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REVIEW OF THE BUREAU OF RECLAMATION

SENEGAL RIVER BASIN - WATER RESOURCES DEVELOPMENT ANALYSIS

by

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SUMMARY

This paper reviews the Bureau of Reclamation January 15, 1975, report "Senegal River Basin - Water Resources Development Analysis", summarizes its findings and conclusions and assesses these for relevance to AID's development policies in combatting the Sahel drought. It analyzes the differences between the OMVS aid requests and the BUREC recommendations. It presents a suggested AID program for short and long term capital assistance in the framework of the Senegal River Basin development plan. The suggested program focusses on assisting, in the short term, in the expansion of irrigated areas using the presently uncontrolled river water as opposed to investment in major engineering works. For the medium and long term periods it proposes that AID assist in financing the engineering studies, design, and construction of less ambitious downstream works, the investigation of possible development of ground water resources, and the creation of artificial optimum floods to expand the valley areas available for traditional flood recession farming.

I. INTRODUCTION

In June, 1974, AID received the eleven volume Synthesis Study "Programme Integre de Developpement du Bassin du Senegal" prepared by the French consultant Norbert Beyrard for the Organization Pour Mis en Valeur du Fleuve Senegal" (OMVS) under a contract with the UNDP. The Beyrard study was presented to AID by the OMVS in preparation for the Donors' Conference convened in Nouakchott, Mauretania, July 11, 1974.

The report was reviewed in AID/W by a committee of consultants and a tentative strategy recommended to the U.S. delegation attending the Donors' Conference. The review noted a number of major deficiencies in the Beyrard study but lack of time to review the documents on which the study was based and to examine the assumptions and analyses of Beyrard prevented the committee from preparing a more detailed criticism.

To provide the detailed analysis required by AID for the preparation of plans to assist in the development of the Senegal River Basin as part of its overall program for the Sahelian drought relief, the Bureau of Reclamation (BUREC) was requested, under a PASA with AID in January, 1975, to review in detail the Beyrard Report together with the original documents on which it was based and such other relevant material as could be found. The time allotted to BUREC was far too short for the task presented to them. Nevertheless, by the employment of a sizeable number of professionals in the fields of hydrology, geology, agriculture, navigation, power, irrigation, and economics, BUREC on January 15, 1975, was able to present an excellent preliminary report entitled "Senegal River Basin - Water Resources Development Analysis", accompanied by an oral presentation to AID and IERD staff. The final version of the analysis was to be prepared at a later date under an amendment to the PASA to be issued by AID.

Final
Prelim
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II. PURPOSE OF THE PRESENT REVIEW

The BUREC analysis contains an evaluation of the proposed development as presented by Beyrard and others, divided into six chapters treating the various aspects of the development, the adequacy of the designs and cost estimates, and an economic and financial analysis. This is followed by a chapter of summary conclusions and a recommended strategy for development. The various chapters of the analysis deal in technical detail with each of the development aspects. In view of this detail and the length of the report, AID decided to obtain a summarizing review which would, in addition, attempt to assess the relevance of the BUREC conclusions to AID's general development policies in Africa and, specifically, to its Sahel drought relief strategy.

This review report has the above as its goal. In addition it points out the differences and analyzes the reasons for the differences between the BUREC conclusions and the expressed desires for development aid of the OMVS as presented in their May, 1974, paper "The Objectives and Main Outline of the Integrated Development Strategy of the Senegal River Basin" and at the July, 1974, Donors' Conference. It also looks at the various alternatives for AID assistance in view of actions already taken by other donors, commitments already made by them, and specific requests made by the OMVS to donors, insofar as these are known to the reviewer.

It is to be noted that the present review is of the BUREC's preliminary analysis paper made available to the reviewer on January 15, 1975. Changes in the BUREC's final report could affect the statements in this review. The reviewer wishes to express his admiration for the excellence of the BUREC analysis and to make it clear that any contrary opinions expressed in this review are not to be taken as a criticism of the work done by the BUREC staff. They reflect only the reviewer's views on the

relevance of BUREC's conclusions or recommendations to the geographic areas involved and to AID's policy and strategy for the area insofar as these are known to and understood by the reviewer.

III. BUREC STUDY PROCEDURE

BUREC had available to it the following data:

1. The 1970 Senegal-Consult study of upstream alternative storage sites.
2. The SOGREAH Delta (Diama) dam study and mathematical flow studies of 1972.
3. The 1974 Beyrard synthesis study.
4. Various soil and agricultural studies of the basin.
5. Various AID reviews and commentaries on the Senegal River Basin development plan.

The analysis reviewed the following seven development sectors:

1. River flow regulation, especially in its relation to agriculture and livestock.
2. Electrical energy and industrial development, including the mining industry.
3. Navigation and river transportation, with particular attention to the requirements of mining and industrial development.

4. Social factors, including potable and agricultural water supplies, health and sanitation.
5. Environmental factors, primarily as related to forestry and fishing.
6. Training and extension work needed for the agriculture and other sectors.
7. Research to increase agricultural production.

The seven sectors were examined to assess the economic justification for major multi-purpose upstream storage (especially the Manantali Dam project) with and without power and navigation benefits and to assess the need and justification for the Delta Dam.

In addition, the BUREC study examined the deficiencies in data, assumptions, analyses, and recommendations in the various documents and listed the additional and auxiliary studies needed in the context of medium and long-term development strategy, prior to the preparation of final designs. In some cases additional data must be obtained before preliminary and feasibility studies can be undertaken, and in other cases studies can be deferred until after final designs are completed.

IV. MAJOR CONCERNS

With respect to the Beyrard Report the BUREC analysis reflected, in general, the same concerns expressed in the AID review of July, 1974, namely:

1. Inattention to the need for a massive training program to develop the large staff of technicians and managers required to plan, implement and operate the development programs.

2. Omission of any reference to a coordinating and managing organism to handle the complex machinery of program implementation.

3. The lack of engineering and other technical data in the report to permit checking the accuracy of its premises, validity of its analysis, and reasonableness of its conclusions and recommendations.

While these were major items completely ignored in the Beyrard Report, it and the other basic documents contain important lapses which throw doubt on the wisdom of some of the basic recommendations in the development plan - items on which the OMVS has placed its heaviest claims for donor assistance. With the strong desire of many donor countries and international institutions to show a willingness to move ahead at a rapid pace in providing financial assistance to the OMVS, there is a real danger that projects with less than optimum economic justification or projects which may actually produce negative results will receive priority financing to the exclusion of less dramatic but more beneficial processes. These considerations will be taken up in more detail in the following sections, but a summary list follows to focus attention on the major concerns:

1. Is a major multi-purpose upstream dam and storage reservoir justified as a priority development component? What are the benefits and, conversely, the dangers involved in early construction of such a dam at Manantali?

2. Do the economics of irrigated agriculture justify large scale priority investment to provide water for this purpose rather than investment in expansion of traditional agriculture methods? Is enough known of the suitability of land in the middle valley region to verify the projected yields?

3. Does the power market justify the investment in multi-purpose dams? Conversely, is the generating capacity of the dams sufficient to provide the power which may be required if all the agricultural, mining, and industrial developments envisioned actually materialize? Will alternate power sources at reasonable cost be available in this event?

4. Are the proposed investments in river navigation and the operating costs justifiable either with or without mineral product traffic?

5. Do the designs of the major infrastructure components (especially the Manantali and Diama dams) produce undesirable environmental disturbances of such magnitude that their benefits would be negated by the overall losses to the area's economy?

6. In general, have there been enough engineering and technical studies conducted to permit early final design and construction of the Manantali and Diama dams and major irrigation works?

7. How effectively and quickly can the proposed development plan be pushed ahead through donor financing without the missing implementing organization? How effectively can its projects be operated and the region's population benefit from them without the institution and execution of massive prior training programs?

V. MAJOR BUREC RECOMMENDATIONS

After reviewing these major areas of concern which emerged from the BUREC detailed analysis of the Beyrard, Senegal-Consult, and SOGREAH studies, BUREC proposes two alternative plans to the one outlined in Beyrard and the OMVS "Objectives" paper.

1. BUREC points out that in converting from dryland and flood recession agriculture to irrigated agriculture, care must be taken not to expand the conversion area too rapidly. Too often, emphasis is placed on the extent of area irrigated rather than on the crop yields obtained. The preferred plan would, therefore, not assign the highest priority for implementation to Manantali, Diama, or any other major construction works. Initial investments of funds and effort should be made to bring about increased food production even with the river in an uncontrolled state. As a first step, irrigated projects of the dike or polder type should be promoted. Since Manantali will not result in flood protection for the valley and delta areas, the design of the dikes and polders will be the same with or without Manantali. The education of farmers in irrigated agriculture, the training of managers and technicians, and the establishment of the organization to plan, build and operate the engineering works and coordinate the services and programs should be begun and expanded where these programs already exist. The polder and dike projects will serve as training grounds. Even though the present water supply is not sufficient for double cropping, large areas can be put into single crop production. The more difficult task of training the flood recession or dryland farmer to adopt irrigated farming techniques can be done at this time, and unskilled workers can be taught to operate a small and simple irrigation system. The changeover to double cropping and large scale irrigation when river regulation is accomplished will then prove to be no problem. All this should be accompanied by a monitoring program established to measure on an ongoing basis the success of the irrigation projects.

2. If, however, the decision is taken to assign priority of investment to the Manantali and Diama dams and the associated power, irrigation and navigation works irrespective of their economic or technical validity at this time:

- BUREC proposes that initially Manantali be used to create optimal flood conditions in an additional 50,000 hectares of valley land for expansion of traditional flood recession agriculture. This could be accomplished in any year in which there were no major flood periods. It would involve lands which are now idle when either low flood or maximum flood conditions occur but which are farmed when medium (optimal) floods prevail. Through regulation at Manantali the periods of optimal flood conditions could be increased. Immediate benefits would be obtained while farmers are being trained for irrigated farming.

- Since there will be no immediate need for the full 100 megawatts of power from Manantali until the development of industry and mineral exploitation, consideration should be given to the merits of constructing a 600 mile transmission line to Dakar to provide that market with a power source independent of oil imports.

- Other parts of the OMVS/Beyrard development plan would follow as funds become available, studies and designs were completed, and construction executed.

Each of these alternatives is discussed in detail below from the viewpoint of justification and relevance to AID strategy.

VI. THE CASE FOR AID AGAINST PRIORITY CONSTRUCTION OF THE MANANTALI DAM

There can be no argument over the premise that self sufficiency in food through agricultural development in the Senegal River Basin is possible only through the availability of a reliable supply of water for irrigation and that the available source is the Senegal River. The flow of the river is highly irregular during the course of the year and is subject to

periodic droughts. At the same time, during high flood periods, large quantities of water which could irrigate vast stretches of arable land go to waste. The logical answer is to regulate the flow of the river to provide as constant a flow as possible throughout the entire year. This would allow the replacement of the existing inefficient flood recession, single-crop agriculture by an efficient, irrigated agriculture on large tracts during more than one growing season. It would also permit the diversification of crops and production of crops for export.

A. Economic factors

If it can be demonstrated that the added product resulting from the construction and operation of the water storage and irrigation facilities exceeds the cost of these facilities, the project is presumed to be justified.

A positive answer to this is given by Beyrard and the OMVS. In 1970, Senegal-Consult studied a number of sites on the Senegal River and its tributaries and concluded that the most feasible location for the initial multi-purpose dam in the river basin system is at Manantali on the Bafing River, upstream of its juncture with the Bakoye which together form the Senegal River. A 70 meter high dam at this point, about 1,000 km from the river mouth at St. Louis, would impound 13.5 billion cubic meters of water and provide a firm water supply to irrigate 428,000 hectares of land, maintain a minimum river flow of 300 cubic meters per second for navigation and allow the generation of 800,000,000 kwh/yr of electrical energy with a maximum capacity of 100 megawatts.

The OMVS is convinced that the construction of this dam and power plant is the key to the entire basin development and that without it the development cannot proceed. Furthermore, the Beyrard report concludes that

the internal rate of return for the entire basin project (Manantali, Diama, irrigation, and navigation and port expansion works) would be 19 percent for the assumed development schedule over a 35 year period.

For the Manantali project these costs are estimated by Senegal-Consult, based on 1969 prices, at $\$102,000,000$. BUREC's review of Senegal's cost estimate concludes that Senegal-Consult either omitted or under-estimated certain items by about $\$3,000,000$, bringing the 1969 estimated cost up to $\$110,000,000$, excluding interest during construction.

BUREC has applied a 50% escalation factor to bring the estimate up to October, 1974, levels, resulting in a cost estimate of $\$165,000,000$. It is this reviewer's opinion that this estimate is very much below the actual cost at today's prices in West Africa and considerably below bids which would be obtained if construction starts in 1978. AID experience on highway construction in West Africa has shown a 20% annual escalation between 1970 and 1973 and a jump of at least 50% during 1973 as a result of oil price increases, followed by a further 30% escalation since 1973. This would indicate that a factor of 2.9 should be applied to 1969 prices to bring them up to January, 1975, levels, resulting in an up-to-date cost estimate of $\$320,000,000$.

The opinion has been expressed that, while these escalation figures are valid for highway projects in the price range of tens of millions, a smaller factor should be applied to larger projects. Recent bids for the Trans-Gabonese Railroad show, however, that bids obtained in 1974 were more than double cost estimates made in 1971. Furthermore, the estimate of over $\$300,000,000$ was confirmed by similar opinions at Nouakchott in July, 1974, from members of the Canadian and IBRD delegations.

Direct revenues from Manantali as presented by Beyrard include: sales of water, power sales to mines and agricultural industries, and river transport taxes on products. Direct benefits to the economy would result from added agriculture production and mineral products.

A close examination of these revenues and benefits results in a much less optimistic picture:

1. The construction of the Manantali Dam will not result in flood control downstream. The Bakoye, Kolimbine, Faleme, and Karakoro streams as well as rainfall run-off are uncontrolled by Manantali. The future addition of reregulating dams at Gouina and Felou on the Senegal are envisioned to provide better flood control. There is, at present, insufficient reliable data to know whether the investment estimates for irrigation infrastructure take into account provisions against their being flooded out by uncontrolled floods. At the same time crop damage or unproductive periods during such flood times would have to be deducted from the estimated benefits.

2. The major market projected for power from Manantali is for the extraction and pelletizing of iron ore and exploitation of other minerals. There is no indication of present interest in iron mines situated at a distance of several hundred miles from the sea in Africa. Experience in Gabon and an opinion obtained by AID from the Bureau of Mines in 1973 confirm this view.

Although the Senegal-Consult study and Beyrard Report call for the installation of 150 megawatts of generating capacity at Manantali, the average capability of the power plant until downstream reregulating dams are built would be only 93 megawatts based on a constant release of 300 cubic meters per second for navigation purposes. This would reduce the annual

energy generating capacity by 130,000,000 kwh from the 800,000,000 kwh rating. At the rate of 5 CFA francs per kwh revenue projected for agricultural industries, the resulting loss in annual revenue would be about \$2,000,000.

Assuming that the mining load does not develop and Manantali is constructed, there will be an excess of power available after the irrigation pumping load is satisfied. BUREC suggests that, with the present high cost of oil, it may prove economically feasible to construct a transmission line to Dakar to provide firm and secondary energy for the growing domestic, commercial, and industrial load in that area.

This alternative solution is based on the following assumptions:

(a) the cost of a transmission and distribution system from Manantali to Dakar will equal the \$31,317,000 allotted to the Manantali-Kaedi power system described in Beyrard,

*The IBRD agrees.
and is exploring*

(b) the cost of construction of a 100 megawatt oil-fired steam plant in Dakar equals the cost of the same size power plant at Manantali.

(c) reliability of electric power supply in a developing country cannot be based on present standards in the United States. On the basis of economic calculations it would, therefore, be possible to rely on a single circuit transmission line and reduced generating capacity during low water periods. ??

I do not believe that these assumptions can be sustained. Taking the last one first, since the transmission line will be serving a growing load - partly commercial and industrial - its reliability must be at least as good as the supply already available in Dakar in 1978-79 when the Manantali

line goes into operation. This means that the first assumption as to the cost of the transmission and distribution circuit is untenable. A double circuit line would be the minimum required to maintain the lowest degree of reliability which the Dakar area would demand. This would raise the construction cost of the line by 50%, and with a 30% escalation factor to bring Beyrard's prices up to 1975, the transmission and distribution circuit cost would rise to \$62,000,000 from the stated \$31,817,000. This would increase the cost of transmission and distribution in Dakar of a kwh of Manantali power from the BUREC's figure of \$0.0211 to \$0.0411 and bring the delivered cost in Dakar to \$0.0538 per kwh, or over 60% more than the cost of generating energy at Dakar.

It is likely that even a double circuit line mounted on a single tower would not be acceptable from a reliability viewpoint. The independent single circuit lines or a standby steam or gas turbine plant in Dakar would further increase the cost of Manantali power.

B. Technical factors

The BUREC report points to many factors which will require further investigation and analysis before the exact location and final design of Manantali can be undertaken. The most important of these are:

1. Stream flow records given by Senegal-Consult and Beyrard are internally inconsistent and contradictory as between the two.

2. There is a question as to the amount of storage which should be provided at Manantali to permit control of the "100 year flood". This will reflect itself in the design of the dam height and, consequently, the project cost.

3. Calculations of future flows downstream of Manantali with the dam in place are inconsistent. With the major drainage area (190,000 sq km) being below Manantali, the upstream dam would have no flood control effect. The Senegal-Consult report concludes that even the 100 year flood of 7,000 cu meters per sec at Bakel would represent considerable danger to valley agriculture and to the irrigation works.

4. Although sedimentation in the Manantali reservoir does not pose a problem, the analysis of sedimentation and erosion downstream resulting from a constant 300 cu meter per sec flow and sedimentation at the Diama backwaters have not been evaluated.

C. Conclusion

The economic and technical factors cited cast serious doubts on the wisdom of assigning a high priority to the construction of a major upstream storage and power generating facility. These present considerations do not rule out such construction for all time. They merely indicate that considerable additional study must be undertaken before an investment of \$400,000,000 or more is committed. Such further detailed studies would lead to a more solid decision on the technical and economic conditions required for the design of the structure, its timing, and its method of operation.

VII. THE CASE FOR AND AGAINST PRIORITY CONSTRUCTION OF THE DIAMA DAM

The argument for construction of the Diama dam at an early stage of the basin development program is easier to present. The main functions of this dam would be:

1. To prevent salt water intrusion.

2. Provide a reservoir of fresh water for irrigation in the Delta region.

3. To supply municipal water for Dakar and possibly for Nouakchott.

The investment in the Diama dam is relatively small, its design is fairly straightforward and it can be completed in a relatively short time so that its benefits would accrue to the area within 2-3 years from the start of construction.

Irrigated agriculture is already known in the Delta area so that expansion of farming areas, training in double cropping and in the operation of irrigation works should present no major problem.

The only objections to rushing into final design and construction are on technical grounds - specifically, the need to accumulate more data, to reconcile inconsistencies in data, to do additional preliminary engineering and to carefully evaluate the environmental effects of the dam. Most important in this respect is the effect on the existing fishing industry, both freshwater and sea fishing. Present fish crops are estimated to supply about 80% of the protein in the diet of about 500,000 inhabitants. About 10,000 fishermen depend on this resource for their livelihood. Both anadromous and freshwater species occur in the basin and there is at present no knowledge of the effect of a dam in the Delta on the spawning and rearing habits of either type or how the construction of a dam and locks and creation of a freshwater pond at Diama will affect the fish population, the location where fishing is most important, and the traditional fish harvesting methods.

The proposed AID environmental study of the basin is expected to provide the information listed by the BUREC as prerequisites to designing the dams and locks.

VIII. SUGGESTED PROGRAM FOR AID PARTICIPATION IN CAPITAL FINANCING

The following suggested program of AID financing participation in the Senegal River Basin Development Plan is based on these considerations:

1. The clearly indicated lack of data, preliminary engineering, and environmental studies required for the successful design and construction of the major infrastructure.
2. The long-term uncertainties of the success of crop production due to lack of soil studies.
3. The medium and long term uncertainties regarding the social effects of population movements, changes in traditional farming and livestock production methods, and the success of organizational and training programs.
4. The probable long delay in development of mineral resource exploitation and uncertainties in the future of agricultural industries.

Based on the above, AID should approach capital financing participation in any of the major engineering works with extreme caution. In fact, it is suggested that AID not offer to participate at this time in the financing of either of the two dams or the river channel improvement, including river ports.

In addition to continuing support of the Agronomic Research Project and financing of the organizational and environmental studies already begun, AID's immediate contribution could best be made in the expansion of crop producing areas through the development of new dikes and polders.

A. Fishing industry

Since there seems to be enough financial support for the construction of the Diama dam and a readiness on the part of donors to proceed immediately with this project, the AID environmental study should focus first on the fishing industry. The information to be sought in this study is set forth in the "Fisheries" section of Chapter B.4(a) of the BUREC preliminary report. The environmental study should propose the design features of the dam, locks, and pondage which would preserve and, if possible, enhance the fishing industry. AID should attempt to influence OMVS and the project donors to hold off the finalization of the project design until this data becomes available and to incorporate the required features into its design.

B. Navigation

Although BUREC finds no justification in major investment in river navigation works, Diama design must take account of the fact that existing river navigation will expand in future years for the movement of agricultural and agro-industry products if not for mineral traffic. The considerations in the "Navigation" section of Chapter B.3(b) and the "Diama Project" section of Chapter B.5(b) should be brought to the attention of OMVS and the project donors.

C. Irrigated areas

AID financing of the expansion of irrigated areas using existing river water should take account of the following:

1. COST. BUREC quotes Beyrard as estimating the cost of dikes, land preparation, pumping stations, and irrigation networks at \$1,300 per hectare. AID's estimate, including access roads, was \$3,500 per hectare and the figure quoted by IBRD representatives at our conference with BUREC was \$5,000 per hectare. In view of constantly rising construction and equipment costs, it would be safer to accept the \$5,000 figure. With a proposed \$20,000,000 AID capital program for the coming fiscal year, 4,000 hectares of irrigated land can be put into production.

2. PRIOR INVESTIGATIONS. The BUREC chapter on "Agriculture" (B.2) points out the deficiencies in the OMVS "Hydro Agricultural Study of the Basin of the Senegal River" in land classification and lack of evaluation of soils for irrigation and crop diversification. The BUREC report states that "a more detailed irrigation suitability survey will be required of the lands proposed for irrigation before construction of the project." The results of such a survey could have a major impact on the economic feasibility of AID investment.

IBRD representatives have mentioned the need for about one year of design work prior to starting the land development and irrigation construction. It is not known whether this includes the investigations mentioned by BUREC. At any rate, if the AID proposed development areas adjoin those of the IBRD joint investigation of land suitability, classification, and drainage characteristics could be undertaken at a considerable saving to both donors.

D. Medium and long term projects

1. DOWNSTREAM WORKS. Whether or not Manantali or other major upstream storage sites are developed, there will be a need for reregulating dams below the junctions of the Bakoye and Bafing rivers and works for control of the Bakoye River. The drainage area above Manantali comprises only 27,800 square km out of a total drainage area above Bakel of 218,000 square km. The 100 year flood discharge at Bakel is 10,700 cubic meters/sec and the Beyrard study postulates that it is necessary to reduce this to the 10 year flood discharge of 7,200 cu m/sec to provide adequate flood control. This requirement cannot be met by Manantali even if its flood control space could be increased by 50% over the design called for in Beyrard and Senegal-Consult. Furthermore, as stated earlier, Senegal-Consult considers that floods of even 7,000 cu m/sec could pose dangers to downstream agriculture and irrigation works.

It would, therefore, appear useful for AID to consider financing or participating in the financing of preliminary investigations, feasibility studies, final design, and construction of reregulating dams below Manantali and on the Bakoye. These dams could, in addition, provide further storage for irrigation use and power for irrigation pumping and other developing loads. If Manantali is deferred, early starts on the smaller structures become logical and beneficial.

2. GROUND WATER. The BUREC analysis states that no attempt has been made in the available documents to determine the quantity, quality, and cost of utilizing ground water. An outline is given in the "Ground Water" section, Chapter B.1(b) of the BUREC report for developing a ground-water study program. AID assistance in financing such a study program could prove very useful. Should there be long term delays in the execution of the

OMVS river regulation and irrigation programs, the availability of ground water as an interim solution could be extremely important. Even with the carrying out of the proposed basin development plan, ground water in remoter, non-irrigated areas could prove more economical than river water for livestock production and for some farming operations.

3. ARTIFICIAL FLOOD AGRICULTURE. As was pointed out earlier, the lack of an early power market for the energy capable of being generated at Manantali may lead to a deferral of construction of the powerplant even if the dam and regulating structures are constructed. In such an event, artificial flooding through Manantali could provide an additional 50,000 hectares of flood recession farming area. Since very little land development or irrigation works are required and the methods of crop growing are already known to the inhabitants, this 27% increase in inundated area, normally idle during small flood periods which occur statistically in 95 out of every 100 years, can be an important factor in increasing flood production without the need for expenditure of electric energy for pumping or the need to wait for training of farmers in irrigation farming and the operation of irrigation works.