Autumn 1976, Vol. 5 No. 3

# A SYSTEMS APPROACH TO ANTIMALARIA PROGRAMMES[a]

H. A. RAFATJAH

## ABSTRACT

The term «system» is defined as «elements standing in interaction». This implies that a change in any given element should bring about changes in other elements of the system and thus may be used to identify the boundaries of a system.

A system can be a machine, a man, or a community. Each of these may be part of a greater system (supersystem) or include several smaller systems (subsystems).

Systems analysis studies the constituent elements of a system and the interactions between them. It will help programme planners and managers to understand the functioning of the system, to use comprehensive approach in planning and to discover deficiences in implementation and find ways to solve them.

## 1. INTRODUCTION

Bertalanffy[1] defined the term «system» as «elements standing in interaction». This implies that a system is made of interacting elements and that the pattern or organization of a system is represented by the result of the continuing interactions. The interdependence between parts of a system implies that a change in any one part will cause changes in others.

---

[a] Planning and Programme Development, Division of Malaria and Other Parasitic Diseases.

[b] Thus the boundaries of the system can be established by determining those elements that do not react and are therefore outside the system.

c UNEP/Who meeting on the bio-environmental methods of control of malaria, Lima, Peru, 10-15 December 1975

Much of the work of man can be viewed as a system. To prove that any given element is part of a system a change in the state of that element should bring about changes in others.[b] The intensity of the induced changes varies with the nature of the change, the state of the other elements of the system, and the relationship between the various elements.

For example, a man can be regarded as a system, the constituent parts of which are related and interdependent. An injury to an arm or leg will generate changes in other constituents of his body. The resultant changes may be physical, mental, social, etc. If the man is to continue to live as before, the interactions between parts must change, and the intensity of the change naturally depends on the nature and intensity of the damage caused to the arm or leg and the state of other elements of the system to make the necessary adjustments.

Similarly, an insect or a machine may be regarded as a system and any changes in the elements of either may change the functioning or state of other parts of the system.

On the other hand, a man may himself be a part of a family or a community or the world community at large. Similarly, an insect is a member of a species, and a machine is a unit in an industrial complex. Thus systems are invariably parts of even greater systems.

In the above examples, man and insect are systems produced by natural processes, while amchines of communities are man-made systems. Of the man-made systems the former is a static system while the latter is dynamic.

If the man is viewed as a system, each smaller constituent element, e.g., the musculature, the vasculature, and even each individual cell, is called a «subsystem». The family or larger communities can then be called «supersystems».

Neither the size nor the complexity of a system is predetermined. Depending on the problem to be solved or the objectives of analysis, the constituent elements may be defined. Since it is often difficult to determine the boundaries of a system, it is customary to regard only the main interacting parts as the system proper and to regard anything outside them as part of the environment, which interacts with the system in the form of inputs and outputs. Whatever their composition or level, the systems encountered in the field of public health function in relation to an environment. They are open systems and very complex, functioning as parts of several social systems.

## 2. Systems analysis

Systems analysis can be described as the study of the constituent elements of a system and the interactions between them. Such analysis when applied to a programme, an organization, or a larger or smaller system provides an understanding of the functioning of the system and an insight into the causes of positive - valued as well as negative-valued outputs. It may be of great help in discovering weaknesses and deficiencies in a system in relation to its objectives and in suggesting improvements and ways of solving problems.

Systems analysis may not necessarily require quantification but mathematical models have been used in restricted fields - e.g., in systems engineering, where it helps to solve operational problems and facilitates decision making in relation to engineering projects such as the development and control of water resources. Systems engineering is both an art and a science and is used to optimize the functioning of a system to accomplish its overall objectives.[2] It helps the decision-makers to select, among the various feasible alternatives, the set of actions that will best achieve the overall objectives within the constraints of law, morality, economics, resources, and political and social pressures. Systems engineering involves substantial engineering content and makes use of mathematical procedures and computers for optimization and quantification.

The major task in the system approach is to modify the controllable or partially controllable inputs so as to maximize the desirable outputs. Systems analysis can help programme managers to follow a comprehensive approach in programme planning, execution, and evaluation by taking into consideration all the physical and social factors affecting the programme's processes.

## 3. Systems approach in antimalaria programmes

The planning, execution, and evaluation of traditional antimalaria programmes is largely done on a technical and scientific basis rather than on the basis of a whole system. The attention given to political social, and economic factors or to theories and practices of administration is often inadequate. This results in problems of various kinds, which may grow to an unmanageable size. The need for a comprehensive approach is therefore evident, particularly in view of the growing concern in developed as well as developing countries over the need for a better utilization of resources, the prevention of environmental deterioration, and firmer criteria for the assessment of benefits.

In antimalaria programmes, as in health and social systems that involve social elements and individual and group behaviour, the elements and their interaction are less well known and thus more difficult to quantify than they are in the physical environment. Likewise, systems analysis methods in these fields are less developed than they are for physical systems. Nevertheless, even in the absence of precise measurements, the system approach can identify the various elements involved, their interactions, and the constraints to which they are subject. It can thus guide planners and administrators in selecting the best feasible solutions in relation to programme objectives and help them to avoid errors and to utilize the available resources more effectively.

In restricted fields, the system approach in antimalaria programmes can make use of analytical methods or mathematical modelling in order to elucidate the effect of intervention methods in natural systems and help in the selection of the best feasible alternatives.

## 3.1 Application to antimalaria programmes

Applied to antimalaria programmes, the system approach calls for the identification of all the elements involved and their interactions, both with each other and with the environment. An analysis of these factors and an assessment of their positive and negative effects should guide planners and administrators of the programme to select among feasible alternatives those that produce the desired results in planning, execution, and evaluation of the programme and in problem solving.

The solution of the mosquito problem in a hypothetical agricultural area, given below, is an example of applied system analysis.

Flooded lands along a river produce immense swarms of mosquitos. The flooded areas have limited value, being used only for cutting firewood.

The identification and analysis of the elements and constraints involved show that:

1. The community's need for firewood is minimal and not necessarily dependent on the existence of the flooded areas.

2. Spraying insecticides for mosquito control is costly. It also involves human and environmental safety implications.

3. The system also requires so much maintenance and repetitive

application and organizational structure that it is scarcely feasible.
4. The land is privately owned and very fertile.
5. The cost of drainage is too great for the farmers to undertake the task themselves.

Taking all the above factors of the system into consideration, as well as the various intervention methods and their positive and negative effects, the manager arrives at a decision to:

- provide engineering service at public expense
- show the landowners how the work can be accomplished
- show the benefits of reclaiming the land
- clear, rough-level, and dike the land at public expense.

The farmers finish levelling the land and install agricultural drainage at their expense.

The result is that the mosquito problem is eliminated permanently, the farmers benefit from extended agriculture, and the public exchequer is repaid through increased taxes collected on increased income. Meanwhile the manager makes substantial savings in his control expenditure.

## 3.2 Planning in antimalaria programmes

Planning in simple terms may be defined as «to determine what to do, when to do it, and how to do it». In more explicit systemic terms it is an orderly process of defining a problem through analysis, identifying the needs and demands that constitute the problem, establishing feasible and reaslistic goals, deciding on their priority, surveying the resources needed to achieve them, assessing and selecting alternative intervention strategies, and projecting administrative actions to achieve them.[1] The outcome is a plan that can be put into action.

Planning starts with the definition of the problem and the analysis and assessment of its effects. When planning health programmes, the latter should not be limited to the health impacts of the problem but must also include an analysis of the effects on the physical and socioeconomic systems.

In a second step, the priority to be given to the problem must be established. In the case of malaria, priority for its control must be established on the basis of the health and socioeconomic impairments it causes as well as on the importance the community attaches to it as a problem.

When a decision on priority is reached, the objectives should be set and feasibility studies organized to assess the resources available and the constraints, whether technical, operational, environmental, financial, administrative, socioeconomic and political.[7]

The feasibility studies pave the way for detailed surveys, investigations, and testing or research on the intervention methods and strategies and for the formulation of programme proposals which once approved will form the plan of operation.

To treat the complex problem of malaria control, the multiplicity of goals and alternatives, and the very real possibility of having only one chance of developing the best course of action requires a logical procedure that can eliminate alternatives rationally and reduce thousands of decisions to relatively few, all on the basis of the rather formidable mass of information in various stages of scientific interpretation. System approach in planning offers practical possibilities for providing the necessary rationality if not in *toto* then at least with respect to important substantial parts of problems in antimalaria programmes.

## 4. Practical steps towards a comprehensive approach

Up to now the programmes of control of parasitic diseases have been planned and directed towards control of a specific disease and attention has seldom been given or action taken to assess the advantages that may be gained or benefits that could be derived from a broadening of the objectives of the programme to control other diseases.

Experience has shown, however, that the control of one disease invariably affects other diseases that have some common grounds in vector behaviour, mode of transmission, treatment, etc. The antimalaria programmes for instance considerably reduced the prevalence of a number of other diseases such as leishmaniasis, filariasis, and Chagas' disease. A study of these programmes shows that, had adequate attention been given to other prevalent diseases of the area, greater and more stable results could have been obtained with little additional investment.

A comprehensive approach could indeed produce additional resources and manpower for the malaria programme or create additional public support and technical and operational advantages. The future of the staff and organization could be better secured, and continuity would allow long-term planning and a rational approach to programme management and execution.

## 4.1 Integrated mosquito control

Integrated mosquito control may be described as the attempt to make an intelligent use of all known methods of control in relation to local conditions, aims, and resources and with due consideration to the possible effects of those methods on man's health and environment.

In planning comprehensive mosquito control, it may be more rational first to define the control measures that are most appropriate to control each mosquito species. Then, on the basis of the established priorities and after an assessment of cost/effectiveness and cost/benefit (immediate as well as long-term), a selection can be made of the methods of control most appropriate under local conditions. The methods of control selected should primarily ensure the control of the mosquito species aimed at and as much as possible of other vector or nuisance mosquitos.

Where feasible, priority should be given to naturalistic and source reduction measures as these, with some exceptions, are effective against all mosquito species. The higher cost of permanent operations is better justified in comprehensive mosquito control because the results yield multiple benefits. Simple filling, drainage, and regulation of water usage and disposal, properly planned and carried out, should be able to control malaria as well as a number of other mosquito-borne diseases or nuisance mosquitos. The additional cost of extending the work to control diseases other than malaria would be in most instances minimal.

Where vector control for a limited period of time is aimed at, as in eradication campaigns, economic consideration may weigh against the extended use of certain basic operations. Here, as in any situation, a forecast of cost and effectiveness/cost, as well as a study of benefit/cost, both immediate and long-term, should be able to demonstrate the most appropriate combinations.[6] It is important to estimate the indirect benefits that may be derived from the basic mosquito control operations in controlling other vectors and nuisance mosquitos or the other benefits that could accrue to the community, such as reclamation of land or provision of excess water for agriculture, industrial or urban use. In antimalaria programmes such studies should take into account the needs of the phases subsequent to the attack, for, as experience has shown, the receptive areas require constant alertness to fight a reintroduction of the disease.

Where mosquito vectors of different diseases have distinctly different breeding habits and separate breeding places, common benefits cannot always be expected from source reduction operations directed against one particular vector, and the cost of extension operations may prove unjustifiably high and beyond available resources. Source reduction operations applied against mosquitos breeding in polluted waters (*Culex fatigans,* etc.)may have little or no effect on freshwater br breeders. In such situations, use could be made of measures directed against the adults. These measures, however, should be so selected as to give added effect to other control measures.

In order to be effective, comprehensive mosquito control should normally cover all the breeding and/or resting places within, and sufficiently around, an area where the disease may be transmitted to the population under protection - i.e., in all areas where people live, work, and seek recreation. Partial coverage, however, may be dictated by limitation of financial or other resources or by environmental, human, or operational factors. In these instances, priority should be given to total coverage in respect of the disease or mosquito problems whose control has the highest priority.

Breeding and resting places should be identified, classified, and mapped in advance for treatment. Identification of breeding areas can be done on the basis of known entomological methods. Due consideration should, however, be given to seasonal variations and changes that may influence the breeding and resting habits and behaviour of vectors. The results should be used also to examine the operational feasibility of selective treatment and to compare its advantages with those of total coverage.

Classification of breeding and resting places simplifies the detailed planning of treatment operations and facilitates the selection of appropriate control methods that would suit each situation best. It should therefore be a basic procedure in comprehensive mosquito control as it allows selection of methods, material, and equipment that would fit local technical, operational, administrative and financial conditions.

In a comprehensive mosquito control programme, the number of different control methods selected should be restricted to as few as possible. Too wide a diversification complicates the execution and supervision of the programme. Pilot field trials may be indicated in situations where experience is lacking with the measures to be applied.

## 4.2 Comprehensive disease control

A broadened concept of comprehensive mosquito control can be applied to the control of parasitic dieseases. The causative agents of major parasitic diseases are transmitted by a number of arthropods or, in some cases, pass part of their development in other animals. Several species of flies, mosquitos, fleas, bugs, crustacea, and molluscs are involved as vectors or intermediate hosts. The complexity of selecting control measures that would yield common benefits and effectiveness can therefore be visualized. A closer review, however, shows that some control measures used against mosquitos are in fact directly effective against other vectors or intermediate hosts (see Table). Again, residual spraying used against mosquito vectors of malaria proved effective against Triatoma bugs, the vector of Chagas' disease (American trypanosomiasis) or leishmaniasis. Similarly, most basic operations used against mosquitos are equally effective against the snails that are the intermediate hosts of schistosomiasis. There are also occasions where two different control methods may be combined and applied in one operation, such as larvicides and molluscicides used in combined application. The latter, however, would require a careful study of the life cycles of the intermediate hosts and vectors concerned, and of the local operational and ecological conditions.[a] In the comprehensive approach to disease control, apart from vector control measures, curative and prophylactic treatment or field assessment and surveys and laboratory operations may also be usefully combined.

Where possible, such a combined approach should be considered to facilitate control operations and simplify organizational and manpower needs. The resulting savings and benefits will be important; the investment needed to cover the staff, field organization, equipment, transport, administrative services, and operational costs will be considerable.

## 4.3 Implementation in the existing disease control programmes

It is obvious that an important step towards a comprehensive

[a] In planning, implementing and evaluating comprehensive programmes for the control of diseases, full consideration must be given to the pathological, clinical, and epidemiological characteristics of the diseases involved.

approach to disease control would be the integration of the existing individual disease and vector control programmes into a single organization where planning, administration and evaluation of all these activities are concentrated. It is only normal that creation of such a «communicable» disease control organization will encounter resistance in the process of absorbing some of the vertical programmes, and therefore an evolutionary rather than a revolutionary approach should be adopted.

The process of reorganization may start with the integration of programmes that have certain activities in common. The attached Table shows those vector control measures that may be of common benefit in various disease control programmes, and it would be helpful to consider them when programme reorganization is contemplated.[6]

From the Table it can be seen that most parasitic and mosquito-borne diseases may effectively share one or more vector control activities. It should also be borne in mind that survey, evaluation, and treatment activities can be integrated only in a comprehensive approach. In most cases the same organization, staff, and facilities can be used to carry out such activities in respect of a number of diseases existing in the area of operation. Slight modifications of schedules or changes in the regimens are often sufficient to attain broader objectives without affecting the programmes' basic requirements.

Therefore in areas where such diseases are mutually present, steps may be taken towards a comprehensive approach. The introduction of such steps at the area level will probably require follow-up changes at higher levels in organization, programme, and functions. There thus appears to be a need for careful planning, preceded by a study of the details of the programmes involved and by an investigation of the most suitable method of evaluation.

Whatever the outcome and plan, it seems advisable that any reorganization be preceded by a period of adjustment during which closer cooperation and working relations between the programmes concerned are stimulated in order to facilitate a harmonious evolution towards a common approach

**POSSIBILITIES FOR A COMPREHENSIVE APPROACH IN OPERATIONS AGAINST PARASITIC AND OTHER MOSQUITO-BORNE DISEASES**

| Disease | Principal vectors | Larviciding | | Residual spraying | | Space spraying & ULV | | Source reduction | | | Biological | | Sanitation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Chemical | Application | Chemical | Application | Chemical | Application | Filling | Drainage | Maintenance (corrective operations) | Fish | Environmental manipulation | Housing improvement | Water supply | Excreta disposal |
| Malaria | Anopheles | x | x | x | x | x | x | x(x) | x(x) | x(x) | x(x) | (x) | (x) | - | - |
| Filariasis | Anopheles Culicine | x | x | x | x | x | x | x(x) | x(x) | x(x) | (x) x | (x) | (x) | - | - |
| Dengue | Aedes | x | x | x | x | x | x | x(x) | x(x) | x(x) | x(x) | (x) | (x) | - | - |
| Yellow fever | Aedes | x | x | x | x | x | x | x(x) | x(x) | x(x) | x(x) | (x) | (x) | (x) | - |
| Encephal. | Culicine Aedes | x | x | x | x | x | x | x(x) | x(x) | x(x) | x(x) | (x) | - | - | - |
| Leish. | Flebotom. flies | - | - | x | x | x | (x) | - | - | - | - | - | (x) | - | - |
| American Trypanos. Chagas' | Triatoma bugs | - | - | x | x | (x) | (x) | - | - | - | - | - | x | - | - |
| Onchocerc. | Simulium fly | x | x(x) | - | - | - | (x) | - | - | x(x) | - | x | - | - | - |
| Trypanos. | Tsetse fly | - | - | x | (x) | x | (x) | - | - | - | - | - | - | - | - |
| Schisto. | Snails | (x) | x | - | - | - | - | x(x) | x(x) | x(x) | - | (x) | - | x | x(x) |
| Protozoa and helminthic intestinal infections (soil-borne infections) | | - | - | - | - | - | - | - | (x) | - | - | - | (x) | x | x |

x = Greatly - (great possibility exists that the same chemicals, methods and equipment will be effective against all diseases marked with an x).

(x) = Partially - (the possibility exists that the same chemicals, methods and equipment will be partially effective or on certain occasions against diseases marked with (x)).

- = Not at all - (little or no possibility exists that the same chemicals, methods and equipment will be effective against other diseases marked with -).

## REFERENCES


1. Schaefer, M. (1974) *Administration of environmental health programmes: a systems view.* Geneva, World Health organization (Public Health Paper, No. 59)
2. Hall, W.A. & Dracup, J.A. Water resources systems engineering. New York, McGraw-Hill
3. Feldstein, M.S., Piot, M.A. & Sundaresan, T.K. (1973) Resources allocation made for public health planning. *Bull. Wld Hlth Org.*, Supplement to Vol. *48*
4. Porter, A. (1969) *Cybernetics simplified.* Bath, Pitman
5. Saksena, N.C. (1975) Automation in collection and processing of Hydrometeorological and hydrogeological data in India, ICID, R. 7, Moscow, 1975
6. Rafatjah, H.A. (1975) A comprehensive approach to vector control in malaria and other parasitic diseases control programmes. Geneva, World Health Organization (Document SEM/ANT. LARV/75/88)
7. Rafatjah, H.A. (1975) Enquêtes de faisabilité et aspects socio-économiques des programmes de lutte contre les maladies parasitaires. (Document SEM/ANT. LARV/75/58)