, yet it is interesting to note that many environment manipulations in the context of environmental management are indeed standard irrigation scheme operation and maintenance activities. If operators pay proper attention to these activities, the scheme can perform well not only in terms of production but also with respect to the health and well-being of the farming community. Project engineers, agriculturalists, and their staff who manage the system should be appropriately trained and motivated to manage the system as a whole, and to the benefit of the farming community. Operation and maintenance functions should not be limited to activities that are directly concerned with increasing agricultural production, but extended to include activities aimed at reducing vector-borne diseases and ensuring environmental protection.

Extension and training

Successful extension and training programmes in agricultural and irrigation projects aim at the achievement of an overall benefit to the farming population, including increased production, greater economic returns, better health, improved education, and a general enhancement of the physical environment, desires and expectations. It is the aim of agricultural extension and education experts to influence the on-farm level technicians and farmers to adopt certain improved and desirable practices that will contribute to increased agricultural production and better family and community living. The management and control of vectors and the prevention of associated diseases in agricultural and irrigation projects can be an integral part of the agricultural extension objectives.

Current agricultural extension and training programmes in most countries do not respond to health problems or the needs of rural communities. The major reason is the lack of communication and co-ordination of the agricultural and engineering ministries with health ministries. Without formal collaboration at higher levels, it would be difficult for extension workers to initiate health-oriented activities in a project area. Thus an important role of agriculturalists and engineers emerges from this analysis, namely, the creation of relevant co-ordinating mechanisms to secure co-operation of government departments, state institutions and local authorities. Perhaps these can best be initiated and followed up by agriculturalists and engineers in the planning and implementation of an integrated extension programme. The inclusion of health and vector control components in an integrated extension package can contribute significantly to the success of agricultural and irrigation development projects and in particular alleviate the health hazards of the farming community.

Intersectoral collaboration between agriculturalists and health workers is essential. Here a health worker is supervising the dipping of nets in a malarial area.

Summary

The demand for food will continue to increase as populations grow and consumption patterns change. Agricultural development, both rainfed and irrigated, receives top priority in international technical co-operation and investment programmes, as well as in national development efforts. Irrigated agriculture, by virtue of its high production potential and the stabilization of production, assumes a high-ranking position in the development of world agriculture.

Agricultural development, however, if planned and implemented in a narrow perspective will not produce the desired goal. To make production efforts sustainable, a holistic approach is essential and in this approach the incorporation and implementation of health safeguards to protect the farming community are vital. Many agricultural and irrigation development projects have failed in the past, through lack of forethought. It is now recognized that health components, particularly measures to control vector-borne diseases in agriculture and irrigation development schemes, should be integrated in the projects' overall planning, development and management phases. Towards achieving this, agriculturalists and engineers play an important role. By developing new and innovative methods of engineering and agricultural technology, assisting in the appropriate and necessary planning, design and management of projects, and establishing intersectoral collaboration and integrated agricultural and health extension and training programmes, agriculturalists and engineers can and must play a vital role in preventing adverse health impacts on farming communities. The task of the agriculturalists and engineers is to ensure that the development process takes into account both positive and negative impacts and applies the most appropriate measures in combating undesirable effects, to ensure maximum benefits from investment and development efforts.

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