When a man-made lake is created, the members of the lake basin population are displaced, crowded, or supplemented by new migrants, and are often stirred by the political repercussions of enforced relocation. Beyond that population, a much larger area is affected by the development of new conditions of life and livelihood. Generally, the larger the lake the greater and more complex the impacts on the socio-cultural system.

The Lake Basin Population

Within the lake basin the human population can be divided into four general categories, of which the first two pose the most problems. These are: 1) those who must relocate because their homes and fields will be partially or totally inundated by the reservoir (the relocatees); 2) those among whom most of the relocatees must be resettled (the hosts); 3) those lake basin inhabitants who are neither relocatees or hosts; and 4) immigrants who move into the lake basin seeking new opportunities which accompany dam construction and reservoir creation.

Throughout the world most relocatees desire to remain as close as possible to their original homes or family or tribal association, although a significant minority opt to use relocation to seek a new life elsewhere. As for the hosts, they may or may not be members of the same society or tribal group as the relocatees. Even if they are, differences in dialect, behavior, attitudes and expectations may set the two populations apart at the time of relocation. Furthermore, both will differ from immigrants who often are risk-takers and more apt to innovate.

Increasingly, planners attempt to bring benefits of the dam to the lake basin population. This is especially true for the relocatees who must give up their homes and surroundings for the national good. For this purpose, it is important during the feasibility studies (I, Fig. 1.4) carefully to analyze the benefits and costs of relocation and of alternate development strategies for the entire lake basin population. Some of those strategies have major implications for other management objectives of the reservoir. The social and economic benefits, for example, of extensive lake margin agriculture, one requirement of which would be regularized drawdown and filling, might be sufficiently great to warrant some sacrifice of power, flood control and other benefits and this now is done in planning projects in certain industrial countries. Also during the feasibility stage, important policy decisions are needed as to who should participate in new resource opportunities and as to the spatial pattern of settlement. If the local people, for example, have no fishing skills, immigrants from other fisheries may move in and fill that occupational niche before lake basin residents respond. The implications of this possibility need to be carefully assessed in terms of a wide range of factors including continued productivity at relatively low costs, immigrant-local relationships, availability of other occupations for relocatees and hosts, capacity of government agencies to provide training, extension and other services, and so on.
The local population is part of a complex socio-cultural system which is intricately interrelated with the physical and biotic components of the lake basin habitat. They are members of a dynamic coping system. Corresponding with the lake basin and the reservoir site, this is, to a considerable extent, already a man-made ecosystem. Though the local people may not be responsible for dam construction, their future activities, and especially their land and water use will modify their habitat just as surely as the habitat will influence these activities. Because we are dealing with people who can innovate or accept innovations, the range of possible interactions with the lake basin is very great.

Lacking a general theory to predict these interactions and their consequences, we must fall back on careful planning as an ongoing process in which attempts are made to assess the impact of particular development strategies ahead of time. Subsequent evaluation of actual activities may then help to identify problems before or as they arise and to propose appropriate solutions.

The Relocatees

From the human point of view relocation has been one of the least satisfactory aspects of reservoir projects. Not only is it an incredibly complex process, but it is expensive in money, personnel and time. Rather consistently, analysis of the implications of relocation has not been included in feasibility studies. The numbers of people involved, as at Kariba, are often seriously underestimated, while the diverse needs of different categories of people (children and the elderly; landowners, tenants, landless laborers and so on) seldom receive sufficient attention. Also seriously underestimated is the financial cost of compensating and physically moving people, and of forming new communities and new systems of production, and the time required for essential help. In the major African projects per capita relocation expenses and final estimates have varied from approximately $200 per capita to more than $2,000. In all of these projects the relocation expenses have been at least three times the original estimates, and sometimes substantially more. Had planners known from the start that relocation costs would rarely be less than 25 percent of the combined cost of power generation and transmission and dam construction, they would have approached feasibility studies in a rather different way. Sometimes financial costs of resettlement may be sufficiently great to offset expected benefits of dam construction in comparison to alternate uses of funds. This is the kind of judgment to be faced in future large projects such as the proposed Pa Mong project in the Lower Mekong Basin.

While it is desirable to involve eventually the entire local population within the integrated development of the lake basin (which itself must be carefully integrated within national and regional development), initially the relocatees require special attention. Compulsory relocation of an entire population incurs stress — physiological, psychological and socio-cultural. Every relocation project has an initial transition period during which the relocatees attempt to alleviate stress. This begins as soon as they become aware of the possibility of relocation, which at the latest, usually occurs during the stage of planning and construction (II). It ends when they are once more economically self-sufficient and when they have come to terms with their new surroundings, including the hosts. For the majority,
the length of the transition period is seldom, if ever, less than one year from the time of actual resettlement. Where the people are incorporated in ambitious but poorly planned government schemes radically to transform their economies and life styles, project failure can prolong the transition period well into the stage of stabilized lake conditions (IV). Even where planning is effective, some, and especially the aged, will never come to terms with their new homes. For them, the transition period ends only with death. A government takes on that social responsibility when it causes compulsory relocation.

The period of transition is a period of active coping, when the socio-cultural system of the relocatees is adapting to new circumstances. Initially the system reduces its behavioral complexity. Certain premises and attitudes may also be dropped. Although the actual situation will differ from reservoir to reservoir according to a wide range of variables including the socio-cultural system and the goals of policy makers, some behavioral patterns are dropped simply because they were tied to the old surroundings or because they are inappropriate within the new surroundings. With insecurity, some people may minimize their vulnerability by doing as little as possible, and others may engage in random exploration. Furthermore, people may cease temporarily to practice distinctive customs for fear of alienating the hosts. The very fact that government can uproot people against their will can undermine confidence in capacity to control their own lives or at least to influence the impact of external forces. By analogy with ecosystems, simplification of the socio-cultural system can be dangerous in that it can lead to breakdown and demoralization. However, it can be a mechanism for leaving behind forms of behavior that are counter-productive in terms of subsequent modernization or that could not be jettisoned in the old habitat. Regardless of the situation, it is important that the relocatees regain their self-respect and self-sufficiency.

The initiation of environmental change thus provokes a crisis of individual and cultural identity. Whereas this appears inevitable in that no preparation can in fact eliminate the shock of being physically uprooted (and the accompanying sense of helplessness), the relocation authority can do a number of things to ease the stress and to end the period of transition as rapidly as possible. These include:

1. Completion of suitable social surveys which will, among other purposes, identify those relocatees who wish to move as communities and those who wish to move as families and individuals. Although those with certain job skills and education may need no government assistance at all in finding new opportunities and homes, even in post-industrial societies, lower income groups, minorities and the elderly will need more help than they have received in the past. In developing areas, the probability is high that most relocatees will wish to move as communities, although in some projects (for example, Nam Pong in Thailand) a significant proportion may wish to relocate themselves. Because of the complexity, costs and high risks associated with planned resettlement, it may be in the government's short-term interests to facilitate wherever possible individual and family movement even though there is some risk of crippling the community by removing leadership. Capacity to facilitate is closely tied to understanding by the relevant agencies of the desires and abilities of the relocatees, linked with flexibility of action.

2. Continual two-way communication with the relocatees (and to a lesser extent,
the hosts) to educate them for the movement and to determine their major wishes and concerns. In spite of a wide range of potential difficulties, special consideration should be given to involving the lake basin population, through carefully selected representatives, in the planning, execution and evaluation of resettlement and lake basin development. Such involvement may undermine local leaders unless they are given a genuine role.

3. Early initiation of educational and training programs so that relocatees and other lake basin residents can benefit from new opportunities. Where people wish to move as a group, it is also important, prior to relocation, to create pilot communities, with supportive land use systems based on means available to the average producer, so that the relocatees can have some idea of what the future holds in store for them.

4. Relocation of people into communities where essential services are operative from the beginning. At the minimum these should include housing (which may or may not be government built), an adequate water supply, sanitary facilities, equipment or domestic stock, and medical services.

5. Restoration of community self-sufficiency at the earliest possible date. By this is meant the development of economic production systems. Whereas the strategies used obviously depend on government policy, lake basin development takes time. Where planning is delayed until actual construction begins there is insuffi-cient time to prepare new land use systems and other economic opportunities. This has been the situation in the major African projects where relocation has taken on many of the aspects of a crash program to remove the people from the reservoir area before inundation. Because new production systems were not operative when relocation occurred at Kariba, Volta, Aswan, and Kossou it was necessary for government to arrange food relief to the people for one or more years. This is an expensive and unproductive operation, and it runs the risk of creating a dependency syndrome among relocatees who come to expect the government to continue to meet their basic needs. Although the best corrective is advance planning, a more flexible timing of dam closure also deserves consideration where warranted by social circumstances. While this has not been possible with narrowly conceived hydro-electric projects where dam construction is rushed to meet rising energy demands, future careful assessment of a wider range of benefits may justify delayed closure in some circumstances. On the basis of past experience it appears advisable to concentrate upon a small and carefully selected number of development activities at the time of resettlement rather than to bombard the relocatees with a wider variety of innovations.

It is also important to involve the hosts in new development opportunities, including, for example, the lake fisheries. Otherwise, deteriorating relationships among administrators, relocatees and hosts interfere with social and political stability and economic growth. Because the better resettlement areas usually are already partially occupied, relocation almost instantaneously increases population density and the demand on land resources and job opportunities. Higher population densities require careful planning so that the land and job opportunities support both relocatees and hosts at an adequate standard of living without causing environmental degradation. In some areas this may not be possible solely with agricultural intensification and may require special provisions for attracting in-
dustry. It may also be necessary to reserve, at least temporarily, the fisheries and the lake shore margin for exclusive use by the lake basin residents. Thus, traditional fishing rights of migrant fishermen may be endangered.

Continuity and Change

Continuity is important for those who must relocate in connection with reservoir formation. Rational irritation and local loss of faith in government may accompany relocation, but rapid and dramatic changes in ideology have not been documented during the transition period for any man-made lakes. Rather, two complementary coping mechanisms have been observed. One amounts to a form of socio-cultural withdrawal, whereby the total inventory of behavioral patterns is reduced. The other, outwardly directed, initiates the process of adaptation first to the threat of resettlement, and secondly, to the new surroundings. While certain dramatic changes in behavior may occur at this time, as, for example, farmers experimenting with full-time fishing, or tenants with land-ownership, it would appear that within the context of resettlement people change only so much as they have to in order to continue the realization of relatively fixed cultural goals.

Neither of the two mechanisms necessarily has negative implications for government attempts to induce change. Whereas a severe crisis of socio-cultural identity may temporarily immobilize much of the population, the dropping of certain customs in the long run may be beneficial. A process of adaptation which includes some experimentation presents selective opportunities to development planners. This is especially true in regard to the better educated, more mobile, and innovative members of the lake basin population. As the proportion of these within the population increases, the opportunities for rapid and radical change rise. Hence, the initial opportunities for economic change within the various lake basins of the Tennessee Valley in the United States exceeded those at, for example, Kariba. Nevertheless, with compulsory resettlement everyone must be moved — the elderly and the conservative as well as the young and the progressive. Even in post-industrial nations with high literacy and mobility, rural populations tend to contain a greater proportion of the elderly and the traditional than do urban centers. Over half of the people resettled in connection with twenty TVA reservoirs were tenants who are less apt to have the resources to innovate than landowners and businessmen.

In past, river systems served as important routes for prehistorical migrations and as corridors for settlement. All too often reservoirs have been created before archeologists have had sufficient opportunity to survey the area to be flooded, and to excavate the more important sites. Similarly, people were moved before historians and social scientists could record their traditions and study their customs and interrelationships with their river-basin habitat. As mankind becomes increasingly concerned about the future, and interested in the past, we cannot afford to destroy our history without some sort of record being first obtained. The reasons to support this view are both practical and theoretical. It is practical in that information about the past is a part of the local heritage which nations may wish to incorporate into their schools and into their national culture, and in that baseline studies of the contemporary population help planners choose an appro
appropriate development strategy. It is theoretical in that knowledge of the past forms a data base for the testing of theories. Archeological, historical and contemporary socio-cultural studies should be completed at some minimum level of expenditure in river basin areas where there is reasonable probability of a future reservoir. It is anticipated that occasionally the findings from these studies will provide sufficient reason for rejecting a particular dam site or height or for choosing another alternative to building a particular dam.

**Incorporation Within the National Fabric**

Reservoir creation speeds up the incorporation of the lake basin population into the nation of which it is part. New roads to the dam site and reservoir channel people, goods and services both in and out. Rural development tends to speed up the integration of local residents into a wider economic context. Construction on the dam requires a large labor force, most of whose members may be from outside the basin and who introduce new ideas and customs. Resettlement is usually accompanied by new schools and other social services.

The benefits and costs associated with this process depend partly on who calculates them. Not only do they vary between various age and occupational categories among the local people, but they also differ as seen by individual members of these categories. From the governmental point of view, benefits and costs will vary according to the interests of the agencies and personnel involved, and the development following impoundment. Increased communication with the outside world causes local expectations to rise. If these are not met through improved job and land use opportunities, the gap between aspirations and achievement widens. Aside from discontent and potential unrest, one probable result is accelerated migration of young people to cities which may or may not be able to absorb them. While a distinctive ecosystem is created, the change knits the lake basin more closely into a widened fabric.

**Central Planning and the Lake Basin Population**

Man-made lakes characteristically are the result of external planning by a relatively autonomous development authority or a centralized agency. In developing countries, big dams like Volta or the Aswan High Dam may be the most expensive projects within national development plans. Partly for this reason, historically the lake basin population has seldom been involved in the planning, execution and evaluation of a program directly affecting its future, although there are important exceptions. So far as communications and time permitted the Volta relocatees were consulted as to plans, but tragic political errors then were made.

Increasingly, social scientists study the interrelationships between the lake basin population and government agencies as part of one system. The effort is to understand the behavior and goals not only of the local people, but also of the administrative officers. Conflicts are apt to arise among agencies, and between them and the local population, and from the outset the resolution of these tensions influences the design of the reservoir and accompanying investment.
Most research on the interrelationships between organizations and populations is undertaken so late as to have little or no impact upon either agencies or people. One responsibility of such research is to assess the capacity of the development agencies to achieve their goals. Another is to explain the ecological system perspective to the developers, to help them better to understand not only the relationships but also the potential sources of friction and inertia within the system. A third responsibility is to facilitate two-way communication between all participants, so as to reduce the likelihood of major misunderstandings. In developing countries a relatively uneducated lake basin population tends to be suspicious of government goals and personnel, while the latter expect the people to be immediately grateful for government help. By contrast, in some industrial societies, the citizenry increasingly demands a role, often a leading one, in decision-making relative to regional development and to reservoir operation. In the absence of effective mechanisms for bringing together those who want a piece of the action, there is need to institutionalize such new concepts as "open planning". It may be expected that future planning of man-made lakes will place growing weight on the part of citizen groups in setting goals and operating schedules.

Lake Basin Development

The Development of New Land Use Systems: Agriculture, Livestock and Forestry

An integrated land use system is the key to increasing the productivity and maintaining the quality of the terrestrial communities of the lake basin in relation to water use and aquatic communities. Agriculture, livestock management and forestry affect each other, and combine to modify the social, physical and biological systems. Forest reserves protect water catchments, tributary banks and the lake perimeter, and their sites influence recreational, domestic and industrial needs. In a developing area they may be the principal sources for wood for family cooking, building, and cottage industries. Livestock pastured along the lake shore margin may promote water pollution, disease and reservoir silting.

Within developing countries, the intensification of lake basin agriculture has been one of the least satisfactory aspects of reservoir projects. While TVA has a more successful record, the extent to which tenant farmers, landless laborers and other low income groups shared in that success is still not clear.

In developing areas the lake basin may be only an incidental part of a big dam project. Agriculture is more apt to be stressed in irrigated areas below the dam. However, agriculture requires discerning attention within the lake basin for two reasons: 1) a large proportion of the lake basin population must continue to support itself by agriculture for a long period; and 2) relocation usually increases population density and thereby increases the probability of severe environmental degradation through over-cultivation and over-grazing. Development of a new land use system, a risk today at Kariba, and a threat at Volta and Kossou, may impair the physical and biotic base of terrestrial communities.

Introduction of agricultural change is complex, intricate, and poorly understood. Settlement schemes have a high failure rate around the world. They provide housing and social services, but often are unable to assure viable land use. Viable here
means a system of satisfactory production, simple enough to administer, which achieves the cooperation of the settler, and does not reduce yields per acre and unit of labor as a result of land degradation. In a broadened content the viability of new land use systems also is linked with their capacity to absorb additional labor if the regional or national economy has increasing unemployment and underemployment.

Few developing countries have a suitable agricultural plan for the lake basin at the time of flooding, let alone the administrative capacity to execute a plan following inundation. More emphasis has been placed on resettlement areas, some of which are outside the lake basin, as in the case of the Aswan High Dam. People usually are shifted before new land use systems are sufficiently productive to support them. One adverse result in connection with the major African reservoirs, with Kainji being the major exception, is a prolonged and potential demoralizing period of food relief.

There is no easy procedure for developing new support systems for relocatees and other inhabitants. In the case of most African projects, except Volta, planning for resettlement and lake basin development was delayed until after preparatory works began at the dam site, and in some instances, until dam construction began. The result was insufficient time to implement new economic systems at the time of resettlement.

The obvious means to avoid this is to broaden the feasibility surveys to include agricultural, socio-cultural and ecological analysis. A major function of agro-ecological studies is to identify areas which can be cultivated. As populations increase, the task becomes harder. Another function of agro-ecological studies is to provide information on how the land may be allocated and used, taking into account individual and community choices. The extra cost of the needed surveys during the feasibility phase is small compared to the potential benefits. Based on information on the economy, habitat potentialities, and individual expectations, training and extension programs can be drawn up.

A technically feasible plan is of little use if the local people are unwilling or unable to exploit it with the desired results. One function of socio-cultural studies is to assess those aspects of present land use systems and farmer attitudes pertaining to the change which the people and agencies think promising. An effective extension service requires two-way communication. On one hand, its task is to extend to the farmers the results of agricultural experience gained elsewhere. On the other hand, it must inform those developing new land use systems of bottlenecks relating to the farmers' capacity, ability and willingness to produce. While some bottlenecks are inevitable, their number and severity can be reduced if the provision of new techniques takes into consideration the strengths and weaknesses of the farmers' present system.

The need for ecological surveys is partially tied up with the expected increase in population density following relocation. Resettlement at both Volta and Kossou, for example, significantly reduced the land available for cultivation on a per capita basis. Risk of land degradation increases if the people attempt to increase short-run production by reducing the period of fallow rotation, or by eliminating green manure crops. Even if production is successfully intensified through the use of mono-cropping, manure, chemical fertilizers, pesticides, herbicides, and supple-
mental irrigation, the ecological implications of such techniques are only partially understood in the tropics, as elsewhere. The risk of ecological boomerangs is sufficiently great as to require periodic assessment of the environmental effects of new land use systems. This has a corollary alertness to breakthroughs in research, the implications of which are compatible with preserving the habitat.

A unique feature of man-made lakes is the drawdown area. Where the primary purpose of the dam is power generation, the annual drawdown may be more irregular than the annual regime of the river prior to impoundment, as at Kariba. In these circumstances, the risks to the farmer are usually too great to justify using the drawdown area for cultivation. This poses a policy choice since the drawdown area at Kariba and other tropical reservoirs has the potential for supporting thousands of small holders. At Volta some research has already been carried out on the biological capacities of drawdown soils for cultivation, and a few immigrants are farming on their own. More research of the same nature is required before new projects are undertaken, and there is special need to test different land use techniques within the drawdown area. These should include a wide range of crops, with and without the use of supplemental water. Fodder crops may be especially appropriate because they have a shorter growing period and enhance the possibility of integrating livestock management. This would be valuable in semi-arid areas during the dry season drawdowns when both water and grazing are at a premium elsewhere.

Efficient utilization of the drawdown area for agriculture and animal husbandry requires that the drawdown regime be carefully regulated. To do so in a multi-purpose project requires that the benefits and costs of drawdown utilization in comparison with other potential uses of the water than the primary uses be computed. Because such analysis is generally lacking, no one knows the extent to which drawdown areas could contribute to national production and employment.

**Fishing**

One of the more gratifying aspects of man-made lakes is the speed with which a reservoir fishery usually develops and the extent to which fish landings and fishery jobs increase. In the tropics, rural residents respond rapidly to new opportunities, and, indeed, fishery development may slow down movement to the cities, and even bring back former migrants. On Kariba's north bank more than 2,000 local fishermen were landing over 4,000 short tons of fish per annum within five years of reservoir formation, and outward migration reduced significantly. At Nam Pong in Thailand approximately 1,000 fishermen were present after a similar time period, while the figure at Volta was estimated as high as 20,000 fishermen using 12,000 canoes and landing up to 60,000 metric tons of fish per annum. The response was spontaneous; fishery development was not facilitated by government action, as at Kariba.

Notwithstanding the potential of reservoir fisheries for providing food and jobs, it cannot be assumed that landings and number of fishermen will increase. Quite to the contrary, the figures quoted from Kariba's north bank correspond to the period of reservoir formation (III). Thereafter landings dropped off rapidly so that ten years after closure they were only about 1,000 short tons per annum, and the number of fishermen fell equally dramatically.
While landings at Kariba began gradually to rise as the lake entered its early stabilizing phase, fluctuations in lake productivity pose complex problems. If the same trend occurs at Volta as occurred at Kariba, perhaps half the fishermen may go out of business. There are at least two possible solutions. One is to slow down the buildup of fishing during the initial period of high productivity; the other is to be prepared to take compensatory action in the fishery at the time productivity peaks, possibly by introducing new gear and techniques, and encouraging the use of previously unused or underharvested species stocks. The latter option, if it can be made to work, may be preferable since otherwise productivity and employment opportunities during the bloom period would be lost to the nation.

At both Kariba and Volta only a small proportion of the reservoir is currently being fished. If improved boats, new gear and techniques, and revised management and conservation measures were introduced before the drop in productivity, it might be possible to employ the same labor force by intensifying the existing fishery and expanding the area fished. Another issue concerns who is to fish a new reservoir. If the lake basin population has no history of commercial fishing, as at Kossou, outsiders may immigrate into the area and fill the new occupational niche. While this may be desirable in some cases, it is also wise to decide before impoundment who best shall compose the population of fishermen. A fishery training program for lake basin residents may diversify their occupational structure and reduce pressure on the land. In any event, the policy decision on the training program needs to be initiated before impoundment occurs.

This, in turn, raises the question of balance between alternative fishing technologies. In a few instances, a highly efficient capital intensive operation employing a small labor force may make sense. Elsewhere, the balance may shift to a small-scale, commercial fishery which does not necessarily correlate with lower labor productivity. The problem is to increase net income to the maximum extent compatible with the habitat while meeting employment needs of the lake basin population.

Even though these questions also arise for temperate reservoirs, there the emphasis on recreational fishing is stronger. In the Tennessee Valley reservoirs the tonnage landed by sport fishermen exceeds the production of commercial fishermen. The overall economic impact of this combined fishery is estimated at about $90 million per annum. For the United States, commercial harvest from approximately 1 million hectares of reservoirs averaged only about 8 kg/ha, although potential yield has been estimated at 23 kg/ha from 2 million hectares of large impoundment. The annual commercial harvest from USSR reservoirs is about 44 thousand metric tons.

Recreational fishing ties in closely with tourism. Seeking the proper balance through time between recreational and commercial fisheries, calls for analysis of the relationship between tourism and development within the lake basin, and of recreational needs at the national level. Once again we return to the need for benefit-cost analysis or regional accounts within a widened context.

*Industrial Development and Lake Basin Electrification*

Industrial development is perhaps the most difficult topic to relate directly to a man-made lake. In planning such development, analysis of regional social ac-
counts is possible for both labor and material resources. There are, however, only trial frameworks for regional and national economic analysis, including the effects of industrial complex development. In the absence of refinements in such methods it is necessary to make practical decisions as to investment and resource management.

Where hydropower is generated by the dammed water, industries may be drawn to the lake basin partly because of plentiful supply of electricity, at reasonable rates, and of water. However, the economics of power transmission are such that most of the generating capacity of the turbines often is utilized outside the lake basin.

In viewing man-made lakes as ecosystems, one problem faced by policy makers is the extent to which the lake basin should be electrified as an aid to development. Here a major factor is the distribution of population and its ability to use electric power. Contemporary extremes range from Kariba, where the entire generating capacity of the dam is exported except for the electrification of Kariba township, to TVA where per capita consumption of local power by the lake basin population is higher than elsewhere in the United States.

Some industries, of course, have little relationship to the lake basin. An example is the Navajo power plant currently under construction within a mile of Lake Powell in Arizona. Most of its power will be transmitted to the major cities of the Southwest, all situated outside the lake basin, and although located in a low income area with high unemployment, the whole operation will be highly automated.

More specifically related to a reservoir are a wide range of service industries and small-scale manufacturing for fishery and agricultural processing and servicing. In developing countries, with encouragement and training of artisans, cottage industries can provide a range of goods and services for farmers, fishermen, tourists, and others. Examples are the manufacture and repair of parts for farming implements, including carts and wagons, and of boats for small-scale commercial or artisanal fishermen. Once again it is important to consider goals and strategies for increasing both productivity and employment.

Industrial development near a lake is intricately related to potentially conflicting national, regional and local interests. If the emphasis is on regional growth in contrast to national economic efficiency, the export-base theory of regional development would stress building the production of products for which the area has clear comparative advantage. Fisheries and other water-related industries would be examples. In fostering the integrated growth of a lake basin, the task is to assess ahead of time the benefits and costs of different types of industry in terms of the lake basin populations, the national interest, the biological production potential (see section IV), and environmental quality.

Communications and Commerce

The formation of a large lake disrupts previous communication routes and creates new needs and opportunities. Lake basin residents who formerly found the river to be little barrier to interaction with people on the other bank, now may find themselves cut off from former associates by miles of water. New and existing feeder roads and waterways will be linked in a new pattern. At the same time, a new waterway connecting the reservoir with upriver (and downriver) areas
offers additional facilities for lake basin development, with accompanying changes in reservoir use.

Adequate water transport systems have yet to be developed for the major African man-made lakes. Indeed, water transport in support of fisheries is a special problem at Kariba and Lake Nasser: many of the fishermen are sited at isolated camps. Just as governments construct and maintain feeder roads in order to facilitate rural development on the land side, there is need to organize effective water transport. Whether the government continues the service, or turns it over to local authority, may shape the course of lake and shore use, and the demands they make on water and soil.

Lake basin development requires that attention be paid to integrated systems of feeder roads and waterways, marketing, banking and credit facilities. Early in the development of an isolated lake basin, the provision of fixed markets and temporary marketing depots, of post offices with postal savings facilities, of mobile banks and of cooperative and other credit unions may be sufficient. Subsequently, as towns and industries develop, expanded commercial service will be required.

Relocation and a possibly cheap source of electric power (the immediate, scattered settlements may pay very high power costs) give incentives to harness radio and television to rural development. Audiovisual techniques and effective transportation can speed up the integration of the lake basin into a wider regional context. Feeder routes can facilitate two-way communication. They enable immigrants and new ideas and ideals to come into the basin; they also make it easier for rural residents to market their produce and for young men and women to emigrate to cities (which may or may not profit from their arrival).

Urbanization and New Towns

The creation of a new lake provides occasion to design new and more productive environments for people, but the opportunity is most often neglected. One reason for this neglect is a lack of the kind of perspective which we have shown in this report. A second reason is the endemic difficulty of insufficient coordination between the agencies responsible for development. A third reason is inadequate survey research and unimaginative studies on which to base innovative planning. Finally, capital for such experiments usually is short.

In isolated areas the first lake basin town is sited close enough to the dam site to house and serve the contractors and their labor force. During construction the township booms. Thereafter its population and commerce may drop off rapidly unless planning provides for a wide range of future functions, including commercial, and service centers, and facilities for tourism, recreation, and industry.

It may be helpful to view the lake basin as a national experimental facility which attempts through land and water use planning to create a more productive total ecosystem. Such experiments may be designed to slow down or reverse the flow of people from rural to urban areas by so enriching and diversifying life within the lake basin as to not only retain population, but attract it.

Public Health

Schistosomiasis has replaced malaria as the number one public health problem in much of the tropics in part because malaria has been reduced for a time and
in part, because construction of man-made lakes and irrigation projects provides a new habitat for the snails that are the intermediate hosts of the schistosomes. The lakes illustrate how a man-made ecosystem may produce results which are adverse to the health of both lake basin population and immigrants. Fishermen are especially threatened. Tourists and other visitors are also endangered. It is difficult to assess accurately the impact on well being and productivity of the spread of schistosomiasis in Lake Volta or in other tropical reservoirs, yet there is no doubt that we are dealing here with a major social cost.

Schistosomiasis, whether of the urinary or the intestinal type, constitutes a hazard to everyone who comes in contact with many tropical lakes and associated irrigation waters. The epidemiology and control of these two closely related diseases is being investigated by an interregional project of UNDP headquartered close to Lake Volta. It will attempt to resolve some of the uncertainties with regard to the prevalence of the diseases and the various methods that might be used to alleviate or control them.

Another medical threat associated with man-made lakes is malaria. While this danger is satisfactorily dealt with in TVA reservoirs by dropping the water level sharply at appropriate times in order to strand mosquito larvae, this technique may encourage mosquito breeding in other types of reservoirs. A particularly complex problem in regard to both schistosomiasis and malaria is the interrelationship between the disease vectors and floating, marginal and substrate weed beds. The transmission hazard of both of these diseases has been increased by irrigation systems and fish ponds associated with man-made lakes in the tropics.

Other problems relate to the redistribution of such disease-carrying hosts as tsetse and Simulium flies, or of people in relationship to these hosts. At Kariba, for example, an epidemic of human trypanosomiasis broke out when several thousand south-bank people were relocated in a formerly uninhabited fly area. At Volta, as expected, Simulium breeding in habitats below the dam increased immensely but at the same time the impoundment reduced the incidence of pests in formerly riverine areas.

Other problems of public health also directly concern relocatees and hosts. During the transition period the stress of relocation and reduced agricultural productivity may have an adverse impact on mental health, on nutrition, and on susceptibility to a wide range of diseases. Even though medical services are improved, in developing countries the increase in population density and crowding following relocation may raise the incidence and intensity of parasitic infections. There is a particular danger of water-borne dysenteric infections because inadequacies in community water supply have eventually developed in all resettlements. Special opportunities for infection exist where people are shifted to a somewhat different habitat, or where non-immunes are mixed with infected persons.

A major weakness in studies of most tropical man-made lakes is the absence of baseline data on public and nutritional health of the lake basin population prior to impoundment and relocation. There have been accounts of elevated morbidity and mortality rates among relocatees, especially children during the transition period, but in the absence of pre-impondation surveys it is difficult to evaluate their significance.
**Education and Training**

If the impact is to be significant, special education and training of lake basin residents should begin before the reservoir is formed, but this rarely happens. By contrast, the record for transferring and upgrading existing schools so that relocated children can continue their education without interruption, and for constructing new schools has often been good.

Ideally, programs for relocatees would start at the earliest possible moment, certainly soon after the decision to proceed with the dam. One function of such programs is to prepare the people for the move. Another is to keep them busy as they face upheaval. Still another is to provide the skills necessary to build new communities, and livelihood.

Given a vision of the kinds of stable livelihoods that can be supported, there is a role for training centers and extension services offering a wide variety of courses involving the entire lake basin population and oriented to training fishermen and service personnel along with small-scale farmers who might cultivate small holdings within the drawdown area or around the lake perimeter.

In spite of tight timing, it may be desirable to train some local people in connection with dam construction, with emphasis placed on skills which can be transferred to other types of construction within the lake basin. To date, very few local people have been employed in the labor force.

**Tourism and Recreation**

The potential of many man-made lakes for tourism and recreation is tremendous although at many sites its development may be deferred. Included are boating, fishing, camping, and the development of a recreational complex as part of the land use system within the lake basin. Such a complex could include, even in low income areas, marinas, hunting and other sports areas and a wide range of parks and related accommodations. The range of drawdown and the control of shore line are crucial in such planning, as demonstrated by intense controversies over public access to shore line and over reservoir fluctuation in some industrial countries.

It is estimated that more than 115 million man-days of angling occurred on reservoirs in the United States in 1970, resulting in gross fisherman expenditures exceeding $ 600 million. Angling pressure has increased 3 percent annually in the past 25 years, and public concern about reservoir operation has mounted even more rapidly. Much of this increased fishing has occurred on new impoundments, as they represent the only fish habitat type undergoing extensive expansion. If all types of recreational uses are counted, in 1969 over 47 million visits were made to the man-made lakes of the Tennessee Valley Authority and, in 1970, some 276 million visits were made to the 300 odd reservoirs operated by the Corps of Engineers (Hofe, 1972). In Europe, the debates over shore line control and the protection of reservoirs from pollution grow.

In Africa there are unique opportunities, best utilized to date at Kainji and Lake Nasser, to create national parks or monuments with lakeshore frontage. In the Kainji case, the Park is primarily a game reserve; at Lake Nasser special ef-
forts are made to preserve irreplaceable antiquities, such as the temples of Abu Simbel and Nefertiti.

The interrelationships among tourism, recreation, and national and lake basin development are complex. In the Tennessee Valley, the local population participates fully in the recreational opportunities. By contrast, at Lake Powell in Arizona the large majority of those using recreation areas are outsiders. In fact, the lake has had very little impact on the Navajo Indians who live close to its southern boundary and rarely eat fish. The range of responses to recreational potentialities is influenced not only by the interests of lake basin residents but by their income levels and their capacity to take advantage of the reservoir's presence.

As policy-makers should ask the question, « Who should fish the reservoir (and what should be the relationship between sport and commercial fishing)? », so also should they ask, « Who should benefit from the recreational uses of the reservoir, and what are the relationships of tourism, recreation and local development to the well being of the people affected? ».

The social perturbations set in motion by feasibility studies of a possible dam project continue throughout the life of the man-made lake. In terms of the relocated and host populations the stress reaches a peak in stages II and III (Fig. 1.4) of the lake history. The impacts upon a widened region build up after filling is completed and then may be expected to fluctuate as new technologies or changing national goals and structure affect the priorities placed on the use of stored water and the shore line. What is done during the early stages may set the pattern for later socio-cultural activity as people and habitat interact, but the changes are rarely irreversible. The dam is likely to remain a long time while the goals and criteria for its use will change and thereby shift the operation of the new water body and the accompanying biological transformations.