INLAND FISHERIES IN DEVELOPING COUNTRIES: AN OPPORTUNITY FOR A FARMING SYSTEMS APPROACH TO RESEARCH AND MANAGEMENT

M. M. Sissoko, S. P. Malvestuto, G. M. Sullivan and E. K. Meredith

INTRODUCTION

In spite of decades of overall fisheries development and national economic growth, most small-scale fishermen in developing countries still live at or below poverty level (Smith, 1979; Panayotou, 1980.). Development efforts have focused almost exclusively on large-scale marine fisheries or aquaculture because many projects are commodity specific. Small-scale fishermen operating in the inland and coastal lagoon fisheries have not received the attention needed from scientists and government planners to improve their socioeconomic conditions. The present condition of most fisheries is deteriorating because of over exploitation. Appropriate management strategies need to be identified that will protect the viability of these biological systems, as well as improve the well-being of the fishing communities.

The efficiency of many conventional management approaches has been seriously questioned in recent years, as most have failed to achieve their objectives. This paper attempts to explore a possible application of farming system research (FSR) to fisheries development. As indicated by Gilbert, Norman and Winch (1980) there is little activity concerned with agricultural and rural development which cannot claim some relationship with FSR, however tenuous. FSR can be broadly defined as any research that treats the farm or the household unit in a holistic manner (1980). This paper sets out a methodology to expand the concept of FSR to apply to artisinal fisheries for riverine systems.

IMPORTANCE OF INLAND FISHERIES AS A SOURCE OF FOOD AND INCOME

Focus on fisheries management is increasing primarily because riverine fisheries represents an important source of animal protein for many nations of the Third World. A riverine fishery refers to the capture of various fish species from rivers for subsistence and commercial purposes (Scudder et al., 1984). In areas of the world that would otherwise suffer from food deficiencies, riverine fisheries constitute a main source for high quality protein. Subsistence fishing from rivers provides an important part of the animal protein requirement in the diet of rural populations in West Africa, East Africa and the Amazon Basin in particular (Emmerson, 1980).

According to FAO, millions of individuals living in developing countries depend upon inland fisheries as a source of food. Fish captured from inland waters represented over 10% of the 72 million metric tons (mt) of the world's marine and freshwater fish harvest in 1980 (Scudder and Conelly, 1984). Inland fisheries provide up to 35% of the total national harvest of fish in many developing nations, particularly those in West and Central Africa, South Asia, the Amazon, and parts of Southeast Asia during this period (Scudder and Conelly, 1984). Production from rivers and lakes in Africa was estimated at 0.7 million tons of fish in 1975 (Welcome, 1979). Inland fisheries provide over 50% of the total animal protein consumed by the people of many landlocked countries. Such is the case of Zambia where, in the later 1970's, annual fish production was estimated at approximately 50,000 mt, as opposed to 21,000 mt of poultry, 16,000 mt of beef, and 3,000 mt of pork (Armstrong, 1978 as quoted by Hayward, 1981b; Scudder, 1984).

In another example, the inland delta of the Niger River plays a significant role in the economy of Mali. Among the agricultural export commodities, fish is ranked fourth after livestock, cotton, and peanuts. Over 80,000 traditional fishermen living in the inland delta of the Niger River depend on fishing as a source of food and income. Total annual harvest is estimated to be approximately 120,000 tons under normal annual rainfall and floods (Operation Peche Report, 1973, Sissoko, 1974).

In the Republic of Niger, approximately 11,900 fishermen were involved in traditional fishing (Burtonboy, 1982). Total annual catch was estimated to be 9,696 mt (FAO, 1971). Unlike in Mali, large numbers of fishermen in Niger are from neighboring countries which makes the problem of management more difficult. Transitory fishermen do not readily adhere to national boundaries and it is difficult to assess their impact on the resource.

The contribution of riverine fisheries in Brazil and India are also quite significant. In the early 1970's, India produced, annually, 2.0 million mt of fish, of which 0.75 mt were from inland waters, with about one-half coming from aquaculture and the rest from the country's extensive river system (Jhingran and Tripathi, 1977, as reported by Scudder and Conelly, 1984).

Inland fisheries are an important source of employment for large segments of populations living in the developing areas of the world. In many countries, fisheries help prevent outmigration to the cities or other economic sectors for jobs. Scudder and Conelly (1984) pointed out that the economic role of traditional fisheries in providing employment opportunities on both a full and part-time basis is often underestimated. Fisheries represent an important mechanism for supporting those who live at the very low income levels, while allowing some people to progress into more lucrative activities. In Zambia, riverine and lacustrine fisheries are reported to function as an important "safety valve" because they have the capacity to absorb the unemployed living in rural and urban areas.

Finally, inland fisheries provide a process in which women play an active role. The transition of most fisheries from a subsistence operation to a more commercialized type has resulted in greater involvement of women in fish processing and marketing. In Mali and Niger, men harvest the fish while women do the processing and marketing of it.

ALTERNATIVE APPROACHES TO FISHERY MANAGEMENT

Fisheries management involves direct and indirect measures for controlling the fishery resource and the fishermen (Panayotou, 1982). Direct management measures include: gear control, catch quotas, limited entry, and site and season restrictions. Indirect measures consist of induced social and planned environmental changes. The traditional analytical concept for the application of biological management objectives is termed the Maximum Sustained Yield (MSY) approach. In fisheries managed under a MSY policy, the objective is to produce the maximum harvest possible on a sustainable basis. Recommendations are based on mathematical relationships which deal with the levels of fishing effort and harvest and with the population dynamics of the fish species involved, without regard to external factors, e.g., environment. The population dynamic models (Beverton and Holt, 1957; Ricker, 1948) are single-species in nature with large data requirements and, in general, are not suited to the assessment of inland, multi-species fisheries, particularly where environmental variability is high.

Of the MSY models available, only the Graham-Schaefer surplus yield model (Graham, 1935; Schaefer, 1957), an application which is based on a time series of fishing effort and harvest data, is general enough to apply to multi-species situations (Turner, 1978; Malvestuto et al., 1980). In the multi-species situation, the surplus yield model can predict MSY, and the associated level of fishing effort, for the entire fishery by considering all the species under exploitation as a single unit. The conventional management measures associated with MSY objectives attempt to protect the fishery resource with the assumption that this will improve the well being of fishermen.

The well being of fishermen is considered more directly in the Maximum Economic Yield (MEY) approach. MEY is a profit maximizing objective in which the focus centers on the costs and returns from fishing rather than on the biological capacity of the fish stock to provide harvest. Under a MEY policy, the fishery is allowed to expand until the difference between the total revenue and the total cost of fishing is maximized. Thus, under MEY, net economic benefit to society is maximized which makes this policy more appropriate than MSY from the standpoint of society. However, Panayotou (FAO, 1982) pointed out that MEY is not tenable in an open-access fishery because the absence of property rights over the resource encourages existing fishermen to intensify their effort and expand in number until no profit exists. Unless measures are taken to adjust the level of fishing effort, the open-access fishery becomes overexploited in the long run. Quantitative relations between MSY and MEY are shown graphically in Figure 1 (Stevenson, Pollnac and Logan: 1982). With either model, realization of the maximum is dependent on being able to control the level of fishing effort. In many instances, controlling fishing effort can be too difficult and too expensive to achieve, as when population density is high and/or fishing effort is spatially dispersed, or sporadic (FAO, 1979).

The Optimum Sustained Yield (OSY) approach endeavours to incorporate biological, economical, and sociological objectives into the assessment and management of fishery resources. In Third World countries, management inputs may be technically and economically viable while resulting in social failure (Sullivan, et al., 1983); OSY addresses the inadequacies of MSY and MEY by meeting the sociocultural needs of the fishermen and their communities. The policy objective of OSY is certainly the most justifiable with reference to fishery development programs where "fishery development" can be broadly defined as the pursuit of socioeconomic objectives through assistance programs (FAO, 1982). The goal of both fishery management and development is to optimize the use of the fishery resource at the individual and community level. According to Panayotou (FAO, 1982), some studies argue that, in areas where hunger is the predominant factor, MSY may be a justifiable objective because there is an expensive surplus of labor with a marginal factor cost equal to zero. The surplus labor can be used for the harvest for subsistence. However, the labor might be more effectively diverted to some other food production activity; and, in any case (MSY or MEY), objectives likely will not be met if the required inputs are not culturally compatible therefore, OSY is the most relevant approach. The problem with the application of OSY policy is that there is no appropriate model for attainment of OSY, i.e., there is no method associated with this fishery management philosophy.

As the following sections suggest, the development of Farming Systems Research and Extension (FSR/E) together with recent emphasis on the functioning of localized, traditional fishery management systems (Scudder and Conelly, 1984), may provide an appropriate model for attaining OSY. FSR/E represents a methodology that can allow for fishermen participation in the design of viable management plans that place the goals of the participants as the highest priority.

THE FARMING SYSTEMS RESEARCH APPROACH TO FISHERIES MANAGEMENT

FSR/E is a systematic approach that views the farmers and their problems in a comprehensive manner and recognizes the interdependencies and interrrelationships between the natural and the human environments (Gilbert, Norman, and Winch, 1980). The primary objective of FSR/E is to improve the welfare of individual farm families by increasing the effectiveness of the farming system in utilizing the limited resources within the context of the entire range of private and societal goals (Shaner et al., 1981; Monu, 1983).

In most developing countries, fishery regulations are designed and enforced by the ministries of agriculture which often give priority to large commercial farming and livestock management programs. Traditional fishermen, lacking political support, are often not well represented at the national level. Consequently, it is not surprising that research on fisheries has been minimal because the fishing communities seldom benefit from public investment. Such failure to include the traditional fishermen in the development process of rural communities around the Third World justifies the necessity to adopt a more wholistic approach such as FSR/E which provides solutions to problems concerning each particular rural activity regardless of its economic importance and political linkage at the national level.

The relation between existing fisheries research institutions and fishing communities is almost insignificant, generally characterized by the traditional top-down relationship which treats fishermen as passive receivers. As indicated by Scudder and Conelly (1984), government institutions continue to stress direct and indirect regulatory measures which reduce the economic efficiency of the fisheries resources. Generally, the enforcement of these regulatory techniques is inefficient and economically irrational as indicated by many studies done in various countries in Africa, Asia, and Latin America. In addition, fisheries personnel are often used to enforce these measures as well as to execute extension programs. This double role has a negative impact on research and extension. Scudder and Conelly (1984) advocate a new approach to management of riverine fisheries which encourages the local community's involvement toward increasing production and raising its living standards. FSR/E provides a solid scientific basis for two-way communication between research institutions and fishermen. The farming systems approach is recognized for providing solutions in the best interest of both private individuals and society, given the conditions of existing resources and constraints.

One important characteristic of inland fisheries is the wide range of factors which affect biological and socioeconomic conditions. Both fish resources and human activities are regulated by seasonal variations in the hydrological cycle of the river. Fishing is an economic activity of the households to meet their requirements in terms of food consumption and income earnings. However, traditional fishing techniques and management must be performed within the limits of the customs inherent to a fishing community. FSR/E has a holistic approach that takes into account fishermen as part of the process; and their knowledge and beliefs are considered as a starting point for basic experimentation that would lead to an improvement of the existing system.

The transition of traditional fisheries from subsistence levels to more commercialized enterprises has resulted in greater division of labor at the household as well as at the community level. Thus, while men specialize in production most women specialize in fish processing and marketing. Other job opportunities include: marketing fishing equipment, equipment repair and transportation. This further specialization has created new problems associated with the distribution, stockage, and transportation of fish. Besides fishing, most households practice agriculture, gardening, livestock rearing, and trading for the purpose of increasing their incomes. The holistic approach of FSR/E provides the research tools for each individual activity, or subsystem, to be viewed in relation to the others.

The use of modern fishing equipment, especially nylon gill and seine nets, has rapidly expanded in many traditional fisheries over the last 30 years. Generally, the new technology was introduced by individual fishermen seeking to increase their harvest efficiency. The fisheries institutions did not play any active role in providing useful information about the types of technology that would be compatible with the productive capacity of the fisheries resources. It is thought that the rapid over exploitation of many traditional fisheries is linked to the introduction of some sophisticated technologies. FSR/E is a good tool for generating new technologies appropriate to fishermen (Byerlee, 1982; Harrington and Winkelman, 1982). Hildebrand (1982) also advocates the necessity for combining FSR/E to achieve such goals.

A CONCEPTUAL MODEL OF A RIVERINE SYSTEM

A river system encompasses many diverse economic and human activities. The key to understanding and managing the system requires knowing how these activities impact on the resource. A further need is to document how outputs from the resource affect the users both materially and in their social relationships with others. It is also important to understand how social organizations and human processes are intertwined with daily fishing activities.

A conceptual model of how the Niger River production and marketing system operates is presented in Figures 2 and 3 (Sullivan et al., 1982). The flow chart illustrates key components of the system and how the system is conceived to operate. The use of a flow chart assists in formulating *a priori* hypotheses about how the system functions for later testing through various scientific methods. The flow chart concept can be particularly useful to researchers and extension workers using FSR/E. With these flow charts, several components of the system can be described individually based on their contribution to the functioning of the system. Key parameters can be identified that need recognition, especially any feedback linkages between components of the system.

The Biological Component

A traditional fishery approach places enormous importance on baseline fish stock assessment including species composition and length frequencies of the fish stocks which document the physical relationships of the fisheries. Catch assessment surveys have traditionally examined catch, effort, and catch per unit of effort in an attempt to quantify MSY. This approach assumes that the productivity of the fishery resource is a function totally of the system. Over exploitation is depicted when increased effort results in decreased catches relative to the productivity of the system. The key variables affecting fishing effort are equipment, capital, and labor and government regulations (Figure 2). The volume of catch has a feedback influence on the stock of fish available for harvest. If the volume of fish caught is too large or of the wrong size, age, or sex category, then the population dynamics could be adversely affected.

The productivity of the river resource for the fish stocks can also be impaired by cropping and livestock systems. Siltation and pesticides in the river from improper cropping practices, especially on fragile and marginal lands, results in low productivity of the resource. Along the Niger River, intensive agriculture (e.g., rice) and irrigation projects are presenting critical problems for maintaining the productive level of the resource. These are key auxiliary variables which need to be evaluated. The FSR/E methodology can be useful in determining detrimental upland agricultural practices and methods for developing technical packages for reducing siltation rates and chemical contamination of the river system.

The Economic Component

Fishing effort on the resource is the major determinant for the volume of catch and productivity of the resource. The fishing effort is a rate variable that can change based on factors influencing effort (connecting dotted lines). Labor allocated to fishing will be a function of what the fishing activity is in the package of all activities done by the individual. Cropping and livestock activities also have an important role to play on the seasonal supply of labor for fishing because of hydrological phases of the river as well as traditional patterns of labor utilization, for example, urban migration patterns.

A unique situation exists on the Niger River system because large numbers of fishermen originate from neighboring countries. The fishing effort expended on the resource is influenced by both local and expatriate fishermen. The local fishermen tend to more subsistence oriented while exploitation of the resource by expatriates requires consideration of the political economy of the region.

Fishing equipment is important to the individual's successful exploitation on the fish stocks. The current stock of investment (both numbers and values) of fishing equipment held by fishermen is important, as well as the rate of change in the growth of the stock of equipment. Fishermen's criteria for investment in fishing is critical to how rapidly exploitation will occur. In the aggregate, an uncontrolled high capitalization rate can be a significant factor in the productivity of the resource, because it can lead to even greater exploitation of the resource (O'Rourke). Age and depreciation rates for equipment and boats is important information to determine replacement rates by fishermen.

The Household Component

The local fishermen are part of elaborate family and village networks that influence how demands for fish are established. Fish have multiple end-uses, and the size and specie of fish caught will determine utilization of the fish.

Household demand for fish will normally be based on nutritional and income requirements that have to be met. Seasonal food requirements will vary because of the influence of climatic conditions on food and cash crops, livestock and fish harvests. The requirements for fish in the diet can be greater during high risk periods of the year (e.g., just before harvest when food stocks are low). Risk levels of fishermen can be measured to indicate how readily a person will deviate from accepted practices.

Household requirements could also encompass social formalities that require an understanding of intra-family and inter-household exchange of food and gifts. Social obligations can be a high priority in how the fishing resource is exploited. These formalities can be significant in how economic values are placed on types of species being caught and their dispositions. These household variables are important in their influence on the Optimum Social Yield (OSY). Subsistence levels of fishermen will determine demand for preferred sizes of fish. Consumption requirements of households and the preference for the size of specie are important factors to know.

The Market Component

The external markets away from the river constitute the commercial aspects of exploitation as well as disposal of fish products. The market values communicated through the pricing mechanism is a significant factor in determining which fish are marketed and in what form (Sullivan and Hunt, 1984). Season of the year and the location where fish are caught influence the form in which fish will be sold.

Two examples are provided from data from Niger on how season of the year affects forms of fish marketed. The major forms of fish are sold in either fresh or processed (e.g., smoked or dried) form. Market data for Niamey, the largest city on the river as well as in Niger, are presented in Figure 4. The vertical lines on the graph demarcate the hydrological periods of the river: March-April--falling water; May-July--low water; August-September--rising water; and October-February--high water levels. (The data are more important for their indication of relative changes rather than actual numbers.) The quantity of fresh fish is highest in the middle of the high water period of January and steadily falls to the lowest levels from May to October. Processed fish marketed is greatest during periods of falling fresh fish supplies. Large supplies of fresh fish are processed during the peak harvest periods for sales later in the year. The volume of fresh fish far exceeds the amount of processed fish marketed in Niamey. Fish from all segments on the river are marketed in Niamey.

Data is presented for an up river market, Ayouru, which is near the Mali border (Figure 5). The market data indicates a reversal in the pattern of fish marketed from that in Niamey. More processed fish was recorded in the market than fresh fish. Limited consumer demand and the lack of refrigeration makes processed fish more prevalent in the remote markets. Ayouru is also a primary market so that fish are sold again in Niamey. The peak of the processed fish sales are in June which is after processed fish sales in Niamey have begun to decline. Interregional trade between these river markets is extensive.

Management of the resource will depend on how great the market pressures are to exploit the resource (e.g. effective aggregate demand). This can be impacted indirectly through the changes in consumers' income, price levels for fish and competing products, income of consumers and their taste and preferences. It is a complex set of relationships, but these relationships can be measured with proper economic analysis of consumer preferences and demand elasticities.

Large amounts of wastage and inefficiencies are identified in this component of the marketing system (Figure 3). Lack of technology and proper facilities can result in higher prices and less usable products than if certain conditions were changed. Any excessive marketing costs will result in lower prices to producers and higher prices to consumers. Food technology measures on degree of spoilage is possible. Fish products are also changed into different forms based on changing market conditions (Street and Sullivan, 1985).

The government, through its policies and regulations, can impact directly on the performance of the marketing system. Regulations create impressions and uncertainties that impact on all participants using the resource. These regulations emit certain responses from fishermen, as well as, from market agents that ultimately cause the system to change.

Feedback Mechanisms

Viable management plans for utilization of the fishery resource need to encompass all the above components to make them viable. The components embody human processes which impact on decisions being formulated and executed whether in fishing, processing, marketing, or consuming. Changes taking place in one component, e.g. household economy, can influence how fishermen will exploit the resource. A fishermen's mesh size of net could vary based on season of the year because of changes in food supplies. If staple foods are not available, greater fishing intensity can take place.

The evaluation of management impacts on the participants can best be achieved by involving the participants to determine all aspects for maximum benefits from the resource. Any changes need to be forthcoming from the existing system that is functioning. It is hypothesized that the FSR/E approach can best fulfill the requirement that participants have major responsibilities in designing and implementing viable management plans.

THE CASE OF MALI'S RIVER FISHERIES

Another example of a unique production system is in the inland delta of the Niger River in Mali, a neighboring country to Niger which shares the Niger River system. The Malian example clearly demonstrates how the FSR/E approach is appropriate given an established traditional management system currently in operation.

The Malian economy depends largely on agriculture, livestock, and fishing which provide a source of employment for almost 90% of the total population. Fishing represents an estimated 3% of the Gross National Product. In 1972, the Ministry of Agriculture estimated the total value of fish captured at U.S. $10 million at the production level and U.S. $17.5 million at the consumption level. Ranked fourth after cotton, livestock and peanuts, fish products accounted for 8% of the total volume of exports (Ministry of Agriculture, Mali, 1973; Sissoko, 1974). A 1973-74 census estimated 80,000 fishermen exploiting the resources of the Inland Delta and the Lake Region for food and income.

Fishing Groups of the Inland Delta

The fishing population in Mali consists essentially of three important groups: Bozo, Somono, and Sorko. The Bozo are a fishing tribe by tradition while the Somono come from various ethnic groups practicing fishing as a profession. These two groups are mostly concentrated in the southern and central section of the Delta and have many sociocultural similarities which resulted from their marital interrelationships and their acceptance of a similar culture and religion. Thus, they live in the same villages, use the same fishing and management techniques, and exploit the same fishing zones under the same traditional regulations.

The Sorko is another fishing group that lives predominantly in the northern and northeastern part of the Delta. Like the Somono, they come mostly from the northern ethnic groups such as the Sonrai and the Djerma. Unlike the Somono and the Bozo, they are less skilled and wealthy, and use inexpensive equipments. The Mali census also indicated the existence of some Houssa fishermen from Nigeria who move upstream each year to exploit this part of the Delta. Like the Somono, the Houssa are very skilled fishermen, and they possess a high level of capital equipment (Sissoko, 1974).

Mobility of the Fishermen

Mobility is an important characteristic of fishing activities dictated by the hydrological pattern of the Niger River (Sissoko, 1974). Fishermen move downstream at a particular time of the year which is a traditional custom of some socioeconomic significance. The main purpose is to increase household production. Each year, after households have partially exploited their fishery resources, each household subdivides into two fishing groups. First, the young and very active fishermen form fishing groups of relatives, friends, or neighbors, along with their wives and children. They conduct six month fishing trips and move along the river, setting up nomadic camps. Permission to fish in these other waters is required from the local authorities in each case.

The fishing trips end when the rising water period begins and the boats are full of dried and smoked fish. On their way back, stops are made at large distribution centers such as Mopti, Diafarabe, Dioro, and Segou, where products are sold. Some fish are kept for their own household consumption during the period of scarcity.

The other group of fishermen, who remained in the village, takes an active part in the exploitation of the reserve zones near the village during their open fishing season. This part of the household is generally composed of adults and older people unable to travel long distances.

Different Types of Property Rights in the Fishing Zones

Most fishing communities located along the river control the fishing zones adjacent to them (Sissoko, 1974). The history of ownership in the Delta area can be defined as: "first in time and space, first in right." The first person to settle on the bank of the river sets the limits of a given segment of the river which gives that person the privilege to control and exploit. Later settlers were required to follow the rules and regulations set by the "waterlord" over the protection, management, and exploitation of the resources. With the increase in the number of new settlers, most fishing zones became properties of the entire community (common properties). Often, the first settlers who own or control the fishing zones may live in the upland section, practicing agriculture, while the fishing village which settled later on the river bank exploit the river resources. Whether the waterlord is a fisherman or not, there is a tacit agreement between the waterlord and the users about how to protect, manage, exploit, and share the resources. Although the fishing zones are regarded as common properties in the sense that they are opened to any member of the community, they are restricted from use by outside fishermen.

Despite present legislation, which declares the river a public property, the Malian Government recognizes the right of the fishing communities along the river to protect, manage, and exploit the resources adjacent to them according to their customs and traditions. Nevertheless, the Government encourages the fishing communities to exploit their fishing zones in mutual harmony. This recommendation is not new to the fishing communities; and over the years, a sense of mutual interest has developed based on the necessity to protect their resources from over exploitation. The Government did not attempt to change the existing rules; rather, use them as a benchmark for fisheries management.

The Reserve Zones

A census was conducted in 1973 of some of the reserve zones about the number of reserves/sectors/subsectors, and their periods of closing and opening, surface areas, and predominant species. The total number of reserves was 219 which represent an estimated surface area of 10,000 hectares (Ministry of Agriculture of Mali, 1975).

Historically, as settlements became larger, the need for organizational and managerial structures became vital for the protection of the community interest. Thus, most villages of the southern and central section of the Delta, inhabited by Bozo and Somono, developed traditional management structures which regulated the use of their resources. They divided their adjacent waters into several "bamo", or fishing zones based on certain characteristics such as the predominance of a particular species (Figure 6). Each bamo was given a name and a specific date or period of closure and opening. Some bamoes were left permanently opened as a source for the community's daily consumption. Flexibility was given as to when to close or open a bamo and how long the reservation would last in case of an unusual situation. In years of low water levels, most bamoes are put in reserve earlier and stay in longer than usual to give the fish stock the necessary time to grow.

The organizational structure for overseeing the management of the reserves is composed of the chief, the spiritual leader and the council. Their role is to: (a) decide which fishing zone will be in reservation; (b) fix the closing and opening date of the reserve zones; (c) provide an effective protection of the resources; and (d) estimate the part of the production that should go to the community for public purposes. In some fishing villages, where most of the inhabitants are relatives, a part of their production from the reserves is sold and the money is used to pay the taxes of the entire community. The spiritual leader is in charge of protecting the resources against magical forces internal or external to the community which attempt to divert the resources away from the fishing zones.

Generally, the reserves are protected by a community watch program; however, there are many cases in which the council selects some of its members as guardians of the reserves. It is in the tradition of the community to respect the rules, and violating them is regarded as a crime and an act of dishonor. Any member of the community, or any outsider who trespasses a reserve zone, is subjected to the payment of a certain fine, usually twice as much as the damage. Repeated crimes by the same individual are reported to the police.

Despite these traditional laws, no fishing village charges exploitation fees to the members of other fishing communities except in a few cases. These rules are intended to protect and to control the resources, and to give local fishermen more privilege than foreign fishermen because each fishing village wants to maximize its production and to minimize the potential danger of over exploitation due to internal pressure. No community imposes fees as long as the others do not.

Between the peak and falling water periods all 5 bamoes are partially exploited by the community. This period coincides with the retreat of the flood from the plains at which time floating and stationary gillnets are effectively used in the mid-section of the river and in the plains. Starting in December, village D puts its "bamoes" D1, D2, D3, and D4 in reservation leaving D0 permanently accessible to the community for its daily consumption and market exchange. Thus,

-D1 is closed December 15, opened February 28.
-D2 is closed December 15, opened March 15.
-D3 is closed December 30, opened April 1.
-D4 is closed January 15, opened May 15.

Other fishing villages fix their fishing schedules in a similar manner with the closing and opening periods at different times. Since all fishing villages interact mutually for the interest of their respective communities, their fishing schedules can be regarded a whole in which individual fishermen have a relatively free access to the reserve zones, as long as they conform to the rules of each particular village.

The Collective Fishing Season

The open season of fishing is also called the "collective fishing period" and is a significant socioeconomic event which takes place from January to June (Sissoko, 1974). Each village opens its reserves according to a schedule and foreign fishermen have access as long as they respect the rules of the village. For almost six months the entire Delta becomes subject to organized fishing in which each village acts independently from the others. Well informed about the opening dates of fishing, those members of the household who stay in the south move from village to village with their equipment. The household production is relatively high and constant during the six month period of fishing. The fish buyers follow this traditional patterns in purchasing their fish.

They travel with their trucks in search of fish for transport to the large consumption centers.

CONCLUSIONS

Traditional fisheries play an important role in providing food and employment for millions of people living in the Third World. Many rural populations in Africa, Asia, and Latin America depend on subsistence fishing as a primary source to meet their protein needs. Despite such economic importance, inland fisheries have received little support from government and international development institutions in the past. The recent interest in inland fisheries as economic systems comes at a time when their biological conditions are being threatened by internal and external factors.

Inland fisheries management has been based on traditional rules and regulations which, for many years, protected the resources as well as the well-being of the fishing communities. However, most of these fisheries have undergone some significant changes which have had serious impacts on their future viability. The growing number of fishermen, due to population increase and entry of foreign fishermen, have led to the inevitable transformation of several restricted fishing zones into common properties. Thus, under the open-access system, the conditions of some of these fisheries have deteriorated to the point of severely declining economic yields.

FSR/E is a conceptual tool for researching the traditional mangagement system. Fishermen's previous accomplishments can be used as a starting point for research on alternative strategies that would improve the protection and the exploitation of community-owned resources. The existing traditional systems can be examined under the umbrella of FSR/E which focuses on a systematic analysis of their physical, biological, and socioeconomic components in a comprehensive manner. Further improvement can be made through extension by helping the rural communities understand more about the nature and interdependencies of these components, and thus, influence fishermen's behavior toward a long term increase in social benefits. The OSY objective may be the target for research and extension offered by FSR/E.

The transfer of technology has proceeded in many riverine projects without previous assessment of the possible effects on the sociocultural and ecological conditions of the environment. The relatively low efficiency of traditional technology is recognized to have been a major factor in maintaining the natural balance of many river systems, despite the growing population pressure. The adoption of certain types of technology has increased the catch per unit of effort, thus causing an imminent threat of over exploitation of resources. FSR/E may be a useful tool for generating appropriate technology compatible with the socioeconomic and ecological components of the fishing environment.

REFERENCES

Beverton, R.J.H., and S.J.Holt. 1957. On the Dynamics of Exploited Fish Populations U.K. Min Agriculture. Fish, Fish invert. (Ser. 2) 19:533p.

Burtonboy, Ministere de l'hydraulique et ole l'environment, "Eaux et Foret," Projet ole developpement oles Peches, NER/79/018, 1982.

Byerlee, D., Harrington, L., and Winkelmann, D.L. 1982 Farming Systems Research: Issues in Research Strategy and Technology Design. Paper presented at the Annual Meetings of the American Agricultural Association, Logan, Utah.

Emmerson, Donald K. 1980. Rethinking Artisenal Fisheries Development: Western Concepts; Asian Experience World Bank staff working paper. 423. Washington, D.C. World Bank.

Graham, M. 1935. Modern Theory of Exploiting a Fishery and Application to North Sea Trawling. J. Cons, int. Explor. Mer 10:264-274.

Gilbert, E.H., Norman, D.H., Winch, F.E. 1980. Farming Systems Research: A Critical Appraisal. MSU Rural Development Paper No. 6.

Hildebrand, Peter E. Farming Systems Research and Technology for Small Farmers: Discussion. University of Florida, AAEA, WAEA Meetings at Logan, Utah.

Malvestuto, S.P., Scully, R.J. and Fernando, G.F. 1980. Catch Assessment Survey: Design for Monitoring the Upper Meta River Fishery. Columbia, South America. Research and Development Series No. 27, Project:AID/LA-C-1176.

Ministry of Agriculture and Rural Development of Mali. 1973. Annual Report of "Project Operation Peche Mopti". Paper presented by Al Hassan Konare at the Project Annual Meeting. Bamako, Mali.

Ministry of Agriculture and Rural Development of Mali. 1975. Annual Report of "Project Operation Peche Mopti". Paper presented by Al Hassan Konare at the Project Annual Meeting. Bamako, Mali.

Monu, Erasmus D. 1983. Farming Systems Research and Agricultural Research and Development in Africa. Brandon University, Canada. Paper presented to the Annual Meeting of the Rural Sociological Society, Lexington.

Norman, D.W. 1980. The Farming Systems Approach Relevancy for the Small Farmer. Michigan State University Rural Development Paper No. 5.

Panayotou, Theodore, 1983. Management Concepts for Small-Scale Fisheries: Economic and Social Aspects. FAO, Paper No. 228. Rome.

Ricker, W.E. and Forester, R.E. 1942. Computation of Fish Production. Bull. Bingham. Oceanogr. Collect. Yale University 11:173-211.

Scudder, T., and Conelly, T. 1984. Management Systems for Riverine Fisheries. Institute for Developement Anthropology. Binghamton, New York.

Shaefer, M.B. 1957. A Study of the Dynamics of Fishery for Yellow Fin Tuna in the Eastern Tropical Pacific Ocean. Inter-Am. Trop. Tuna Comm. Bull. 2:247-268.

Shaner, W.W., Philipp, P.F., Schonelil, W.R., 1981. Farming Systems Research and Development. Prepared for USAID.

Sissoko, Macki. 1974. Le Revenu du Pecheur Malien (Unpublished thesis). Polytechnical Institute of Agriculture and Rural Development. Katibougou, Mali.

Sissoko, Macki. 1978. Annual Report of the "Project Operation Peche on Fish Production and Marketing in the Inland Delta of the Niger River". Mopti, Mali, unpublished.

Stevenson, David, Pollnac, Richard, and Logan, Phillip. 1982. International Center for Marine Resource Development. University of Rhode Island. Kingston, Rhode Island.

Street, D.R. and Sullivan, G.M. 1985. "Equity Considerations for Fishery Market Technology in Developing Countries: Aquaculture Alternatives." Paper presented at the World Mariculture Society meetings, Orlando, January.

Sullivan, G.M., Malvestuto, S.P., Malvestuto, M.J. 1983. Project Proposal for a Socioeconomic Assessment of the Fishery System for the Niger River. USAID/Niger UNFAO.

Sullivan, G.M. and Hunt, D.S. 1984. "A Comparison of Market Channels for Commercially-Caught Catfish and Cultural Catfish in Alabama's Lower Tombigbee River Basin." Journal of World Mariculture Society. In press.

Turner, J.L. 1978. Status of Various Multispecies Fisheries of Lake Victoria, Tanganyika and Malawi Based on Catch and Effort Data. Pages 4-15 in R.L. Welcome, ed., Symposium on River and Flood Plain Fisheries in Africa. CIFA Technical Paper No. 5. Food and Agricultural Organization of the United Nations, Rome, Italy.

Welcome, R.L. 1972. The Inland Waters of Africa. FAO Paper No. 1. Rome.

Welcome, R.L. 1979. Fisheries Management in Large Rivers. FAO Paper No. 194. Rome.

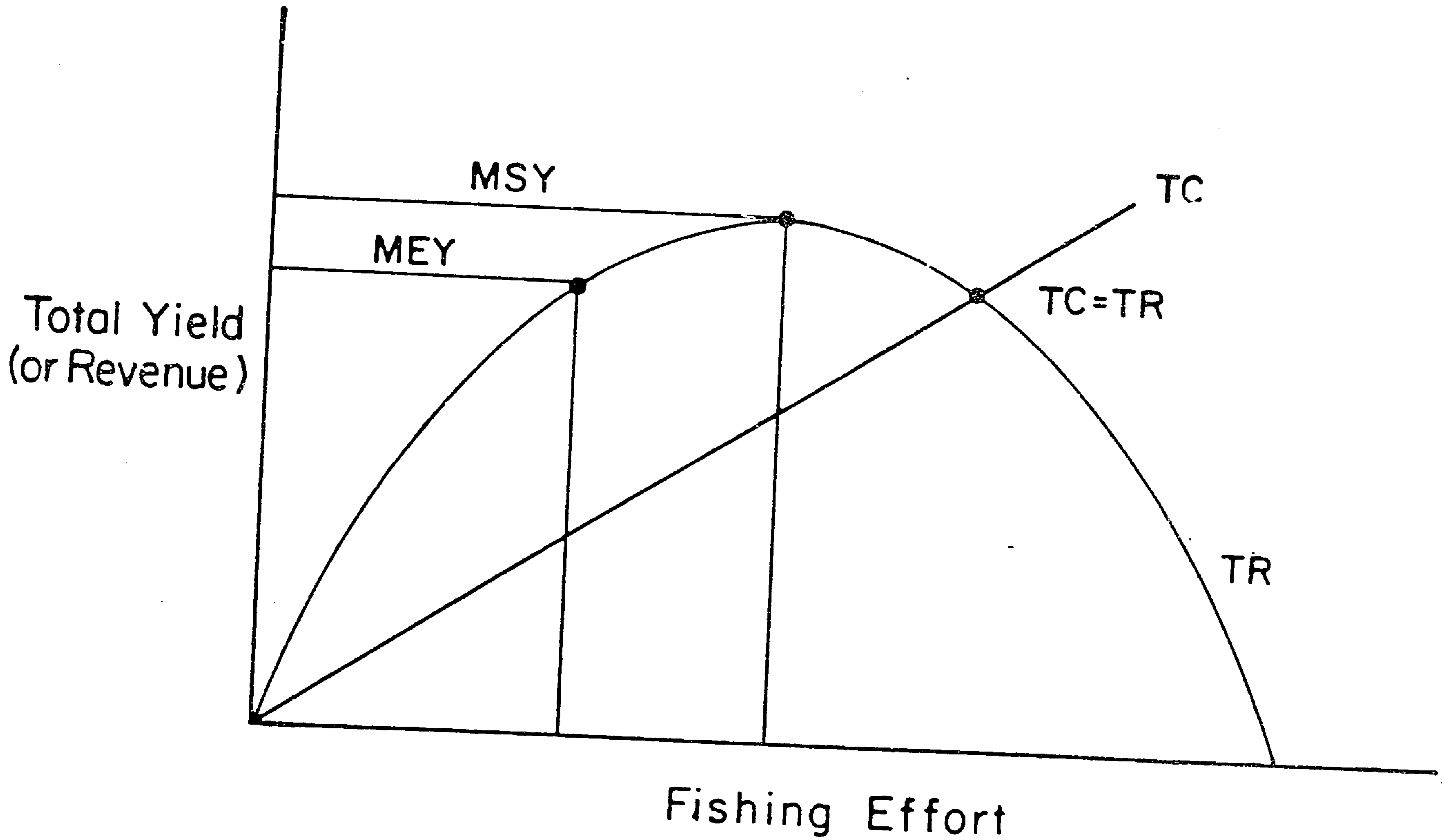

Figure 1. Yield-effort curve for an exploited fishery resource showing how equilibrium
This model is based on the premise that equilibrium yield is equivalent to the rate of increase in population size and that maximum sustainable yield (MSY) is reached at one-half the maximum amount of effort (and half the maximum population size). If yield is multiplied times price, the curve becomes a total revenue (TR) curve. Furthermore, if total costs (TC) of effort increase proportionately with effort, a point is reached where TC = TR. Maximum economic yield (MEY) is achieved when total revenue exceeds total cost by the maximum amount.

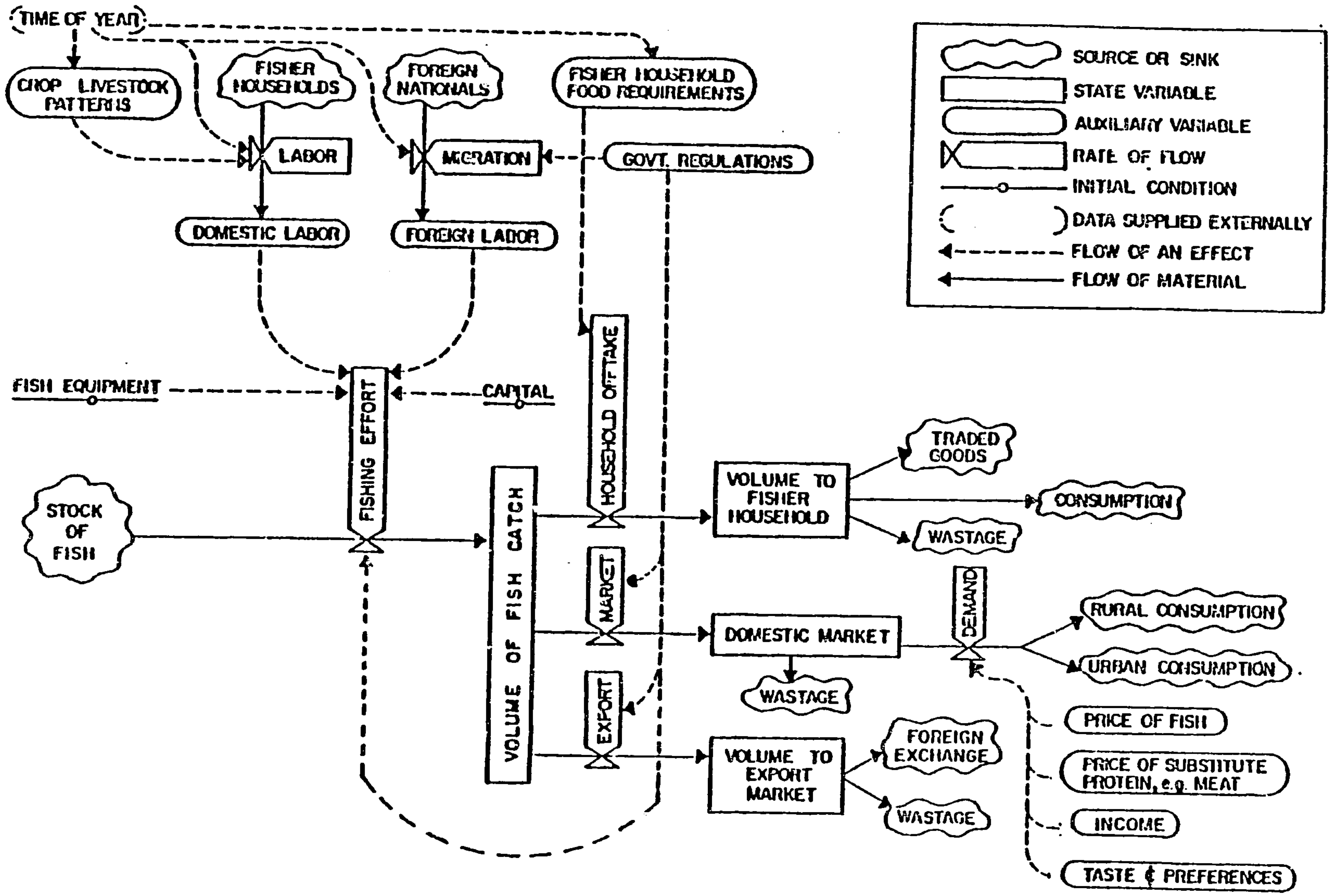

Figure 2. Flow Diagram for Production and Marketing of Fish on the Niger River in Niger.

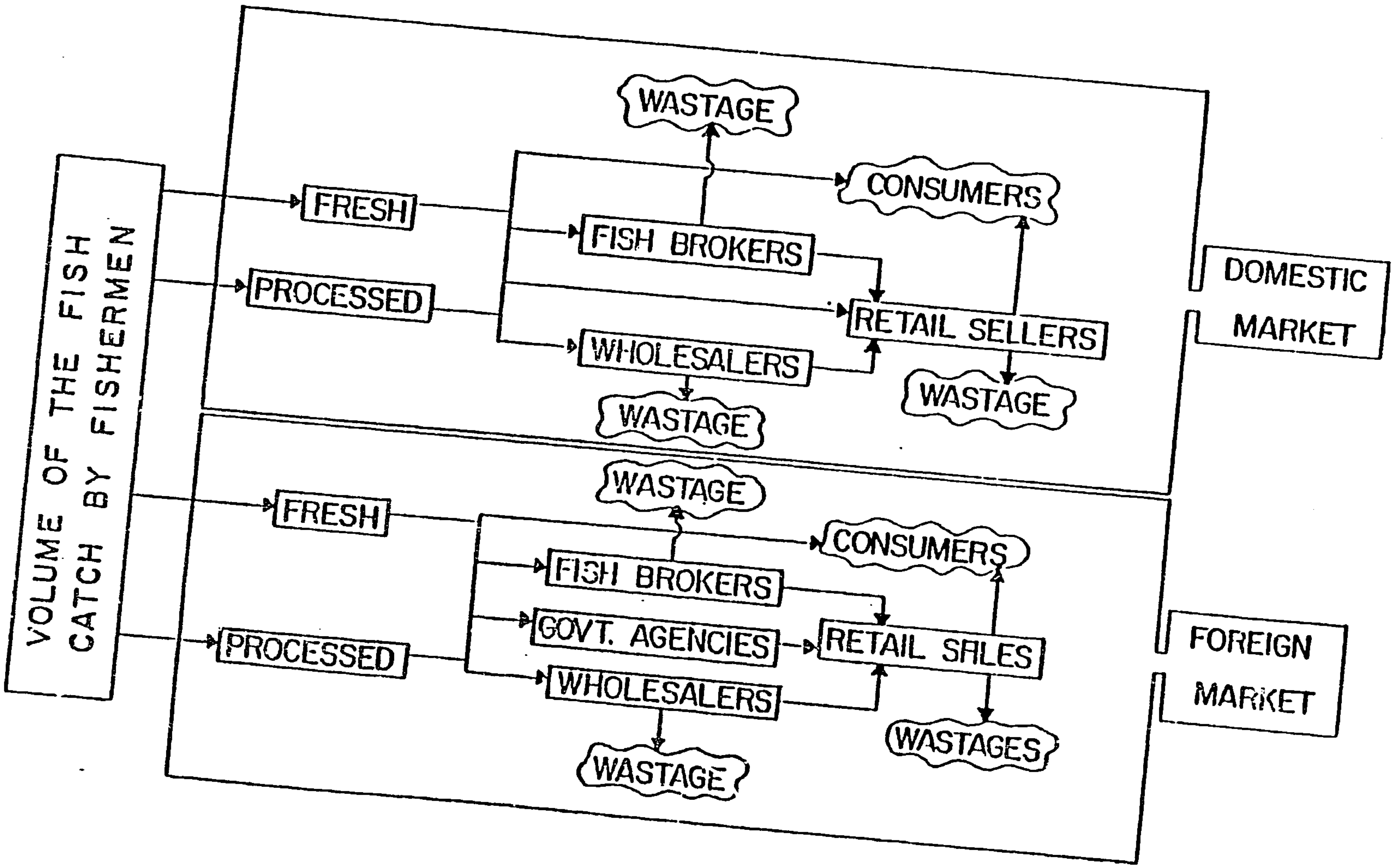

Figure 3. Flow Diagram of Sub-Model for Domestic and Foreign Markets.

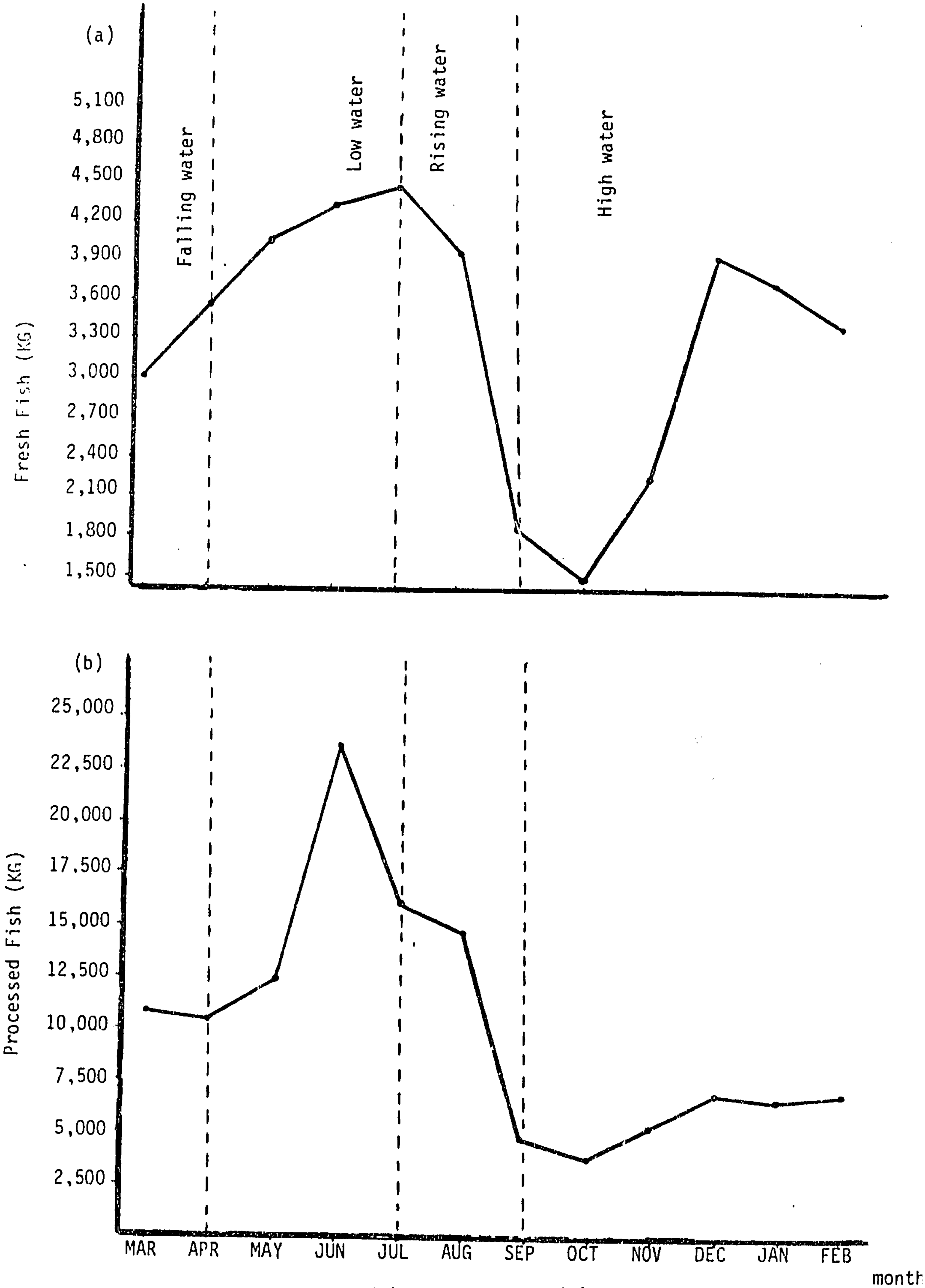

Figure 4. Quantities of fresh (a) and processed (b) fish reported for the Niamey market in 1981-82, Niger.

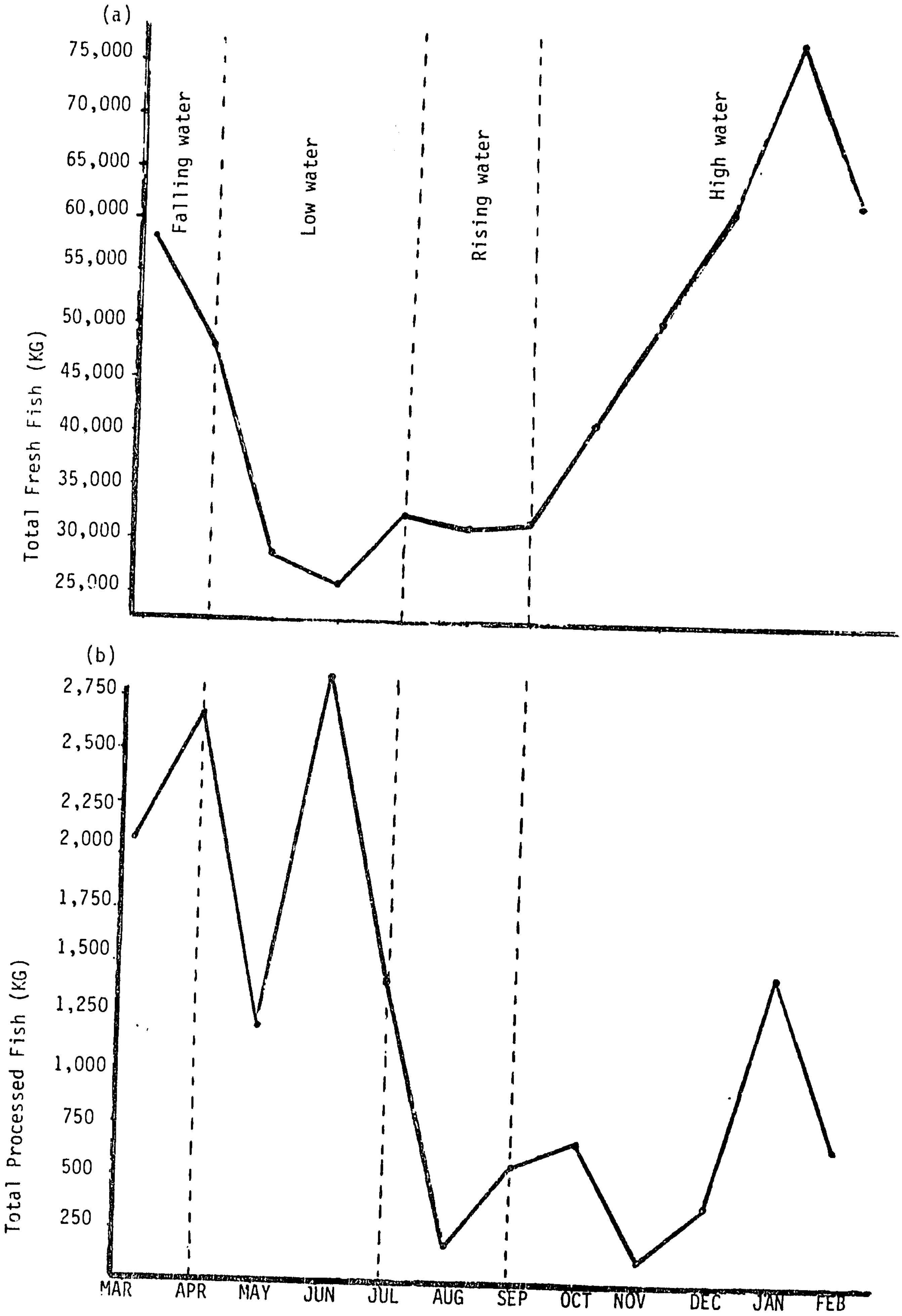

Figure 5. Quantities of fresh (a) and processed (b) fish reported for the Ayorou market in 1981-82, Niger.

(----) Signs indicating the Boundaries between reserve zones owned by a given village

(——) Signs indicating the boundaries between reserves owned by two villages

(P) Common zone between villages generally opened to all fishermen

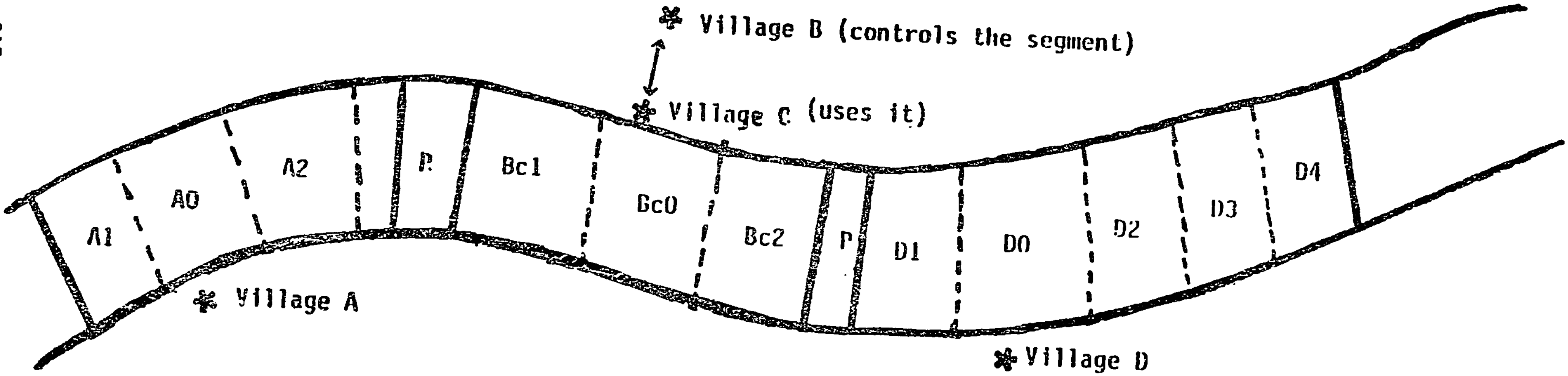

Figure 6. Illustration of some types of ownership and traditional management systems in the inland delta of the Niger River.