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II PAPERS / ARTICLES / BÉITRÄGE

IRRIGATION SYSTEMS: SOME ORGANIZATIONAL CONSIDERATIONS

by

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I. INTRODUCTION¹

The key problem of water resources development is the increasing demand for domestic and agricultural purposes. As societies are becoming more complex and diversified and demands continuously expand in scope, the use of scarce water resources and the preservation of the natural environment become important items in the planning and implementation of water resources projects.

In any area of human habitation three major aspects are to be considered which call for the immediate attention of the persons and organizational bodies concerned:

- (i) Continuously changing economic and social conditions, such as increasing population, and rapid urbanization.
- (ii) The presence of institutional factors, the result of long historical and cultural practices, reflected in laws and traditions of a given society and community.
- (iii) The environmental circumstances as conditioned by geographical and physical factors (e.g. humid, arid zones), the use of and misuse of the land and the pollution of the water resources.

Irrigation facilities are associated from early historical times with many civilized societies. After the very beginning of irrigated agriculture some thousands of years ago, irrigation systems have continued to be built and have been sources of national wealth and power for many countries. At the same time, all irrigation projects have been associated with efforts for local growth and diversification.

Many tropical countries seem to have abundant water resources,

but a number of studies and observations show that as these nations grow, the limitations of the land and water resources available become a matter of great concern. To a large extent efficient resource development will be dependent on the combined efforts of the proper governmental and autonomous agencies. On the other hand, organized efforts are needed at the local community level to let rural people participate in irrigation projects for rural development.

A key element of strategy is that water be treated as an essential production input, and that priority be given both in new irrigation and in improving existing systems to the creation of facilities which would allow farmers to make full use of modern implements, and to providing an assured water supply and drainage system down to the sized efforts are needed at the local community level to let rural people participate in irrigation projects for rural development.

2. TOWARDS A SYSTEMATIC APPROACH OF MAN-MADE AND NATURAL ENVIRONMENTS

In order to examine the interconnection between physical and social environments, it becomes imperative to provide a broad view of natural resources and a careful analysis of individual and community levels of water resources development. This is particularly true in irrigated agriculture which is functioning within a complex social and technical framework with varying degrees of success. Many of the basic decisions related to water development are made not only with technical considerations in mind, but increasingly call for a better understanding of the political, legal and institutional factors which control the allocation of water. Yet, in most water development schemes, there are a number of unknown processes with many interactions between the several factors involved which confront us. For this reason accurate predictions of the outcome of any proposed water development scheme are not possible. The limited water resources, the increasing population and the increasing demands for water supply call for new integrated forms of organization and execution. Also, a better understanding should be established between several disciplines concerned with water development.

From the sociological point of view part of this complex problem involves also a consideration of the organizational capability of present water management systems. New organizational forms contribute to more effective uses of existing services and to more efficient ways of

distributing the available water supply. While the overall supply of water is vital in any future planning of resource utilization, equally important from the social point of view is the fact that as pressures for water supplies increase there is also a stronger concern for proper social control against the waste of water and water quality deterioration.

A systems analysis

To develop a systematic framework for the consideration of social aspects of water resource development a systems analysis approach may be used. By this approach water development is understood as a system operating in a given environment where inputs (of a physical and social nature) processed through the organizational structure result in outputs or goals established for the functioning of the system. The systems approach makes it possible to identify not only component parts, but also various conditions under which the parts are functioning in relation to each other.²

Simply, a particular system implies a certain number of people, devices and procedures intended to perform a function. A systems model is a working model of a social phenomenon, capable of achieving a goal and involving the systematic exploration, analysis and evaluation of all the possible consequences of proposed alternatives to an on-going system. More specifically, an irrigation system may be defined as the application of water by human intervention to achieve maximum agricultural productivity.

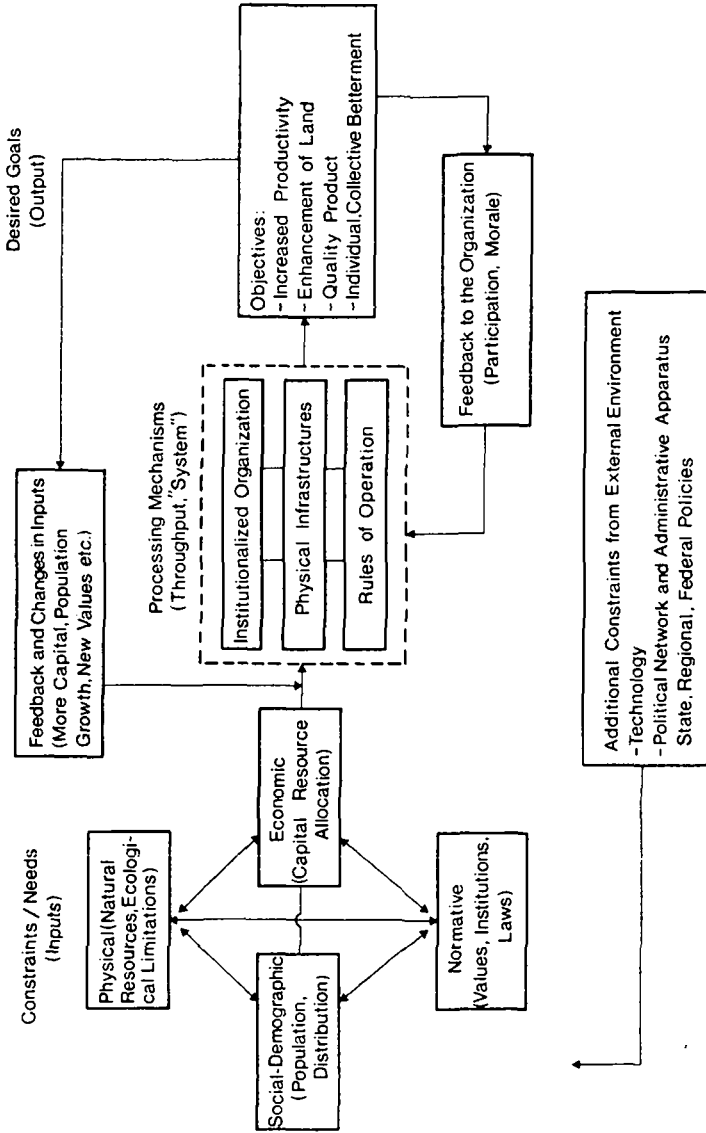
In Figure 1. one can distinguish four major environments. The first is the physical environment with particular ecological features (and its limitations); the second consists of the social stratification and the distribution of the population; the third represents the economic resources and potentialities. The fourth stands for the normative behaviour consisting of norms, values and legal institutions. These four entities provide the major inputs for the operation of a system or organization.³

Some of the most important inputs are those ways of normative behaviour that influence water use. The very central part of the normative behaviour, i.e. the legal norms and the institutionalized arrangements are among the crucial elements for the operation of an irrigation system.

The inputs from a variety of environments are processed through the structures and administrative procedures of the organization

Figure 1: A Simplified Version of an Irrigation System

Source: Vlachos 1972



concerned. The organizational system includes the intangible aspects of organizational structure, such as rules of operation, communication pattern of leadership, efforts for control, information, and ways of interacting with other organizational bodies. Although each organization contains these elements every particular structure is unique and is varying in size, scope and complexity from region to region.

The desired goals or objectives in an irrigation system stand for the output part and consist of a variety of goods and services for individuals, communities and regions. Recently, in addition to such well known objectives as increased productivity, wealth, health, security, etc., attention has been called to such qualitative goals as betterment of quality of life, equity, regional balance and others. These confront us with infinitely more difficult problems of evaluating the performance and effectiveness of an irrigation system.

Organization and inputs from the environment are linked with the output of an irrigation system, through two feedback loops. One loop provides feedback to the organization proper by way of increased participation of individuals, organizational strength and direct interaction between users and members of the organizational unit. The other feedback loop is understood as additional inputs such as more capital invested, increased needs and changed attitudes towards the four above mentioned environments. Ideally, feedback processes could serve as correction measures, which could increase the organizational effectiveness in coping with new circumstances (Vlachos, 1972, p. 297).

With the assistance of systems analysis as a working model we may be able to examine one aspect of water resources development as one affecting all parts of the system. Thus it will be easier to examine its functioning as a result of three types of changes in an irrigation system:

1. Changes in the external environment, such as changes in the total number of people, changes in the economy, changes in technology, etc.
2. Changes in organizational structures and procedures because of changes in size, capacities, different roles or patterns of communication.
3. Changes in output resulting from goal displacement, new targets or values and new policies of national or local authorities.

3. OBJECTIVES IN WATER RESOURCES DEVELOPMENT

As all development work is interconnected with policy making, it is first of all a matter of defining the policy issues and objectives. As a

second step one may select and design organizational measures which could foster the desired change in the state of affairs. Thus in estimating the possibilities of irrigation development it will be necessary to have an idea of the structure of the social and economic organization envisaged. Examples are the pattern of ownership of the land, control of water access, allocated budget, available personnel, etc. During the planning and construction phases of projects care must be taken that social objectives and economic feasibilities receive as much attention as technical considerations.

Careful compromises have to be made between different sets of development goals:

- 1) welfare and well-being of the people
- 2) revenue and foreign exchange for government
- 3) good use and conservation of natural resources.

A positive approach is also needed towards existing norms and traditions, acknowledging that the social organization serves vital needs. Social scientists should be consulted at the initial stage to ensure that plans are based on local needs and capacities. In many instances, however, they are only consulted at the implementation stage, in the hope that they can find solutions for social problems caused by the technical plan of operation.

The answers to these questions are not only related to policy objectives but also to the outcome to be expected from applying alternative solutions. Thus one needs to know not only the choice of organizational measures but also how the effectiveness of their operation will relate to technological, economic and social factors. It is relatively easy to calculate the costs of technical provisions suitable to different types of irrigation users: independent farmers, co-operative farmers or State farmers. It may also be relatively easy to forecast cropping patterns and their water requirements. It is a different matter, however, how these organizational patterns relate to the social characteristics of the people concerned. Is it possible, for example, for marketing to be organized on a small-group basis or should it be centrally organized for the whole irrigation settlement?

On the one hand, the objectives in water resources development can be considered in terms of benefits sought. Individual peasants in traditional circumstances have been using irrigation mainly under conditions of subsistence farming. With the opening of wider markets and introduction of modern technology, however, small irrigators have recently been profit-making.

On the other hand, it may be an objective to increase the degree of autonomy of the irrigating farmers in public schemes. Problems arise, however, when officials do not intend to delegate powers as this would decrease their powerful positions in the organization. A matter of interest in public schemes is the point in the distribution sequence where water is transferred to the farmers or farmers' associations. The larger the farms, the more knowledgeable the farmers and the more reliable the water supplies, the earlier in the process of distribution can the task be delegated (Levine, Capener & Gore, 1973). The local social structure, including land tenure arrangements, are of vital importance here, however. Unless access is equitable to all users, the landlords or those nearest the group-controlled water course will benefit most.

3.1. *Social objectives and consequences of irrigation development*

Although one of the objectives of irrigation development, is to raise farmers' income one should be aware of some consequences which work in the reverse order. Irrigation facilities constitute an important asset needed for agricultural development. High yielding varieties cannot be grown without regular watering during the crop season. Irrigated agriculture thereby forms a very advantageous proposition to the larger farmers and the rural elite.

Another effect of the green revolution has been a widening of regional differences. As the new technology depends to a large extent on the controlled supply of water and a package deal of agricultural implements, its adaption has tended to exacerbate existing inequities in income and wealth between the irrigated and non-irrigated regions (Rao, 1974). "The explosive widenings of regional income disparities is one of the most intractable consequences of the Green Revolution. It is the poorer class in the backward regions who suffer the greatest inequity in economic development" (Lele & Mellor, 1972).

Notwithstanding such adverse conditions, for most countries the pursuit of the green revolution seems a necessary condition to increased employment and welfare for the farmers. It stands to reason that production oriented policies should include guidelines for agricultural research, education, extension, etc. Public policies must be developed for distributing the results of technological change to the farming population as a whole.

Improving the conditions of the small farmer is important in the context of the general welfare policy; it also prevents him from falling

into even poorer strata of the population (UN, 1974; p. 23). To reduce the problems of risk and uncertainty involved in innovating farming methods vigorous action is to be undertaken to face these limiting factors. The provision of access to credit schemes that reduce risk is another step. As implements like fertilizers are scarce, methods should be introduced that they are not only allocated to the larger farmers. Furthermore, improved processing and marketing facilities are to be created to reduce price fluctuations.

3.2. *Efficiency in water management*

Thornton (1974) suggests to distinguish two categories of criteria by which irrigation schemes might be assessed as a first step to improve performance. Where water supply is becoming increasingly scarce it is important to apply suitable criteria.

Water utilization efficiency, if measured in terms of the water finally absorbed by plants as a percentage of the water diverted from the original source, is a function of the design of the scheme and the skill and outlook of the users. Generally speaking, small private schemes can be expected to achieve a fairly efficient use of both the initial investment and the subsequent flow of water. Transport distance is short and the supply can be carefully regulated, thus reducing waste.

In public schemes water utilization efficiency for a number of reasons is likely to be much lower. Large public schemes suffer for instance from serious water wastage through evaporation and seepage because of transport over long distances and from various defects in design. Raj (1960) estimated in the case of the Bakra-Nangal Scheme in Northern India that only 44 per cent of the water supplied was reaching the crops. Thornton (1974) reports that a certain slowness of farmers to recognize the benefits of irrigation, mismanagement during water allocation and ineffective charging arrangements seem to be the main causes of inefficiency in some South-east Asian countries.

The users must be strongly motivated to economise and the authorities should be alert to give the necessary information about regulations and distribution patterns, so that the farmers become familiar with irrigation practices. Rules of operation and maintenance as described in the systems analysis approach become thereby important features of any local irrigation system.

As regards efficiency in water administration, very few studies are available. Mellor and Moorti (1971) have studied and compared the

public and private tubewells in India. Public tubewells are larger, yet they are much less profitable and less popular among farmers. The quality of the personnel employed to maintain and control these tubewells appears to be inferior resulting in stoppages in water supplies, and corruption in the distribution. In the more complex public schemes with large numbers of users, administrative efficiency appears to depend on the following items:

- (i) effectiveness of two-way communication within the organization and especially across the gap between the public body and the users;⁴
- (ii) adequacy of technical knowledge about the requirements of maintaining effective water system;
- (iii) strength of morale at all levels of personnel (to be improved by suitable terms of employment) and
- (iv) adequacy of reporting on water quantities used, conditions of the canals, dealings with the farmers, etc.

On these lines it should be possible to work out a set of criteria by which to assess administrative efficiency.

3.3. *Some pressing problems*

Some thought should be given to a number of difficulties which are connected with nearly all irrigation projects to which little attention is given when planning and building water systems and organizational bodies.

First, knowledge about new methods of cultivation and irrigation requirements has been gathered and developed at research stations, but seems to be locked up in learned articles and books. They often do not reach field workers and farmers who should benefit from the knowledge collected. Also, the needs of the local population are not known because of a lack of proper communication between the farmers and the irrigation officers.

Secondly, farmers' values – their aspirations for better incomes, standard of living and attitudes to governmental institutions – change during their life-time and in between the generations.

Thirdly, rapid changes occur within the rural institutions themselves, baffling the public and the personnel as well.

Fourthly, it seems very difficult, when introducing a new technology like irrigation which can raise farmers' incomes, to avoid an increase

in income inequality. In some cases results are not satisfactory. For a number of reasons, income through irrigated agriculture has not grown as fast as expected and has been overtaken by population growth. Sometimes taxation systems which would reduce inequality become ineffective for lack of revision, or those with local political strength acquire certain priority treatment, whether this be agricultural credit, technical advice or water supply (Thornton, 1974).

Some solutions to these problems seem to include:

- (a) a better understanding of the role of research stations in rural development and better communication between stations, field-workers and farmers. Good examples in this respect are provided by Taiwan (Lionberger & Chang, 1970);
- (b) at least in large irrigation schemes, initial planning regarding the active role of the farmer in the several stages of irrigation development;
- (c) at all stages, whether at local or national level, close co-operation between those responsible for various aspects of the farmers' total environment, i.e. those providing extension services, credit, health, education and irrigation water.

Preserving water resources

In water resources development utmost care should be given to preserving the valuable sources of water themselves. Every year hundreds of square kilometres of tropical forest are replaced by agricultural land, roads, dams and other constructions. Little attention is given to the fact that when the forest is felled, surface soil is carried away by erosion, and the whole ecosystem is destroyed (Richards, 1970). Assistance should be required from governmental authorities (especially forestry services) to provide for measures to curb these tendencies and to protect the vulnerable mountain slopes and areas where rivers originate.

The cautious use of water resources and the preservation of the natural environment become important issues in the planning and implementation of water resources development.

4. PATTERNS OF ORGANIZATION AND CO-OPERATION

4.1. *Organized efforts at the local level*

As communities differ from each other and within communities different wants exist, the plans for integrated development projects must consider these various wants and needs. Careful planned projects are based on the economic and social life of the villagers and centre around their needs and circumstances. Under voluntary conditions of participation in planning, people will contribute some of their energy and time to those projects which assist in meeting their needs. In practice, however, many development plans have been marked by centralization, bureaucratic procedure, direction and control. Within this context it becomes understandable that there are many misgivings about the little initiative shown at the local level. In the long tradition of authoritarian leadership local people naturally expect the government to make and execute plans.

If the programme objectives aim at building self-reliant communities, there can be no better way of fostering patterns of confidence and self-reliance than to involve them in the planning process at the local level. That does not mean, however, that everything should be left to the jurisdiction of the communities. "Involving" assumes that the planning process has been started by an outside agency and is extended to the local bodies concerned for their contribution.

The people's participation can be best ensured through some form of organized effort, i.e. through local committees which can function on a continuing basis. If properly composed, these committees represent the major interest groups and reflect the various economic and social levels. As these bodies are frequently dominated by the local elite one should take care to include representatives of the lowest income groups. It becomes therefore necessary to ensure that supplies and services received from outside are distributed in an equitable manner and utilized for the purposes intended. Means of effective control, guidance and supervision by service agencies are in this respect essential elements.

4.2. *Modern forms of organization in traditional communities*

Some traditional communities have shown a certain coherence through informal relationships and undifferentiated institutions. Although they manifested a sense of internal unity, especially under stress from the

outside, their activities had no relationship with modern development. In many cases their primary motive was security and self-preservation. Improvements in education, and new relationships through better communications caused differentiations in groupings and associations. Also, in some instances traditional groupings broke down completely and gave way to crises and conflicts between locality members.

While there have been instances of social evolution, outside agencies have been trying to accelerate this process. Seeking to promote development in communities they tended to impose institutions and services without sufficient attempts to adapt and assimilate them to the local needs and customs. Accepted by some community members because of personal interests, these attempts have had many detrimental effects on the community as a whole. Coward (1973) calls attention to the fact that in most modernized irrigation systems water authority roles are performed by members of some government agency. These staff members are part of a professional group that is concerned with the design of complicated physical structures and procedures for water use. "Their concern is often translated into attempts to elaborate the social organization of the water users through irrigation associations, rotation groups of lateral leaders" (Coward, 1973, p. 211).

In establishing new forms of organization one should be very careful not to overlook already existing patterns of co-operation between the villagers. In this regard very interesting forms are found on the isle of Bali. There effective forms of water control are found in the *subak*. Commonly translated as "irrigation societies" *subaks* play a central role in irrigated agriculture on Bali. In fact, these age-old societies cover other sectors of social life as well: they function as agricultural planning units, as autonomous corporations and as religious institutions (Geertz, 1967). These ingenious and effectively functioning local bodies could serve as models for co-operation at the local level.

Another example is given by Downs & Mountstephens (1974) who studied a number of independent farmers' schemes in North-east Thailand. With respect to distribution practices, each farmer maintains his independence as far as possible, constructing and looking after his own appliances. These are usually very crude: the trunk of a banana-tree and some mud suffices for a check and a wooden tunnel through the canal bank, stopped with mud and leaves, forms an outlet. The farmers choose a leader to manage their scheme, and he appoints assistants. The men are unpaid, but are free of the taxes levied for the

maintenance of the weir. The leader arranges rotations of canals when the water supply is scarce, and arbitrates in occasional disputes. Above all, his principal responsibility is the repair of the weir, which is necessary in most years.

There are no pressing reasons why larger irrigation projects should not comprise independent units. These could be autonomous associations modelled on the farmers' irrigation schemes, of the internal affairs of which the farmers would have complete control. The units would form the lower grades of management and to them could be passed much of the maintenance costs. With these arrangements, proper attention will be given to the details of irrigation, vital at the farmers' level.

Co-operation and conflict

With the emphasis which is laid on creating forms of co-operation between farmers one may tend to overlook the existence of conflicts. Especially in irrigated areas causes for conflict between irrigators are always present. One of the common grounds for conflict is constituted by inequalities with respect to water access. Farmers at the far end of a water canal have to wait longer in preparing their fields and are eager to reduce this waiting period. Unless efficient measures are taken for rotation in water access disputes arise between farmers at the farthest and nearest side of the water head. Other causes for conflicts are the damage done by stray cattle to dykes and negligence in maintenance work by neighbours.

Pasternak (1968, p. 337) reports that conflicts over water occurred in one village in Taiwan during periods of unusual drought. At such times, the number of irrigation group meetings increase drastically. "Distrust, hostility and general anxiety permeate the village and farmers stay up all night to patrol their field and doublecheck the watchmen". The same author has found also that the introduction of waterpumps and pumping stations in recent years has resulted in a decrease of conflicts over water. At the same time, these new means have reduced the necessity for co-operation in water management and have caused a shrinking of local co-operative networks. This example shows that the introduction of new technology may result in the deterioration of existing patterns of communication.

4.3. Co-ordination at regional and national level

As a nation's water resources development continues to grow choices

must be made involving alternatives, sometimes on a medium regional scale or on large scale multi-purpose schemes including irrigation and hydro-electric power. In both cases central decisions should be made at regional level. The form of such decision structures and their links with the national administration apparatus must be centrally decided.

National boundaries frequently cut across river basin areas, giving rise to the need for collaboration between nations. A well-known example is the Mekong Basin, where representatives of the four riparian states have had regular meetings to discuss the several problems of riverbasin development.

National laws become necessary for the control of natural resources in order to provide for a rational way of development and to prevent their exploitation for private ends. Irrigation policy must be seen in the larger context of rural development, and is inseparable from such issues as land policies, settlement projects and land reform.

It may become necessary to co-ordinate several irrigation developments in order to ensure optimal phasing of water resources development and to secure sufficient uniformity in the overall procedures so as to arrive at a broad equality of opportunity for water users.

A number of alternative organizational models is conceivable for the integration of project development in a broader national framework. It may be argued, however, that a degree of regional decentralization is always desirable, where co-ordination between governmental departments can be established (Thornton, 1974). Whatever models may be conceived, highest priority should be given for providing workable structures that deliver best services to the farmers concerned.

5. EDUCATION AND TRAINING

As is the case with so many aspects of rural development education and training are vital issues in water resources development. One can make a distinction between education and training by conceiving the former as the more deeper and fundamental issues of learning; and the latter as consisting of elements of a more practical nature.⁵

In order to obtain effectively operated irrigation systems it is essential to provide for education and training of the higher staff of engineers and administrators. Not less important is the provision of a broad training programme for intermediate levels of personnel. Within the latter, two categories could be distinguished. The first category

consists of the new employees or newly transferred employees within the service; the second category is formed by the regular employees. Although the training programme deals mainly with the operation and maintenance of irrigation schemes, differences between the two are shown by the type and length of the courses. A comprehensive analysis of the demand for manpower at the project and sectoral level is an essential step in determining the specific requirements of water resources development (Mehta, 1966).

After a careful selection new employees should be given the broadest knowledge possible in the allotted time. In order to enhance the practical nature of the training it is recommendable to remodel existing training institutes or to create new centres. If properly staffed and located in representative areas these centres serve as ideal training grounds. They could also be used for experimentation and demonstration purposes (see next section). This pre-service training should be so devised that in addition to providing the requisite knowledge, the trainees receive a better understanding of the objectives of irrigation development. A good introduction in rural development work, and methods of working with rural people should be included in the course.

For the regular employees in-service training courses are suitable if given on a regular basis. In a period of 6-10 days covering different subjects the programme should bring the personnel up to date on the latest methods of work and new equipment. Much time should be allotted both to discussing the several experiences gathered and to the problems connected with field work. Well-documented case-studies are valuable assets in describing a particular project, stimulating the participants to consider possible solutions of the problems involved. The case-studies could include the operation of the distribution system, new maintenance techniques, working with irrigation associations, etc. The information received from the participants gives the training staff on their part a better appreciation of the practical problems involved in field work.

So far we have considered some points in the training of personnel within the organization. In order to broaden the scope of the programme training should be extended to the people being served by the organization. It is vitally needed that training services reach the several sections of the rural population. Unless farmers have a reasonable understanding of the irrigation at the receiving end, disputes may arise about distribution patterns. This kind of training

is commonly called orientation training. It is a difficult form of training because it aims at influencing people's attitudes, and attitudes can be very hard to change. Nevertheless, orientation training has given some remarkable results, e.g. in the Philippines with the implementation of the national community development programme in the sixties (Villa nueva, 1961).

Just as in the other types of training skilled trainers are needed and these are in short supply. This being the case, it is advisable to plan all training courses well in advance. Care should be taken that they do not serve as mere propaganda talks on the part of the organization. Basically useful information is needed about the functioning of the irrigation system and the help the users can give in maintaining the canals. In establishing irrigation associations special training courses for local leaders and council members may be developed.

6. RESEARCH AND EVALUATION

Research of varied types is needed in accelerating water resources development. The growing needs in this field will necessitate a continuous flow of new knowledge from research institutes to potential users. Already a great amount of technical and engineering research has been undertaken in the development of irrigation systems. Studies with a social and economic impact have so far lagged behind. Recently, more interest is expressed in undertaking such studies by international agencies as Food and Agricultural Organization (FAO), International Institute of Tropical Agriculture (IITA) and International Rice Research Institute (IRRI). It is recognized that detailed studies of the farmers' environment are needed.

These could include:

1. Physical features – soils and vegetation
2. Land tenure and farm size
3. Inventory of crops and animal husbandry
4. Village composition and settlement patterns
5. Social organization, family composition and division of labour
6. Cultural situation and literacy
7. Diet, health factors and level of living
8. Harvesting, processing and storage of food stuffs
9. Rural extension activities
10. Sources of credit available and marketing.

These and related subjects will require the contributions of sociolo-

gists, anthropologists, economists, agronomists and geographers. For the more technical aspects early consultations with irrigation engineers, soil scientists and botanists are needed. Although the scope of such studies may appear formidable, a review of available information from various sources and literature saves much time and energy.

Smallholders in the developing countries need information about the required quantities of water for their various crops. They also need simple irrigation structures that could facilitate development of small watersheds and conservation of water. Investigations of these aspects and the more general water requirements of tropical crops under supplemental irrigation are worthwhile. One of the most important aspects of water management research, however, is the study of social and ecological implications of irrigation projects of various types and scales (Okigbo, 1974).

In any case, studies should be of a practical and operational nature, leading up to conclusions and recommendations for action. The research programme could stipulate the importance of the position of the farmer, his current practices and the structural conditions and changes he is facing.

Execution of integrated research programmes involves many disciplines and not all relevant staff may be available at the appropriate time. In this respect projects can be farmed out to scientists in universities and research institutes. Visiting scientists and graduate training programmes may also assist in the solution of this problem. In executing an integrated research project there is need for flexibility to allow researchers to carry on some study in their own disciplines, provided that this work is related to the established priorities. There is also much scope for co-operation at the personal level.

Seeing the pressing needs of applied research in the several stages of development, special attention is to be given to field-experiments, demonstrations, evaluation and operational research. Research findings should be adapted to the general understanding of development workers and farmers and *not* exclusively to the readers of learned journals. The systems analysis approach has shown farmers form the most important part of the social environment of any irrigation system. They therefore should be treated as the main beneficiaries of the studies' outcome.

NOTES

¹ An earlier version of this paper has been presented to the Symposium on Social and Non-Economic Factors in Water Resources Development at Bangkok (9-15 December

1975). The symposium was convened by the Economic and Social Commission for Asia and the Pacific (ESCAP).

* A useful introduction to the systems approach in the social sciences is given by W. Buckley (1967), *Sociology and Modern Systems Theory*. In the application of his ideas to the present subject the author has greatly benefited from the paper by E. Vlachos (1972).

† In fact there are other inputs as well, stemming from the state of technology, the larger political structure and the linkages with other administrative units.

‡ This includes the elements of "feedback" as mentioned in para. 2, i.e. information about the performance of the system, about unanticipated effects, etc.

§ A thoughtful treatise on education as "the transmission of ideas of value" is given by Schumacher (1972, Part II section 1).

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SUMMARY

The paper attempts to present a framework for a number of sociological considerations involved in the analysis of water resources development practices. Special emphasis is given to the nature of some organizational implications connected in irrigated areas in tropical countries and to various constraints affecting the development and future use of water resources for agricultural purposes.

The main argument is that in many heavily populated countries there is much scope for the improvement of organizational measures concerning water utilization besides the development of natural water resources as such. In describing problems of water development a systems approach is advocated, which attempts to integrate social and physical dimensions in order to achieve maximum utilization of water resources.

The conclusion is the paper delineates the importance of the participation of water users in the planning and implementation of projects and to make provisions for flexibility in water management.

RÉSUMÉ

Cet article essaye de présenter un cadre pour tout un nombre de considérations d'importance pour l'analyse des méthodes employées dans le cadre du développement des ressources en eau. L'accent est mis tout particulièrement sur la nature de certaines implications pour l'organisation dans les zones irriguées des pays tropicaux, et sur les différentes contraintes affectant le développement des ressources en eau et leur usage ultérieur dans l'agriculture.

L'argument principal est que dans beaucoup de pays très peuplés,

parallèlement au développement des ressources naturelles en eau, il y a un large champ de manœuvre pour améliorer l'organisation de l'utilisation de l'eau. En décrivant le problème du développement des ressources en eau, nous défendons une approche systématique qui essaie d'intégrer les dimensions sociales et physiques afin d'atteindre une utilisation maximale des ressources en eau.

La conclusion de l'article esquisse l'importance d'une participation des utilisateurs de l'eau à la planification et à la mise en œuvre des projets, et celle d'une grande flexibilité dans le cadre de la gestion de l'eau.

ZUSAMMENFASSUNG

Dieser Artikel versucht einen Überblick über eine Anzahl soziologische Problemstellungen in Bezug auf die Analyse der Entwicklung von Verfahren zur Nutzung von Wasserressourcen zu geben. Besonderes Augenmerk wird dabei auf die Bedeutung einiger organisatorischer Gesichtspunkte in bewässerten Gebieten tropischer Länder und auf diverse Constraints, die auf die Entwicklung und auf den zukünftigen Gebrauch von Wasserressourcen für landwirtschaftliche Zwecke Einfluß nehmen, gerichtet.

Neben der Entwicklung natürlicher Wasserressourcen, so das Hauptargument, besteht in dichtbevölkerten Ländern ein großer Spielraum zur Verbesserung organisatorischer Maßnahmen zur Wassernutzung. Bei der Beschreibung von Problemen der Entwicklung der Wassernutzung wird ein Systemansatz befürwortet, der soziale und physische Dimensionen zu integrieren sucht, um hierdurch zu einer maximalen Ausnutzung der Wasserressourcen zu gelangen.

Die Schlußfolgerung dieses Artikels zeigt die Bedeutung sowohl der Teilnahme von Wassernutzern an Planung und Durchführung von Projekten, als auch der Sicherstellung der Flexibilität in der Wasserbewirtschaftung.

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