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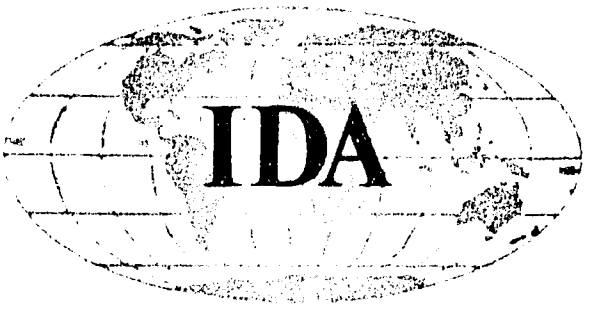

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Senegal River Basin Monitoring Activity II:

EXECUTIVE SUMMARY

by

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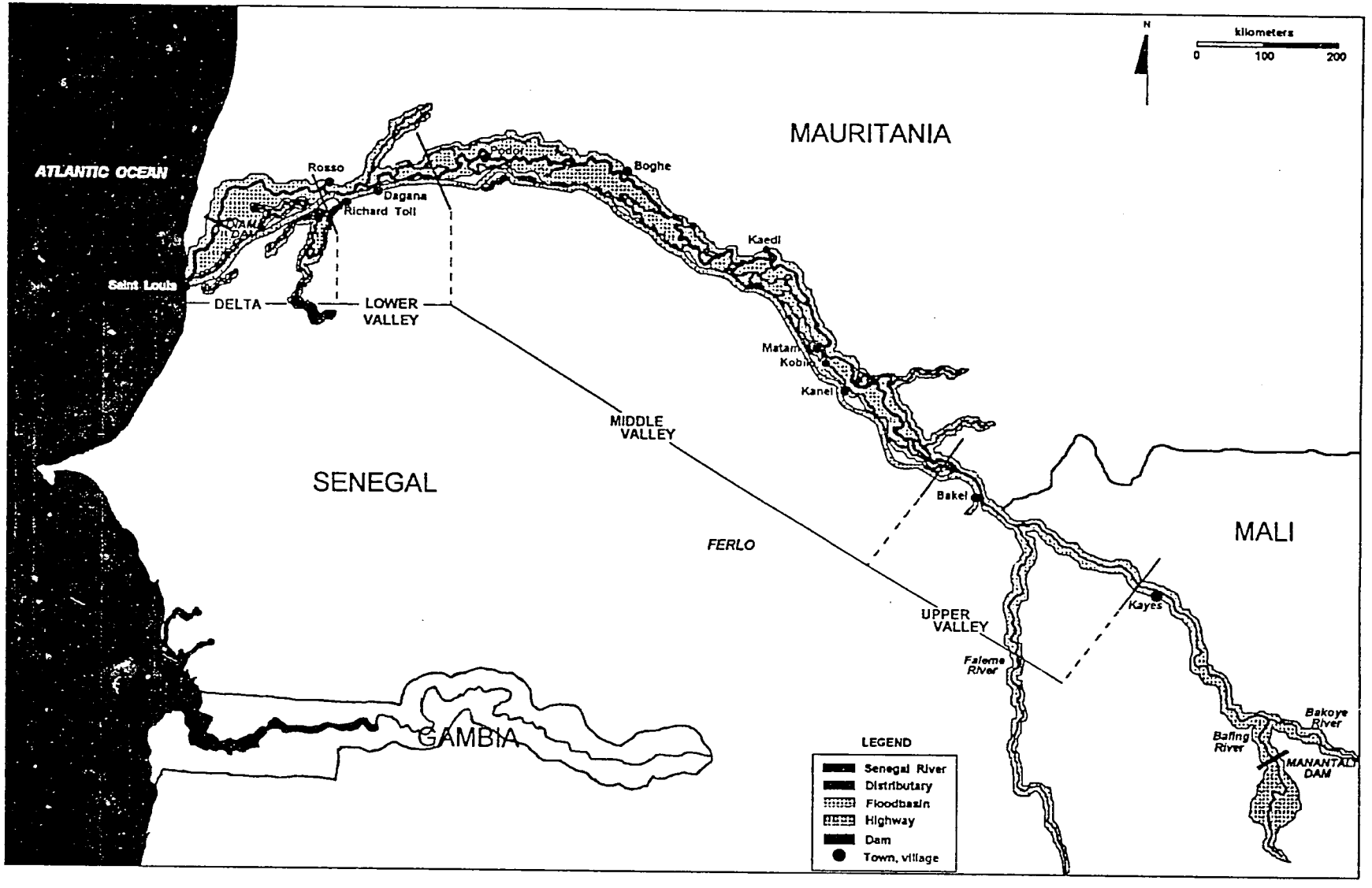
ATLANTIC OCEAN
MAURITANIA
SENEGAL
MALI
GAMBIA
FERLO
Saint Louis
Rosso
Dagana
Richard Toll
DIAMA DAM
Podor
Boghe
Kaedi
Matam
Kobi
Kanel
Bakel
Kayes
Falème River
Bakoye River
Bafing River
MANANTALI DAM
DELTA
LOWER VALLEY
MIDDLE VALLEY
UPPER VALLEY
N
kilometers
0
100
200
LEGEND
Senegal River
Distributary
Floodbasin
Highway
Dam
Town, village

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EXECUTIVE SUMMARY

I. PROJECT BACKGROUND AND RESEARCH OBJECTIVES

In recent years, the government of Senegal has become increasingly preoccupied with the status of food security, especially a growing dependency on imported cereal grains to feed the nation's burgeoning rural and urban populations. Partly in response to persistent drought and environmental instability in the last several decades, development authorities have embarked on an ambitious program to bolster agricultural production and mitigate against food shortages in the Senegal River Valley by promoting irrigation technology. The completion of two dams, the Diama antisaline intrusion barrage near the Atlantic coast in 1985, and the Manantali Dam upstream in Mali in 1988, was expected to further three goals:

- The generation of hydroelectricity to supply both urban centers and rural hinterlands.
- The attainment of regional food sufficiency in cereal production, particularly rice, through irrigated agriculture.
- The realization of an internal port of trade at Kayes, Mali and inland riverine development of regional and local centers of trade and commerce through inland navigation.

In order to attain these objectives, the river's downstream flow must be regulated and stabilized throughout the year, essentially eliminating the peak flow and the flooding cycle at the height of the wet season. This regularization of the water regime poses a direct threat to the livelihoods of approximately one million rural inhabitants of the river valley who rely on the annual flooding of their fields for their agricultural and pastoral production systems and fisheries.

At the request of the Senegalese government and under the sponsorship of USAID/Dakar, the Institute for Development Anthropology (IDA), through its Cooperative Agreement, "Systems Approach to Regional and Sustainable Resource Assistance" (SARSA), launched a multiyear research initiative in 1988, the Senegal River Basin Monitoring Activity (SRBMA), to explore the socioeconomic and environmental impacts of river impoundment at Manantali on communities located downstream in the Middle Senegal River Valley. The study was undertaken in consultation with the Senegalese government counterpart agency responsible for post-dam development in the Senegal River Valley, the Cellule Après-Barrages (CAB).

Research was implemented in two phases. Phase I, undertaken from 1988 to 1990, involved intensive household studies at three village sites—Thiemping, Doumga Rindiaw, and Boyenadji Roumde—located in the Department of Matam in the Middle Senegal Valley. During this period, data were collected on household consumption, production, labor allocation, land tenure, revenues, and expenditures. Drawing on findings of the initial study, field research for Phase II was carried out from 1990-1992 by expanding the scale of investigation to 331 households in 32 villages in the departments of Matam and Podor. In this manner, preliminary

observations and working hypotheses from Phase I could be further explored and tested on a much larger scale. Most importantly, empirical study and observation at the regional level allows conclusions about emergent patterns of human social behavior and adaptive responses to environmental constraints to be more easily validated and generalized.

The focal point of the SRBMA research has been to explore the socioecological and political-economic parameters of production in the Middle Senegal Valley, and to understand the differential responses of smallholding households to changing conditions of river hydrology and flooding resulting from impoundment of the Senegal River. In this context, project research has been shaped by three broad objectives:

(1) to assess the costs and benefits of terminating an annual flood at regional and national levels;

(2) to understand the nature of resource diversification and the components of the farm and off-farm household economy (including dryland farming, irrigation, flood recession cultivation, animal husbandry, fishing, commerce, and migration); and the relation of these various components to household food security and disposable income;

(3) to promote a policy of economic development that provides for the safeguard and enhancement of a sustainable natural resource base.

In the second project phase (SRBMA II), research has focused on understanding the impact of the changing regime of the Senegal River on the socioeconomy of the Senegal River Valley. The goal has been to determine how Middle Valley households make use of scarce resources in responding to perceived opportunities and dealing with perceived obstacles. The research indicates which combinations of opportunities, constraints, and external circumstances affecting households prove to be beneficial in achieving an optimal mix of productive activities, and which more often lead to loss and failure. An understanding of the heterogeneity of farming households is essential for the realization of broadly based participatory development in the region.

The mix of floodplains and irrigation schemes in an area was therefore an important criterion in the selection of research sites. Using the relative presence of recession and irrigation land (strong, average, weak) as a major criterion, geographical knowledge of the area (including the fact that irrigation is much more widespread in the Department of Podor than in Matam),

and various map resources[1] providing spatial images of each zone, four types of agricultural regions were distinguished (Table 1).

Table 1. Types of Agricultural Regions[a]

Category	Waalo	Irrigation	Location
1	weak	weak	Extreme southeast of the Department of Matam
2	strong	weak	Center and west of the Department of Matam
3	strong	strong	Center and east of the Department of Podor
4	weak	strong	Extreme west of the Department of Podor

[a] Waalo is flood recession land.

The first category—weak waalo/weak irrigation—is found in the extreme southeast of the Department of Matam (Arrondissement of Semme). Spurred by the Sahelian drought of 1967-1974, small-scale irrigation spread rapidly in the Middle Valley. By 1985, 522 small perimeters, which extended over an area of 10,000 hectares and involved over 35,000 households, had burgeoned on both sides of the river (Diemer and Van der Laan 1987:47). The area of Semme was not so favored, however. This omission was probably prompted by higher rainfall in the Semme area than in the downstream regions, even in the deficit years. Higher rainfall has also caused Semme to be favored by many herder groups, whose permanent villages are upstream but who gather here at the outset of the rainy season to allow their animals to graze and browse, hoping to gain cultivation rights to land in the *jeeri* (rainfed agricultural land).

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[1] In this effort several map resources were consulted. These include:

- The work carried out in 1971-1973 by André Lericollais and Yveline Diallo, which appeared in 1980 under the title, *Peuplement et cultures de saison sèche dans la vallée du Sénégal* (ORSTOM). The work consists mainly of a series of maps at the 1/50,000 scale (Lericollais and Diallo 1980).

- The 1986, 1988, and 1989 SPOT maps of the flood, commissioned by OMVS and reproduced at a 1/50,000 scale by Samba Dia of OMVS (Dia 1987, 1989).

- The SAED maps for the *délégations* of Podor and Matam (SAED 1985). These 1/100,000 scale maps indicate the location of irrigated perimeters and their surface area.

- The 1969 FAO/PNUD/OERS maps at a 1/50,000 scale (FAO, PNUD, OERS 1969).

The second category—strong waalo/weak irrigation—includes the rest of the Department of Matam. It is in the lower portion of the department (Arrondissement of Thilogne, roughly between Kobilo and Orefonde) however, where one encounters this extreme contrast between the presence of vast tracts of *waalo* land and the nearly total absence of irrigation. The Diamel, a distributary of the Senegal River, originates downstream from Matam, feeding several cuvettes that supply water to irrigated schemes on both sides of the river. Starting near Kobilo,[2] it disperses among a vast number of *marigots* (creeks) that culminate in what is known as the Plain of Thilogne. Accordingly, this part of the valley is among those best endowed with waalo land, but with few permanent sources of water that would make irrigation possible. These very features have given the area a high population density but also, with deteriorating conditions of hydrology and rainfall, large-scale emigration. Ironically, this emigration has made it one of the most prosperous regions in the Fuuta.[3]

A fairly large number of irrigation perimeters, especially village irrigated perimeters (*périmètres irrigués villageois*--PIVs), exist in Matam's arrondissements of Kanel (center-east) and Ogo—formerly known as Ourossogui—(center-west), along large areas of floodplain. In general, however, access to recession cultivation is much greater than access to irrigation in these arrondissements.

The third category—strong waalo/strong irrigation—is found primarily in the east and center of the Department of Podor. In this region, where uncertain rainfall makes rainfed agriculture very hazardous, another distributary, the Doue, runs parallel to the Senegal River and to smaller defluents (such as the Gayo) for approximately 150 km, enabling both recession and irrigation farming to take place.

Downstream from Podor (Arrondissement of Thille Boubacar), the alluvial valley narrows, creating a considerably smaller floodplain. Recession cultivation is restricted largely to horticultural production on the riverbanks, or falo, where relatively large garden plots may be found. A substantial amount of irrigation compensates for the scant possibilities for recession cultivation and the precarious conditions of rainfall, putting this area in category four.

The basic unit of analysis in SRBMA II has been the **production space (PS)** exploited by a group of historically connected villages (Figure 1 and Table 2). In the nine production spaces that have been selected (containing 32 villages overall), the relative dominance of floodplain (recession cultivation, herding, fishing) and irrigation activities is assessed by examining the comparative productivity of these systems in terms of land, labor, and capital, and by determining household production goals and labor strategies in the context of a set of

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[2] A mid-sized irrigated perimeter that was envisaged for Kobilo as part of SAED's program for Matam, Phase III, had to be deferred because of anticipated water supply difficulties.

[3] Generally, the region inhabited by the Fulbe, largely herders.

Figure 1. Research Zones: Departments of Matam and Podor

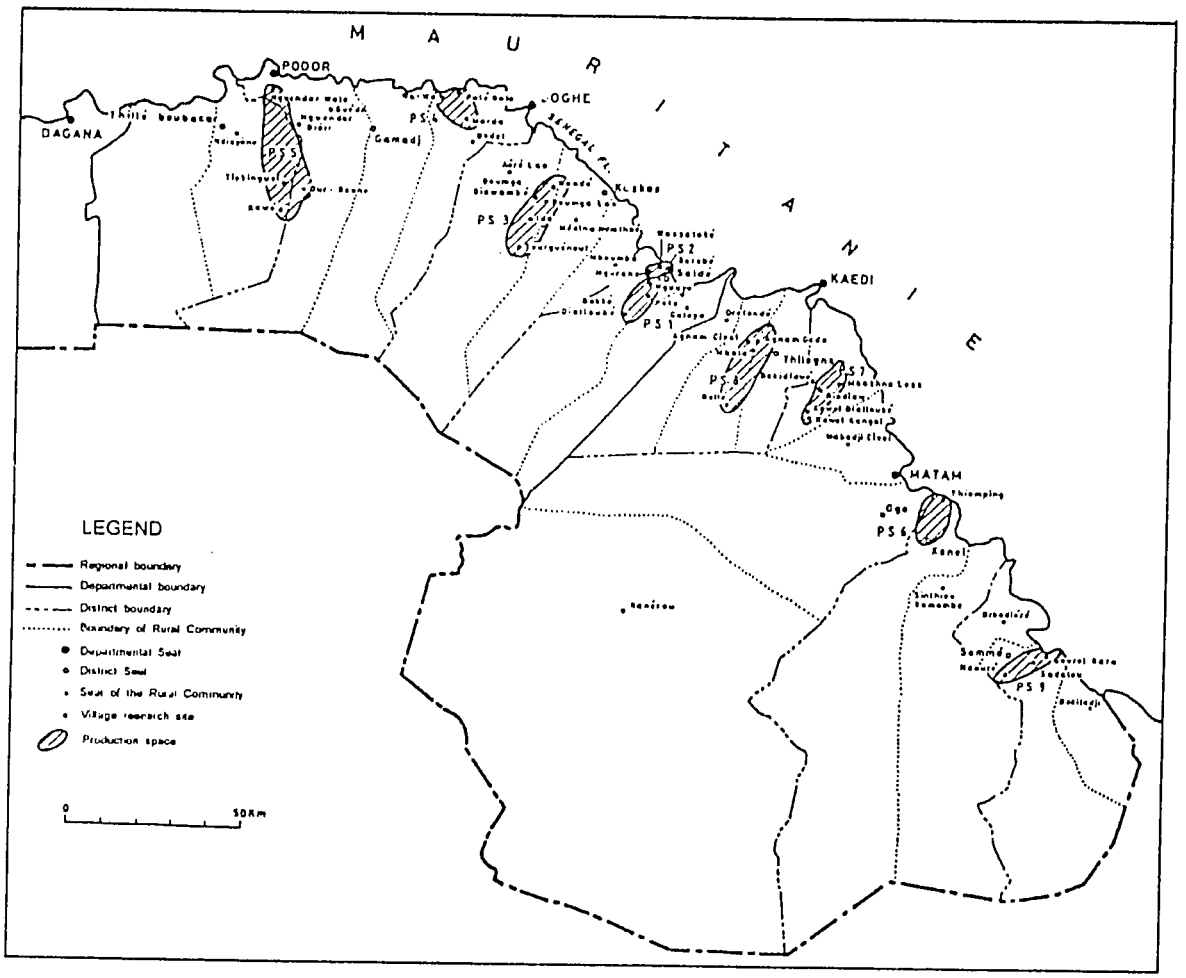

Table 2. Production Spaces (PSs) Studied under SRBMA II

Department	Arrondissement	PS No.	Villages	Research Assistant
M A T A M	SEMME	PS 9	Haoure Sadatou Gourel Dara	Mamadou Oumar Diallo
	KANEL	PS 6	Thiemping Kanel	Moussa Diop
	OGO	PS 7	Doumga Rindiaw Kaawel Dialloube Kaawel Cangal Mbakhna Less	Nafissatou Sow
	THILOGNE	PS 8	Agnam Godo Agnam Civol Belle Mberla	Mamoudou Athie
P O D O R	SALDE	PS 1	Ngouye Pete Boke Dialloube	Moussa Kane
		PS 2	Wassatake Barobe Ngarane	Moussa Ba
	CASCAS	PS 3	Doumga Lao Doumga Diawambe Wande Ida Tourguenol	Mohamadou Camara
	GAMADJI	PS 4	Pate Galo Wa-Wa Marda	Elimine Sow
	THILLE BOUBACAR	PS 5	Nguendar Jeeri Nguendar Waalo Kawe Ouro Boune Tekinguel	Aissata Ba

incentives and constraints. In this fashion, one production space was identified in each of the arrondissements of Semme, Kanel, Ogo, Thilogne, Cascas, Gamadji (the former Arrondissement of Ndioum), and Thille Boubacar. The Arrondissement of Salde in the Department of Podor was considered sufficiently complex to require two PSs.

II. THE POLICY CONTEXT

The summary findings from Phase I (Horowitz and Salem-Murdock 1990) reveal a changing policy environment with respect to river basin development and hydrological management of the Manantali Dam. The policy optic of the tri-member river basin authority, OMVS (Organisation de Mise en Valeur de la Vallée du Fleuve Sénégal), initially envisaged a

period of transition in which seasonal variation in river flow (flood peaks and dry-season troughs) would gradually be evened out resulting in a nearly constant flow throughout the year. Area farmers would be allotted a short period of time (approximately ten years) in which to make the transition from customary recession farming to full-time engagement in irrigated agriculture. In the meantime, controlled water releases from the Manantali Dam were to simulate natural flood conditions and enable the local peasantry to continue to undertake cultivation of the fertile floodplain bottomlands.

Based on the research findings of SRBMA I (summarized below), a revised policy stance in favor of the long-term maintenance of a controlled flood was adopted by the government of Senegal (Horowitz and Salem-Murdock 1990). Hydrological data demonstrated conclusively that in all but the severest drought years (of which there were only eight between 1904 and 1984), a controlled release from Manantali assuring a minimum flood of 50,000 ha would not jeopardize the minimum hydroelectric output desired of 86 megawatts of power (ibid.:33). In this respect, the government of Senegal had taken a bold stance in opposing the position of its neighboring states and constituent members of OMVS, Mauritania and Mali, who continue to embrace a policy of flood cessation and a full transition to irrigation technology at the cost of total abandonment of recession farming.

Despite the Senegalese position, the early phase of post-dam management at Manantali has yet to set a clear policy guideline with respect to instituting a controlled flood release for the benefit of area farmers, fishers, and herdsmen. Close monitoring of dam releases at Manantali from 1988 to 1991 indicates that in only the first year, 1988, was any successful attempt made to replicate the natural flood cycle. From 1989 to 1991, water releases have either been too small to affect a flood (1990) or poorly timed in relation to discharge from two principal distributaries, the Faleme and the Bakoye.

In a macroeconomic context, current policy directives aimed at restructuring the Senegalese economy work to the disadvantage of the individual smallholding peasant. Agrarian reform initiatives carried out by the state, such as the New Agricultural Policy (1984) and an IMF-mandated Structural Adjustment Program in the 1980s, have created a policy environment in which commodity markets in land, labor, and capital are being liberalized and disengaged from the public monopsonies of the state. In particular, the withdrawal of government subsidies for producer inputs (infrastructure, seed, fertilizer) from the agricultural sector is placing a greater share of the capital burden on the shoulders of the smallholder. In the Middle Senegal Valley, this structural change will translate into rising producer costs for irrigated rice farmers who are already hard pressed to invest adequate sums of capital at current low levels of crop output.

III. SUMMARY OF SRBMA I RESEARCH FINDINGS

The findings of SRBMA I research argue in favor of preserving a seasonal wetland ecosystem by means of a regularized controlled flood from the Manantali Dam. Such a strategy would enhance the array of diversified production activities available to area smallholders on and

off the farm. It is posited that the net benefits accruing at local, regional, and national levels under such a dam management strategy will exceed those that would result from a planning strategy that suppresses natural flood conditions in order to maximize hydroelectric and irrigation output (Horowitz and Salem-Murdock 1990:11-35).

The SRBMA I research advocates a policy position of resource *diversification* (by instituting a controlled flood) rather than resource *homogenization* (by an exclusive commitment to irrigation technology) on economic, environmental, and sociopolitical grounds. The most salient findings from the initial research phase supporting this conclusion are addressed below.

A. Economic Considerations

1. A Cost-Benefit Comparison of Recession and Irrigated Agriculture

Principal Research Finding:

> *Recession agriculture provides a comparative advantage over irrigation in two out of three production factors, labor and capital.*

The ability of many families to meet their reproductive needs, particularly in food production, depends in large part on their labor capacity and capital resources. Each family is faced with a critical decision affecting its reproductive welfare during the course of its domestic developmental cycle—when to retain labor for on-farm production, and at what point to export it for the economic needs of the household. The research findings from SRBMA I demonstrate in quantitative terms that recession farming, with its low input requirements, is the agricultural strategy most compatible with optimizing the mobility of labor and capital, both on-farm in producing food crops, and off-farm in generating revenue in urban areas. Irrigated farming, on the other hand, proves to be the most constraining of all production alternatives, leaving little room for allocating labor and capital in other productive domains.

While this simple finding may be self-evident, it is this basic observation, supported by hard data, that is grossly overlooked in the current planning of the river basin. Development authorities in the region are easily beguiled by the convincing logic of superior crop yields, or returns per unit land, in rice cultivation. But it is the central adaptive feature of customary floodplain farming—the modest endowment of labor and capital—that proves highly compatible with the uncertainties of a mutable regional ecology and flagging socioeconomy. By continuing to practice a form of low-input agriculture, Middle Valley smallholders are able to minimize risk on the farm while concurrently optimizing the allocation of scarce labor and capital both for on- and off-farm subsistence and for revenue-generating opportunities. Herein lies the oppositional logic of the peasant and the state: the survival of the former is defined by a strategy of diversifying resources and minimizing risks; the national and regional food-security objectives of the latter are defined by a policy of homogenizing resources and maximizing production.

The conclusions here are supported by a cost-benefit analysis comparing the returns to land, labor, and capital in a sample study of recession cultivators and irrigated rice farmers at three village sites in the Middle Valley (Horowitz and Salem-Murdock 1990:11-19). In comparing the crop yields attained in both systems, the superior output of irrigated crops goes unquestioned. The relative success of irrigated agriculture in boosting crop productivity beyond that found in customary regimes, however, involves a sizable investment of labor and capital that is generally downplayed by irrigation proponents. When production outlays (land use and cash costs) are factored into the cost-benefit equation, irrigation loses much of its edge as a superior production strategy. Data from the cost-benefit analysis show that while rice production outstrips sorghum yields by a considerable margin, a disproportionate increase in the amount of labor and capital is required in order to achieve higher yields.

2. Floodplain Intensification

Principal Research Finding:

> *Intensification on the floodplain, including returns to farming, fishing, and herding, exceeds that on irrigated perimeters.*

Attempts to bolster irrigation production by the government of Senegal have been based on a projected rate of intensification of production of 1.60 (GERSAR/CACG et al. 1990:96). This means that of the total surface area developed for production, 160 percent will be farmed in a given year. This translates into a double cropping season (wet and dry seasons) in the irrigated perimeters. Horowitz and Salem-Murdock (ibid.:20) point out, however, that the current per annum rate of intensification is only about half the projected figure above, or 0.83. Goals by the state to double the rate of intensification in a short time frame, then, seem highly optimistic and very difficult to attain.

Customary use of the floodplain for farming, fishing, and herding activities provides a rate of intensification that is unmatched by irrigation regimes, however. The sequence of recession farming, floodplain fishing, and herding on the valley bottomlands enables area smallholders to exploit the wetland ecosystem during much of the year, and thus provide for an extensive network of exchange of grain, fish, and dairy products among the diverse communities of the region. An estimation of the market value derived per hectare from the primary products of the floodplain—sorghum, fish, and livestock—proves to surpass that generated from rice production in the irrigated perimeters (Horowitz and Salem-Murdock 1990:20-26).

B. Environmental Considerations

1. Forest Regeneration

Principal Research Finding:

> *The* Acacia nilotica, *a valuable woodland species in the Senegal River Valley, is dependent on periodic flooding of the valley floor for its regeneration and survival.*

The Senegal Valley floodplain is colonized by vast tracts of *Acacia nilotica* (French: *gonakié*), a large portion of which has been cleared over time to make full use of the land for floodplain recession agriculture. This hardwood species is extremely important to the regional ecology and economy, and it is integrally linked to the river's natural flood regime for its survival. Germination occurs through such natural seed-dispersal mechanisms as flooding and the grazing and browsing of the seed pods by small ruminants. The tree is cut for fuelwood and used as local building material, and the forests provide a refuge for large nesting bird flocks (van Lavieren and van Wetten 1990:21). Woodland galleries like these provide not only a protective canopy for the seasonal migration and refuge of many European birds and waterfowl, they also provide shelter to rapidly dwindling numbers of small primates such as the red monkey, and act as a fertile habitat for the seasonal migration and reproduction of riverine fish.

2. Fisheries Regeneration

Principal Research Finding:

> *The annual volume of freshwater fisheries is directly dependent on the magnitude and duration of flooding of the inner-lying plains that serve as the vital feeding grounds for spawning and biological reproduction of riverine fish.*

The annual flooding of bottomlands provides a temporary aquatic habitat essential to the growth and proliferation of freshwater fish. Their reproductive success is integrally tied to the flooding of these lowland plains where the seasonal discharge of sediment and decomposition of deposited plant and animal detritus creates a nutritional environment ideal for the spawning and growth of young fry. The maintenance of biospecies diversity of fish populations in the region depends on the annual flooding of the region's inner plains.

3. Domestic Water Supply

Principal Research Finding:

> *Catchment areas in the Senegal Valley reduce surface runoff by absorbing much of the rainfall and seasonal floodwaters, thus acting as a natural reservoir for ground aquifer recharge.*

Groundwater recharge in the Middle Senegal Valley has been demonstrated to come, in part, from the valley wetlands. Concern over cessation of natural flooding and the effects on potable water supply was raised in the SRBMA I study (Horowitz and Salem-Murdock 1990:29-30). Hydrological studies by Hollis (August and November 1990) confirm that shallow aquifer recharge is flood dependent. Horowitz and Salem-Murdock (1990:30) estimate that a drop in water tables and loss of potable water supply would necessitate the drilling of 64 borehole wells at a cost of approximately 9,590,400,000 FCFA. This finding exemplifies a lack of foresight on the part of river basin planners. Furthermore, it underscores the need for hydrological monitoring of groundwater tables in post-dam downstream operations in the region.

C. Other SRBMA I Findings

1. Social and Political Considerations

A decision to terminate flooding of the valley plains will reduce the production options available to local smallholders and raise the risk of human conflict by increasing competition for a dwindling resource base (Horowitz and Salem-Murdock 1990:3). This was the case in 1989, when violent conflicts over land on the Mauritanian right bank of the Senegal River led to the expulsion of thousands of villagers into Senegal and wide-scale expropriation of their valuable farm lands. The influx of refugees places added pressures on a shrinking resource base in Senegal and heightens the potential for future conflict.

2. Irrigation and Migration

In farming communities heavily dependent on customary recessional regimes, the loss of such fertile lands and the consequent shift to irrigation farming could have the paradoxical effect of accelerating rather than impeding migration outside the region. Research findings from the SRBMA I study suggest that adult male labor may increasingly seek off-farm wages in order to finance the rising capital costs of production in village rice schemes (Diemer and Van der Laan 1987:93,104; Horowitz et al. 1991:223). If one of OMVS's goals is to retain rural farm labor through the expansion of irrigation technology in the river basin, this observation points to a possible inconsistency between means and end.

3. Changing Gender Divisions of Labor

A pattern of extensive wage migration by adult males has prompted a restructuring of the gender division of labor in agriculture, whereby the shifting burden of production is increasingly being assumed by the most disadvantaged sectors of the population, women and children.

It is widely assumed that a restructuring of the age and gender division of labor in agriculture in the Senegal River Valley has placed a disproportionate burden of the workload on women and children. This position is partially borne out by the findings of SRBMA I on time studies of labor allocation in recession farming, where women make up a significant portion of the total labor force and provide approximately the same proportion of total labor input. Labor-

time allocation data on youth and children below the age of 15, on the other hand, are inconclusive, perhaps suggesting that they are underutilized in recession farming.

The strongest evidence of changing gender roles is in irrigated rice farming, where women are actively engaged in previously male-defined tasks such as weeding, seeding, and transplanting. In one study, women constitute a majority of the labor force available and provide nearly one-half the total labor invested in the perimeters.

4. Declining Productivity of Irrigation Perimeters

Poor performance on irrigated perimeters is related to their heavy production expenses and labor requirements and to customary land distribution and inheritance practices that gradually undermine producer group cohesiveness (Horowitz and Salem-Murdock 1990:17-18).

Farmers have become progressively indebted since 1986, as an era of state devolution and structural adjustment has shifted costs to the producer. A process of "disguised wage labor" has been observed in the SRBMA I study (Horowitz et al. 1991:216). Farmers short of capital, but with sufficient labor power, sharecrop the fields of landholders who find themselves in the opposite situation: short of labor but able to buy production inputs. Thus, the government aim to democratize land ownership through the establishment of irrigated perimeters has not been achieved. A dwindling number of rich farmers are financing the capital inputs of a growing majority of cash-poor farmers who are no longer able to cultivate their own fields. The long-term effect of this growing polarization between resource-rich and resource-poor farmers may be an increasing disparity in access to land and an intensification rather than diminution in the level of socioeconomic stratification among smallholders in irrigation.

Since the acceleration of irrigation agriculture in the Middle Valley in the 1970s, large numbers of perimeters have experienced deteriorating conditions of production, both physically, in terms of breakdowns in scheme infrastructure, and socially, in terms of the erosion of membership and organization in the PIVs. The smaller number of participants remaining in the cooperatives are called on to invest increasing amounts of labor in the repair of canals and maintenance of the schemes. The result has been a high rate of abandonment of perimeters. For every 2,500 ha of new lands brought into production each year, approximately one-half that amount is abandoned. Farmers who continue to work in the perimeters become more and more indebted as production costs must be shared by fewer and fewer participants. In response, a common strategy among smallholders until recently has been to reorganize cooperatives and establish new perimeters, benefiting from government subsidies for inputs. The movement of farmers from one scheme to another after accumulating heavy debts has been observed and described elsewhere in Matam Department as a strategy of "shifting irrigation" (Nuttall 1990:10-11).

5. Household Budgets and Food Security

SRBMA I's biweekly monitoring of income flows, expenditures, and food consumption patterns at the household level reveals that peasant families in the Middle Valley are heavily dependent on revenue generated outside the agricultural sector. Labor migration and petty trade are the primary sources of off-farm income, accounting for between 45 and 72 percent of household income in the study sample (Horowitz et al. 1991:261). From 50 to 80 percent of total household expenditures is spent on food (ibid.:263). As household incomes earned off the farm are critical in maintaining food security, families prefer to engage in agricultural activities that do not divert substantial sums of household revenue to production. Recession farming, which is virtually free of capital costs, takes precedence over irrigation in this respect, giving participation in a flood-dependent agrohaliopastoral production complex the advantage of freeing up labor seasonally for a broad array of farm and nonfarm activities necessary for the household's reproductive well-being.

In conclusion, the findings of SRBMA I demonstrate that it makes sound sense, on both economic and environmental grounds, to sustain downriver production patterns that are compatible, not competitive, with demands for hydroelectric power generation and capital-intensive irrigated agriculture.

IV. SUMMARY OF SRBMA II FINDINGS

It is important to note at the outset that the environmental context in which the SRBMA II study was carried out has been critical in shaping the outcome of the research findings. Seasonal deficits in precipitation in both Podor and Matam departments for 1990, 1991, and 1992 resulted in nominal, and often no, harvests on rainfed lands. These shortfalls in harvest were coupled with no floods or poor floods in 1990 and 1991 and ill-timed water releases from the Manantali Dam, which meant that smallholders lost floodplain crops as well. Market prices of sorghum rose precipitously in many of the areas of study at a time when farmers were forced to become buyers rather than sellers of this subsistence grain.

The SRBMA II researchers gathered information through formal questionnaires and informal interviews about a wide range of activities relating primarily to farm production and income generation. The most salient findings of the research, summarized below, include analyses of land tenure, labor time allocation by age and gender, returns to factor inputs, labor migration strategies and their implications for agricultural development, and household consumption patterns.

A. Land Tenure

A broad survey of land tenure in 32 villages in the 9 production spaces (PSs), involving 3,405 households or 28,803 persons, reveals the primacy of waalo recession lands in the repertory of production activities among area smallholders. Producers have greater access to waalo recession lands (68 percent) than to either falo river gardens (17 percent) or irrigation

parcels (30 percent).[4] This prominent position of floodplain agriculture in the Middle Valley suggests that curtailment of flooding would have serious consequences for a large number of households. A smaller, more detailed study of 331 households, shows that fewer than 40 percent were able to undertake waalo cultivation because of poor flood conditions during the study period. Many of these households are located in areas where access to an alternative production strategy, such as irrigation, is not geographically feasible. Thus they depend on ample flooding of the valley bottomlands for survival. Prolonged absence of flooding may force greater numbers of young males to seek wage labor opportunities outside the region or significant numbers of families to move to large urban centers such as Dakar.

1. Land Distribution

Access to agricultural lands is highly variable within any given production system and from one system to another. The findings that follow, on access by system and caste, result from the study's survey of waalo, falo, and irrigated systems.

- **Waalo lands.** Of 3,405 households, 1,090 or 32 percent have no access to waalo fields, while another 37 percent, or 1,253 households, have access to a single field (Table 3). This difference in access to land may be a function, in part, of the location of a given village: a village in the jeeri drylands, for instance, may be at some distance from an interior floodplain. The unique history of each locale also shapes patterns of land use that are determined by the social composition of caste groups in each setting.

Table 3. Distribution of Waalo Fields by Caste (number of households with access)

Caste	Number of Fields										
	0	1	2	3	4	5	6	7	8	10	Total
Fulbe	259	208	143	47	20	12	3	2	0	1	695
Toorobbe	322	464	296	102	31	9	3	1	0	0	1,228
Jaawambe	26	46	24	10	10	6	0	0	0	3	125
Sebbe	44	58	43	17	5	3	2	1	0	0	173
Subalbe	121	142	48	16	3	1	1	1	0	0	333
Nyeenybe	117	71	46	4	0	0	1	0	0	0	239
Maccube	178	243	105	26	10	1	1	0	1	0	565
Other	23	21	2	1	0	0	0	0	0	0	47
Total	1,090	1,253	707	223	79	32	11	5	1	4	3,405

[4] These percentages add to more than 100 because some households have access to more than one kind of land.

• **Falo lands.** Access to falo fields is even more restricted than access to waalo. Some 2,840, or 83 percent of all households surveyed had no access to river garden lands (Table 4). An additional 446 households, or 13 percent, had access to one field, leaving fewer than 4 percent of households with more than one field.

Table 4. Distribution of Falo Fields by Caste (number of households with access)

Caste	Number of Fields						
	0	1	2	3	4	5	Total
Fulbe	638	47	10	0	0	0	695
Toorobbe	1,066	141	19	2	0	0	1,228
Jaawambe	120	4	1	0	0	0	125
Sebbe	122	42	7	2	0	0	173
Subalbe	120	145	42	21	3	2	333
Nyeenybe	219	19	1	0	0	0	239
Maccube	510	46	8	1	0	0	565
Other	45	2	0	0	0	0	47
Total	2,840	446	88	26	3	2	3,405

• **Irrigated lands.** Access to irrigated plots is similar to access to falo. Of the 3,405 households, 2,386, or 70 percent, had no access to irrigation, while another 20 percent, or 671 households, had access to a single plot (Table 5).

Table 5. Distribution of Irrigation Fields by Caste (number of households with access)

Caste	Number of Fields								
	0	1	2	3	4	5	6	7	Total
Fulbe	607	76	8	3	0	1	0	0	695
Toorobbe	820	230	162	11	4	1	0	0	1,228
Jaawambe	120	4	1	0	0	0	0	0	125
Sebbe	126	41	6	0	0	0	0	0	173
Subalbe	94	154	58	17	5	2	1	2	333
Nyeenybe	181	43	11	2	1	1	0	0	239
Maccube	398	119	46	1	1	0	0	0	565
Other	40	4	2	1	0	0	0	0	47
Total	2,386	671	294	35	11	5	1	2	3,405

Further findings on land access in relation to social standing (caste status) reveal differential levels of ownership and use rights within the various production systems. As noted, this is to some extent a function of the geographical location of the various social groups in relation to the environmental niches in which particular production activities are carried out. Below is a summary of some salient findings concerning the status of caste groups with respect to land tenure.

- **Toorobbe.** The most pertinent finding about this maraboutic caste of prominent social position is their advantaged position vis-à-vis access to irrigated lands (except for large-scale perimeters, only one of which was examined in the sample). Table 5 for the survey shows that Toorobbe, who comprise 36 percent of the households, had access to 42 percent of the 1,443 irrigation fields.[5] In the more closely studied sample of 331 households, Toorobbe made up 33 percent of the sample households but had disproportionate direct access (as owner/cultivator or as part of a collective group—*in joowre*) to irrigated parcels: 60 percent of the plots in private perimeters, 52 percent in PIVs, and 50 percent in middle-sized perimeters. This appears to be in part a result of the sociopolitical power and position of this group in controlling land allocation and access to strategically valuable resources.

- **Subalbe.** As anticipated, the Subalbe fishermen are favored in their access to river falo lands: although fewer than 10 percent of the households in the survey, they had access to 43 percent of the falo fields. They constitute 8 percent of the households in the study sample, but own or cultivate jointly nearly 48 percent of the available falo plots. This finding confirms the historical position of the fishing caste, which has long held control of the river and its passageways, as well as much of the garden lands adjacent to these watercourses.

- **Fulbe.** The Fulbe (largely herders) control considerably smaller proportions of falo and irrigation land than their proportion of the survey (9 and 7 percent, respectively of the lands; 20 percent of the households). In both the survey and the sample, their access to waalo is about proportional to their representation among households. In rainfed jeeri cultivation areas, however, where large numbers of pastoral settlements are found, the sample shows somewhat higher Fulbe access to plots than their sample proportion. This finding is consistent with the seminomadic lifestyle of many herders, a mode of living that may preclude their engaging in agricultural activities on an extensive basis.

- **Nyeenybe.** The Nyeenybe are underrepresented in their access to all agricultural systems. As artisans, they have not been as dependent on land for their livelihoods as other castes. Their historically subordinate status in relation to their higher-status patrons remains intact insofar as it is reflected in their marginal position as landholders in the various agricultural production activities.

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[5] The number of fields, from the bottom line of Table 5, is 671x1 + 294x2 + 35x3 + 11x4 + 5x5 + 1x6 + 2x7, or 1,453.

- **Sebbe.** The Sebbe, former warriors compensated in land for their defense and protection of high-status maraboutic families, today maintain control of considerably more waalo plots than their proportions in the survey or the sample. Their access to falo also is relatively high in the survey.

- **Maccube.** The Maccube, former bond servants working largely as laborers in the fields of their masters, comprise nearly 17 percent of the survey and had access to 15 percent of waalo fields and only 9 percent of falo. The more detailed information of the sample, where Maccube made up over 20 percent of the households, indicates they have direct control over only 12 percent of waalo and 2 percent of falo fields, suggesting their continued marginal status as landholders in the Middle Valley.

2. Land Tenure in Irrigation

Irrigation units in the Middle Valley have undergone important changes in control from year to year. Those obtaining de facto ownership of perimeter parcels by such means as inheritance or purchase in the informal market are becoming more numerous, while original scheme participants are fewer. Several important findings on land use practices in irrigated perimeters may be drawn from the SRBMA II study.

- Regardless of the age of the perimeter, **the original recipients of parcels** ***(premières attributaires)*** **today remain the large majority of landholders,** averaging 68 percent of all owners. In only eight years (the average age of the perimeters studied), however, approximately one-third of all parcels have changed ownership. Thus, the jural principles of land registration by the state, meant in part to allow for more democratic access to land, are being eroded by actions of producer groups at the village level.

- The **redistribution of parcels** occurring at the initiative of the producer group, through subdivision and replacement of landholders, varies between 15 and 20 percent of all parcels issued, depending on the period during which the perimeter was created. This proportion is highest (20 percent) in perimeters created between 1988 and 1990.

- Land **access through inheritance** involves 8 percent of all parcels (194 out of 2,435). This figure is influenced by the age of the perimeter, however. The number of parcels inherited equals or surpasses 10 percent in irrigation units that are more than 12 years old (established before 1980).

- The **sale of parcels** constitutes an illegal transaction, but it occurs, nevertheless, involving 4 percent of all land (104 parcels). This is not a function of the age of the irrigated perimeter. Only 1 percent of all parcels in perimeters created between 1975-1978 were sold, while 9 percent were sold in perimeters established in 1979.

- **Access by women is limited.** In the irrigation units studied, women represent only 6 percent of all landholders (152 out of 2,435). They constitute barely 4 percent of present

holders who are original owners of land. Among all women cultivators, 16 percent obtained their parcels through inheritance. Women occasionally obtain irrigated land through purchase as well. Ten percent of all parcels held by women were obtained in this manner. The actual level of access by women to irrigated land remains modest, falling far short of their labor contribution in production and their economic role in the region.

- **Gerontocracy in the perimeters.** Irrigation is marked by the gerontocratic organization of production. Although the population in the Middle Valley engaged in irrigated production is relatively young, the average age of landholders in the schemes is older, 54 years. The average age of those owners holding parcels as original scheme participants (*première attribution*) is 56, while those subsequently receiving land by replacement of the original landowner or by inheritance is relatively young: 46 years for the former and 42 years for the latter. It is through inheritance, then, that the rejuvenation of membership within the producer group takes place.

- **Absenteeism in irrigation.** The absentee rate among landholders is relatively high, involving 19 percent (466 of 2,435) of all scheme members. This absence, largely of migrant landholders who earn income away form the irrigated perimeters, may be viewed both as a potential constraint, creating problems of absentee management, and as an advantage, a way of generating capital for purchasing production inputs.

These observations on land tenure in irrigated agriculture are especially important in relation to national policy on agrarian land reform. The National Domain Law of Senegal, promulgated in 1964, has yet to achieve its goals. Attempts at jural land reform, such as the National Domain Law and the Territorial Administrative Reform, have been undermined and restructured according to customary land use practices at the local level, practices that remain very strong in irrigated perimeters.

A second finding is that certain social groups that are heavily engaged in the region's economy, including women, youth, migrants, and castes of lower social standing, have been marginalized in their access to irrigated land. The traditional gerontocratic and aristocratic social structure has assumed a central role in the control of land in irrigated perimeters. The existence of these disparities, despite ideological concerns for equity and democratization, may become a major constraint on agricultural development in the region.

3. Summary Observations on Irrigation

Observations from the SRBMA I study on irrigation have been re-examined in SRBMA II. Expanding the scale of analysis to the 22 villages (of the 32 villages in the study area) that participated in irrigation farming, a number of conclusions derived from the initial pilot study were confirmed. These are summarized under three subjects:

(1) Organization of producers and land tenure practice in the perimeters

- access to irrigated land is not as democratic as has been assumed;
- peasant cooperatives, because of problems of land inheritance, gradually lose their cohesion and ability to mobilize labor;
- as the number of members forced to withdraw from production rises, it becomes increasingly difficult for the remaining producers to manage the sizable perimeters;
- as members withdraw and group cohesion erodes, costs of production become excessive for the remaining producers;
- the eventual result is dissolution and reorganization of producer groups and the creation of new perimeters.

(2) Paying for production costs

- irrigation is financed primarily by earnings from migration, but migration creates a scarcity of labor for production on the perimeters;
- producers without migratory remittances must finance production by selling off livestock, consequently reducing the level of inputs (such as fertilizer), and thus reducing crop yields.

(3) Tightening of the land tenure system

- the absence of a legal commodity market in land has resulted in share-tenancy arrangements that are contrary to the spirit of the National Domain Law, and in the abandonment of parcels, which keeps intensification ratios low;
- because of the acquisition and accumulation of land by a social stratum of gerontocratic elite, individuals of inferior social strata, women, and the young are excluded from organizational management and often from access to the perimeters.

B. Labor Time Allocation

1. By Type of Agricultural System

Distinct age and gender divisions of labor are a salient feature of agricultural production in the Middle Senegal Valley. In tandem with the growing absence of adult males from farm production in search of off-farm income, it is widely assumed that those segments of the population remaining on the farm—in particular women, children, and the aged—are increasingly being called on to make up for the resultant scarcity of labor. The research findings of SRBMA I noted earlier (section 3.3.3) only partially confirmed this hypothesis. Data collected on labor time allocation studies in SRBMA II point to the substantial involvement of women in most farming activities and are consistent with the preliminary findings of SRBMA I. The most important findings on labor deployment in each agricultural system include the following:

• Waalo lands. In a subsample of 15 households in each of 9 production spaces (135 households in total) we found that the contribution of men in recession farming was somewhat greater than that of women (60 percent vs. 40 percent). This is most evident in age groups 8 to 14, 46 to 60, and 60 and over (Table 6). **In the 15-to-45 age group, however, women contributed nearly the same amount of labor time as men (24 percent vs. 29 percent for men), suggesting that the labor contribution of the most productive segment of the female population is crucial to the reproductive welfare of Middle Valley households.** As has been noted, the significant involvement of women in this age group reflects primarily the sizable absence of male cohorts who have left the farm in search of migrant wages.

Table 6. Average Hours of Labor per Household in Waalo Fields, by Age and Gender: 1991-1992 (54 households)

Agricultural Operation	Male						Female					
	0-7	8-14	15-45	46-60	61+	Total	0-7	8-14	15-45	46-60	61+	Total
Field Preparation	0	0.37	5.35	1.20	1.06	7.98	0	0.15	0.91	0.17	0.06	1.28
Planting	4.09	35.87	65.43	14.74	9.17	129.30	5.02	27.91	86.20	3.61	1.46	124.20
Replanting	0	0.52	2.50	0.39	0.15	3.56	0	1.30	1.83	0	0	3.13
Fence Construct.	0	4.44	1.78	1.70	0.41	8.33	0	0	0	0.07	0.28	0.35
Weeding/hoeing	1.43	45.63	86.48	23.89	11.28	168.70	0	0.31	6.46	1.50	0	8.28
Fertilizing	0	0.19	0.19	0	0	0.37	0	0.19	0.09	0	0	0.28
Transplant./thin.	0	0	0.26	0	0.20	0.46	0	0	0.41	0	0	0.41
Guarding	3.13	29.46	28.78	14.50	7.83	83.70	4.65	27.87	53.96	17.31	10.50	114.30
Harvesting	0.30	4.31	14.07	2.74	1.70	23.13	1.85	6.15	19.61	3.13	1.11	31.85
Threshing	0	0	7.28	0.59	0.15	8.02	0	0.52	7.65	0.35	0.89	9.41
Transporting	0.13	1.94	5.70	1.11	0.30	9.18	0.26	0.50	1.98	0.13	0	2.87
Other	0	0	0.19	0	0	0.19	0	0	0	0	0	0
All	9.07	122.74	218.00	60.87	32.24	442.92	11.78	64.89	179.11	26.28	14.30	296.35

• Falo/foonde lands. Older women, particularly those over 45, contributed more time (relative to men's time) to falo production in 1991/92 than to any other agricultural activity, with the exception of irrigated vegetable gardens. Overall, falo cultivation is the primary domain of women, who contributed 55 percent of total labor time in the fields (Table 7). Falo gardens offer women an important economic niche for generating small household revenues.

As with the falo gardens, foonde lands are farmed largely by women, who use them for small-scale production of vegetables, grains, and legumes. The proportion of labor time invested by women in foonde gardens is slightly greater than that in the falo and the highest among all regimes, at 62 percent of total labor inputs, with men providing 38 percent.

Table 7. Average Labor Hours per Household in Falo Fields, by Activity, Age, and Gender: 1991-1992 (46 households)

Agricultural Activity	Male						Female					
	0-7	8-14	15-45	46-60	61+	Total	0-7	8-14	15-45	46-60	61+	Total
Field Preparation	0	0.65	3	1.59	0.57	5.80	0	0.13	1.5	2.09	0.07	3.78
Nursery Preparation	0	0	0	0	0	0	0	0	0.65	0	0	0.65
Planting	0.22	2.98	12.28	4.52	2.37	22.37	0.35	3.5	38.30	10.48	0.83	53.46
Replanting	0	0.04	1.39	0	0	1.43	0	0.13	1.15	5.28	0	6.57
Fence Constr.	0.15	1.57	5.65	1.87	0.35	9.59	0.78	1.02	2.07	0.63	0.04	4.54
Weeding	0.26	4.11	29.63	4.52	4.96	43.48	1.72	2.04	6.37	1.48	0.67	12.28
Irrigating	0	0	0	0.26	0	0.26	0	0	0	0	0	0
Fertilizing	0	0	0	0.021	0	0.02	0	0	0	0	0	0
Transplanting	0	4.96	10.54	0.35	0.11	15.96	2.89	3.41	8.41	1.98	1.70	18.39
Guarding	0	10.26	43.80	3.63	13.89	71.59	6.50	8.96	27.02	31.61	2.07	76.52
Harvesting	0	4.11	7.80	0.37	1.54	13.83	2.74	4.15	20.80	5.09	3.07	35.85
Transporting	0	1.91	5.65	0.07	0.43	8.07	1	1.74	8.78	0.85	0.52	12.89
Other	0	0.39	1.04	0	0	1.43	0	0.93	1.20	3.39	0	5.52
Total	0.63	30.98	120.80	17.20	24.22	193.83	15.98	26.02	116.26	62.87	8.96	230.09

- Jeeri lands. Production on jeeri lands was carried out almost entirely by boys and adult males between the ages of 8 and 60 (Table 8). Overall, males provided 85 percent of the total labor in the production system; males between 8 and 60 provided 75 percent. In both 1990 and 1991, the number of producers harvesting a rainfed crop was nominal (19 of 59 farmers who planted on jeeri in 1991, and 38 of 77 farmers in 1992) because of the scant and erratic nature of rainfall. Rainfed farming is the only agricultural regime in the region in which women are notably absent from production. This may be due in part to the arduous nature of weeding and field clearing, which are carried out almost exclusively by males.

Table 8. Average Labor Hours per Household in Jeeri Fields by Task, Age, and Gender: 1991-1992 (88 households)

Agricultural Operation	Male						Female					
	0-7	8-14	15-45	46-60	61+	Total Task	0-7	8-14	15-45	46-60	61+	Total Task
Unknown	0	0.05	0.045	0.05	0	0.14	0	0	0	0	0	0
Field Preparation	0	9.88	12.61	4.94	3.28	30.72	0	0.10	0.60	0.14	0	0.83
Planting	2.28	24.36	39.68	6.68	6.64	79.62	2.73	7.63	24.18	3.01	0.96	38.50
Replanting	0.20	0.69	0.72	0.20	0	1.78	0	0	0.14	0	0	0.14
Fence Construct.	0.10	15.56	27.24	6.48	5.58	54.94	0.22	0.34	0.48	0.14	0	1.18
Weeding/hoeing	9.89	88.30	138.80	29.14	18.96	285.07	0.32	1.16	3.50	1.20	0.23	6.41
Irrigation	0	0	0.05	0.11	0.19	0.34	0	0	0.06	0	0	0.06
Transplant./thin.	0.08	0.15	0.31	0.30	0	0.83	0	0.30	0.30	0	0	0.59
Weeding/irrig.	0	0	2.97	0	1.63	4.59	0	0	0	0	0	0
Guarding	10.64	16.69	24.10	10.32	6.85	68.59	3.90	12.13	12.75	1.14	1.70	31.62
Harvesting	0.60	5.61	11.29	1.21	2.41	21.11	0.08	1.85	10.44	0.74	0.13	13.24
Threshing	0	0	0	0	0	0	0	0.07	0.07	0	0	0.14
Transporting	0	1.24	4.26	0.66	0	6.16	0.06	0.36	1.74	0.07	0.09	2.31
Other	0	0	0.18	[illegible]	0	0.18	0	0	0	0	0	0
Total	23.76	162.49	262.24	60.06	45.52	554.07	7.31	23.93	54.23	6.43	3.10	94.86

- Irrigated lands. Despite its high labor and capital demands and its relatively recent emergence in the area, irrigation has become an important component of the agricultural production system in the Middle Senegal Valley. Theoretically, irrigated parcels are cultivated three times a year—in the rainy season, the off-cold season, and the off-hot season—but the reality is otherwise. While 48 of our subsample households cultivated private village perimeter (PIV) plots in the rainy season, only 18 households cultivated in the off-cold season and 10 in the off-hot season. There are substantial seasonal differences in labor hours as well. While the average household in PS 6, for example, expended 2,549 labor hours in the rainy season, the off-season average number of labor hours amounted to only 217 (Table 9). When the difference between energy expended in the rainy and cold seasons is small it is not because farmers are putting more energy into the off-season crop, but because farmers could not or would not work for many hours on the rainy season crop, as in PS 1.

Irrigated rice farming is very labor intensive, easily surpassing the labor demands of jeeri farming and recession cultivation, especially when we consider labor per hectare. Yet the net returns per unit of labor are low, ranging from minus 6 FCFA for PS 1 to plus 150 FCFA for PS 4.

Table 9. Average Hours of Labor per Household in PIV Fields in Three Seasons, by PS: 1991-1992[a]

PS	Rainy Season	Cold Season	Hot Season
1	189	168	0
2	670	0	0
3	581	283	0
4	586	46	160
6	2,549	217	0
7	621	0	238
9	125	125	0

[a] PS 5 and PS 8 have been excluded because they had no PIVs.

2. Labor Inputs in Agricultural, Nonagricultural, and Domestic Farm Activities

Three sectors of household labor activity were observed and recorded in relation to age and gender: agricultural, nonagricultural, and domestic. Findings from these three data sets provide the observations that follow.

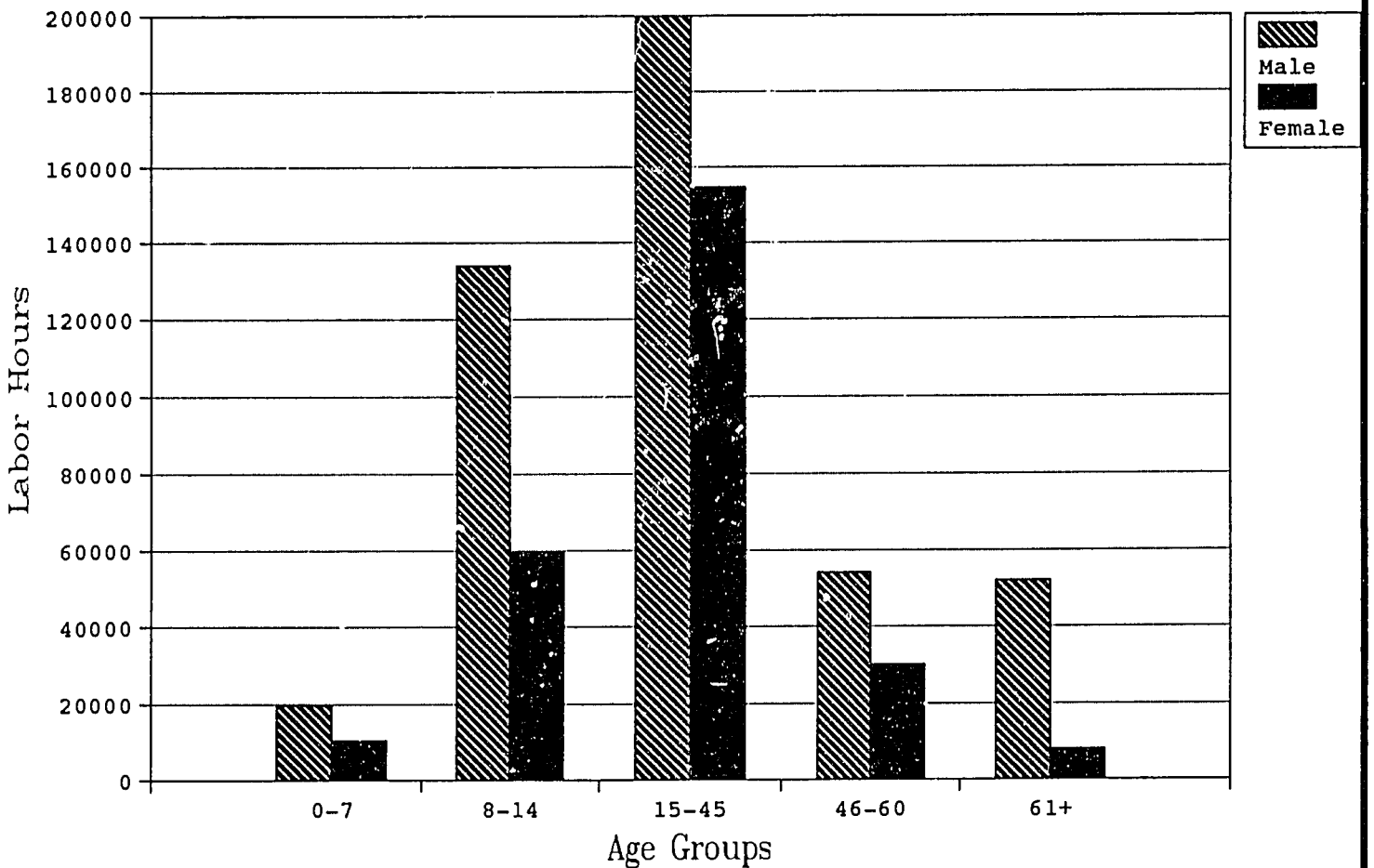
- **Agricultural labor**

Two different sets of data were collected with respect to agricultural activities. Farm-level data, referring specifically to agricultural field tasks, were gathered from a subsample on a biweekly basis during the course of each production cycle. A second data set on household agricultural labor was collected monthly throughout the course of a year. This information was solicited in a 24-hour recall period and involved the entire sample of 331 households. The labor data presented below involve all agricultural production systems in the study zones (recession, rainfed, and irrigation).

For all agricultural tasks, and in all age groups, men spend more hours in agricultural activities than women (Figure 2). Of the total hours recorded for production, male labor constituted 63.7 percent; those of ages 15-45 provided the largest proportion (27.7 percent). Women of this same age group contributed the next largest proportion of labor (21.4 percent) of total hours. This finding confirms the observation made earlier above that women in their most productive adult years contribute significantly to farm production in the absence of their adult male counterparts.

Fig. 2. Male and Female Differential

Agricultural Labor Input



- **Nonagricultural labor**

As Figure 3 shows, men are much more involved in nonagricultural tasks than are women. These include commerce, fishing, artisanry, such service-oriented activities as tailoring, baking, and butchery, salaried labor, herding, hunting and gathering, and schooling. Among all activities considered nonagricultural, the category that for all schooling activities (including French, Arabic, Koranic, and Pulaar literacy), is the single most time-consuming activity for men. Since education in all its forms is geared much more toward males than females, especially in the age groups 8-14 and 15-45, the inclusion of schooling skews the data on nonagricultural activities in favor of males. While males in these two age groups spend 108,319 and 78,799 hours respectively on schooling, females cohorts spend only 29,119 and 25,139 hours (Figure 4).[6] In the age group 46-60, however, men and women are almost equally likely to be involved in schooling—in this case literacy training—with women exceeding men by a small margin.

The largest gap in schooling activities is in the age groups 8-14 and 15-45. For the youngest group, children 7 and under, almost half as many girls attend school as boys. The proportion of boys to girls increases as they get older (8-14), as girls are pulled out of school at an earlier age than boys. Girls in the age group 15-45 spend more hours on schooling activities, on average, than those between 8-14, however. The gender gap in the age group 15-45 narrows because some boys also leave school as they get older and some attend school elsewhere. The upper end of this age group includes adults attending literacy training classes, in which the number of women sometimes exceeds the number of men.

Thus, the narrowing of the schooling gap between women and men aged 46-60 may be a function of the dramatic increase of literacy in Pulaar in the Senegal River Valley. Literacy teachers say that women frequently are far more enthusiastic about literacy than men and attend classes more regularly. The proportion of women declines after the age of 61.

A quite different portrait emerges when we examine involvement in nonagricultural activities by gender but exclude schooling (Figure 5). While the male/female gap in nonagricultural activities remains, the magnitude is far less. Gender differences in age groups 0-7, 46-60, and 61 and older are almost unchanged, but the gaps between the male and female age groups 8-14 and to a lesser extent 15-45 are substantially reduced: in the school-age groups, girls attend school with far less frequency than boys, and the gap between boys and girls increases as the age goes up.

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[6] Schooling as a nonagricultural activity covers only what occurs in the village. Boys and girls who attend school outside the village are included in the category "miscellaneous activities," although they are coded as being absent from the village for schooling purposes.

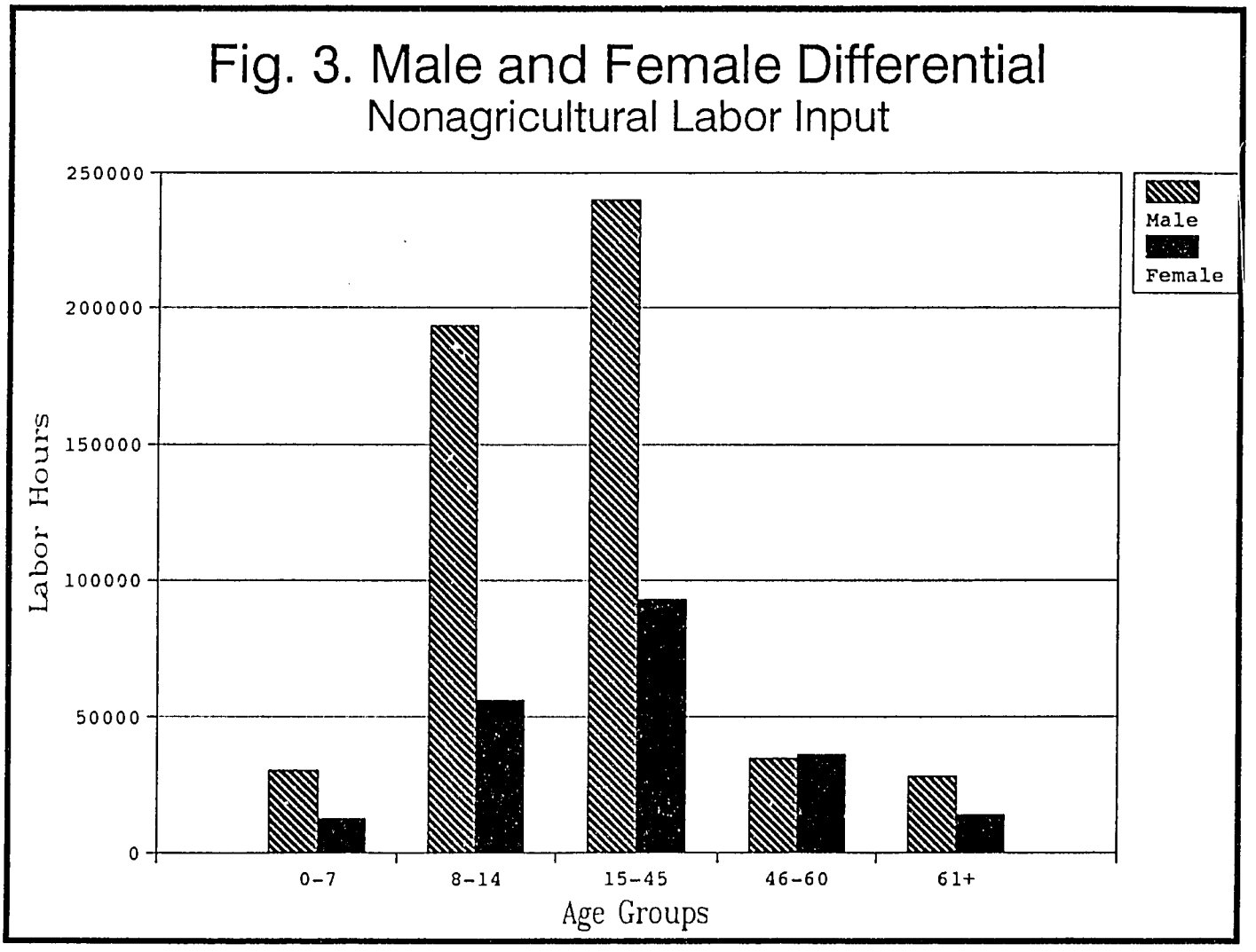


Fig. 3. Male and Female Differential
Nonagricultural Labor Input
250000
200000
150000
100000
50000
0
Labor Hours
0-7
8-14
15-45
46-60
61+
Age Groups
Male
Female

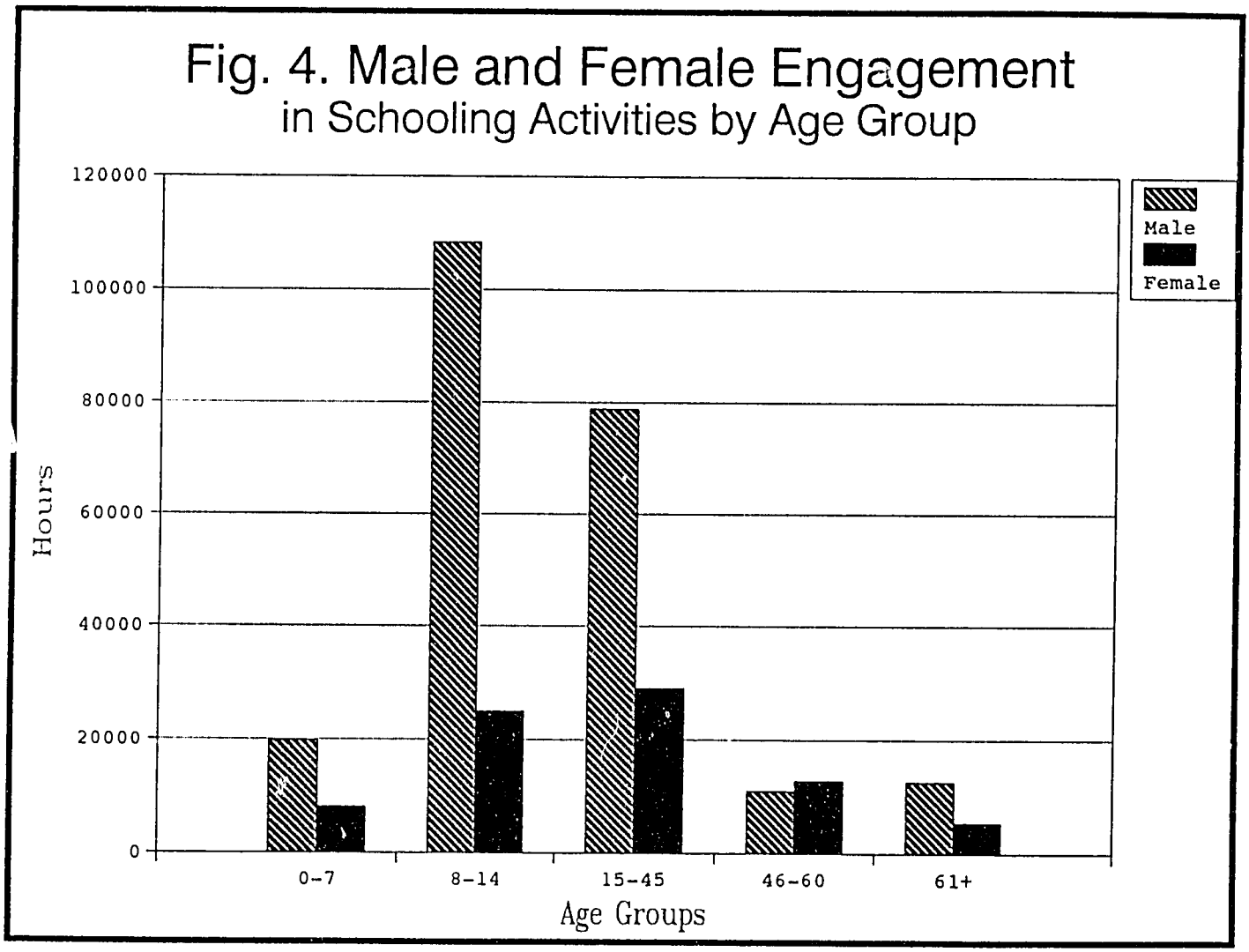
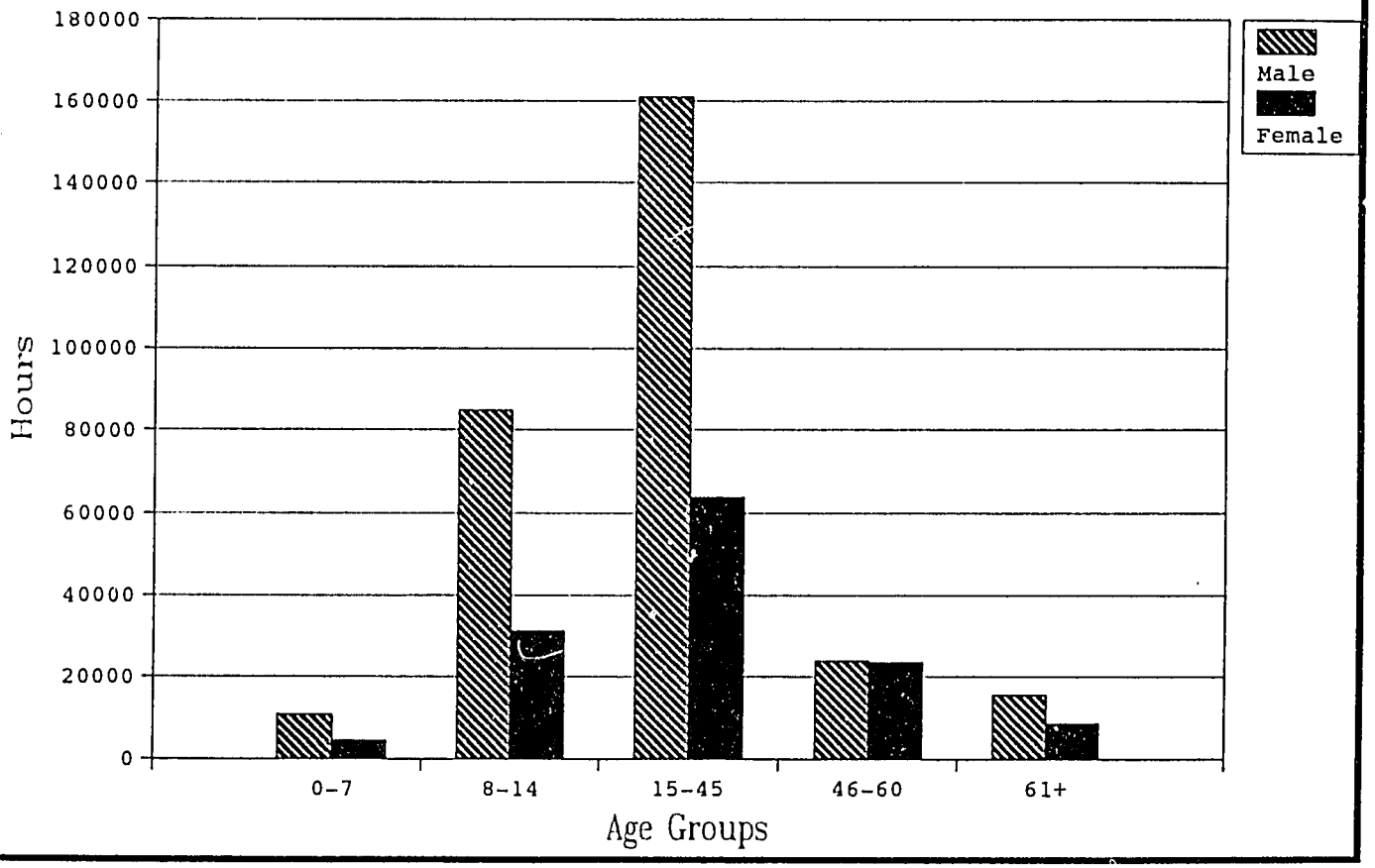


Fig. 4. Male and Female Engagement
in Schooling Activities by Age Group
120000
100000
80000
60000
40000
20000
0
Hours
0-7
8-14
15-45
46-60
61+
Age Groups
Male
Female

Fig. 5. Male and Female Engagement in Nonagricultural Activities Excluding Schooling



- **Domestic labor activities**

Women are much more involved in domestic activities than men, as would be expected. The level of activity steadily increases after childhood and declines only late in life, after age 60 (Figure 6). The activities most commonly engaged in are food preparation and the collection of firewood and water.

C. Returns to Production Factors: Land, Labor, Capital

Table 10 compares average yield per hour of labor, average yield per hectare, average expenditure per hectare, and average labor hours per hectare for irrigation, distinguishing among large-scale perimeters (GPI), middle-scale perimeters (CIN), private irrigated perimeters (PIP), village irrigated perimeters (PIV), and irrigated vegetable gardens (MJF); waalo (WLO); falo (FLO); jeeri (JRI); and foonde (FND). Among the 405 parcels cultivated by the subsample from which we gathered extensive farm labor data, one-third (131 of the 405) yielded no harvest, telling evidence of the risks associated with agriculture, especially dryland farming, in the Senegal River Valley.

Table 10. Land, Labor, and Capital Productivity: 1991-1992 (405 parcels)

Agricultural System	Average Yield per Hour (FCFA)	Average Yield per Ha (FCFA)	Average Expenditure per Ha (FCFA)	Average Hours of Labor per Ha
Irrigation: Mid-Scale Perimeters (CIN)	252	385,436	80,336	1,531
Falo (FLO)	160	220,939	4,512	1,381
Foonde (FND)	24	13,207	1,410	557
Irrigation: Large-Scale Perimeters (GPI)	275	209,508	52,630	761
Jeeri (JRI)	27	5,562	869	209
Irrigated Vegetable Gardens (MJF)	17	27,358	17,656	1,589
Irrigation: Private Irrigated Perimeters (PIP)	5	13,644	37,520	2,849
Irrigation: Village Irrigated Perimeters (PIV)	135	196,581	35,040	1,454
Waalo (WLO)	140	37,772	1,836	271

In order to make comparisons among the differently valued crops, we converted the physical weights (in kilograms) into monetary values, using average prices received by farmers or average market prices for a given season.

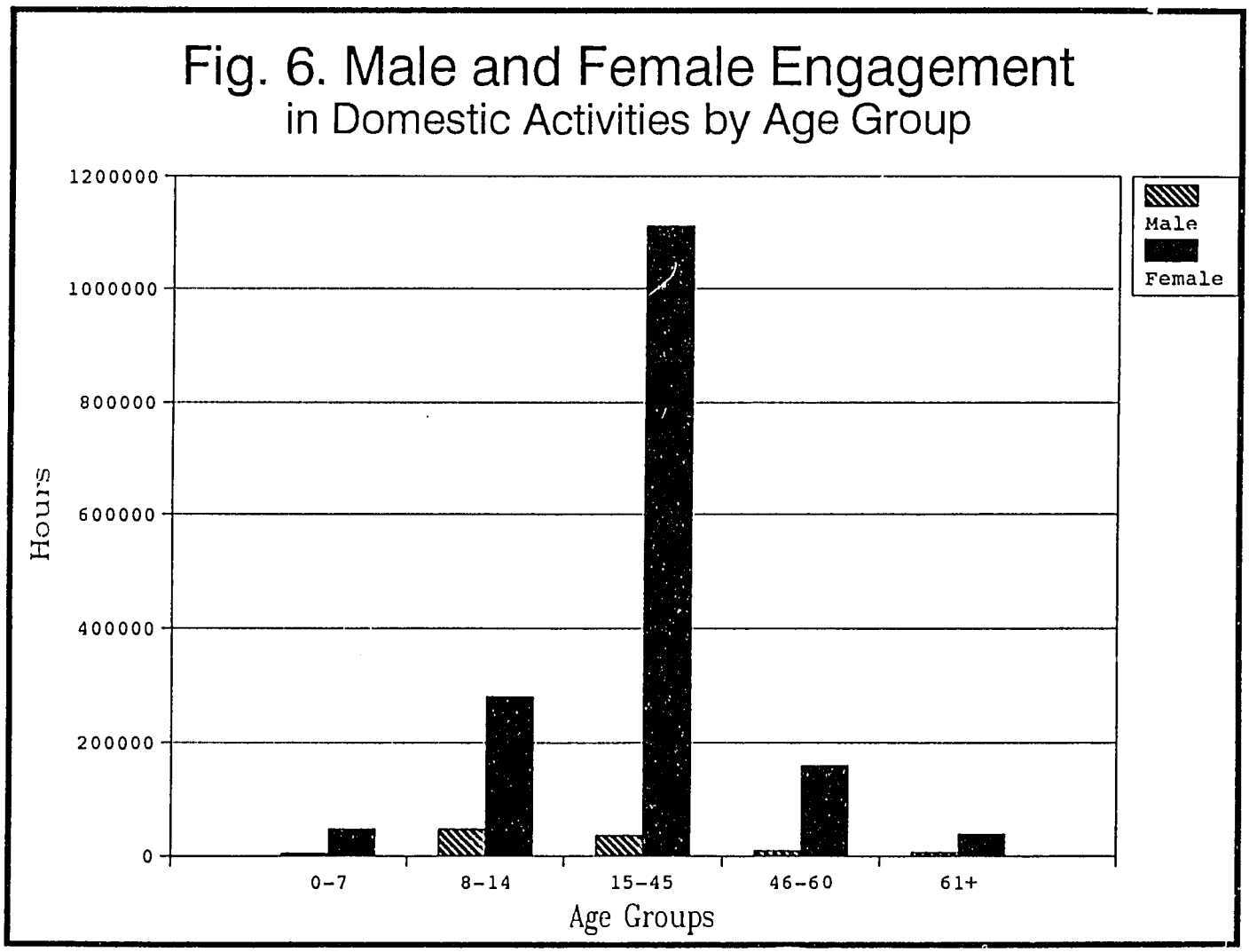


Fig. 6. Male and Female Engagement
in Domestic Activities by Age Group
1200000
1000000
800000
600000
400000
200000
0
Hours
0-7
8-14
15-45
46-60
61+
Age Groups
Male
Female

In terms of yields per labor hour in FCFA (Table 10 and Figure 7), the larger irrigated parcels, whether large-scale irrigated perimeters (GPI) or middle-scale perimeters (CIN), appear the most rewarding. This is predominantly a function of the much heavier use of machinery in irrigated agriculture, especially in large-scale, middle-scale, private, and village irrigated perimeters, a variable that was not factored in when we calculated labor. This overvalues the labor hour of a person on a tractor, given its heavy cost. In an attempt to resolve this problem, we started by calculating the number of animal and machine hours recorded on the various parcels, as presented in Tables 11 and 12.

Table 11 and Figure 8 reveal that among irrigated parcels, only village irrigated perimeters reported using animals (mostly donkeys or animal-drawn carts), in large part to move harvests. As to machinery (Table 12), only two types of parcels, private irrigated perimeters and village perimeters, reported employing heavy machinery (specifically harvester/threshers and tractors), with PIPs reporting 18 hours of harvester/thresher use, and PIVs reporting 21 hours of tractor use.

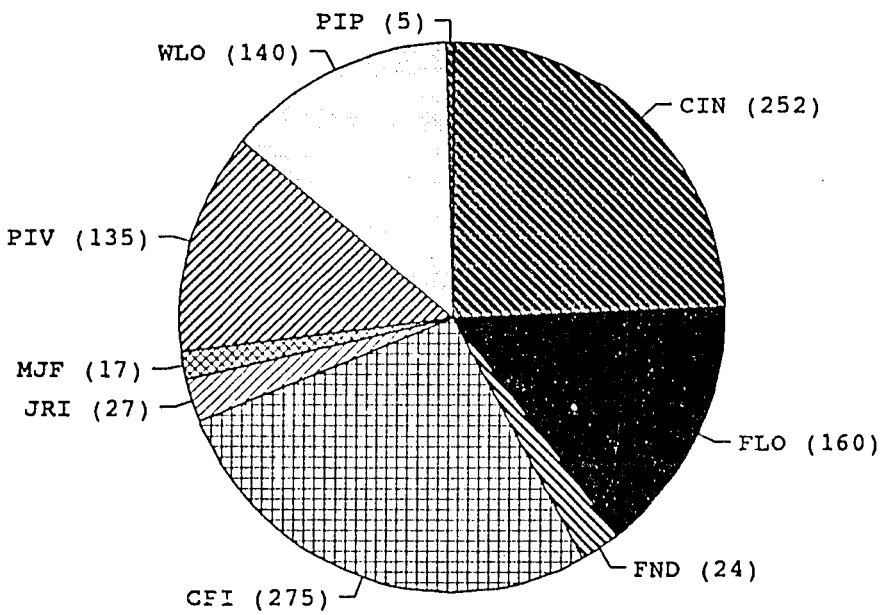
Table 11. Number of Animal Hours by Type and Agricultural System: 1991-1992

Agricultural System	Donkey	Horse	Plough	Animal-Drawn Cart
Falo (FLO)	41	0	0	38
Foonde (FND)	0	0	0	16
Jeeri (JRI)	0	266	543	124
Village Irrigated Perimeter (PIV)	40	8	0	21
Waalo (WLO)	14	22	27	102

Table 12. Number of Machine Hours by Agricultural System: 1991-1992

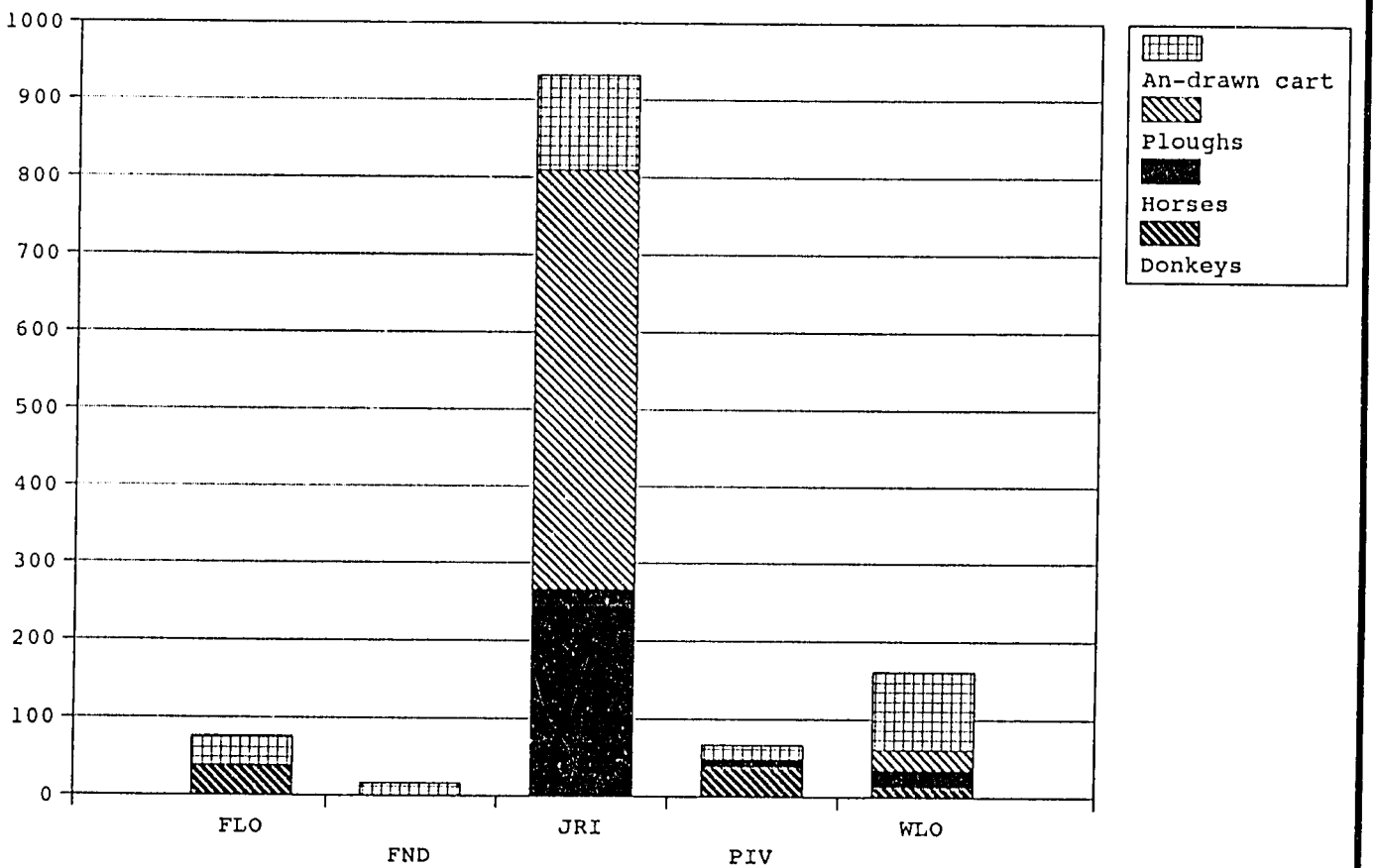
Agricultural System	Harvester/Thresher	Tractor
Private Irrigated Perimeter (PIP)	18	0
Village Irrigated Perimeter (PIV)	0	21

Fig. 7. Average Yield per Labor Hour: 1991-1992 (in FCFA)



PIP	Private irrigated perimeter
CIN	Middle-sized irrigated perimeter
FLO	Falo
FND	Foonde
GPI	Large-scale irrigated perimeter
JRI	Jeeri
MJF	Irrigated vegetable garden
PIV	Village irrigated perimeter
WLO	Waalo

Fig. 8. Number of Animal Hours by Agricultural System: 1991-1992



As we know that both tractors and harvester/threshers are used in at least two other types of irrigated parcels, large-scale and medium-scale perimeters, we looked at production charges to discover the amounts of money that farmers reported having paid for machine services (Table 13).[7] For hiring tractors, farmers spent FCFA 107,400 on large-scale perimeters (9 instances of use), 105,000 on private perimeters (3 instances of use), 86,000 on middle-scale perimeters (18 instances of use), and 78,000 on village-irrigated perimeters (14 instances of use) (Figure 9). Average cost per use varies widely among systems, from the high reported for the three private irrigated perimeter instances to the considerably lower cost per use of the mid-scale and village perimeters.

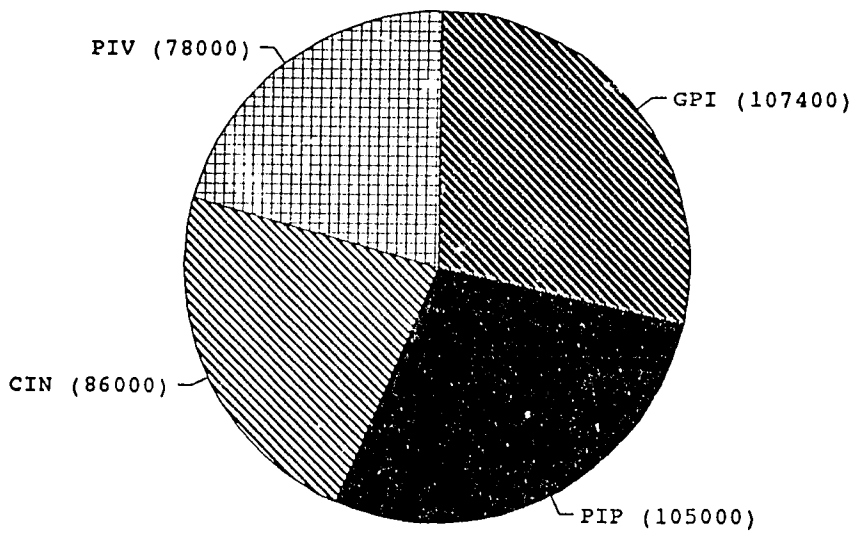
Table 13. Tractor Use by Agricultural System, Number of Uses Reported and Cost: 1991-1992

Agricultural System	Number of Uses Reported	Total Cost (FCFA)	Cost per Use (FCFA)
Large-Scale Perimeters (GPI)	9	107,400	11,933
Mid-Scale Perimeters (CIN)	18	86,000	4,778
Private Irrigated Perimeters (PIP)	3	105,000	35,000
Village Irrigated Perimeters (PIV)	14	78,000	5,571
All	44	376,000	8,555

Leaving aside the complications of returns to labor because of mechanization in the irrigated systems for the moment, a comparison of yield per labor hour among the unirrigated systems shows falo and waalo farming to be the most rewarding, with per hour yields of, respectively, 160 FCFA and 140 FCFA (Table 10). The generally low labor returns are a result of the disastrous agricultural year, with—as noted above—out of 405 parcels cultivated, 131 or 32 percent reporting no harvest.

[7] Farm labor and cost data were collected in the fields, cost data on a monthly basis, and labor data every two weeks. Many of the heavier agricultural operations, such as plowing and harvesting on government-operated irrigated schemes, be they large-, medium-, or village-level, are coordinated and operated by the government or a designated agency. Fees for such services are recorded as part of the credit that each farmer/parcel owes and are charged against harvest, if there is any, at the end of the season. Accordingly, farmers (and therefore research assistants) often do not know what these charges are until some time after the season is over and gains and losses are calculated.

Fig. 9. Use of Tractors by
Agricultural System 1991-1992 (in FCFA)



In yield per hectare, the value of output of falo is almost six times that of waalo, 220,939 FCFA as opposed to 37,772 FCFA (Table 10). Village irrigated perimeters, at 196,581 FCFA, are closer to falo than to waalo in per-hectare yield. As expected, on irrigated parcels that rely on heavy machinery, whether large- or middle-scale, yield per hectare is quite high: 385,436 FCFA on middle-scale perimeters and 209,508 FCFA on large perimeters, though falo returns per hectare in our sample exceeded returns on the large-scale perimeters (Table 10 and Figure 10).

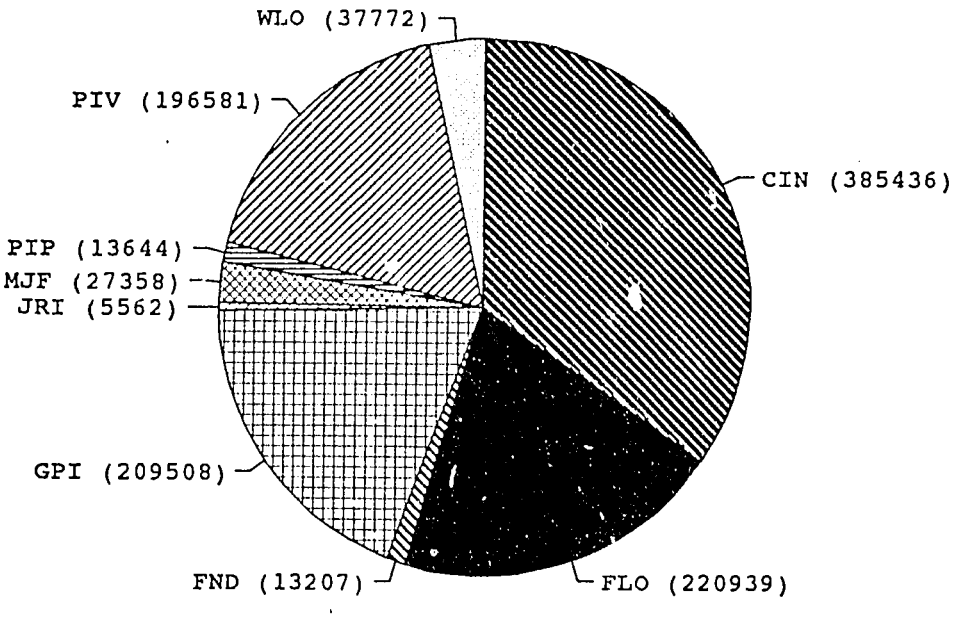
Largely because of the use of heavy machinery, fuel, insecticides, and herbicides, the cost of production per unit of irrigated land, for middle-scale perimeters (80,336 FCFA), large-scale perimeters (52,630 FCFA), private irrigated perimeters (37,520 FCFA), and village irrigated perimeters (35,040 FCFA) are high (see Table 10 and Figure 11). Cost of production for falo cultivation, 4,512 FCFA, exceeds that of waalo (1,836 FCFA), foonde (1,410 FCFA), and jeeri (869 FCFA). Compared to the cost of production on irrigated gardens (17,656 per hectare)—the least costly among irrigated parcels—however, falo production costs seem quite modest. In calculating cost, we note that farmers did not report seeds saved from the previous year's harvest as a cost.

Despite the use of heavy machinery, which increases the value of labor, as seen above, larger-scale irrigated farming is still very demanding of labor. Private perimeters reported 2,849 labor hours per hectare, middle-scale perimeters 1,531 hours, village irrigated perimeters 1,454, and large-scale perimeters 761 (Table 10 and Figure 12). As was also mentioned earlier, falo gardening is labor intensive (1,381 hours per hectare), but this is justified by higher returns, especially returns to units of land and labor. While falo gardening demands an average of 173 person-days on the basis of eight hours a day per hectare, a little less than what is required on PIVs (182 person-days), waalo farming, among the least demanding of the systems, requires 34 person-days. (Labor hours as used here are unweighted.)

D. Fisheries

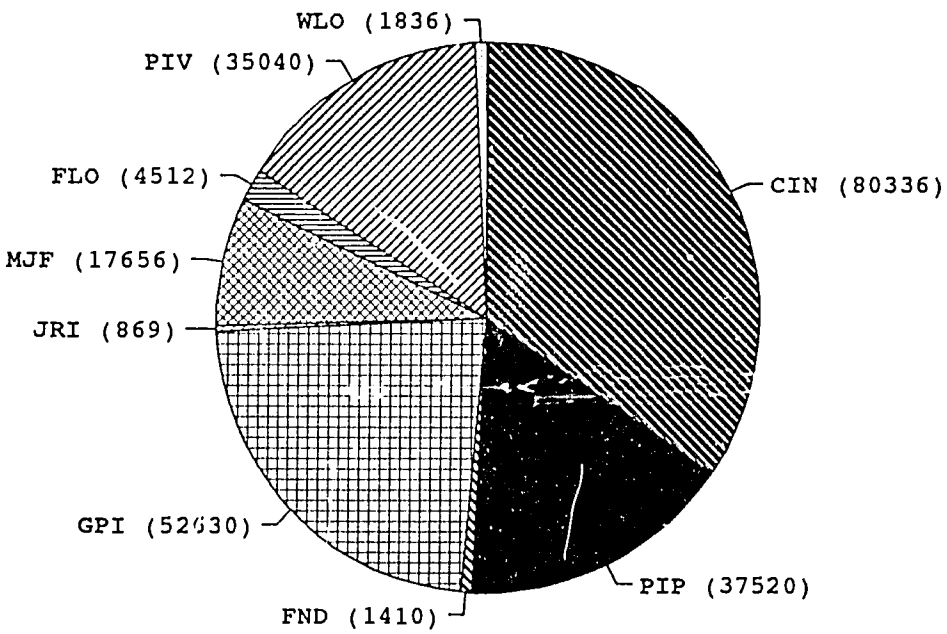
Research from the SRBMA I study highlighted the importance of maintaining a seasonal annual flood of the inner-lying basins in order to assure the reproductive viability of freshwater fish populations in the river valley. On-site observation of the effects of poorly timed water releases from the Manantali Dam in 1991 reveal the detrimental consequences for downstream fisheries. The repeated release of waters at Manantali washed fish populations downstream toward Richard Toll, making it difficult for fishers to bring in good catches. The timing of a flood release from the dam is thus critical to the seasonal migration, feeding, and spawning patterns of riverine-wetland fish and affects the livelihoods of thousands of fishing families throughout the valley.

Fig. 10. Average Yield per Hectare: 1991-1992 (in FCFA)



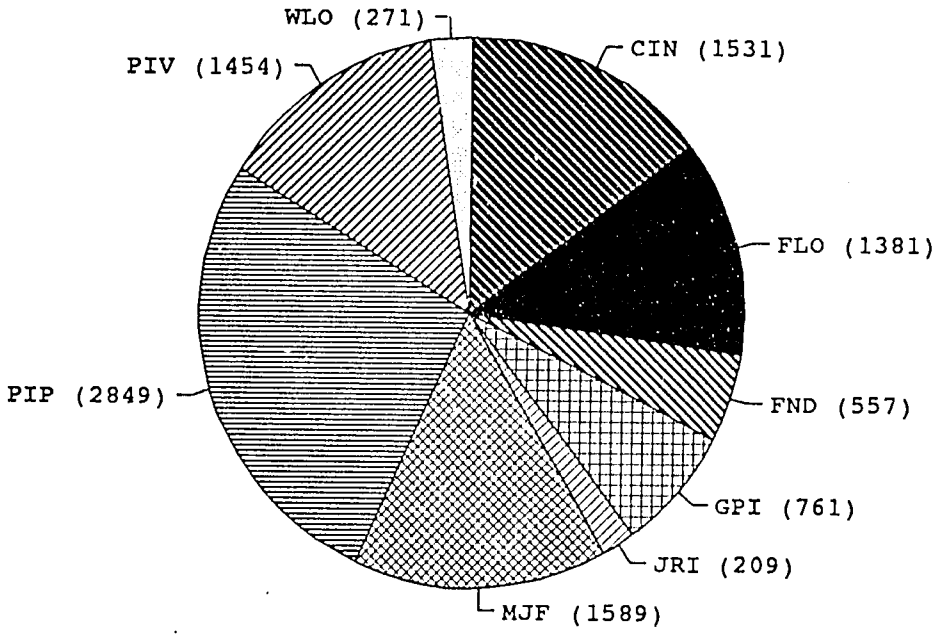
WLO	Waalo
CIN	Middle-sized irrigated perimeter
FLO	Falo
FND	Foonde
GPI	Large-scale irrigated perimeter
JRI	Jeeri
MJF	Irrigated vegetable garden
PIP	Private irrigated perimeter
PIV	Village irrigated perimeter

Fig.11. Average Expediture per Hectare
1991-1992 (in FCFA)



WLO	Waalo
CIN	Middle-sized irrigated perimeter
PIP	Private irrigated perimeter
FND	Foonde
GPI	Large-scale irrigated perimeter
JRI	Jeeri
MJF	Irrigated vegetable garden
FLO	Falo
PIV	Village irrigated perimeter

Fig. 12. Average Total Labor Hours per Hectare: 1991-1992



WLO	Waalo
CIN	Middle-sized irrigated perimeter
FLO	Falo
FND	Foonde
GPI	Large-scale irrigated perimeter
JRI	Jeeri
MJF	Irrigated vegetable garden
PIP	Private irrigated perimeter
PIV	Village irrigated perimeter

E. Migration

One of the most important findings from the SRBMA I study was the pervasive nature of both seasonal and long-term wage migration among adult men. This phenomenon has significant implications in shaping the outcome of on-farm production, for which adequate labor must be mobilized strategically in a seasonal fashion among a broad array of activities in farming, fishing, and herding.

A general survey of regional demography in SRBMA II reveals the extensive nature of migration outside the valley. In a sample of 331 households involving 3,476 persons, 737 or 21 percent were absent. Among males aged 15-45, a large number—52 percent—were absent. For females of the same age group, the rate was only 14 percent. The potential impact of this very high rate of migration on the availability of labor in the Middle Valley is evident. With nearly half of the active males absent (444 of 915, or 48.5 percent of those aged 15-60), serious labor bottlenecks are likely to present themselves in peak agricultural seasons. Paradoxically, it is this high rate of labor migration that finances the capital intensive demands of irrigated agriculture among Middle Valley households.

The SRBMA II study has closely examined two aspects of migration. First, a comparative topology of migration patterns has been identified for the Podor and Matam departments. This enables one to compare and assess the implications of migratory destination for the sending communities in the region. Second, seasonal migratory patterns in relation to the various contexts of involvement in irrigation and recession agriculture have been identified and elaborated.

1. Incidence and Patterns of Migration

Among the absent, migrant destinations include other regions of Senegal (69 percent), other countries in Africa (25 percent), and areas outside the continent, principally Europe (6 percent). Contrary to popular opinion, migration in the Department of Matam (20 percent of the population) is slightly less than in the Department of Podor (22 percent). On average, remittances to their village households are greater among Middle Valley migrants living in other African countries than among migrants remaining in Senegal, due in part to greater distances from family members who require considerable financial support.

The highest rate of nonremittal of income by migrants (37 percent) occurs among migrants remaining in Senegal. This very likely reflects the difficult economic conditions that obtain in the country and the high concentration of river-basin migrants in Dakar who are unable to find gainful employment. Migrants in other African countries and outside the continent had nonremittal rates of approximately 21 and 24 percent, respectively.

Migrants in other African countries contributed the largest amount of remittances per household for a one-year period, averaging 285,402 FCFA. The next largest source of remittance income was from migrants within Senegal. Long-term migrants remitted 140,575

FCFA while seasonal migrants sent back 66,181 FCFA. Only 17 sample households had migrants outside Africa. For those who sent money home, however, remittances per household were higher than those from migrants within Senegal and lower than from those in other African states, at 214,524 FCFA. The higher remittances of migrants in non-Senegal Africa than those overseas may result from the difficult economic conditions that migrants encounter outside the continent. In turn, this may reflect the greater cultural familiarity and ease with which migrants assimilate in an African context as opposed to the more unfamiliar milieu of a European or American setting.

The distribution of remittances by age, gender, and destination shows that among seasonal migrants within Senegal, men over 60 remitted the highest annual per capita amount (82,275 FCFA a year). The next largest amount for seasonal migrants was sent by men between the ages of 46 and 60 (54,075 FCFA). Men aged 15-45 remitted an average of 49,224 FCFA. Women, too, migrate seasonally and send home remittances, although in every age group women migrants in the sample remit on average less than men. A large majority (70 percent) of female seasonal migrants are between the ages of 15 and 45. Those aged 60 and over remit the largest sums of money (25,386 FCFA per capita). This is an important finding, as it has been widely believed that women of the region play no significant role as migrants.

Among long-term migrants remaining in Senegal, remittances were greater for both men and women than remittances of seasonal migrants. They were highest for men in the 46-to-60 age category (143,995 FCFA per capita), and for women in the 15-to-45 age category (70,048 FCFA per capita).

Migrants to other African countries, 80 percent of whom cited commerce as their main occupation, sent per capita annual remittances that were substantially higher than those of migrants staying in Senegal. The highest per capita amounts were remitted by men age 46 to 60 (412,197 FCFA), almost three times as large as those from Senegal. Per capita amounts remitted by women in non-Senegal Africa averaged slightly less than the amount remitted by female seasonal migrants and considerably less than the amount remitted by women migrants remaining in Senegal. Only women in the 15-to-45 age group sent home remittances (averaging 21,454 FCFA). Women's rates of participation in this type of migration, moreover, was lower than the participation rates of seasonal and long-term women migrants in Senegal.

The principal residence of 19 migrants was overseas in Europe (France) or the United States. These individuals remitted 41 percent less per household than did migrants living in African countries other than Senegal. Per capita remittances were highest among men aged 46 to 60 (168,993 FCFA). On the other hand, women who migrated to countries outside the continent remitted considerably more than either seasonal or long-term female migrants in Senegal or in other African nations, averaging 173,571 FCFA per capita in the 15-to-45 age group.

Summary statistics on the incidence and profitability of migration by destination, gender, and age show that households with migrants in Africa had the highest rate of remittal and on

average the highest annual remittance earnings. Thus, among SRBMA II's sample households, and contrary to popular belief, Europe and the United States were not the most profitable destinations for migrants. Men between the ages of 15 and 45 participated most heavily in migration, but it was men between 46 and 60 who sent home the most per capita. Among women, the 15-to-45 age group was most active in migration and remitted the most income per capita. In terms of participation rates, seasonal migration and longer-term migration within Senegal engaged the most households. Except where seasonal migration is concerned, women participated only marginally in migration.

2. Migration and Agricultural Development

A key concern of agricultural development in the Senegal River Basin is the large outflux of men that impedes the development and expansion of irrigation in the region. Analysis of SRBMA I data demonstrated the contradiction associated with irrigation and migration. On the one hand, migration draws labor from the region, labor that could be used on the farm, particularly on irrigated perimeters. On the other hand, migration is an extremely important source of revenue for households, helping households to cover food costs, especially in years when rainfall and floods are inadequate. Most importantly, it is crucial in financing irrigation inputs.

The data from SRBMA II show that remittances were less important for households with access to irrigation than for households with access to flood recession agriculture. The 331 sample households were sorted into eight groups, differing by their access to the various combinations (from zero to three) of recession, rainfed, and irrigated agriculture (Table 14). Groups 1-4 have access to irrigation, groups 5-8 have little or no such access; groups 1, 2, 5, and 6 have access to land for recession agriculture, groups 3, 4, 7, and 8 have not; and groups 1, 3, 5, and 7 have access to rainfed agricultural land, while groups 2, 4, 6, and 8 do not. This finding about remittances appears in annual household remittances as well as in the number of migrants per household. Migration rates were slightly lower for households with access to irrigation than for households that farmed flood basins, suggesting that to a certain extent the presence of irrigation tends to curb the flow of migrants from the region.

With respect to crop yields in irrigation, several important variables are critical in determining levels of output. These include income, the type of perimeter farmed, and the amount of labor deployed in other production systems. The amount and percentage contribution of remittances in income are important in determining which households financed production costs themselves. Thus, although the presence of irrigation seems to inhibit out-migration slightly, there is also strong evidence that irrigation continues to rely on remittances for its ongoing survival.

Table 14. Farm and Off-Farm Revenues by Household Configuration Groups (FCFA and percent)

Group	Average Income (FCFA)		Remittances per Household (FCFA; percent)	Average Annual Off-Farm Revenue	Average Annual Income (FCFA; percent) from:				
	Total	Per Capita			Recession Agriculture	Irrigated Agriculture	Rainfed Agriculture	All Farm	Livestock
1	321,782	37,948	115,657 35.9%	201,570 62.6%	34,046	61,110	3,801	101,461 31.5%	18,751 5.8%
2	489,532	50,899	212,794 43.5%	258,057 52.7%	111,800	86,972	723	215,306 44.0%	16,169 3.3%
3	361,859	50,794	89,873 24.8%	269,569 74.5%	0	62,475	2,828	58,890 16.3%	33,400 9.2%
4	357,383	42,912	51,096 14.3%	224,545 62.8%	0	89,833	0	86,301 24.1%	46,537 13.0%
5	480,355	49,047	223,893 46.6%	346,830 72.2%	90,016	-3,675	10,889	107,625 22.4%	25,900 5.4%
6	456,479	58,456	246,379 54.0%	392,918 86.1%	40,545	0	4,221	44,726 9.8%	18,835 4.1%
7	329,127	41,973	205,477 62.4%	275,204 83.6%	-2,060	0	9,165	9,160 2.8%	44,763 13.6%
8	327,294	45,011	237,680 72.6%	319,363 97.6%	-1,510	220	399	-218 0.0%	8,151 2.5%

F. Household Consumption

SRBMA II data allow us to examine the impact a poor flood period has on food consumption patterns of households classified by income and access to production systems. It is hypothesized that high-income households are less vulnerable to changes in climate and dam management policies and thus in a better position to feed themselves. Low-income households, by contrast, are directly harmed by poor flood conditions. Because of their limited access to resources, particularly to cash income, they rely heavily on traditional flood and rainfed production methods. In years of poor flooding and rainfall, they are unable to compensate fully for reduced agricultural output by purchasing food or engaging in capital-intensive production. As a result, they consume less food, including such staples as rice, sorghum, and millet, than do households with higher incomes and depend more heavily on gifts, borrowing, and exchanges as sources of food.

Analysis of data from one research site in SRBMA I supported this hypothesis, revealing that wealthy households relied less on traditional production methods to feed themselves than did poorer households. Large land and labor resources and high cash incomes allowed wealthy households to engage in irrigation and to purchase a large part of what they ate. Households

with fewer resources depended more heavily on low-cost traditional flood recession and rainfed production methods.

In examining the SRBMA II data, an initial analysis by income deciles, ignoring effects of climate, geography, and infrastructure, yielded somewhat unexpected results. While consumption patterns differed among household income groups, the differences were not large. Low-income groups tended to consume less per capita than high-income groups, but the sources of food and the composition of diets did not differ substantially among income groups (Table 15).

Table 15. Value of Annual Total and Per Capita Household Consumption by Income Decile

Decile of Per Capita Income	Average Number of Consumers per Household[a]	Income Per Capita (FCFA)	Annual Household Food Consumption (FCFA)	Annual Food Consumption Per Capita (FCFA)
1	8.40	5,865	392,865	46,770
2	9.57	12,096	391,805	40,941
3	9.17	17,217	502,662	54,816
4	9.34	21,335	438,285	46,926
5	8.00	26,364	582,258	72,782
6	7.89	33,739	465,754	59,031
7	8.57	40,422	528,560	61,676
8	7.70	47,979	679,472	88,243
9	9.62	61,702	739,153	76,835
10	7.80	116,475	735,386	94,280

[a] Weights are by age group: children 0-7 years = 0.5; 8-14 years = 0.75; 15-60 years = 1.0; 61 and over years = 0.75.

Our findings indicate that the value of food consumed by low-income households was substantially less than the value consumed by high-income households. Although the correlation is imperfect, the value of per capita food consumption in the four lowest income deciles is well below that of the highest four deciles (Table 15). Purchases are also lower among low-income households than among high-income households (Table 16). Furthermore, when we group households by access to production systems as well as income, we find that the value of grains consumed is less for low-income households than for high-income households. These findings also support our hypothesis. An additional finding is that food received by low-income households as gifts or through exchange is higher than it is for high-income households. Food obtained on credit, however, is substantially higher among high-income households (Table 16). Overall, gifts, exchanges, and credit provided the lowest income groups with a small proportion of the total food they consumed—from 7 to 19 percent in the lowest four deciles. This does not

differ from the proportion for the highest deciles (ranging from 10 to 20 percent), but the composition differs, as indicated: more in gifts and exchanges at the low-income level, more in credit at the high end. Our findings do not allow us to conclude definitively that high income households produced and consumed more irrigated rice in poor flood years.

Table 16. Sources of Food Consumed, by Income Decile (FCFA and percent)

Decile of Per Capita Income	Purchase	Exchange	Gift	Credit	Household Production	Land Payments	Other	Total
1 FCFA	267,900	14,245	28,708	30,175	37,703	12,895	1,240	392,865
Percent	68.2	3.6	7.3	7.7	9.6	3.3	0.3	100
2 FCFA	265,578	12,334	23,199	14,072	57,834	14,821	3,968	391,805
Percent	67.8	3.1	5.9	3.6	14.8	3.8	1.0	100
3 FCFA	314,056	22,044	49,451	16,450	87,408	7,549	5,705	502,662
Percent	62.5	4.4	9.8	3.3	17.4	1.5	1.1	100
4 FCFA	295,843	7,214	9,178	14,066	99,956	7,422	4,607	438,285
Percent	67.5	1.6	2.1	3.2	22.8	1.7	1.1	100
5 FCFA	408,855	10,029	63,908	26,119	66,712	3,621	3,013	582,258
Percent	70.2	1.7	11.0	4.5	11.5	0.6	0.5	100
6 FCFA	308,964	15,832	7,571	49,541	70,617	8,478	4,752	465,756
Percent	66.3	3.4	1.6	10.6	15.2	1.8	1.0	100
7 FCFA	342,299	15,542	13,530	74,005	79,425	3,041	718	528,560
Percent	64.8	2.9	2.6	14.0	15.0	0.6	0.1	100
8 FCFA	506,767	5,668	6,613	71,215	81,257	4,615	3,337	679,472
Percent	74.6	0.8	1.0	10.5	12.0	0.7	0.5	100
9 FCFA	589,125	6,584	5,785	59,105	73,625	2,387	2,540	739,153
Percent	79.7	0.9	0.8	8.0	10.0	0.3	0.3	100
10 FCFA	550,330	8,084	17,824	51,079	89,102	11,096	7,872	735,386
Percent	74.8	1.1	2.4	6.9	12.1	1.5	1.1	100

G. Household Budgets and Income

1. Sources of Revenue

The data show that households diversify the sources of their income quite widely. The degree of this diversification and the total and proportions of the amount earned from diverse activities varies by production space (PS) and, to a lesser degree, by caste. Twenty different sources of income are reported in Table 17. Of the twenty sources of income listed, most PSs resort to at least fifteen of them, although the degree of reliance on a particular activity, measured in terms of the total income generated, varies widely.

The highest average household income observed is in PS 6, which relies heavily on migratory remittances (accounting for 45 percent of total income). This production space, along with PS 7, PS 8, and PS 9, is located upstream in the Middle Valley, in Matam Department. On average, a greater proportion of total income for all these PSs is generated by migratory remittances (58 percent) than the proportion found in the other PSs. These other production spaces, which are downstream in Podor Department, average 28 percent of income generated by remittances. Conversely, the portion of total revenues derived from agricultural activities is twice as great in the Department of Podor (27.6 percent) as in Matam (13.6 percent). To what extent this is a function of geographical location is not yet clear: the presence or absence of substantial access to irrigation, for example, is important.

In sum, diversification is a necessary survival strategy in the Middle Senegal Valley. In most areas, we see a very high dependency on migratory remittances, followed by agriculture and herding. Other sources of revenues, regarded individually, look much less impressive. Aggregated, however, they contribute importantly to household survival.

2. Crop Transactions

Crop production is largely for local subsistence rather than market exchange. Crop purchases exceeded sales by a wide margin, in part, due to poor growing conditions in 1991 and 1992. As a result, large quantities of imported cereal grains (rice and sorghum) were bought on the market to make up for severe shortfalls in local cereal production.

Differences in the market price of crop sales and purchases indicate that smallholders in the Middle Valley are caught in a spiral of declining terms of trade. In general, peasant households purchase imported food grains (rice and sorghum) in the marketplace at prices greater than prices at which locally produced grains (paddy rice, millet, and recession sorghum) can be sold. Unfavorable climatic conditions that did not allow many local farmers to produce a surplus crop for the market forced households to buy imported grains, at higher prices than local grains sell for when they are available.

Table 17. Percentages of Household Income Earned, by Revenue-Generating Activity and PS

PS	1	2	3	4	5	6	7	8	9
Number of Households	32	25	37	32	35	34	53	38	45
Total Income (FCFA)	14,488,854	7,269,396	8,445,265	13,572,601	8,606,532	29,283,975	10,309,575	15,250,931	19,039,223
Total Income (percent)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Revenue Source									
Farm Income	2.37	49.21	21.70	35.08	29.80	22.52	15.09	14.82	2.24
Sale of Livestock	7.69	2.08	28.16	1.64	23.10	0.40	4.01	6.17	11.08
Hunting	0.00	0.00	1.75	0.00	0.00	0.00	0.00	0.00	0.00
Fishing	2.51	1.54	3.49	0.18	2.17	1.52	3.65	5.10	1.14
Artisanal	0.71	0.13	1.06	2.22	0.52	1.75	0.56	4.46	0.81
Service	6.76	5.48	4.24	5.54	5.09	0.85	0.41	1.12	2.35
Commercial	1.17	0.00	2.00	2.86	15.09	0.27	2.04	1.08	0.00
Small Shop	0.12	0.00	0.60	0.00	1.75	0.09	0.09	1.02	0.66
Transport	0.00	0.00	0.04	0.94	0.67	0.60	0.00	0.44	0.00
Ag. Equip. Rental	0.69	0.00	1.63	0.96	0.00	3.61	0.01	0.30	0.48
Rental Property	6.22	4.21	1.73	0.00	0.03	3.93	0.19	0.86	0.23
Sale of Personal Effects	2.36	2.30	0.59	0.53	0.56	0.24	0.14	0.51	0.41
Marabout	2.58	0.00	0.00	0.93	3.46	3.37	0.00	1.07	0.05
Government	0.97	0.00	0.00	0.00	0.05	4.06	0.00	0.03	0.00
Herding	0.00	0.00	0.32	0.00	0.00	0.20	0.00	0.00	0.13
Food Sale	0.03	0.00	0.00	0.00	0.00	0.06	0.01	0.00	0.03
Migration Remittances	32.87	31.39	25.95	41.26	9.60	45.01	67.22	47.52	71.28
Retirement	..29	2.26	0.00	0.02	1.20	3.46	2.33	2.29	0.00
Private Sector Salaries	6.35	0.28	0.00	1.47	0.00	0.03	0.09	0.22	0.00
Other	18.31	1.11	6.74	6.37	6.90	8.02	4.17	13.00	9.11

3. Livestock Transactions

The sale of animals exceeded purchases considerabiy during this study due to drought-like conditions during the two-year period. Geographically, a disproportionately large number of sheep were sold in two production spaces, PS 3 and PS 5. Fulbe-headed households were the caste group most prominent in sales of these animals.

With respect to the purchase of sheep, distinctions were noted by PS and caste. PS 6 had by far the most households purchasing sheep (23 of 63 households, or 37 percent) and the most sheep purchased (61 of 134 sheep purchased, or 46 percent). This may well reflect the greater purchasing power among households in this production space: average household income is almost twice as great as that of the other PSs. Among caste groups, the Toorobbe were the most prominent buyers of sheep.

The greatest proportion of goats purchased (more than 50 percent of the total) occurred among households in PS 3 and PS 4. As with sheep purchases, the Toorobbe were the most prominent buyers of goats.

Only three purchases of cattle (cows and bulls) were recorded in the sample survey. Sales were much more frequent, probably reflecting the deteriorating environmental and economic conditions during the study period. A large number of the animals sold (44 percent) occurred among a relatively small proportion of households in PS 9. Fulbe were the most frequent sellers of cattle. Oxen, as well, were more frequently sold than purchased. Again, Fulbe were the prominent group selling these animals. No distinction in geographical location could be discerned, however. For all cattle and oxen sold, the average income of the owners was substantially above mean income for the entire study sample. Sheep and goats, especially the latter, are within the means of low-income households; cattle are usually not.

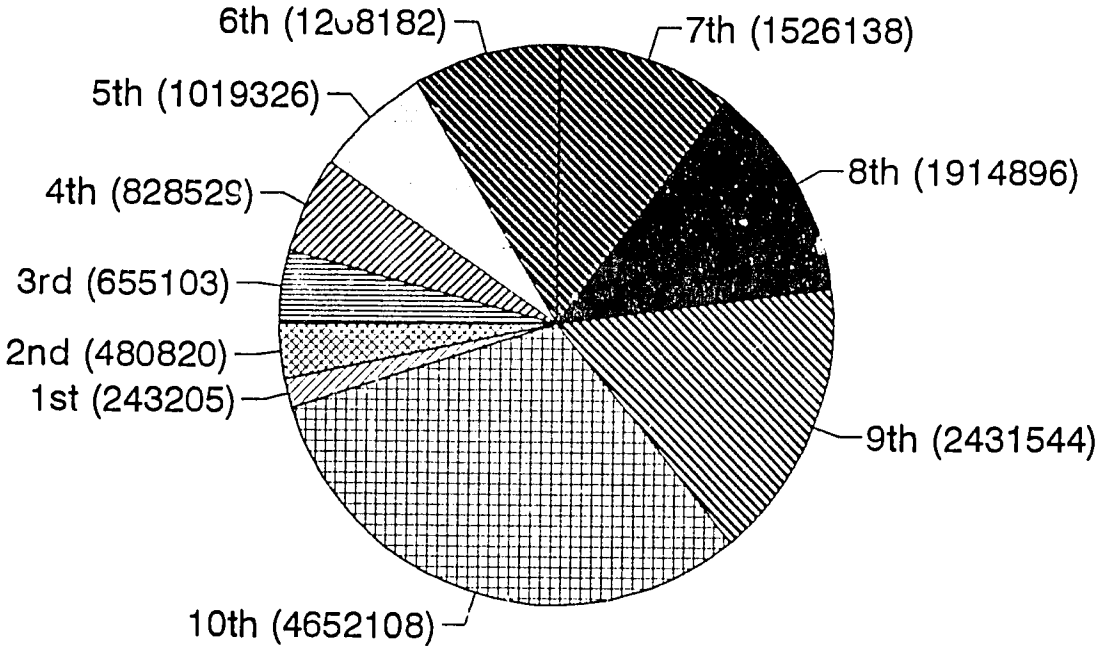
4. Income Levels by Caste

Levels of household revenue generation by caste reveal that one group, the Jaawambe (former advisors to the Toorobbe), have incomes far in excess of the other groups. Interestingly, their revenues are generated from a less diversified range of activities than that of the other groups, relying equally on agriculture, migration, and other nonfarm income sources.

5. Distribution of Income

Significant disparities are noted in the overall distribution of household income by deciles (Figure 13). Nearly half of all income goes to the wealthiest 20 percent of all households in the sample. While the lowest decile controls less than 2 percent of total income (1.62 percent), the highest controls almost 31 percent (30.97 percent). The lower half of income receivers control 21 percent, the upper half 79 percent of income (in kind and in cash) of the sampled households. In absolute terms, the minimum per capita income of households is 1,455 FCFA, while the maximum rises to 339,711 FCFA, while the average household income (45,377 FCFA) exceeds

Fig. 13. Income Distribution by Decile Among Middle Valley Sample Households (FCFA)



the median (34,695 FCFA) by nearly a third, another manifestation of the skewing of the income distribution toward high-income households.

V. RECOMMENDATIONS

The following recommendations are based on the understanding that the Government of Senegal has opted for the simultaneous maintenance of a controlled annual flood from water releases from the Manantali Dam—in other words the development of all flood-related activities, including recession cultivation, herding, and fishing—and the expansion of irrigation. Our recommendations should be considered in the context of what our data reveal as the four major obstacles to development: (1) poor crop productivity in all agricultural production systems; (2) severe capital shortage and low disposable household incomes; (3) chronic labor scarcity due to high out-migration in search of cash income; and (4) a dislocation of cooperative social organization and local institutional structures.

In addition, development planning and assistance in the river valley must be placed in the larger macroeconomic context of structural adjustment. As the burden of economic development shifts from the public to the private sector, state support in the form of heavy infusions of capital for infrastructure and subsidies to the agricultural sector will be increasingly scarce, and foreign donors and the private sector will be solicited to provide the bulk of capital investment and serve as the primary engines of development. Hence, proposals for even the most modest levels of capital expenditure are not likely to be absorbed by the area smallholder, as witnessed by the rapid deterioration in rice production that has accompanied the shift of the financial burden to the farmer since 1987. In this context it is imperative that aid strategies be cost effective and grounded in the local reality of a capital-scarce socioeconomic environment. Before addressing specific target areas of intervention, two other issues will be addressed: socioeconomic diversification and environmental and socioeconomic sustainability.

A. Issues of Socioeconomic Diversification

Until now, development aid in the Senegal River Valley has been heavily oriented toward capital-intensive agriculture, narrowly focused on improving rice production. This requires significant infusions of both capital and labor, a demand often poorly suited to the socioeconomic and demographic realities of the area. When financial returns on investment are considered, the results are mediocre at best, if one examines the track record of rice production in the Senegal River Valley during the past two decades. The proposals set forth below therefore adopt a more modest, low-cost approach to development, avoiding many of the expensive high-technology remedies that have characterized development in the region thus far.

Future aid must encompass more of the diversity of economic activities that already exists within the local economy. Efforts should focus on the gamut of small informal, subsistence sector, on-farm activities that have the potential of providing greater household revenues if developed properly. At present, this sector has received virtually no attention from development officials. Activities such as vegetable gardening and cereal cropping in customary

agriculture, small livestock husbandry and dairy production, fisheries, local artisanry, and petty commerce constitute the base of the local economy. Our findings reveal the important cash revenues that are derived from customary falo and foonde horticultural gardens, for example; yet little research or donor support has been devoted to either activity. The data also show that those households with the highest gross annual incomes have the most diversified sources of on- and off-farm revenues. Moreover, a substantial portion of locally generated revenues come from commerce, agriculture, fishing and livestock sales. Thus the research suggests that considerable potential for small-scale income generation is possible if an array of informal sector activities are developed simultaneously.

Successful ventures in more capital-intensive enterprises such as improved rice agriculture will be realized by local smallholders only **after** they have begun to increase substantially their on- and off-farm disposable incomes. Yet, an a priori assumption of current development policy appears to be that of developing a modern agricultural sector at the expense of an underdeveloped or neglected subsistence farm sector. This approach is equivalent to the logic of the cart leading the horse. The choice is not between a policy that builds on existing indigenous knowledge and production systems, or one that favors an externally imposed model of modern high-input agriculture. We want to strike a balance between the two, based on the conviction that development of the former is a prerequisite for the successful attainment of the latter.

B. Environmental and Socioeconomic Sustainability

Development in the sense advocated here must concentrate not only on raising family incomes by improving on- and off-farm productive capacity, it must also be sustainable in both environmental and socioeconomic terms. The decision to preserve or abandon floodplain agriculture is not simply an agronomic or hydrological issue. The decision to transform the biological diversity of the plant and animal habitat of the floodplain into a more homogeneous landscape for rice cultivation will mean increased risk of environmental degradation. In the short term, the clearing and leveling of the floodplain by extensive felling of trees and removal of shrubs for new irrigation perimeters will exacerbate current low levels of fuelwood supply and the excessive energy demands already being felt in the region (GERSAR-CACG et al. 1989:21-24).

The replacement of traditional polycultures by more modern agricultural methods that rely heavily on chemical fertilizers and monocropping will mean a decrease in the natural resiliency of the floodplain ecology and a greater risk of collapse of the artificially created habitat during periods of drought or other environmental stress. In the long term, the possible lowering of groundwater aquifers, which rely on an annual recharge from the natural flood, may have grave economic consequences for the many villages that depend on such sources for their potable water supply. The loss of natural refertilization of the floodplain soils from nutrients deposited each year during the flooding season may imply, as well, a gradual decline in soil fertility over the long run and an eventual fall in agricultural productivity on the irrigated perimeters.

The transformation of floodplain ecology may have many other far-reaching implications for the human populations exploiting the natural resource base. The loss of traditional grazing routes and fodder supply for livestock, of spawning and feeding grounds for riverine fish, and of cropping systems that provide a nutritionally varied diet will threaten a traditional way of life and the basis of subsistence for diverse socio-occupational groups that depend on this habitat. Thus, the true value of a natural ecosystem is difficult to quantify. If alterations in the system are to be environmentally sustainable over time, the full economic costs in maintaining that system may well exceed the benefits to be derived from it.

In socioeconomic terms, development interventions must be sustainable. The financial benefits accruing to the producer must be high enough to absorb the operating costs. At present, the recurrent costs of production in rice agriculture for most producers in the Senegal River Valley outweigh the financial benefits to be derived. In economic terms, the profit margin to the smallholder is nominal, as production levels barely cover the capital outlays required. As long as household revenues from on-farm production continue to remain low, most families will be unable to support the recurrent costs of rice cultivation to be anticipated in the future.

C. Target Areas for Development Interventions

The specific measures proposed here adopt an integrated, multidisciplinary approach to development assistance. An ongoing dialogue and a team approach integrating both physical and social scientists will be required. The scope of work of the Cellule Après-Barrages (CAB), which is in charge of development activities in the Senegal River Basin, might be expanded to include the facilitation of improved channels of communication and the establishment of a more coherent and consistent development policy among the donor agencies active in the region. At present, a competitive and untrusting atmosphere prevails among the bilateral aid agencies, with each donor group having carved out its own turf. The end result is a potpourri of projects, contradictory objectives, mixed messages to the farmers in the valley, and a poorly articulated global development strategy for the basin. The present no-man's-land philosophy of "doing your own thing" is a self-serving approach that belies the interests of those whose well-being international aid should be benefiting.

The areas outlined here for target intervention serve simply as general topical indicators to guide development policy. They are presented at a broad conceptual level and do not spell out a detailed step-by-step technical approach to solving each problem. Substantive solutions at this level will require the professional input of planners, economists, engineers, and social scientists, working together. The proposals delineated below address the four major constraints encountered by smallholders: (1) crop productivity, (2) household revenues, (3) labor scarcity, and (4) local institutional organization.

1. Crop Productivity

a. Environmental Engineering of the Floodplain

Under conditions of controlled flooding from the Manantali Dam, we envision a rational policy of land use management, in which a spatial compatibility is sought between traditional recession and modern rice agriculture, by optimally exploiting the different geomorphological features of the floodplain. Rather than promoting one production system to the exclusion of others, we advocate a sort of microengineering of the floodplain, in which the most productive low-lying areas of *hollalde* soils are designated for recession cultivation, and the higher adjacent *foonde* soils are developed for irrigation. Perimeters could be situated in such a manner as to provide seasonal drainage into the waalo. This would have the advantage of increasing soil fertility in the hollalde by providing nutrient runoff from the rice schemes. It would also assure the productive life span of the perimeters by introducing a system of periodic flushing of the soils, a technique that is essential in maintaining soil fertility in irrigation.

This engineering of the floodplain will require a mastering of its hydrological features in order to understand the nature of the water flow and the varying rates of soil immersion by the flood, according to topography and soil type. At present, virtually no scientific knowledge of the internal hydrological dynamics of the floodplain is available. A thorough analysis along these lines will be necessary to determine the economic feasibility of transforming much of the floodplain for rice agriculture. The contours of the plain and the physical features of the small feeder tributaries vary greatly from one bottomland to another, and within the bottomlands as well. In most instances, the costs of attempting to reconstruct the landscape for irrigation through leveling and of pumping water from the feeder streams to the perimeters may prove to be prohibitive. In the case of the floodplain Cangay Dow Seyji, discussed in the body of this report, the principal ravines providing water are at a considerable distance from the plain, and the smaller streams traversing the interior are very shallow and wide. Feeder canals for irrigation would be extremely long, and pumping costs very expensive.

A geographical model designed to permit a harmonious exploitation of both recession and irrigation systems in the floodplain area has been proposed by Nuttall (1989). This would entail the introduction of physical infrastructure in the form of small sluice gates placed in the main floodplain channels to regulate the height and duration of flooding at specified elevations in the plain. Areas above a certain elevation could then be protected from flooding and designated for irrigation. Sluice gates placed at strategic locations near the river could also serve as small bridges for transport over major waterways that disrupt travel during the rainy season between the villages and larger towns such as Matam. The construction of sluice gates for controlled water flow has already been introduced in the ferlo region of the Lower Valley at Lac de Guier, in the 1960s (Gac and Cogels 1986). This has been highly effective in managing the water levels of the lake and providing an important source of potable water for the capital, Dakar. An added benefit has been an increase in the fish population of the lake. The Lac de Guier project might serve as an appropriate model for application in the floodplains of the Senegal River Valley.

b. Agricultural Research

Applied research in agriculture should focus on boosting the yields of traditional cereal grains, such as sorghum and millet. These indigenous crops have received little attention, and few efforts have been made to develop improved high-yield varieties. The introduction of more drought- and insect-resistant plants, in combination with controlled flooding, could provide significant increases in crop yields. Experiments with controlled flooding alone have produced dramatic improvements in sorghum yields in the Lac R'kiz region of Mauritania, where crop yields of over 2,000 kg/ha have been recorded (Baltzer 1988). Research and development efforts could focus on the following four areas:

- **Plant and insect research.** One of the major problems faced by area farmers is the constant threat of crop losses from attacks by plant viruses and insects. Energies need to be concentrated on developing seed varieties more resistant to these predators. High yield varieties resistant to drought should be researched as well. Improved seed must be available at little or no cost initially if it is to be adopted by farmers.

- **Insecticides and fertilizers.** Manual and aerial application of insecticides is one of the most cost-effective initiatives that could be taken to improve crop yields. The results of both applications in 1989 in the recession zone studied testify to the impressive gains that can be made simply by assuring protection of crops from insect attack. Aerial spraying is obviously expensive and difficult to carry out logistically on a yearly basis. Manual use of insecticides however, can be extremely effective if carried out properly. Such resources are currently available to villages in the Matam Department through the local office of the state agricultural service. Serious problems exist of equitable distribution, inadequate storage facilities, poor dissemination of information, and difficulties in transporting the insecticides to the rural areas. Considerable financial and logistical support will be necessary to assure better access to government subsidized agricultural inputs such as these.

  Experiments have been undertaken to boost crop yields in rainfed and recession agriculture by the use of fertilizers such as nitrogen and phosphate (Poulain, Sapin, and Reynard 1968). Positive results have been attained but under experimental conditions only. Initially, the cost of fertilizers will have to be absorbed by the state or other outside sources.

- **Cropping systems.** Experiments should be undertaken to explore with farmers different crop mixes in traditional agriculture. It is possible that production could be improved by developing better agroforestry principles in certain systems, such as the rainfed jeeri. Cash crops that bring a high market value may be mixed with subsistence crops. In the floodplain, for example, beans are cultivated and sold at high prices to merchants coming from the Dakar region. Efforts to expand commercial production will require development of improved feeder roads and market conditions as well.

• **Crop protection.** Another major cause of crop loss is predation by birds and animals. Small ruminants occasionally enter fields protected by thorn fencing and ravage the crops. Improved fencing would be particularly useful in the falo, jeeri, and irrigated perimeters. Crop storage facilities as well could be improved. Mud granaries used by families are inadequate for preventing infestation by insects and rodents.

c. Agricultural Extension

The success of applied research in agriculture will depend highly on the quality of extension services and village-level training programs. Increased funds for training and logistical support are necessary for agricultural extension agents; moreover, an incentive structure might be created to stimulate rural agents to provide more effective service to villages. For example, cash bonuses or other material benefits could be linked to production quotas. A stronger follow-up and monitoring unit should also be introduced to see if farmers are adopting ideas and agricultural techniques proposed by extension agents and equitably receiving services they provide. Vehicles, motorcycles, spare parts, and fuel are all in scarce supply at present, preventing many agents from carrying out their work. Village-level training programs in improved agricultural techniques, basic accounting, and organizational management of cooperatives should be linked with agricultural extension. Emphasis should be placed particularly in developing the organizational capacity of women's groups, as women are now carrying such a large burden of agricultural responsibility in the villages. Most importantly, extension services should be strongly linked to functional literacy programs in which village-based training occurs in the local language (generally Halpulaar), and, preferably, is carried out by indigenous speakers from the region. Such a program should be executed over an extended period of time.[8]

2. Household Disposable Income

The fundamental obstacle encountered by smallholders, one that restricts the growth of the local economy, is a chronic shortage of household income, particularly income generated from on-farm production activities. Research findings indicate that household disposable income is at present derived primarily from off-farm wage labor and migratory remittances. On-farm revenues from agriculture, fishing, livestock, commerce, and artisanry are very low. These sectors of the local economy have received little development attention despite their potential for generating substantial revenues. Data on falo river gardens from SRBMA I, for example, show that smallholders derived more cash income from this production system than from irrigated rice cultivation. An accumulation of small amounts of revenue from a diversified farm sector provides more security and spreads risk for the smallholder. Therefore, an emphasis should be

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[8] A successful pilot program of village-based adult literacy incorporating skills in accounting, organizational management, health care, agriculture, and a host of other functional activities has been introduced by a Dakar based NGO, Associates in Research and Education for Development (ARED), Inc.

placed on increasing revenues that build on existing local knowledge by improving production techniques in the rural sector activities of customary farming, fishing, and small livestock production. A decision to focus revenue generation on one particular activity (irrigation) at the exclusion or neglect of others (recession farming) only narrows options to the farmer and swells the risk of financial hardship under unforeseeable circumstances of climatic uncertainty. Increased disposable income may be achieved by developing a well-balanced mix of the following local farm sector activities: dryland farming, recession cultivation, irrigation, fishing, herding, and commerce.

3. Labor Scarcity

One of the most significant accomplishments of the SRBMA research has been to document the manner in which labor in the rural sector is deployed, both seasonally and long-term, to mitigate risk and optimize the revenue-generating capacity of the household. Thus rural smallholders generally prefer to engage in farm activities that minimize the demand on labor and capital, freeing up these resources for use in a wider range of on- and off-farm subsistence- and income-producing activities. Development objectives set forth in the farm sector should seek to **enhance** rather than **constrain** the mobility of labor in choosing among a range of production options. Recession farming strategies are well adapted to this objective since they allow for the seasonal movement of labor on and off the farm and are modest in their requirements for capital. Conversely, irrigation is highly intensive in its use of these resources. Thus, policy should be directed toward finding the appropriate fit between irrigation and recession activities. This will require sound sociological inquiry and site specificity in identifying the repertoire of production activities at each locale.

Production strategies should be tailored to the existing constellation of farm activities found in each setting. Where irrigation is the only available farm strategy, it should be expanded and improved on, using information drawn from a thorough sociological assessment of community organization and social structure. Where recession farming is the only viable option, agronomic and infrastructural improvements such as those proposed above should be adopted. When recession and irrigation systems are found side by side, policy should be aimed at striking a balance between the two regimes, seeking to bolster production in each system without causing dislocation of either activity. In such situations, the temporal demands on labor must be conscientiously taken into consideration to see that periods of peak labor output do not conflict or become competitive among the various systems.

The important point here is to avoid a monolithic approach to development or the application of a universal "development template." Natural and human resource endowments are unique within each community. Development initiatives should attempt to build upon these existing social and environmental features as opposed to radically restructuring or dismantling them.

4. Local Institutional Organization

The SRBMA research has documented the problematic nature of irrigated cultivation in the Middle Valley. Poor performance and the eventual abandonment of production has been attributed to two primary causes: excessive demands on labor and capital, which frequently result in technical breakdowns or extensive downtime in production, and customary land distribution and inheritance procedures that slowly erode group cohesion within the perimeters.

One of the most seriously neglected areas of research and development within the region is the comprehensive analysis of social organization and those socio-institutional features that directly affect the ongoing operation and longevity of irrigated perimeters. Policy initiatives should be directed toward a more thorough re-examination of the sociology of irrigated rice and vegetable cultivation with an emphasis on creating new institutional structures better configured to the social dynamics of each community. Smaller organizational units based on kin and patron-client ties may be more appropriate than current village-wide communal structures that are often marked by intragroup dispute and contestation over water and resources. Structural reorganization might shift from the larger village cooperative model of irrigation or PIV (Périmètre Irrigué Villagois) to the smaller individualized GIE (Group d'Intérêt Economique). Particular aspects of social organization within the perimeters to be re-evaluated and targeted for specific policy change include:

- **Procedures for land inheritance and land distribution.** It is important that jural mechanisms of land allocation and *de facto* use rights in land be consistent. Currently, land is often entrusted, through inheritance, to family members who might not have time, labor, or adequate resources for its optimal exploitation. As a result, land is often left uncultivated or loaned out under disadvantageous terms.

- **Gender organization of production and decision-making.** Increasingly, women are assuming heavier work burdens in the perimeters. In the decision-making processes that directly affect their economic well-being, however, they are relegated to the position of passive objects. Policy directives must take into account the central role of women in production and introduce measures that will increase their autonomy and protect their rights as active farmers.

D. Collaborative Research and Development

The policy recommendations noted above call for a multidisciplinary and collaborative approach, where social and physical scientists work hand in hand. More importantly, host and Senegal-based institutions such as ISRA (Institut Sénégalais de Recherche Agronomique), CSE (Centre de Suivi Ecologique), and ENDA (Environnement et Développement du Tiers-Monde) should be invited to provide their expertise in establishing an ongoing monitoring unit charged with the documentation of social, environmental, and economic changes occurring throughout the river valley. For example, an extensive ecological inventory of the full range of flora and fauna in the various production niches (jeeri, waalo, falo, foonde, jeejegol), as well as seasonal monitoring of variations of fish species in the main river channel and the floodplain should begin

soon and continue over time, in order to discern how dam management strategies impact the natural resource base downstream. Among the resources that should be monitored longitudinally are:

- **Vegetation.** This should include tree, bush, and grass species composition.

- **Water.** This should include quality, flow, and volume of all hydrological sources, including riverine-wetland, aquifer, rainfall, and runoff water supplies.

- **Fauna.** This should include small and large livestock (cattle, horses, camels, sheep, and goats), fisheries (riverine and floodplain), and aquatic reptiles.

- **Soils.** The structure, composition, and processes of soil aggradation and degradation in the various microenvironments should be documented.

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