Irrigation Research Priorities for Nigeria

Irrigation Research Priorities for Nigeria

Proceedings of a National Seminar held at the University of Ilorin, Nigeria from 20 to 23 April, 1993

Organized by the
International Irrigation Management Institute (IIMI)
and the
University of Ilorin

Emem U. Nwa and Prachanda Pradhan, editors

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Preface

It has long been agreed that irrigation is needed to assist in producing enough food for Nigerians. In response to this need, the Federal and State governments invested substantial sums of money, particularly between 1973 and 1984, in developing irrigation infrastructure in the country. The irrigation systems developed so far have not performed as well as expected in their contributions towards meeting the food needs of the population. A number of reasons have been advanced for this relatively poor performance, one of the reasons being that the research to support irrigation development and management has been grossly inadequate.

Obviously, this must be the reason why the International Irrigation Management Institute (IIMI) believed that they could make a contribution towards the improvement of irrigation system management in Nigeria. Therefore, in 1991, IIMI established its office in Kano and started research into irrigation management problems using the Kano River Irrigation Project as a pilot centre.

The idea of a seminar to develop irrigation research priorities for Nigeria was initiated by IIMI-Nigeria programme leadership and the University of Ilorin felt that they were in a position to help in bringing about the realization of such a timely and lofty objective.

Few papers were invited for the seminar since it was decided that much of the time should be spent on the discussion rather than on the paper presentations. Participants were invited from the Federal Ministry of Agriculture, Water Resources and Rural Development; the River Basin Development Authorities; the State Ministry of Agriculture and the ADPs; the Research Institutes; IIMI; FACU; the Universities, and the private sector. These are the groups involved in, and benefiting from irrigation development in Nigeria. The papers, discussions and the recommendations of the seminar form the content of this book entitled "Irrigation Research Priorities for Nigeria".

The book has been arranged starting with the Summary and Recommendations and contains fourteen (14) other chapters. The book is intended to serve less as a reference material but more as an action programme for all those who are interested in developing sustainable irrigated agriculture in Nigeria.

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Acknowledgements

The Editors wish to sincerely thank the International Irrigation Management Institute (IIMI) for financing the seminar on Irrigation Research Priorities for Nigeria and the publication of this proceedings. The Vice-Chancellor of the University of Ilorin, Professor J. O. Oyinloye permitted the entire department of Agricultural Engineering of the University to mobilize its human resources to ensure the success of the seminar and also sent his personal representative, Professor J. S. O. Adeniyi, the Dean of Engineering and Chairman, Committee of Deans to present his welcome address.

We are grateful to the Secretary of State of the Federal Ministry of Agriculture, Water Resources and Rural Development, Alhaji Isah Mohammed, for sending a representative to deliver his keynote address. The Director-General in the Ministry, Dr. Alex U. Kadiri facilitated the input from the Ministry. The Director of Planning, Research and Statistics, Engr (Dr.) F. I .Soribe, and the Director of Irrigation and Drainage, Engr. M.H. Ibrahim also sent papers to the Seminar.

The Kwara State Ministry of Agriculture and Natural Resources, through the Honourable Commissioner of Agriculture, Iyiola Oyedepo ESQ, and the Diector-General, Alhaji M. S. Koro, made some accommodation available to some of our distinguished guests from outside Ilorin. We thank them for this and for their participation. The staff of the Department of Agricultural Engineering, University of Ilorin, did not have closing hours of work during the period of the seminar. We are grateful for their efforts.

There would have been no seminar without the contribution of the authors. The participants were wonderful. Mr F. E. Schulze travelled from IIMI-West Africa Programme, Ouagadougou, Burkina Faso. Mr Henry Thompson of the Hadejia-Nguru Wetlands Conservation Project, Nguru and Mr. Frank Hicks of the Ford Foundation, Lagos also participated actively. We are grateful to all of them.

We thank in advance those who will use the recommendations in this book to advance sustainable irrigation in Nigeria.

Summary and Recommendations

A Seminar was organized by the International Irrigation Management Institute (IIMI) in collaboration with the University of Ilorin from 20th-23rd April, 1993, at Ilorin, to address the issue of irrigation research priorities for Nigeria.

The Seminar drew a select group of participants representing various interests involved in irrigation development and management in Nigeria such as the Federal Ministry of Agriculture, Water Resources and Rural Development, the River Basin Development Authorities, State Government Agencies; ADPs; IIMI; Universities; Polytechnics; Research Institutes, and Private Sector, etc.

The Seminar highlighted the serious problems facing irrigation development in Nigeria. After thorough and in-depth discussions on these problems and on research priorities needed to solve them and to develop sustainable irrigation for the country, the seminar unanimously adopted the following recommendations and action programmes:

A. IRRIGATION RESEARCH PRIORITIES

Six major areas which require priority research attention were recommended. These are:

1. Irrigation Performance Assessment

1.1 Develop usable indicators and methodology to assess various types of irrigation systems (large, medium, small, etc.).

1.2 Develop the mechanism for, and actually undertake continuous project monitoring and evaluation.

1.3 Study the irrigation efficiencies and water use efficiencies of the systems in all their ramifications.

1.4 Collect routine data on the irrigation systems. Although this is implied in 1.1 to 1.3 above, 1.4 is repeated for emphasis. Some of the routine data to be collected include:

a) crop area survey data
b) groundwater levels
c) surface and groundwater quality data
d) salinity and alkalinity data
e) canal water losses
f) soil fertility data
g) climatological, hydrological, hydrogeological data
h) etc.

1.5 Study the inter-relationship between the design, operation and management of irrigation systems.

1.6 Carry out rigorous appraisal of project feasibility studies.

1.7 Study the degree of capacity utilization of the existing schemes.

1.8 Study the productivity of water and labour in irrigation systems.

1.9 Investigate the effectiveness of the input and extension delivery systems.

1.10 Develop the procedure for rehabilitation and modernization of irrigation systems.

2. Economic Issues

2.1 Study the comparative cost advantage of small-scale vis-a-vis large scale irrigation projects.

2.2 Study the impact of the Structural Adjustment Programme (SAP) on the performance of the various types (large or small) of irrigation systems.

2.3 Investigate the problems of cost recovery and undertake studies that would lead to the determination of appropriate water charges in irrigation systems.

2.4 Study the cost effectiveness of the various irrigation systems and how to increase the productivity of capital.

3. Technological Issues

3.1 Study and develop appropriate and sustainable irrigation technologies for Nigeria.

3.2 Develop local raw materials for use in irrigation and drainage.

3.3 Develop alternative water lifting devices for fadama irrigation.

3.4 Design and fabricate hydrometric and soil and water measuring instruments.

3.5 Develop alternative sources of energy for pumping water, alternative to the conventional fossil fuel.

3.6 Study and improve water application methods.

3.7 Study crop water requirements and irrigation scheduling to include:

a) Evaluation of ET models in different ecological zones of Nigeria, and
b) Crop yield response to irrigation water management.

3.8 Study the control of salinity and groundwater problems.

3.9 Investigate the reduction of irrigation water losses.

3.10 Study the management of the maintenance of irrigation systems.

3.11 Investigate the integrated management of water resources on catchment basis.

3.12 Undertake the computer simulation of irrigation systems.

3.13 Undertake studies to determine the best methods of recharge of various aquifers particularly for the National Fadama Development Project (NFDP).

4. Institutional Framework for Irrigation Management

4.1 Investigate Institutional framework and legal basis for effective farmer participation in irrigation development and management.

4.2 Study the establishment of farmer organizations such as Water Users' Associations, Fadama Users' Associations, Farmers Cooperatives, etc.

4.3 Investigate land property relationship issues e.g. ownership of land in public irrigation systems; and impact of land subdivision on irrigation management.

4.4 Study the alternative approaches to involve the private sector in irrigation development.

5. Environmental Issues

5.1 Undertake environmental impact assessment of the irrigation systems in relation to health, salinity, alkalinity, rising water table, etc. hazards.

5.2 Study the impact of dams and reservoirs on the environment.

5.3 Investigate downstream compensation releases - ie. how much water is to be released downstream of dams to enhance downstream environmental quality.

5.4 Undertake groundwater and surface water studies to ascertain the sustainability of the washbores and tubewells in the National Fadama Development Project.

6. Sociological Issues

6.1 Studies to overcome the sociological problems that make it difficult to obtain accurate and up to date data on irrigation development and management.

6.2 Studies of the socio-cultural attitude of the beneficiaries and potential beneficiaries of irrigation projects.

6.3 Studies of issues such as displacement, resettlement and adjustment.

6.4 Women in irrigation.

6.5 Studies of the sociology and methodology of introducing irrigation into new regions that have not been familiar with irrigation.

6.6 Study the methods of reducing conflicts between crop farmers and pastoralists and those of re-integrating the activities of crop farmers and pastoralists for mutual benefit.

B. FRAMEWORK FOR IRRIGATION RESEARCH AND A PILOT PROJECT

1. The seminar adopted and recommended a proposal by Nwa (see publication in this issue) as a framework for irrigation research in Nigeria.

2. The seminar recommended that a pilot project using Anambra-Imo and Hadejia-Jama'are catchments be instituted to test the framework recommended above.

C. IRRIGATION RESEARCH NETWORKING

1. The Seminar recommended that an "Irrigation Research Network" be set up for the purpose of disseminating research results and other irrigation information among its members that would be both institutional and individual.

1. General Introduction

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1.1 INTRODUCTION

Self-sufficiency in food has always been a policy of very high order of all governments in Nigeria including the colonial government. As an example, according to Nwa (1987), in 1919, the colonial Secretary, Northern Provinces, sent the following circular to all Residents (provincial administrators), Nothern Provinces:

> I am directed to draw your attention to the necessity of increasing the cultivation of rice for the following reasons: In 1914, no less than 212,000 cwt (10,770 tonnes) of rice was imported into Nigeria. At the present moment, there is a danger of a serious world shortage of rice. It is therefore of great importance that in this respect, Nigeria should become self-supporting.
>
> I am to ask your views as to the measures that might be taken in your province to stimulate the production of rice.

Self-sufficiency in food will, and should, continue to be a policy of all future governments. The difference between the past and present governments and the future administrations should be that the policy should be translated into reality.

Irrigation was introduced into the Nigerian agriculture in an effort to translate policy into reality. So far the contributions made by irrigation have not been sufficiently impressive. The present danger is that internal and external economic and political pressures could cause an irrational decision to be taken that could adversely affect irrigation development in Nigeria. The fact that detached professionals and the beneficiaries of irrigation have decided to examine the problems of irrigation in the country at this time and suggest the ways of looking for the solutions is apropos and pre-emptive. "Irrigation Research Priorities for Nigeria" is aimed at providing the scientific support for proper irrigation development and management in the country.

1.2 PROBLEMS ADDRESSED

There are many problems that affect irrigation development and management in Nigeria. It is not possible and it was not intended to address all of them here. This publication has directed attention to six important areas of research that require urgent attention. These are:

1. Irrigation Performance Assessment,

2. Economics of Irrigation,

3. Irrigation Technology,

4. Institutional Framework for Irrigation Development and Management,

5. Environmental impact of Irrigation, and

6. Sociology of Irrigation.

1.3 PROBLEMS NOT ADDRESSED

As stated previously, some problems that affect irrigation development and management have not been addressed here. This does not imply that these problems are not important but it is expected that they will be addressed by other groups of professionals. Some of the areas include:

1. Irrigation Extension and Extension Methodology Research,

2. Irrigation Agronomy particularly Irrigated Crops Improvement and Management,

3. Irrigation Manpower and Manpower Research,

4. Transportation, Processing, Storage and Marketing of the Output from Irriagtion Projects, and

5. Problems of Farm Input and Farm Support Services.

1.4 CONCLUSION

The issue now is not that of irrigation or no irrigation or that of small scale or large scale irrigation. The issue, according to Nwa and Martins (1982) is how to sustain irrigated agriculture for the permanent benefit of the Nigerian population.

1.5 REFERENCES

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Nwa, E. U., and B. Martins. 1982. Irrigation development in Nigeria. Proc. Fourth Afro-Asian Regional Conference of the International Commision on Irrigation and Drainage, Vol I (Publ. 01):1-18.

2. Views On Irrigation Research Priorities For Nigeria.

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2.1 INTRODUCTION

I have the honour to be invited among distinguished people as are present here today. The issue of irrigation research in Nigeria cannot come at a better time than this. We are all living witnesses to the nation's rapid population growth and the decline in crop production to meet up with the population explosion. In short, our agricultural production has to be improved upon to ensure that food supply keeps pace with increasing population and urbanisation.

2.2 HISTORICAL DEVELOPMENT OF IRRIGATION IN NIGERIA

Rainfall is not adequate for the sustained yield that is expected, and some measure of uncertainties go along with this. We are all aware of the sporadic occurrences of drought, desertification and flood menace that adversely affect our agricultural production. In order to obviate the effect of these scourges, irrigation practices is of vital importance. Formal irrigation therefore started in early 70's with a humble beginning and it has now assumed prominence. The government established eleven River Basin Development Authorities (RBDAs) and charged them with water resources development in their respective areas of operation. In spite of the teething problems the achievements recorded so far has been tremendous. Large, medium and small dams have been constructed all over the country and these have impounded water capable of irrigating over 500,000 ha of farmland. Due to some constraints however only about 70,000 ha are put under irrigation. Plans are afoot to utilise fully all impounded water in our dams. Apart from the achievements of the RBDAs, the State Irrigation Departments and the State Agricultural Development Projects (ADPs) are also involved in irrigation, the latter mainly exploring the fadama areas. In all a lot of experience has been garnered over the years on irrigated farming and of course a lot of problems have also been encountered. While immediate solutions may have been got for some of these problems, others are either partially solved or remain to be solved. These areas require some form of research to arrive at a lasting solution, solutions that are adaptable to our own conditions.

One of the major considerations in irrigation the world over is the ability to know how to manage the system, to know how much and when to apply water to our different crops. The performance of the different crops (maize, beans, onions etc) depend mainly on the optimum application of water on the principal soil types.

-silty clay loam (heavy textured soil)

-medium loam (fairly ideal agric soil)

-sandy loam.

2.3 IMPROVING CROP WATER REQUIREMENTS

In order to develop an irrigation programme, it is necessary to give the timing and amount of irrigation required. Particular attention has not been paid to establishing or monitoring the water requirements of our various crops by the various irrigation authorities. In actual fact, many of our farmers wrongly believe that if some water is good for the plants, more is better, whereas the productive yield of that crop is being compromised through ignorance. Apart from this aspect of research, the need for extension workers in irrigation is also very vital.

2.4 SALINITY HAZARDS

Attention is also required in improving water use efficiency of irrigation projects. It is our experience that tremendous water losses occur due to faulty conveyance system and wrong field application. These losses essentially occur due to unlined or poorly maintained canals. This often leads to the raising up of the water table and build-up of the salt concentration which often lead to crop failure.

A number of our irrigation projects have experienced this salinity problems arising from frequent use of nitrogen and potassium fertilizers and the salt accumulation that goes on with irrigation waters. There is therefore the need to evaluate the salinity, sodium and specific ion hazards of groundwaters for irrigation purposes. The role of various parameters such as soil characteristics, salt tolerance of crops, water and crop management practices need to be investigated to maximise utilisation of available water supply. Several metric tonnes of salts per hectare are usually added to the irrigation soils annually. Since plants transpire water and only small amounts of these salts are taken up by the plants, the concentration of soluble salts in the soils increase. Without leaching, salt constituents will accumulate in the soil with successive irrigation until the solubility limit of each soil is reached. The limits for the different salts need to be researched into in particular soil types and a schedule drawn up for leaching to lessen the accumulation of salts. It is therefore necessary to conduct research into salt build-up on irrigation fields and their control.

2.5 DATA COLLECTION AND ANALYSIS

The importance of a consistent data collection, analysis, storage and dissemination, is highly recognized. This enhances an accurate planning, design and implementation of our projects.

It is an open secret that lack of reliable data (climatological, hydrological, hydrogeological etc) has been the major constraints in our planning and operational purposes. Adequate attention has not been given to data collection. It is often regarded in certain unexpected quarters that fund allocation for this purpose amounts to unprofitable ventures. It however needs to be reiterated that for a successful irrigation project, a constant research need to be undertaken, using unbroken long period of hydrometeorological data (rainfall, wind velocity, evaporation, temperature, river discharge etc.). This ensures an accurate determination of available rainfall, evaporation, critical temperature for plant pollination and fertilisation, among other things. Our professionals on the field still pay only a passing attention to these studies, forgetting that the success and sustenance of our irrigation projects depend on this.

River discharges and staff gauge measurements on a regular basis and analysis of data also ensure spatial and temporal distribution of available water critical for irrigation projects.In determining the crop water requirement in different soils, the rates of evapotranspiration and percolation are no doubt very important. These are mainly determined by climatic conditions. The country, compared with other economies, is still young in experience in irrigation matters, there is a lot of room for improvement in this realm.

2.6 IMPROVING WATER USE EFFICIENCY

As aforesaid, a lot of water losses is encountered in the operation of irrigation systems. This includes water lost in the farm due to seepages, leakages in dykes, over application of irrigation water, scheduled and unscheduled drainage and spillage, conveyance losses through cracks, crab holes and gates, and illegal diversions including evaporation from water surface and evapotranspiration of weeds in the surface and slopes of canals. These losses (farm waste, farm ditch, conveyance), need to be reduced to the barest minimum and underscore the need for research on improving water use efficiency of irrigation projects.

In order to have a historical and up-to-date crop acreage of a project area, an overall crop acreage survey has to be carried out during each major crop season. All pieces of crop land in the area have to be field-checked against the service map being used at the date of the survey. It is also essential to carry out the determination of the optimum size of an irrigated plot in relation to soil, technical and economic parameters for the different agroclimatic zones in Nigeria.

2.7 IMPACT OF IRRIGATION ON LABOUR EFFICIENCY

The purpose of irrigation is to increase crop production output. Increase in yield means increase in labour efficiency. The impact of irrigation on labour's efficiency should be constantly checked to ensure a good ratio between input and output. A catalogue of reasons can be attributable to inefficient labour. These include unavailable or poorly maintained equipment, poor land levelling, lateness in carrying out operations, failure or inability to maintain irrigation channels. The impact of irrigation on labour efficiency need to be evaluated on a regular basis.

2.8 MANPOWER RESEARCH AND TRAINING

It is also imperative that the irrigation personnel and farmers should be sufficiently trained and well oriented in the various aspects of water management to make them aware and recognise the importance of their duties. Special training and refresher courses should be organised for irrigation superintendents, watermasters, ditch tenders, gatekeepers, farmers-irrigators etc. to enhance smooth operations of irrigation projects.

2.9 SOCIO-ECONOMIC AND HEALTH IMPACT

While irrigation is good and ensures self-sufficiency in food production as well as raw materials for the industry, it also has some health implications, and disturbs the ecosystem of an area. In this connection the socio-economic and health impact of these irrigation projects on the populace need to be constantly evaluated.

Modern irrigated agriculture as aforesaid is fairly new in Nigeria. There is therefore a need to research into the social impacts of irrigation development as it affects the life style of the beneficiaries. The so called simple irrigation methodology like irrigation scheduling could cause major upheaval in life of the benefitting farmers. Take the example of Bakolori Irrigation Project located at Talata Mafara in Sokoto State. Talata means Tuesday and it is an important market day in Talata Mafara town. What happens if you schedule to deliver water to some farmers on Talata (Tuesday). You have problems in your hands. This is just an example.

2.10 CONCLUSION

Ladies and gentlemen, the research into irrigation systems in Nigeria is not exhaustive. In Nigeria, irrigation research has not been given the prominence it deserves. This is partly because the country is relatively young in embracing this modern system of farming and expectedly our experience is limited. In spite of this limitation, we are striving hard to improve the irrigation practices in Nigeria through organised research studies. I am happy this forum will also afford us opportunities to learn, from veteran professionals, of improved irrigation practices in other countries.

I thank you for giving me the invitation to be with you today.

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Abuja

2.11 INTRODUCTION

With the teeming population, insufficient food production and poor state of the economy, this discussion is very timely indeed.

Irrigation in Nigeria covers, at present, about 0.9 million hectares (including double cropping) or 2.8% of the total cultivable area, most of which is planted with rice and produces about 8.2% of the total annual crops. The total irrigation potential is estimated at 2-2.5 million hectares capable of producing 25-40% of the total current annual crop production. This, therefore emphasizes the need for continued irrigated agricultural practice.

Food production has increased with the establishment and involvement of some organizations such as the River Basin Development Authorities (RBDAs), Agricultural Development Projects (ADPs) etc through the initiation of small to large scale irrigation projects spread across the country coupled with researches and extension services carried out by various Colleges and Institutes of Agriculture, Polytechnics and Universities.

It is of utmost importance particularly at this time of serious economic constraints to identify some specific irrigation research priority areas to be tackled since all the irrigation problems cannot be solved at the same time.

2.12 IMPORTANT AREAS FOR IRRIGATION RESEARCH

2.12.1 Irrigation Scheduling

1. Modeling and Measurement of Irrigation scheduling parameters.

2. Evaluation of E_T models in different ecological zones of Nigeria.

3. Crop yield response to irrigation water management.

The usual purpose of irrigation is to supply the water requirements of plants, therefore, successful irrigation scheduling requires a thorough understanding of the principles governing water flow through the soil, plant water uptake from the soil and water loss to the atmosphere.

2.12.2. Equipment and Instrumentation

The design and fabrication of simple hydrometric equipment and other instruments needed to measure soil and water parameters will reduce the high cost needed to import these equipment for research purposes.

2.12.3 Evaluation of Methods of Irrigation Water Application

The main considerations in selecting an irrigation system are the suitability of the system to the site, its costs, availability of water and labour and the expected returns on investment. Systematic studies will lead to sound decisions in the choice of irrigation methods.

2.12.4 Environmental Impact Assessment of Irrigation and Drainage Projects

The employment of irrigation, especially medium/large scale, sometimes involve the construction of reservoirs, dams, conveyance and distributary canals, ditches etc. However, these activities often lead to some undesirable health and environmental hazards, if not properly managed.

Among the health hazards are water related diseases such as bilharzia, river blindness, elephantiasis, malaria, guinea worm etc., while some of the environmental hazards are water-logging, salinization, aquatic and agricultural weeds, pests, sedimentation, water pollution etc. Some of the social problems include resettlements, compensation and change of lifestyles. Because of the importance of environmental conservation, it is a necessity in irrigation projects that the environmental impact assessment be carried out before and after the establishment of the project.

The Federal Ministry of Agriculture, Water Resources and Rural Development recently demonstrated its belief in environmental impact assessment by incorporating it in the terms of reference of four World Bank assisted irrigation projects executed by the ministry. To date, the Ministry has been involved directly in the assessment of environmental impact of some irrigation and drainage projects. These are:

a) The assessment of irrigation schemes in North-West Nigeria. This assessment was carried out in collaboration with Hydraulic Research Ltd, Wallingford, UK and Institute of Ecology, Obafemi Awolowo University, Ile-Ife, Nigeria.

b) Environmental Impact Assessment of National Fadama Development Project (NFDP) for Northern States. This assessment was carried out under the auspices of the Federal Agricultural Co-ordinating Unit (FACU), Ibadan, Nigeria.

c) Environmental Impact Assessment of four major irrigation projects. These are Jere Bowl (Alau Dam), Lower Anambra, Kano River and Dadin Kowa Irrigation projects.

2.12.5 Feasibility of renewable energy as alternative power source to conventional fossil fuel.

Energy is required in irrigation to pump certain quantity of water to meet crop demand. A list of available energy sources is large. This includes fossil, direct solar, wind, nuclear, geothermal etc. However in Nigeria, virtually only one source which is fossil is exploited as farm power source, there is need to explore other power sources.

2.13 CONCLUSION

Needless to mention, there are many areas of research interests which need development. With the involvement of all the organizations involved in irrigation, there is no doubt that research will bring the expected improvement in irrigated agriculture in the country.

3. The Status of Irrigation Research in Nigeria

Nigeria

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3.1 INTRODUCTION

One of the goals of the irrigation sub-sector in Nigeria is to accelerate the achievement by the nation of self-sufficiency in food. To achieve this goal a large amount of capital was invested in irrigation between 1973 and 1984. Unfortunately the contribution of irrigation to food production has not been very impressive because the development of irrigation in the country has not been very effective.

A great number of problems face the irrigation sub-sector. These range from inconsistency in government policy to inadequate funding and inadequacies in system management. Clearly one of the problems inhibiting a rapid and an effective irrigation development in Nigeria is that research support for irrigation is very weak. Irrigation development can hardly be efficient without an effective research support.

It is intended in this paper to present a picture of the current situation of irrigation research in Nigeria and to suggest a strategy that could be used to strengthen research support for irrigation in the country.

3.2 CURRENT RESEARCH INSTITUTIONS AND RESEARCH ACTIVITIES

3.2.1 Irrigated Crops Research

Currently the best organized research programmes in support of irrigation are in the area of irrigated crops improvement. The irrigated crops include wheat, rice, maize, sugar cane, barley, cowpea and vegetables among others. A number of Research Institutes have the mandate to undertake research to improve these and other irrigated crops. These institutes include the Institute for Agricultural Research (IAR), Samaru, Zaria; National Cereals Research Institute (NCRI), Badeggi, Niger State; Lake Chad Research Institute (LCRI), Maiduguri; and the National Horticultural Research Institute (NIHORT), Ibadan (Nwa, 1983). The International Institute of Tropical Agriculture (IITA), Ibadan, has a programme based in Kano to develop cowpeas for irrigation. Perhaps the only groups working on sugar cane is the small "Sugar Research Institute" based in the University of Ilorin and NCRI.

In addition to the Research Institutes, there are three Universities of Agriculture and at least 23 Faculties of Agriculture in the country's universities, some of whose members do carry out research to improve irrigated crops. However, most of the university based research depend on individual staff interest and on his ability to secure research funds. This is to say that most of the research is not based on "a mandate" backed up with research funds.

3.2.2 Other Irrigation Research

The other aspects of irrigation research are less organized than irrigated crops research (Nwa, 1983). It appears that only three Research Institutes have the mandate to undertake other aspects of irrigation research. These are IAR, LCRI and NCRI.

The Institute for Agricultural Research organizes its irrigation research programme under three sub-programmes (IAR, 1992) namely, Water Resources Development and Management, Irrigated Cropping Systems, and Environmental Implications of Irrigation. The Lake Chad Research Institute has also carried out some irrigation research in addition to irrigated crops research, but being a younger Institute, its irrigation programme may not be as wide as that of IAR.

Other irrigation research are being undertaken, but these are by individuals and small groups scattered all over the various universities and centres in the country. The University of Ilorin, for example, is studying small scale, farmer managed, non-formal irrigation systems in its vicinity; and the University of Nigeria, Nsukka is examining water resources development for small scale irrigation in its zone, just to name two.

The socio-economic issues relating to irrigation are being studied at Bayero University; Centre for Social and Economic Research, ABU, Zaria; National Institute of Social and Economic Research (NISER), Ibadan, among many other places.
The environmental aspects of irrigation involves:

- public health
- fisheries
- aquatic weeds
- considerations for wildlife
- downstream hydrology
- agricultural pest management
- increased use of fertilizer
- impacts on groundwater
- drainage costs, and
- social costs

The Institute of Ecology of Obafemi Awolowo University, Ile-Ife, has been carrying out studies on the health aspects of irrigation. For example, they studied the vector-borne disease problems of small scale water resource development projects in Nigeria and they have developed guidelines for rapid assessement of these problems in irrigation projects. The Nguru wetland project is also another attempt to study the environmental impact of irrigation with particular reference to wildlife. Some other aspects of the environmental impact of irrigation are being studied by other groups.

Using remote sensing techniques, the IITA is leading a programme to classify inland valleys in West Africa. This could be a prelude to the study of the irrigation of these valley bottom lands which are more prevalent in southern Nigerian just as the fadamas are prevalent in the north.

In 1991 the International Irrigation Management Institute (IIMI) established its office in Kano and started research into irrigation management problems using the Kano River project as a pilot centre (Pradhan, 1992). Four major areas are the focus of this collaborative action research, namely:

- institutional aspects
- mode of management
- operation and maintenance procedure, and
- resource mobilization.

In this section of this paper, an indication has been given of some of the on-going irrigation research activities in Nigeria. As stated previously, some work are being done at various locations. Perhaps one of the outcomes of this Seminar would be to find a way to document all the various research activities and results for easy reference.

3.3. POTENTIAL IRRIGATION RESEARCH INSTITUTIONS

As indicated in section 3.2, many individuals are carrying out irrigation research at various places. Most of this work are being undertaken out of the personal interest of the researchers and not from demand by third parties to solve specific problems. This is one of the reasons the results are not being applied as much as they should be. This is also one of the reasons why many individuals and institutions with potential do not take part in irrigation research. This situation could be reversed easily by specifying what problems need to be solved and by providing funds to solve priority problems.

Today (March 1993) there are 24 Federal and 12 State universities, excluding the military universty,in Nigeria. Several of these universities have departments of agricultural, civil, water resources and environmental engineering; geography; geology; applied geophysics; meteorology; agronomy and water management in addition to the department of management sciences.

Table 3.1 gives the numbers of departments of some of the courses available in the Nigerian universities. In addition there are expertise in ecology and in environmental and community health at several centres. These are some of the departments and groups with the potential to undertake irrigation research. If these institutions and groups are organized and funded, there is no doubt that much more effective irrigation research could be undertaken.

Table 3.1 Numbers of departments of various courses available in Nigerian universities (March, 1993)

	Courses	Number of departments
1.	Agricultural Engineering	14
2	Civil Engineering	22
3.	Water Resources and Environmental Engineering	1
4.	Geography	25
5.	Geology	15
6.	Applied Geophysics	3
7.	Meteorology	3
8.	Agricultural Meteorology and Water Management	1
9.	Agronomy	3
10.	Soil Science	Several but as part of Agriculture

Source: JAMB (1992)

3.4. PROPOSED FRAMEWORK FOR IRRIGATION RESEARCH

It is proposed here that the irrigation research potential of the existing institutions be utilized to support existing and planned irrigation projects in the country. Already Nigeria has been divided into 11 catchment areas (river basins). It is proposed that all the institutions be divided into 11 groups and that one group should take care of one river basin. All the problems of the RBDA projects, those of the ADPs of the states in the basin, and all the problems of the private sector projects in the same basin are expected to be solved by the respective research group. One of the institutions in the group is to coordinate the work of the group.

Table 3.2 gives the river basins and their States and the proposed institutional groups and the coordinating institutions. It is suggested also that this scheme be started on a pilot basis using one basin in the north and another one in the south. The lessons learnt from the pilot project would be used to modify the scheme if necessary before implementing it all over the country. Based on the level of development of the existing projects in the basins, it is recommended that Anambra-Imo and Hadejia-Jama'are river basins be used for the pilot study. The details of the implementation procedure should be worked out before starting the project.

Table 3.2. Organization of institutions to support irrigation research

River Basin	States	Institutions	Coordinating Institution
1. Anambra-Imo	Abia Anambra Enugu Imo	UNN FUTO NAU UMUDIKE ABSU ESUTECH IMSU	UNN
2. Benin-Owena	Edo Ondo	BENIN FUTA EDSU OSUA	BENIN
3. Chad Basin	Borno Yobe	MAIDUGURI BAUCHI YOLA LCRI	MAIDUGURI
4. Cross River	Akwa Ibom Cross River	UYO CALABAR	UYO
5. Hadejia-Jama'are	Bauchi Jigawa Kano	IAR ABU BAUCHI BAYERO KANO ICRISAT IIMI IITA	IAR
6. Lower Benue	Benue Plateau	MAKURDI JOS UNN BESU	MAKURDI
7. Niger Delta	Delta Rivers	DELSU RSUST PHC	RSUST
8. Niger River	FCT Kaduna Kogi Kwara Niger	ILORIN ABU ABUJA MINNA NCRI NWRI	ILORIN

Table 3.2. contd

River Basin	States	Institutions	Coordinating Institution
9. Ogun-Oshun	Lagos Ogun Osun Oyo	ABEOKUTA IBADAN LAGOS OAU LAUTECH LASU OGUN IAR & T IITA NIHORT NISER	ABEOKUTA
10. Sokoto-Rima	Katsina Kebbi Sokoto	UDU ABU IAR ILORIN NCRI	UDU
11. Upper Benue	Adamawa Taraba	YOLA BAUCHI JOS MAIDUGURI LCRI	YOLA

Note: See the appendix for the abbreviations

3.5. CONCLUSIONS AND RECOMMENDATIONS

In this paper the current research institutions and research activities in Nigeria were examined. The two major conclusions of this paper are that:

1. The infrastructure for irrigated crops improvement research are much better than those for the other aspects of irrigation research, and,

2. Research support for irrigation could be improved by exploiting the tremendous potential for irrigation research which exists in the Nigerian universities and other institutions.

In order to strengthen research support for irrigation the following recommendations are made:

1. A mechanism should be developed to document all the on- going research activities and the research results and other published information on Nigerian irrigation; these should be made easily acessible to researchers and other interested parties.,

2. The framework for research proposed in this paper should be adopted to support irrigation, and

3. A pilot project using Anambra-Imo and Hadejia-Jama'are river basins should be instituted to test the framework proposed in this paper.

3.6. REFERENCES

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APPENDIX

Institutional and Other Abbreviations

ABEOKUTA	- Federal University of Agriculture, Abeokuta
ABU	- Ahmadu Bello University, Zaria
ABUJA	- University of Abuja
ABSU	- Abia State University, Uturu
ADP	- Agricultural Development Project
BAUCHI	- Abubakar Tafawa Balewa University, Bauchi
BAYERO	- Bayero University, Kano
BENIN	- University of Benin, Benin City
BESU	- Benue State University, Makurdi
CALABAR	- University of Calabar, Calabar
DELSU	- Delta State University, Abraka
EDSU	- Edo State University, Ekpoma
ESUTECH	- Enugu State University of Technology, Enugu
FCT	- Federal Capital Territory
FUTA	- Federal University of Technology, Akure
FUTO	- Federal University of Technology, Owerri
IAR	- Institute for Agricultural Research, Samaru

IAR & T	- Istitute for Agricultural Research and Training, Ibadan
IBADAN	- University of Ibadan, Ibadan
ICRISAT	- International Crops Research Institute for Semi-Arid Tropics
IIMI	- International Irrigation Management Institute
IITA	- International Institute of Tropical Agriculture
ILORIN	- University of Ilorin, Ilorin
IMSU	- Imo State University, Owerri
JAMB	- Joint Admissions and Matriculation Board
JOS	- University of Jos, Jos
KANO	- Kano State University, Bagauda, Kano
LAGOS	- University of Lagos, Lagos
LAUTECH	- Ladoke Akintola University of Technology, Ogbomosho
LASU	- Lagos State University, Ojo, Lagos
LCRI	- Lake Chad Research Institute, Maiduguri
MAIDUGURI	- University of Maiduguri, Maiduguri
MAKURDI	- Federal University of Agriculture, Makurdi
MINNA	- Federal University of Technology, Minna
NAU	- Nnamdi Azikiwe University, Akwa
NCRI	- National Cereals Research Institute, Badeggi
NIHORT	- National Horticultural Research Institute, Ibadan
NISER	- National Institute for Social and Economic Research, Ibadan
NWRI	- National Water Resources Institute, Kaduna
OAU	- Obafemi Awolowo University, Ile-Ife
OGUN	- Ogun State University, Ago-Iwoye
OSUA	- Ondo State University, Ado-Ekiti
PHC	- University of Port-Harcourt, Port-Harcourt
RBDA	- River Basin Development Authority
RSUST	- Rivers State University of Science and Technology, Port-Harcourt
UDU	- Usmanu Danfodiyo University, Sokoto
UMUDIKE	- Federal University of Agriculture, Umudike
UNN	- University of Nigeria, Nsukka
UYO	- University of Uyo, Uyo
YOLA	- Federal University of Technology, Yola

4. Research Priority of Irrigation Management in Nigeria.

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4.1 INTRODUCTION:

Irrigation is gradually taking an important place in the overall agricultural development of Nigeria. It is a strategically important sector of the economy because it does not only help to produce the food required for an increasing population but also helps to ensure food security, maintenance of law, order and peace in the country. It is, therefore, important to pay attention to the better management and improvement of the irrigation sector.

There are several agencies involved in the irrigation sector. These include the policy making agencies at the ministry level, the implementing agencies such as the River Basin Development Authorities (RBDAs) and the Agricultural Development Projects (ADPs), and research and training institutions such as the universities and training centres. These agencies have to sit together to identify the problems afflicting the irrigation sector. With mutual understanding and respect, they are also the group to solve the identified problems so that the irrigation system could perform better.

Since the available resources will not be adequate to solve all the problems at the same time, it is necessary to set priorities on the basis of the order of importance of the problems to irrigation management.

This paper aims at presenting:

a) features of the irrigation sector in Nigeria,

b) problems and issues identified in the sector, and

c) criteria for setting research priority for improving the irrigation management in Nigeria.

4.2 FEATURES OF THE NIGERIAN IRRIGATION SCENE:

Nigeria is a densely populated country in West Africa, with a population of 89 million according to the official census although many people estimate it to be much more. It is also one of the largest countries in West Africa and dominates the region in irrigated agriculture.

About 90 percent of the area under irrigation in Nigeria has traditional irrigation systems while only 10 percent has modern irrigation systems defined as those with large dams or diversion weirs and headworks with water control structures. They have an elaborate network of infrastructure to deliver water and are managed independently by the irrigation agency or jointly by the irrigation agency and beneficiary farmers. Some of the features of irrigated agriculture in Nigeria are given in Table 4.1.

Table 4.1: Features of irrigated agriculture in Nigeria.

1	2	3
i)Total land area	98.3 million ha.	-
ii)Cultivable area	73 million ha.	74% of 1 (i)
iii)Crop coverage	25 million ha.	34% of 1 (ii)
iv)Cereal crop coverage	13 million ha.	52% of 1 (iii)
v)Rice coverage	01 million ha.	08% of 1 (iv)
vi)Irrigated area	01 million ha	08% of 1 (v)
vii)Area under traditional irrigation	900,000 ha.	90% of 1 (vi)
viii)Area under modern irrigation	100,000 ha.	10% of 1 (vi)

Source: IIMI Nigeria. 1992b.

The World bank has projected that rain-fed agriculture will not be adequate to feed the people of Nigeria after the year 2000. According to FAO estimates, even after an imposition of a ban on food imports, Nigeria imported 800,000 MT in 1989. Imports have declined to 540,000MT in 1991 according to the same source. There is, however, a need for irrigation sub sector development in Nigeria to meet short-term and long term food requirements of the country.

4.3 LARGE- AND SMALL-SCALE IRRIGATION SYSTEMS

Nigeria has both small-scale traditional irrigation systems as well as large-scale public sector irrigation systems. The history of the traditional irrigation system dates back to the 9th century although public sector irrigation development commenced only about two decades ago. The economic implications of the nation's dependence on food imports led to the adoption of new policies by the Government of Nigeria, aimed at attaining self-sufficiency in food. Consequently, substantial investment in irrigation infrastructure development was made by the government during the years 1970-1980. The Government of Nigeria invested about US$ 3 billion in irrigation development over a period of two decades, through River Basin Development Authorities (RBDAs) which are parastatal agencies of the Federal Ministry of Agriculture, Water Resources and Rural Development (this amount does not include the money expended on irrigation development through Agricultural Development projects). Under this programme, dams and major structures of many systems have been constructed although the irrigation distribution network remains to be completed. As of 1991, the total irrigated area under large-scale irrigation was only 70,000 ha. There are public sector irrigation developments by the State Ministry of Agriculture as well. However, the area under public sector irrigation is expected to increase considerably by the end of 1992. The low performance of the large-scale irrigation systems is reflected in the shortfall between the achievement and the target set out in the national Development Plan of Nigeria (Adams, 1991).

4.4 TECHNOLOGIES ADOPTED FOR SMALL-SCALE IRRIGATION DEVELOPMENT

In the later 1980s, a new programme designed to develop small-scale, farmer-based, privatized irrigation systems in fadama lands for wheat and vegetable cultivation, especially during the dry season, was implemented by the government through the Agricultural Development Projects (ADPs). Fadama is low land flood plains or valley bottoms with a high water table. The technologies adopted for irrigation development in these lands included water lifting from streams or rivers with the help of small or large pumps depending on the size of the land to be irrigated. Construction of ponds and wells and small earth dams, and installation of washbores or shallow tubewells (STWs), were undertaken as part of the development programme. Most of these systems are managed by the beneficiary farmers themselves. The Nigeria Government's policy promoted small-scale irrigation for farming of winter crops such as wheat and vegetables, especially in the northern States of Sokoto, Kano, Katsina and Bauchi (Brown and Nooter, 1992.).

Valley bottom irrigation systems for rice cultivation are prevalent in the central zone of the country. These irrigation systems are constructed to divert water from the valley bottom streams to the rice fields. There are different techniques of irrigation used before and after the flood plain and such systems could be found around Bida in Niger State. Many of these systems are managed by the farmers themselves. However, the State Government has provided occasional assistance for improvement of these systems. It has been identified that vast potential exists for improving agricultural production in these areas through appropriate assistance programmes for better water management (Izac.et.al., 1991).

The potentiality of small-scale irrigation development in Nigeria is tremendous. Over one million ha of fadama land can be developed for irrigated agriculture. This needs to be considered from the point of view of appropriate technology, both efficient and economical, to the farmers and developing a suitable institutional base at the farmer level. The important issue to be taken into consideration in small-scale irrigation is the process developed by the agencies to assist farmers develop their systems.

4.5 AGENCIES RESPONSIBLE FOR IRRIGATION DEVELOPMENT

There are three public sector agencies responsible for irrigation infrastructure development in Nigeria: the State Ministry of Agriculture and Natural Resources; Directorate of Foods, Roads and Rural Infrastructure (DFRRI); and River Basin Development Authorities (RBDAs). The State Ministry of Agriculture and Natural Resources implements irrigation infrastructure development programmes through the provision of credit to small scale-farmers for construction of boreholes, installation of STWs, and purchase of pumps and also through the construction of medium-scale irrigation systems. Small-scale (less than 50ha) and medium-scale (50-2000 ha) irrigation systems come under the jurisdiction of the State Ministry of Agriculture. Parastatal institutions such as the ADPs were established with a view to promoting agriculture and irrigation development in the States. Although DFRRI also has a mandate for small-scale village-based irrigation system development it plays a more active role in potable water schemes. RBDAs are responsible for the construction and management of the large-scale irrigation systems.

Water is a scarce resource in northern Nigeria. Therefore, it needs to be conserved and better utilized. Consequent to the severe drought that prevailed during the period 1972-1974, 11 River Basin Development Authorities were established with responsibilities for developing infrastructure for irrigation, increasing agricultural production and undertaking rural development activities in systems with a command area of above 2,000ha. However, the performance of these irrigation systems under the RBDAs, was marred due to shortfalls in achieving their area targets, operating only at 50 percent efficiency, wastage of water, lack of maintenance of the systems and shortage of spare parts for the maintenance of machinery. It is reported that the main reason for the poor overall performance of the systems is lack of funds. Although RBDAs were initially formed with multiple functions, at present, they are only responsible for water-related activities and are no longer involved in direct agricultural production.

4.6 NEW POLICY THRUST IN PUBLIC SECTOR IRRIGATION

The commercialization and privatization policy adopted by the government in 1987, as a package of the Structural Adjustment Programme (SAP), has made the River Basin Development Authorities (RBDAs) to be partially commercialized. With the implementation of this programme, the cost of services provided by the RBDAs is no longer subsidized but has to be borne by the beneficiaries themselves. Hence, the policy of commercialization and privatization has brought about institutional re-organization in the legal system of irrigation management, in the role of users' organizations, in water charge collection, and in sharing of responsibility jointly by the agency and the farmers for the operation and maintenance of the system. The government is to provide funds for the construction of the infrastructure while the completed irrigation systems have to mobilize resources internally to meet the recurrent costs of operation and maintenance of the system.

4.7 GLOBAL TREND IN IRRIGATION SECTOR

Over the last thirty years, developing countries outside of Africa have met their food needs in large part by extending their cultivable irrigated areas, in combination with the provision of improved seeds and other inputs and with supportive policies and institutions. The success of those developing nations in increasing agricultural production has hinged mainly on the output from irrigated fields.

But the experience of these last three decades is unlikely to be repeated. Expansion of irrigated areas has already slowed down and will slow down further as the best sites are exploited and the cost of new projects in poorer sites rises disproportionately. In the seventies, the annual rate of expansion of irrigated areas in developing countries was 2.22 percent; in the eighties the figure was 1.19 percent (IIMI, 1992a).

On the other hand, food demand continues to grow rapidly, stimulated by demographic expansion, by urbanization, and in many countries, by rising standards of living. At the same time, in many of the same countries, large numbers of people are living in poverty, without employment and unable to afford the food they need. The problem of food supplies remains acute, but future expansion of irrigated areas will not contribute to a solution on the same scale as in the past. Since there have not been major breakthroughs to enable rain-fed agriculture to play a dynamic role in meeting production targets, where are developing countries to find an engine of growth?

The answer lies in more intensive use of existing irrigated areas, coupled with carefully planned horizontal expansion of irrigation. The productivity of irrigated agriculture will need to rise by as much as three percent per annum, and in some areas by even more, if the basic food needs of developing nations are to be met (IIMI, 1992a).

Much of this increase in productivity can be achieved by improved irrigation management. Perhaps there is no other sub-sector of world agriculture in which the pay off will be higher - although reaching that pay off will not be easy.

Only a few irrigation schemes in the developing world are operating at their full potential because:

a) Areas cultivated are much smaller than areas commanded.

b) Water deliveries rarely correspond in quantity and timing to the requirements of the crops.

c) There are sharp inequities between supplies to farmers in the head reaches of a system and those located downstream.

d) Maintenance is often poor, leading to the silting of distribution channels and the corrosion of machinery and equipment.

e) Flooding, lack of adequate drainage, poor operation and maintenance, and inefficient water application have contributed to the environmental degradation of irrigated lands through waterlogging and salinization.

Improvements in irrigation policies and management are preconditions for meeting future food requirements - although not, of course, sufficient by themselves; they must be accompanied by many forms of technological advance, including improved crop varieties.

4.8 CURRENT ISSUES IN NIGERIA'S IRRIGATION DEVELOPMENT[1]

Within the overall context of irrigation development and management, it has been identified a number of issues or problems affecting the development of Nigerian irrigation, which either have arisen already or seem likely to deserve attention in the near future by the policy makers and research institutions in order to make irrigation a viable and sustainable sector of the national economy. These are:

4.8.1. Issues Concerning the Performance of Irrigation Systems.

(a) *Monitoring of System Performance*

At present it seems that there are not enough data about the performance of the existing irrigation systems, to guide decision-making by managers. Monitoring and evaluation of such parameters as cropping intensity, crop output, water input and various others would probably improve the quality of management decisions and actions.

(b) *Under-Utilization of Irrigation Facilities*

In several cases, formal irrigation facilities which the government has created are not being used by farmers to their full potential capacity. The reasons for this seem to be complex. They include question of farmers' attitudes and motivation, as well as institutional and technical causes such as insufficient performance of maintenance. The reasons for under-utilization, and remedies for it, need to be understood urgently because of their impact on revenue collection by the RBDAs.

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[1]This section is adopted from the IIMI - Nigeria Mission Report, 1992, prepared by Mr Charles Abernethy, Dr Derrick Thom and Dr. Prachanda Pradhan.

(c) *Development of usable indicators and methodology by the system managers*

The managers of irrigation system need to have usable indicators and methodology to access the performance of irrigation systems. Hence, it is important to develop feasible methodology and indicators that can be used by the managers.

(d) *Socio-Economic Impact*

It is necessary to understand the impact of irrigation on equity, profitability, poverty alleviation, property relationship on land and gender relations so that irrigation development does not create a big gap between rich and poor and inequitable resource distribution.

4.8.2. Issues Concerning Management of Water

(a) *Integrated Management of Water Resources*

It appears that in the northern states, and perhaps in states in the middle belt as well, the most rapid growth of irrigation is occurring through small-scale pump-based activities by individual farmers, abstracting water from streams or shallow aquifers. It is sometimes claimed that the areas served by these are increasing up to ten times as fast as formal irrigation. There are risks of water- table decline, environmental change, and deprivation of other water users, unless there are regulatory processes to govern use of the total water resources. This question is critically relevant in the three northern-most river basins.

(b) *Productivity of Water*

The three northern river basins (Sokoto-Rima, Hadejia-Jama'are, and Chad) are extremely deficient in surface water. These three basins contain about 35% of the area, and 27% of the people of Nigeria. The available surface water resources of $478m^3$ per person per year are, by international standards, very small (for comparison, Egypt has about twice as much), and the average annual rainfall received is now about 65% of which it was 30 years ago. In these circumstances, it is essential to ensure that policies are adopted which maximize the benefit obtained from each use of this very scarce resource.

(c) *Prevention of "Irrigation Water Loss"*

Irrigation water is a valuable commodity. Irrigation water is lost in several ways; through seepage and percolation from canal and fields, through the release of more than required water, poor maintenance causing wastage of irrigation, delivery of water at wrong time and through leaks and breaches in conveyance system. The issue of water loss is related to understanding the technical aspect of the field situation of water use and institutional arrangement for prevention of "water loss".

4.8.3 Issues concerning management of the irrigated agriculture sector

(a) *Economics of different scales of irrigation development*

Irrigation is being undertaken in various modes, ranging from individual activities based on shallow-well pumps up to formal systems backed by very large dams. To guide policy decisions about the thrust of future irrigation investments, there appears to be need for economic analysis of the cost-benefit performances of different types of irrigation. Such economic analysis would need to take account of the economic perspective of the individual farmer and of farmers' groups or users' associations, as well as that of the managing agency and the national economy,

(b) *Introduction of irrigation to new regions*

There are specific management problems associated with the introduction of formal irrigation systems in areas where irrigation has not previously been practiced much. The agency staff and the farming community may both need to develop new attitudes and skills. Training and information campaigns are needed, and better understanding of the constraints affecting both groups of people is also desirable. This issue is most likely to arise in states of the middle belt where rainfed production is a strong competitor for the available labour resources.

(c) *Farmers' participation in management processes*

Changing the relationship between the managing agencies and the farming community seems to be a necessary step in the solution of some of the other issues. Formation of water users' associations is one element of this, but there are numerous other matters that may need attention if participatory policy is to be put into operation. These include better definition of the legal framework, water rights and land rights; and adoption of planning processes so as to guarantee to farmers some formalized opportunities to understand and influence the evolution of projects that will affect them. The farmers participation is also important for the implementation of privatization and commercialization policy of the government.

4.8.4. Issues concerning the management of public irrigation organizations.

(a) *Cost recovery*

Current policy of the Federal Government requires that operational costs be borne by the users (of formal irrigation) rather than by the federal budget. The present level of cost recovery from users is however low. Means have therefore to be devised, which will enhance cost recovery, yet will not aggravate the other problems by, for example, reducing further the levels of system utilization.

Next >>

(b) *Improving the existing public irrigation organizations*

There is need of improvement of existing public irrigation organizations. These improvements take place by institutionalizing the management training programme and strategic planning exercise. It also can be done through internal structural change and adoption and introduction of new techniques in management. Hence, the improvement and reforms of existing organizations is to be considered from the standpoint of alternative strategies for effective improvement programme in order to achieve the efficiency and productivity of these organizations.

(c) *Management training*

There are already several universities, polytechnics and other types of institutes which provide training in irrigation technology as part of agricultural or civil engineering courses. There seems to be a need to supplement these kinds of technical training, by developing curricula in the organization and management of irrigation.

(d) *Management of maintenance*

Maintaining the irrigation facilities in good functioning condition is a normal duty of management. Its importance increases where the agency is endeavouring to induce farmers to pay fees at a level they are not accustomed to. The agencies are also trying to reduce their own costs, so there must be close attention to developing efficient and cost-effective management of maintenance. Farmers' associations may be persuaded to take on lower-level maintenance tasks. However, if they do so, they are likely to demand that the agencies improve their maintenance of the larger facilities.

(e) *Financial Autonomy*

The question of irrigation organization status is important. It is relevant to look into the effect of financial autonomy of irrigation systems on effectiveness, profitability and sustainability of the system.

4.8.5 Issues Concerning Community Irrigation Organizations

(a) *Formation of irrigators' Associations*

The formation of sustainable organizations of farmers, and the strengthening of these so that they can become valid partners of the government agencies, are generally perceived as desirable. Movement in this direction has however been slow, because there is a lack of replicable organizational models in the country as yet, and because a process for encouraging the creation of such organizations has yet to be developed. Among the issues here is the problem of identifying factors that will motivate the farmers to want to support such organizations and will bind the organizations together.

(b) *Organizations for Small-Scale Irrigation Development*

Although small-scale irrigation has flourished in recent years, it has not yet been accompanied by much institutional development among the farmers. This seems to be needed if these systems are to remain sustainable in the longer term. Such organizations would not be the same as those in the medium or large formal systems, and should probably be designed on the basis of studies of traditional modes of cooperation in fadama agriculture. Apart from the institutional questions, the rapid spread of small-scale pump-based irrigation may present issues of zoning of development areas, and integration with other users of water and land.

(c) *Intervention Strategy in Fadama Development*

There is fast development of small scale, farmer based, privatized irrigation systems. There is need to understand alternative intervention strategies in order to provide assistance to these systems when they stand for assistance. The important issue to be taken into consideration in small scale irrigation is the process developed by the agencies like the ADPs and departments of irrigation of States to assist farmers develop their systems.

(d) *Strengthening the Local Organization for Irrigation Management*

There has not been deliberate effort to strengthen local organizations for irrigation organization. The government policies announced on different occasions indicate the participation of the farmers and their responsibility to share the cost of maintenance and management of the irrigation systems. Issues relating to strengthening local organizations for irrigation management is to be investigated.

(e) *Legal Basis of Self-Management and Farmer Participation*

Irrigation management is not only technical proposition, it consists of socio-institutional and technical aspects. There is need to investigate the legal framework required for self-management of irrigation systems by the farmers and farmers' participation through the water users association.

4.8.6. Other Issues

(a) *Public Health Impacts of Irrigation*

Schistosomiasis has a definite linkage to irrigation in several formal systems in Nigeria. The association of other diseases such as malaria, onchocerciasis, guinea worm and diarrhoeal diseases with irrigation is possible but less clear. It is not known whether small-scale irrigation development has more or less impact on schistosomiasis, than formal irrigation has. Reduction of the impact of schistosomiasis requires attention to features of the design of new systems, and also of operation and maintenance of existing systems.

4.9 CRITERIA FOR SETTING RESEARCH PRIORITY IN IMPROVING THE IRRIGATION MANAGEMENT

There are always grumblings that we know the problems and we know the solutions as well. However, there has not been systematic way of resolving the problems. The list of issues as identified in earlier sections need proper attention to seek solution. Often times, one encounters the argument that these problems have come due to unavailability of financial resources. They say that if financial resources are available, such problems can be taken care of easily. The argument is only partly correct. We have to recognize other factors which contribute to improved management of irrigation systems.

A comparative study of rehabilitation and modernization of the irrigation systems in Sri Lanka shows that the benefit/cost ratio and internal rate of return are higher in those rehabilitation schemes where research component was included during the process of implementation of rehabilitation and modernization programme (Brewer. et al., 1992). In countries where there is strong tradition of interaction between research institutions and irrigation systems, performance of irrigation systems are comparatively better. Hence, research input in irrigation system management helps improve the performance of the system.

Morocco is a case in point. Examples from the United States of America and European countries definitely support this argument. Similar example can be found in Philippines, Taiwan, Malaysia, Thailand and Indonesia. Among the south Asian countries, Sri lanka has demonstrated the positive relationships between the research input and better performance of irrigation systems. Gal Oya Irrigation project is a typical example.

As indicated in the previous section, irrigation is strategically very important sector of the economy. It also helps to ensure food security which contributes to law and order and peace in a country. Hence, it is important to look into the question of performance in irrigation sector. All issues enumerated in the earlier section cannot be resolved immediately. some of the issues require long term preparation and others can be resolved immediately. In doing so, we have to set priority. The priority for irrigation management research is to be reviewed on the following four important considerations;

(a) Overall national policy (agricultural policy)

(b) comparative advantage in undertaking research into a particular component

(c) specific objective to contribute to national policy

(d) expected high rate of return on investment.

The discussion forum of researchers, officials and irrigation managers at the field level would help prioritize the components of irrigation management research. Such forum will establish a communication link among the policy makers, planners, implementors and researchers. In the absence of open and frank interaction through discussion forum of different actors, each one may be suspicious of the other. The credibility of implementation of improvement programme by the managers may be questioned so also may the research results. Hence, efforts and resources may be wasted. Such situation is to be avoided. Priority on irrigation management improvement research is to be decided by the process of collective interaction of different actors involved in the irrigation sector.

One might ask the question: where is the list of research priorities in irrigation management in this paper?

However, the emphasis in this section is to highlight the elements that are to be taken into consideration in prioritizing the research for irrigation improvement. Along with the components to be taken into consideration, the process as to how the prioritization takes place is also equally important. The listing of topics as research priority areas without going through the process of interaction with different concerned actors may not be very useful . As far as the potential issues seeking answers are concerned, the list is prepared in section two of this paper. More issues can be added to the list.

4.10 IIMI - HJRBDA PRIORITIZATION PROCESS

The following section attempts to present the prioritization process adopted by IIMI in interacting with the HJRBDA to spell out the priority area of action research activity to promote joint - management in Kano River Irrigation System.

The Federal Ministry of Water Resources wanted IIMI to help in promoting participatory irrigation management in public sector irrigation systems in Nigeria. The Ministry mandated IIMI to work with HJRBDA.

The Hadejia Jama'are River Basin Development Authority (HJRBDA) is responsible for the construction and management of the Kano River Irrigation Project (KRIP) in Kano, northern Nigeria. The Project is being developed in two phases. Under Phase I, 22,000 ha. of irrigation system will be developed; of this 15,000 ha have already been fully developed. The second stage will concentrate on the development of another 40,000 ha.

Agricultural production and crop coverage in KRIP have increased over time as a result of farmers adopting irrigated agriculture as a viable alternative to rain-fed agriculture. The system has achieved about 120% cropping intensity. There is potentiality for increasing cropping intensity. During the wet season, 50 percent of the area is under rice. Farmers also plant non-rice crops such as sorghum, millet, maize, cowpea and vegetables during this period. KRIP has large areas under wheat during the dry season and a smaller area under maize and other crops.

The privatization and commercialization policy adopted by the Government of Nigeria in 1987 aims at handing over public sector enterprises to private-sector management. This have resulted in a change in the mode of management of irrigation systems from agency-management to joint-management. In the latter, both agency personnel and farmers become partners and share the responsibility of management and resource mobilization. The new policy also calls for the transfer of increased responsibilities for operation and maintenance of irrigation systems to the users.

HJRBDA, in collaboration with IIMI, has undertaken action research to support the turnover of management of irrigation systems to their users. The HJRBDA-IIMI Collaborative Action Research Program in KRIP focuses on four issues (Pradhan. 1992b).

1. **Institutional Aspects.** This action research component is directed at strengthening the institutional support for irrigation management. It addresses such issues as legal provision for the role of the farmers, legal basis for farmer organizations in relation to water management, and procedures to form water users' organizations.

2. **Changes in Mode of Management.** The transition from agency-management to joint-management requires a change in the existing power structure of the agency. In order to help make this transition, re-orientation programmes for the farmers and officials are being organized to discuss ways and means of implementing joint-management.

3. **Operation and Maintenance (O & M) Procedures.** This is an important area which needs an analysis of the work to be done and costs and responsibilities to be shared. The O&M procedure concerns farmer organizations as well as resource mobilization.

4. **Resource Mobilization.** Internal resource mobilization is a prerequisite for better operation and maintenance of irrigation systems. This research component includes an analysis of alternative sources of resources and development of a procedure for the collection of a higher percentage of water fees as these are the major sources of revenue for KRIP.

The expected outputs of the programme are a greater awareness among irrigation managers and users regarding the requirements for successful joint-management of irrigation systems, establishment of procedures for joint-management, recognition of users' organizations, and improvement in the operation and maintenance of the system. The lessons learned will be relevant for other systems in Nigeria.

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5. Sustainable Irrigation Option For Nigeria: The Large or The Small

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5.1 INTRODUCTION

Irrigation has been practiced in Nigeria for centuries, although on a small scale, and in the drier northern parts of the country. In the past it was restricted to the seasonally flooded or floodable floodplains along major savanna channels and/or the depressions on the adjacent terraces -- the valley bottom areas now known by its *Hausa* word fadama. It was a very valuable piece of land devoted to highly priced crops. Until the 1980's this small-holder irrigation was dependent on the shaduf system of lifting water, concentrated mainly on market gardening crops, and the plot size was very small, averaging 0.2 to 0.4 ha. A variety of the irrigation of that time was the one dependent on residual moisture utilization technique for the production of rice which was experienced in the extensive floodplains of the Hadejia River.

But the droughts of the early 1970's demonstrated the inadequacy of the system to satisfy the need of the ever-growing population in the face of inclement climatic conditions. The answer to such devastating drought was found in large-scale irrigation on the upland plains and river terraces. Although attempts had been made earlier in the century to irrigate on a substantial scale, the activities of the mid-1970's really marked the beginning of serious large-scale irrigation projects. Kano State (now shared between Kano and Jigawa states) was the leading actor, and remains the hub (and show case) of large-scale irrigation in the country today. Not surprisingly, large-scale irrigation came with the construction of dams to conserve water. Consequently, nearly all the large-scale schemes existing in the country today, except the South Chad Irrigation Scheme (SCIP) and Lower Anambra Irrigation Project, depend on the impoundment of water behind one dam or the other. The largest dam constructed mainly for irrigation in the country is the Tiga Dam in Kano State. The second largest is the just-completed Chalawa Gorge Dam also in Kano State. In fact these two dams effectively control the two major feeders of the Hadejia River system. Other popular dams built for irrigation, among other things, include the Bakolori in Sokoto State and the Goronyo in the same area. The SCIP depends on water extracted from Lake Chad. Although the states took the initiative for developing large-scale irrigation and dam construction, these exercises soon passed to the River Basin Development Authorities (RBDAs).

In spite of their initial benefits, it was not long before the undesirable effects of the large-scale irrigation projects, and particularly the concomitant dams and reservoirs became noticeable. Researches started to reveal physical, social and economic adverse side effects. The call for a re-think and an investment in small-scale irrigation became resounding, championed by both home-based and foreign researchers (Adams, 1985; Matlock, 1985, and Turner, 1977, among others). The call was not lost on the World Bank which proposed and aided the establishment of Agricultural Development Projects (ADPs) whose main objective was to improve the age-long small-holder irrigation system in areas outside the control of the RBDAs, increase food production and correct the main setbacks of the large-scale projects. The states bought the idea and the ADPs grew rapidly in number and in strength. However, after ten years of the ADPs, the rosy picture earlier painted and initially achieved has become a mirage and it is clear that "modernization" is killing the sustainability of the traditional small-scale irrigation system, re-enacting the ills of the large-scale one. Indeed, a few of the ADPs (e.g KNARDA at Watari) has ventured into large-scale projects. The question that emerges from all this is: Which way then?

Using mainly the Kano/Jigawa states' experience as a case study, this paper examines the successes and failures of both the small- and the large-scale irrigation projects, highlighting the factors, and suggests what would seem to be the appropriate option to be adopted for a sustainable irrigation endeavour in Nigeria.

5.2 SMALL-SCALE IRRIGATION IN NIGERIA BEFORE LARGE-SCALE HYDRO-AGRICULTURE

The development of the seasonally flooded and floodable floodplains along major rivers and the depressions on low terraces (known as fadama land) in the savanna zone of Nigeria for small-scale dry season irrigation of rice, tomatoes, green vegetables, sugar cane, onions, pepper and the like, dates back to distant history. Irrigation was based largely on natural recycling of nutrient through annual silt addition by flooding rivers. The floodplain of the Hadejia and one of its main tributaries (River Kano) were especially noted for their dry season cultivation before the inception of dams and large-scale irrigation on the interfluves.

Before the era of dams two distinct zones of fadama cultivation existed. These are: the zone of defined storm channels with low terraces with or without narrow floodplains such as the headstreams of the Hadejia; and the zone of extensive alluvial channel complexes such as the Hadejia and Yobe complexes. In the first zone the shaduf system of lifting water from dugout pits at the edge of the storm channel, or ponds on the low terrace was popular. Calabashes were used on the shaduf to irrigate plots divided into basins. In the second zone, flooding was very extensive and lasted for longer periods. Thus, residual moisture utilization technique which required no water lifting device was applied. Climatic variations determined the extent of annual floods as well as the number of hectares cultivable each year. Needless to state that the uncultivable parts of the fadama provided pasture for grazing. In both zones the basin technique of irrigation was favoured. Inputs were limited, largely, to labour and seeds usually purchasable in the local markets, or from the last harvest. Labour was based largely on individual family labour (*gandu* or *gaiya)*. Hire was not very common. The droppings of animals allowed to graze farm residues and occasional addition of household refuse (*tarki*) supplemented the natural silt to replenish the nutrient of the land. The materials needed to construct and operate the shaduf constituted the other additional inputs. The system was no doubt labour intensive.

Rice was very popular in the extensive floodplains, while tomatoes, sugar cane, pepper (tatatse), green vegetables, onions, and other market gardening crops were popular in the confined floodplains and low terraces. Rice and sugar cane occupied the wetter areas while the other crops were grown in better drained (slightly raised) sections. Also, inter-cropping of the green vegetables and relay planting were very common.

It was a sustainable, organically balanced system, although on a small scale and catering mainly for urban dwellers. But the dams and large-scale irrigation came under the River Basin Development Authorities, and the fadama land and its development have not been the same again.

5.3 THE INCEPTION OF LARGE-SCALE HYDRO-AGRICULTURE

5.3.1 The Dams and Their Effects

When the dams and large scale irrigation came, particularly in the Hadejia headstreams (Figure 5.1), flood water no longer reached the low terraces and the extensive Hadejia floodplain was left high and dry, as most of the wet season flow became restricted into a much narrower channel, while the dry season discharge from the Tiga merely trickled to the area. As early as 1977 a village head in the Hadejia Emirate had occasion to complain to the officials of the Water Resources and Engineering Construction Agency (WRECA) Kano that "the land is dying" (Kulatunga, et al. 1977). Indeed, in the numerous cases where no perennial discharge has been maintained downstream of the dams, the pre-dam fadamas have either been lost outright, or are impoverished. For example, Nichol (1991) has estimated a loss of 656 ha of the 876 ha pre-dam cultivable fadama downstream of the Jakara Dam, although 661 ha of the cultivable and uncultivable fadama has been open up for rainfed cultivation. She was certain that 611 ha of the pre-dam uncultivable fadama could no longer be classified as such in 1981, about two years after the inception of the dam. Similarly, Adeniyi (1973) has reported losses of fadama land amounting to between 44 and 70% of the pre-dam extent along a stretch hundreds of kilometres downstream of the Kainji when its gates were closed in 1968. Similar losses of fadama land have been reported downstream of the Bakolori at Birnin Kebbi and elsewhere in the Sokoto-Rima basin by Adams (1985) and O'Reilly (1981).

It has often been argued that some of the fadama land drowned under an impounding reservoir is gained through the cultivation of the drawdown (risk) zone. But it has been shown that the drawdown zone is but a negligible part of the farmland drowned, and a very small part of the pre-impoundment fadama. In her study, Nichol (1991) estimated a recovery of 10.2% of the pre-impoundment fadama in the Jakara case. In fact, the cultivation of this risk zone portends another danger: excessive soil erosion leading to a rapid reservoir siltation.

In all the known cases of savanna dams, it is only in the small stretch of about 60 km below the Tiga that a positive transformation of the storm channel has occurred. Here, between the Tiga Dam and the confluence with the Chalawa River, the magnitude of the perennial flow maintained in the channel (at first 9.6 m^3/s, and later about 13.2 m^3/s) has proved to be optimum to enhance positive metamorphosis of the pre-dam storm channel within the reach. Thus, the effective channel today is approximately 30 m wide and is incised into the former storm channel to a depth of about 1.4 m creating an overbank zone (new low terrace) which is approximately 210 m wide (but not evenly distributed left and right of the new effective channel) on the pre-dam sandy accumulation. The new land is covered by post-dam nutrient-rich

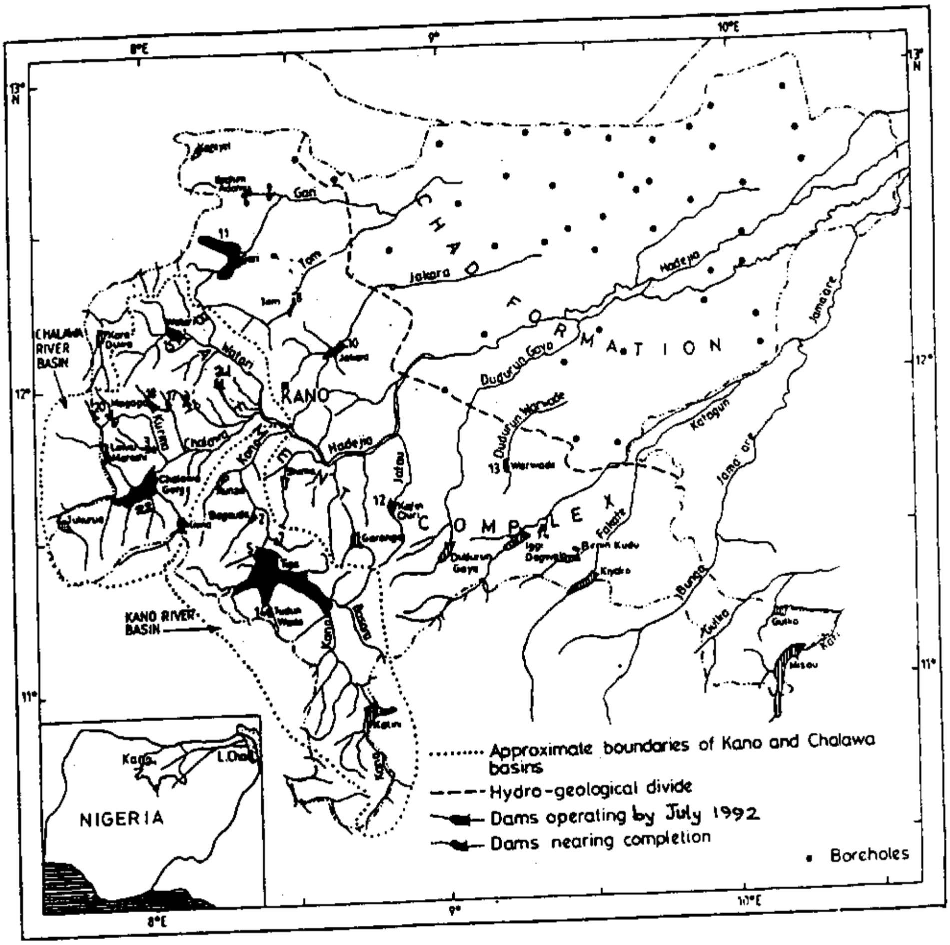

Fig. 5.1: Dams and Boreholes in the Hadejia-Jama'are Basin

silt + clay sediments which is more than 15 cm thick to evolve a new fadama land at least 1200 ha and already shown to be richer than the upland soils (Olofin, 1991a). In this reach, this new land is an addition to the pre-dam fadama land which could still be irrigated, although with artificial fertilization.

It is regrettable that such optimum perennial discharge is not maintained downstream of other dams in the region. Indeed, the water maintained downstream of the Tiga has not been sufficient to generate similar positive changes further downstream, say in the Hadejia area. In short, the gains in the creation of new fadamas are far short of the losses. These losses have some socioeconomic consequences not the least of which are: the loss of fadama land by some peasants who are usually forced to change their mode of production or migrate to urban centres; the reduction in the number and size of plots in respect of lucky ones who are still able to continue; the encroachment on pre-dam uncultivable fadama which are generally sufficiently drained for irrigation and the concomitant conflicts with the pastoralists which seem to multiply geometrically. For example, in a survey involving 389 farmers in Jakara and Warwade areas in 1987/88, Main (1988) found that the number of fadama plots per participating farmer decreased from a pre-dam 3.5 to a post-dam 0.1, while fadama land as a percentage of total cultivated land decreased from a pre-dam 56% to a post-dam 4%, and 85% of the total land lost was fadama land. Further, 57 respondents with an average of two plots pre-dam lost their plots completely and had to migrate to Kano metropolis to seek other occupations.

5.3.2 Large-scale Irrigation: Successes And Failures

Large-scale irrigation has produced a mixture of successes and failures. In the more successful ones such as the Kano River Project, the establishment of large-scale irrigation has increased the total production of particularly tomatoes, wheat, maize and rice, allowed for double cropping, increased farmers' income and achieved some measure of import substitution and improved the Gross National Product. In other words the projects have brought some gains (Olofin, 1992). Whether or not such gains have been cost effective in terms of the net national income is best left to the imagination. Where such projects have not achieved much success, such as the South Chad Irrigation Project and the Bakolori Irrigation scheme, large-scale irrigation has become a national waste-paper basket, justifying the criticism of researchers. In all cases, large-scale irrigation and its concomitant dam have led to the dispossession of peasants of their land, unsatisfactory resettlement schemes, and/or inadequate and delayed compensation (Jega, 1987); all of which have resulted in serious resentment, lack of cooperation, or outright revolt (as in the case of Bakolori 1980) on the part of the peasantry against the authority. In the face of such failures, rural urban migration has increased and many peasants have abandoned farming for other city jobs (Main, 1988 and Olofin, 1991b). Indeed, such large-scale projects have encouraged expropriation of land by the State, capitalization of holdings by a few rich farmers, commercialization of production, gross inequality in the project areas as a result of unequal access to inputs, finance and other means of production, and the emergence of absentee land owners. The peasant finds that he has become a hired hand to till his erstwhile farm.

Compounding the problem is the realization that large-scale irrigation with its over-dependence on agro-chemicals, is not kind to the land itself. Incidence of waterlogging, the removal of the fine soil particles, and a gradual but sure accumulation of certain salts are reported from several irrigated fields (Alonge, 1985;

Daniel, 1985 and Kodiya, 1988). More recently, Essiet (1990) has shown that between 1974 (before irrigation) and 1988 (after thirteen years of irrigation) the clay content of the soils in the irrigated fields decreased from 16% to 10% while the silt content decreased from 13 to 10%. Over the same period the exchangeable potassium (K) increased from 0.08 me per 100g to 0.90, exchangeable sodium (Na) from 0.1 to 0.43 and exchangeable Calcium plus Magnesium (Ca + Mg) from 5.16 to 7.22. Also total phosphorous increased from 40.0 ppm to 273.5 ppm while available phosphorous increased from 20.0 to 59.7 ppm. Although the levels of these elements are not critical, except those of silt and clay, the trend should be of concern for the future; especially when it is reported by the same author that between 1977 and 1990 silt and clay fractions, exchangeable Na and Ca + Mg in the soils of the un-irrigated tracts under small-holder rainfed cultivation within the same project area remained virtually unaltered, while exchangeable K actually decreased from 0.1 to 0.06.

5.3.3 Initial Management Response

Faced with these unfavourable effects (or pains) of large-scale irrigation and dam construction, it was easy for researchers to condemn such projects and advocate for small-scale ones as mentioned earlier. The argument was that improved numerous small-scale projects would yield the benefits of a few large-scale ones without the problems of the latter.

So the World Bank listened and brought the necessary funds and the ADPs multiplied. That of Kano/Jigawa known as Kano State Agricultural and Rural Development Authority (KNARDA) and its supply company (KASCO) provide a good case study to measure the performance of the ADPs. KNARDA financed by the World Bank and assisted by KASCO went about drilling tubewells and washbores, supplying, at an initially subsidized price, diesel and, later, petrol water pumps for lifting water, providing tractor hiring services, supplying improved (dressed) seeds, herbicides and chemical fertilizers. For example,in the extensive abandoned Hadejia floodplains, tubewells fitted with hand pumps provide water directly to plots in which they are sunk within the old channel beds, but through connecting hoses and petrol pumps to basins on higher meander terraces. It must be stated that the first set of water pumps were diesel types which proved very unsuccessful. Later the petrol pumps were introduced which have proved more effective, but getting out of the reach of the small-scale operator. Kimmage & Falola (1991) have reported that between 1983 and 1989, 1773 tubewells and 3111 washbores were sunk by the Kano State Agricultural and Rural Development Authority (KNARDA) in the Hadejia-Nguru floodplain, while the Kano Agricultural Supply Company (KASCO) sold about 44,582 3-cm petrol pumps to the farmers. The extent to which these pumps were adopted is illustrated by the fact that the supply by the KASCO represented only 54% of the pumps in use during the field survey in 1989.In another survey conducted in the Jakara area by Mr. N. A. Oyeniyi of the Geography Department, Bayero University, Kano in 1989 (Olofin, 1991b), wheat had become the most important crop in the fadamas and 95% of the 250 small-scale irrigators interviewed grew the crop in that irrigation season. This emphasis on wheat is confirmed by Kimmage & Falola (1991) in their own survey in the Hadejia-Nguru floodplain in the same season. Further, mixed cropping and relay cropping have been phased out in many areas as wheat has become the mono-crop over large areas.

The success within the first few years was sufficient cause for celebration in many quarters. But the ovation did not last long. First, as stated above, the dams have reduced the extent of fadama land while the new incentives encouraged the clearing of larger tracts -- usually the former preserves of pastoralists -- for cultivation. Secondly, policy issues substituted new crops such as wheat and maize for the traditional ones. And finally, there emerged an unequal access to inputs, finance and other means of production. Thus, the self-same problems of the large-scale projects soon appeared in the "modernized" small-scale fadama cultivation. Land expropriation, dispossession of peasants of their land, capitalization of holdings, commercialization of production, and social inequality have been reported under the improved small-scale system (Kimmage & Falola, 1991, and Olofin, 1991b). In addition are escalated pastoralist-cultivator conflicts (Hadejia 1991, and Kawuwa, 1991) and the overpumping of the groundwater in the areas of operation, leading to a progressive drying out of the fadamas. Indeed, the objectives and proposed mode of operation of FACU (Umar & Tyem, 1993) would most likely compound some of these problems rather than solve them.

5.4 AGGRAVATING FACTORS

It is appropriate to pause and ask: why are both systems performing less than expected? Some of the factors working against an acceptable measure of success in the operation of large- and small-scale irrigation are implied in the discussion above.

One of such factors is the poor management of reservoir water which denies areas downstream of adequate discharge. Except for the case of Tiga Dam where water is released into the natural channel as described earlier, none of the other dams serve downstream reaches with water. Thus such reaches are fixed permanently in an erosion phase and the fadama land along them are left high and dry. Further, it is such impoundment in the headstreams of rivers discharging into Lake Chad that is partially responsible for the drying up of the lake and the failure of the SCIP based on it. The claim that it is the current prolonged droughts that is the culprit is not stating the full truth.

A second constraining factor is the poor, inadequate and at times complete absence of feasibility studies for most of the projects, and the omission of environmental impact assessment for such projects. Most of the undesirable side effects are usually unexpected. Consequently, there are no contingent measures to tackle them when they emerge, resulting in crisis management rather than risk management. This inadequate knowledge of the variables involved in the projects is compounded by lack of post-implementation monitoring and periodic post-implementation evaluation of the projects. In many cases, it takes studies by academics in search of higher degrees, or materials for journal articles, to discover some of the set-backs. This factor is summed up by Umar & Tyem (1993) as weak agricultural services, especially national research. Another aspect of the lack of adequate knowledge is poor coordination among development agents such as the RBDAs, ADPs, NALDA, and FACU to mention a few. The result is that a measure of success achieved in one part of a basin may spell doom for efforts in another part (e.g. the case of SCIP stated above).

A third factor is the introduction of technologies which are beyond the ready understanding of the participating farmers and, particularly, without adequate back-up maintenance facilities including spare parts, trained technicians and so on. This constraint is contributive to the failure of the petrol water pumps; the inability of tractors, harvesters and other farm machineries for large-scale operations to perform when they are needed most; and the wrong application of fertilizers and other agro-chemicals by farmers who only understand that "the more the better".

The procedure usually followed to formulate some of the policies including those informing the introduction of new technologies constitute the fourth constraining factor. In general, agricultural policy formulation since the colonial days till now has followed the top-to-bottom (top-down) approach where the experience and perception of the participants are not considered. Resenting participants are usually forced, rather than be persuaded to adopt such policies some of which alienate such peasants. For example, farmers who resent planting certain crops in the Kano River Project either leave plots ear-marked for such crops fallow, or rent out the plots to eager commercial cultivators (field experience). The process of outright sale of holdings starts that way.

A fifth constraint is what Umar & Tyem (1993) have listed as imperfections in the rural finance market which has limited access to institutional credits. The argument here is that the main problem is not a complete lack of credit facilities, but the creation of artificial scarcity which has resulted in unequal access to available credits. The rural farmer loses out while the city, big-time, absentee farmer smiles all the way home with an agricultural loan which he either diverts to other uses, or utilizes to buy off the rural farmer from the land. The same unequal access is experienced in inputs and extension services both for the large- and the small-scale projects, with an increasing concentration of means of production in very few powerful hands who fleece the actual farmers through expensive hiring services. For example, quite a number of non-farming businessmen in Kano own petrol water pumps which they rent out to willing (poor) farmers (field experience). It must be this unequal access to credits, technology and inputs that Umar & Tyem (1993) list as 'inefficient input procurement and distribution system, especially for fertilizer and seeds'.

A sixth factor is poor farm management characterized by over-dependence on chemical fertilizers to the neglect of organic manuring, annual or twice-a-year heavy tillage and uneconomic use of irrigation water. Such poor farm management has resulted in the depletion of soil nutrient, the removal of fine soil particles from the top layer, waterlogging and the accumulation of salts in irrigated areas, both large and small.

Compounding all the factors identified above is a nebulous, but very effective factor usually referred to as the "Nigerian Factor". This factor consists of a heavy load of constraints such as corruption, nepotism, sectionalism, bribery, falsehood and so on; all of which render the "truth" useless and dangerous, and make project-implementors pursue the unreal. This is the bane of the failure of both the large- and small-scale projects in this country. For example, although the SCIP has virtually stopped except for a couple of hundred hectares since 1983, official pronouncements state that the scheme is doing well, and that it was only marginally affected by the recent droughts. Also, a visit to the Bakolori Project would show that the elaborate hydro-power station has become a museum piece, the diesel back-up in shambles and only the national electricity grid supplies a limited amount of power that runs a negligible part of the sprinklers. A larger area, but drastically below the official claims, is under gravity irrigation which was not the major emphasis for the project. While some of the factors listed above may be responsible for the initial failure of these two cases, the Nigerian penchant for side-tracking the truth is responsible for perpetuating the problem, and making it impossible to adjust each project to suit known realities.

5.5 WHICH WAY THEN?

From our survey, it is clear that neither of the two systems is working well, but we cannot abandon irrigation since it has its advantages. Such advantages should be cultivated, while the problems should be avoided, or minimized. To this end, the factors listed above must be removed, or reversed in each of large- and small-scale project. For example, reservoir water should be managed such that perennial flows are maintained in natural channels below the dams; continuous monitoring of soil and water in irrigated fields must be taken seriously, and the results from such studies used to take appropriate steps to safeguard the quality of both soil and water; whole-basin approach and comprehensive feasibility studies should be undertaken with accurate environmental impact assessment before projects (large or small) are undertaken; policy formulation should benefit from grass-root contribution; while the participating peasants should have priority access to facilities, credit and inputs. Farm management practices should be improved and indiscriminate introduction of exotic technology should be curtailed. For example, there is a need to teach efficient water utilization in all irrigation projects, to facilitate organic manuring and reworking of part of farm residues into the soils, to practise minimum, or infrequent tillage and to adopt other conservational techniques. The greatest task, however, will be scaling over the hurdle of the "Nigerian Factor".

5.6 CONCLUSION

To save the age-long sustainable small-holder irrigation from destruction, the construction of dams and uncontrolled modernization of fadama development must be given a hard look. Similarly, to get the best out of the large-scale irrigation projects the measures enumerated above must be taken. Unless these measures are taken, and promptly too, it may soon be found that the construction of dams for large-scale irrigation helps to transfer the problems associated with such large-scale projects to the fadama cultivation, and make irrigation an unworthy venture in the country. Yet the country needs both the large- and the small-scale projects, but in appropriate dimensions.

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Small scale systems / irrigated farming

6. ADP Experiences With Fadama Development: Achievements, Problems and Prospects

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6.1 INTRODUCTION

The introduction of irrigation in the Agricultural Development Project (ADP) system dates back to the late seventies. Initial involvement of the ADPs in fadama development focused on upland water conservation through the controlling of surface runoff in the wet season and included the provision of measures for improving the total soil infiltration and storage capacity. The Bida enclave ADP made very good impact on the farming community and increased production by developing and using some of the fadama. The approach was mainly through informal irrigation systems which is cost-effective and unlike formal irrigation schemes do not involve a large budget for providing extensive irrigation structures such as dams,pump houses, canals with water distribution and drainage systems.

Bida ADP developed simple irrigation schemes in fadama areas using controlled flooding by constructing water control structures, head dykes, two peripheral canals and a drain in the middle. Full farmers' participation was ensured in the design, construction, operation and maintenance of these schemes. Fifty percent of these schemes were constructed for year-round irrigated agriculture, with most farmers producing rice especially during the wet season.

In Kano, Bauchi and Sokoto ADPs, irrigation in fadama started with bunding and impounding runoff, using residual moisture to produce a second crop and supplying farmers with 3" diesel pumps and hand pumps procured through the Farmers' Supply Company. This approach effectively replaced the existing shaduf, and served areas that could not be covered by the River Basin Projects.

The technical experts on these projects carried out investigations in 1982 to ascertain the existence of suitable shallow aquifers beneath the flood plains and established appropriate technologies for exploiting same. The low cost drilling technology and irrigation by small portable petrol engine pumps were thus introduced. The 3" diesel engine pumps and the low lift hand pumps were replaced by 2" and 3" petrol engine pumps keeping in view the portability, convenience, ease of operation and maintenance aspects. Provision was then made for a similar type of development in

Borno, Kaduna, Katsina, MSADP II* (Multi-State, ADP) States and redesign of MSADP I. Provision was made for pilot irrigation schemes in MSADP III States.

6.2 POTENTIALS FOR FADAMA DEVELOPMENT

Fadama lands are of significant occurrence along the Niger, Sokoto - Rima, Yobe and Benue river systems. These flood plains vary in width but are underlain at varying depths by extensive aquifers which are hydraulically connected to various river systems and, therefore, are largely rechargeable. Existing data, based on reports prepared by Water Resources Consultants who worked for various ADPs, show that about 3.5 million ha of Nigeria's landmass are fadama lands out of which some 2 million ha can be put under small scale irrigation. These have been classified as irrigable fadama. Fadama areas classified as having potentials for full development have either perennial streams or rivers in their proximity and/or shallow ground water that can be exploited by simple technologies of drilling and washboring. A summary of this data is presented in table 6.1:

Table 6.1: Potential fadama lands in ADPs where studies have already been conducted

State	Available fadama land (ha)	Potential (irrigable) fadama (ha)	Area by washbores and tubewells (ha)	Area by direct pumping (ha)
Borno	489,300	489,300	277,620	211,680
Yobe	362,000	362,000	205,392	156,608
Plateau	166,000	158,000	70,000	88,000
Kwara/Kogi	255,700	255,700	218,600	37,100
Kano/Jigawa	163,000	132,700	26,000	106,000
Sokoto/Kebbi	400,000	164,000	140,000	24,000
Bauchi	235,000	181,000	71,000	110,000
Katsina	46,000	40,000	12,150	27,850
Niger	110,000	Studies are underway to classify these		
Adamawa/Taraba	995,000	statistics		
Benue	298,000			
TOTAL	3,520,000	1,782,000	1,020,762	761,238

Source: 1: Staff Appraisal Report, National Fadama Development Project, 1992
2: Groundwater studies of respective states

* MSADP I States consist of: Abia, Akwa-Ibom, Anambra, Benue, Cross-River, Delta, Edo, Enugu, Imo, Ogun and Plateau.
MSADP II are: Adamawa, Kwara, Kogi, Niger and Taraba
MSADP III are: Lagos, Ondo, Osun, Oyo and Rivers

6.3 ACHIEVEMENTS SO FAR

Because of the role played by the ADP system, every state of this country has come to accept the fact that irrigation is potentially viable and necessary in all agro-ecological zones of Nigeria. Closely related to this is the observed participation of farmers from all parts of the country in profit-oriented irrigated agriculture.Furthermore, in close liaison with the Federal Agricultural Coordinating Unit (FACU), a simple technology for exploiting shallow groundwater by tubewell drilling has been widely disseminated by the ADPs and adopted by the farmers. The 2" and 3" petrol engine driven pumps often used for constructing washbores are also used in pumping water for irrigation purposes from these wells in addition to their uses in direct pumping from surface water sources.

ADP achievements can also be discussed in quantitative terms. It is on record that prior to the involvement of the ADPs in fadama development in 1985 about 20,000 ha were under annual irrigation using the traditional system. Table 6.2 shows the hectarages developed as at the end of 1992, categorized in terms of areas cultivated based on lift irrigation by direct pumping, areas developed using shallow groundwater from tubewells and washbores, and parcels of fadama land put under irrigated cropping as a result of successful stream diversion and controlled flooding projects undertaken by some ADPs. The figures in the table show clearly the commendable efforts of the ADPs.

Table 6.2: Irrigated area and washbores/tubewells drilled in Middle and Northern zone states of ADP system (1985 - 92)[1]

State	Washbores and tubewells (ha)	Lift irrigation by direct pumping (ha)	Diversion flood control and other methods (ha)	Total (ha)
Bauchi	5,200	17,000	1,000	23,200
Benue	20	2,000	500	2,520
Borno	1,550	17,500	3,050	22,100
Gongola	200	1,300	2,000	3,500
Kaduna	400	13,000	0*	13,400
Kano	5,700	56,000	4,000	65,700
Katsina	250	500	0	750
Kwara	100	400	0	500
Niger	10	2,500	5,950	8,460
Plateau	290	11,800	1,000	13,090
Sokoto	6,300	19,000	500	25,800
TOTAL	20,020	141,000	18,000	179,020

[1] Data prior to the creation of new states in 1991

* Zero means the area under that particular type of irrigation is neglibile

6.4 PROBLEMS FACED IN FADAMA DEVELOPMENT

A comparison of the fadama potentials and the area actually under cultivation shows that about 90% of this resource remains undeveloped. In spite of the remarkable achievements of the ADPs several obstacles have had to be faced. A major constraint to fadama small scale irrigation development is the funds to meet the cost of irrigation equipment and infrastructure (such as pumps, tubewells, washbores, stream diversion modules) and other exigencies of irrigated agriculture.

6.4.1 Land Preparation

Fadama soils are usually of the heavy clay type. Tractors which are ideal for land preparation (ploughing and harrowing) are inadequate. Farmers are increasingly finding it difficult to expand their plots based on manual land preparation; neither can they afford the high charges for tractor services. Even where they can afford such services, timeliness of operation is affected and in most cases the available tractor hiring services cannot cope with the demand of the farmers.

6.4.2 Conflicting Uses of Fadama

Conflict between users of fadama for irrigation purposes in the dry season and pastoralists who find it ideal to graze in the same areas during this period is a social problem which needs to be addressed.

6.4.3 Inadequacy of Qualified Personnel

Another problem that is being faced in developing fadama is the scarcity of experienced and skilled manpower in areas of irrigation. The anticipated irrigation technology transfer from FACU/ADP staff to the farmers will not happen satisfactorily if those who are given the responsibility are ill-equipped technically or would not stay long enough on the assignments to ensure effective acquisition of knowledge and skills by farmers and village level workers in irrigation management. Critical areas for technology transfer in irrigation include (a) tubewell drilling (b) improved tillage technologies (c) irrigation water management and (d) improved crop management.

6.4.4 Marketing System

Inefficient input procurement and distribution systems especially for fertilizers and seeds also constitute a problem. Similarly, post-harvest handling of irrigation produce in terms of storage, processing and marketing is poorly organized and may constitute a serious bottleneck to the expansion of fadama development in the country.

6.5 FUTURE PROSPECTS

With these constraints, in mind, and having realized that small- scale irrigation in fadama could be a key to agricultural growth in the Northern States, FACU prepared a Fadama Development Projects proposal for external funding by the World Bank. The project covers the States of Bauchi, Kano, Jigawa, Sokoto and Kebbi.The project, known as the National Fadama Development Project (NFDP) has since received the blessing of the World Bank and its implementation is already effective for the concerned states.There is provision for a facility to fund fadama development in other ADPs, though the available funds can not cater for the irrigation needs of the entire country.

It may be mentioned that the NFDP aims at accelerating the pace of fadama development by:

i) improving infrastructure, especially roads into and within the fadama lands;

ii) improving irrigation management;

iii) using improved but simple technology for shallow tubewell construction; and

iv) privatizing drilling activities and building the capacity of state and federal institutions to support the project.

The National Fadama Development Project supports private production but participating farmers are organized into Fadama Users' Associations to facilitate credit sourcing, loan administration and recovery. NFDP looks quite promising because: it guarantees autonomy of management by each farmer; technologies applied are simple and the low cost of owning and operating a scheme makes it widely acceptable.

6.6 RESEARCH PRIORITIES

Based on FACU's experiences in the operation of the ADP system, it is possible to isolate areas of research which are essential to the improvement of the technical and managerial factors that contribute to improved irrigation services, cost reduction; efficacy of farmer management; as well as financial and environmental sustainability.These areas, broadly categorized would include but will not be limited to:

a) Irrigation technology development;

b) Crop Agronomy in irrigated fields;

c) Water Management;

d) Economics/marketing of irrigated crops;

e) Institutional: issues of agricultural and sector policy; and

f) Environmental protection/conservation.

Areas of research could include: development of simple, economical and widely useable shallow groundwater drilling equipment, new techniques for aquifer recharging by introducing water in the depressional areas using existing dams, land preparation simplification in fadama, etc.

Date of planting, varietal selection and soil ferility management are agronomic issues which are still unresolved for a number of crops grown under irrigation in Nigeria.

Research on alternative irrigation scheduling techniques to improve water use efficiency would also be important. Furrthermore, research in salinity and erosion control in irrigated fields has not been adequately covered.

Cost-benefit analysis of small scale irrigation, storage/prservation and processing of irrigation produce, credit sourcing and administration, marketing channels and infrastructure also constitute critical areas of research.

Of recent, environmental quality mainteenance has been receiving prominence particularly in water resources development.

Disturbance of ecological set-up, wildlife displacement, breeding of disease-carrying molluscs, mosquitoes, etc. have been pointed out as threats to the environment. How true these are and to what extent they affect agriculture and irrigation development need to be ascertained through reseach.

Finally, stability of agricultural policies affect both internal and external financing. Sector policies on livestock, fisheries and agro-forestry for example, have to relate to irrigated agriculture; this way a mutual linkage can be developed and applied. As it is now, fadama holdings are heavily fragmented, implying a need for a policy on land consolidation. The feasibility of such a land reform exercise would require to be studied. It is the practice under the ADP system that recommendations generated by research institutes and universities are tested and proven through trials on farmers' fields with full farmer involvement before they can be considered suitable for general dissemination. Such on-farm adaptive research would have to be extended to irrigated agriculture. The modalities for adaptive research on irrigated lands are yet to be fine-tuned.

6.7 SUMMARY AND CONCLUSION

It was argued that one path for national agricultural growth in Nigeria lies in the approach adapted by ADPs in fadama development - the small scale approach. Although achievements recorded so far may not be significant, the foundation laid is quite reassuring. Thus in the not-too-distant future, mass participation of small holder farmers in fadama development could be a reality.

Major obstacles to small scale irrigation in fadama lands were highlighted but they are certainly surmountable. The paper points to the needed research priorities in small scale irrigated agriculture as a means to solving some identified major constraints to fadama development.The need for private sector participation in fadama development cannot be over-emphasized. In this regard, ADPs already in NFDP have pioneered the involvement of private contractors in tubewell drilling and washboring. In the years ahead, private sector investments in actual production in fadama lands would be a welcome complement to efforts of the Government.

Finally, the authors are of the opinion that real prospects for agricultural development lie in the ability of Nigerian farmers having two or three cropping seasons a year where only one existed before; as well as in ensuring that seasonal shortfalls in rains do not reduce crop yields.

6.8 REFERENCE

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7. Preliminary Indications of Research Needs for Improved Irrigation Management of River Basin Development AuthorityProjects in Nigeria

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7.1 INTRODUCTION

In order to identify the general trend of research needs of the River Basin Development Authorities (RBDAs) projects, questionnaires were distributed to the 11 RBDAs. At the end of the preparation of this short report, 6 questionnaires were returned to the researchers. They are grateful to those Managing Directors who have taken time to fill in the valuable information about the RBDAs.

The questionnaires were divided into eight different components. These components are interrelated and interdependent for better performance and management of irrigation systems. These components are:

a. Performance improvement of irrigation systems,

b. Management of water resources at regional level,

c. Socio-economic aspects of RBDA projects,

d. Organizational improvement activities,

e. Farmer participation in irrigation management,

f. Interaction with Research Institutions, and

g. Research priority list

It is not claimed here that all the answers have been found for the problems and issues encountered by these RBDAs. This presentation based on the questionnaires returned is only a humble attempt to present the trend at the RBDAs in those interdependent and interrelated components.

7.2 ANALYSIS AND DISCUSSION OF THE RESPONSES FROM THE QUESTIONNAIRES

a. Performance Improvement of Irrigation Systems

Four (4) out of 6 RBDAs reported that they have monitoring systems in place. However, water measurement activity against the design capacity is reported only by 2 out of 6 RBDAs. Crop coverage survey is done by all RBDAs. The knowledge of productivity difference between head end and tail end is reported only by one RBDA out of 6. No substantial effort was undertaken to correct those differences between the head end and tail end of the system. This issue raised the question of equity, timely delivery of water and efficiency of the system.

In response to the question of under utilization of the system, the general reasons given include lack of funds, manpower shortage and poor response of the farmers.

In relation to performance improvement, a question was asked whether RBDAs have formulated indicators to evaluate the performance of their systems. Four out of 6 responded that no indicators have been prepared. One system suggested that it is using crop yields as one of the indicators to evaluate the performance of the system. However, caution is necessary when crop yield is taken as one of the indicators. Several complications are involved in crop yield surveys and their interpretations. Four out of 6 did not have socio-economic impact survey. Two of them indicated positive results of socio-economic impact surveys.

b. Management of Water Resources at Regional Level

Another set of questions posed by the questionnaire was in relation to the regional nature of RBDAs. In response to questions regarding regional plans for integrated management of water resources, three RBDAs suggested that they have integrated management of water resources. These three RBDAs have established mechanism for conflict resolution and resource utilization through coordination committees of relevant agencies and coordination with state agencies as well.

Water losses in irrigation systems is also identified as one of the major problems by five RBDAs. It is reported that the problem was prevented by the physical improvement of the system and enlightenment of the farmer about the utility of water.

c. Socio-economic aspects

The RBDAs are not only technical agencies, but they also have to perform several socio-economic activities as well. In this respect, attempts were made to find out the socio-economic activities of the RBDAs. Four out of 6 RBDAs responded that they have economists and social scientists among their staff. Four out of 6 mentioned that they undertake rigorous economic analysis before investment. Five out of 6 RBDAs indicated that they have consultants for such jobs. Three RBDAs reported that they have developed an in-house capacity for such socio-economic analysis.

d. Organizational Improvement

The improvement of any organization is and should be a continuous process. In this regard, a question was asked whether there has been any reorganization of the RBDA management structure after the introduction of commercialization and privatization policy. Five out of 6 reported that they underwent a reorganization process. When asked to identify three prominent areas where changes have taken place, they identified staff reorganization, change in the composition of the board and better service condition for the staff. Other changes made include project priority setting, giving autonomy to units, review of tariffs and strengthening of commercial services.

The commercialization and privatization policy involves the issue of resource mobilization. Questions were asked about the possibility of cost recovery in the system. Five out of 6 suggested that it is possible to have cost recovery. Only one out of 6 responded negatively. They were also asked whether their organization should be centralized in future. Three out of 6 expressed the belief that centralized system could be effective. Four out of 6 supported financial autonomy to individual systems whereas only one out of 6 moved in the direction of giving financial autonomy to individual systems.

e. Farmer Participation in Irrigation Management

The new reorganization of RBDAs and farmer participation in irrigation systems are closely related. Five out of 6 reported that they have been promoting farmer participation, and 3 out of 6 have Water Users Associations (WUAs) as well as units to look after such associations. Three RBDAs have yet to set up WUAs as well as the organizational support for them. Three RBDAs have given some maintenance responsibility to the WUAs while two out of 6 are trying to legitimize the activity of WUAs under the authority of RBDAs. Three RBDAs have not yet given any thought to legal status of WUAs. It is interesting to note that 5 out of 6 RBDAs reported that they have assigned staff to take care of WUA activities.

f. Interaction with Research Institutes

The improvement of irrigation systems takes place through interaction between the implementers and research institutes. Two questions were asked whether they have been utilizing the research results in improving the performance of their systems, and whether they have made requests to research institutes to investigate their problems.

Four out of 6 indicated that they have been using the research results of the research institutes and 4 out of 6 have made requests to the research institutes to investigate their problems. This trend is very encouraging.

g. Research Priority List

The list of research priorities supplied by the 6 RBDAs could be grouped into 6 headings as follows:

1. Biological:

Weed control and control of bird havoc.

2. Engineering:

Irrigation and Drainage needs in south eastern Nigeria.

Seepage and conveyance loss in water channels.

Water quality, salinity and water logging problems.

3. Management:

Land consolidation,

Preparation of farmers to cultivate wheat in early period of the season.

4. Technology:

Development of techniques for furrow irrigation in sandy terrain.

Development of low cost sprinkler system.

Low cost irrigation method.

Conversion of sprinkle irrigation to gravity system.

5. Irrigated Crops:

Development of export crops such as Ginger, Banana, etc.

Crop diversification.

Disease and pest control.

6. Soils:

Soil type analysis and determination of appropriate type of crops

Control over the degradation of the quality of soil, high water table impact on crop production.

3 CONCLUSION

This study and its findings have limitations. The report is based on the basis of a questionnaire. One could assume that there are biases both from the questionnaire formulators and from the respondents. Often times, responses are infuenced by the events of the particular moment.

The objective of administering the questionnaire was to find out only the trend in the rersearch needs of the RBDAs. No conclusive findings were obtained. Further verification of the trend would be useful to formulate strategies for further research activities in the RBDAs.

However, these preliminary results do indicate that there are several problems that need to be solved in the RBDA projects. Through well designed and executed research , these problems could be solved and this would lead to improved and sustained irrigated agricultural development.

APPENDIX 1: TABLES (7.1 - 7.6) OF RESPONSES TO THE 6 CATEGORIES OF QUESTIONS

Table 7.1: Performance improvement of irrigation systems

ITEMS	YES	NO
Do you have monitoring system?	4	2
System of measuring water against design capacity	2	4
Crop coverage survey	5	1
Knowledge of productivity difference between head end and tail end	1	3
Are measures taken for head- tail difference?	1	3
Reasons for under utilization	See text	See text
Indicators to evaluate the performance of the system formulated	1	4
Indicators used	1	4
Socio-economic Impact of the system	2	4

Source: RBDA Questionnaire Response, 1993

Table 7.2: Management of water resources at regional level

ITEM	YES	NO
Regional Plan for integrated management of Water Resources	3	3
Mechanism for conflict resolution exists	3	3
Irrigation Water loss problem	5	1
How have they been prevented?	See text	See text

Source: RBDA Questionnaire Response, 1993

Table 7.3. Socio-economic aspects

ITEM	YES	NO
Economist and Social Scientist as staff in the organization	4	2
Rigorous economic analysis before investment	4	1
Who does such analysis		
- consultant	5	1
- in- house staff	3	1
Socio-economic and other study prior project implementation	6	0

Source: RBDA Questionnaire Response, 1993

Table 7.4. Organizational improvement

ITEM	YES	NO
Reorganization after the introduction of commercialization and privatization policy	5	1
Three prominet changes		
- staff reorganization	6	0
- project priority/autonomy	2	-
- financial/strenghtening	3	-
- commercial service	2	-
Cost recovery in the system	5	1
Belief in centralized system	3	2
Cost recovery under centralized system	1	4
Financial autonomy to individual systems	4	2
Have efforts been made for financial autonomy?	1	4

Source: RBDA Questionnaire Response 1993
- means that the question was not answered

Table 7.5 Farmer participation in irrigation management

ITEM	YES	NO
Promotion of participatory irrigation management	5	1
Presence of WUA in RBDA	3	3
Unit for WUA in RBDA	3	3
Maintenance responsibility of channel to WUA (tertiary level)	3	3
Staff in charge to organize farmers	5	1
Legal status of WUA	2	3

Source: RBDA Questionnaire Response, 1993

Table 7.6. Interaction with Research Institutes

ITEM	YES	NO
Utilization of Research findings in improving the system management	4	2
Request to Research Institutes to investigate the problems	4	2

Source: RBDA Questionnaire Response, 1993.

APPENDIX 2: LIST OF RESPONDENT RBDAs

1. Benin - Owena River Basin Development Authority
2. Chad Basin Development Authority
3. Cross River Basin Development Authority
4. Hadejia-Jama'are River Basin Development Authority
5. Sokoto-Rima Basin Development Authority
6. Upper Benue River Basin Development Authority

Irrigated farming

8. Research and Extension in Irrigation Technology Development in Nigeria

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8.1. INTRODUCTION

The importance of irrigation in agriculture has long been appreciated in the Northern States.The contribution of irrigation as a complementary means of food and fibre production' cannot be over emphasized. Also irrigation provides employment to a great number of rural people during the traditionally idle period of the long dry season. The importance of irrigation is enhanced due to the potentiality of growing economically important cash crops such as vegetables and wheat during the dry season. Hence, irrigated agriculture is a critical component that can ensure Nigeria's food self-sufficiency.

In the early period, the various governments of Nigera, through the ministries of agriculture, constructed small earthen dams for irrigation development. In the 1970's, the Federal Government established River Basin Development Authorities (RBDAs). The National Fadama Development Project (NFDP) to be executed by the State Agriculture Development Projects (ADPs) is the latest attempt by the government to realize the nation's goal in irrigation development.

Against this background, this paper presents the role of research and extension in irrigation technology development, and also presents a priority setting technique based on the attributes of the technology package to be adopted. Reccommendations on how to improve irrigation development projects through revised research and extension strategies are made.

8.2 ROLE OF RESEARCH AND EXTENSION IN IRRIGATION TECHNOLOGY DEVELOPMENT.

If irrigation were only water storage, lifting, conveyance and distribution, then water supply companies and corporations (like the state public utility boards) should be the right organs to do so. The fact that many irrigation development projects in Nigeria start with huge water supply systems makes many people, including politicians, to place wrong emphasis on the water supply component of irrigation development, neglecting what happens to the water when it gets to the field (Agodzo,1991). This often leads to difficulties in management of such projects sometimes due to rivalries among certain groups of professionals and usually results in poor performance of irrigation systems. It is important to evolve effective irrigation reseasrch and extension processes for the development of appropriate technologies for irrigation farmers. There is a consesus that appropriate irrigation technologies that can be managed by the farmers are those which have certain attributes.These technologies are to be:

- simple and economically viable,

- technically sound,

- socially acceptable and consistent with the natural enviroment; and should have

- relative advantage over existing practices.

Irrigation research and technologies in themselves are useless in the Nigerian context if the developed technologies are not extended to farmers for adoption and use. However,the rural farmers must understand them in order to adopt and successfully use them. For this to happen, there is the need for effective teaching and education of the farmers by the extension units of the irrigation development schemes. Farmer-managed irrigation extension education in Nigeria should be the systematic methods of creating, transmitting and applying scientific knowledge to bring about positive change in the irrigation behaviour of farmers. This helps them to live a better life through learning better ways of water resource management for optimum food production.Irrigation extension education should not be concerned only with teaching and securing farmers adoption of a particular improved practice. It should bring change in total outlook of the farmers and encourage them to initiate activities for improving their farms to ensure higher productivity. Irrigation extension programmes can not only "take research results to farmers" and impart " knowledge and skill" but it can also influence the farmers to change their traditions and values associated with rainfed agriculture. Through irrigation, risk and uncertainties can be minimized from the minds of the farmers.

8.3. RECOMMENDED RESEARCH ACTIVITIES

In some parts of the country, water resources development in river basin have already overstreched the existing water resources. It is therefore necessary to simulate such systems on monthly, seasonal and annual time intervals in order to identify appropriate levels of utilization. This also helps to formulate water resources management options.Such options should include;

- setting limits to the annual rate of water resources impoundment,

- limiting the capacity of canal systems for water delivery,

- limiting irrigation canals and land levelling to reduce losses; and

- setting limits like pumping capacities designed to maintain the level of water table etc.

In other parts of the country, the problems are peculiar to the individual projects. The problems include drying up of the water sources; poor engineering designs, construction and supervision. In such cases, research should be geared towards:

- verifying aggreement or otherwise between the design and actual regime and water balance of reservoirs, and

- improving methods of computation and forecasting of the water regime and balance of the reservoirs capable of ensuring rational use of the head-works or the downstream areas.

The problems of the water and salt balance of irrigated land is of great concern. Due to unsuitable irrigation practice, unfavourable changes of salt balance and nutrients frequently occur. The consequence of this problem is that despite the completion of new irrigation schemes, the total irrigated area may not increase significantly because of salinization and other operational problems of the existing schemes. A reason for the salinization of the schemes lies in an insufficient study of the water and salt balance of the soils in the initial hydraulic designs while another is due to an insufficient study of the same balance under the influence of irrigation. There is, therefore, the need for efforts to be geared towards solving this problem (Soribe, 1992).

A number of states are already participating in the NFDP which is about to take off. Reports from some of the participating states have already indicated areas of potential problems that the project have to address for a successful tenure. In this regard, special attention should be paid to:

- base line data collection and information on the soils prior to the project take off.Continous soil and water analyses throughout the life of the project should be carried out,

- shallow ground water studies that will determine among other things, the storability and transmissibility of aquifers, water table fluctuations, and safe yield of the aquifers,

- development of alternative water lifting devices to be used in the fadamas, and

- promotion of improved soil and water management techniques in the irrigated fadamas.

8.4 SUMMARY AND CONCLUSION

This paper attempted to place irrigated agriculture in the proper context of the country's struggle for self-sufficiency in food production. The paper recognized the efforts of both the Federal Government and the World Bank in introducing the NFDP to some states and recommended proper research to make the project sustainable.

The paper finally observed the important role of extension in the irrigation sub-sector and recommended the strenghtening of the extension components of all the irrigation projects. For the irrigation sub-sector to achieve the desired success, the beneficiaries (farmers) should be involved right from the planning stage of most research activities.

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9. FIVE ENDURING IRRIGATION RESEARCH PRIORITIES FOR NIGERIA

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9.1 INTRODUCTION

It is hardly appreciated that development of irrigated agriculture in Nigeria dates back to pre-colonial time. Before the beginning of this century the shaduf system of irrigation practice prevailed in the Northern region of Nigeria. The first planned irrigation development dates back to 1908 when the colonial administration established the first experimental irrigation farm in Baro in Niger State. By 1925, the first formal irrigation project was developed in the then Sokoto Province but it was not until in 1963 with the advent of FAO studies that the establishment of institutional framework of RBDA's was first initiated (Nwa and Martins,1982).

There has not been sufficient progress in irrigation development in Nigeria after such a long period of practice. Nigeria is estimated to have about 226 billion cubic meters of surface water resources capable of irrigating 1.60 - 1.85 million hectares of farmland. In contrast, only about 11.7 million cubic meters representing less than 5% of the nations surface water potential has been harnessed. Similarly, of the estimated 3 million hectares of irrigable land, only a total of about 900,000 hectares are under irrigation today, representing about 30% of the nations irrigable potentials. Unfortunately the factual, even if unpalatable prediction of the World Bank/FAO that the third world, particularly Africa may not survive on rain-fed agricultural production beyond the year 2000 - keeps drawing uncomfortably nearer with each year that passes by.One of the main reasons advanced for the sorry state of our irrigation development inspite of many years of practice and huge financial investments, is the past inability to incorporate research as part of the irrigation development process. The purpose of this paper is to focus attention on what is considered to be the five enduring irrigation research priorities for Nigeria.

9.2 RESEARCH PRIORITIES

1. The first of these research priorities has to do with the view shared by many politicians, and economist from the point of view of this author that Nigeria requires an appropriate irrigation technology that is labour intensive to address the problem of high unemployment.

This simply does not appear to rhyme with the views held by our rural farmers. There may still be bullock carts, hand held farm implements and shaduf in our rural areas rather than tractors, but what powers our agricultural production effort are the ubiquitous petrol pumps in the tube wells on the banks of our perennial rivers and the irrigation farms in what is otherwise considered to be the arid area of the nation. What is being said here is that what is appropriate is quite simply what makes the economy's resources most productive. This requires a careful research to identify what is appropriate and what is sustainable (Musa,1991).

2. The second priority is also closely related to irrigation technology. It is the realization that capital resources are increasingly becoming scarce and new capital investment in irrigation development is gradually diminishing in real value. There is, therefore, the need to increase the productivity of the existing capital investment.

Afterall, performance is all about applying capital productively.It is important for all concerned to come to terms with the fact that our irrigation institutions and their managers are created and paid, respectively, to manage productivity especially the productivity of capital, on which in the last analysis, all the productivities depend.

3. The third research priority relates to irrigation systems efficiency: There is a need by our researchers to look into how to improve existing irrigation systems efficiency either by way of modernizing existing systems or developing new approaches to the design of new systems that are relevant to current and future needs. There is also the persistent problem of finding cost effective solutions to operational problems of irrigation. Efficient irrigation systems require provision of water in right quantities, of appropriate quality and applied at the right time, along with adequate and timely provision of improved seeds, fertilizer and other inputs for improved agricultural productivity.

Closely related to this is the issue of cost effectiveness of irrigation system. The input and output analysis of our irrigation activities has revealed that most irrigation farmers hardly make appreciable profit on their farming efforts. Although the factor responsible for this may be more related to economy of market forces, yet a general survey of irrigation farming activities have also revealed, that most crops being put under irrigation hardly attract enough returns on their investment.

4. The fourth research priority is that relating to end-users or beneficiaries of irrigation. Most of the time,research efforts at improving irrigation system efficiency are focused mainly on the structures, technology and environment rather than on the end users - the actual beneficiaries and operators of the irrigating facilities. If research efforts are to succeed it is believed that more attention needs to be paid to the farmers on the field. There is the need to fully understand their socio-cultural attitudes, values and idiosyncracies. Attitudes and cultural believes of farmers differ from one geographical location to another. The climatic and environmental conditions of farmers differ from one location to another and so are their values and priorities to crop production. All these need to be understood and put into perspective,if efforts are not to be wasted on developing irrigation culture and facilities on one geographical location that hardly needs it. The understanding of the users of irrigation will also assist in the search for appropriate technology.

5. The fifth research priority relates to environmental issues. Irrigation is among the most productive input for agricultural development. Irrigation can lead to a six-fold increase in root crops. It also increases the stability and efficiency of cropping systems and diminishes the risk of drought and desertification.

However the history of irrigation agriculture is loaded with setbacks. It triggers off changes in all the major ecosystems(soil,water and atmosphere). The ecological changes create conditions for foreign plant and insect species including vector diseases. Again interference with the hydrological cycle may cause underground flooding and water logging, with the deposition of salt, which in turn cause defects in the entire irrigation system. Irrigation is not only costly, it is also technically complex and requires skill and experience to realize full benefits.

Very often the negative effects of irrigation are related to wrong irrigation practice, lack of necessary social infrastructures and limited experience of field staff and the farmers. Farmers are the most critical resource on an irrigation projects, and it is, therefore, important for the irrigation agency not to ignore the farmers' health. One method of water born disease vector control has been the application of toxic chemical to the water bodies. This is expensive and dangerous to the environment and the result is likely to be limited.

It has however been acknowledged that engineering and environmental control measures have an important role to play during disease eradication. We however need to establish in Nigeria the extent to which disease transmission in, and around, irrigation projects resulting in human morbidity can be reduced by an agreed package of engineering and environmental control measures. It would be of interest to know the effects of modification of design through shoreline sheeping; improved outlets and bypass canals as well as the best operational changes such as periodic draining and water level fluctuations on environmental changes.

9.3. CONCLUSION

It is difficult to find all the solutions to the ongoing irrigation growth crisis in Nigeria. But it is fairly easy to at least prevent the reoccurrence of such a crisis. This can be done through comprehensive and concerted research efforts.

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10. Some Considerations In Developing Irrigation Research Priorities For Nigeria

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10.1 INTRODUCTION:

Irrigation may be defined as the application of water to the farm land to eliminate soil moisture deficiency that may make land preparation difficult or hinder optimum crop performance. The practice usually includes the development of the water resources and the conveyance systems, the distribution of the water supply at the field level and the necessary water management exercises to achieve the intended purpose (Fig.10.1). It is most profitable when judiciously operated in conjunction with other modern agronomic practices such as scientific application of soil amendments (fertilizers, lime,etc), herbicides and insecticides, soil conservation and land drainage practices.

10.2 THE NEED FOR IRRIGATION IN NIGERIA

As a developing country with an ever-increasing population, Nigeria is faced with the basic problem of how to produce food supply in sufficient quantity to satisfy domestic demands. Traditional farmers desire white-collar jobs for their children as a means of attaining higher standard of living. Drifting of the youth to State capitals and urban settlements has been on the increase following the creation of more States. It is now clear more than ever before that Nigerian agriculture must shift from peasant level to modern business. A necessary pre-requisite is to shift from rainfall-based to irrigation-based agriculture. In parts of the country that experience rainfall in what is usually considered sufficient amount to support crop production, rainfall frequently does not occur at the right time or in the right amount to satisfy crop water requirement for optimum performance. In addition to controlling the uncertainties of rainfall distribution, the development of appropriate irrigation technology for Nigerian agriculture offers the following benefits:

i). Increased crop yields: With optimum soil moisture condition at each stage of growth, crops yield their optimum if all other requirements are simultaneously satisfied.

ii). More than one cropping season a year: Most field crops that mature within 3 to 5 months may be cultivated two or three times a year in a properly programmed irrigated crop rotation practice under the Nigerian tropical climate (Chukwuma,1984).

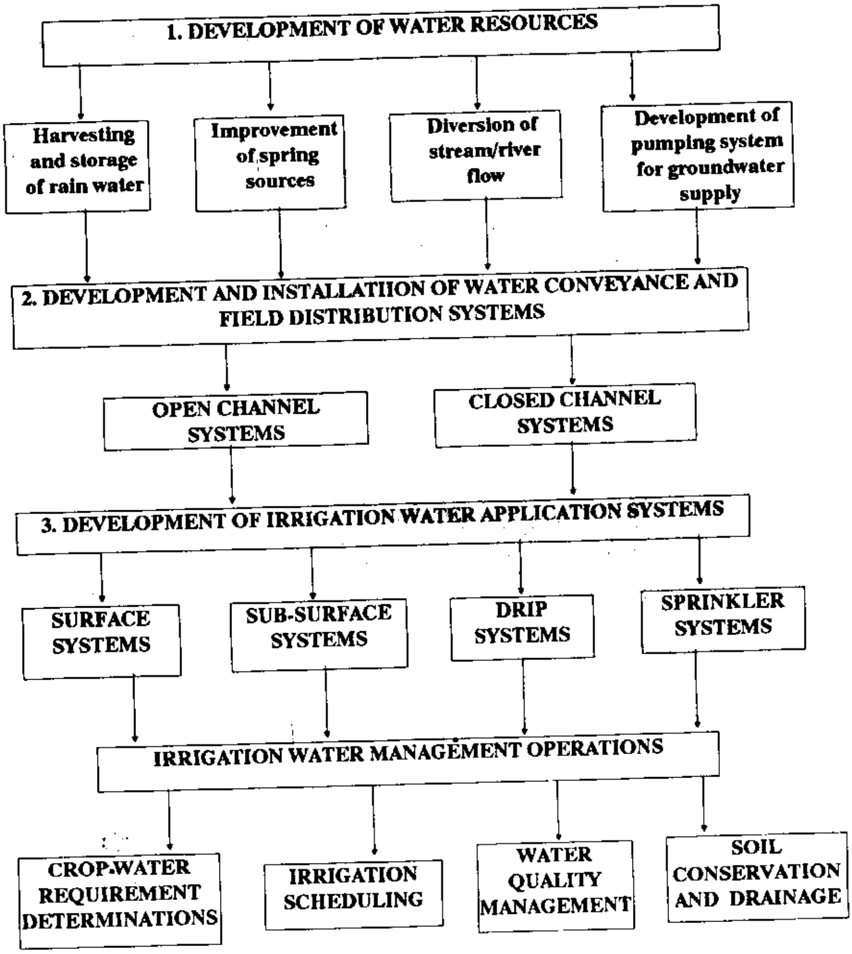

Fig. 10.1: Development and management operations in irrigation practice

iii).Minimize storage losses: Food products raised in the rainy season and stored over a long period for use all year round are subject to insect attacks and quality deterioration under most traditional storage techniques. As irrigation extends crop growing season the need for long term storage is eliminated.

iv) .Cut down Labour Cost: Rain fed agriculture subjects farmers to labour competition that tremendously raises labour charges. Irrigation spreads out labour requirement over the entire year, thus creating opportunity for year-round employment which makes labour charges more reasonable.

v).Improve and stabilize National Economy: Irrigation is a major component of the modern agronomic package that will enable Nigeria attain self-reliance in food production. Food importation will stop and food exportation will resume on a wider scale than before.

10.3 THE MOVE TO IRRIGATED AGRICULTURE IN NIGERIA:

For Nigeria to shift from a predominance of rain-fed agriculture to irrigated agriculture both the public and private sectors have very important roles to play. The development and management operations shown in Fig. 10.1 will require substantial financial backing from the Government, Industries and Philanthropists. Better coordination is required among research scientists. A two-way flow of ideas must be maintained between farmers in the field and research scientists in the laboratories through well-equipped extension service (Fig.10.2). Given the needed sponsorship, research scientists and/or the extension personnel will organize training programmes (Seminars, Workshops and field demonstrations in addition to formal education opportunities) for up-dating farmers with progress in irrigation research.

With the understanding of irrigation research as a leading component of the machinery that will move Nigerian agriculture from rain-fed to irrigated status, the presentation on research priorities is hereby made to stimulate discussion amongst interested parties.

10.4 RESEARCH PRIORITIES

10.4.1 Studies On Past And Present Irrigation Development Plans And Implementation Strategies:

There is an urgent need to review all efforts by the Government of Nigeria at various levels to introduce irrigation practices into Nigerian agriculture giving attention to the specific objectives in each case. Accurate information on the success so far realized and problems hindering anticipated success at different parts of the country may help justify the investment so far. It will also constitute a better background for further actions.

10.4.2. Land Classification And Development Studies

The total land area of Nigeria is said to be 941,849 sq.Km. About 75.3% of this land area has been considered good for cultivation (Popoola,1987). Arability classification of this land area will require studies on weather and soil requirements for the crops that will best grow on each land class, the suitability of which has to be graded. Irrigability classification considers the economics of irrigation on each piece of land in relation to available water resources and necessary management operations for optimum crop performance. Some of the information obtained through Land Classification studies may be useful in land development operations such as land grading or terracing.

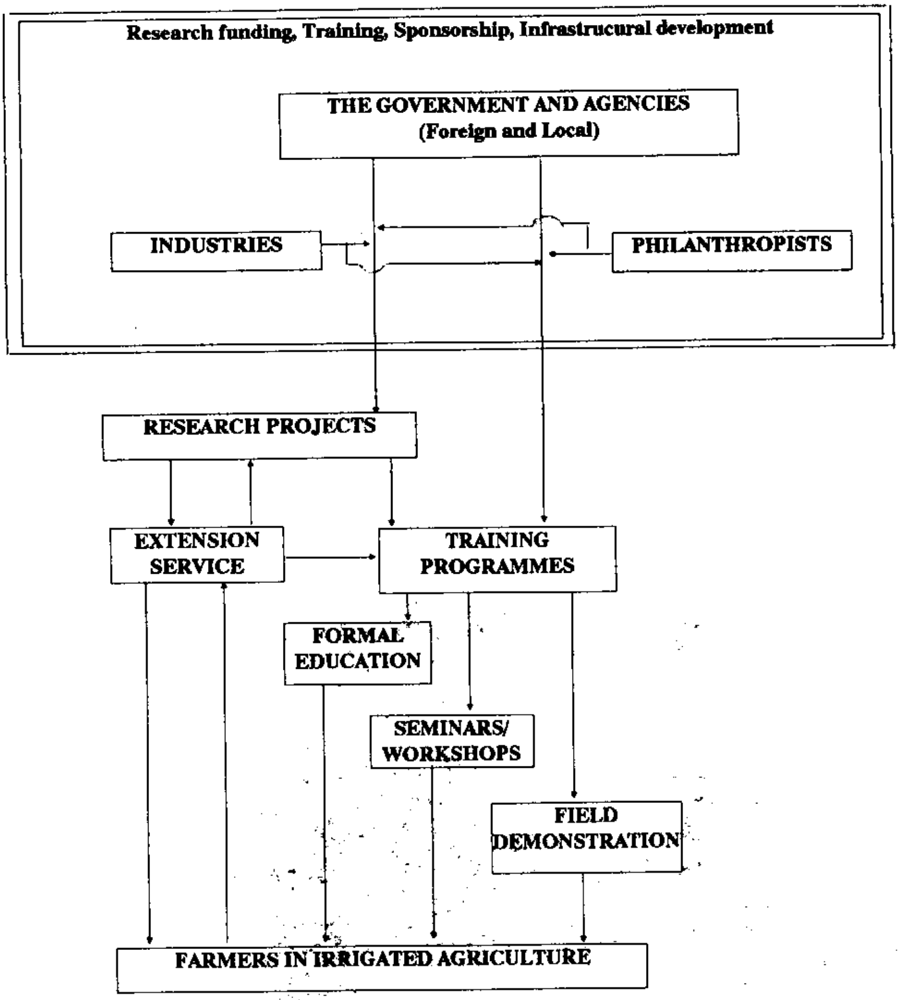

Fig. 10.2: Needed support and operations for moving from rain-fed to irrigated agriculture in Nigeria

10.4.3 Hydrologic Data Collection And Analysis

Lack of adequate and reliable hydrologic data in Nigeria calls for hydrological research studies to be aimed at improving the weather and water supply data base for selection, design and management of appropriate irrigation systems. Along this line, Agodzo (1988) emphasized the need for establishing suitable methodologies for collecting and analyzing hydrologic data. Weather variables such as solar radiation, temperature, relative humidity and wind speed influence crop water requirement, as well as evaporation loss from stored water surfaces. Setting up hydrologic research stations within the various ecological zones (Nwa, 1977) will facilitate:

i) The study of the effect of land use and soil conservation practices on the hydrology of watersheds and

ii) The development of appropriate hydrologic models for local conditions.

10.4.4 Water Resources Development Studies

Nigeria is endowed with abundant water supply by way of rain fall, surface and sub-surface water resources. Major achievement by the Government in developing the water resources of this country is the establishment of the River Basin Development Authorities. One of the objectives of these River Basin Development Authorities is to develop irrigation schemes for the production of crops and livestock and to lease the irrigation land to farmers or recognized associations in the locality of the area concerned (Nwa,1977). Idike (1987) proposed appropriate water resources system for small to medium scale irrigation applications; such systems will be supplemental to the gigantic projects the River Basin Development Authorities focused on from their inception. Data collection and analysis on resources will furnish reliable information for determining appropriate level of irrigation schemes to develop in each locality within the limits of other factors of production. An on-going Linkage Research Project between the Department of Agricultural Engineering, University of Nigeria Nsukka and the Centre for Irrigation Engineering, Catholic University Leuven, Belgium aims at studying the water potential and improving the water supply availability for domestic and small scale irrigation in south eastern Nigeria. This kind of study should be extended to other parts of the country and should be well coordinated. Some of the considerations in water resources development studies include

i)methods of harvesting and storing rain water,
ii)ways of improving spring sources
iii)techniques for river/stream flow diversion, and
iv)development of low cost pumping systems from local materials.

10.4.5 Studies On Irrigation Water Application Systems

The common methods of applying irrigation water in the field include the use of surface, sub-surface, drip or sprinkler systems. Studies on local soils will aim at developing design parameters for surface methods including border, basin and furrow methods. Drip and sprinkler irrigation systems can be developed locally through coordinated research studies.

10.4.6 Studies On Irrigation Water Management Operations

The problem of when and how much water to apply needs to be addressed locally in each ecological zone. Imported data on crop water requirement is meaningless when one considers variations in climate and soils. Studies like that of Sule and Yusuf (1988) on water management programmes for small scale irrigation need to be extend to other parts of the country. Studies on quality status of irrigation water sources in Nigeria (Okereke,1988) will reveal necessary management practices for sustaining high productivity levels.

10.4.7 Agronomic Studies

The challenge for research studies on irrigation in Nigeria draws attention to the following local crop groupings:

i) Cereals: Maize, Millet, acha, sorghum,rice, wheat.

ii) Grain Legumes: Cowpea, yam beans, soya beans, green peas, sword beans, lima beans, groundnuts

iii) Roots/Tubers: Cassava, Yam, Coco-Yam, Sweet potato, Irish potato

iv) Oil Seeds and nuts: Benniseed, dikanuts, walmit, sheanut, kolanuts, cashewnuts, melonseed, coconuts.

v) Fruits/Vegetables: Okra, pumpkin, onion, kafy vegetables, pineapple, avocado pear, banana, plantain, mango, oranges, lime, lemon, grape fruits, pepper, tomato.

vi) Cash crops: cotton, kenaf, sugar-cane, oil palm, coffee, rubber, tea.

Most of these crops have not experienced any form of irrigation at all in Nigeria. Irrigation studies on each of them in their suitable ecological zones will yield valuable information for irrigation systems design and water management.

10.4.8 Studies On Socio-economic Aspects Of Irrigation

A minimum level of education and health infrastructure is generally considered basic to durability of irrigation development projects. Sound social relations at the family level and within the larger community requires the observations of experts and recommendations even at the policy making level as well as all through the implementation strategies. Studies on the socio-economic background underlying all past and present efforts to develop Nigerian agriculture through irrigation schemes may throw some light on the level of success so far attained. It will also help in monitoring current exercises in pursuit of the objectives.

10.5 CONCLUSION:

Observing the need for a means of accelerating food production in Nigeria, irrigation as a major part of the modern agronomic package is considered in the light of the research priorities in Nigerian agriculture. This is intended to offer a sense of direction for illuminating discussion among interested parties.

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11. Aspects of Water Management in the Badeggi Rice Irrigation Scheme: Problems and Prospects

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11.1 INTRODUCTION

In operational terms, irrigation covers the task of finding, developing and distributing suitable water supplies to the soil to supplement the natural sources of water for crop production. In Nigeria, because of economic constraints and topography, most irrigation systems in the developed inland valley swamps are of the diversion type. The first irrigation scheme in Nigeria was built around Shella stream in 1929 but was later washed off by floods in 1946 (Singh and Maurya, 1979). In 1949 the Northern Regional Government established the first irrigation Division in Nigeria in the Ministry of Agriculture with responsibilities for development of small-scale irrigation schemes. At that time (and up till now) the Niger province (Niger state) was the largest producer of rice in the Federation. Therefore, in order to take advantage of the potential for rice cultivation in the province, a number of medium and small scale irrigation schemes were initiated in the early 1950's and the Badeggi Rice Irrigation Scheme was one of them (Table 11.1).

The Badeggi Rice Irrigation Scheme is located 12km East of Bida town in the River Gbako flood plains, which is one of the many tributaries of the River Niger which passes through the State. Irrigation water is supplied by gravity from headworks on River Musa to irrigate about 800ha of land. In 1978 engineering work started on the improvement of the drainage system and was continued from 1980 - 1983 by the World Bank assisted Niger State Agricultural Development Project. Government intention for initiating the scheme was that double cropping of rice would be encouraged, but since the inception of the scheme it has not been possible for the farmers to produce two rice crops a year. The objectives of this paper are to examine the problems and prospects of the rice scheme.

Table 11.1 Irrigation schemes in Niger State

Name of Scheme and LGA	Location	Gross Hectarage Planned	Water Source(s)	Area Under Cultivation (ha)
1. Edozighi (Gbako LGA)	Kaduna left bank flood plain, Wuya Bridge	1000	R. Kupanko R. Ejiko	920
2. Badeggi (Gbako LGA)	R. Gbako right bank flood plain east of Bida	880	R. Musa	690
3. Guzan (Lavun LGA)	Niger flood plain, west of Bida	1440	R. Yiko	80
4. Baba (Lavun LGA)	Niger flood plain, south of Mokwa	1000	R. Niger	72
5. Gbakogi (Gbako LGA)	Gbako/Niger flood plain	2800	R. Gbakogi	5
6. Edo-Lapai (Lapai LGA)	Niger Valley near Baro	920	R. Etswan	30
7. Tungan Kawo (Mariga LGA)	R. Kpabugi fadama	800	R. Kpabugi	Nil
8. Loguma (Agaie LGA)	Niger flood plain west of Baro	120	R. Emi	60
9. Toroko (Gbako LGA)	Tributary of R. Kaduna, north of Bida	80	R. Kanko	24
10. Wawu (Magama LGA)	Kainji Lake shore	40	Kainji Lake	-
11. Baratsu (Lavun LGA)	Right bank of R. Kaduna, west of Bida.	72	R. Ije	20
12. Sugar Estate, Sunti (Lavun LGA)	Niger valley, east of Mokwa	1600	R. Niger	Nil

Table 11.1 contd.

Name of Scheme and LGA	Location	Gross Hectarage Planned	Water Source(s)	Area Under Cultivation (ha)
	Small Schemes and Market Gardens			
13.Zara (Rafi LGA)	Near Pandogari North, Niger state	140	R. Mando and tributary	40
14. Lioji (Mariga LGA)	Tributary of R. Malendo	80	R. Lioji	40
15. Kuta (Chanchaga LGA)	South-west of Shiroro	70	R. Kuta	60
16. Lemu (Gbako LGA)	North of Bida, on Bida-Zungeru Road	1	Well	1
17.Chanchaga (Chanchaga LGA)	South of Minna	8	R. Chanchaga	8
18.Lanzu (Bida LGA	In Bida	6	R. Lanzu	6
19. Abuja (Abuja LGA)	East of Abuja town (Suleja)	6	R. Yiku	6
20.Masuga (Mariga LGA)	5 kms from Kontagora	-	-	-

Source: (Max Lock Group, 1980)

11.2 THE ENVIRONMENTAL SITUATION

11.2.1 CLIMATE

i. Rainfall:

Among the climatic elements in the area of the irrigation scheme, rainfall shows more annual fluctuations than any other climatic factor. Although most of the rainfall is from April to October, the rivers which feed the irrigation scheme are still flooded past the main rainfall months. This is because of the porous nature of the geologic formation (Cretaceous sandstones) on which these rivers flow. Often the peak of the rainfall is in the months of August and September preceded by an earlier smaller peak in the month of June (Fig. 11.1). The annual rainfall averages 1129.9mm (1956- 1992). Generally the months of November to March have no rainfall.

ii. Temperature:

The temperature range more than any other factor is very consistent over the years during the period from January until the onset of the rains. Both daily maximum and minimum temperatures rise to their annual peak just before the beginning of the rains. During the rainy season, daily maximum temperature drops to its lowest level of 28°C about August, but the drop in minimum temperature is negligible. Both the maximum and minimum temperatures continue to ascent gradually until the rise after January. The effect of these temperature conditions have not been assessed in this area, but Best (1959) reported that optimum temperature for grain yield is between 29°C to 32°C, although higher temperature of 37° generally accelerate the growth and heading for rice, they have been found to decrease grain yields.

iii. Relative Humidity:

In the dry months of November to March, the relative humidity is lowest in February although decreases appear in November and continue to the harmattan months of December and January. The relative humidity is high during the rainy season between May and September rising to more than 80% in August.

iv. Solar Radiation:

The trend of the solar radiation follows closely that of the air temperature. It is lowest during the month of heaviest rainfall (27gm - cal, cm in August) when the sky is overcast with clouds.

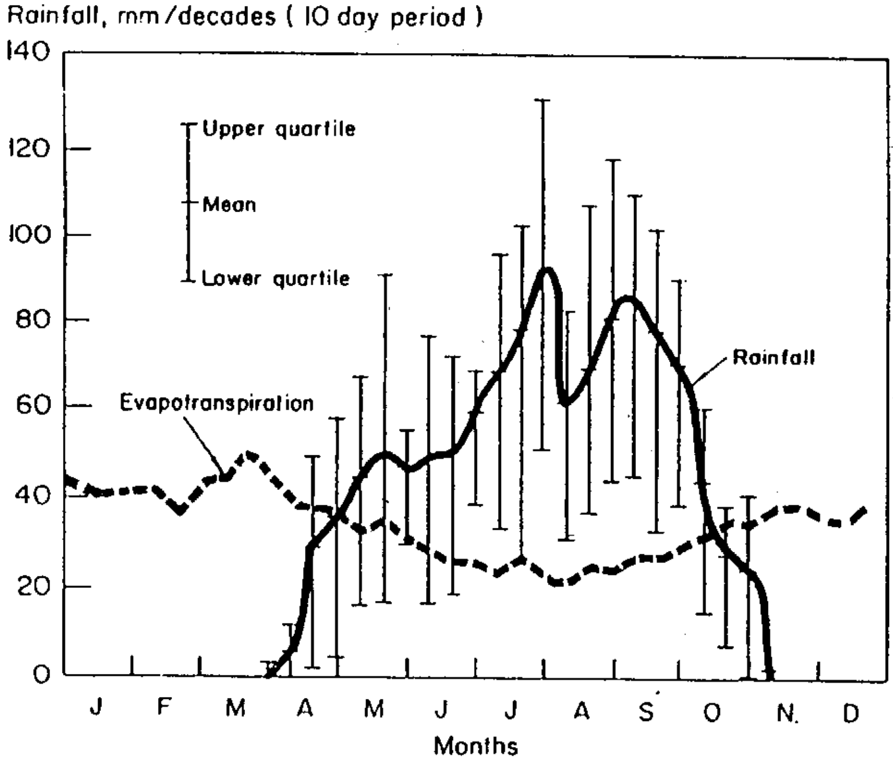

Figure 11.1 Rainfall for 10-day periods (decades) at Bida, Nigeria (1961-83)

v. Evaporation:

The evaporation from an open sunken water surface shows a relatively close pattern with air temperature. Although there are annual fluctuations from month to month, the lowest evaporation is in August. The average daily evaporation is maximum between March and April with 6mm, decreasing to the lowest again in August, to 3mm per day.

According to Williams (1968) the ratio of evapotranspiration of the rice plant to evaporation of water from an open water surface was found to be 1.2 in the wet season and in the dry season in the Phillipines. Therefore in terms of evapotranspiration of the rice plant under Badeggi conditions, the estimated value would probably fall between 800mm (8000m/ha) in the dry season and 600, (6000m/ha) in the wet season for a crop of 120 days growth duration.

11.2.2. GEOLOGY AND PHYSIOGRAPHY

The Badeggi Rice Irrigation Scheme is sited in cretaceous rock of mesozoic origin. The sandstone is generally known as Nupe sandstones of the Niger-Kaduna-Gbako river system.

Physiographically the site is located within the Gbako flood plains. The soils of the Badeggi irrigation scheme are considerably complicated. This is due to the fact that at Badeggi the frequent changes in course of River Gbako have caused the various textures of recent alluvium to be laid down in an intricate pattern of sandy alluvium where the river flowed fairly rapidly, clayey where it is sluggish or stagnant, and very clayey where it was left in Lakes as the river course changed (Moss, 1954). In addition the older alluvium (which is clayey and was probably laid down a considerable time ago by a river flowing in the present Gbako basin, during a previous period of geological time) is often only covered by about a meter of the more recent alluvium and sometimes protrudes through it.

The soil series found in the scheme vary in texture from pure sand through clayey sand to sandy clay soils in the surface layer and through the profile. These differences in texture determine their suitability for rice cultivation in terms of water retention and ease of drainage and land preparation.

11.2.3 HYDROLOGY

Generally in April/May, the main river in the scheme area shows a rise followed by a single peak in September and subsequent decline thereafter. As the area is underlain by the Nupe sandstone, river Gbako shows a smaller seasonal variation in flow and the small rivers and streams are very often perennial. The seasonal flows of the Gbako River become more attenuated owing to the lower direct runoff after rainfall and the consequent inflow of groundwater to the river throughout the season to the extent that in March around Badeggi and down stream, the flow is high and it is directly pumped for the water works which supply both Bida and Badeggi towns.

11.3 THE EXISTING FARMING SYSTEMS

Most farmers have both upland and wetland farms varying in sizes from 0.4ha to 2.0ha in the wetland and from 1.2ha to 4.0ha in the upland. According to Ward (1983) the average farm size of farmers using fertilizer was 0.83ha and the average size for non-users was 0.39ha in 1980. Land ownership in the area is based on the 'fief' holder system where land rights are not heritable. Tenants pay rents or tributes to land owners which are only symbolic.

The principal crops grown in the area are sorghum, millet, rice, maize, sweet potato, groundnut, melon, cassava and yam. Intercropping is the common farming practice for most crops except rice which is a sole crop 100% of the time and yam 84% of the time. The average area allocated to major crops is shown in Table 11.2. In each household, the area under sorghum is the largest (0.87ha) followed by melon. The average acreage under millet, groundnut, rice and yam is almost equal (0.21ha). On the other hand, almost all farmers grow sorghum (97%) followed by groundnut (48%), millet (40%), rice (35%), melon (34%) and maize (32%) (Ward, 1983). Except for rice, more than 50% of the other major crops are planted in April and during the first half of May. The situation with rice is different as more than 90% is planted after the first half of May or more than 40% still remain to be planted after August when most of the other crops have been planted (Table 11.3).

Table 11.2 Crop areas, cropping systems and yields

	Guinea Corn	Millet	Melon	Groun-dnut	Yam	Rice
Average area per household (ha.)	0.87	0.21	0.44	0.21	0.19	0.21
% of household growing	87	44	63	40	57	58
Intercropping %						
Sole crop	32	21	0	49	84	100
2 crop mixture	56	39	56	36	13	0
3 crop mixture	11	34	42	13	3	0
4^+ crop mixture	1	3	2	1	0	0
Average output per household (kg)	1459	231	13	260	1113	577
Yield (kg/ha.)						
Sole crop	1968	1086	0	1202	4942	1702
2 crop mixture	1353	1189	41	1057	3509	0
3 crop mixture	1498	763	26	922	2428	0
4^+ crop mixture	1372	768	19	538	0	0
Overall	1518	1030	38	1119	1583	1702

Source: Ward, 1983

Crop production practices depend largely on manual labour and use of hand tools such as hoes and cutlasses. Farm labour consists of family labour and hired labour. Hired labour contributes a high proportion (40%) of total labour use without tractor. This situation makes labour shortage a common occurrence during peak periods of land preparation, planting, weeding and harvesting. Table 11.4 shows that female labour is utilized for about 25% of the time of family labour for farm cropping activities. It is shown that women are involved with planting, threshing and winnowing and transportation of crops, from farm to homestead and transportation of inputs to the farm. Female labour is also involved with the harvesting of groundnut. The women may also have independent farms in which case they depend on hired labour for land preparation and weeding.

Table 11.3 Planting time of major crops in 1981/82 (%)

	Guinea corn	Millet	Melon	Ground-nut	Maize	Rice
Before April	19	16	24	14	18	0
April 1st half	17	24	24	26	14	0
2nd half	12	20	12	16	8	0
May 1st half	26	24	29	29	34	2
2nd half	8	3	5	6	15	8
June 1st half	8	9	5	6	15	8
2nd half	5	2	3	3	2	15
July 1st half	4	2	0	3	0	11
2nd half	0	0	0	1	0	8
August 1st half	0	0	0	0	0	16
2nd half	0	0	0	0	0	21
After August	0	0	0	0	0	13
Total	99%	100%	102%	105%	99%	100%

Source: Ward, 1983

In Table 11.4 it is also shown that weeding is the most demanding activity followed by land preparation, both of which amount to 143 mandays/ha on an average size farm (Gebremeskel an de Vries, 1985). Figure 11.2 shows that for the rice - based farming system average house hold labour input is substantially below labour supply during February and March and considerably above labour supply during May and June, but almost equal to supply during July through December.

Yields of major crops are low owing to a number of interrelated factors as low soil fertility, erratic rainfall which leads to drought stress and heavy infestation of the parasitic weed Striga on maize and sorghum on upland farms. In rice production, major constraints are poor water control, inefficient land preparation, weeds, iron toxicity, low soil fertility (Tables 11.5 and 11.6), low plant population and low yielding varieties. Also farming activities in the upland farms result in delays of rice planting in the wetlands. Likewise, harvesting of major upland crops like sorghum coincides with rice harvest. Consequently establishment of upland crop or a second rice crop after rice harvest has to be delayed or neglected all together because farmers allocate much of their labour to post harvest activities.

The major socio-economic constraints revolve around the following (Ayotade and Okereke, 1984).

- Land fragmentation related to increasing population pressure;

- Poor infrastructure in terms of road and transport systems, and marketing facilities resulting in high transport costs and low farmer's prices;

- Unavailability at the time required and/or the high costs of modern inputs, such as improved seeds, fertilizer, insecticides and machinery;

- High costs and low productivity of labour;

- Lack of credit, poor pricing structure and low incomes;

- Lack of research with farming systems approach to technology development and use; and

- Little effective technology transfer through extension services.

Table 11.4 Labour use by labour activity and labour type for five crops in mandays per ha.

	Guinea corn	Rice	Yam	Gound-nuts	Maize
Labour activity+					
Land preparation	26	38	22	22	30
Planting	7	17	9	7	7
Fertilizer application	9	12	9	7	5
Weeding	30	41	17	34	27
Harvest	13	27	12	20	14
Transport + store	12	22	8	5	9
Threshing	9	17	-	3	20
Labour type					
Male	48	102	54	37	62
Female	7	10	3	6	17
Total family	55	112	57	43	79
Hired	45	57	18	49	23
Total Labour	100	169	75	92	102

Source: BADP farm management survey, 1980

+Labour averages for all labour activities are calculated only from cases where the activity was reported. So, if fertilizer is applied on rice, it required an average of 12 mandays. But since fertilizer was not applied on all rice farms, the average total labour use on rice (169) was less than the sum of activities (174).

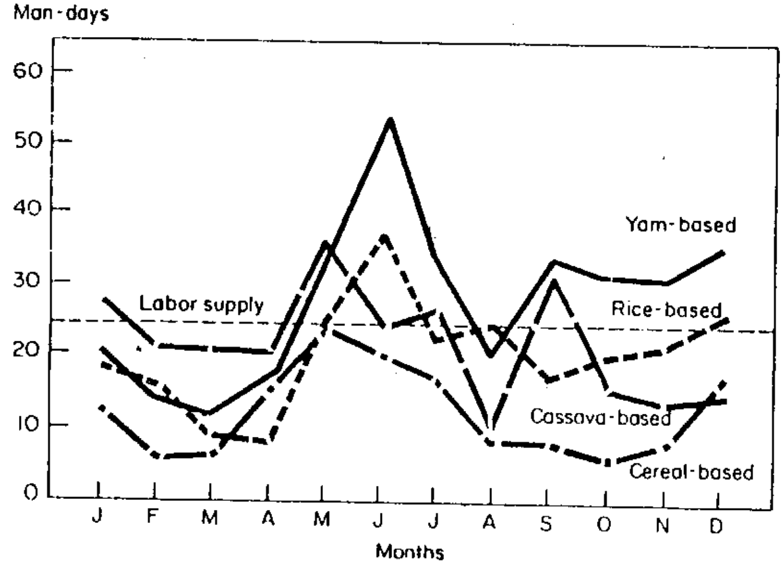

Figure 11.2 Average household labour input (man-days) for agricultural activities in various cropping systems, Bida ADP 1983

Source: Ashraf et al., 1985.

Table 11.5 Physico-chemical properties of a representative surface soil in the Badeggi irrigation scheme, Bida area, Niger State, Nigeria

	Mean	Range	Sample No.
Physical properties			
Sand (%)	71.7	56.4 - 85.6	48
Silt (%)	18.5	7.4 - 29.6	48
Clay (%)	9.8	6.0 - 16.2	48
Chemical properties			
pH	4.2	3.6 - 4.8	48
Qrs carbon (%)	1.22	0.12 - 2.9	48
Total N (%)	0.087	0.02 - 0.15	48
Avail P (ppm)	6.84	0.43 - 12.05	48
Exch. Cations (Meq/100g soil)			
Na	0.02	0.01 - 0.02	48
K	0.21	0.09 - 0.70	48
Ca	0.87	0.63 - 0.86	48
Mg	0.31	0.16 - 0.46	48
Exch. Acidity	0.42	0.23 - 0.97	48
CEC	1.83	1.29 - 2.53	48

Table 11.6 Some chemical characteristics of soil developed over alluvium in Niger state, Nigeria.

Depth (cm)	pH (H_2O	Ca	Mg	K	Ma	CEC	BS	OM	Av.P (ppm)
		Meq./100g of soil							
Shega Series									
0-42	6.8	2.3	0.2	0.5	0.34	5.1	65	n.d	n.d
Sogi Series									
0-31	6.6	1.9	0.2	0.6	0.56	5.3	76	n.d	n.d
Efoghi Series									
0-48	5.8	6.0	0.4	0.9	1.30	18.0	43	n.d	n.d
Ezun Series									
0-20	5.7	8.5	0.6	1.6	0.34	27.0	46	n.d	n.d

Source: Electro Watt Consulting Engineering and Planners Nigeria 1980. Semi-detached soil survey in Kaduna River Flood Plains.

11.4 OPERATION OF THE SCHEME

The Badeggi Rice Irrigation Scheme covers an area of about 800ha divided into eight (8) blocks which vary in size from 70ha to as large as 159ha. It depends on the available stream flow of the Musa River which is diverted into a main canal that branches out into eight (8) laterals and field canals and to a limited extent into farm ditches. Water distribution is by rotation in the main canal on five (5) day-basis. The system also supplies water for domestic use of villagers around the scheme through the laterals.

The present practice of irrigation is to irrigate fields far from the lateral canal by allowing water to flow across neighbouring farms upstream. The dry season stream flow is usually not sufficient to meet irrigation and domestic water requirement from January to May. All farmers allocated land in the scheme pay a fee of ten Naira/ha only and this fee has not been collected since 1990.

11.5 EXISTING PROBLEMS

The introduction of improved water management under irrigated agriculture is a complex problem involving the whole of rural society and agricultural administration. Any loose link in the chain causes problems. Therefore measures to accelerate benefit from the water development project must necessarily be grouped around the farmers fields. The farming practices and social structure of the farmers in the scheme have developed on subsistence agriculture and their priority is therefore food production. The government objectives on the other hand is to take advantage of the potential for rice cultivation in the flood plain to produce two rice crops a year by providing water for irrigation and for domestic uses. It appears that the needs of the farmers were not properly identified by the authorities and this has led to inefficiency and malfunctions of the scheme.

As can be seen in Table 11.2, sorghum is the major staple crop of the rural population in the scheme. It is cultivated by more than 90% of the households on about 66% of the total area under crops. Almost all farmers who cultivate rice in the scheme have upland crops as their priority. Before the end of May, about 50% of the upland crops have been planted. Thus, it is only after sowing and weeding of upland crops that the farmer comes to prepare land for rice by which time the probability of having more than 75mm of rain still to fall is less than 50%. Therefore only one crop of rice can be grown instead of two rice crops a year.As the scheme is also to supply water for domestic uses of the surrounding villagers, the main canal and laterals are at full capacity when the rice fields are still fallow during the rainy season. Therefore, flat fields and the foot of slopping areas are waterlogged although all outlets in the distribution canal are closed. The waterlogging is the result of losses of irrigation water due to leakages from the canals and percolation from the fields. This water adds to the groundwater reservoir thereby raising the watertable and with consequent iron toxicity problems in these areas.

Also at this time, the 32ha research farm of the National Cereals Research Institute is being supplied with water through a distributary canal carrying water to irrigate 159ha of rice fields. Therefore water supply to the farm is in excess of its requirements because the farmers' fields upstream and surrounding the research farm are yet to be cultivated. The result is waterlogging and sometimes flooding of low-lying fields.

Besides the distribution related problems, the poor performance of the scheme is also affected by engineering, agronomic, institutional and socio-economic factors.

There is poor performance of the scheme because of engineering problem even after rehabilitation of sections of the main and distribution canals in 1983. The irrigation and especially the drainage network are below standard. All the collector drains from each irrigation block are designed to empty into a depression (Lake) near the bank of the Gbako River.In most cases the approach to the lake is higher than the drain level.The result is inefficient drainage of fields with consequent flooding of low lying fields during peak rainfall in August or September. Also the Gbako River often overflows its banks during this period and the flood water fills up the lake into which the drains empty.Thus the irrigated fields are sometimes waterlogged or flooded from backfilling of the drains.This unforeseen feature and faulty design result in loss of about 25% of the land during the cropping season.

The uneven topography which was not taken care of by the engineering works resulted in inefficient water distribution. Less than 30% of the 90ha of Block 2 receives irrigation water.This is because the DC2 irrigation canal was designed to rise with the land with consequent deficit water supply at the end of the canal.The primary objective of government in initiating the scheme which is that of producing two crops of rice a year has not been achieved because of agronomic problems.This is mainly due to the late maturing rice varieties planted by farmers in the scheme.Two rice crops can be produced in one year if early maturing rice varieties are planted in June which can be harvested in September while the second rice crop is planted before the end of September.

Another contributary factor to low crop intensity is competition between irrigated and rainfed crops.It often happens that at the peak of labour requirement for rice(Nursery preparation,Land preparation and Transplanting) a lot of time is devoted to rainfed crops on the upland fields.Also related to this is the failure of farmers to master the techniques of double crpping which implies tackling various problems of adjusting cycles of threshing the harvest,promoting land preparation under water and transplanting.

The institutional constraints also lead to under utilization of the scheme.The staff of the managing authorities lack managerial and technical experience in irrigation,drainage and irrigated crop production.

Further, if water is to be effectively used by the farmer without long-time deterioration,he must have adequate means to do so and must also have incentives to sustain his efforts.In this scheme,socio-economic constraints are overwhelming.Often farmers can not pay for the input associated with irrigation,especially now that subsidies have been removed on all farm inputs with increased cost of transportation that kill farmers' incentives.

11.6 PROSPECTS FOR IMPROVEMENT

Although irrigated farming is supposed to eliminate the risk of water shortage and guarantee crop production, it should not be taken as a purely technical solution to a technical problem because it represents a new way of life for the people in the project area. There is therefore a need to raise local awareness for a successful development of the water project.It is clear that the many problems encountered in this scheme stem mainly from the neglect of the sciological and human factors of the new way of life brought about by the scheme.Therefore in order to increase the performance of the scheme,the following short and long term solutions must be implemented.

The short term solutions will include:

- Repairs to broken irrigation canals and continuous clearing of the drainage channels.

- Reducing the gradient of the approach of collecting drains into the lake.

- Provision of pumping facilities to reduce volume of water in the lake whenever necessary.

- Provision of unrestricted shallow drainage to enable cultivation of upland crops during the wet season.

- Provision of independent storage structures at the level of the laterals to extend growing season for crop diversification.

- Promotion of village associations to take greater responsibilities in the management of the scheme.

- Provision of in-service training to technical staff of the authority in irrigation and drainage techniques to enable them provide information,guidance and training on continuous basis to farmers in the correct use of water, such as how to prepare fields for the application of water and how to remove excess water.

The socio-economic and human factors involved in irrigation schemes imply that the long-term solution for improving the performance of the scheme should rely on the farmers to develop cropping systems adapted to their needs and given access to market economy.In order to achieve this goal;

- Machinery stations are to be provided with tractors and implements or animal power needed to undertake timely land preparation for both upland and irrigated crops,

- Provision of collection and service centers to facilitate marketing of produce,

- Provision of credit facilities to support the purchase of farm inputs such as seeds, fertilizer, and other agrochemicals.

The above solutions must be accompanied by engineering works on land leveling, reconstruction of irrigation canals and drainage channels.However,as the main problems in this scheme are also found in the other schemes in the state,it is proposed that in the interval between the application of the short and long-term solutions a comprehensive study of the local situations in all schemes should be conducted. The analysis of the results will identify the point of intervention and whether same solutions are applicable to all schemes in the state.

11.7 RESEARCH NEEDS

The implementation of the rehabilitation programme will not be effective or possible without increased emphasis on research into irrigation and drainage technology development, of appropriate cropping systems for irrigated agricultrure and the socio-economic impact of irrigation. Therefore, some of the research needs are:

1. To study the influence of irrigation on natural and social environments.

2. To evaluate the operational performance of small-scale irrigation schemes in Niger state

3. To study the effect of drainage methods on the performance of upland crops during wet season.

4. To evaluate land preparation methods for submerged conditions.

5. To determine the optimum soil moisture conditions for rice land preparation by animal traction.

6. To screen rice varieties for tolerance to flood.

7. To determine the effect of land preparation methods on turnaround time for double cropping system.

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12. Rehabilitation And Modernization: A Research Agenda For Nigeria's Irrigation Systems.

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Ahamadu Bello University,
Zaria.

12.1 INTRODUCTION

The development of large scale irrigation systems in Nigeria dates back to the early 1970s. But notwithstanding the Federal Government's commitment to this sector, its performance has not been entirely satisfactory. Part of the cause of this poor performance is the fact that the design criteria have not conformed with realities. All the irrigation projects tend to suffer from inherent structural defects; a discordant relationship between the design criteria and socio-economic as well as the physical realities, which creates technical limitations (Kolawole, 1989). These systems would seem to have been designed with erroneous climatic and socio-economic presumptions. It is probably in this light that the process of rehabilitation and modernization is called for.

Rehabilitation is defined as the process of renovating a project which has fallen into disrepair and whose performance is failing to meet the original criteria and the needs of the project. It enhances improvements to the physical infrastructure, the operation, management, and institutional aspects which are designed to improve the economic and social benefits to the project (Weare,1989). On the other hand,modernization is the process of improvement of an existing project to meet enhanced criteria which, otherwise, is meeting the original criteria. It enhances changes to the physical infrastructure and the operation, management and institutional aspects which are designed to enhance the economic and social benefits of the restoration to the original design criteria. Modernization implies development to meet enhanced criteria.

But why is rehabilitation necessary. The need for rehabilitation may arise from the effects of climatic variability which no longer accord with the original design criteria, with the attendant dysfunctional consequences for the physical infrastructural facilities. The other need arises from the rapid changes in the socio-economic parameters which informed the original philosophy of such projects.

12.2. CLIMATIC VARIABILITY AND CHANGES IN PHYSICAL STRUCTURES:

The linkage between climatic change and water resources development is probably the most neglected aspect in water resources development. This apparent neglect, according to Novaky (1985) derives from a number of principal factors. First, the accelerated socio-economic transformation at present tends to create situations for which little or no historic experience is at hand. Second, the rapid advances in science and technology have not only triggered the process of socio-economic changes,but have also offered new strategies and tools for coping with climatic impact, nevertheless, without historical experience. Third, recent technological innovation has also reduced apparent demands for water, which have often proved to be illusory. Fourth, historic experience of responses to climatic changes need to be supplemented by systematic impact assessment of the processes of climate formation.

The neglect has had profound implications for the planning and design of water resources development projects on the one hand, and their operation and management on the other. thereby revealing one of the major weaknesses of conventional engineering statistics (Kolawole,1992a). Armed with conventional statistical figures, design engineers tend to have a myopic conception of climate events. In some cases, designers treat climate events either as an extraneous factor; taken for granted, ignored altogether, or an irrigation project is seen as a panacea for climatic changes. More than often , they assume a periodic re-occurrence of climatic anomaly but failing to recognize the possibilities of clustering of events; a non-periodic variation, that is, the likelihood of persistence of drought up to four years or even longer as in the case of the sudano-sahelian droughts of 1969 - 73 and that of 1979 - 85, respectively. Climatologists have argued that there is a tendency for abnormal wetness or drought to persist from one year to the next or succeeding years in this environment. There is no doubt that major water management activities are indeed variously affected by climate events, depending on their time-scale within-year, whether yearly fluctuations, multi-year variations, and century or longer cases (Novaky,1985). This is because all forms in which drought expresses itself involve water deficiency as manifested in withering of vegetation, including crops; dehydration or death of animals, including man; excessive overdraft on controlled human water supply; and insufficient natural running water for public utilities, waste transport, low river discharges and lake levels (Hewitt and Burton,1971).Longer fluctuation could adversely affect the level of upper ground-water and stream flows, as well as the underground water.Longer fluctuations in climate also alter the level of large lakes thereby affecting navigation,hydropower production, and riparian access as in Lake Chad and the Nile (Grove and Kolawole,1987). Protracted drought usually leads to canal siltation,salinity,alkalinity and deterioration of irrigation infrastructures such as pumps following from long disuse.

12.3 CHANGES IN THE SOCIO-ECONOMIC PARAMETERS.

Large Scale irrigation projects under the aegis of River Basin Development Authorities(RBDAs) adopted advanced and sophisticated intrinsic irrigation technology package which cannot be separated and introduced bit-by-bit but goes together(Stewart,1978). This would seem to be obvious given the fact that the use of the high yielding varieties of crops requires for their effective performance not only the irrigation superstructure but also a wide range of supportive services such as heavy mechanization; technical expertise and high level administrative organization; and water legislation.

RBDAs were established at the height of the oil-boom and were consequently financed largely from internal resources generated from the petroleum economy. This has had some striking implications for irrigation development in Nigeria. As they were financed mainly from the oil revenue, there was no need to fulfil any of the conditionalities expected by donor countries, notably detailed feasibility studies. Where feasibility studies were carried out, the benefits had been bloated to the detriment of costs, ostensibly to justify their establishments. Therefore, technical viability, detailed economic analyses and cost recovery were not given profound consideration as the RBDAs were seen in the main as "social service" or form of "drought relief package"(Kolawole,1992b).

With the down-turn in the economic fortune of the country in the early 1980s, however, Nigeria, like other less developed countries of the world, had to adopt the structural adjustment programme(SAP) in 1986.This led to the re-organization of the RBDAs, which involved a radical shift in the original philosophy of the programme,thereby undermining the intrinsic technology package(Kolawole,1992b). With this re-organization, the role of the RBDAs was confined to the sale of irrigation water; both the extension and the input delivery systems were transfered to the state controlled World Bank assisted Agricultural Development Projects(ADPs) in their respective areas . In addition, farmers were enjoined to pay fully for all the infrastructural facilities and services of the RBDA hence the hike in water charges.

The various questions to ask are: Can large scale irrigation projects originally conceived and operated as "social service" function as a commercial enterprise? Can the farmers optimize the productivity of water without the necessary supportive services?

12.4 RESEARCH AGENDA

The theory of what needs to be done has been itemized as follows by Weare(1989):

i) define overall objectives;

ii) carry out diagnostic analysis of existing systems-in particular identify the causative factors that brought about the need for rehabilitation in the first instance. It may not be simply a matter of age of scheme;

iii) learn from the farmers and managers, by bringing them into the rehabilitation process;

iv) look at operational rehabilitation. In most cases operational rehabilitation has to be carried out first, followed by physical rehabilitation to achieve a particular set of hydraulic conditions; and

v) evaluate the benefits. Ideally a monitoring programme should be established from the diagnostic phase to evaluate benefits throughout the rehabilitation programme.

The research methodology is multi-disciplinary. This is based on the understanding that irrigation is a field of study which concerns the relationship between the natural environment and society, presenting a totality that no single academic discipline could claim as its own. The disciplines concerned range from the hard sciences such as engineering (agricultural, civil, mechanical, electrical) to the softer sciences (agronomy, chemistry, biology, agricultural communication, entomology) and the humanities (history, geography, economics, sociology and politics) to mention but a few. The cost of rehabilitation and modernization could be significantly high, and has to be balanced against the benefits that could ensue.

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13. Some Comments, Questions and Answers

13.1 INTRODUCTION

During the presentaion of the papers some comments and questions were raised with respect to specific papers. Some answers were also given by the authors. This was a prelude to the special session that further discussed the issues before arriving at the final recommendations. Some of the comments, questions and answers are given in this chapter.

13.2 THE STATUS OF IRRIGATION RESEARCH IN NIGERIA: E. U. Nwa

Question:

Should any present institutions have a national or cathment mandate? If so, which ones?

F. Hicks, Ford Foundation.

Answer:

No. There is no need for a national or catchment mandate. This proposal calls for cooperation among the existing institutions. The coordinating institution will serve as a clearing house for activities agreed upon by all the member institutions. The proposed Irrigation Research Network and occasional meetings or seminars will be the major mediums for coordinating at the national level.

E. U. Nwa

Question:

The paper was based on the premise that we do not need a new institute or establishment. The idea is to mobilize the potentials in the existing establishments. Has the writer any recipe for this mobilization which essentially means securing cooperation and coordinating the irrigation research efforts of the existing establishments?

F. A. Adeniji

Answer:

The beauty of this proposal is that it does not interfere with the mandate of any institution. It is also true that no single institution can solve all the problems in a particular catchment alone. In the new arrangement, the owners of irrigation systems in a catchment area will come together with research organizations and agree on research priorities and each institution will take what their mandate permits and what it can handle. Cooperation in this regard should not be difficult to obtain. At least six institutions are already working in the Hadejia-Jama'are catchment.

E.U.Nwa

Question:

What will be the role of nationally mandated organizations such as FACU, NALDA, etc. which do not normally work with universities and institutes in the schemes? How can this institutional problem be resolved?

E. A. Olofin

Answer:

I do not believe that your statement is correct. I am sure that FACU, NALDA, etc. will be happy to have their problems solved through this arrangement.

E. U. Nwa

Comment:

The speaker indicated that the returns from irrigation projects have not been commensurate with the level of investments. People may like to know the reasons for the poor returns before considering your proposal

J. B. Gbenedio

Answer:

Finding out the reasons for the poor returns is one of the purposes of the proposal

E. U. Nwa

Comment:

The middle belt zone should be considered in the proposed scheme.

M. A. Olawuyi

Answer:

The pilot scheme as proposed will only be a starting point.

E. U. Nwa

13.3 RESEARCH PRIORITIES OF IRRIGATION MANAGEMENT IN NIGERIA:

Prachanda Pradhan

Question:

What are the effects of the recent River Basin Development Authority re-organization on the operation and maintenance of the irrigation systems? How would the farmers accept the idea of cost recovery given the fact that the RBDAs were initially set-up as a drought relief package.

Are Kolawole

Answer:

The farmers are adjusting themselves to some extent to the idea of cost recovery. They are also providing some of the maintenance services hitherto provided by the RBDAs.

Prachanda Pradhan

Question:

On water charges, what are the various factors that will interplay to arrive at the rate farmers should pay?

A. O. Nnachi

Answer:

The first consideration should be whether farmers are to pay water charges on the basis of total cost recovery or only for O & M. In many places, it is recognized that the farmers pay only the cost for O & M. It would have been easier if volumetric charge could be fixed. Many of gravity irrigation systems do not have such facility. Hence, the water charges are to be fixed at the paying capacity of the farmer based on the income from the crop. In some countries, different water charges are fixed for different crops depending on the irrigation water use.

Prachanda Pradhan

Question:

Please provide some further explanation regarding research priorities, namely, expected high rate of return on investment especially given the fact that there are typically several groups or agencies operating along any given hydrologic catchment area who often have competing interests.

F. Hicks

Answer:

This is a pertinent issue. Many agencies with competing or conflicting interests are operating within a given hydraulic or catchment area. The only way to come out with acceptable priority for research within a given area is through the process of testing the research issue against the national policy. If it conforms with the national policy, it becomes an important research issue which cuts accross many competing agencies. Hence, it is expected to have a high rate of return on investment in research activities.

Prachanda Pradhan

Question:

What are the criteria for water utilization efficiency?

F. A. Adeniji

Answer:

It could be based on the hydraulic viewpoint of application efficiency, on social equity or it could be based on crop yields.

Prachanda Pradhan

13.4 SUSTAINABLE IRRIGATION OPTIONS FOR NIGERIA: THE LARGE or THE SMALL: E. A. Olofin

Comment:

This paper has done what I expected it to do, namely, itemize problems of small and large scale irrigation systems. The proposal by Nwa to have model basins should address/tackle the problems itemized. One may also note that there is no country without problems associated with irrigation. The task is to seek solutions to the problems whether the irrigation system is large of small scale.

F. A. Adeniji

Answer:

Agreed.

E. A. Olofin

Comment:

Large or small scale irrigation, there are always problems. Some of these problems could be anticipated and adequately taken care of by proper pre-project environmental impact assessment studies. I hope that this Seminar will look into the issue of modelling the extent of environmental impact of irrigation projects.

O. E. A. Olu

Answer:

This is very important.

E. A. Olofin

13.5 RESEARCH AND EXTENSION IN IRRIGATION TECHNOLOGY DEVELOPMENT IN NIGERIA: S. Z. Abubakar, T. O. Arokoyo, Y. D. Yiljep and M. B. Zaria

Question:

Considering the limitations of educational background of most Nigerian farmers, how do we expect them to participate in irrigation management?

Yusuf Olakunle

Answer:

In our project area around Nsukka we usually go down to the farmers' level through the Extension Service to identify their problems and profer solutions. Their educational level has never been a barrier.

G. O. Chukwuma, Rapporteur

Question:

This paper calls for a change from research after a problem has occured to research before the problem occurs which policy makers often fail to appreciate. What is the current status of irrigation research funding?

F. A. Adeniji

Answer:

Research priorities should be tackled just as we are attempting to do in this Seminar. The question of research funding should be directed to higher quarters.

S. Z. Abubakar

SOME CONSIDERATIONS IN DEVELOPING IRRIGATION RESEARCH PRIORITIES FOR NIGERIA: G. O. Chukwuma

Question:

You have addressed the social aspect, how do you correlate farmer-farmer relations? Considering the four (4) areas of irrigation you have discussed, what efforts have been made in the area of developing farmers participation for the sustainability of the irrigation systems?

R. A. Babura

Answer:

With respect to the social factors, experts in the area are always challenged to step in. Regarding farmers participation, the farmers are involved in identifying research problems in the area. Appropriate measures are developed and tested. A field demonstration is planned through the extension services whose responsibility it is to transmit the final solutions to the farmers.

G. O. Chukwuma

14. Opening Ceremony

14.1 Welcome Address

PROFESSOR J. O OYINLOYE,[1]
Vice-Chancellor, University of Ilorin,
Ilorin.

Distinguished Ladies and Gentlemen,

It gives me great pleasure to welcome you to this National Seminar on Irrigation Research Priorities for Nigeria. I must first of all congratulate the International Irrigation Management Institute (IIMI) and my University for taking the initiative to organize this very important Seminar.

I have been informed that Nigeria is not likely to meet its food needs from rainfed production alone after the year 2000. This means that irrigation is essential if Nigeria wishes to feed its people conveniently. However, I have also been informed that the existing irrigation systems are not performing as well as they are expected to perform. A number of reasons have been advanced for this less than optimal level of performance of the systems. These range from inadequate funding to management problems and also include the fact that research support of irrigation is very inadequate. If Nigeria is to be self-sufficient in food, then the contribution of irrigation to this effort must be greatly enhanced and this will be possible if efforts to develop irrigation is strongly backed by serious commitment to irrigation research. This is why a Seminar such as this one which is aimed at identifying irrigation research priorities for Nigeria is of vital importance.

In our own small way the University of Ilorin is helping the irrigation research effort by establishing the Irrigation Water Management Field Laboratory (IWMFL) on our campus. A lot more financial resources are still required to improve this field laboratory. When completed the laboratory (IWMFL) will be used both for teaching and research purposes.

[1] Delivered on his behalf by Professor J. S. O. Adeniyi, Chairman, Committee of Deans, University of Ilorin.

The participants at this Seminar are said to include irrigation policy makers, researchers, financiers, irrigation users and the private sector of very high calibers. No other group of people than this is in a better position to recommend irrigation research priorities for Nigeria after an in-depth discussion of the situation of irrigation in the country. Of equal importance is the follow-up action following your deliberations and recommendations. This is what will ensure sustainable irrigation development for Nigeria.

Ladies and Gentlemen, once more I welcome you to this Seminar. I hope that you will find time to visit our two campuses and, indeed, Ilorin metropolis while you are here.

I wish you very fruitful deliberations and a safe journey back to your various destinations.

Thank you.

14.2 Keynote Address

ALHAJI ISA MOHAMMED,
Honourable Secretary of State
Federal Ministry of Agriculture, Water Resources
and Rural Development, Abuja

Ladies and Gentlemen,

I feel honoured and priviledged to come and address this gathering of eminent scientists, experts and professionals on this occasion of a meeting to discuss and deliberate on Research Priorities on Irrigation for Nigeria.

The series of droughts experienced in Nigeria for the past three decades particularly in the Northern zones of the country coupled with the rapid population growth and the reduced rainfall witnessed of recent has necessitated the active development and growth of irrigated agriculture nation wide. Hitherto, Nigeria had basically depended on rain-fed agriculture which had obviously become inadequate for sutainable food production, though limited and simple forms of dry season irrigation have probably been in practice for centuries in Northern Nigeria.

The various Government effort in the promotion and development of irrigation in Nigeria has included the establishment of the River Basin Development Authorities, Agricultural development Projects, State Irrigation Departments, grants and support to Research Institutions, participation and liaison with regional and international irrigation related orgaisations, as well as manpower training and development. Research on irrigated crops is being carried out by some institutes such as the

Institute for Agricultural Research, Zaria, Lake Chad Research Institute, Maiduguri, the Nigerian Institute for Horticultural Research, Ibadan, and the national Root crops Research Institute, Umudike to mention but a few. Experimental works carried out by these institutes have been the basis of most technologies currently used by irrigation farmers. Some known achievements include the introduction of a number of high yielding varieties of wheat, barley, rice, tomatoes and onions, and the establishment of fertilizer rates, optimum planting time, as well as pests and disease control methods for these crops.

According to recent studies, for example by Food and Agriculture Organisation, Research Institutes in Nigeria are neither effectively communicating research results to farmers nor receiving the necessary feedback from them and may be divorced from problems experienced by the average irrigation farmer to the detriment of the objectives of the research activities. Also, effective development of irrigation in Nigeria will require a review of irrigation-oriented agricultural research and its subsequent reorganization and intensification. Establishment of Irrigated agriculture, like other man-made programmes for development, usually lead to problems in other areas. Also such programmes invariably require improvements and development of more appropriate techniques and methodology.

The aforementioned problems give rise to the need for research in irrigated agriculture. At this particular point in time, in the nation's development with the present economic down turn, this seminar on irrigation research priorities becomes very apt. It is my belief that priorities should be placed on the research needs of the country in order to maximize utilization of the scarce resources (financial and otherwise) available and also to develop appropriate methods of performance suitable for the needs of the farmers and the country.

Research objectives in irrigation should be directed towards such areas as the impact of irrigation on the environment, efficient management and development of available water resources, development of suitable methods of irrigated soil management, surface mechanized irrigation, fertilizer and herbicide use as well as trials with alternative crops and production of breeder seeds. Government also desires a situation whereby private organisations and agro-based industries would be actively involved or sponsor research programmes in irrigated agriculture. Also the role of irrigation should be oriented towards developing strategies for ensuring effective communication between researchers, managers and disciplines concerned with agricultural production for dissemination and application of developments in irrigated agricutlture, aiming to pass on to farmers.

I therefore wish you fruitful deliberations and discussions, and a successful hosting of this useful seminar.

Thank you.

14.3 Vote of Thanks

DR. PRACHANDA PRADHAN
Project Leader
IIMI - Nigeria Programme, Kano.

Distinguished Guests,

This is an important occasion for us because of your august presence before the opening of the serious discussion and debates on prioritizing research areas in irrigation management in Nigeria. The importance of this national seminar is also amply demonstrated by the presence of the representatives of the Secretary of State, Federal Ministry of Agriculture, Water Resources and Rural Development,and the Vice - chancellor of the University of Ilorin. It is now known to all that rainfed agriculture can not support Nigerian population beyond the year 2000. Hence, irrigated agriculture will play an important role in the Nigeria economy in the coming years. Nigeria has both small scale traditional irrigation systems. The history of traditional irrigation systems dates back to the 9th century although public sector irrigation development commenced only about two decades ago. The economic implications of the nation's dependence on food imports led to the adoption of new policies by the government of Nigeria, aimed at attaining self - sufficiency in food. Consequently, substantial investment in irrigation infrastructure development was made by the government during the year 1970s - 1980s. The Government of Nigeria invested about US$ 3 billion in irrigation development over a period of two decades through River Basin Development Authorities (RBDAs) which are parastatal agencies of the Federal Ministry of Agriculture, Water Resources and Rural Development. Substantial investments were also made for fadama development through ADPs. As of 1991, the total irrigated area under large scale irrigation was only 70,000 ha.

Water is a scarce resource in Northern Nigeria. Therefore, it needs to be conserved and better utilized. Consequent to severe drought that prevailed during the period 1972-74, 11 River Basin Development Authorities were established with responsibilities for developing infrastructure for irrigation, increasing agriculture production and undertaking rural development activities in systems with a command area of above 2000 ha. However, the performance of these irrigation systems under RBDAs was marred due to shortfalls in achieving their area targets, operating only at 50% efficiency, wastage of water, lack of beneficiary participation, deterioration of structures, lack of maintenance of the systems and shortage of the spare parts for the maintenance of the machineries. It is reported that the main reason for the poor overall performance of these systems is lack of funds. The commercialization and privatization policy adopted by the government in 1987 as a package of Structural Adjustment Programme (SAP) has made the River Basin Development Authorities to be partially commercialized. Hence, the policy of commercialization and privatization in the user's organizations, in water charge collection and in sharing of responsibility jointly by the agency and farmers for the operation and maintenance of the systems.

There are many problems yet to be addressed in irrigation sector of Nigeria. Nigeria is an interesting country from irrigation perspective. She has more irrigated land and greater potential for irrigation expansion than any other West African country. Both the size of Nigeria's irrigated sector and the rapid changes in the management make the country an important one for International Irrigation Management Institute (IIMI), allowing opportunities both to study the process of change and to provide inputs from experiences elsewhere in collaboration with national partners that will help guide that process and ensure its successful outcome.

International Irrigation Management Institute (IIMI) is an autonomous, non-profit international research and training institute supported by the Consultative Group on International Agriculture Research (CGIAR). IIMI's mission is to strengthen national efforts to improve and sustain the performances of irrigation systems in developing countries.IIMI has at present country programmes in ten countries in Asia and Africa. With its headquarters in Colombo, Sri Lanka, IIMI conducts world wide programme to develop and disseminate improved approaches towards irrigation management.

I am sure that this national seminar will be able to identify the areas for further research with the hope to find out improved approaches toward irrigation management in Nigeria. Experiences of many countries have demonstrated that research inputs in irrigation management have resulted into better performance of the systems as well.

At the end, I would like to propose on behalf of IIMI and University of Ilorin vote of thanks to the Secretary of State, Ministry of Agriculture, Water Resources and Rural Development, Vice - Chancellor, University of Ilorin, Directors of Ministry in charge of Water Resources, Managing Directors of RBDAs, IIMI West Africa Regional Representative and other distinguished guests for honouring this occasion.

I would like to express my sincere gratitude to Professor E.U. Nwa for taking the responsibility of organizing this national seminar in Ilorin University. I once again thank you all.

Appendix

LIST OF PARTICIPANTS

1. Dr. Prachanda Pradhan, IIMI-Nigeria Programme, Kano
2. Mr. Joseph S. Omotowoju, IIMI-Nigeria Programme, Kano
3. Mr. Rabiu A. Babura, IIMI-Nigeria Programme, Kano
4. Mr. F. E. Schulze, IIMI-West Africa, Ouagadougou, Burkina Faso
5. Professor E. U. Nwa, University of Ilorin, Ilorin.
6. Dr. O. O. Babatunde, University of Ilorin, Ilorin.
7. Dr. A. O. Ogunlela, University of Ilorin, Ilorin.
8. Dr. E. O. Nwosu, University of Ilorin, Ilorin.
9. Mr. O.E.A. Olu, University of Ilorin , Ilorin.
10. Mr. K. A. Adeniran, University of Ilorin, Ilorin.
11. Mr. C. J. Ejieji, University of Ilorin, Ilorin.
12. Mr. T. O. Atoyebi, University of Ilorin, Ilorin.
13. Dr. F.P.A. Oyedipe, University of Ilorin, Ilorin.
14. Dr. I. E. Ahaneku, NCAM, Ilorin
15. Engr. I. A. Bajah, NCAM, Ilorin
16. Mr. Yomi Kasali, NCAM, Ilorin
17. Mr. J. B. Adeniran, MANR, Ilorin
18. Mr. S. A. Bayaro, MANR, Ilorin
19. Mr. S. A. Omoniyi, MANR, Ilorin
20. Mr. Olu Adetifa, MANR, Share, Kwara State
21. Mr. A. Olugbenga, Current Affairs Unit, Radio Kwara, Ilorin
22. Mr. Gbenga Akanbi, Ministry of Information, Ilorin
23. Mr. M. A. Olawuyi, Kwara ADP, Ilorin
24. Mr. Rapheal Olawuyi, Kwara ADP, Ilorin

25. Mr. A. M. Abatan, Kwara Polytechnic, Ilorin

26. Engr. J. B. Gbenedio, Jades Ventures Ltd, P. O. Box 6281, Ilorin

27. Mr. D. S. Akanbi, FMAWRRD, Ilorin

28. Mr. J. O. Adeniyi, FMAWRRD, Abuja.

29. Mr. Dickson Ahabuje, FMAWRRD, Abuja.

30. Professor E. A. Olofin, Bayero University, Kano

31. Mr. Bala H. Gezawa, KNARDA, Kano

32. Mr. Usman H. Sharada, KNARDA, Kano

33. Mr. Khalil B. Barwa, KNARDA, Kano

34. Mr. Dauda Abdulahi, BSADP, Bauchi

35. Professor F. A. Adeniji, University of Maiduguri, Maiduguri

36. Dr. Are Kolawole, CSER, Ahmadu Bello University, Zaria

37. Mr. S. Z. Abubakar, NAERLS, Ahmadu Bello University, Zaria

38. Dr. G. O. Chukwuma, University of Nigeria, Nsukka

39. Dr. S. Abdulmumin, Director, National Water Resources Institute, Kaduna

40. Mr. G. O. Olaniyan, NCRI, Badeggi

41. Mr. S. O. Afolayan, NIHORT, Ibadan

42. Professor N. B. Mijindadi, Head, FACU, Ibadan

43. Engr. A. O. Nnachi, AIRBDA, Owerri

44. Engr. I. K. Musa, MD, NRBDA, Minna'

45. Engr. T. A. Aduragba, NRBDA, Minna

46. Mr. Tunji Mafolasire, OORBDA, Abeokuta

47. Engr. Jimi Omoliki, OORBDA, Abeokuta

48. Mr. Umaru Sha'ba, Nigerian Sugar Company, Bacita

49. Mr. Henry Thompson, Hadejia-Nguru Wetlands Conservation Project, Nguru.

50. Mr. Frank Hicks, Ford Foundation, Lagos.