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COOPERATIVE AGREEMENT ON HUMAN SETTLEMENTS AND NATURAL RESOURCE SYSTEMS ANALYSIS

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AGRICULTURAL ACTIVITIES IN THE LOWER AND MIDDLE VALLEY OF THE SENEGAL RIVER: PROBLEMS AND PROPOSED SOLUTIONS

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I. ENVIRONMENTAL CONDITIONS

1. This region covers a surface area of approximately 12,000 square kilometers in the valley proper (FAO 1973) and 100,000 square kilometers in the entire watershed (Okidi 1986). The region is located in the two countries of Senegal and Mauritania (see map, page 31). There are approximately 1 million rural inhabitants in the valley (Gibb 1987). The population density in the watershed is therefore 10 inhabitants per square kilometer. This figure, which can be estimated to be 20 or 30 inhabitants per square kilometer of arable land, is high, given the local ecological conditions.

2. The climate (FAO 1973) is typical of the sahelian zone. The yearly rainfall, occurring from July to September, is low (averaging from 300 to 500 mm per year). Furthermore, it is extremely irregular, as has been dramatically demonstrated in recent years. The dry season is harsh. The dryness is even further accentuated by the harmattan, the dry, hot wind that blows from January to March. The potential yearly evaporation is from five to ten times higher than the total yearly precipitation. This type of climate limits the production of rainfed crops and justifies careful management of water resources.

3. The principal water resource is the Senegal River. Deep underground aquifers are located at a depth of from 50 to 100 meters below the surface. A shallower aquifer (15 to 20 meters) produces a low and irregular discharge (FAO 1987). The average discharge from the Senegal at Bakel is about 90 m^3/sec at low water and 3215 m^3/sec at peak flooding (Gibb 1987; Guerber 1985). The average flood begins in August and terminates in October; it is variable in all its characteristics. It can begin in June or terminate in November, for example. The volume of the flood has reached a maximum of 39 billion m^3 and a minimum of 6 billion m^3; correspondingly, the flooded surface area has been estimated to vary from 1500 to 4000 km^2, but it has never been measured exactly. The duration of the flood is equally as variable, ranging from 15 to 45 days at a single point along the river.

4. The soils in this region have been the subject of numerous studies (FAO 1973; Gibb 1987; GERSAR 1980a; SOGREAH 1975; BCEOM 1983; GERSAR 1980b). The soils forming the highland plateaux (or diéri) bordering the valley are classified in the group of brown sub-arid soils. Very sensitive to erosion, these infertile soils have limited potential. The vegetative cover has been heavily degraded by efforts to clear the land, by the harvest of fuel wood, and above all, from the overgrazing by pastoralists' flocks.

5. The soils in the valley vary according to their topographic situation, which determines the influence of the flood on their formation. Schematically, the main channel of the river is bounded by banks where large-grain sediments suspended in the river water are deposited. Finer-grained sediments are deposited in the lower parts of the flood plain. The distribution of soils is, in fact, much more complex because the Senegal has often in the past changed its course, and the gaps in the banks have connected the main channel with the flood plain. From that action has resulted a series of basins that flood during high water, and whose lowest portions have become permanent swamps. In the lower valley and the delta, before the construction of the Diama dam, salt water flowed upstream in the main channel towards the end of the flood. The deeper soils are therefore full of salt and the water table is salinized during the dry season. The natural vegetation consists of various bushes and thickets of gonakiers (Acacia nilotica) on the low terraces. These wooded areas have been degraded by the harvest of fuel wood and the production of charcoal.

6. The bank soils (or Falo) are sandy, extremely permeable, and steeply sloped. These limited surfaces are suitable for short-cycle crops (corn, vegetables) because they are flooded each year. The summit of the banks, almost always above the reach of the flood, is the site of villages, vegetable gardens, and fruit trees. On the slopes of the banks, the length of the floodable basins, the soils (or foundation) consist of clay-limestone, relatively porous and gently sloped. Their productive potential is good. They are suitable for numerous crops (grains, legumes, tomatoes, sugarcane, cotton, etc.). Their productivity is, however, subject to the variability of the flood.

7. The soils in the basins (or hollaldé) are vertisols, or black clays, that fissure when dry. Their fine texture and unstable structure render them difficult to plow. The agricultural calendar should respect the changes in the various soils' water-holding capacity subsequent to the recession of the river water. The soils are even more difficult to cultivate when they are salinized. They are suitable for the cultivation of sorghum and rice, but their fertility is mediocre.

II. TRADITIONAL RURAL ACTIVITIES

8. Millet is practically the sole diéri crop. Each field is cultivated one or two years in succession and left fallow for three or four years if the level of population density permits. In May or June any vegetative growth is cut and burned. The fields are planted with the first rains in July, weeded in July and August, and then harvested in October. Average yields are estimated at 300 kg of grain per ha. They vary significantly from one year to the next according to the amount of rain and the regularity of the rainfall after planting. For these reasons the recent drought years have reduced diéri production to virtually nothing. Destruction of the crops by grain-eating birds (quelea) and locusts (grasshoppers) can cause heavy losses as well. Approximately 50 days of work are required per ha of millet. The total surface area, estimated at 80,000 ha, yields a total production varying from 0 to 25,000 metric tons of grain (Castiaux 1970; Club des Amis du Sahel 1977).

9. The hollaldé fields are cultivated every year with sorghum. When the earth is firm enough, approximately a week after the retreat of the flood waters, the field is weeded and planted. Maintenance consists of several weedings and above all guarding against attacks by birds and wild boars. The sorghum is harvested in February and March. Average yields are estimated at about 400 kg/ha, the product of about 80 days of work. Depending on the degree of the flooding that supplies all the water for the crop, several factors contribute to variation in the yields for the crop. First is the topographic situation of the field, which determines its more-or-less regular inundation. The characteristics of the flood play a role as well. Too brief a flood will not supply enough water. A flood that is too slow will merely clog up the fissures in the nonporous vertisols before the water has a chance to penetrate to any depth. The date of the recession is equally important, since the local varieties of sorghum are photoperiod sensitive. If the recession is late, the flowering is poor since it takes place during the harmattan, when the growth cycle is shortened. Too rapid a recession will not leave sufficient time for the farmers to plant their fields in optimal soil moisture. The variation in total yields as a function of each of these different factors has not been measured. It appears, however, that the yields are lower than yields obtained on diéri fields. This seems to depend more on the placement of the field than on the particular year.

10. The total surface area devoted to recession cultivation on the hollaldé soils has never been measured precisely. According to several estimates (Gibb 1987; Juton and Mutsaars 1970; Hamnidou 1974) it varies, depending on the year, from 5,000 to 100,000 ha. Note that from 1957-1958 a

MISOES survey calculated the surface area to be 125,000 ha, the most precise measurement to date. Depending on the flood, the total production of sorghum would vary therefore between 6,000 and 40,000 tons, almost double the maximum obtained on the diéri.

11. There are a wide variety of crops grown on the river banks: corn, tomatoes, niébé beans, tobacco, vegetables. Cultivation of these crops, a supplementary activity for the farmers, occupies little surface area, about 10 percent of the cultivated land in the valley (Gibb 1987).

12. Raising cattle and small ruminants is an important activity in the valley. The cattle belong either to the farmers or to nomadic pastoralists. During the rainy season the animals graze on the uncultivated highlands and on the harvested millet fields. During the dry season they graze in the valley. Animal traction is rare in this region. As is often the case in tropical Africa, this nomadic pastoralism has little effect on agriculture; the animals that are frequently bedded at night on fields prepared for planting, however, supply the fields with organic fertilizer. On the other hand, the rights to common grazing land lead to the destruction of many trees. There are approximately one million cattle and seven million sheep and goats in the region (Gibb 1987; GERSAR 1980b). This figure is not particularly meaningful since it has been estimated that 2/3 of the flocks belong to Mauritanian pastoralists who travel great distances in search of pasture. It appears that more than half of the flocks disappeared during the last drought.

13. Fishing is an important activity as well. During the flood, many species of fish reproduce on the flood plain. Specialized fishermen, who are located especially in the delta, where the estuarine waters contain many fish, sell their catch. For farmers in the valley, who fish for their own family's consumption, fish constitute 80 percent of their protein intake (BCEOM 1983). The total annual production of fish is estimated to be between 40,000 and 50,000 tons (Okidi 1986).

14. The inhabitants of the valley collect their firewood from the naturally wooded areas. The estimated individual consumption (FAO 1987) of 0.8 kg per day corresponds to 400,000 m^3 of wood per year. This figure, much higher than the potential production of the 30,000 ha of gonakiers (Okidi 1986), the principal local forest resource, explains their progressive disappearance. The process has been exacerbated by the recent drought, which has retarded the growth of the trees. At present the region imports charcoal.

15. It is difficult to describe an average farm representative of the valley. The characteristics of the farms really depend first on the traditions of the different ethnic groups and on the resources to which they have access: land, labor, and capital. Numerous ethnic groups are represented in the valley. The extraordinary complexity of the land tenure system on the alluvial plain is underscored in the literature (Mathieu 1985; Schmitz 1986). From a technical point of view, the above studies show that these social groups, and the families within these social groups in the order of their social standing, have attempted to disperse their plots to minimize the risks associated with the irregularities of the flood. Similarly, there are muitiple use-rights to a single plot; such a mosaic will complicate the development of a scheme.

16. A sketch of a typical farming enterprise, drawn from a variety of sources, would include 10 people of whom 5 would be old enough to participate in agricultural work. This family would cultivate 1.5 ha on the diéri and 2.5 ha on the alluvial plain--of which 2.25 are located on the hollaldé and 0.25 on the fondé and falo. The estimated average yield is enough to cover the family's needs in an average year, but not enough in the event of a deficient flood or sparse rainfall. Outside activities and salaries of the family members who have migrated are the sole sources of monetary income. The fields on the alluvial plain produce 70 percent of the family's consumption requirements, a percentage that indicates the importance of recession cultivation. Recession crops demand 3/4 of the total family time spent on agricultural work. The work potential of the family seems to be underutilized 2/3 of the year: with the exception of certain tasks such as weeding diéri millet and planting recession sorghum, there is a considerable amount of seasonal agricultural unemployment.

III. IMPROVING TRADITIONAL SYSTEMS OF PRODUCTION

17. Few studies and experiments have been conducted on the diéri and walo crops. Those that have been carried out have produced interesting, if not-yet definitive, results.

18. Studies on rainfed crops have demonstrated that reforestation and organic fertilizer can augment yields as well as stabilize crops on the better soils (FAO 1987). Planting such tree species as the Acacia Senegal and other local acacia species, or imported species such as the eucalyptus, increases the production of fuelwood, gum arabic, and leaves used as fodder for cattle. Vegetative cover reduces wind-caused erosion. Leaf matter enhances soil fertility by raising the level of organic matter in the earth either directly through defoliation or indirectly through the manure deposited by animals that have digested the leaves. Several agroforestry projects have been funded in the vicinities of Podor, Richard-Toll, and Bakel in an attempt to introduce these techniques at the village level. Long-term projects like these require 10 to 15 years before the first noticeable results can be observed. This delay is a result of the slow growth of the trees.

19. The success of these projects implies a fundamental transformation of local traditions. In order that newly planted young trees remain safe from flocks of animals, either they must be protected by enclosures or traditional communal grazing rights must be rescinded. Given the high cost of fencing small areas of land (800 meters of fencing per ha for units of 0.25 ha; 40 m/ha for land units of 100 ha; 13 m/ha for units of land of 1,000 ha), collective action and year-round restrictions against wandering flocks are the only realistic solutions; these policies have been established already in countries in the temperate zone. Furthermore, the level of work that each farmer must invest in his fields is so high that he will not do it if he does not receive exclusive land-use rights that can be transferred to his descendants. The application of these techniques requires then a veritable upheaval of the societal rules at work in these collectivities. This process will take many years. Despite everything, diéri crops will remain at the mercy of the rains. Production may double or triple with new techniques in a good year, but it will still be nothing in years when there is no rain.

20. Research on recession crops has been interrupted since 1975 (Castiaux 1970; Sapin and Reynard 1968); much information about them remains unclear. It has been demonstrated, however, that in periods when water is available, sorghum production can yield up to 1,000 to 1,200 kg/ha, approximately 2.5 to 3 times more than the normal yield.

This improvement is dependent on:

- early planting with specially selected varieties treated with fungicides and insecticides;
- an early thinning out; weedings facilitated by early removal of weeds with animal-drawn machinery before the flood arrives;
- the application of 35 kg of nitrogen fertilizer per ha.

The only monetary expense is the acquisition of the fertilizer and other chemicals, whose use can result in a 25-30 percent increase in the total yield. These techniques can therefore be cost-effective.

21. The partial control of the flood by the Manantali dam and the blockage by the Diama dam of the infiltration of briny water diminish the risks for recession sorghum posed by the irregularity of floods. In the basins where farmers are assured the possibility of planting before the end of November in moisture-saturated soils, grain yields of from 1,000 to 1,200 kg per ha are possible.

22. The establishment of simple schemes would provide some security to recession agriculture. In fact, the Manantali dam controls only 45 percent of the discharge from the Senegal. A study of a possible scheme for the Dirol basin was undertaken in Mauritania (Le Bloas 1986). It consists of a dike to retain flood waters for 4 to 6 weeks on cultivable land with sluice gates controlling the entry of the water from the river. There would be a fourfold increase in sorghum production in the basin; control of the submersion would allow for expansion of the total surface area under production and would justify the use of more intensive, more productive techniques. Investment costs would be 900 U.S. dollars per arable ha, if the work is undertaken by private enterprises without participation of the farmers. If the beneficiaries contribute their free labor to the construction of the dike (which seems both possible and logical), the costs would be lower and the returns higher. Utilizing the methods outlined above, the profitability has been estimated at 20 percent, an excellent return.

23. Potential improvements of recession cultivation are therefore promising. However, all the associated problems have not yet been resolved. Studies and investigations should be resumed without delay. Topographic data must outline precisely the location and extent of the flooded hollaldés as a function of the predictable discharge from the Senegal in August and September. For each basin it is sufficient to determine the probability of optimum flooding, given the existing variability in the cycle of the river. Topographic maps and available hydrographs should permit a basis of departure. A survey conducted among local farmers would provide informa-

tion concerning their recall of past water levels and the dates of the flooding of the basins where their fields are located. The analysis of photographic SPOT spreads taken during the high water period would provide useful flood maps.

24. It would be necessary to determine the height and duration of an optimal flood as well. These factors depend on the texture and permeability (the type) of the soil. Pedological studies available seem suited for identifying the different types of soils in the valley. A survey of farmers would allow local information and knowledge to be gathered concerning the optimal flooding. Trial studies on representative sites in the valley would permit verification of the results of the survey and the analysis of the effect of different types of submersion on the storage of water in the soils.

25. Agricultural experimentation might lead to improvements in production techniques on the flood plain. Related factors include:

- selection of sorghum varieties;
- production techniques (preparing the fields, weeding, fertilizer, parasite control, soil improvement through the addition of sand or limestone, the transplanting of nursery stock [a technique that is practiced in other alluvial plains in Africa]);
- perfecting the production of crops grown subsequent to the sorghum harvest such as niébé or forage crops (Castiaux 1970);
- improving the river bank crops (vegetables, fruits, tobacco), although this activity is less urgent, given the relatively small percentage of surface area devoted to these crops;
- reforesting uncultivated zones through the introduction of fuelwood and fruit trees;
- the production system of natural pasture land.

26. The results of these studies could be available quite rapidly, at which point it would be possible to choose basins where the existing natural conditions would favor improved recession cultivation and to define the characteristics of the desired schemes. It is not only purely technical factors that must be taken into consideration. The defined interests of each village group in relation to the proposed schemes, as well as problems related to land tenure, are at least as important to the potential success of planned action. When both technical and social factors are identified it will be possible to determine the costs and benefits of the proposed actions to improve traditional production in the valley, a study that has never been done. Based on the data available from the Dirol project, it would seem that the results of actions initiated on 100,000 hectares could be spectacular.

IV. IRRIGATION

27. Activities related to irrigation have always been given high priority in development policies concerning the Senegal River Valley. The first attempts, quickly abandoned, took place in 1926 at Richard-Toll. Then, beginning in 1935, development policies were outlined. Initial construction began after the end of the Second World War. Hydroagricultural schemes established under the auspices of the State of Senegal were expanded under a multistate framework that eventually resulted in 1972 in the creation of the Organization for the Development of the Senegal River (OMVS) which groups together the countries of Senegal, Mauritania, and Mali. Within the hydroagricultural sector outlined by OMVS, the construction of the Diama and Manantali dams was supposed to result in the irrigation of 375,000 ha of which 366,000 were located in Senegal and Mauritania. The annual goal was set at from 3,000 ha to 5,000 ha for each of the two countries. By the year 2030, irrigated agriculture was to have replaced entirely recession agriculture.

28. The first large irrigated scheme was established at Richard-Toll between 1948 and 1958, covering 6,000 ha. The development technique was simple: controlled submersion. A dike protected the perimeter against flooding. When the level of the river rose, water was admitted onto cultivable land by a regulated opening. Rice was produced on the perimeter by a private company with significant numbers of laborers and a high degree of mechanization. This simple technology functioned poorly and was subsequently improved: water was pumped up from the river and a secondary network of small dikes was constructed to limit the depth of the water to 25 cm at any given point. The private company declared bankruptcy, however, and a state organization took over the production in 1961. In 1966, the rice was replaced by sugarcane and the management of the scheme was turned over to another state organization, the Senegal Sugar Company (CSS). The total surface area of the perimeter managed by CSS was 7,300 ha in 1985. Two other perimeters operating in a similar manner under two other state organizations were mass-producing tomatoes on 400 ha.

29. In 1965, the Society for the Development and Management of the Delta (SAED) was created in Senegal. Its activities were later expanded throughout the valley. In 1974, Mauritania created the National Society of Rural Development (SONADER), responsible for agricultural activities

throughout the country, including the river valley (SONADER 1985; SAED 1985a).

30. These two state organizations were responsible for constructing large-scale irrigated perimeters of more than 1,000 ha each. Initially the technique of controlled submersion was utilized; and, after 1975, as at Richard-Toll, more improvements were introduced: flooding by pumping, a network of secondary dikes, an internal network of distribution and drainage canals, and drainage by pumping. The production of rice was controlled by settlers grouped in cooperatives to facilitate surveillance by SAED or SONADER. These organizations, responsible for the establishment and maintenance of the schemes, undertook the heavy field tasks (plowing, threshing) with their mechanized equipment: they furnished seeds, fertilizer, and chemicals, and monopolized control over the entire yield of rice produced by the settlers. They polished the rice at their rice mills and marketed it. The role of the settlers was essentially to undertake production tasks that were not easily mechanized (planting, weeding, harvest). Each participant cultivated approximately one hectare. In 1985, the total surface area of these large settler perimeters was 13,000 ha, 1500 ha located in Mauritania and 11,500 ha in Senegal.

31. From 1974 on, SAED and then SONADER came to the aid of villagers who wanted to establish irrigated perimeters as well. These were small-scale schemes of from 10 to 50 ha. The irrigation technique consisted of pumping water to the interior of a perimeter isolated from the flood waters by a dike. The management organizations helped local participants with the heavier tasks (construction of the dike, principal canals, pump installation); they also were responsible for maintaining the pumps and for furnishing seed stock as well as other necessary materials. They polished the rice in the factories and marketed the rice. Peasants organized into cooperatives undertook the finishing tasks and the secondary field leveling; they performed the manual labor associated with hoeing, planting, weeding, irrigation and harvesting. Each participant worked approximately 0.25 ha. The total surface area under production was 15,850 ha in 1985, 2,600 in Mauritania and 13,250 in Senegal.

32. In 1985, SAED began constructing village perimeters of intermediate size. Perimeters of several hundred ha each are divided into units of 60 ha; each of these units is exploited by a peasant cooperative that uses mechanized equipment and manages the scheme under the auspices of SAED. Construction work is performed by private enterprises with heavy equipment. The agricultural labor and maintenance of the perimeter are the respon-

sibility of the members of the cooperative. In 1985 this system was used on 700 ha.

33. In 1984, to contain the deficits of the public sector, the governments of Senegal and Mauritania decided to limit the interventionary practices of their development organizations, SAED and SONADER, to land management and agricultural extension. Other activities for which they were previously responsible (supplying materials, grain processing, marketing, and providing agricultural credit), were to be progressively undertaken by the private sector or specialized organizations.

34. In 1985, the improved surface area totaled 36,550 ha: 7700 ha were under the management of agroindustrial enterprises in Senegal, 13,000 ha were large-scale perimeters, and 15,850 ha were represented by village perimeters (SONADER 1985; SAED 1985a). During the past few years, the managed production area has grown by 3,000 to 4,000 ha per year (2,500 ha to 3,000 ha in Senegal. 500 to 1000 ha in Mauritania). But the total land area under production represented only 90 percent of the improved land and the total area harvested represented only 85 percent of the improved land. These losses are due either to deficient agricultural techniques (improper leveling that hinders effective irrigation or drainage), or to mechanical difficulties with pumps that were not repaired in time to be of use. In some cases, the farmers did not have the means to buy the fuel necessary to run the pumps. Improving production techniques (controlled submersion with complete control of the water by pumping) permitted a reduction in nonproductive fields from 25 percent to 5 percent in 20 years.

35. Irrigated agriculture in the Senegal Valley has therefore yielded significant results. Practiced by nearly 20 percent of rural producers, it yields 16 percent of the total grain produced in Senegal and 10 percent of the grain produced in Mauritania (Club des Amis du Sahel 1977; FAO 1985).

V. PROBLEMS ASSOCIATED WITH IRRIGATED SCHEMES AND POSSIBLE SOLUTIONS

36. The problems encountered while developing the irrigation potential of the Senegal Valley are considerable. This is not surprising considering that the natural conditions in the valley, contrary to what had generally been published about the area, are very unfavorable to the development of irrigated agriculture. Irrigating a flood plain by pumping from the main channel of a river that is not fully controlled is indeed difficult. This technique is associated with every type of handicap imaginable. First, it is necessary to protect the perimeter from the highest possible floods with a correspondingly high dike. Past experience has shown, however, that exceptionally high, unpredictable flooding can occur. A sudden, total submersion of the scheme is sufficient to destroy it completely, an event which fortunately has not yet happened in this region. Furthermore, the floodplain of the Senegal has a tortuous microrelief; each basin must be protected individually. The relationship between the length of the dike and the number of hectares it protects is higher here than in flood plains where it suffices to construct a single dike along the main channel. The limited degree of control afforded by the use of the Manantali dam will not preclude the necessity of constructing dikes, nor will it allow significant reduction of the height of the dikes, since half of the river's discharge is not controlled.

37. Next, it will be necessary to pump the water from the main channel to the perimeter. Drainage water must later be pumped out when the flood prevents its drainage by gravity flow. Rice is not a swamp plant. In the delta, where the water table is briny, insufficient drainage will lead directly to quasi-irreversible degradation of the soils through salinization. A complex management technique of this kind is necessary. Proof of this lies in the failure of the simple techniques of management of controlled submersion. Relinquishing this latter method permitted SAED to quadruple the yield of rice per cultivated ha.

38. The difficulties posed by the natural environment have been exacerbated by ambitious development programs that emphasized a high degree of technical assistance and motorized equipment. Methods that may have worked well in other circumstances are not necessarily useful in a simple peasant agricultural system that has had no past experience with irrigation.

Management methods and their costs

39. The most important issue related to the difficulties of developing irrigated agriculture in the valley of the Senegal concerns the high investment costs. According to reports this cost is estimated to be 3 to 6 million FCFA (11,000 to 22,000 $US) per ha for large-scale perimeters and from 1 to 1.5 million FCFA (3,000 to 4,500 $US) for village perimeters (GERSAR 1980a; Koita 1986; SAED 1985b; Platon 1981). The range in figures is easily explained. Note that the figure of 3 to 4 million FCFA cited by SAED does not include the portion of SAED's contributions that is considered a public service. This civic contribution is certainly important but difficult to evaluate precisely. Note also that the cost necessarily varies considerably from one perimeter to the next according to the locality, which dictates the height and length of the dikes. The cost of small village perimeters is lower due to the farmers'labor contribution (earthworks, secondary leveling). But these improvements, which are often superficial (SAED 1985b) and which must be repeated again after each high flood season, end up being quite expensive (Boutillier 1980).

40. Investment costs in the Senegal Valley are four to five times higher than those in countries in Southeast Asia. This high cost is due to environmental conditions as well as to two factors whose respective effects are difficult to distinguish. The first factor is that salaries and input costs are much higher in West Africa than in Southeast Asia. The second factor is associated with the development policy employed in the Senegal Valley, where important responsibilities lie in the hands of administrative organizations rather than in the hands of the producers or in private hands, when, throughout the world, government organizations are the least efficient producers of goods and services.

41. These costs will not diminish unless development policy is modified. In fact, they will probably increase (République du Sénégal 1984). As more and more land is brought under production, the new schemes will be located on land that is increasingly marginal: the land will be lower and farther from the river, requiring higher development costs. Presently, for the most part, the village perimeters are located on fondé land that is situated at a higher altitude and is therefore easier to protect from the floods. It will not be the same on hollaldé land.

42. Two solutions to reduce the investment costs in Senegal have been suggested: bring the more important construction contracts under more simplified administrative procedures--the use of the military engineering corps. It has been estimated that the national stock of earth-moving

equipment could be used to bring 4,000 ha per year into production. A more rapid execution of state contracts is said to allow a 5 to 10 percent reduction in costs. More frequent use of local public works enterprises would in the long run represent a further reduction of 20 to 25 percent, judging from current contracts. The utilization of army resources represents simply the transfer of fiscal responsibilities from one state agency to another; in addition, it would shake up the relatively narrow public works contract market. It hardly seems realistic to hope for an investment cost reduction exceeding 25 percent using these methods. Moreover, it is assumed that the availability of the long-term financial arrangements necessary to launch these programs will be available.

43. Another solution is possible: the use of manual laborers from among the peasant population. Most of the irrigated perimeters in the world were constructed by farmers themselves without outside funding, whether in the Nile Valley, in Sri Lanka, or in Southeast Asia. These schemes took time to construct, but they are still in operation, and are functioning well. Expanding or modernizing these schemes with the use of outside funding represents only a minute fraction, probably less than one percent, of what was already invested by the farmers. Meanwhile, in the Senegal Valley, the work force is largely underemployed, and capital is hard to come by. Bringing new land into production could be based more upon the work of farmers than the work of machines. The example of village perimeters indicate that the investment costs could be reduced by two-thirds.

44. Thus it seems justifiable to give absolute priority to village perimeters. This would involve a change in the methods of intervention. Development organizations, instead of carrying out the construction work themselves or having private enterprise undertake the work, should teach the villagers to work on their own and should guide them in their efforts. The technical help related to the conception and execution of manual construction work requires a competent staff: terracing, dike compacting, construction, maintenance and repair of water distribution networks, field leveling, and maintenance of sluice gates and pumps. All the tasks can be done by hand or with light equipment. Again, it is necessary to teach these techniques to the farmers. For that, extension agents and their supervisors must be familiar with and have practiced the techniques. This is particularly important for leveling, which is cited as one of the most poorly conducted activities in the Senegal Valley, even though leveling expenditures represent half the costs of completed schemes. An excellent job of leveling can be accomplished without motorized vehicles which are not, in any case, used in rice fields in countries where rice culture is traditional.

45. The general conception of irrigated schemes must be reconciled to the necessity of manual labor. It is sufficient to reduce the size of the individual plots to facilitate leveling. Scheme plans are often based on plots of 0.5 ha, a figure justified in the case where machines are used (GERSAR 1980a). But, by dividing the plot size by a factor (n) similarly divides by (n) the volume of earth transported. When the fields are worked by animals, their surface area must not exceed 0.1 to 0.2 ha, and thus the task of leveling would be divided by a factor of from three to five. This, incidentally, is the calculation used by all traditional rice farmers. So in such areas as the Betsileo region in Madagascar, where all the work is done by hand (construction and production), plots that are located on the steepest slopes are no bigger than several square meters. Similarly, in the Kabré region in Togo, terraces are used not for irrigation purposes but for combatting erosion.

46. It would also be possible to reduce the terracing while keeping in mind the production potential of the soil type in question. Fondé soils should not be used for rice production because they are too permeable. Rice cultivation should be reserved for hollaldé soils, although presently rice is for the most part grown on fondé soils in the village perimeters. Rice irrigated by submersion requires plots that are perfectly flat so that the layer of water is a consistent depth throughout. Other crops, better suited to the fondé soils, are watered in furrows. In this case it is unnecessary to grade the fields; it is sufficient to break up clods and fill in depressions to obtain an even slope. The goal is to allow the water to circulate everywhere in the field without pooling in particular areas. In fact, a natural slope in each plot is useful in that it facilitates drainage. In countries that cultivate rice in rotation with other crops such as soybeans or corn, the farmers construct rows of ridges after the rice harvest to facilitate the drainage of the second crop. These ridges are subsequently leveled in preparation for the next crop of rice. This method of rotation requires a great deal of work and perfect mastery of leveling techniques. It can only be expected in countries where farmers have had significant experience with irrigation.

47. State aid should consist above all of technical advice and training, not of subsidies. Where local farmers believe that their free time is otherwise better occupied than with constructing irrigated perimeters, public subsidies for construction will serve only to throw the local economy out of balance. An additional drawback of subsidies is that they tend to lessen the feeling of responsibility of those who receive them. Loans will be necessary for the acquisition of pumps and other equipment, the only monetary expenses of these investments. It should be clearly stated from the outset that all loans must be repaid with appropriate interest.

48. If priority is given to the construction of village perimeters, site identification of these projects must not be determined solely on physical criteria. Rather than choosing regions where the topography and the soil types lend themselves best to irrigation, what should be considered first is the interest manifested by the villagers themselves. The capacity of the collectivity to undertake this investment and to manage the scheme are also decisive criteria. Economies of scale are particularly important in relation to the irrigated plots: the higher the number of participants, the easier the construction.

49. If priority is accorded to village initiative, the annual expansion of irrigated land will most likely not reach the projected goal of 3,000 to 5,000 hectares. But this ambitious goal is significantly higher than past achievements have indicated is possible. Furthermore, it would require outside funding that has never been obtained. The total cost of developing irrigated large-scale perimeters on the basis of investment costs per ha would be six to seven times the cost of constructing the two dams.

50. The irrigation program could also solicit the contribution of private entrepreneurs who have access to capital and wage labor. The role of development organizations would be to help them locate available land and to make available technical advice that the entrepreneurs may need. The low return on marketing irrigated grains does not lead one to expect that these private businesses will play a significant role. They could, nevertheless, find themselves a niche in garden crop production or other ventures with high value-added but for which there is a limited market. In 1985, privately owned irrigation production was carried out on only 205 ha (SAED 1984).

Methods of production and their costs

51. The irrigated perimeters produce rice on 80 percent of the area under production, not counting the agroindustrial schemes. The predominance of rice is surprising given that most of the schemes are not located on soils conducive to rice production. The schemes created by village-based groups are located on fondé soils that are better suited to the production of corn, sorghum, or niébé. The predominance of rice is probably linked to the politics of the development organizations that buy and process the rice. Other crops such as tomatoes (6 percent of the non-agroindustrial surface area), maize, and sorghum (15 percent of the same surface area), are produced during the dry season but not in rotation with rice. There has never been double cropping on these schemes.

52. The first reason given for the absence of double cropping in the delta was the lack of fresh water, since in the dry season salt water flowed upstream. This reason did not hold well in the middle valley and it was no longer tenable with the construction of the dams. A second reason given was the poor state of the available equipment, used predominantly on the large-scale perimeters but often in disrepair when needed for agricultural work (World Bank 1979). If planting is delayed because of the unavailability of machines, the agricultural calendar is shifted, and a second crop is no longer possible in the time remaining. On small-scale perimeters, the frequent breakdown of the pumps (Boutillier 1980; Seymour, McPherson, and Harman 1985) and availability of only manual labor can alter the natural cycle of production as well.

53. Animal traction, while well known in Senegal, is not used in irrigated schemes. The possibility of its use has been raised, but the only specific programs existing propose the establishment of cooperatives for agricultural mechanization (CUMA). SAED suggests equipping each unit of 60 irrigated ha with a CUMA possessing a 60-horsepower tractor with attachments, the cost of which is estimated at 16 million FCFA, the equivalent of $1,000 per hectare (SAED 1985b). With this equipment, the land that could be cultivated by an individual could be enlarged from O.25 to O.75 ha (République du Sénégal 1984). Thus for a family of ten members of whom two are assumed to be active in agriculture, mechanization would allow the cultivation of 1.5 ha instead of the 0.5 ha under production at present. Actually though, it is recognized that in a family of ten members, half participate in agricultural tasks according to their capabilities. Furthermore, the standard rice-culture situation in the Far East demonstrates that a family of seven or eight members of whom three or four participate in the work cultivates 2 ha of rice paddies, 60 percent of which is double-cropped (in other words, 3.2 ha during the year) thanks to the use of animal traction. It seems therefore of vital importance to introduce animal traction to farmers working with irrigated agriculture. Trained draft animals exist in the valley region, as well as some plowing and transport equipment, with the exception of leveling harrows.

54. The use of draft animals presents an opportunity to associate animal husbandry with irrigated agriculture. The animals could be fed with by-products of the harvest (straw and rice bran, corn husks). Eventually, forage crops could be introduced into the crop rotation. Draft animals could be fattened up for slaughter at the end of their productive years. This idea could be extended to include the participation of nomadic pastoralists. SAED, believing cattle to be inept at this task, foresees the introduction of

buffaloes to work the irrigated land. However, rice farmers in Madagascar and in India have demonstrated for centuries that cattle are perfectly capable of working in rice fields. The use of the buffalo, as in Egypt and Southeast Asia, presents numerous disadvantages: a low rate of reproduction, susceptibility to disease, a relatively short daily work potential. The experimental introduction of the buffalo should not obscure the fact that the as yet unharnessed potential for animal traction exists already in the Senegal Valley.

55. If a certain degree of mechanization proves to be indispensable, the emphasis should be oriented toward small rototillers. Certain models were perfected in the 1960s by the International Rice Research Institute (IRRI) in the Philippines. This type of 5- to 7-horsepower cultivator, and not the heavy models constructed in Europe and Japan, is 1/10 the price of an imported 45-horsepower tractor ($750 vs. $76,000 in 1976). It is generally used for plowing the rice fields and pulling threshers. IRRI provides its blueprints to industrial engineers who are willing to construct the small cultivators, which would be possible in Senegal.

56. Rice plants are grown directly from seed and not transplanted from nursery stock. The use of nursery stock could reduce the amount of water needed because it shortens the occupation of the fields by 20 to 25 days. The necessary increase in work (20 to 25 days per ha) is partially compensated for by eliminating one or two weedings of valley soils that are conducive to a high weed growth. The farmers currently use high doses of chemical fertilizers. The yields per ha are adequate: on the order of 4 tons of paddy per planted ha and 4.75 per ha harvested (SONADER 1985; SAED 1985b). The maize yield is good: 3 tons per ha (SONADER 1985). Yields have increased noticeably in the last twenty years: between 1965 and 1975 the yield of rice was estimated to average 1.5 tons per ha as opposed to 4.75 tons today (SAED 1985a).

57. The main technical problem is the difficulty in irrigation due to poor field leveling. Variations of up to 20 cm in water depth have been observed in a single plot. In such cases the rice in higher parts of the field dries out while rice in the lower parts of the field drowns. Numerous fields are invaded with strains of wild rice, Oryza Barthii; this particular spontaneously germinating species found in the valleys of West Africa is very difficult to eliminate, especially because of the practice of sowing seeds on uneven fields. Wild rice proliferates in the lower parts of the fields and cannot be pulled out during the first two weeks of growth of the young plants. Plowing the land in its bare, dry state would permit the elimination of the rhizomes

of wild rice; the subsequent transplanting of nursery stock would provide the time to weed out the second growth of the wild plants.

58. Research on the intensification of irrigated agriculture should be undertaken. Main emphasis should focus on:

- the use of animal traction for field leveling, plowing, and weeding;
- the selection and weeding of short-cycle varieties (rice, sorghum, maize, niébé) that permits double culture;
- crop rotation on different types of soil, with appropriate corresponding fertilization;
- the battle against parasites and weeds;
- forage crops to fatten cattle.

59. A study conducted in 1980 (Boutillier 1980) estimated the production costs per ha in Senegal not including manual labor, to be 129,000 FCFA ($460) for the large-scale perimeters. This figure was reduced to 76,700 FCFA ($274) thanks to subsidies for fertilizers, fuel, and mechanized labor. These two cost estimates represented the equivalent, respectively, of 3 tons and 1.8 tons of paddy. Water pumping costs constituted 33 percent of the total, mechanized tasks 39 percent of the total, and fertilizer and seed stock the rest. The costs did not include amortization or maintenance or the overhead expenses of SAED. This document estimated the production costs of the small-scale perimeters to be between 30,000 and 50,000 FCFA per ha (110 to 180 dollars). SAED calculated the returns on the paddy on the large-scale perimeters to be 99 FCFA per kg (35 cents)(République du Sénégal). The costs are outlined below:

	Total cost FCFA/kg	Subsidy FCFA/kg
Crops	21.22	8.32
Repayment by settlers	26.10	
Maintenance	5.78	5.78
Amortization-equipment	16.50	16.50
Amortization-construction	15.93	
Training	13.44	13.44
Technical assistance	13.45	13.45
Total	112.42	73.42
Total without technical assistance	98.97	59.97

This indicates an undertaking by the state of 61 percent of the final cost not including the technical assistance. Adding processing and marketing costs, the total cost per kg would be approximately 150 FCFA (54 cents).

60. A different study conducted in Mauritania estimates production costs per ha to be 50,000 UM ($1087) on large perimeters and 16,700 UM ($363) on small perimeters, not counting family labor (Koita 1986). When amortization and maintenance costs are added, the annual costs per ha rise to 140,000 UM ($3,045) on the large perimeters and 80,500 UM ($1750) on the small ones. The subsidy totals in relation to the costs of production were 75 percent on the large perimeters and 58 percent on the small ones. The cost of a kilogram of paddy was estimated by SONADER to be 16 UM (35 cents)(SONADER 1985). The total subsidy, excluding amortization, maintenance, and familial labor, was calculated at 17,300 UM ($376) per ha for rice and 89,000 UM ($1935) for maize.

61. The differences between these estimates are due to the differences in time and, probably, to the methods of calculation. But all the studies indicate clearly that the costs of production here are extremely high. Rice produced in the Senegal costs 50 to 100 percent more than rice imported from Thailand and delivered to Dakar. These differences in price can be eliminated by means of customs duties or financial procedures if the governments involved decide to do so. It is important to note, in any case, that peasant producers in a country where the per capita gross national product is double that of Senegal (Thailand's was 800; Senegal's 370; Mauritania's 420, in $US in 1985) can sell their rice at a CIF price that is half the FOB price in the Senegal Valley. These studies show, too, that production costs are lower on less-mechanized village perimeters. Mechanization is expensive above all in foreign currency--equipment, spare parts, fuel, and lubricants being imported. Finally, it appears that the production cost of maize is lower than that of paddy because it requires less water.

62. Irrigation is a significant expense to the state, which must undertake the maintenance and amortization costs of the perimeter construction. This is a frequent problem in numerous countries with large-scale perimeters constructed by public works. The belief that income from production should cover at least the maintenance costs is an endemic point of friction on all modern perimeters in the tropics region. In this case it is aggravated by the considerable cost of the agreed-upon investments. Subsidies for fertilizer, fuel, and mechanized construction are additional burdens. Past experience has indicated that while subsidies can initially facilitate the introduction of a new technique, they are disastrous long term. Producers greatly resent the removal, which they interpret as harassment. It is usual to experience a drastic drop in fertilizer use as a reaction to the abrupt increase in its price when subsidies for fertilizers are stopped. Yet to require farmers to bear the full costs of production, SAED proposes to augment the price of

irrigation by 100 percent and the cost of labor by 350 percent (République du Sénégal 1984). Along the same lines, SONADER foresees raising the price of fertilizer by 50 percent.

63. All these costs slow down the programs of the regional development organizations. SONADER has been operating in the red for several years (SONADER 1985). Its indebtedness to those outside the state totaled 188 million UM ($US 4 million) in 1985, for a total investment and operating budget of 843 million UM ($US 18 million). Lacking the financial means for regular maintenance, SAED estimates that 6,000 ha of its perimeters will have to be rehabilitated (République du Sénégal 1984). Excessive production costs drag down the development of production at the producer level as well. Farmers must have access to abundant monetary resources to pay for fertilizer, pumping fees, and mechanized labor. This they do not have. They could ask for loans from regional development organizations or from organizations offering agricultural credit. It is probable that a large number of farmers hesitate to borrow, however, and thus they limit the amount of land they cultivate, especially when repayment costs represent 1/3 to 1/2 of the total harvest.

64. It is crucial that the profitability of irrigated agriculture be increased. The principal objective should be--as is the case for any investment--to lower the cost of production, given that yields are already at acceptable levels. It is also important to be able to extend the productive life of the irrigated fields: it is easier to amortize investments and to cover the maintenance costs with two crops per year rather than one. The standard methods of peasant irrigated agriculture could inspire an improvement program in the Senegal Valley. The first step would be to respect the productive potential of the soils: rice on heavier soils, and maize, sorghum, or niébé on fondé soils. This would reduce by two-thirds the water consumption in perimeters located on fondé soils. In order to have double cropping, it is necessary to introduce animal traction on a large scale. This would allow for rapid preparation of fields and therefore respect a tight agricultural calendar. It would also permit an expansion of land under production. Its financial cost is very low, given the surplus value of the animals when they are resold for slaughter.

65. Costly mechanization should be limited to those situations where it is indispensable: the first plowing of heavy soils. Short-cycle varieties of rice (100 to 120 days) do exist and should be used in order to free up the land earlier. The transplanting of nursery stock could conserve 200 cubic meters of pumped water and shorten the agricultural cycle at the beginning of the season. Even if supplementary research is useful, these basic techniques are

already wellknown and could be popularized right away. The most important effort should be the training of extension agents and production foremen. This training should emphasize practical aspects. The extension agents must themselves always be capable of demonstrating the methods associated with the techniques they are advocating. The poor maintenance of the village perimeters and the small amount of land cultivated by each family derive in part from ignorance of the practical aspects of irrigated agriculture.

The organization of irrigated perimeters

66. Serious problems related to the organization of production are apparent as much at the producer level as at the level of the development organizations or the regional coordination. It is widely accepted that good organization is the key to successful development. But putting this banal concept into operation is not easy, as the failure of so many projects reveals.

67. At the producer level, efficient operation of a perimeter demands solid cohesion of the participants and strong authority on the part of the group leaders. This concept is as applicable to irrigated agriculture as it is to improved recession agriculture techniques; both require strict control of water flow. Dates set for the inflow and drainage of water must be fixed and respected. These dates affect everyone who is dependent on the same source of water or the same drain; they must therefore synchronize their field preparation and harvests. The distribution of water among the farmers must be regulated as well. All the producers must be gathered together to maintain and repair the dikes, canals, and distribution gates; maintenance of the dikes must have priority over all other tasks. The history of project failures due to the absence of authority or to insufficient group cohesion is long and widespread. There should be a person in charge of the whole perimeter--whether a member of the cooperative chosen by his peers or a traditional authority figure--whose orders will be carried out.

68. Studies have shown that these sorts of problems have surfaced in the Senegal Valley (Schmitz 1986; Horst 1986). In this region coexist ethnic groups in which the authority of village dignitaries is more-or-less recognized and the traditional collectivity is more-or-less strong. To this social diversity is added the complexity of land tenure policies. To repeat, it seems of critical importance that in any irrigation program priority should not be given to soils, topography, or hydrology. These factors are definitely secondary as compared to social criteria that are the veritable guarantees of long-term success of such schemes.

69. At the level of the development organizations, the problem lies in furnishing no more than the necessary aid. Public support must never substitute for individual initiative and social groups. This priority given to the spirit of enterprise can delay the development of the irrigation scheme. It is relatively easy for a public agency to manage a perimeter if it so desires, but in the long term, the public service will be more efficient if it is taken over by the personal efforts of the beneficiaries. If not, as was demonstrated by the experience of SAED and of SONADER, the public organizations progressively take responsibility for an increasing number of factors related to production. They start with the construction, then the maintenance, the plowing, and the acquisition, processing, and marketing of the harvest. Interest in irrigation is evident; it is now up to the producers to carry the ball.

70. The governments of Senegal and Mauritania have very logically decided to limit the activities of the development organizations to the sectors where public service is indispensable: research, extension, training, surveillance. The limited resources of the state budget can thereby be devoted to these essential factors. It is planned that specialized agencies (agricultural credit) and private organizations (supplying, marketing, processing) will undertake activities formerly controlled by SAED and SONADER. Mechanized agricultural work, when necessary, can also be under the auspices of private industry. Past experience has demonstrated that private agricultural enterprises are always more efficient and less costly than cooperatives. The problem lies in the transition from the multiform activities of SAED and SONADER to specialized private action. Farmers must not be brusquely confronted with the disappearance of services on which they have become dependent and whose help they need. Loans and technical support can be offered to enterprises that will agree to expand their business into the Senegal Valley. This could also be the occasion to eliminate production subsidies.

71. The main channel of the river represents the administrative border between Senegal and Mauritania, but the technical problems are identical on both the left and right banks of the river. The inhabitants are similar. Many farmers have fields on both sides of the river. A large proportion of the animal flocks in Senegal belong to Mauritanian nomads. A tight coordination between the development activities in Senegal and Mauritania is desirable; it has not always existed (SAED 1985b). In 1983, the selling price of fertilizer was 45 FCFA/kg in Senegal and 84 FCFA in Mauritania, while the buying price of paddy was 60 FCFA/kg in Senegal and 87.5 FCFA/kg in Mauritania. Farmers therefore tried to buy their fertilizer in

Senegal and to sell their paddy in Mauritania. The operation was profitable for those who drew on both subsidies, but not for the states who furnished them.

72. The same need for coordination is imposed by agronomic research. Both countries lack qualified personnel and financial means for it. Three groups are currently involved with such research: OMVS, the National Center of Agronomic Research and Development (CNRADA) in Mauritania, and the Senegalese Institute for Agronomic Research (ISRA) in Senegal. Also involved is an international organization, the Association for the Development of Rice Culture in West Africa (ADRAO). It is essential for these four groups to work closely together. Goals and programs must be identified jointly. Various tasks must be allocated according to the capabilities of each group, and the results must be shared. Overlapping or redundant tasks must be eliminated.

73. The struggle against crop enemies, particularly birds and locusts (grasshoppers), necessitates communal action of all basin inhabitants, for which purpose an international organization, OCLALAV, was established. Due to lack of agreement among the participants, its activities have been severely limited, however. The danger of such a situation was clearly demonstrated by the recent invasion of locusts, which would never have occurred had OCLALAV remained as it had been.

VI. CONCLUSIONS AND RECOMMENDATIONS

74. The productivity of all rural farming systems in the Senegal valley can be improved through the use of known technologies. These improvements must be carried out on a more or less long term basis requiring more or less extensive modifications of rural traditions. Otherwise their effects will not have much impact.

75. Improving the production of rainfed crops on the diéri requires little financial investment, but it implies a radical change in the land tenure and pastoral systems. The average results from such improvements are relatively undetectable because of the irregularity of the rains. This type of intervention can therefore be considered very long term. That does not mean it should be neglected, but, on the contrary, that it must be based on training and demonstration more than on massive amounts of material inputs. In this area, political activities are more productive than technical activities.

76. Recession crops can be unambiguously and rapidly improved. The improvements are easy and do not involve major social or land tenure problems. A certain number of investments are necessary, but their security is guaranteed after the construction of the Manantali dam, which will reduce the risk of insufficient flooding. Improvement of recession crop cultivation should be a high priority. It will enable the attainment, in short order and at a minimum cost, of significant production increases, thereby eliciting the support of the farmers. The only drawback to recession cultivation is the incorrect evaluation of water costs. Estimating to the nearest meter the depth of the water necessary for a good crop of recession sorghum, 10,000 m3 of water will produce only 1200 kg of grain. Thus this prioritized action should not represent the ultimate goal of development programs.

77. Irrigated crops have the highest productive potential in the valley. Water use is most cost effective in this system; thus with 10,000 m3 of water, one can irrigate a hectare of rice yielding 4,500 kg of paddy or 2,900 kg of rice, or three ha of maize yielding 6,000 to 7,500 kg of grain. But irrigated crops require high investment and a significant modification of traditional organization of agricultural activities. The development of irrigated agriculture should be the long-term objective of agricultural planning in the Senegal Valley.

78. Hydroagricultural schemes must tap the heretofore underexploited human agricultural labor potential. In countries like the Senegal River Basin states, it is advisable to restrict financial investments to a minimum since recourse to national monetary resources are limited and costly. The

beneficiaries must supply the bulk of the work required by the construction and use of the perimeters. Animal traction would increase their efficiency.

79. The reduction of financial expenditures is particularly urgent for producers for whom the products are largely if not entirely for subsistence. Especially at the beginning of the program, the irrigated surface area is too small to produce much; when family needs are covered, the sale of any available surplus will not be enough to fund costly techniques.

80. It would be of utmost importance then, to obtain the active participation of rural collectivities in the proposed irrigation programs for the development of irrigation. Such participation, which will reduce the cumbersome burden to the state, would also represent a guarantee for the future. Farmers will better maintain structures they themselves have built than ones that the state has given them. To obtain producers' support of development programs, experience has shown that it is helpful to try to solve their immediate problems. Long-term activities cannot obscure the difficulties related to daily concerns. It would be judicious to begin with activities that will have rapid results, in other words, activities concerned with recession crops, before attacking activities involving such long-term results as irrigated agriculture. This order of events is even more logical since schemes constructed for recession crops can often be improved, at modest cost, to adapt them to irrigated agriculture. An example would be the Dirol project (Le Bloas 1986).

81. All activities must be organized within the framework of the village communities. No improvements in traditional agriculture in the Senegal Valley can be applied by individuals acting alone. This does not imply that individual initiative should be downplayed, but that everyone must be involved for the program to succeed. Development plans in the Senegal Valley rely on the cohesion of collectivities and then influence of their leaders.

82. Consideration should be given to establishing irrigated perimeters for settlers and by private capitalists. Estimating that half of the traditional producers (50,000 to 75,000 people) are interested in irrigation, and that each of them cultivates 2.5 ha, the traditional surface area would total 125,000 to 180,000 ha. The total irrigation potential which depends on anticipated water resources is 360,000 ha. The area irrigated privately or by settlers would be of the same order of magnitude as the preceding. It has been emphasized (see para. 50) that the private perimeters will be limited in size. The management techniques and cultivation methods should not be very different from traditional production. The limited access to capital and

financial profitability holds for settlers as well as for peasants. The settlers must therefore participate in construction work as well. But, having no other resources available to them, the settlers must rely on development organizations to supply them with the means of surviving until the first harvests. To reduce the time necessary for constructing the schemes, certain heavy earth-moving tasks should be mechanized (the main dike): this can be justified on economic grounds. Double cropping and the use of draft animals will be imperative to amortize the heavier public investments.

83. The organization of settlers in producer collectivities will be the key to successful avoidance of perpetual management conflicts. The organizational difficulties associated with settler projects are well known. Here again, the state representatives must avoid becoming responsible for problems that should be resolved by the settler organizations. The classic example concerns the distribution of water among farmers. Outside structural support is required, but an omnipresent state stifles the initiative of local groups.

84. The Diama and Manantali dams will improve hydraulic conditions in the valley, but only 50 percent of the river's discharge will be under control. The depth of water in the river will not be constant, even if extreme variations are statistically evened out. The risks of drought or devastatingly low floods will persist. The dangers for poor farmers must not be underestimated. The average statistical risk means nothing to a farmer who sees a month's work ruined in one day. The dikes must not be lowered under the pretext that the Manantali dam will be diverting a part of the flood.

Recommended study and research

85. The first thing that must be known for any hydroagricultural program in the valley is the water-level pattern (hydrograph) that can be expected after the dams are put in service. It is anticipated that the dammed water at Manantali will be partially used to produce electricity. The hydroelectric plant will provide a way to repay the investments, but it can also disturb the water supply to the irrigation networks downstream by releasing water when the farmers have no need of it. A certain conflict exists between the two functions of the dam: control of the discharge (for agriculture) and production of energy. This problem must be sorted out by OMVS. It is crucial to the development of hydroagricultural projects.

86. When the definitive hydrograph is known, it will be necessary to determine the location, extent, and length of submersion in the valley (see para. 23).

87. A great deal of information has already been gathered concerning the village perimeters. It would be useful to synthesize this material in order to determine the major technical, economic, and social problems.

88. Experimentation and research needs to be undertaken on recession crops (see para. 24 and 25). Studies on irrigated agriculture must be intensified (see para. 58). All of this work should be coordinated by OMVS.

Training

89. A substantial training effort is necessary at all levels, from farmers to managers in development organizations. Seminars could be organized for employees in organizations and technical ministries. Their goals would be to analyze specific problems and the find solutions to those problems. The participation of foreign specialists would allow for a comparison of local experiences with those in other regions in the world.

90. Extension agents could take part in periodic training sessions. At the beginning of the agricultural season, an 8- to 15-day workshop would be devoted to the major technical concerns of the forthcoming season and to extension methods. During the course of the season, one- or two-day workshops concerning techniques specific to each crop could be offered. This training effort should be designed above all to enable the agents themselves to perform the tasks that they are advocating for the farmers.

91. It would be useful to send a group of extension agents during one agricultural season to an area where irrigated agriculture is practiced in a traditional manner by peasant producers. The northeast section of Thailand is one such region, among others. These agents could be assigned to an experiment station located in an agricultural region (not in an urban center). Their task would be to learn the specialized methods of producing the crop at first hand: leveling and plowing in irrigated agriculture, nurseries, transplanting nursery stock, harvesting, and threshing. They must participate actively in the work as manual laborers in the experimental fields or, if possible, on peasant plots. On their return they would be able to participate in practical training of their colleagues in techniques that are foreign to the Senegal Valley.

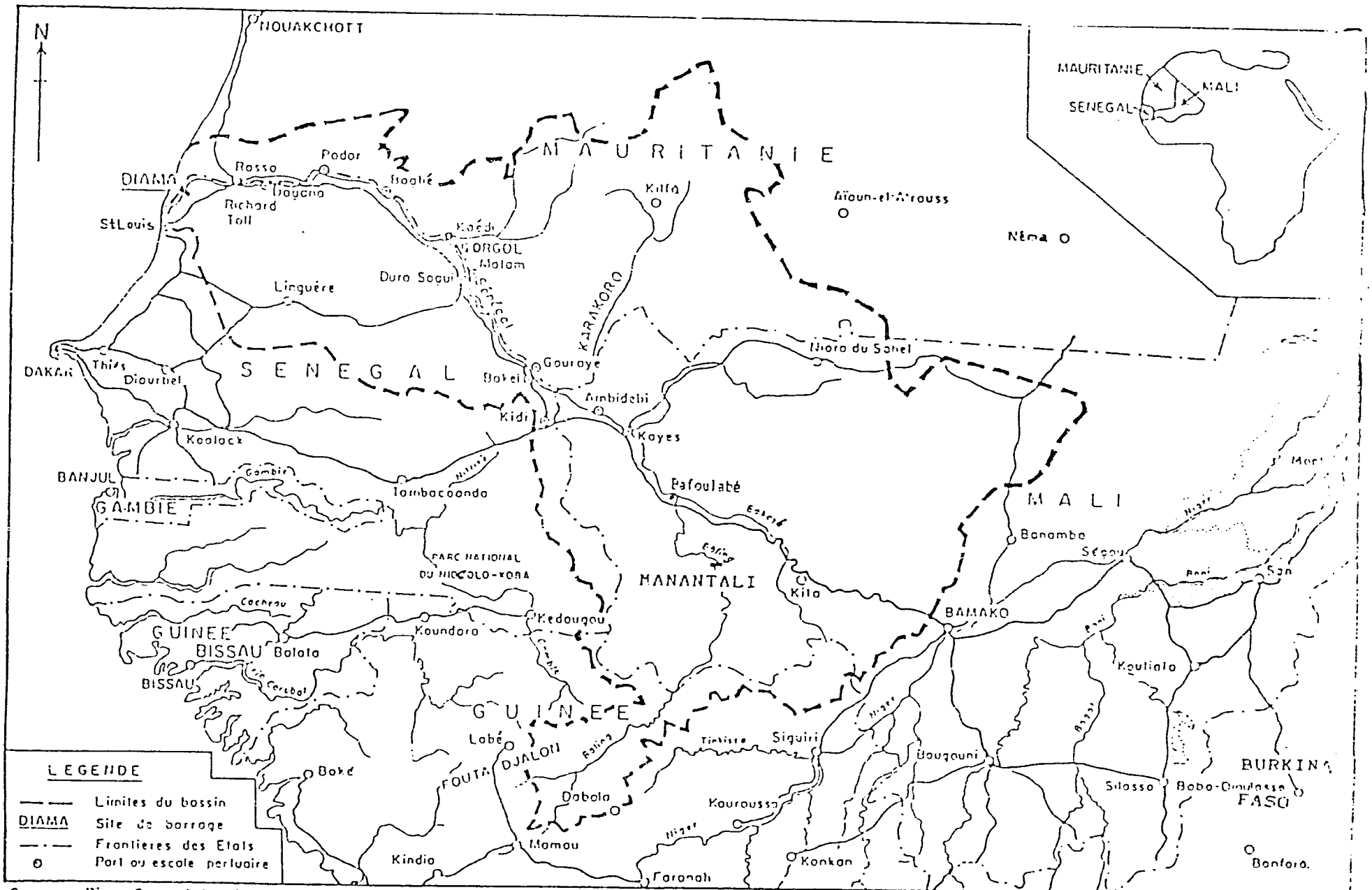
92. Training centers for leaders of the peasant producers could be established in the valley. The objective would be to teach several farmers in each village techniques that they could then demonstrate to their neighbors. A single session could bring together twenty or so farmers for one or two days at the most. Each one of the planning and production aspects of recession agriculture and irrigated agriculture would be discussed: construction and compacting of a dike, leveling, construction of secondary dikes and canals, animal traction, transplanting nursery stock, parasite control, threshing, maintaining the water networks and pumps, etc. Farmers trained in such a manner would then serve as go-betweens for extension agents and other farmers.

93. It would be helpful to demonstrate in the field the efficiency of the proposed development program: the improvement of recession cultivation followed by a move to irrigated agriculture. A demonstration project of this sort should cover quite an extensive surface area and involve a sufficient number of farmers to have to confront realistic management problems. As has been previously mentioned, the technical solutions are already more or less known and their actual application does not pose major difficulties. On the other hand, the organization of large numbers of farmers into groups so that they take active part in the establishment and management of a hydro-gricultural scheme is difficult. Such social problems cannot be studied and resolved in exemplary fashion with ten or so families on a pilot project of 10 or 20 hectares. The project planned for the Dirol basin is a good example of such an activity. It is possible that better examples in other places can be found. The studies proposed above may be among them.

94. The report of the Ministry of Planning of the Republic of Senegal that describes development perspectives and strategies after the construction of the dams, states: "Thus it would be inconsistent for the funding agencies, aft having furnished large sums of money to finance the construction of the dams, to make no additional effort to exploit their potentiality, particularly in the domain of hydroagricultural schemes" (République du Sénégal 1984:41).

95. The Senegal Valley has real potential. But it is the potential of rural production and not that of the dams. Foreign financing is neither the sole nor the most efficient means of realizing this potential.

THE SENEGAL RIVER BASIN



Source : River Senegal by OMVS, 1979 pp. 19–20.

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