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NIAMEY PRODUCTIVITY PROJECT PAPER

TECHNICAL ANNEXES

VOLUME 2

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NIAMEY PRODUCTIVITY PHASE I

VOLUME 2

TECHNICAL ANNEXES

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ANNEX A

An Agronomic Report for Assisting in Development of the Land and Water Resources of the Niamey Productivity Project

by E. Don Hansen
Agronomy-CID
Consultant June 3-July 3, 1975

Introduction

The project's general objectives are to improve the agricultural production, net family incomes and quality of the life for the rural population of the project zone, in such a manner that it can become self-sustaining. The key to the successful development of the project is an organizational structure which will effectively integrate the activities of the various government agencies. This will assure access to and cooperation from national level ministries, which will allow the project to respond rapidly to development needs.

The agronomic technology input is but one of several necessary for a well-functioning integrated program.

Initial concentration will be placed in improving rainy season dry land agriculture, and the production of millet, sorghum and niebe. There will also follow the development of the land and water resources of the dallols, bas fonds and mares.

1.0 Previous Agronomic Research

1.1 Soils

Two soil studies at a reconnaissance level have been previously made and are important for the project area agricultural improvement:

1. Etude Pedologique dans La Vallee du Dallol Basso, avec cartes pedologique; echelle: 1:100,000, 1963; SOGETHA (Societe Generale des Techniques Hydro-Agricoles, Paris).

2. Carte Pedologique de Reconnaissance de la Republique du Niger; echelle 1:5000,000; 1967; ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer), Paris.

These reconnaissance studies have very good summary data on the general soils of the area covered by the Niamey Productivity Project. However, soil maps and soils data are not of sufficient detail in profile nor laboratory data to be properly utilized for large scale project development on a small farm size basis, or for small scale rural development project areas.

A review of the availability of the aerial photos in Niamey at Service Topographique et Cadastre indicates that aerial photo contact prints and negatives 9cm X 9cm, scale 1:60,000 flown in 1975 by a French aerial photographic company are available. Copies can be ordered through Institute Geographique du Niger or enlargements or mosaic maps at scales of 1:20,000, 45cm X 45cm or 1:5,000, 90cm X 90cm.

It is recommended that aerial photos be ordered at 1:20,000 scale, 45cm X 45cm, to cover the extent of the Niamey Productivity Project. These should be then used to make a land capability classification of the upland areas using similar land capability classification standards used by the U.S. Department of Agriculture. On the dallol, bas fond and river areas where irrigation could be developed, a land classification should be made using similar land classification standards for potential irrigable lands as utilized by the U.S. Bureau of Reclamation. Enlargements of the 1:20,000 aerial photos to a 1:5,000 scale should be used for land classification of irrigable development schemes in the dallol, bas fonds area. This would assist to efficiently develop the full potential capabilities of all arable lands in the project area. These same maps can be used for more complete ground water and surface water surveys.

INRAN has done some basic research on some soils such as texture, apparent specific gravity, moisture at different pF's, infiltration, compression of wetted front, water holding capacity, moisture content by nuclear technique and some subsoiling in field with heavy equipment. This organization is currently engaged in all phases of agricultural research and can be an effective research organization.

1.2 Water

An energetic program of constructing wells to assist the rural population meet their needs has been fostered by the government through CARE. This work continues to bring better water supplies to village people and particularly when possible to drier areas where needs are greatest.

Irrigation development has tended to center around the River Niger flood plain area where some rice, vegetable and fruit production has been developed. Some of this has been for commercially growing fruits and vegetables for export. But developing agricultural water resources for the peasant farmer in the interior areas of the country has been largely limited to the areas around Agadez by the Catholic Church mission and the CARE well development projects near Baleyara in the Dallol Bosso.

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Fully developing the ground water and mare areas of the Dallol, Sa' Fonds areas in the area of the Niamey Productivity project has become one of a principal objectives to assist the rural people of these areas to more efficiently utilize these water resources. It is this type of water development that can help the small farmer most. Better means must be developed to help him get more water, more efficiently - from this ground water resource. Specifically - how to move the water from a good producing well to his small parcels earlier, faster and in larger quantities is highly important to improve his agricultural production capability.

The technology available in Niger in soils and irrigation appears to be much more in quantity and quality than the presently available African technically trained personnel can utilize in implementing project development such as in this one. Several are in the U.S.A. at universities completing graduate work and will return within the next three years hopefully to bring leadership in these and related fields. Only one is scheduled to return shortly to assume responsibility for operation of the new soils laboratory.

1.3 Climate

The elements of climatic observations of utmost importance in evaluating a program of dryland agriculture in a Sahel country such as Niger are precipitation, evapo-transpiration, maximum and minimum temperatures, and wind direction and velocity. Since most of the rainfall comes from high intensity thunderstorms of great variability in location, more weather stations are desirable to maintain these records for calculating soil-water balance over as many years as possible.

This can lend assistance to agriculturists in indicating favorable times and intervals for planting, growing and harvesting food grain crops such as millets, varieties of sorghums and some legumes adapted to short growing seasons.

Since there is great variability in rainfall from north to south in the Sahelian and Sudanian ecological zones there is considerable need for more weather stations to be established to give more knowledge of seasonal and yearly variations in rainfall, evapo-transpiration, temperatures and wind direction and velocities for more sections of the project area. These records, properly interpreted over a spread of years, can give a trend of expectancy for drier or wetter years and for more dependable moisture data for planting the principal food grain crops. Peasant farmers at present move to plant when their first rains come, but sometimes this may be too early if a period of drought follows before the second rain comes. Longer weather records for more stations will eventually give more reliable data for planting and growing of short season food grain crops.

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It would be desirable, therefore, to make data from more weather stations available throughout the project area, and particularly in localities where the soils and water resources are better, and have greater capability for development. One good example of this is in the Dallol Bosso. While present weather stations are located at Filingue and Tabla, there should be one located north of Filingue, one between Filingue and Tabla (or at Baleyara) and one or more south along the Dallol Bosso. Each weather station should be equipped and capable of making accurate daily observations for rainfall, evapotranspiration, maximum-minimum temperatures, and wind direction and velocity. The collection and processing of meteorological data is the most important step in providing a basis for logical water and soil management, particularly for a rainfed agriculture.

1.4 Crops

1.41 Fruits Research on types and varieties of fruits that can be successfully grown in Niger and adaptable in the project area are being efficiently investigated at the IRFA (Research Institute of Tropical Fruit and Citrus) station at Gabougoura. Good varieties of grafted mangoes, citrus, and guava are available each year for planting. Cultural practices and different methods of irrigation are being investigated. Other fruits being investigated are pineapple, bananas, and passion fruit. It would seem that grapes should be introduced here also under irrigation for garden production and perhaps later for commercial production if proven successful. This station is quite capable of supplying planting materials to a project at a reasonable cost per unit. Research on fruits in francophone Africa is quite well developed.

1.42 Field Grain Crops and Grain Legumes

1.421 Millet - Selections have been made in Niger for developed varieties which presently seem to be adapted to the project area. One variety is P_3 Kolo, which is recommended for the southern part of the project area, and HKP, for the northern zonal area.

Other improved varieties can be secured from ICRISAT and Samaru in Nigeria as they become available through the Niger Cereals Project at Maradi, once this project is operational.

1.422 Sorghum - A variety that has been selected for the sandy dune areas of the west is P_2 Matankari (selection Garoba) and should be used in a rotation after millet or peanuts. For valley conditions, which would include the bas fond, dallol drylands, a variety called Jan-Jaré is

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recommended. It can follow cotton or niebe in rotation and can even be irrigated for forage production but needs at least 5000 cubic meters of water per hectare.

As improved varieties are released these can also be secured the same as the source for millet described in 1.421 above.

1.423 Niebe (cowpeas) - In the drier area of the northern part of the Niamey Productivity Project area, two varieties (70 day) recommended are TN 36-64 and TN 88-63. Within the 400-500 mm rainfall range TN 469 has been found most reliable. In the extreme southern part of the project area the 130-150 day variety TN 88-63 is recommended. Improved varieties should be obtained from the Niger Cereal Production project in Maradi once it is operational, which in turn will introduce new seed material from Ahmadu Bello University, Zaria, Nigeria, IITA at Ibadan, Nigeria, and Bambey, Senegal. Until the NCPP becomes truly functional the above sources for new materials will be best.

1.424 Maize - Corn cannot be an important crop in the upland areas but could become very important as a food crop in the small irrigated farm areas of the Dallol Basso, bas fond areas and similar areas where water could be made available from wells for irrigation. Varieties need to be obtained from IITA at Ibadan, Nigeria or from Samaru, Ahmadu Bello University in Nigeria, that are responsive to irrigation and higher inputs of nitrogen and phosphorus. Varieties should not be hybrids, because the peasant farmers of Niger are not yet ready to handle hybrid varieties. Suggested variety is P_3 Kolo, but others should be introduced. A strong maize research program exists at IITA in Ibadan. It is building a capable staff and is developing associations with CIMMYT in Mexico and the International Center of Tropical Agriculture in Mexico. These combined sources of germ plasm can be tapped for new corn varieties for Niger.

1.425 New Crops

1.4251 - Pigeon peas (Congo peas, Cajanus Cajan) are important as a nutritious food and as a promising soil building legume. In India it has yielded as high as 5000 kg/ha and in Puerto Rico a high yield of 7000 kg/ha has been obtained; both under irrigation, however. These should be introduced and grown by obtaining varieties from India from ICRISAT or from IITA at Ibadan where a research project has been started.

1.4252 - Mung beans, green gram (Phaseolus mung); Winged bean (Psophocarpus tetragononolobus L. D.C.); and perhaps even improved species of the lima bean (Phaseolus lunatus)

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should be introduced and tried. Mung beans have been used as a staple food crop in India, China and other countries of the Far East for many years.

Likewise the winged bean has been grown in Asian countries. It rivals soybeans in protein and oil content (34% protein, 18% oil). Its tubers are protein enriched also and can be utilized after two months. Seed material for both varieties should be available through IITA, Ibadan, Nigeria or from the Far East through a cooperating relationship with ICRISAT in Hyderabad, India.

There has been a research program on P. linatus, lima bean in the Malagasy Republic and research is also being conducted at IITA, where planting materials for trial could also be obtained.

All these beans would need irrigation for optimum production yields, but mung beans (Phaseolus mung) may give a limited production as a rainfed crop in the higher rainfall area of Niger--perhaps in the southern zone on the better quality soils.

1.43 Vegetables

Some varieties of onions, okra, peppers, sweet potatoes, and tomatoes have become fairly well established to give acceptable yields under growing conditions in Niger and help to fulfill in-country demands as well as have an excess for export to adjoining countries. However, these varieties need to be tested more thoroughly against other introductions, which may have greater yield potential and greater acceptability. Tomatoes and onions have become particularly important items in the African diet. Yields of tomatoes of 50 tons/ha have been achieved in Nigeria with selected varieties grown under irrigation. Onions are an important export crop within Africa. Seventy (70) percent of Niger's annual crop of 38,000 tons is exported southward. Piment (hot peppers) are almost as important as onions and tomatoes.

Other vegetables which have been tried near Niamey and in the garden areas of the Dallol Basso bas fond areas are: lettuce, squash, eggplant, radish, carrots, cabbage, melon (cantaloupe), watermelon, turnip, bell peppers, garlic, pumpkin, red beets, beans (snap beans), and beans (Phaseolus vulgaris) for dry beans. Most of these varieties of vegetables have been comparatively recently introduced by CARE or by Church World Service groups and no concrete information of adaptability or acceptability has yet been compiled on performance of these vegetable crops. As need arises by increased demand for any of the vegetables some organizational arm of

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the Department of Agriculture should institute varietal trials and introduce other varieties which may have promise. Existing experimental stations close to Niamey on the river could easily broaden their research effort on vegetables. Perhaps the research program of IRFA could be broadened to include vegetable trials and research on particularly those crops which are presently important to Niger: tomatoes, onions, and okra. On tomatoes a considerable amount of research needs to be done on control of insect pests, and especially diseases that attack during its growing period; development of tolerable varieties; cultural practices to produce highest yields, and removal of such barriers to production such as transportation and marketing.

Onions also need more research, particularly to develop higher yields, better keeping qualities and better storage and processing techniques. Other local vegetables require as much more concentrated research effort in selection and to establish more clearly their potential and greater acceptability in the country.

While manioc is essentially a vegetable crop, most varieties have been found locally acceptable both for quality and yield and no particular research has been sought nor is planned for the future, except perhaps more careful selection for quality and yield characteristics. Manioc production in 1973 and 1974 was only about 700 ha each year in the project area but production in 1974 was nearly 50% greater. Production ranged from [illegible] kg/ha in Ouallam to 12,000 kg/ha in Niamey arrondissement. The great difference was due to uneven rainfall distribution.

Rice is considered a specialty crop with high water requirements and is not recommended for cultivation in the vegetable garden areas of the Dallol, bas fond areas, where heavy use of the water resources from wells or mares would not be recommended. Rice culture should be largely limited to existing areas along the Niger River. However, small plots of rice in favorable poorly drained areas of the bas fond areas, or next to mares with high water tables or poorly drained bottomlands. INRAN has a research section on rice which is already assisting on production problems along the river Niger. This organization could be of assistance in appropriate areas of the Niamey Project area.

1.44 Oil Crops

Oil crops in Niger include plants such as groundnuts (peanuts in the U.S.) and sesame (benni seed). Any increase in production of oil crops would be important to Niger be-

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cause practically most of it required for consumption must be imported. The largest production of oil seed crops is groundnuts and except for local consumption and some extraction in three plants near Maradi the balance is exported in unshelled nuts to Nigeria where many large oil mills are located. Last year the harvest of groundnuts was so small that all were processed in Niger and none were shipped to Nigeria.

Hectares area grown in the project area is relatively small. In 1974 the area grown was 1.000 hectares mostly all grown in the Guallam area with a production of about 400 kg/ha. Countrywide production for 1974 was 129 thousand tons versus 77 thousand for 1973.

There are no agricultural production records showing any sesame grown in the project area in 1973 or 1974, but this crop could become more valuable as a cash crop in the project area. Production within Nigeria increased from 77 thousand tons in 1973 to 122 thousand tons in 1974.

On the sandy soils of the project area erosion hazards are significant and labor requirements are large. Peasant farmers with their predominantly hand labor cannot sow groundnut seeds as close as necessary for satisfactory results with the short season varieties they must plant. Simple mechanical seeders like those used in Senegal can offer real advantages to farmers. If reproductive efficiency can be improved and field losses from diseases and insects reduced, very likely present yields can be more than doubled.

Sesame production could receive more attention in the project area. High yielding varieties have not yet been developed, but sesame yields a high quality oil and a protein rich oil cake and would make a good cash crop where farmers could successfully grow and market it. More locally available processing should be provided before it should become a regular cropping possibility in the project zone.

2.0 Major Constraints to Dryland Crop Production

The peasant farmer in Niger lives in a modern era but with the mold of traditional agriculture still imprinted on his behaviour, much as was practiced several centuries ago. Few minor improvements have benefited life for him and his family in his agricultural pursuits and his daily living.

2.1 Moisture Limitations

2.11 Upland areas In the drier upland areas and on less favorable soils, the peasant farmer has been limited in his

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food production efforts principally by scanty poorly distributed rainfall. It has given him short uncertain periods of rainfall during which he has been able to grow millet, sorghum, and cowpeas with high risk of failure during recent years when often recurring droughts caused complete or partial crop failure. This limits the production capabilities to short season adaptable varieties of these crops or others that can be introduced with an expectation that one year out of five--there may be a complete crop failure due to drought. Longer and more complete weather data as it becomes available can assist him by supervised guidance into accepting shorter season, higher producing varieties and more secure planting dates as better summarized weather data becomes available.

2.12 Dallol, Bas-fond areas These represent the greatest potential for water utilization of most of the interior areas north of the river valley area of the Niger River. The available groundwater of these areas has not been fully exploited.

Wells have been constructed in greater numbers and many are better constructed by cementing, but at high cost. Heretofore wells in these areas have contributed little toward agriculture except to provide the peasant's family and his animals with necessary water. Well water, relatively easily available and of good quality, has been utilized to only a limited extent for irrigation of small garden areas adjacent to them. Few methods have been adequately developed for moving the water from the wells to the land to enable the small farmer to more efficiently apply the water to his crops. The daloo, shadouf and inefficient methods of dipping and pouring have made his progress slow here in improving his small scale agriculture by irrigation. Whereas in the Agadez area or near Lake Chad or in other developing countries improved animal traction methods or shadouf have been successfully used in raising water from shallow wells or bodies of water in relatively large amounts or in pumping. These methods have found little acceptability in the project area. There has been reluctance to use animal traction for such work except principally in the Agadez area, where it has been highly developed by the Tuaregs. It is a method that should also be utilized in this area. How can it be fully accepted as a method--we must answer.

3.2 Limitations in Hand Tools

His continued use of simple hand tools without benefit from animal traction in his cultivation techniques keeps most of the peasants in the frame of marginal traditional agriculture.

One item of hand tools that has been made available to him that is a definite improvement to him is the Niger indigenous long handled weeding hoe. The origin and development of its present form would

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make a most interesting account. The local names associated with and identifying it are as follows:

The relatively thin blade made by local blacksmiths out of tempered scrapiron is called in:

Djerma - koumbou or ankana
Hausa - hauwiya or koukou

The handle is called in:

Djerma - Koumboubon*
Hausa - Kunghauwiya*

*Meaning head or handle for.

His other principal hand tools are his planting hoe on a crooked stick, occasional use of a short handled "daba" hoe for digging, a machete, his locally made chopping axe for cutting firewood, and his locally made sickle for harvesting his grain. More and better and improved hand tools need to be developed that will find as ready acceptability as the "koumbou".

2.3 Animal Traction

Animal traction has not become as highly developed nor as desirable to use as it has been in some of the adjoining African countries. In the Niamey Productivity Project area animal traction has had very little use and acceptability. Those farming in this area should be taught to utilize methods or acceptable methods that could be adapted from the Agades Tuaregs use of animal traction by use of camels or oxen in raising water from wells; or from the Maradi area where the farm center of Dr. Ockers has developed animal traction methods for cultivation by donkeys and oxen as well as developing their use for raising water from wells for local irrigation for vegetables and other crops. In northern Nigeria many of the farmers also make use of well trained teams of oxen for crop cultivation and other purposes. These methods and techniques need to be further investigated for implementation in the project area.

2.4 Cultivation Techniques

Since animal traction is so rarely used in the project area the peasant farmer's crop production practices are mainly accomplished with his hand tools for cultivation, planting and harvesting. This limits the amount of land which he can farm by hand methods.

2.41 Planting It has also given rise to certain planting techniques which limit his yield capabilities. The traditional methods of planting his millet, sorghum and niebe is a restraint against higher yields. The hill method provides for competitive numbers of plants in each hill, which in turn causes competition for the limited moisture and limited available nutrients. There is also the serious possibility that the practice of interplanting with cowpeas does not stimulate yield as much as rota-

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tion would with alternate solid plantings of legumes and millet in separate fields. There are advocates both for and against the two planting technologies, but only using well designed plot experiments for several years to include them all, could this question be answered effectively.

2.42 Fertilizer use Although it is demonstratably known that fertilizer use does increase yields, it has now become a constraint because of high cost per unit of all major fertilizer elements. The improvement of soil fertility need not be dependent entirely upon commercial nitrogen fertilizers since legumes may be grown to supply these nutrients--supplying up to 200 kg/ha of nitrogen. At least it can be partially supplied without purchase of high cost commercial fertilizers to the best advantage when it is necessary to import and utilize this high cost import. Experiments should be designed--wherein limited use of fertilizers is used to obtain increased yields. Rotation experiments which include greater use of green manure crops and use of more animal manure and other available organic material should be introduced by INRAN for backstopping the project program.

2.5 Lack of Credit Facilities

This has been an important constraint in most developing countries and needs to be built into any development program which involves the small farmer. The peasant farmer has little or no credit facilities available to him unless he is a member of an organized local cooperative organization. In most villages these facilities are not yet organized in the project area.

2.6 Lack of Effective Extension Activity

The lack of motivation to change methods, practices and techniques for the better by the farmer himself may be from either socio-economic reasons or because of not having been given sufficiently sound technical reasons for the change. Extension personnel, often called monitors or by any other name, have a responsibility to take practical research results to the farmer for his implementation. Sufficient provision must be made for this type of activity and the training of a sufficient number of personnel. However, if there are social or socio-economic restraints, these must be fully understood, before extension efforts can be properly implemented to hurdle these roadblocks to progress.

3.0 Basic Agronomic Research Needed

3.1 Soil and Land Classification and Water Surveys

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In the project area, these surveys as outlined in 1.1 and 1.2 above are necessary to more efficiently utilize the land and water resources in the upland and bas fond, dallol areas away from the Niger River valley area. These can provide the basic information for implementing improved soil and water management practices, to conserve soils and water and prevent the high rate of erodibility, waste of fertility, and inefficient use of available rainfall, ground water and surface water.

Improved soil utilization and agronomic improvements are outlined in this agronomic report and combined in detail in the corresponding report of the irrigation specialist of CID (Consortium for International Development). These contain coordinated initial recommendations for more adequately developing the land and water resources throughout the project area. Initial proposals for irrigation from the wells in the Dallol Bosso and bas fond area near Cuallam, of fruits, vegetables and some crops are set forth in detail. The reader is referred to the details of this report in which this agronomist has collaborated.

3.2 Agro-meteorological

Several more meteorlogical stations should be established to assist in monitoring the monthly-weekly-daily climatic variations so important to agriculture: precipitation; evapotranspiration, maximum-minimum temperatures, wind direction and intensity. Water balance between precipitation and evapotranspiration can then be calculated for the optimum rainfed cropping period.

3.3 Crops

Principal research efforts should be concentrated on:

- Evaluating different planting dates for short medium and longer cropping periods to correlate with incidence of early rains and seasonal variability of rainfall in various sectors of the project area.

- Cheaper and more efficient methods of insect and rodent control.

- Evaluating row and solid plantings of millet, sorghum and niebe, with different seeding rates and row spacing versus traditional methods.

- More field trials of insect and disease resistant varieties of food grains and legumes.

- Introduction and trials of new food crops, vegetable crops, forage crops and oil crops--both irrigated and dry land--for improved human and animal nutrition and for cash crops (e.g. Phaseolus mungo (green gram); winged beans; new strains of alfalfa; pigeon peas; soybeans; safflower).

- Introduction of more improved varieties (higher yields faster maturing) of millet, sorghum, and cowpeas.

3.4 Soil Management

Principal research efforts should be to:

- Test different methods of land preparation and planting to conserve moisture, establish seedlings and protect soil from erosion (e.g. contour planting).

- Develop methods of soil management which will increase the intake of the high intensity rains with higher storage of moisture, less runoff and less soil loss by erosion.

- Identify adaptable soil and water conservation practices, rotations, and fertility practices for long term benefits at minimum costs.

3.5 Water Management

Principal efforts in this category should be to:

- Develop more efficient and cheaper methods for well construction.

- Develop more efficient, faster extraction and distribution of water from shallow wells of dallol bas fond areas.

- Determine the most practical method of utilizing the water resources of the mares.

- Increase efficiency of rainfall runoff distribution to promising upland areas.

- Construction of erosion control structures of major gullied areas adjacent to both the Niger River drainage and the major Dallol bas fond areas.

Workers and researchers on the Niamey Productivity Project (NPP) should become acquainted with a (1974) publication of the National Academy of Sciences, Washington D.C., U.S.A., entitled, "More Water for Arid Lands". This contains promising technologies and research opportunities for arid-land water development. It has a resumé in Arabic, French and Spanish. This research report has some outstanding examples of technologies used in other parts of the world to save water in arid lands. Important selected readings are listed as are also important contacts in various countries of organizations and research centers where expertise and information is available for water technologies for saving and using limited water supplies from rainfall, underground or surface waters. This small booklet is well illustrated with diagrams, photographs, and aerial photo reproductions. It is

highly recommended for all to become well acquainted with to help implement some of these ideas into this project and others. Some of these highly innovative methods could well be applied in Niger in arid areas.

4.0 Agronomic Analysis of Major Technological "Packages" to be Introduced in the Project

The first item of importance in the "package of practices" that is proposed for the production of mil, sorghum and niebe in the project area is time of planting. It has been recommended that planting of millet be delayed until at least June 15th in order that sufficient rains may follow in close enough sequence so replanting may not be necessary. Review of meteorological research records by INRAN organizations covering a significant number of years indicate that this would be a sound procedure that can be modified as more annual records are averaged and plotted for the optimum period of crop growth from seed to seed. Sorghum is usually not planted until after millet and cowpeas are planted.

The varieties recommended should be planted until better yielding varieties can be made available to replace them. These are namely:

Millet--P_3 Kolo (Maradi variety) in the south of the project area
IKF in the northern zone

Sorghum (dunaire)--P_2 Mantankari (sel. Bagoba) should be in rotation after millet or groundnuts
" (de vallée)--Jan Jaré
" for improved conditions--#137-62 or 137-62 X Jan Jaré*

*These two varieties of sorghum which can be used for improved growing conditions, can be irrigated for forage, but require a high water requirement under irrigation of 5000 m^3/ha.

Niebe--Depending on the average rainfall available from north to south in the project area the following varieties are recommended:

Average Rainfall (mm)	Growth Period (days)	Varieties Recommended
300-400	70	TN 36-64, TN 88-63
400-500	90	TN 469
500+	130-150	TN 98-63

Seeding rate of 4 kg/ha should be followed until improved methods of seeding are developed.

Seed treatment with 2 g/kg of Thioral or Aldrex is absolutely necessary and should always be followed for all grain and legume crop seeds.

Density of seeding and distance and plant population should be also maintained as presently recommended. These items may need to be changed as soon as research can substantiate doing so. There appears to be a serious possibility that traditional planting of millet, sorghum or niebe in hills of 3 plants each does not encourage higher production since there is competition for moisture and nutrients that inhibit maximum top growth and root development. There is also need to test in well controlled replicated plots the merits of row plantings with single seeds planted at 15-20 cm spacing in the row with reasonable spacing between rows. Such spacing has been practiced with groundnuts and cowpeas but not with millet.

These observations are illustrative of opportunities for greater productivity that will produce greater yields and be more pronounced in years of average rainfall, but may be crucial in years of deficient rains.

Plant Protection in the cropfield as presently organized and provided for should be adequate, but more thought should be given to insects and rodents which take a great toll in harvested and stored food grains in storage, or even invasions in the field.

Little is known of the ecological reasons for sudden explosions of rodent populations in the fields, and it is not known if strains of crops to rodent attack exists. At present no research institution is working on rodent control measures, but there be should build a regional capability in rodent research and control in this part of Africa--also for storage.

Technical backstopping for improving spray materials and techniques can be secured through the Canadian technical entomological mission operating in Niger, and could be furnished from Ibadan, Nigeria from the University of Ibadan, and IITA. In the francophone zone entomological studies are undertaken by the universities of Abidjan, Dakar, Brazzaville and Tananarive; at the research centers of ORSTOM at Abidjan, Ivory Coast and Brazzaville, Congo; at Organisme de Coordination et de Coopération pour la lutte Contre les Grandes endémies (OCCGE) at Bobbo-Dioulasso, Upper Volta in liaison with ORSTOM.

Animal traction is recommended and could be very important to improve crop production in the project area. It is not a recommendation to be taken very seriously, however, without a well planned and operated training program to provide peasant farmers themselves the opportunity to buy and train their own animals under the tutelage of skilled teachers of animal traction. Not only good strong, healthy, well-tamed animals should be available, but also well designed tillage implements and animal harnesses for pulling and driving the animals

must also be available. Technical assistance should be requested from Northern Nigeria or other Sahel countries where animal traction has proven successful; from the farm center at Maradi where Mr. Ockers has developed significant farm mechanization with both donkeys and oxen, or from Fehl or Tuareg trainers from Agadez or other areas within the country or adjoining ones.

ADDENDUM

A trip which was made to Maradi June 29-30 served to amplify my observations; experience and recommendations concerning greater use of animal traction for small farmer holdings. It was a real privilege to see the activity that had been built into the Maradi area agriculture as a result of the work of John Ockers through his activities in the Maradi area.

However, there appears to be several principal needs in order for the program as it is presently functioning to contribute more to progress of animal traction activities in Niger. Specifically as they would relate to its increased use in the Niamey Productivity Project, the following items need to be seriously considered:

1. The cost of--machinery, equipment and animal for a peasant farmer to buy must be financed or in part subsidized to him through some credit facilities of UNCC or the Department of Agriculture, or others. Even the cheapest animal traction unit--donkey, harness, cultivator, and seeder are way beyond his means, (45,000-55,000 cfa), the price of the donkey being the main variable. The price in the Maradi area, at least, has escalated to 10-15,000 cfa. This price may be different than in the Niamey area, but the donkey animal traction unit would still be the most economical. The cost can be briefly summarized as follows:

CFA	
25,000	donkey drawn seeder
10,000	donkey (good young animal)
10,000	donkey drawn cultivator with duck feet weeders
750	donkey harness
45,750	Total cost

At the IRAN station, Maradi, where animal traction work is done, by large bullocks, the cost becomes illustrative of being more prohibitive to the small farmer. Besides the cost of harness, neck-yoke, cultivator and seeder to be used with an oxen, the cost of only one ox would be 50-60,000 cfa; more than the total cost for a complete donkey animal traction outfit.

2. An efficient, well-equipped, well-managed fabrication facility needs to be built, geared to the annual needs of the country

of Niger for animal traction equipment for bullocks and donkeys. Bullock drawn equipment can be designed sturdier and larger than donkey drawn, although more of volume of the lighter weight donkey drawn equipment should be programmed.

At the present time at Maradi, there is no building that houses the fabrication of donkey-drawn equipment. This is done mostly in a compound with locally limiting hand methods of assembly--steel cutting, forming, drilling, welding and blacksmith techniques. More modern shop facilities are needed to be able to turn out the required number of units on an annual delivery basis. A source is needed to plan, design, and build such a facility--a fabrication plant for manufacture of animal drawn farm equipment or perhaps a facility with sub-units to build and design various types. Units that should be included for fabrication manufacture are:

donkey carts
" drawn seeder
" " cultivator
" harness
bullock carts
" drawn seeder
" " cultivator
" neckyoke and pulling harness

Certain items which are not available in Niger could be imported, for example:

wheels from standardized selections of used cars
axles " " " " "
seeder hopper attachments from Senegal or France
duck foot cultivator tools
packing wheels on seeders
carriage " " "
Stock steel of various dimensions
strap iron " " "
iron cultivator or seeder wheels
rod steel for axles for cultivators or seeder wheels
rod steel for axles for cultivators or seeders
welding supplies and equipment
steel fabrication machinery for cutting
drilling, forming machinery, etc.

3. Trained personnel requirements for a fabrication facility. There are six locally trained persons at the present facility at Maradi. These are a part of the large number of trained people in animal traction that John Ockers has trained in his 27 years in the area, and are doing an admirable fabricating job for no more than they have to work with. This could be an initial cadre.

4. Manager for an animal traction fabrication facility. This eventually would require a Nigerien, preferably trained under John Ocker's program. Some mechanical ability, but more importantly managerial ability to handle men, equipment, finances and business management. In the first two year phase until such a local individual could be located and trained, a mechanical agricultural engineer or graduate student equivalent--an expatriate should be employed with particular talent in mechanics and machine shop or with steel fabricating background.

5. Animal Traction training should receive added emphasis and assistance in all the young farmers training centers (Centre de Formation des Jeunes Agriculteurs--CFJA) in Niger--and particularly in those centers where the young participants would be from Djerma farm communities, where animal traction is least understood and appreciated. This should also include a "re-cycling training" of agricultural agents of UNCC and of the various Ministry of Agriculture departments.

In other words, promoting greater development of animal traction should be a uniform goal countrywide, even though the main thrust may actually be considered in limited areas such as the Niamey Productivity area. The facility at N'dounga could function for this area.

The other CFJA's at Belyende, Tarna and Diffa could be likewise strengthened and fully activated, with perhaps another one be set up at Tahoua. Cadre and trainees of John Ocker's farm school he originally assisted in setting up at Tarna could be used for nucleus cadre at the other young farmer training centers. The emphasis at each would be practical training to such an extent that each graduate could have the potential of successfully promoting use of animal traction around his home village area--being fully able to handle animals and each piece of animal drawn equipment.

Weeding as necessary seems to be adequately covered in the "package of practices" as recommended, when accomplished with the "kourbou" or "antana" that is so expertly used by the Niger peasant farmer. It is designed for use with small weeds and not weeds of any size. When used about 8 days after seeding with the second weeding 15 days after the first weeding and others as needed, it should adequately keep weeds under control.

Fertilizers: Soil fertility improvement need not necessarily be dependent upon commercial nitrogen fertilizers since legumes may be grown to supply this element. In addition all forms of organic material need to be added to the soil when they can be made available--such as compost, peanut hulls, manure and all kinds of plant residues--before use of commercial fertilizers is considered. Experiments should be

designed to learn how best to use phosphates and other mineral fertilizers. This can be done by placing these minerals in bands in shallow furrows under the intended crop row, with the addition of animal manure when feasible and covered lightly with soil, on which the seed is placed. Cheaper raw rock phosphate and the interaction of manure should be so tested in tropical soils of Niger in order to circumvent when possible the high prices of commercial double super, tri-super phosphates and ammonium phosphate fertilizers. For the present time this item of commercial fertilizers for the "package of practices" should be purely optional--until research can furnish data for economic use to the small farmer who cannot presently afford to do so.

Adaptive research from the Niger Cereals Production Research Station at Maradi as presently proposed will rapidly evaluate the complete package of plant materials, cultural practices, soil fertility improvement, and pest control; and to measure the net yield increase against the costs of the collective inputs. When this evaluation is made it will be the basis for:

- seed multiplication activity
- field demonstrations for the farmers
- extension programs to encourage prompt adoption by cultivators of improvements they can understand and replicate on their own farms

In this manner the complete package of practices can be improved as additional knowledge flows from research.

4.1 The Socio-Communication Gap

This is a terminology that is indicative of the keystone to successful adoption of new methodology and technology which may be introduced to the peasant farmer for his benefit. Adapted agricultural research information must reach the farmer in a manner that will appeal to him and be acceptable to him as something that will definitely provide him and his family better income. If he is sufficiently motivated he may be a focal point for an important demonstration to induce others to accept the improved practices.

The real gap in communications lies in the chain of people and institutions through which research information must move to reach the farmer, and conversely the selection of key problems of a peasant farmer must move back up to the researchers. The cultural and sociological and language differences that we find in so many developing societies make this especially difficult. To better understand the difficulty involved in this exchange let us illustrate the communication process by the simple diagram below:

$$S \underset{M}{\overset{M}{\rightleftarrows}} C \underset{M}{\overset{M}{\rightleftarrows}} R$$

For communication the sender "S" sends a message "M" through channel "C" to receiver "R". There is an encoding of "M" by "S" and a decoding of "M" by "R". The channel "C" can well be the extension or the animation organization which should transfer the message so "R" can understand it. The latter process describes the language-cultural problem--the researcher must be able to speak the language (encode) that extension workers and farmers can understand (decode) and vice versa. The crucial point is that the researcher and farmer must be two-way, i.e. both must act both as sender and receiver. To do this successfully, each must be able to understand and appreciate the other's cultural outlook and capabilities. There usually exists an interruption in the channel "C" which is represented by an extension facility. Messages sent in either direction are not clear. This gap can be closed by choosing locations or specific sites where adaptive research can be combined with demonstration programs. This can be a research station or in a farmer's field. The type of programs that involve the farmer and his cultural community should be used to a much greater extent than they have been.

4.2 Animation and Extension

This is the GON functional arm that helps to assure that the two way communication above between the farmers and researchers remains open. This can be accomplished by general awareness meetings; talks; field visits; community gatherings; discussions of food needs, land and water problems; needs for equipment or fertilizers; seed problems, etc; demonstrations of new methods or techniques; plant protection needs discussion of planning activities to be carried out by local people themselves cooperatively or individually; discussions of cooperative employment; introduction of proper seeds, fertilizers or insecticides; field demonstrations in soil management; proper irrigation techniques; water use; conservation storage, marketing; animal traction; television and radio programs, etc.

Using innovative and well organized extension type activities is the strong arm of any program and is the principle means which will greatly accelerate the effective implementation of all elements of the Niamey Productivity Project programs.

4.3 Training

The trained manpower needed to properly implement the various program phases of the Niamey Productivity Project will be drawn into activity by the Ministry of Agriculture, Ministry of Rural Economy, Genie Rural and other subagencies, INRAN, IRFA, Niamey Department of Agriculture, UVCC, the Niamey Prefects Office, and others.

Before real implementation from an integrated program approach can move into action, training programs need to be instituted for the cadre and extension personnel who will carry the program into the

rural and village areas of the project area. Selection and training of these personnel should be commenced as soon as possible. It is only when a well trained cadre of personnel is ready to extend important agricultural information to the farmer and his rural communities that the project can expect to move progressively forward.

4.4 Alternative Food or Cash Crops

There may be several cash or food crops which could be introduced which would help to lend diversity and financial help to the farmers sagging economy. Several of these have been mentioned previously, but should be relisted with various other possibilities for introduction and trial by appropriate agencies. Outlined below under either dry farm areas or irrigated areas are some of these possibilities; some of which will show up in either listing:

Dry Farm Areas	Irrigated
buffel grass	winged beans
love grass	mung beans
mung beans	alfalfa
stylosanthes legume	cocoyams
wax gourd	safflower
Jojoba seed	pigeon or congo peas
safflower	yams
pigeon or congo peas	cashew nut
yams	plantain
sunflower	better adapted varieties of:
soybeans	melon
other adaptable range grasses	watermelon
adaptable drought resistant legumes	field corn
	potatoes (Irish or Idaho)
	sweet corn
	popcorn
	soybeans
	lima beans
	avadado
	grenadine
	mangosteen
	improved varieties:
	pineapple
	date palms
	tomatoes
	chick peas
	Pennisetum purpurum (forage)

5.0 Major Potentials and Restraints for Agricultural Production in the Dallol - Bas Fond Areas

The five main potentials of these areas are:

1. More readily available water in shallow wells and mares for exploitation for irrigation and animal use.

2. More fertile soils with better capacities to retain water for plant growth.

3. More people residing within the area.

4. Reasonably good roads of which the principal ones could be all-weather surfaced into Niamey.

5. Good market centers exist at Filingue and Balyeara.

An initial plan which is proposed to develop more efficient agricultural use by irrigation from the concrete shallow wells in the bas-fond areas, and in the Dallol Basso area is described in detail in the report of the CID (Consortium for International Development) irrigation specialist. This includes six different small scale alternate irrigation schemes involving methods for extracting water from wells and distributing and applying it to the land. Associated with it are planting schedules for each irrigation scheme prepared by the CID agronomist for recommended crops for both winter (November-April) dry season and summer (May-October) rainy season, and for perennial agricultural crops and established fruit crops. Seed requirements are included and new introductions for irrigated crops are detailed.

The principal restraint to develop the agriculture in these areas is the lack of an economical program to fully utilize the water from the mares which are substantial in area and need an integrated program for their development.

6.0 Applicability of the National Plant Protection Program to the Project

Technical backstopping of this organization into the project area should be part of the organizational structure. Its resources should be made available and programmed into the technical support structure both budgetwise to make spray materials, equipment and field personnel available when needed in any part of the project area. Consultation on a technical basis when the need arises in addition to plant protection demonstrations for farmers sponsored by extension workers should characterize their participation in the total project agricultural program.

7.0 Special Technical Input Assistance

Several special technical assistance imputs should be mentioned which could help to insure that technological packages required for the project area are developed. Technically accurate advice should be organized in sufficient detail and yet simple enough to be easily managed in project application.

This would account for technical inputs from the organizations outside of the GON implementing agencies in the project area.

Valuable assistance could be rendered by the National Cereals Program for planting materials of new seed and new agronomic techniques, to incorporporate into the package of practices to keep them current.

The technical resources of such international agencies and international research institutes such as IITA at Ibadan, Nigeria; ICRISAT (India), with liaison at Samaru, Nigeria; ORSTOM; FED; CIDA; UNDP, USAID, and others if needed, should be invited to contribute technical inputs into the project development and implementation of the program.

Appendix

Itinerary of E. Don Hansen, Agronomist, in Niger June 3-July 3, 1976 and for conferences and field trips:

June 5 - arrival in Niamey.

June 6 - field trip with John W. Wolfe, Craig Buxton, and John Holzman to Cuallam and return to Niamey the same day.

June 7-12 - Conferences with:

Adrien Everts - Prefect's office.
John Soldate - CARE
Moussa Saley - Directeur Department of Agriculture for Niger.
Abdou Hassan - Director of Hydrology.
M. Soulez - IRFA, (Fruits).
M. Demay - INRAN, Rice, Maize, Sorghum.
M. Valet - INRAN, Irrigation Division

June 11 - visit to the fruit nursery and experiment station at Gabougoura with John Wolfe under supervision of M. Soulez.

June 13 - field trip with John W. Wolfe accompanied by Robert Vandenbroele, translator-interpreter, to Filingue. Visited Market. Remained overnight.

June 14 - Short conference with Subprefect in Filingue. Conference with Filingue Arrondisement Department of Agriculture representative, Zakari Madougou. Visited dispensary to see work engaged in by PCV's Pat Watkins and Allyn Kay Writesel. Returned to Balyeara for conference with PCV Bud Rice and visited agricultural projects he works with at Ngala, nursery of CARE project at the Tabla Block, and at Elkama. Visited Market. Returned to Niamey.

June 15-June 28 - Conferences with:
Prefect Amadou Seyni.
Charles Sweet, REDSO.
Al Baron, USAID/RDC.
Jim Livingston, USAID
Louis Sisnel, "
Herb Miller, "
Sid Bliss, "
Dave Knowlton, SIM
Dr. Jim Conway, C.W.S. Director

June 29-June 30 - trip to Maradi.

July 3-4 - Accompanied by John W. Wolfe returned to the U.S.A.

Trip Report to Maradi

June 29-30, 1976

E. Don Hansen
Consultant Agronomist
Consortium for International Development

The principal observations and recommendations concerning the animal traction program developed over a period of over 20 years in the Maradi area by John Ockers have been already incorporated in the text of my main agronomic consultant report for the Niamey Productivity Project.

Other aspects of my short visit to Maradi, however, need to be summarized. Being able to take advantage of a SIMAIR flight both ways enabled me to spend more time in the field. It would have been possible for me to have covered more details had more readily available automobile transportation been at my disposal. I had to depend on the availability of transportation that the SIM organization had to offer, which was much appreciated. It was John Ocker who was mostly responsible for getting me around.

The highlight of the trip was seeing the donkey drawn cultivators and planters in operation on the SIM farm. It was very dry when I arrived and the millet fields were in dire need of moisture. That same evening a 11½ mm rain came and the next morning everyone was out planting peanuts and cultivating. The small cultivator that the donkeys pulled has a large duckfoot with a smaller one on each side for weeding. A young boy 11-14 years of age can easily handle the cultivator, with an even smaller boy leading the donkey down between the millet rows. The cultivator is light enough that if the blades of the duckfeet start to cut into the row he can easily lift them over the plants. This often happens when the rows are crooked as they are often inclined to be.

The little one row planters, donkey drawn, are an improved version of an original French imported model. There was much activity after the rain planting peanuts and there were six or seven donkey seeders in operation in various fields. Each planter is adjustable for depth and with several replaceable seed discs for planting different sized seeds. The principal difficulty is that trash tends to collect in front of both the furrow opener, and in front of the two small duckfoot tools behind used for furrow closing. A more pointed furrow opener and a different mechanical arrangement for furrow closure would be important modifications. The seeder is light in total weight and is easy for the donkey to pull.

The donkey traction equipment is generally well designed for cultivation of sandy soils for millet, sorghum, niebe and peanut production,

but would not perform as well in medium textured soils and would not be recommended in clayloam or clay soils.

The irrigation method used on the orchard and garden soils on the Sil farm is one of the types that could be adapted to the Dallol, bas fond garden soils of the Balyeara-Filingue area of the Niamey District. The distribution system from the well tank has been constructed of fired V-shaped tiles mortared together to form channels to deliver the water to orchard rows and to individual earth basins constructed around each tree. For garden crops such as pole beans, cucumbers, squash, melons and tomatoes they are using extensively the new development—pot irrigation—which uses round unglazed earthen pots 12-14 inches in diameter which are widely available and very cheap (10 cfa). The pot is buried to its neck in the soil and filled with clean water. Vegetable seeds are planted around it. Sufficient water seeps through the pourous walls of the pot into the root zone to maintain plant growth. Very little evaporation occurs because there is no standing surface water and grows vegetables to maturity with very little water (less than 2 cm/ha for an 85 day growing period).

Two visits were made to the INRAN research station during one of which I conferred with Moussa Adamou, a recently returned participant from Oklahoma State University in plant breeding. He is working on millet and sorghum, and recently returned from a very successful conference on foodgrain and legume production of new varieties at the International Institute of Agriculture (IITA) at Ibadan, Nigeria. He will be concentrating his efforts on breeding and production of promising millet ans sorghum varieties. On the other visit I conferred with a new expatriate staff member, Michael Ghery, who lately transferred to Maradi from Senegal. He is experienced in genetic research for peanuts and will be using planting material from Upper Volta, Senegal and U.S.A. Field activity was seen in bullock drawn one row planters seeding peanuts and a new Massey-Harris 185 tractor with an 8 row hydraulically mounted EBRA (French) seeder, which was also planting a peanut variety for seed multiplication.

This station appears to be well staffed and equipped for dry land research on the principal food grain crops, Millet, sorghum, and niebe and peanuts for an oil crop. There seems to be sufficient land (300 ha approximately) for trials of new crops that could be introduced.

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3. Project Review Papes - Niamey Department Productivity and Development Project (Project #638-11- -) 12/1/75.

4. Pro-Ag - Niger Cereals Production - 1/17/75 USAID

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8. Report on Project Proposal: "Niger National Cereals Productivity Program, Applied Research Component, prepared by H. B. Sprague, Consultant.

9. Etude Pédologique dans La Vallée du Dallol Bosso "Etude de Reconnaissance" - SCETHA - Société Général Des Techniques Hydro-Agricoles. Paris, Juillet, 1963.

10. The Politics of Natural Disasters. The Case of the Sahel Drought, edited by Michael H. Ghantz. Praeger Publishers. New York, Washington, London. 1976. (340) pp.

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Glossary of Acronyms and Abbreviations

CFJA - Young Farmer's Training Center (N'Dounga)
CID - Consortium for International Development (U.S.A.)
CIAT - International Center for Tropical Agriculture (Centro Internacional de Agricultura Tropical) (Mexico)
CIDA - Canadian International Development Agency
CIMMYT - International Maize and Wheat Improvement Center (Centro Internacional de Mejoramiento de Maiz y Trigo) (Mexico)
CIP - International Potato Center (Centro Internacional de Papa) (Peru)
CWA - Central West African Region
FAO - Food and Agricultural Organization of the United Nations, (Rome)
FED -
GON - Government of Niger
GTZ - German International Cooperative (Bonne, Germany)
IAR - Institute for Agricultural Research, Ahmadu Bello University, (Zaria, Nigeria)
ICRISAT - International Crops Research Institute for the Semi-Arid Tropics, (Hyderabad, India)
IBRD - (World Bank) International Bank for Reconstruction and Development, (Washington D.C.)
IFAC - Institut Français de Recherches Fruitières Outre-Mer (France)
IITA - International Institute of Tropical Agriculture (Ibadan, Nigeria)
INRAN - Institut National de Recherches Agronomiques du Niger
IRAT - Institut de Recherches Agronomiques Tropicales et des Cultures Vivieres (French)
IRFA - Institut de Recherche de Fruit Tropicale et Agrumes (Niger)
IRRI - International Rice Research Institute (Philippines)
NCFP - Niger Cereals Production Project
NPP - Niamey Productivity Project (Niamey Department)
OFEDES - Office of Underground Water (Niger)
SMC - Seed Multiplication Center
UNCC - Union Nigerien de Credit et Cooperative (Niger)

ANNEX B

June 1976

Report of the Irrigation Scientist, John W. Wolfe
Assigned to the Niamey Productivity Project for
the Period June 3 to July 4, 1976.
Cropping plans were prepared by E. Don Hansen.

This report is in six sections corresponding to the six tasks outlined in the Statement of Work, followed by a section which summarizes or makes general comments.

Section I

Categorize the various conditions found in the marshland and bas fond areas of the project zone and determine their potential as sources of water for agricultural production.

Field inspection included the mare area south of Guallam and the dallol region from south of Baleyara to Filingue. Additional information was obtained from officials of Genie Rural, Hydrology Service, OFEDES, Department of Agriculture INRAN and other agencies and individuals.

I have concluded, as others have, that these water sources do represent a significant potential for development for irrigation. I like the philosophy of the farmers in the region who have already begun some irrigation. That is, they are developing areas where water is available at or close to the surface and where the soil has productive potential. It seems logical that the first irrigation research trials be concentrated in these areas because they should have there the greatest chance for financial success. Experience gained here can serve as a basis for evaluating sites that would be more expensive to develop. Using this line of reasoning and what information I have obtained, I would categorize these areas in the order in which I think they should be studied for development as follows:

1. Bas fonds and mares with a permanent shallow water table less than 5 m. from the ground surface, and with rather smooth, level, potentially productive overlying land.

2. Sites similar to No. 1 except that the land to be irrigated is undulating, or it slopes up noticeably from the surface of a mare.

3. Mares that retain some water long enough to mature a crop when its water is lifted onto the adjacent land.

4. Bas fonds and dallols with a permanent water table at a depth greater than 5 meters from the land surface during the dry season, but which do have suitable aquifers within reach, using economical but satisfactory methods of well construction.

5. Mares that are not fed by a water table and do not have sufficient depth to retain water long enough to mature a crop.

Surely there will be some useable sites that do not fit any of these categories. Those with poor soil should be set aside for now. The arbitrary 5 meter depth was chosen as the maximum practical suction lift for centrifugal pumps resting on the ground surface. Hand pumps at the surface can lift 6 or 7 meters, and of course for a higher cost the cylinder can be placed in the well for a greater lift. Whatever the pumping method used, including pulling buckets, the cost and/or effort increases significantly below these depths.Of course, there are available in developed countries efficient deep well turbine irrigation pumps capable of developing rather large quantities of water from deeper depths, but the deep well type of pump is considerably more expensive than the horizontal centrifugal adapted to shallow wells and mares. Also, the cost for the well, pump, and power increase with depth. For these reasons the first research on methods of development are recommended only for the areas with a permanent water table close to the surface. The others could follow if the shallow developments prove successful.

This report makes no attempt to estimate the total water resources in these areas, and the corresponding area of land that could ultimately be developed. Such an estimate could be made, but it would either be very costly or of questionable accuracy or both. Instead, I recommend keeping a permanent record of weekly readings of the level in at least four key wells in the Dallol Basso, and perhaps one or two in the Ouallam area if early development is desired there. Then if the water levels recede at a rate predictable from the increased area of land irrigated each year, a projection could perhaps be made of the effect of future developments, assuming that the lowering would cease if the irrigation ceased to increase. At a later date if the situation warranted, a hydrologic analysis could be made to estimate the maximum safe sustained yield of the Dallol Basso and perhaps smaller hydrologic units. By then there would be more well information to aid in characterizing the aquifer.

To collect data that will be needed for possible future hydrologic analyses, including evapotranspiration estimates, a U.S. Weather Bureau type evaporation station is recommended for installation near Baleyara, and a second one near Bankoukou would be desirable. The measurements needed are rainfall, pan evaporation, maximum and minimum temperature and wind velocity. About four wet bulb and dry bulb temperature readings per day would also be helpful.

Of the different types of marshlands and bas fonds, the least information was obtained on category no. 5, the mares without a shallow water table. They are not recommended for experimental development during the first two years because apparently a reservoir would have to be excavated with adequate depth, and protected from drifting sand, before a water distribution scheme could be established.

Section II

Assess the Current Research and Experimentation Regarding the Development of Irrigation Systems for these Areas.

There are a few efforts underway to develop methods, systems, or procedures for irrigating these areas. Most of them are striving to use the minimum possible imported material and equipment. Pertinent features of some of these are described below.

The CARE project near Baleyara has tried several ideas with varying degrees of success. A fence surrounding the plot area was built from treated wooden posts, steel corner posts, and four barbed wires plus wire mesh. Behind it a living fence was planted to take over when this one fell victim to the termites. So far this fence looks good except for cost and the fact that most of it is imported. The large concrete wells constructed by OFEDES are of relatively high quality. For those that go 10 m or more, they are probably not overdesigned. Possibly the shallower wells could be built with a bit less concrete, but at the start, it is not always certain how deep they must go, so their system is probably the best. If it is known in advance that a well will only be used for dipping by hand, some money could be saved by (a) not requiring that it be deepened until it will yield 40 m^3 per hour, and (b) reducing the diameter slightly, say to 1 m. The last point may not be practical if there must be room for several irrigators at once . The OFEDES official testified that there had been casing failures, both due to lack of structural strength and to misalignment due to cavities caused by pulling sand into the well. The first type of failure suggests that the casings are not overdesigned, or that more rigid quality control on the concrete mix is required, or both. The second type of failure can only be avoided if they are able to guess in advance the size and gradation of the particles in the aquifer. They could imbed pieces of well screen in the walls of the casing with openings small enough to hold back about 50% of the particles (in this case, sand). They employ this technique already, but perhaps haven't always selected the slot size small enough.

Each well in this project was supposed to cover two hectares but it is not possible to draw that much water by local methods, including the deleu. Some of the land is undulating, and no adequate method had been developed so far to smooth it. Apparently at least one attempt has been made to scrape off the humps with a wooden scraper behind an animal.

Testimony indicates that the fruits and vegetables were thoroughly enjoyed. However, no evidence of adopting these techniques by private enterprise was observed. Apparently the investment required for the well and fence are too great for the small area that can be irrigated.

The use of a deleu has been introduced in this area, but so far it has not been adopted Bud Rice, PCV at Baleyara says that he has filled a tank holding 4 m^3 easily in one half hour with his camel but Genie Rural testified that 3-4 m^3 per hour is a better estimate of its capacity. The deleu consists of a bag that is lowered, filled, lifted and dumped by walking an animal back and forth at the end of a rope. A shadoof has also been demonstrated, but it has even less capacity. Pulling buckets by hand is the usual way. A capacity of 4 m^3/hr operating 12 hours per day will serve only about 1/3 hectare of a crop like alfalfa in hot weather, even if very little water is wasted. Thus, even the best of these methods for extracting water from wells permits only a very small parcel of land to be irrigated from each well.

We saw little evidence of efficient distribution systems for water after it had been withdrawn from a well or mare. At a German-sponsored project near Ouallam there were some small reasonably level basins around each seedling citrus, but at the same station the rows of vegetables ran up and down the slope instead of on the contour. It seems to me that wherever the soil has enough clay to permit, short level furrows laid out exactly on the contour with the vegetables planted on the bed between would save more water. Basins that have been precisely leveled would be good for forage crops, cereals, fruit trees, and other crops. Any land smoothing that could be done prior to laying out a system would permit the contour furrows to be more nearly parallel and perhaps longer. By contrast, at the INRAN experiment station for fruit trees at Niamey, there were sprinkler systems that appeared to be operating efficiently, and individual level basins constructed around many of the mature trees. They appeared to be irrigating with little waste of water.

The people responsible for these projects all seem to be aware that something besides a ditch in sand is needed to transport the water to the furrows and basins after it has been lifted to the ground surface. We saw no such facility except hand-carried buckets. Concrete-lined ditches

have been proposed, but until such time as the fields have been accurately graded, and some idea is obtained on the permissable length of furrows and basins, such a ditch might prove to be of little value. Some method of extracting the water from the ditch to supply the furrows and basins would also be necessary, such as siphon tubes.

In summary, we have not seen any irrigation schemes being tried at the farm level which offer much hope of being adopted without financial aid from outside. In my opinion, a successful scheme would have to be either (a) so simple that the cost of the well and fencing would not prohibit the development of a single, small, profitable garden plot, or (b) so large that the capability of an expensive well would be fully utilized by an efficient irrigation method. In the latter case, it is assumed that a local entrepreneur could borrow money to develop a system, and sell his produce to his neighbors as cheaply as they can grow it themselves. Modern pumps and equipment would be required.

Section III

Determine What Types of Low-Cost Systems are Appropriate for Each of the Various Bas Fond and Marshland Conditions Found in the Project Zone and the Requirements for Their Development

This section is the most detailed of the report. It contains plans for the development of six irrigated plots on a trial basis, hoping that the most successful ideas can be used as a basis for development in the second phase.

All bills of material must be regarded as tentative, subject to review and recommendations, and finally subject to review and revision by me or someone else who has had opportunity to investigate the availability in the U.S. and expected performance characteristics of certain of the items when subjected to the Nigerien environment. Since I am more acquainted with American products, I would recommend that certain key items be obtained in the U.S., if time permits, and in some cases a particular item may be specified by part number and supplier to insure quality.

No detail for fencing has been included. More research is needed to find a satisfactory fence that can be built for a lower cost. Perhaps the manufacturers of fencing materials in the U.S. could be invited to suggest a minimum design that would be expendible after the living fence was established, or conversely, would be fully reusable for another plot after this period, and then another, etc. Electric fence has been suggested (and scoffed at for fear it would not be kept hot). I am inclined to share this fear. It is suggested that fencing for these irrigation trials be conserved by grouping the plots together into not

more than two or three enclosures. For example, the three plots using a deleu (Schemes No. 2, 3 and 4) could be grouped together. The sprinkler plot Scheme No. 5, could be by itself or beside any of the others. The three plots using hand pumps could be grouped together, but I recommend instead that the drip irrigation plot for orchards be established within the experiment station at Bankoukou (part of Scheme No. 6) The other drip plot from Scheme No. 6 for vegetables could be omitted, or could be included in the enclosure with Scheme No. 1. If all six schemes are approved, and if two suitable sites can be located in the Dallol Basso, I would suggest that the sprinkler system be enclosed by itself and that all other plots except the drip system for orchards be included in the other enclosure. The two areas would be about the same size, and could even be the same shape.

The site selection for these plots should insure that the root zone has adequate depth, that the salt in the soil is not severely limiting and certainly not more than the average of other soils in the area, and that the texture is neither so sandy that good crops cannot be grown nor contains so much clay and/or sodium salts that infiltration will be limiting. The sprinkler site can be undulating, but all other plots require land as smooth as possible, although a gentle slope is desirable, say 1% or less. If a smooth site cannot be found, then the humps should be scraped and spread, perhaps with a locally fashioned board behind an animal. An indication of soil texture, including changes with depth, should be obtained. Field capacity and wilting point would be desirable if they can be obtained. A topographic map consisting of elevations on a 25 m grid, made after any smoothing has taken place, is recommended as an aid to selecting the areas assigned to furrows and borders, and to discover which direction the contours will take.

Water quality at the selected sites should also be obtained, unless sufficient information is already available from existing wells in the vicinity. Total soluble salts, plus the quantity of each of the principal anions and cations should be known from which a classification of the water can be made. A test for boron should be included, since some plants, especially citrus, have a tolerance less than one part per million.

The planting schedules for all irrigation schemes for both winter (dry season) and summer (rainy season) plantings are to be flexible. The suggested crops are to be used if possible, but others which would produce better or would be more desirable or more economical may be substituted. Lengths of growing periods may differ on either end of

the winter or summer seasons but these should be adjusted as necessary to dovetail in. Many crops of short growing season vegetable crops can be grown and harvested during the year. It may also be possible to grow three crops of maize or short season beans--where day length differences are not a factor.

The important thing to remember is that the well water should be available the year around which should allow multiple cropping. Regular interval irrigation can occur during the dry season with only supplemental irrigation as necessary during the summer rainy season.

Varieties recommended are those which appear to yield best for the particular growing season, but as others are found which produce better they should be substituted.

Perennial crops such as fruits, alfalfa and perennial forage grasses would be irrigated the year around as needed.

Short season crops such as lettuce, radishes, turnips, etc., can be planted and harvested many times during the year.

The idea of planting irrigated alfalfa and perennial forage grasses on these schemes is to raise the production of supplemental livestock feed which is often necessary during the long droughty dry seasons--or as an emergency against real Sahelian drought. Several cuttings can be made during the year--up to 8 or 10--the cuttings dried as hay and stacked or baled for later use. Silage should also be considered.

It is difficult to assess and budget for all the seed needs for these projects for a two year period. Many of the requirements can be met locally. Source of supply for the variety of alfalfa grown at Agadez should be initially utilized. A Tunisian variety, Badrie, hard red wheat, should be initially planted with the same seed source being used. Most of the vegetable seeds can be secured from French sources for the varieties that can presently be recommended here. Nigeria should be a good source of supply for tomato onion, okra and eggplant seeds which are not available in Niger.

A seed budget of $1,000 should be sufficient for the first phase of the irrigation trial plots. Both seed and fertilizer requirements should be a contribution by GON. Fertilizer and seed requirements should be more closely calculated after selection of the final irrigation schemes are made.

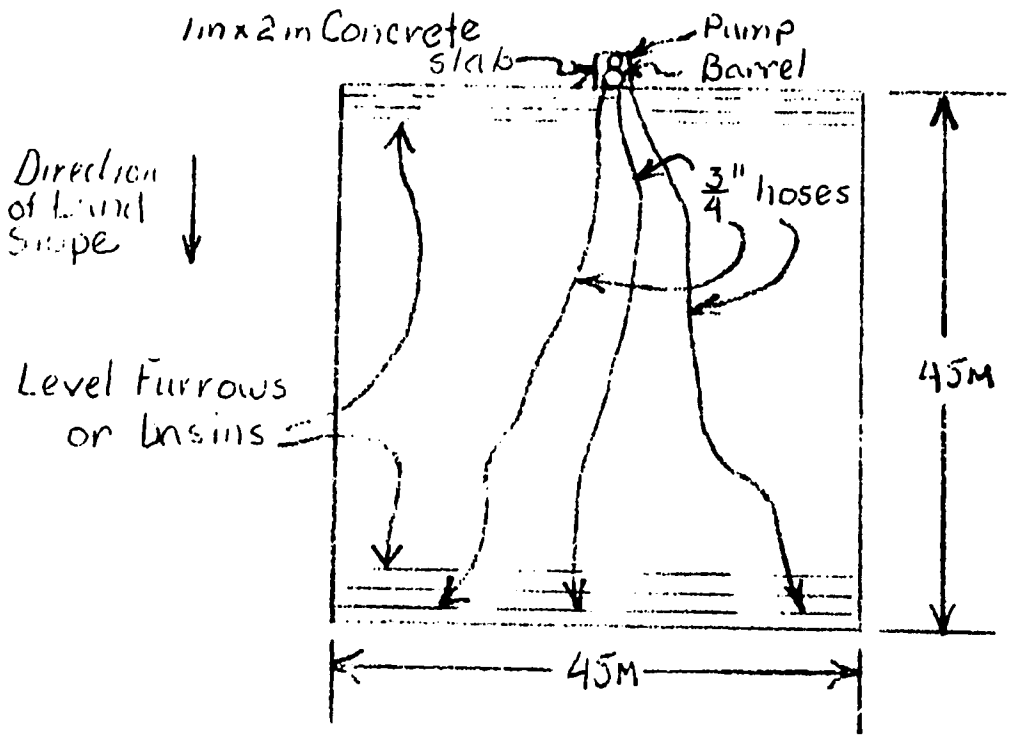
Irrigation Scheme No. 1

This scheme is an attempt to develop a less expensive well that may be within the reach of a small farmer who can borrow money. It consists of a 1-1/4 inch sand point driven into the aquifer. It requires that the water table be located in a suitable aquifer at a depth not to exceed 5m below ground surface, and that the level durir., pumping never exceed 5.2m below the surface. It assumes that a shallow-well pump with all working parts above the ground can be mounted at a convenient height at the top of the 1-1/4 inch driven pipe and produce at least 5 gallons per minute (gpm) or 0.32 liters per second (lps) with continuous pumping. The well and pump are to be located at the center of the upper edge of a smooth piece of irrigable land about 45m X 45m. If less than 0.32 lps are produced, the area must be proportionately smaller. The water is to be distributed to level furrows through three flexible hoses, each 3/4 inch in diameter and 165 feet (50m) long. All three hoses should be operated simultaneously with the valves wide open if adequate water is to be supplied to this much land during a period of peak use.

For the hoses to deliver sufficient water, they must tap into the bottom of a container that is at least 80 or 90 cm high and kept full of water.

Irrigation Scheme No. 1

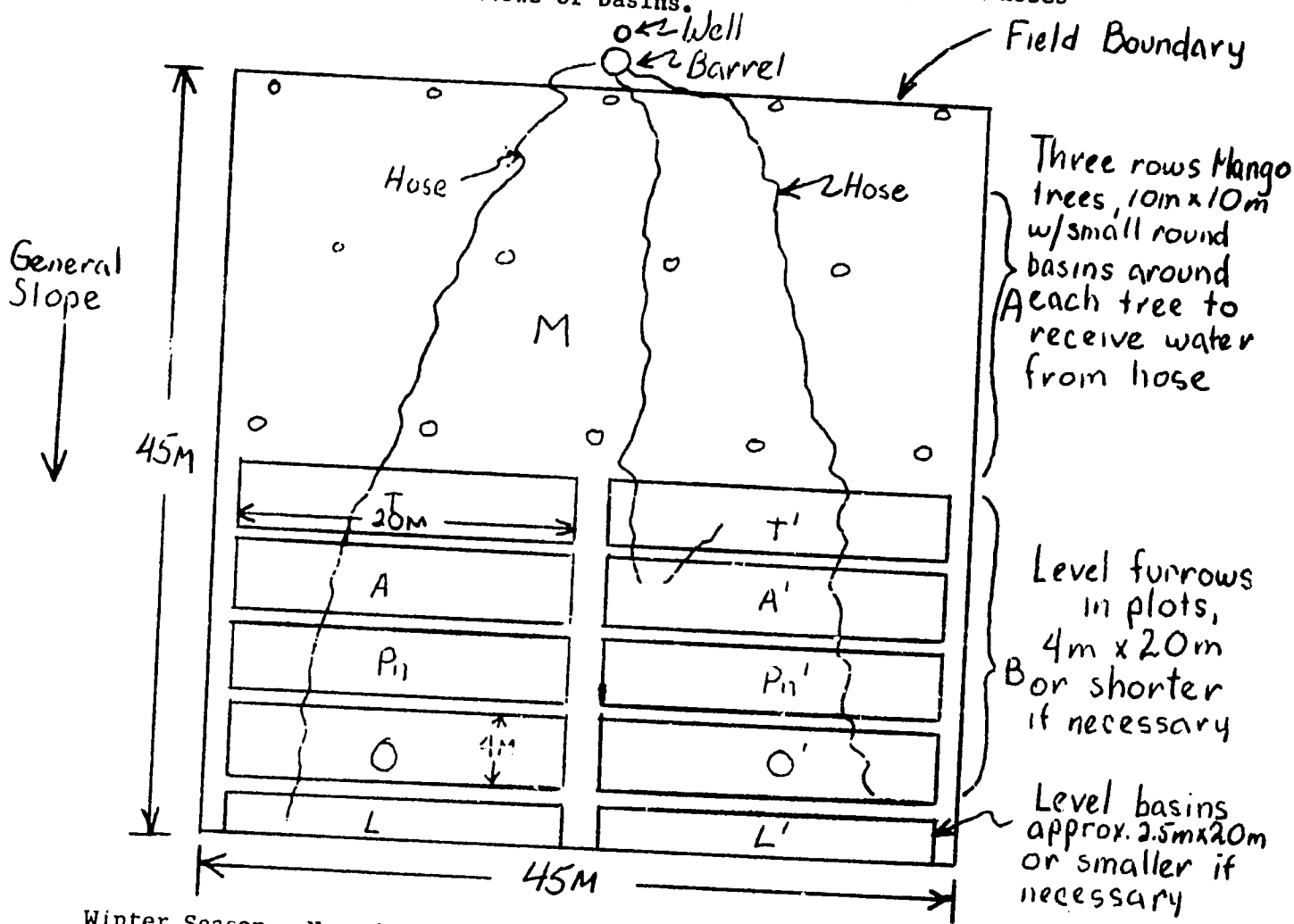
Hand-pumped Driven Well with Garden Hoses



1. Shallow driven well with 1-1/4" pipe, sand point, pitcher pump.
2. Barrel to collect water, with hose bibs attached at the bottom.
3. Three 3/4" hoses each 175 ft (53m) long.
4. Level furrows or level basins.
5. Small within-row furrows for irrigating seedlings.
6. 5 gpm (0.3155 lps) is assumed to be available from pump up to 15 hrs every day.
7. Part of plot may be in seedlings, part in mature plants at any one time.
8. Plot selected on gently sloping land, say 1%.

Planting Guides for Irrigation Scheme No. 1

Irrigation: delivered by hand pumped driven well with garden hoses long enough to reach furrows or basins.



Winter Season - November-April

Hectares	Section	Crop	Variety	Type planting / Type Irrigation	Planting Distance (cm)
0.016	T,T[1]	Tomate(Tomato)	Ronita	Level furrow	40X80
0.016	A,A[1]	Aubergine (Eggplant)	Violet (local) longue native	" "	60X70
0.016	Pn,Pn[1]	Piment(Hot peppers)	de Cayenne (local)	" "	60X70
0.016	O,O[1]	Oignon(Onion)	Local(Nigerian variety)	" "	15X20
0.010	L,L[1]	Laitue(lettuce)	Batavia Blonde de Paris	Level basin	10X25
0.1 ha	M	Mangier (Mango)	(Budded)/Hayden/ Davis/Julie	Individual basin	10mX10m

Annually: Section A (November-April)

Season: Winter Season - Section B as outlined above.
Summer Season (May-October) - Section B
Fallow (May-June)
Green manure crop (July-October)

Otherwise there will be insufficient head to deliver adequate water through them. When the full length of hose is not needed, one or more sections should be disconnected.

The plot selected should be relatively smooth and gently sloping. The smooth feature will permit levelfurrows to be nearly parallel. Ordinary hose bibs mounted near the bottom of the barrel will serve to regulate the quantity of flow to the hoses, but if the pump can keep up these valves should be left wide open.

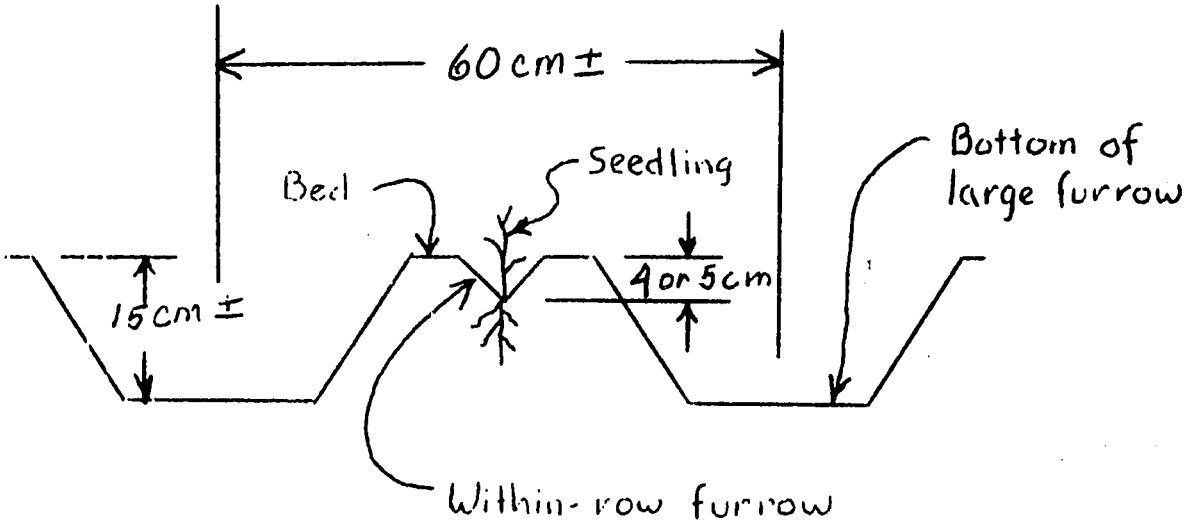
Ideally, furrows should be constructed exactly on a contour with a tolerance of, say, $\pm$ 1 cm. For very sandy soils they should be placed quite close together, for example 60 cm on center, and the bottom of the furrow should be as wide and as level as practical for the particular crop. The best length of the furrow will be determined by the rate of intake of the soil, and by the smoothness of the land. Longer lengths tend to become less parallel when the land has not been accurately graded. Soils with a high intake rate tend to require shorter furrows, because the water should reach the length of the furrow (wet the entire furrow bottom) in no more than 1/5 of the total time elapsed between the start of irrigation of a particular furrow and the disappearance of water from that furrow after the water supply has been shut off. Trial and error is required to determine the best length. Any furrow length can be cut in half by constructing a small dam in the center.

The most popular depths for furrows range from 10 to 20 cm, and will depend on both soil and crop. Again, a trial and error procedure will help select a depth within this range. The surface of the bed between furrows should also be made as level as possible to insure a uniform penetration of water to the soil in the bed. Some kind of heavy cloth or other material may have to be attached to the end of a hose to avoid causing a hole to be scoured by the stream of water. A typical irrigation can be completed by filling the furrows to a depth of 5 to 10 cm and allowing it to be absorbed. This will vary with soil and crop.

When a new row crop is being established from seeds, the practice of within-row irrigation will save water. It consists of constructing a shallow furrow on top of the bed and planting the seeds in that furrow. In dry weather, a pre-irrigation will be required in the small furrow on the bed before the seeds are planted. This is usually adequate for germin tion but on sandy soil it may not. Quite likely the next two or three irrigations can be made in the small furrows also, while the plants are small and the roots do not extend below the bottom of the big furrows. Later the large furrows must be used to apply an adequate irrigation. The sketch on the next page shows a cross-section of such a furrow system, with typical dimensions. The actual dimensions will vary with soil and crop, and must be determined by experience. The method does demand, when used with level furrows, that the top of the bed is also level. For Scheme No. 1, however, the hoses offer the alternative of moving along the within-row furrow with a small stream of water.

For crops that are not usually classed as row crops, level basins are suggested. Like the furrows, these must also be carefully leveled over their entire surface, ideally to $\pm$ 1 or 2 cm They can be any size or shape providing the 1/5 rule described above for furrows is complied with. Otherwise too much water will be absorbed by the soil at the end where the water is introduced, by the time enough water is absorbed at the other end When a small stream like the one proposed for Scheme No. 1 must be used on sandy soil, it is not certain that a large enough basin could be used to be practical. However, the method has been very successfully used in other parts of the world on basins as much as 10-15 m wide and more than 200 m long. For a basin like this a large stream of water from a canal or pump must be available, as well as soil with a fairly low intake rate. This gross example is cited only to emphasize that the method of level borders and level furrows is becoming recognized world-wide as a very efficient method of gravity irrigation so long as the 1/5 rule is followed. Crops best suited to level basins are forage, cereals, and other close-growing crops. The method is also used advantageously by constructing an individual basin around the base of each fruit tree. In fact row crops can be grown in basins if desired.

Furrow System - Cross Section



Tentative Bill of Imported Materials for Scheme No. 1:

Estimated Cost in US	Quantity	Size	Item
$ 40	1 pc	1-1/4" dia.	Standard galvanized steel pipe, 21 ft. long.
100	1 pc	1-1/4" dia.	Sand point, with 0.010 inch (0.254 mm) perforations and containing a total area of perforations (open area) of at least 50 square cm (8 sq. in.).
30	1 pc		Driver, consisting of a section of pipe about 90-100 cm long, just large enough to slip over a 1-1/4 inch pipe cap, with a weighted drive cap at one end.
5	3 pc	1-1/4"	Pipe cap, galvanized to protect pipe threads while driving well
50	1 pc		Pitcher pump if available, otherwise a diaphragm pump, capable of delivering 5 gpm (0.32 lps) from a depth of 5.2 m (17 ft.)
1	1 pc		Small roll of teflon tape
40	4 pc	3/4"	Hose bib including valve, plus necessary nuts, gaskets, washers, etc., for mounting these through a drilled hole in a steel barrel.
80	500 ft.	3/4"	Nylon-reinforced plastic garden hose in 50 ft. sections. Sections must be equipped with standard hose connections for quick coupling.
18	100 ft.	3/4"	Nylon-reinforced plastic garden hose in 25 ft. sections. Extra rubber gaskets for couplings on hoses listed above.

Estimated Cost in US	Quantity	Size	Item
$ 10	2 gross		Extra rubber gaskets for couplings on hoses listed above.
10	10 pc		Repair fittings that can re-connect a garden hose that has become severed.
50	2 pc		Replacement parts for each component of the hand pump listed above that is subject to wear or deterioration from continuous use while exposed to hot desert environment. If any of these components are much more likely to fail than others, the quantity supplied should be doubled.
10	1 pc		Hack saw w/extra blades
30	2 pc		18-inch pipe wrench.
25	1 pc	1-1/4"	Pipe die w/handle
10	1 pc	1"	Drill bit equipped with brace for hand operation (for drilling holes in steel barrel to mount hose bibs).

$509 total ($404 without tools)

The total cost of imported materials, if purchased in the US, is roughly estimated as $509. However, $105 of that is for tools that will be required for installation. The second and third wells (irrigation scheme No. 6) should cost only about $400 each, plus shipping since the same tools can be used. Included in this cost are extra hose lengths and replacements and repair parts believed adequate for a five year period. On-site costs will include a used 55 gal. or smaller barrel (about $6) and a 1X2 m. concrete slab. Except for the fence, the only other input that would be required of a farm family making this installation would be the labor of construction, land smoothing, and farm operations. Their reward would be the produce from 0.2 hectare.

An installation of this kind could easily last 20 years or more. Presumably the hoses will have to be replaced after five years in the sun. Actually, they will receive considerable shade from the luxuriant crops. Only the best quality hose with nylon reinforcement should be selected. Pump leathers will need to be replaced more frequently, perhaps depending on the number of times they are permitted to dry out. A sun shade erected over the pump would likely extend the life of the leathers and the pump operator as well. Assuming a pitcher pump with at least a 5 gpm capacity can be obtained, replacement of the pump leathers and an occasional repair of a cut hose will be the only maintenance anticipated on the equipment over a period of many years.

As with the other five schemes, this irrigation devebpment would save both soil and water. The contour furrows and level basins will hold all the rain that falls if dike heights and furrow depths are maintained at about 15 cm. If there is no runoff, there is essentially no erosion. If the site were located where runoff from the area just above would tend to fill the upper furrow to overflowing, a diversion dike across the upper edge of the plot would protect it. No drain ge problem can be created, since the water supply is from the shallow water table.

Irrigation Scheme No. 2

This scheme, and also No. 3, are designed to use materials and skills that are mostly available here or can be developed here. Of course, fencing will likely still have to be imported, and perhaps the valves for the concrete tank. Materials for the deleu are presumed available and are not detailed in this report. The scheme is labor intensive, relying on carrying water by hand from small constructed lined basins to furrows or irrigation basins. The only proposed developments beyond the stage observed on the CARE project are (1) to obtain the maximum possible rate of delivery from a deleu, and (2) to deliver the water through a small lined ditch or flume to four constructed boxes or basins, each located in the center of the 1/4 of the tract area to be irrigated by it.

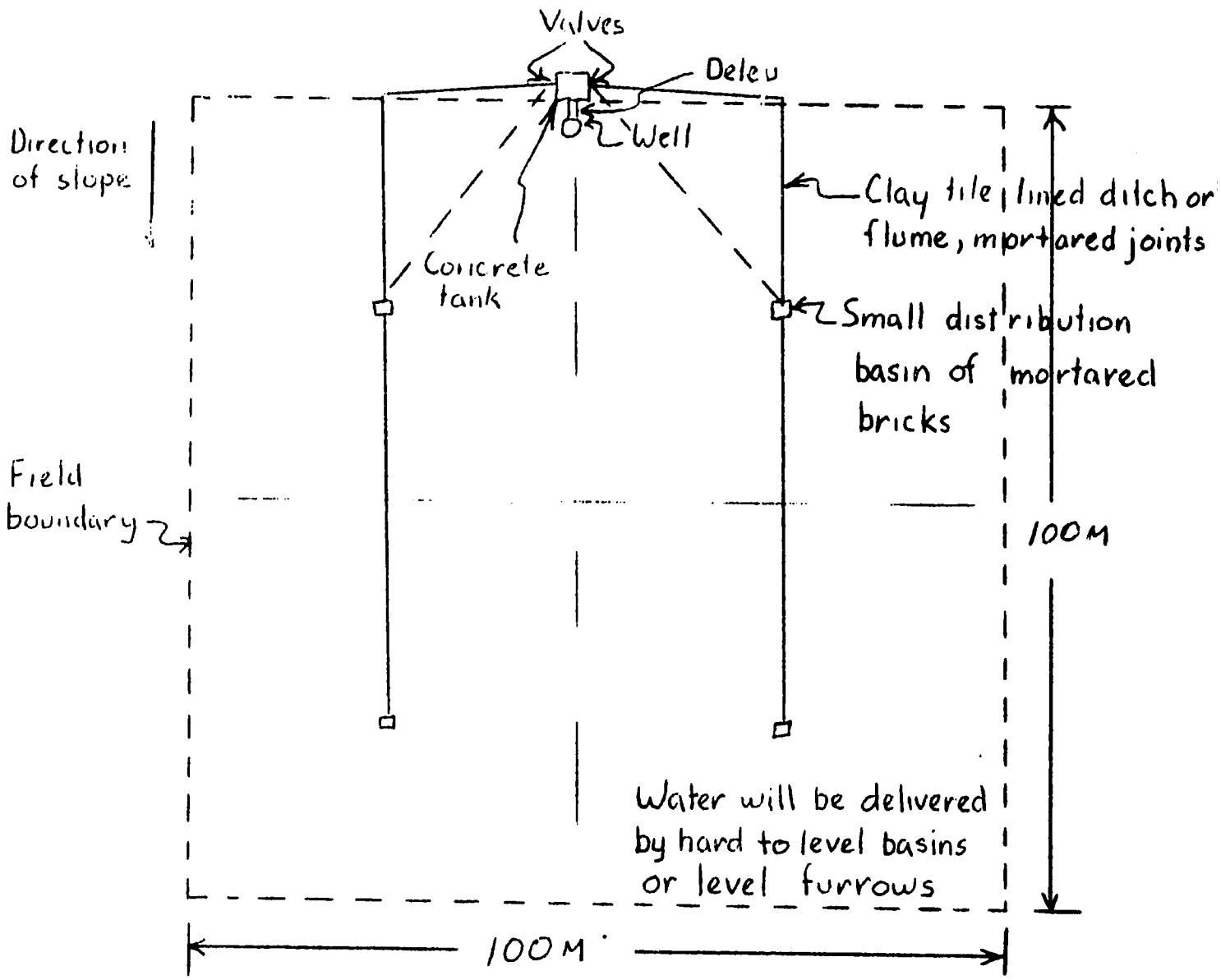
Mr. Bud Price, PCV at Baleyara, says he has used a deleu to fill a $4m^3$ concrete tank within a 30 minute period, using his camel for power and has done it very easily. It has been my hope that improvements could be made to increase this rate to $11m^3$ per hour and continued for 12 hours per day. With this in mind, the size of tract for each of Schemes 2, 3 and 4 was selected as one hectare. If a deleu will yield only 3 or $4m^3$ per hour, as estimated by officials at Genie Rural, then probably not more than 1/4 or 1/3 of the hectare can be in crop during the hot periods of peak use, assuming each crop is at a growth stage which demands the maximum water at that time. At other times of the year, or if part of the area is in immature row crops a bit more of the area can be planted. One observer from Agadez estimated that one deleu serves 1/2 hectare when lifting water 8 meters. The lift at Baleyara and Bankoukou is expected to be only about half that much.

The scheme includes a shallow concrete well to be constructed by OFEDES, an above-ground concrete tank 2mX2mX1m, and a deleu that hopefully will be assembled by, or at least with the help of, the local farmers. The concrete tank should have two 2-inch gate valves, or equivalent, mounted at a level where they could each drain the tank, and located on two opposite sides of the tank as shown in the sketch. This much of the facility can be built according to the designs of those in the CARE project.

The distribution system will be surface ditches lined with burned clay tile sections. Some experience already exists here of making short sections of burned clay in the shape of the inside layer of a semi-circular ditch. These sections are designed larger at one end so they fit snugly together, one inside the other. A thin layer of mortar will likely be required at the joint to insure no leakage. One idea for constructing a mold for making these tiles is attached. It was furnished to me by Mr. Arian Everts. The mold would form tile sections 30 cm long and 13 to 16 cm wide. Perhaps with further experience the dimensions could be increased, providing there is not too much tendency for breakage.

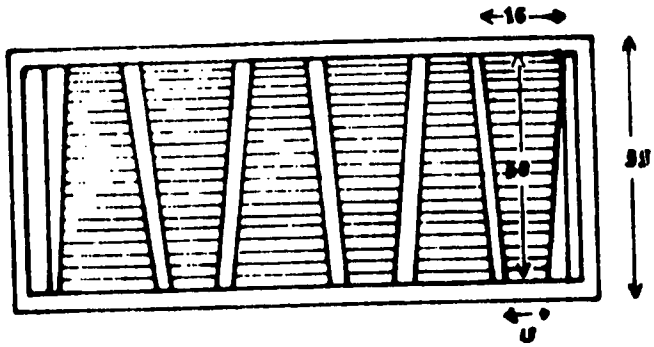
Irrigation Scheme No. 2

Concrete Well, Deleu, Concrete Tank, File Flumes,
Four Distribution Basins
Water Application by Hand



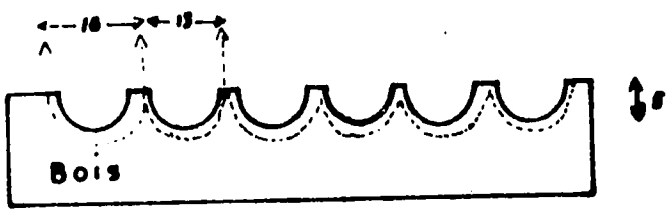
Moule pour Tuile.

Top -View- Vue en dessus



Parties creuses, en ciment ou platre.
Hollow parts in cement

Front-view - Vue en face



N.B- Le bois dépasse le ciment d'un centimètre exact, afin de permettre la formation facile des tuiles d'un centimètre de épaisseur, avec l'aide d'un rouleau en bois

N.B- The wooden front exceeds the cement, thus forming a rim of one centimeter high; this for easy construction of one centimeter thick tiles with a rounded wooden tool.

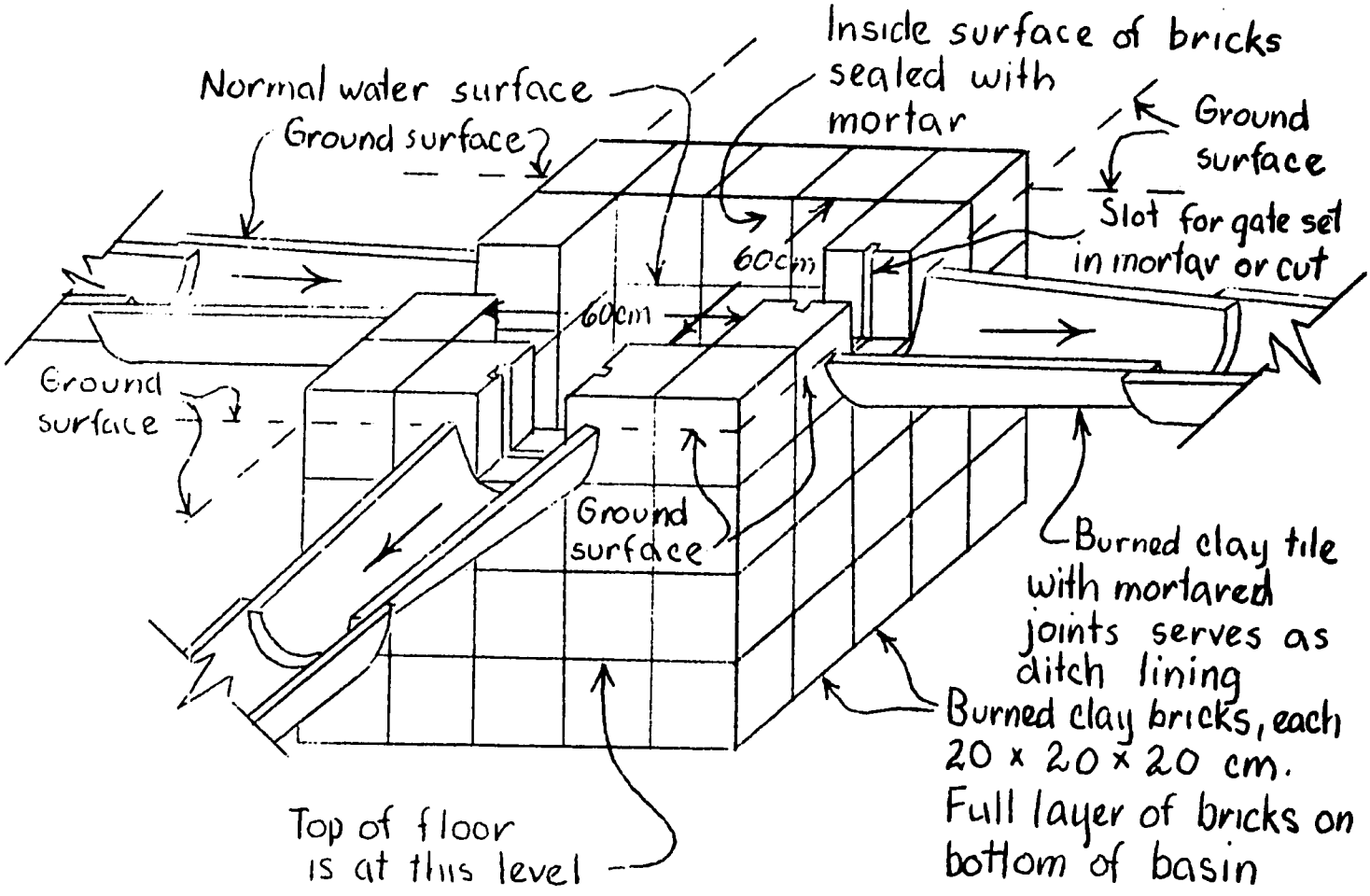
The attached sketch of the plot layout shows these lined ditches going two directions from the tank, then proceeding directly down the slope to small constructed boxes or basins. After the site is selected for this plot and the slope of the land is known, the required size of these ditches can be calculated. They should each have enough capacity to carry half of the total capacity of the deleu, which hopefully will be $11m^3$ per hour, or $5.5m^3$ per hour. The last section of each ditch will need only half this much capacity theoretically, since it will be serving an area only half as large but it may be more convenient to make it the same size. The cost of the first section of each ditch likely could be reduced by cutting it diagonally across to the first distribution box, as shown by the dashed lines. This change would increase the grade of the ditch and shorten it, but it would cut up the plots in an inconvenient way. It is recommended therefore that the location be as shown with the solid lines, and that that portion of the ditch be placed on a uniform grade by cutting and/or filling.

The four distribution boxes can be built in some fashion, perhaps similar to that shown in the attached sketch. The one shown would have a reservoir capacity 60 cm X 60 cm X 40 cm. The walls of the box extend one layer of bricks above the normal water level, and the floor consists of one solid layer of bricks below the reservoir. The bricks are shown as a cube 20 cm on each side. They are to be made locally, burned in ovens fired with local wood supplies. The box can be sealed with a mortar lining. For Scheme No. 2 the boxes will have either one or two openings, and no gates will be required for these openings. The boxes are situated essentially below ground, and are intended as a reservoir to dipwater from to fill the furrows and basins.

During the period of peak use, assuming as much of the land is planted to crop as the deleu capacity will allow, the system should be operated constantly 12 hours a day, with water being withdrawn from all four boxes during that period and carried to the plants most in need of water, permitting no water to escape as runoff from the lower boxes.

The cost of Schemes No. 2 and 3 is very difficult to estimate since much of the labor of construction could be accomplished by the farmers. The well and concrete tank, if built by government agencies, may cost about $1600 and $600 respectively, depending on the depth of the well. The deleu requires an animal, but otherwise has successfully been fashioned at Agadez entirely from materials found locally. Perhaps $300 or $400 would cover the animal and materials. For Scheme No. 2, 200 m of ditch lined with burned clay tile is proposed. A technique for building these tiles will require some experimentation and the construction

Distribution Boxes Used
for Schemes 2 and 3



A distribution box with two outlets serves also as a division box. If it has less than two outlets, no sliding gates are required. Water reservoir in basin is 60X60X40 cm. Irrigators will dip water from these boxes. The box shown here would be located at position 3 on Scheme No. 3. Only those boxes at positions 1, 2, and 3 in Scheme No. 3 will serve as division boxes and thus require slots for gates.

of a mold. Genie Rural already has some experience building tile like this, but they would need to experiment to find the best size and shape of the tile for this purpose. After the experimentation is completed and a prototype for the mold developed, it should be possible to reproduce the mold for, say $100. The concrete portion of the mold could be made in a re-usable form. Then the two boards could be fixed in place to complete the mold. Once the molds are in the hands of the farmers, their principal out-of-pocket cost should be for the wood to fire their ovens or "kilns," The bricks for the boxes would be made in a similar way, but the cost should be less because no mold would be used. Also, they would not need to be fired as hard. Perhaps the finished tile for the ditches could be estimated at 10¢ per 30-cm section and the bricks @ 5¢ each.

Adding the cost of the mortar may bring the cost of the materials for the ditch to $0.50 per meter, and for the boxes, $10 each. At this rate, materials for the ditches in Scheme No. 2 would be $100, and for the boxes, $40. Containers for carrying water, and valves for the tank, can likely be fashioned from skins and other materials available to the farmers at little cost. Excluding fencing, the total cost to a farmer for materials to develop Scheme No. 2 would, according to assumptions made here, be:

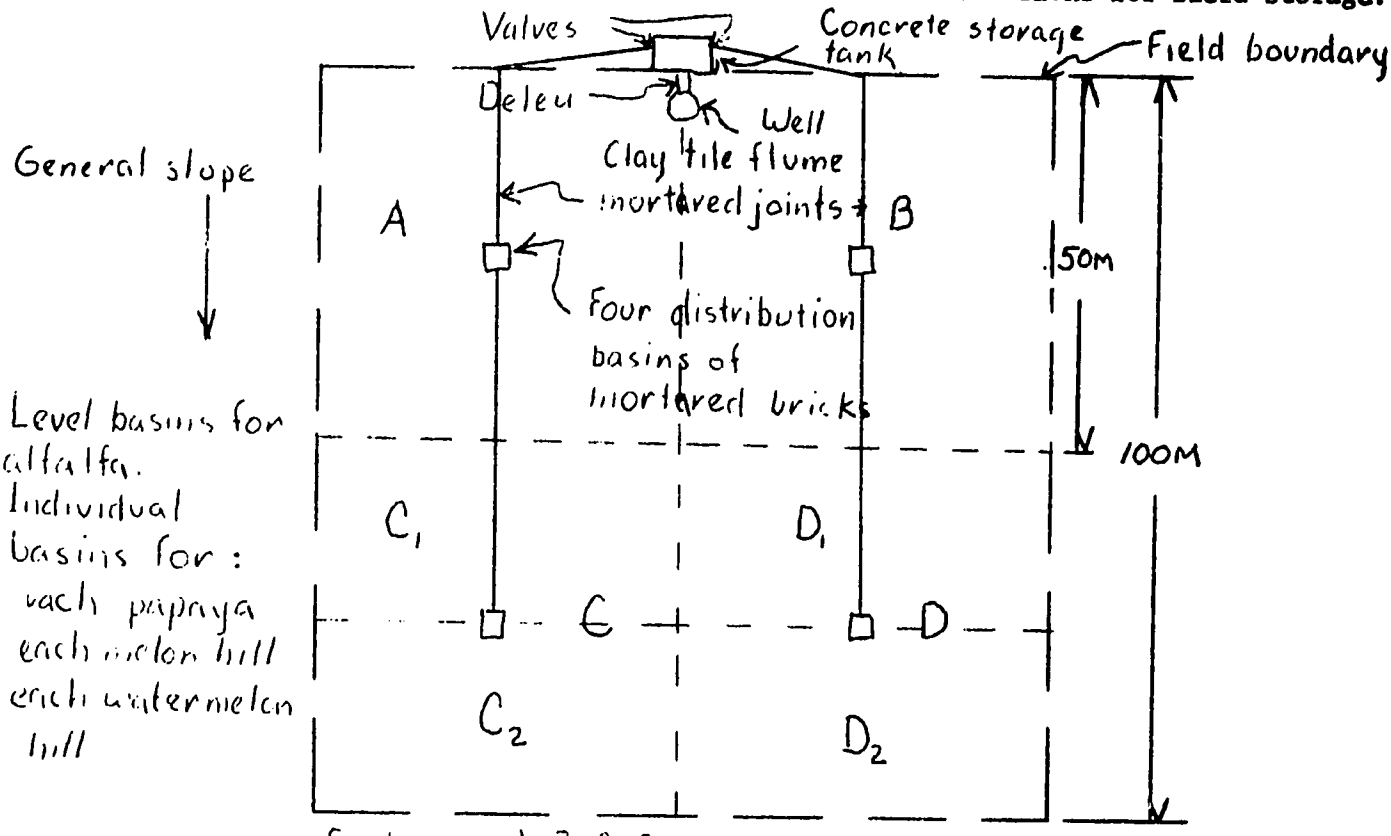
well	$1600
tank	600
deleu	350
boxes	40
ditches	100
TOTAL	$2690

If this scheme should, after trial, appear to have promise, it is possible that the cost of the well and tank can be reduced. Already, in the Agadez region, crews of local people are being trained to construct concrete wells of a type very similar to those so successfully designed and built by OFEDES. Apparently there are times of the year when farmers in the Niamey project area have little or nothing to do so the more of the construction they can learn to do, the cheaper the installation cost will be. Also, experience may show that a smaller tank would suffice.

Longevity of an irrigation scheme like this will depend mostly on the interest of the people in retaining and maintaining it. The well and tank could, with periodic maintenance, easily last for 100 years. The mortar in the ditches will occasionally need patching or replacing, but otherwise the ditches will be durable. Other materials will need to be replaced more frequently.

Planting Guide
Irrigation Scheme #2

Irrigation: A concrete well (OFEDES); dilōō for delivery of water from well to concrete tank for storage; tile flumes with mortared joints for water distribution; and four distribution basins of mortared bricks for field storage.



Sections A, B, C, D - each an area of 0.25 ha.

Season: Dry Winter (November-April)

Hectares	Section	Crop	Variety	Type Planting	Planting Distance
0.25	A	Le Papaye. (Papaya)	Carica	Individual basin	3m X 3m
0.25	B	Alfalfa	(Var. from Agadez)	Level basins approx 3mX10m 0.003 ha each	Broadcast seed
0.25	(C_1 0.125 ha (C_2 0.125 ha	Melon "	Cantelope Charentais Honey Dew (110 da)	Hill-basin " ""	100cmX100cm
0.25	(D_1 0.125 ha (D_2 0.125 ha	Pastéque (Water-melon	Striped Klondike Crimson Sweet (80 da)	" " " "	200cmX200cm " "

Season: Summer (May-October)
A) continued annually
B)

C) May-June - fallow
D) July-October - Green manure crop

Irrigation Scheme No. 3

This plan is nearly identical to Scheme No. 2. The principal difference is that there are 25 distribution boxes instead of four. The greater number of boxes means less walking required by the irrigators, so a fewer number of people will be required at any one time. Each box serves 1/25 hectare, if all of the plot is in cultivation.

Boxes numbered 1, 2, and 3 on the layout sketch will serve both as division boxes and distribution boxes. They will each contain a provision for inserting a board or a piece of sheet metal as a gate, thus controlling the relative quantity of water diverted into each line or row of boxes. All except the five boxes at the ends of the lines have a second opening to spill excess water down the ditch to the next box.

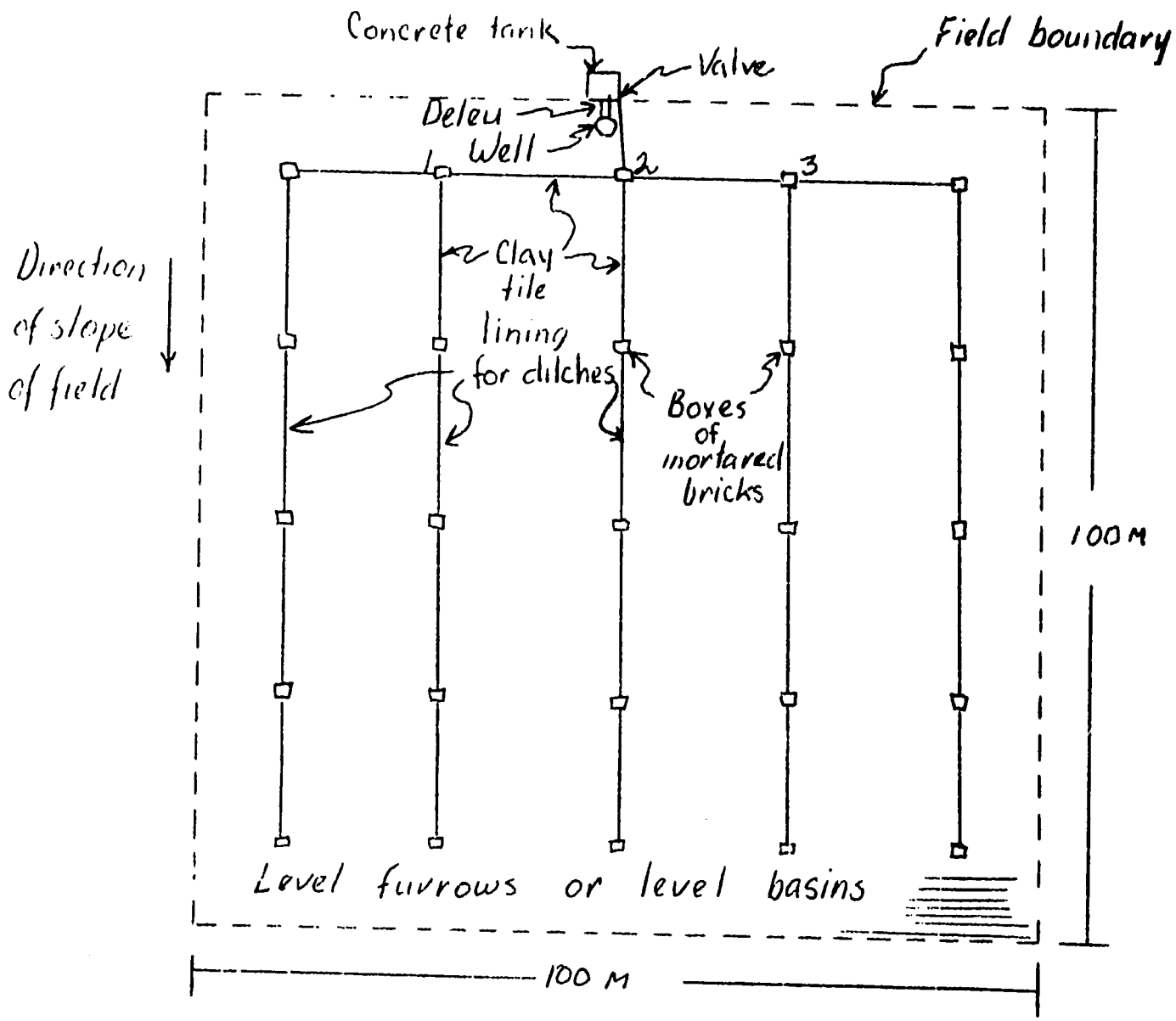
As in Scheme No. 2, the size of the ditches required to carry the maximum quantity of water expected from the deleu must be determined after the slope of the land is known. If one assumes that a ditch constructed like this would have a roughness factor "n" as used in the Manning equation, of 0.02, and if the minimum top width of a semi-circular, lined ditch is 15 cm, a uniform grade of 0.004 meters per meter will be required to carry the 11m^3 per hour streamflow required for one hectare, when the ditch is brim-full. A steeper gradient or a larger ditch would be better, to avoid possible damage from overtopping. With the exception of the short section of ditch leading from the tank to distribution box No. 2 in Scheme No. 3, no ditch will be required to carry this much water, even if the deleu could pump this much.

In normal operation, it is assumed that the valve at the tank will be kept fully open, and that the division boxes will be adjusted to distribute the water in the quantity desired to each of the five lines of boxes, and that one or more irrigators will be working from each of those boxes located nearest to the plants needing irrigation at any particular time. As in Scheme No. 2, the portion of the one-hectare plot actually irrigated at one time will be roughly proportional to the portion of 11m^3 per hour that can be pumped. During the rainy season and the winter season, the water will stretch to more land.

The cost for Scheme No. 3 will be identical to that of Scheme No. 2 except for the extra length of ditch and the number of boxes. Estimated cost will be:

Irrigation Scheme No. 3

Concrete Well, Daleu, Concrete Tank, Tile Flumes,
Twenty-five DistributionBoxes
Water Application by Hand



25 boxes @ $10	$250
490 m ditch @ $0.50	245
Well, tank, deleu	2550
Estimated Total Initial Cost	$3045

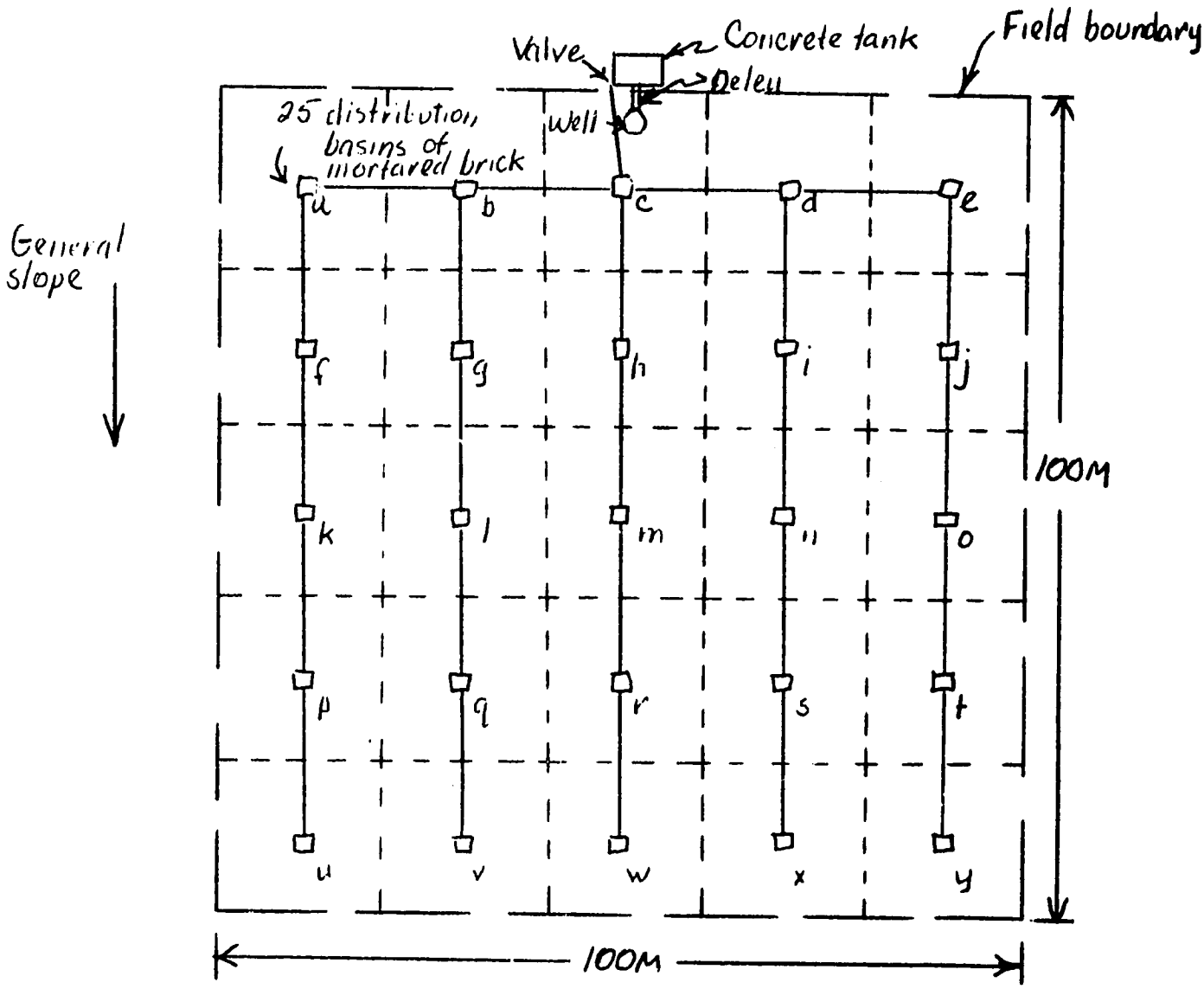
Whether or not 25 distribution boxes will be needed is a matter of speculation. The optimum number may be determined by the point at which the inconvenience of more ditches to cross and the maintenance on those ditches and boxes exceeds the labor saved by shorter trips with a bucket of water. By comparing Schemes 2 and 3, the farmers should be able to choose an optimum layout. If only half, say, of this tract can be irrigated due to limited supply from the deleu, a decision might be made to install the ditches and boxes on only a part of the area, at least at first.

A comparison of the cost per irrigated hectare is interesting at this point. The figures will not be exactly comparable because they do not include labor, and Schemes 2 and 3 will require more labor than Scheme No. 1, especially for construction. Also, it is not yet certain how much area each can adequately cover. If Schemes 2 and 3 each irrigate half a hectare, the initial cost per hectare for No. 2 would be about $5400 and for No 3, $6100. These costs could be reduced by supplying more of the construction labor locally or by increasing the capacity of the deleu. If a suitable pump can be found for Scheme No. 1, five installations together would irrigate one hectare for a material cost, FOB United States, of about $2200. Installation labor would be only driving the well and assembling the barrel and concrete base. All three systems require considerable operating hand labor. It appears therefore that Scheme No. 1 could prove to be initially cheaper, and require less total labor than the other two schemes, even if the deleu could somehow produce enough water for an entire hectare.

Schemes 2 and 3 were designed for carrying water from the boxes by hand on the assumption that the soil is too sandy to permit the use of any unlined distribution ditches. If instead, a particular site has enough clay to make short earth ditches feasible, then the tile-lined ditches should all be placed on a slight fill, so the water surface is about 15 cm above ground level. The boxes should be at the same appropriate level and serve as division boxes only. The boxes could be smaller and not so deep, and each would need two or three gates through which water would be released into small ditches for further distribution by gravity. Each division box should be placed at the upper edge of the area it is to serve. This plan would work better for Scheme 3 than for Scheme 2.

Planting Guide
for
Irrigation Scheme #3

Irrigation: A concrete well (OFEDES); dilou for delivery of water from well to concrete tank for storage; tile flumes with mortarized joints for water distribution; and 25 distribution basins of mortared bricks for field storage.



a,...,y = 25 plot areas of approx. 0.04 ha. each

Planting Guide for Irrigation Scheme #3 continued

Season: Dry Winter (November-April)

Hectares	Area(s)	Crop	Variety	Type irrigation Type planting	(cm) planting distance in row/bet row
0.04	a	Betterave (Beets)	Rouge plate d'Egypt	row-furrow	25 X 30
0.04	b	Carotte (Carrotts)	1/2 longue nantaise	" "	10 X 30
0.04	c	Haricot nain (Green beans)	Triomphe Faray des Vertes	" "	20 X 30
0.04	d	Navet (Turnip)	Race Marteau	" "	20 X 30
0.04	e	(Haricot (Mungo (Green gram)	Phaseolus Mungo	" "	15 X 30

Season: Winter (November-April)

0.4	f	Chicorée (Endive)	Chicoree scarole	" "	30 X 40
0.4	g	Chou Cabas (Cabbage)	Coeur de boef gros	" "	50 X 60
0.4	h	Gombo (Okra)	Local	" "	60 X 70
0.4	i	Celeri (Celery)	a couper	" "	20 X 25
0.4	j	Laitue (Lettuce)	Batavia Blonde de Paris	" "	10 X 25
0.4	k	Piment (Hot Pepper)	de Cayenne	" "	60 X 70
0.4	l	Courge	Burpee's Fordhook Zuccini (57 da)	hill-bed	100 X 100
0.4	m	Oignon (Onion)	Violet de Galmi	row-furrow	15 X 20

Planting Guide for Irrigation Scheme #3 continued

Hectares	Area(s)	Crop	Variety	Type Irrigation Type planting	(cm) planting distance in row/bet row
0.4	n	Laitue (Lettuce)	Kagraner Somer	row-furrow	25 X 30
0.4	o	Piment (Hot pepper)	Local	" "	60 X 70
0.4	p	Radis (Radish)	18 Jours	bed-basin	broadcast
0.4	q	Spinach (Basella alba)	Malabar Spinach (70 da)	row-furrow	10 X 25
0.4	r	Radis (Radish)	Rond Rouge a bout blanc	" "	"
0.4	s	Tomate (Tomato)	Marmande	" "	45 X 80
0.4	t	"	Piernita	" "	45 X 80
0.4	u	"	Ronita	" "	45 X 80
0.4	v	"	Red Jacquet	" "	45 X 80
0.4	w	"	Fournaise (F1)	" "	45 X 80
0.4	x	Piment Vert (Green Pepper)	"Sweet Bell"	" "	60 X 70
0.4	y	Aubergine (Eggplant)	Violette de Barbentane or Local	" "	60 X 70

Season: Summer (May-October)
Fallow - May-June
Green manure crop - July-October. One-half (1/2 ha) of the field. The other half should grow vegetables adapted to rainy season plantings.
These should be reversed every other year so each half of the hectare area receives the benefit of the green manure crop to build up the structure and natural fertility.

Irrigation Scheme No. 4

This scheme starts with the same water supply as Schemes 2 and 3, that is the well, the concrete tank, and the deleu. It also has the same size and shape of plot to be irrigated, and is subject to the same inability to cover this much area because of the limited capacity of the deleu. Like all three previous schemes, it employs level furrows and/or level basins.

This scheme differs from Schemes 2 and 3 in the method of distributing water to the furrows and basins. Gated pipe is proposed for metering the water to each furrow or basin. A sufficient length of supply pipe to conduct the water from the tank to the gated pipe would be included. This will be portable aluminum pipe, 4-inch (10 cm) diameter, mostly in 30-ft (9 m) lengths, but with a few shorter lengths to permit more precise placement of gated sections. The gated pipe sections will extend 150 ft (46 m), or about half the length of one side of the plot. Since the deleu may not be able to supply the entire plot, the gated sections could be laid from the upper edge of the plot, and extend down the slope nearly to the center.

In operation there will likely never be a large enough flow of water to supply the gates in more than two or three sections of the gated pipe at any one time. If so the unused gates should be kept closed Later, when the irrigation set is completed, the first gates will be closed and the next set opened. There may be occasions in very sandy soil, where the entire available flow should be discharged from a few wide-open gates This would permit the larger stream of water to advance down the level furrow faster, thus permitting a longer run. In this case, and possibly in all cases, some protection should be provided to prevent a scour hole from developing in the bottom of the furrow where the stream of water lands This could be a piece of heavy cloth, a skin, a bucket, or anything that would dissipate that energy. Even if a hole did scour, it would stop enlarging when the water cushion was deep enough, and could be scraped full again when the irrigation was completed. If the soil happened to contain about the right amount of clay, and if the field were graded so accurately that furrows could be both level and parallel, the length of run could extend the entire 100 m length and the pipe would not have to be moved until or unless the lower half of the field were to be developed. With the short runs anticipated for the sandy soils in the Dallol Basso, the gated pipe sections would have to be shifted across the field to successive positions until the entire cropped area had been irrigated.

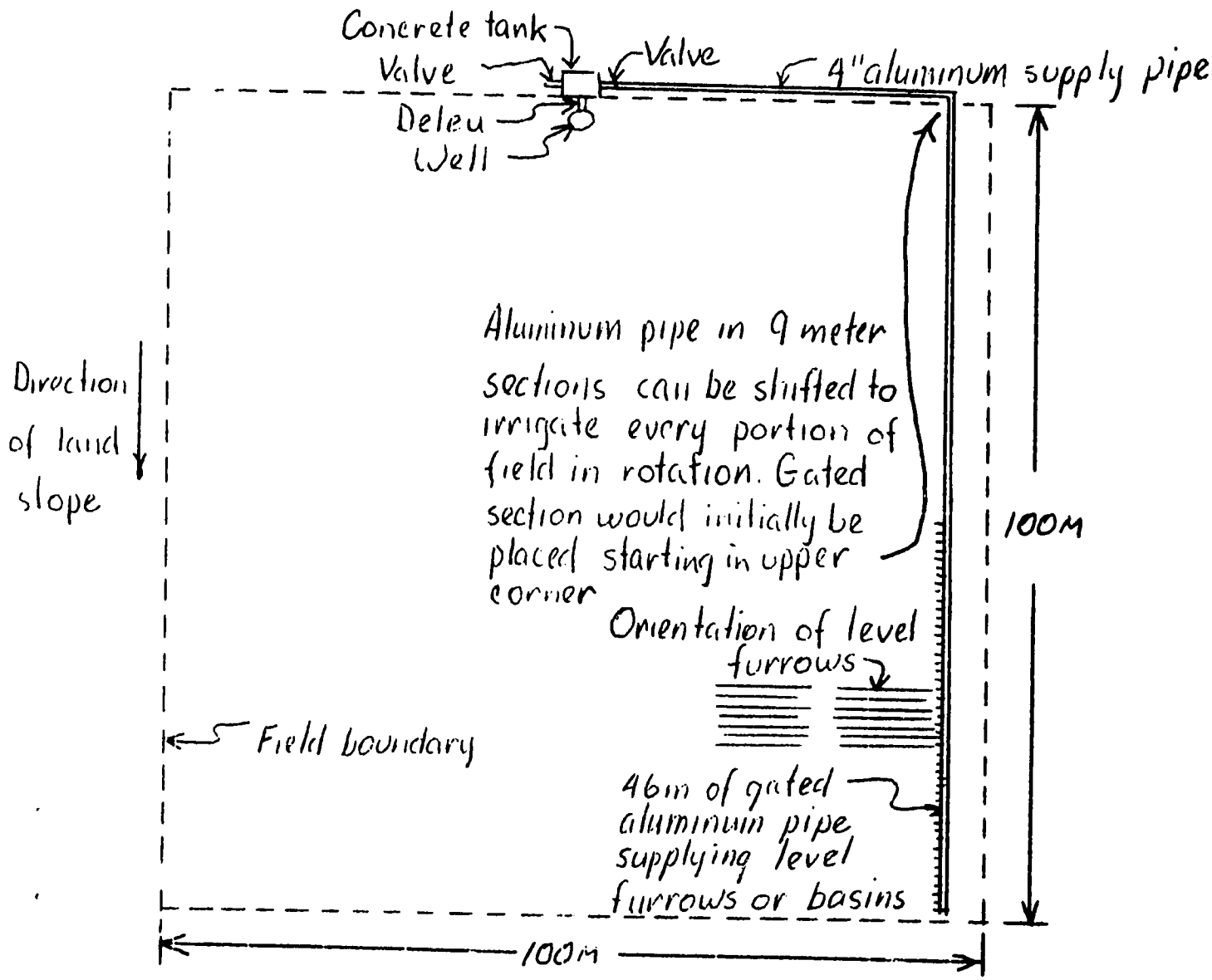
The sketch shows 2 valves one on either side of the tank, to control the flow into the pipe. One valve would suffice if it could be placed on the upper or lower side of the tank, if a reversible elbow were available to permit the supply pipe to extend either direction, and if the pipe would not likely be damaged in that position. Whether one or two valves are installed, an adapter and coupling or elbow will be required at the valve so that the aluminum supply pipe can be quickly coupled and uncoupled. Something less than a 4-inch gate valve will be adequate. A 4-inch globe or butterfly valve, a 2-1/2 or 3-inch gate valve with appropriate adapter, or other comparable less expensive arrangement could be selected.

For basin or border irrigation, several gates can be discharging into one basin For furrows spaced at distances greater than the 60 cm spacing between the gates, some of the gates can be left closed. Some reshaping of the ends of the furrows may be required if any one is not positioned quite right to receive the water from its nearest gate. If a 30 cm furrow spacing is desired, the stream from one gate can be divided into two furrows Sometimes it is necessary to lay a sheet of plastic or other material on the ground to prevent erosion that would change the equal division of the stream.

As with Schemes 2 and 3, this equipment would adequately serve one hectare. If the deleu can supply only enough for a half hectare or less the cost per irrigated hectare goes up proportionately. The following bill of materials and estimated US prices has been prepared without the benefit of suppliers' catalogues or current prices. Like the other bills of material, it does not necessarily contain sufficient description and specifications to submit for purchase on contract bid.

Irrigation Scheme No. 4

Concrete Well, Deleu, Concrete Tank, Portable
Aluminum Gated Pipe and Supply Pipe



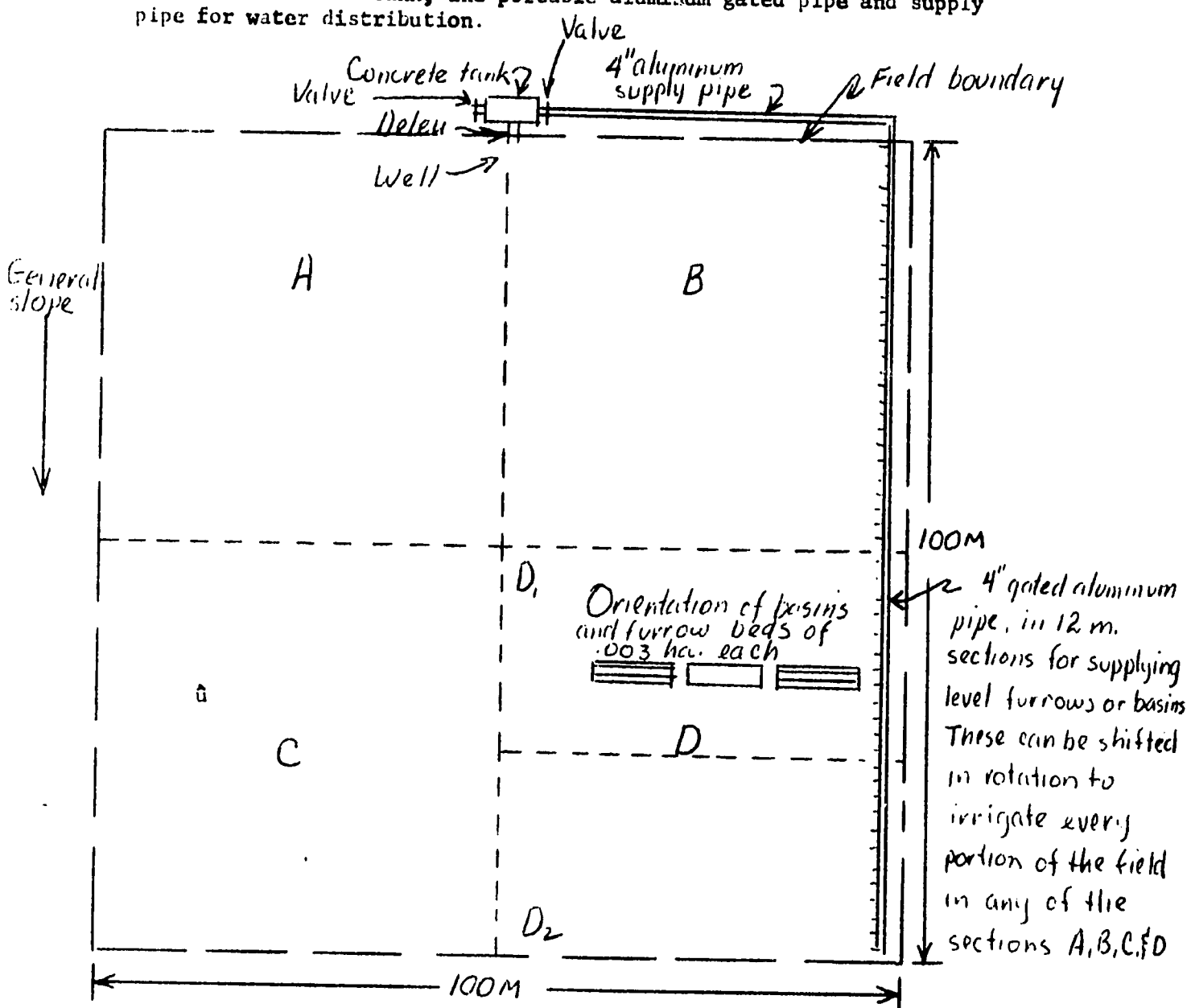
Materials List

Quantity	Size	Item	Estimated Price in U.S
100 m (330 ft)	4-inch	Portable, quick-coupling, low pressure aluminum supply pipe in 30-ft. sections.	$430
18 m (60 ft)	4-inch	Aluminum supply pipe in 10 and 20-ft sections.	90
46 m (150 ft)	4-inch	Low pressure gated aluminum pipe, 30 ft. sections, 2 ft. gate spacing.	350
2 pc.	4-inch	Valves with adapters and couplings, including one foot long pipe to be set in concrete tank wall.	150
2 pc.	4-inch	End plug	12
2 pc.	4-inch	Reversible elbow	40
50 pc.	4-inch	Extra gaskets for pipe couplers.	48
		Total imported material	$ 1120
		Well, tank, deleu	2550
		Total estimated initial cost	$ 3670

For the purpose of cost analysis, portable aluminum pipe has often been estimated to have a life of 15 or 20 years. If neither the water nor soil are especially corrosive, it will last much longer, perhaps 50 years. On the other hand, the rubber gaskets may have to be replaced after five years, some of them anyway and occasionally a piece of pipe is damaged by being run over by heavy equipment, or by other means, and must be replaced. A twenty-year average life expectancy might be reasonable for this proposed system in Niger. Compared with Schemes 2 and 3, there is essentially no labor of installation. Operating labor will be much less also. The pipe is completely portable and can be tried at different wells and on different soil types. The estimated total price of imported equipment is $1120, FOB United States. Adding the well, tank and deleu brings the total to $3670. If this is for a half hectare, the per hectare cost would be $7340, the most expensive scheme so far. It is one of the better ones though, because of its simplicity, low maintenance, and moderate longevity.

Planting Guide
for
Irrigation Scheme #4

Irrigation: Concrete Well (OFEDES), concrete tank, delou for delivery of water from well to tank, and portable aluminum gated pipe and supply pipe for water distribution.



Sections A,B,C,D- each an area of 0.25ha. These should be leveled across the slope, if possible. If not, then furrows and basins should be oriented across the slope on the contour. In each section, the furrow beds or basins, should be about 3m x 10m. Gated pipe will have openings every 60 cm, allowing for about 5 gated openings per basin or bed width and about 16 for across slope delivery.

Planting Guide for Irrigation Scheme #4 continued

Season: Winter (November-April)

Hectares	Section	Crop	Variety	Type Irrigation & Planting	Planting Distance (cm)
0.25	a	Alfalfa	(Variety from Agadez)	Level basins, solid planted by broadcast.	Broadcast
0.25	b	Oignons (Onion)	Local (Nigerian)	Level furrows rows 3x X 10m	20 X 30
0.25	c	Maize dulce (Sweet corn)	Illini Early Xtra-Sweet	Level furrow rows 3m X 10m	25 X 60
0.125	d_1	Aubergine (Eggplant)	Monstrueuse de New York Local	Level furrow rows 3m X 10m	70 X 80
0.125	d_2	Haricot	Kentucky Wonder pole beans (65 da)	Hills in rows with furrows both sides of hill-rows	60 X 100

Season: Summer (May-October)

a - Continue on annual basis
b, c, d - May-June-fallow
July-October-Green manure crop
An alternative may be to plant 1/2 of b, c, d to these same vegetable crops for the rainy season or other adaptable ones and alternate each half with a green manure crop only every other year

Irrigation Scheme No. 5

Since the wells constructed by OFEDES are generally developed until they produce 40 m^3 per hour, and since none of the pumping methods based on hand labor or animal traction tried so far promise much more than one-tenth of that capacity, it follows that the most successful schemes could be those which could increase the land irrigated from each well by pumping more water. A sprinkler irrigation system with a centrifugal pump and gasoline engine offer a logical solution. The high cost of the well can be somewhat nullified by increasing the area served by it

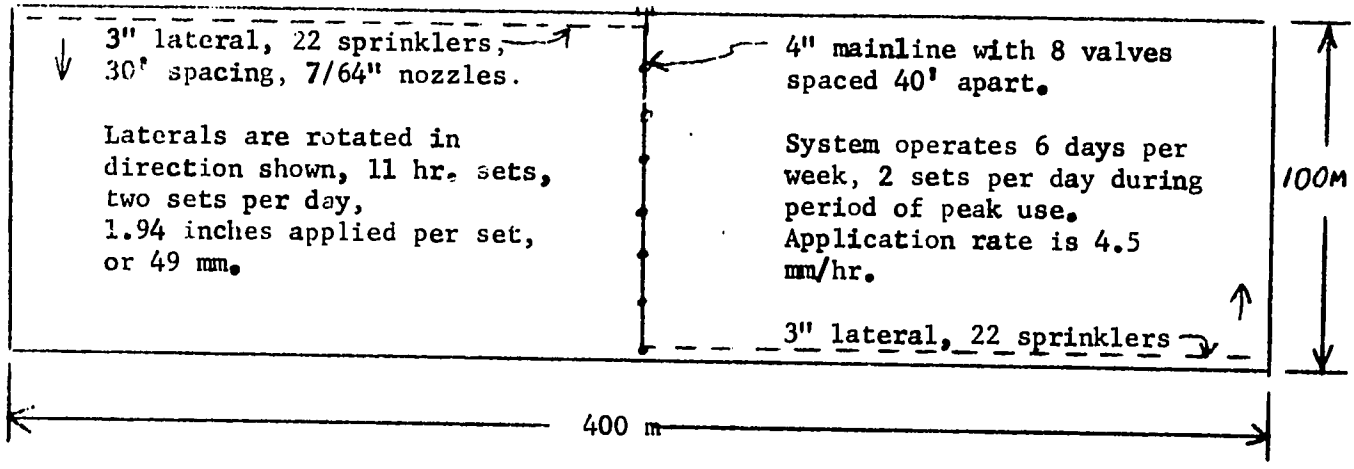
This scheme proposes to irrigate four hectares from one well. A horizontal centrifugal irrigation pump and engine mounted together on a base would rest on earth fill at the edge of the well. This base should be below the level of the casing, just enough so that the horizontal portion of the suction pipe will rest on the casing, or at least on shims resting on the casing. The suction assembly consists of a 5-inch suction pipe 25 feet long, with a foot valve and strainer at the bottom and a 90° elbow at the top. A dresser coupling connects this short horizontal portion of the suction pipe to an eccentric tapered reducer, which in turn connects to the suction entrance to the pump. On the discharge side, a 60 cm long tapered reducer expands from the pump discharge connection to a 4-inch gate valve, which in turn is followed by whatever is necessary to connect rigidly to a 4-inch coupler from the sprinkler system. A 1-inch outlet is tapped into the top of the long tapered discharge adapter, about 20 cm from the gate valve. Proceeding up from this outlet is a 1-inch globe valve (or gate valve) and above that a diaphragm-type priming pump. The gasoline engine will be mounted on the same base as the pump, with its shaft connected to the pump shaft with a flexible coupling and in alignment with it. The irrigation pipe leading away from the pump will bend immediately down to the ground with an elbow and short section of pipe, and then with another elbow it will head straight down the center of the field to be irrigated, lying on top of the ground.

The two sketches show the layout of the proposed sprinkler system and the probable layout for the pump and engine assembly. The pump sketch is schematic only and not to scale since the configuration of the pump and engine are not yet established. However, it represents a type of layout that has proved most effective and efficient with US equipment. On the suction side of the pump, it is very important that no part of

Irrigation Scheme No. 5

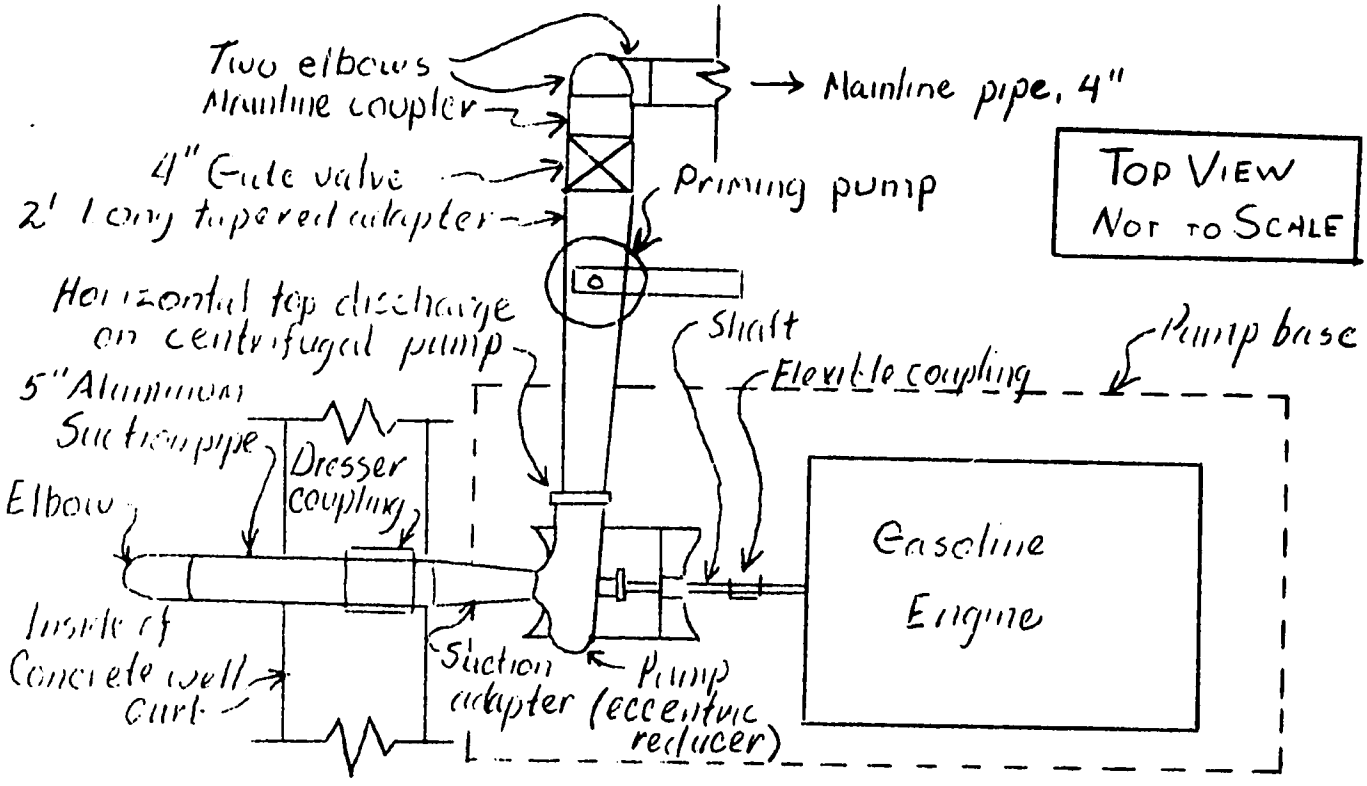
Sprinkler Irrigation of Vegetables and Alfalfa

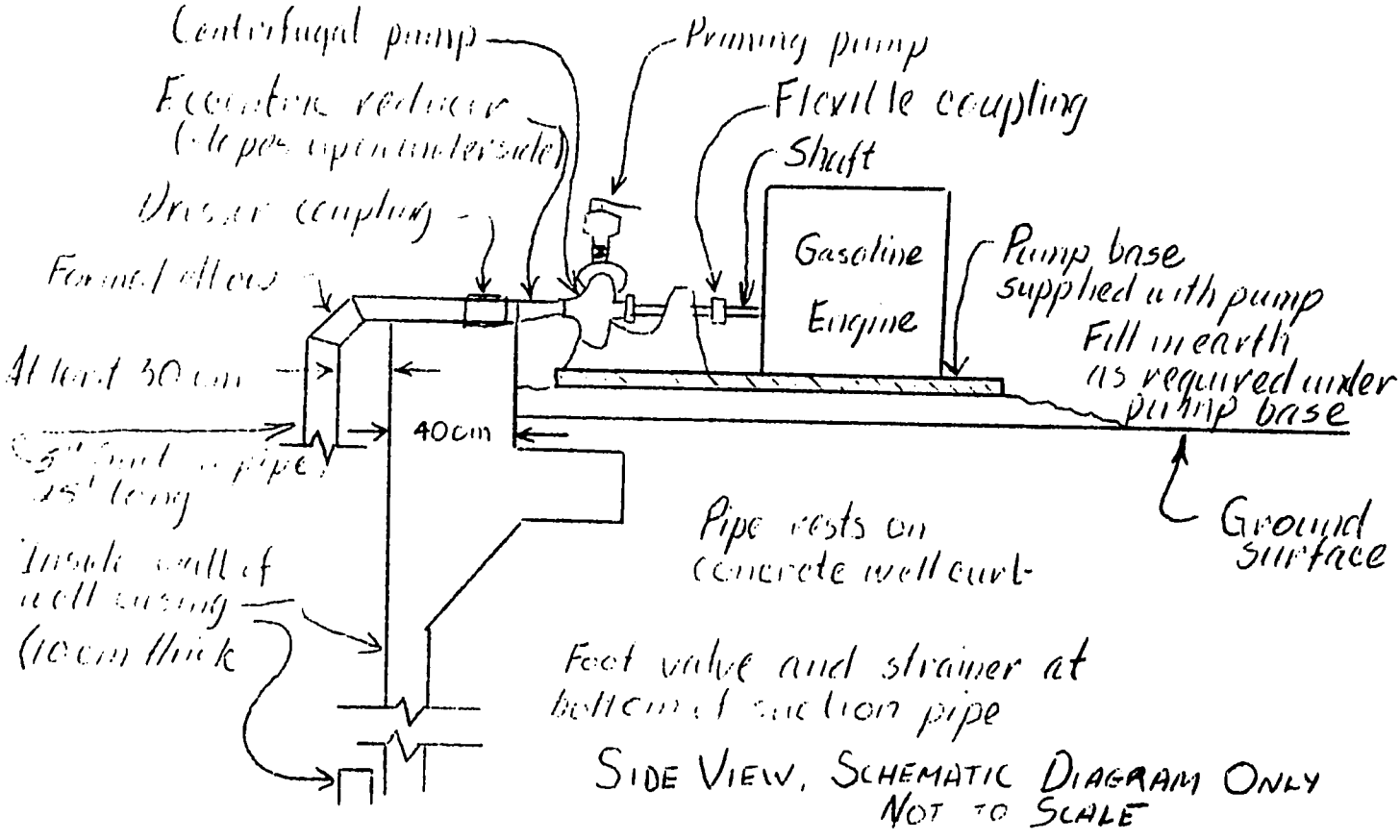
Concrete well, gasoline driven pump, portable pipe



When the plants are young and the root systems not fully developed, the system can be operated less time each day. When the plants are full size and the weather is cool or rainy, the system can remain shut down more days each week. But when the plants are blossoming and the weather is hot and dry, the system should never stop, except possibly on Sunday.

Pumping Plant Layout





the suction pipe is at a higher level than the top of the suction entrance to the pump. If it were it would cause the pump to lose prime easily, perhaps operate inefficiently, and may even severely damage the inside of the pump. That is why the suction adapter has all its taper on the bottom side On the discharge, a longer taper is required but it should not be eccentric. To prime the pump it is necessary to close the 4-inch discharge valve, open the small 1-inch valve below the priming pump, and then pump by hand until water comes. At that time the small valve is closed the engine is started, and then the large discharge valve is opened gradually until the line is filled and sprinklers turning. After that the discharge valve should be opened all the way. The engine speed should be governed to produce 40 psi (2.72 atmospheres or 2.81 kg/cm^2) on the sprinklers, not more. Centrifugal pumps, unlike piston pumps, will not be damaged in any way by the high pressure that builds up when the discharge valve is completely closed. In fact, the engine is not working as hard then as when the valve is open. The pump would become overheated if it were run a long time with the valve completely closed, but this is no problem in the short time required for priming. The engine might become overloaded if the discharge valve is opened too fast at first. That is why the pipelines should be filled while the valve is only partly open. Also, a wide open valve could cause damage to the pipeline when the large stream of water hits the end with a bang. A waterproof shade erected over the pump and motor, sloping away from the well, might cause the engine to run cooler if it did not restrict air movement too much, and keep the sprinkler water and rain from hitting the engine.

The automatic aluminum foot valve, not shown in the sketch, is clamped tightly to the bottom of the suction pipe. When open, it permits water to flow through it in a straight line. When closed it should hold the pump prime if the engine is shut down for one hour while moving the sprinklers.

The mainline of the sprinkler system starts at the pump discharge with two elbows, one to take the pipe immediately to the ground where it is more out of the way, and the second to direct it across the middle of the field to be irrigated. The 4-inch mainline has 8 valves spaced 40 feet (12.2 m) apart. If the field to be irrigated is exactly 100 m in this dimension, and if the valves are evenly spaced, the first valve will be 24 feet (7.3 m) from the upper edge of the cropped field, and the last valve will be the same distance from the lower edge. By making the section of mainline from the pump to the first valve also 40 feet long, the distance from the upper edge of the field to the near edge of the well would be about 17 feet (5.2 m). If this much space is not available, that section of pipe can be shortened. Some water from the sprinklers

will reach beyond the edge of the field from these two settings, but the amount wasted will be insignificant. In fact the first few rows on the upper and lower edges of the field will receive less water than the rest of the field and should be observed to learn on which row the reduction in yield begins. The mainline valves are opened with a valve-opening elbow, which in turn attaches to a lateral line. If there is only one irrigator to move two laterals, he should allow the pump to continue to run while he closes the valve on one lateral, moves it ahead to the next setting, opens that valve, and then repeats the process for the other lateral.

There are two irrigation laterals, each with 22 sprinklers. The pipes are 3 inches (7.6 cm) in diameter and 30 feet (9.15 m) long, except that the first sprinkler on each lateral is on a pipe only 15 feet long. The pipe sections will couple and uncouple automatically when the pipe is manipulated from its midpoint. The normal riser height is 36 inches (91 cm) for crops as tall as some planned for this area. In fact, an 18-inch extension could be added if these are not high enough, and if the appropriate fittings are available. An 18-inch riser by itself is much easier to handle, much less subject to damage, and lighter to carry than the taller risers, and would be preferred if the crops are not too tall. When the risers are more than 18 inches, a small board (assumed available locally) must be fastened to the base of each coupler to stabilize it. An end plug is required at the end of each lateral and also the end of the mainline.

One practice used extensively by irrigators in the US when they are moving a lateral from one set to the next is to open the mainline valve slightly when they first attach the valve-opening elbow to it. This discharges a small stream of water into the first pipe section. Each section of pipe in turn has this stream of water running through it as soon as it is connected. The water flushes out any foreign material that may have been picked up and that would tend to clog the sprinklers. When the last section ofpipe is put in place with the end plug already attached, the pipeline is quickly filled and the sprinklers start operating slowly. As the irrigator walks back along the line he can check each coupler for leaks and straighten any tipping sprinkler. When he reaches the mainline he opens the valve until the sprinklers have the desired pressure. This procedure often saves a second trip down the line to correct a malfunction.

The sprinklers designated are Rainbird Model No. 20 with a 7/64-inch nozzle, each discharging 2.20 gpm (0.139 lps) at 40 psi (2.72 atmospheres). On a 30 X 40 foot spacing, the theoretical gross application rate is 0.1765 inch per hour (4.48 mm per hour) and in an 11-hour set, the gross application is 1.94 inches (49.3 mm). The system will complete one irrigation in 8 sets, or 4 days @ two sets per day. Then it is ready to repeat the process for the next irrigation.

This schedule is considered to be sufficiently flexible to meet the soil conditions likely to be encountered when the site is selected. Hopefully the application rate is low enough for those soils with clay, and the amount per irrigation is not too much for the very sandy soils. If the application efficiency is 70%, the net application will be 34.5 mm or 1.36 inches. This could be too much for a shallow-rooted crop on very sandy soil. In that case smaller, more frequent applications would be desirable. One way to accomplish this would be to make three sets per day, starting the first one at the earliest moment it is light enough to see, and ending at the deepest dusk possible, with one set halfway between. The last setting in the evening can be stopped before morning at any desired time by placing only so much gasoline in the tank. Of course, if either the weather or the crop were not at a state of peak use a less ambitious schedule would suffice. Fortunately, crops with the highest use rates also tend to have deeper root systems, so the proposed schedule is likely to be found adequate for any crop, and more than adequate for some.

In conference with the local government officials who will be responsible to place this system in operation should it be approved, the feeling was expressed that the system should be turned off between 1200 and 1600 hours. There is a belief that the water at that time will damage the plants, and that adequate labor will not be on hand then. I <u>strongly</u> recommend that this system <u>not</u> be shut down during those hours during the first year of operation, or until it can definitely be proved unprofitable to do so, for the following reasons:

1. In spite of many fears and allegations there are very few instances where daytime sprinkling has proved harmful.

2. If certain crops should positively show damage, they can be shifted to the furrow and basin plots.

3. The water analyses I have seen suggest that the salts they contain will likely not be damaging to most crops

4. Sprinkler equipment is expensive and is not paying for itself while lying idle.

5. This system may not have adequate capacity for the area planned if it is not run continually.

6. The planned 12-hr sets would be hopelessly destroyed by this schedule.

7. 12-hr sets are much better than shorter sets because a distorted distribution pattern caused by a 3-hour wind would have a minor effect on the total irrigation.

8. Irrigation has a cooling effect on the crop and might cause a higher yield due to the lower temperature.

If the first year's experience suggests that changes are needed in the system design or operation, some of these can be made rather easily. For example, the next larger size of nozzle could be installed. This would require that about 5 sprinklers be subtracted from each lateral, or perhaps a bit less if the pump can be speeded up some. The pipe sizes specified are large enough to allow for this much flexibility. By changing the sprinkler model, a smaller nozzle could be tried.

In case the well will not yield as much water as expected without excessive drawdown, the acreage irrigated will have to be reduced, or the system moved to a different well. Centrifugal pumps cannot be expected to lift water efficiently on the suction side more than 4 or 5 meters. Testimony indicates that the wells already installed at the experiment station at Bankoukou would each meet the requirement of this system

A number of extra or overage items are included in the materials list to allow for replacements anticipated.

Sprinkler Irrigation System
Approximate Materials List
Based on Wade Rain Equipment, R.M. Wade and Co., Portland, OR

Quantity	Size	Item	Estimated U.S. Price
360 ft.	4-inch	Aluminum mainline in 40 ft. sections and 40 ft. valve spacing (press-in valve couplers)	$ 580
1320 ft.	3-inch	Aluminum lateral line in 30 ft. sections.	1300
45 ft.	3-inch	Aluminum lateral line in 15 ft. sections.	50
6 ft.	4-inch	Aluminum supply line with pressed-in coupler	20
3 pc	4X3 inch	Valve opening elbows	100
3 pc	3-inch	End plugs	16
2 pc	4-inch	End plugs	12
3 pc	4-inch	Reversible field elbows	60
50	1-inch	Aluminum riser pipes 36 inches long with zamac fittings	163
50	1-inch	Similar aluminum riser pipes 18 inches long	110
50		Zamac adapters to join an 18-inch and a 36-inch riser if desired	45
60	3/4X1/2 inch	Bushing, zamac	36
60		Model No. 20 Rainbird sprinklers with 7/64 inch nozzles	405

Sprinkler Irrigation System
Approximate Materials List (continued)

Quantity	Size	Item	Estimated U.S. Price
1 unit		Horizontal centrifugal irrigation pump and gasoline engine, mounted as one unit on a base, and with suitable flexible shaft connections. Pump must be capable of delivering 100 gallons per minute against a total dynamic head of 120 feet at 60% or better efficiency. Engine must be capable of operating the pump at its proper speed continuously for long periods, 24 hours per day, without overheating in 120°F ambient temperature. It must have adequate air filtration and bearing sealing to protect it from West African sand-dust storms. It must be equipped with protective controls that will stop the engine if the pump loses prime or there is a failure of the engine lubrication or cooling system. It must be accompanied by adequate instructions for operation, maintenance, and repair, written in French.	1500
1 kit		Spare parts, special tools, replacement filters, etc. considered adequate for 5 year period of nearly continuous a operation.	800
1 unit		Suction assembly per attached sketch	150
1 unit		Discharge assembly per attached sketch.	200
50 pc		Rubber gaskets for couplers, mostly 3", some 4".	65
		Total material estimate - - - - - $	5612

This sprinkler system is more elaborate than I first thought it would need to be. It now has two laterals instead of one, and has mainline valves which I had thought at first could be omitted for the sake of simplicity. However, because it will likely be located on sandy soil, it is better to have sprinklers that apply less water in a 12 hour set, which means more laterals. The current estimate of cost of materials in the US is about $5600. To that must be added the cost of the well, say $1600, for a total of $7200, plus fencing cost. For omparison with the others, this is only $1800 per hectare, plus whatever items have been omitted, so it is the cheapest cost per hectare of any of the schemes, based on these estimates. Furthermore, it will likely produce more because of more uniform irrigation, and will not require the land smoothing the other schemes do.

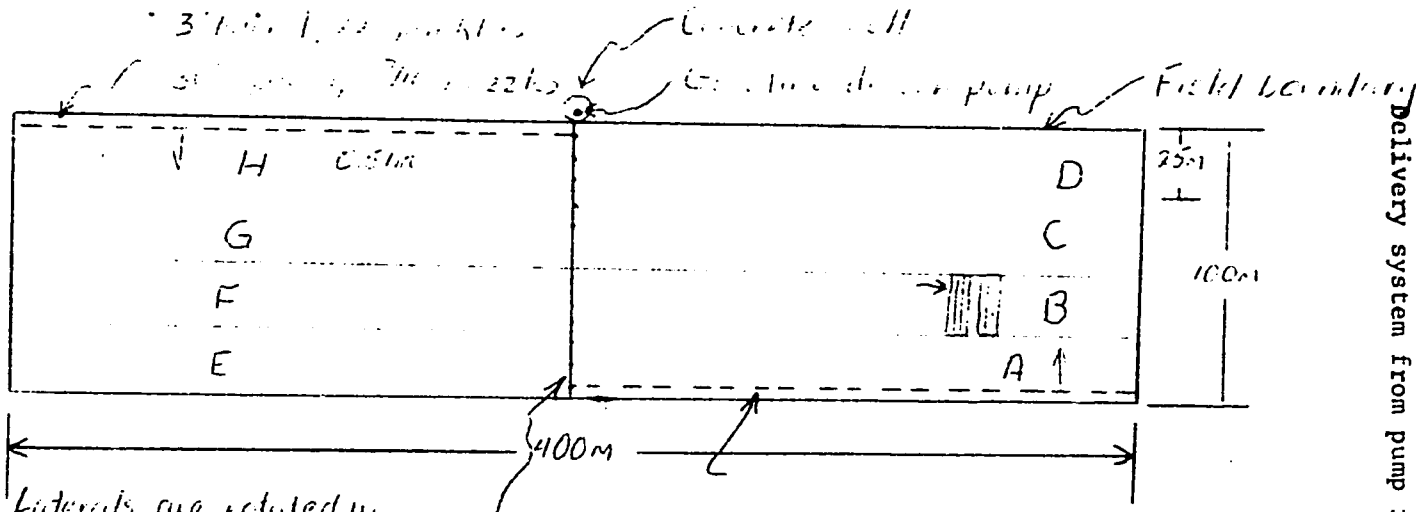
The longevity of the system will perhaps average about 10 to 15 years. Because of year around cropping, the pump may or may not last that long. The engine will likely have to be replaced sooner. Sprinklers may have to be replaced sooner also. But the pipe will mostly last longer, barring mishaps.

The biggest question is whether or not the engine can be properly maintained under these conditions, and whether a satisfactory operating schedule and maintenance schedule can be adopted. My guess is that once the good job of irrigation has been evaluated in terms of increased produce, every effort will be made to keep it running. Labor will be much less for it also. Even as unskilled worker can do a good job of irrigation if he will move the pipes according to schedule. Lubrication and other maintenance on the engine must be continually checked by supervisors.to make sure it follows instructions. It will be interesting to see if it can be kept running because it probably stands the best chance of being economical. Fuel consumption should be not much more than 1/2 gallon per hour.

A diesel engine could be substituted for the gasoline engine, if in the opinion of experienced local observers it would be longer lasting and more easily maintained.

Planting Guide
for
Irrigation Scheme #5

Irrigation: Sprinkler irrigation of vegetables and alfalfa.
Supplied from concrete well by gasoline-driven pump.
Delivery system from pump is by portable pipe.



Laterals are rotated in direction shown. 11 hour sets, two sets per day, 1.94 inches applied per set.

4" mainline w/8 valves spaced 40' apart

System operates 6 days per week, 2 sets per day during period of peak use.

When the plants are young and the root systems not fully developed the system can be operated less time each day. After the plants are normal height and the weather is cool or rainy, the system can be shut down more days each week.

Row, furrow and plot orientation will be as shown above, to facilitate movement of the sprinkler pipe for set changes, for walking between plots. Subplots should be 3m X 25 mm (.0075 ha) in each of the eight sections, ABCDEFGH.

Planting Guide for Irrigation Scheme #5 (Sprinkler) (continued)

Season: Winter (November-April)

Hectares	Section	Crop	Variety	Type planting	Planting Distance(cm)
0.5	A	Forage (Alfalfa)	Agadez	Broadcast + barrowed in	Broadcast app 20 X 20 m
0.5	B	Sorgho-Forage (Sorghum)	Jan-Jaré	Drilled rows	20 X 20
0.5	C	Tomate	Ronita	Row	40 X 80
0.5	D	Green Gram Phaseolus Mungo	Variety from Nigeria-IITA, Ibaden "Mung Bean"	Row	15 X 30
0.5	E	Pomme de terre (potatoes)	Variety grown in Agadez or Maradi	Row	40 X 80
0.5	F	Pomme de terre (potatoes)	Bintje	Row	40 X 80
0.5	G	Forage (Gramineae)	Pennisetum purpureum	Drilled row	10 X 10
0.25	H_1	Ble (Wheat)	Mexipak	Drilled row	10 X 10
0.25	H_2	" "	Siete Cerros et Florence Aurora	" "	"

Season: Summer (May-September)
Supplemental Irrigation

A - same crop annually
B - another annual crop for forage
C - tomatoes adapted to summer season
D - another planting of greengram
E - seed multiplication-millet
F - " " -cowpeas
G- same crop annually
H_1 and H_2 - green manure crop after wheat followed by maize (questionable - may be too late for maize ?)

Irrigation Scheme No. 6

Drip irrigation is proposed in this scheme on a trial basis. It has become very popular in parts of southwestern US for orchards, and in Hawaii for sugar cane. Some claims made for it have been highly exaggerated, but this much has been quite well established: (1) For row crops with a wide space between rows, like orchards, vineyards, cane berries, etc., it will save water when compared with any method of irrigation that keeps the entire soil surface fairly wet, i.e., sprinkler. (2) Comparable yields can usually be obtained, though for some crops and situations yields tend to be a bit more and in others a bit less, when compared with other good irrigation methods. (3) It has been used successfully on steep, rocky terrain near San Diego which could not be irrigated profitably by any other method, and (4) By careful management, it has been more successful with irrigation water containing very high salinity than other irrigation methods have. The method also has some serious problems, including clogging of the orifices or drippers by silt particles or by precipitated salt. On steeper terrain there is also a problem of pressure control to keep the various components of the system discharging the same quantity of water.

For the installation proposed here, the biggest problems are expected to be (1) clogging of the orifices or emitters, and (2) possible deterioration of the plastic pipe by sunlight, accidental abrasion, or termites. To reduce the first problem, the water source would be from a driven well with a sand point containing perforations fine enough to hold back the sand. Also, the container into which the water is pumped would have a 100-mesh stainless steel screen covering the entrance, and firmly attached to it to discourage removal. Of course, the orifices are smaller than this screen. Some fine silt particles could enter with the water or blow in through the screen. These will settle in the bottom of the pipelines because the water moves so slowly through them. The lateral lines containing only orifices must be placed with the orifices on the top side. This tube or pipeline is flexible, but it assumes a flat cross section when the pressure is off. It can be placed on top of the soil with all the orifices up and expected to remain there until disturbed. It could also be covered with 2 or 3 cm of soil to protect it from sunlight. The number and spacing of the orifices can be selected in advance to correspond to the desired plant spacing in the row. They are precisely installed at the factory using a laser beam, and cannot be successfully added to or cleaned out by any mechanical means in the field. This kind of lateral line has been used mostly for row crops, especially sugar cane in Hawaii. The type of lateral line containing emitters is sufficiently rigid to maintain a circular cross section. Emitters are of many different types, but nearly all are installed so that the water that enters the emitter comes from the center of the circular cross section.

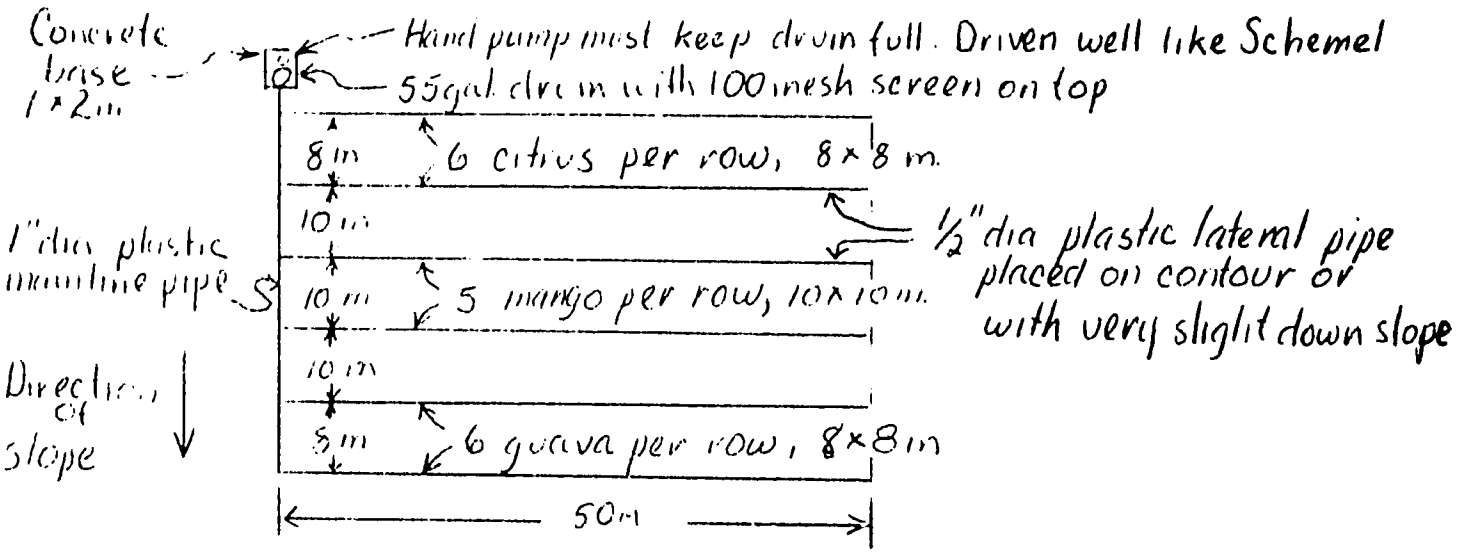
In this way, silt can accumulate in the bottom of the lateral line without entering the emitter. This type of lateral is more likely to be used for orchards, ranging from one emitter for a small tree up to two to five for a large tree. For both types of lateral lines, freedom from clogging of the emitters or orifices may depend on a periodic flushing out the end of each lateral to remove the silt accumulated in the bottom of the line. Even the mainlines may need to be flushed, but less frequently. It would be desirable to have a plant or row of plants at the end to be irrigated with the flushing water. Automatic valves which open at a pre-set interval to flush the lateral lines are available in the U.S., but for this installation, manual flushing would I think, be better. If a clogging problem develops from salt in the water, it can be avoided by periodically adding a chemical treatment to the water.

The second problem--that of deterioration of the plastic lines, may prove more difficult to overcome but only experience will tell. Certainly the pipes could be buried two or three cm to reduce exposure to the sun. The plant foliage will also provide shade. In the U.S. the emitter lines are often left lying on top of the ground for several years in orchards with little concern. In Hawaii the perforated lines are often buried several centimeters in the cane rows but the objective in this case is mostly to avoid burning when the fields are fired before harvest. They are hoping for a 6-year life of the lines in sugar cane because the fields are re-planted at that interval and the lines would be destroyed anyway. For this proposed trial, it is hoped that, by burying the lines in row crops not more than two to five cm, they can be easily withdrawn before they would be damaged by any harvesting or planting procedures. Nevertheless, they might be accidentally cut, so some repair inserts must be provided. It is conceivable that, in the case of row crops the roots might make it more difficult to withdraw the line without damage. Different procedures can be tried in an attempt to overcome any difficulties that may arise.

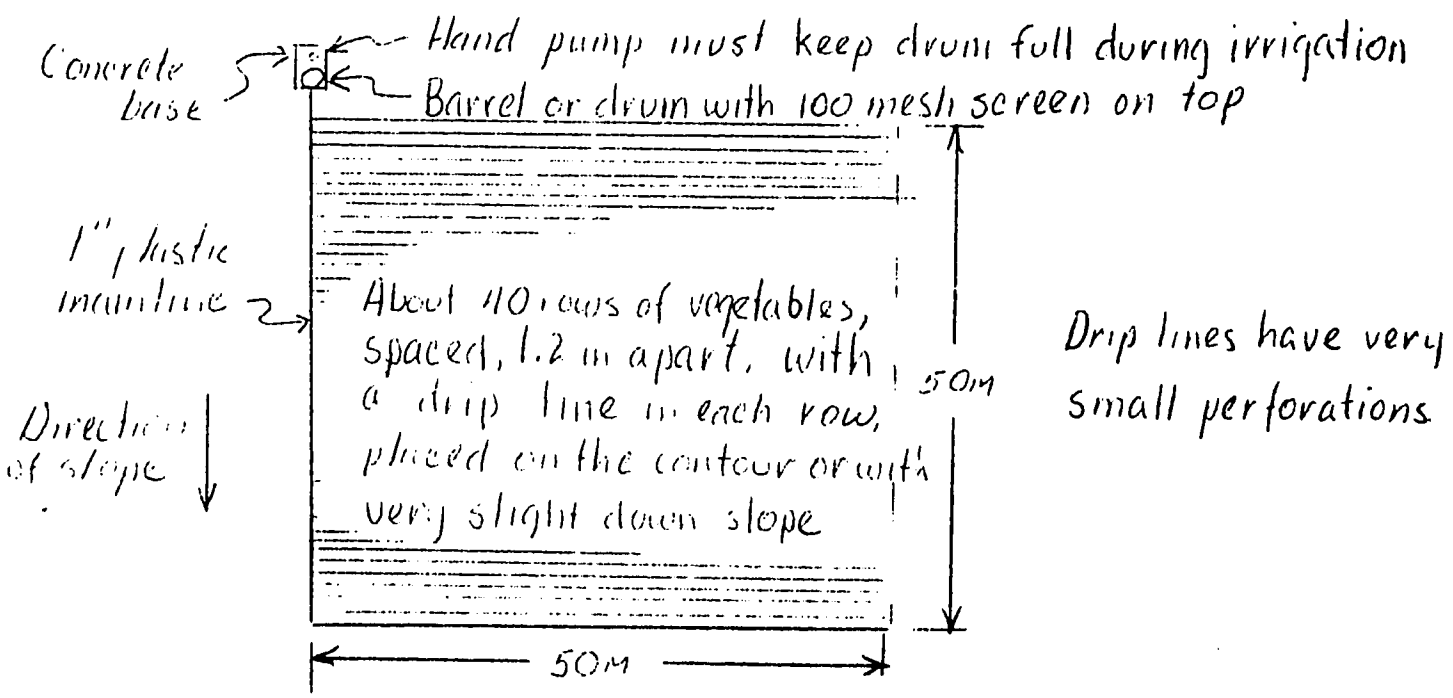
Two drip plots are proposed, as shown in the sketch. Each is about 50 m X 50 m, or 0.25 ha., although the fruit block is closer to 50 X 54 m. The fruit block would employ drippers of some type, possibly the small spaghetti tubing only. The spaghetti tubing has the advantage of being cheaper initially, and also the advantage that the drip point can be moved if desired to keep it the proper distance from the tree trunk as the tree grows. It is also a simple matter to add a dripper by punching a hole in the line and inserting another drip tube. Other types of emitters are equally easy to install. In the case of the spaghetti tubing, the flow rate is determined by the length of the tube and the pressure on the system. Most emitters are calibrated at 15 psi (one atmosphere) and higher, but hopefully some, like the spaghetti tubing,

Irrigation Scheme No. 6

Two driven wells with hand pumps, each supplying a drip irrigation system covering 0.25 hectare. One block in fruit, one in vegetables



Fruit block, with up to 4 drippers per citrus or guava tree and 5 per mango tree



Vegetable Block

can be operated at much lower pressures, because according to these plans they will have only one or two psi. The perforated tubing would likely work better at these lower pressures than the emitters. Partly for this reason, and partly because Mr. Soulez, in charge of fruit research for INRAN, has knowledge of drip irrigation, I recommend that the fruit block be established at the experiment station at Bankoukou. Mr. Soulez informed us that this station already has several concrete wells, and a centrifugal pump that is moved from well to well for sprinkler irrigation. He has already proposed a project to his director that would construct a tank to maintain a constant pressure on the emitters. A 15 psi pressure would require a head of about 10.5 m. Even if he does not get approval for a high tank, an inexpensive tank could be assembled from a 55-gal. drum set on some kind of a stand at a lower height, and filled by hose or small pipeline from his sprinkler pump. The water could be introduced to the drum through a common float valve used in a toilet tank. This would insure a constant head while the pump was running, without overflowing the tank. If the elevated tank idea cannot be put into being, then a new well could be driven and pumped by hand as shown in the sketch. Drippers that operate at low pressure would have to be selected. A seedling would require only one emitter, but more must be added as the tree grows. The suggested cropping as shown on the sketch has Mr. Soulez's suggestions incorporated in it.

The vegetable block could be located at a different place. Again, it is an advantage to have the land gently sloping down the mainline, and the laterals nearly on the contour, or slightly down hill. About 40 cm fall from the upper corner to the lower corner of the field, across the diagonal, would be ideal for both systems, with the slope as uniform as possible. The perforations in the laterals will be spaced uniformly unless otherwise specified, and close enough together to make a continuous line of wet soil along the row. Likely other spacings can be obtained by special order, so that for melons, squash, and even tomatoes, the perforations can be clustered in a short space, with longer distances between clusters. In this case I suggest laying out the lines before planting the crops, so the wet spots can coincide with the planting. This system has a greater chance for being economical for crops normally planted with wide row spacings, and hence the narrowest spacing proposed is 1.2 meters. It is believed that unstaked tomatoes, manioc, and sweet potatoes would meet this criterion, plus melons and cucumbers. Watermelons and squash can be spaced about 2m X 2m.

Unless Mr. Soulez develops a water supply from an elevated tank, each well, pump, and barrel or drum can be assembled and installed on the upper corner of the selected field in a manner like that for Scheme No. 1.

One difference is the addition of the stainless steel screen. It could be welded to a metal ring just large enough to slip over the barrel, and the ring held securely in place with setscrews anchored under the rim of the barrel. The mainline could be tapped into the barrel about 5 or 6 cm above the bottom to allow for sand settlement in the bottom. A drain plug set lower could be used for flushing the tank as needed.

To operate the system, an appropriate number of irrigators could be lined up behind the pump waiting their turns on the handle. Depending on the pumping equipment that can be located, the capacity of the well, etc., this job could be sufficiently exhausting to require frequent relief If the screen tends to clog, another job, in turn, would be keeping it brushed off. The barrel must be kept nearly full to provide the maximum head possible for the drippers. During peak use over the entire block, this may require nearly continuous pumping during the daylight hours. If some rows do not require water, their laterals can be closed temporarily. No furrows or beds are required. If all goes well, the only labor required after the system is laid out is pumping, and occasionally flushing and checking.

Tensiometers can be used to tell when pumping can be stopped for the day, and whether or not in the rainy season it needs to start again the next day. They should be installed about 30 cm from a dripper and about 30 cm from the stem of a plant, or perhaps from a principal tree root. One criterion followed in California is to start irrigating when the tension is 40 centibars and stop when it gets down to 20. This schedule could be tried here, and if successful could be used at least long enough to learn, by keeping records, what kind of pumping schedule is needed for each crop at different times of the year and at different stages of growth. Tensiometers are somewhat delicate and sometimes a person will not recognize when they are reading incorrectly, so they may not prove to be the most satisfactory instrument for these plots. The other guide that can be used is pan evaporation from the nearest weather station. Here again, the use of tensiometers could help get a correlation established with pan evaporation for each crop. In Oregon we have successfully estimated the water requirement from pan evaporation by considering the ground area covered by the shadow (of a tree, for instance) at high noon, and applying each day the volume of water through the drippers that would be required to spread over that area to the depth of the pan evaporation on the previous day.

A detailed material listcannot be prepared until access to suppliers' catalogs in the U.S. is available. Following is a generalized list.

List of Imported Materials for Scheme No. 6

Quantity	Size	Item	Estimated Price in U.S.
2 units		Materials for well (see Scheme No. 1)	$ 800
2 pc		Stainless steel screens	100
10 pc		Tensiometers	300
2 units		Drip irrigation system	800
		Estimated Total	$2,000

Again the cost of fencing must be added to this, plus the concrete pump base, the used barrels, and the shipping costs. Since this is for [illegible] hectare, the total will be in excess of $4,000 per hectare.

The longevity of the plastic drip equipment is unknown in this climate. Some growers in the U.S. are expecting their systems with emitters to last 10 years or more. The lighter weight perforated tubing might have to be replaced sooner because of mechanical damage, but it is tough. The answer can only be determined by trial.

A more serious question is whether or not the system can be kept operating without serious plugging problems or mechanical damage problems. Since this scheme proposes using only well water it has a much better chance of success than it would with surface water. The scheme would be better if the systems had a little more pressure, but lifting it higher by hand is a lot of work. A uniform distribution of water is more dependent on having a smooth field at about the right slope when the pressure is low, so this trial might show that the pressure must be increased, or the field smoothed a bit.

Because drip irrigation has promise as a better method for arid areas like Niger, this scheme should probably be included as a trial in spite of the problems that may arise. Although the details of material selection must be worked out later, this design has been kept as simple and as trouble-free as possible, and will succeed if any design could.

One precaution that must be followed is to pump the well first until no more sand comes up. The well screen size has been chosen large enough to pass some sand, but with hard pumping, this will soon stop. At that time the pump leathers may have to be replaced. From then on there will be little or no sand, and the drip system can be connected to the barrel or tank, and operations begun.

Section IV

Assess the Capabilities of the GON Rural Engineering Service and Other Agencies for the Development and Implementation of These Systems

After two conferences with Mr. Seyni Ali and his adjutant, I have become very impressed with their enthusiasm and the confidence they have in the ability of Genie Rural to carry out any irrigation scheme that might be proposed. They asked intelligent questions about each of the six irrigation schemes as each was explained to them. I'm quite sure they understand the basic concept intended with each scheme. They have had experience with sprinklers, and likely could assemble the pipe with only a layout plan and instructions in French. Maintenance of the engine may be another problem. A rigid schedule for lubrication, filter changes, etc. appropriate for this dusty, sandy environment must be detailed in French, as well as a manual for major overhaul. Lubrication of the pump, tightening and replacing the packing, etc., must be included. I do expect them to be hesitant to run the sprinklers during the heat of the day, but I hope they will not give up on it without an adequate trial period.

Apparently they had not seen gated pipe, but when they were shown a picture, they comprehended immediately. They were quick to recognize that on sandy soil the length of run in level furrows would not be very great I did not discuss the 1/5 rule with them, but assume they will be given a translated copy of the pertinent parts of my report, explaining operational procedures. I think the drip system is new to them and possibly they did not completely understand the need for regular flushing. I'm sure some guidance and explanation will be required to help them sort out the pieces and get each system using imported equipment operating as intended. We did not talk much about the method of driving a well. It would be extremely helpful if someone like a PCV could demonstrate this technique for them.

Schemes No. 2 and 3 were easily understood by them. However, they were disturbed that I had not placed the ditches on fills so water could flow out onto the land by gravity. I think they made a good point here, so I added a paragraph to Scheme No. 3 suggesting that this change be made if the soil is not too sandy. They may need some help to figure out that, if the field is sufficiently smooth, one head ditch running down each side of each elevated lined ditch might be all the distribution system needed from each box to serve all the contour furrows in that small block. For Scheme No. 3 to work well, each of these unlined head ditches would have to be about 20 m long and serve parallel contour furrows 10 m long. A man with an irrigator's shovel would direct the stream into each furrow, probably one at a time.

Mr. Moussa Saley, Director of Agriculture, explained that their role would be to monitor the progress of each irrigation trial, evaluate its relative success, and prepare a report on it. They depend on Genie Rural to install and operate the irrigation systems. Genie Rural will, in turn, attempt to motivate and educate the local farmers who will be doing the work under their supervision. If it works as planned, the farmers after the installation, would be doing the planting, weeding, irrigating, and eating the crops. They would also be expected to make the brick and tile for Schemes 2 and 3, do any land smoothing necessary, and install the tile and brick in the ditches. Hopefully, a satisfactory way would be found for them to help with the well construction and fence construction.

OFEDES appears to be doing a good job of concrete well construction. They apparently solicit local help for the first part of the excavation that can be done by hand, and reduce the charge accordingly. They service each well every 3 years for a fee. A few of their wells in sand aquifers have failed from cave-ins due to sand entering the well and continually being pumped out, but in general they have held up better than others. They could stop the sand problem by using No. 10 well screen, but the cost would be much more. However, I like the approach being used by Church World Service at Tabelot and in the Afassas Kori. They have constructed metal forms for casting concrete well casing in one meter sections. They follow a similar procedure to OFEDES, by digging out inside to settle the casing, except that it is all done by hand. They cannot get as far into the aquifer without equipment, but far enough apparently to obtain sufficient yield for a deleu. Their wells cost only one tenth as much as the OFEDES wells. I think it would be a big help if an effort like this could be started in the Dallol Basso.

INRAN appears to be operating a fairly good research program. I would expect them to be successful in keeping a drip system operating on fruit trees. Mr. Soulez is currently in the U.S. where he will have an opportunity to see drip irrigation in southern California. He will be impressed with the importance of screening and flushing to avoid clogging, and this experience will make him better qualified to solve problems that may arise here.

Section V

Develop a Time-Phased Plan for the Research, Experimentation, and Implementation Necessary to Tap These Sources of Water for Agricultural Production, with Specification of Technical Assistance Required

Experimentation on irrigation methods and associated techniques will, it seems to me, need to continue through the entire period of development and implementation. Hopefully, enough will be learned from the irrigation schemes tried during the first two years to know which ones are more likely to be practical, feasible, and acceptable. Perhaps these trials will generate new ideas, better than any of the first ones, but that still need to be tried before implementing on a larger scale.

The following schedule is a rough estimate of the order in which tasks should be initiated during the first two years, after approval of the project, by month. Some items will be completed quickly while others will continue. One unknown is how long it takes for delivery of imported material. The "technician" refers to one person only for all items, a Peace Corps type who has had considerable irrigation experience plus some related academic training, and a lot of natural mechanical ability.

Tentative Operations Schedule
First Two Years

Month	Task	Technician Required ?
1	Write specifications and place orders for all imported irrigation equipment and instruments for weather station. (To be done in the U.S.).	No
1	Investigate possible alternative fencing methods and materials. Select the one or two best ideas and place orders for the materials for them. One of them could be electric. (To be done partly in the U.S., partly in Niger)	Yes
2	Select tentative sites for irrigation trials. Make inventory of soil and water properties. If favorable, smooth all except sprinkler site. Make topog survey of all except sprinkler site .	Yes
2	Experiment with making tile and bricks for lining irrigation ditches. Cast several forms for use by farmers for making their own tile.	No

Month	Task	Technician Required ?
2	Develop procedure whereby farmers can construct their own concrete wells by hand. Make at least one set of steel forms available to them. Train a sufficient number to serve as construction supervisors for future wells while constructing the wells for Schemes 2, 3 and 4 on the test sites.	Yes
3	Construct OFEDES well for Scheme No. 5.	No
3	Obtain animals and materials for constructing deleus. Construct deleus and train animals to extract the water. Use all local materials if possible.	Yes
3	Choose 4 preferably unpumped, concrete wells in the Dallol Bosso and one or two in the Ouallam area for weekly measurement of water level, to be taken at the same time each day, one day per week. Keep permanent records. Reference curb elevation to nearest benchmark.	No
5	Construct lined ditches and distribution boxes for Schemes 2 and 3.	
8	Install weather station and fence around it, and start daily readings for permanent record.	Yes
10	Drive wells and install pumps.	Yes
12	Install irrigation systems.	Yes
13	Prepare contour furrows, basins, etc., for subplots and selected crops.	Yes
13	Plant crops and irrigate.	No
17	Harvest first crops and plant second crop.	
18	Place orders for any equipment required for expansion of those schemes favored for installation during third year, including any promising new schemes for trial.	Yes

Month	Task	Technician Required ?
19	Choose additional sites for next probable development of areas with shallow permanent water tables. Prepare sites for development.	No
24	Evaluate results of research on irrigation schemes	Yes (Economist)

Tentative Schedule
for Years 3 Through 6

Year	Task	Technician Required?
3	If deleu shows promise of being used successfully, continue education and training on construction and use.	No
3	Continue help to farmers for constructing their own concrete wells, deleus, lined ditches, etc.	No
4	If deleu is not satisfactory try to develop other methods using animal traction and mostly local materials, such as an endless belt built with hand-made ropes, or a slow speed vertical centrifugal pump, locally assembled from imported materials.	Yes
5	Consider expanding effort to areas with a permanent water table 5 to 8 meters deep. Include consideration of feasible schemes using imported equipment, if any.	No
6	Continue encouraging expansion to the most desirable sites with the best methods.	No

It is most urgent that orders for any imported equipment be placed as soon as possible after approval of the project. However, if the schemes using local materials are approved, they need not be delayed, but should continue as rapidly as the training of people and animals will permit.

During the second phase, the schedule is more vague and indefinite. A lot depends on the success of animal traction with the deleu. Most of the alternatives involve imported equipment, with all the problems that come with it. If a shallow well can be constructed for one-tenth of the cost of the OFEDES well, as is being done near Agadez, then the deleu system, if also built by hand, has a much better chance of showing a profit.

Section VI

Identify any Water Conservation Measures that May be Appropriate in These Areas, and Make Recommendations as to How They May be Implemented

The irrigation schemes proposed herein are all water conservation measures. The level furrows and level basins will not only help to obtain uniform distribution of irrigation water, but will hold the rainwater in place, without runoff, as well. The sprinkler system is well adapted to land too undulating to be used for level furrows without the availability of heavy equipment for land leveling. The drip system is probably the most economical of all for the amount of irrigation water required for a crop.

Pumping from a shallow water table is a water conservation measure in itself No drainage problem can be created because the water table is the source of water. Excess water applied by over irrigation is not all lost, because much of it returns to the water table.

One type of development scheme which would be a water conservation measure is the development of a mare without a permanent shallow water table by excavation of a reservoir at the lowest point. The depth of excavation would have to be significantly greater than the expected evaporation, and the total volume no greater than the expected annual yield of the basin. It would have to be in an area with subsoil very slowly permeable, so the contents of the reservoir would not be lost to the water table. Of course, even losing the water to the water table might be acceptable if it would be recoverable at a shallow depth someplace below. The excavated material from the reservoir could be spread uniformly over the adjacent land if it is satisfactory for growing crops. It could be used to fill depressions and thus level the land. However it is placed, it must not in any way obstruct the overland flow of water into the reservoir. If the reservoir is surrounded by relatively level land, the excavation could include ditches radiating out from the reservoir to the boundary of the area to be irrigated. The ditches would need to be excavated to the same depth as the bottom of the reservoir and no wider than needed to maintain this depth. The volume of the ditches should be included with the calculated volume of the reservoir.

One reason a development scheme of this kind was not included as one of the schemes for trial during the first two years is that I did not inspect a site such as I have described here. They have been described to me by others, however. A development scheme similar to the one I

described has been proposed to me by Genie Rural and by Jim Livingston. Mr. Livingston stated that he and an agricultural engineer had at one time estimated a development cost for excavation at $2,500 per irrigated hectare. If so, this cost compares favorably with a $1600 OFEDES well that will be used for only 1/2 hectare, but not so favorably with a concrete well constructed by hand for one tenth of this cost, as CWS claims to have done. Mr. Livingston also suggested the possibility of erecting a deleu over each ditch to withdraw water for irrigation.

The other reason mares of this type were not recommended for early development is the experience Genie Rural has had with Sanam Mare. Mr. Seyni Ali stated that this one had been excavated in 1965, but because there was no money for maintenance, it filled up with silt and sand, mostly blown in.. He realizes that extensive windbreaks would be required to prevent this, and that somehow the windbreaks must be established before the excavation. The latter may be difficult if there is not enough water at that time to keep them growing. Mr. Ali also mentioned another constructed mare that was to be filled by diversion from a dike, but the dike broke, and there was no money to repair it. These incidents serve to emphasize the need for careful engineering planning and design to avoid failure, plus a provision for adequate maintenance, all of which add to the cost.

It would seem to me that sometime during the second phase, if an ideal mare of this type can be found, it could be cautiously developed, providing the cost per irrigated hectare is not too great, and there is enough local interest to develop and maintain it.

I feel compelled to list one more water conservation measure that would also conserve soil. I'm sure this has been suggested before, but a system of level, flat-channel type terraces on the millet fields surrounding the bas fond areas might prove very beneficial. My concept would be to make the dikes high enough to prevent any possibility of overtopping from the hardest rains, with a flat, level channel behind the dike wide enough to produce an optimum yield of grain in the channel. On land that is very gently sloping, essentially all of the area would be in either flat channel or dike. On steeper land, less area can be flattened. Normally only the channel would be seeded. In fact, if there were an inexpensive way to make the sloping portion both waterproof and erosion proof, that would be ideal. If a heavy rain exceeds the moisture holding capacity of the soil in the flat channel, the excess would likely reach the water table in the bas fond, with less loss to evaporation than it would otherwise have. Such a terrace system would have to start at the top of a hill or divide, or else a diversion terrace would have to be provided to protect the upper level terrace from overtopping. Of course, an extensive scheme like this is highly impractical without heavy equipment, but a few plots of a few square meters each could be constructed by hand on a trial basis. The objectives would be to determine what surface configuration would result in the greatest average yield increase over the gross area.

A Few Random Thoughts in Summary and Conclusion

Ever since I began to grasp enough of the problem of developing the bas fond and mare areas for irrigation, three problems have loomed as seemingly insurmountable obstacles, assuming that the development course must be based as much as possible on local materials and local talents. These three are:

1. The seeming necessity for, and the high cost of fencing to protect the establishment of a living fence around garden plots.

2. The high cost of OFEDES wells.

3. The lack of a locally acceptable method for extracting water from wells using animal traction, and the limited capacity of the methods most successful in other places.

After seeing the garden developments northeast of Agadez, I have taken new hope that farmers can, with technical guidance, learn how to construct satisfactory shallow concrete wells by hand at a fraction of the cost of OFEDES wells. This is a tremendous step forward, and seems to me to be the direction that must be taken here. My proposals for driven wells were another attempt to reduce well cost, and should be tried, in case the cheaper concrete wells fail to materialize. The driven wells will also produce cleaner water for drip irrigation systems. In case both the cheaper concrete well and the driven well should for some reason be unsuccessful, the only other idea I could suggest would be to send a sizeable cadre of potential entrepreneurs to the U.S. to learn well drilling techniques by actually working for a year or more on different types of rigs. Then, if some could get financial backing they could go into business, competing with each other and with OFEDES for relatively shallow wells. Of course, this would only create a new problem of how to extract the water from these wells.

The deleus I saw operating successfully near Agadez also gave me new optimism. In those locations they are built entirely from local materials, and were producing about enough water for 1/2 hectare. Of course, more water delivery would be better, and that is why I proposed one scheme with a centrifugal pump. I believe the pump and sprinkler system should be tried, but now I also favor placing very great emphasis on developing the use of the deleu.

Still remaining is the high cost of fencing. Surely, there must be a cheaper solution, even if it has to be a portable electric fence that could be moved when it had completed its duty in one place. I have not come up with a satisfactory suggestion for this problem, except to say that if farmers are expected to ultimately be able to develop gardens without gifts or grants from outside, a better solution for this problem must be found.

ANNEX C

PROFILE OF THE PROJECT ZONE

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B. Demographic Characteristics
C. Economic Activity in the Project Zone

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I. OVERVIEW OF THE PROJECT ZONE

A. PHYSICAL CHARACTERISTICS

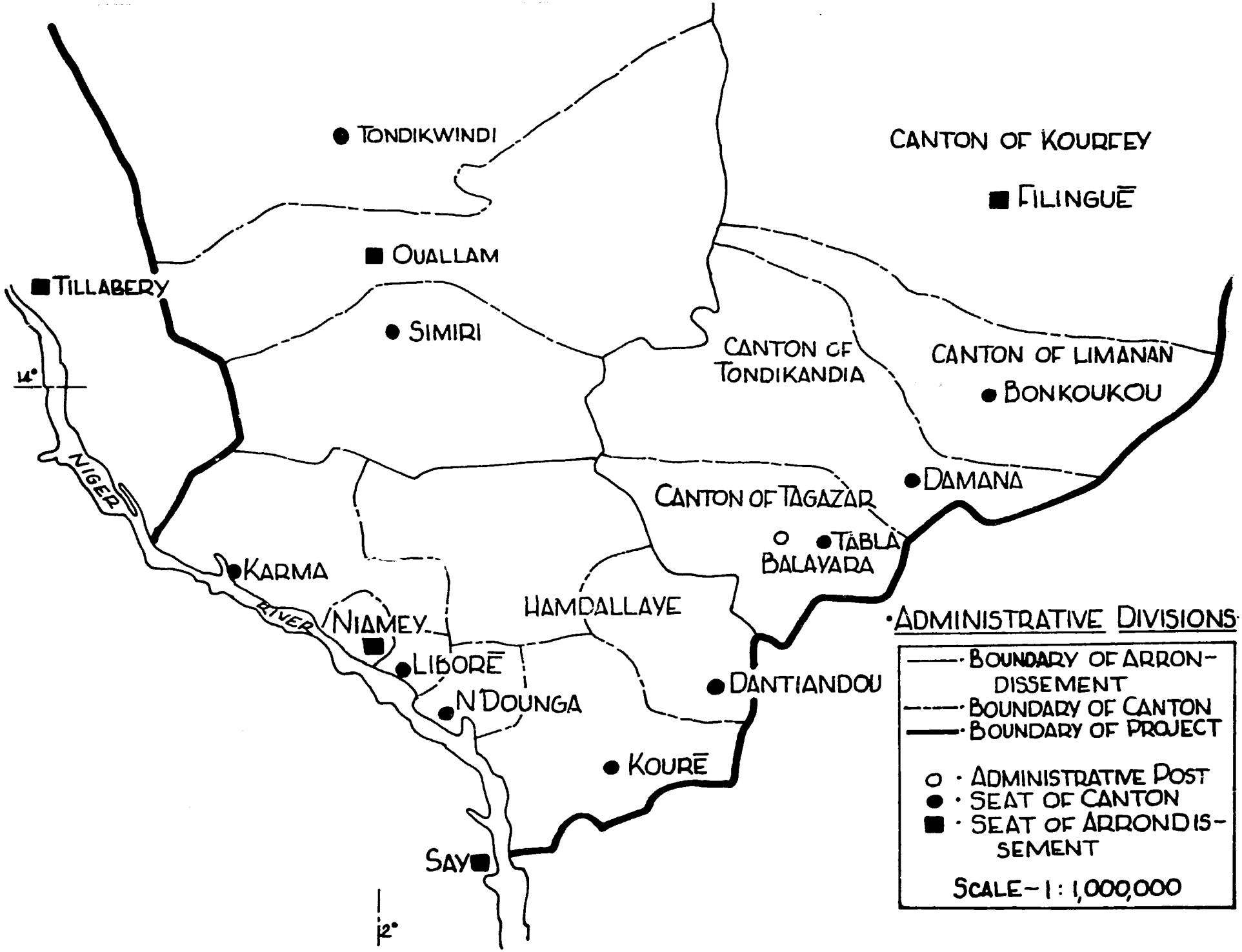
The Department of Niamey is situated in the southwest corner of Niger, covering an area of 90,293 square kilometers and including a population of 1,065,000 inhabitants. The project zone itself comprises three arrondissements on the northeastern side of the river: Niamey, Ouallam and Filingue. The arrondissements are named after the three principal towns in the area with Niamey being the nation's capital and largest city (population of greater metropolitan area: 133,500). The project zone has a surface area of about 30,000 square kilometers and it extends northward to a latitude of 14°40'. The rural population to be affected is approximately 435,000 and includes at least 700 villages.

Arrondissement	Population	Number of Villages
Niamey	284,028	155
Ouallam	145,571	187
Filingue	191,329	264
TOTAL	620,928	606

The project area can be divided into two zones, a Northern and a Southern one, according to annual rainfall figures. This division is represented by a line indicating annual precipitation of 500 mm on the basis of figures compiled during the last 25 years. This line cuts the project area below Ouallam and Filingue, with the Northern zone receiving an average of less than 500mm of rainfall each year and the Southern zone more. Since the drought, annual precipitation figures have fallen short of the average annual totals for the last 25 years, therefore the 500mm isohyet figure is misleading. The Northern zone has an essentially nomadic population while the Southern zone is composed primarily of sedentary farmers.

The climate in the project area is a Sahelian one, with a long dry season lasting from October to May and a rainy season from May to October. Humidity is about 65%-75% during the rainy season and 20% to 25% from January to April. Consistently high temperatures and high water evaporation rates characterize this climate, along with dry season winds from the north and northeast (the harmattan).

Another essential feature of this Sahelian climate is the variability of annual rainfall, and its uneven distribution in terms of both place and time. The


TONDIKWINDI
CANTON OF KOUREEY
FILINGUÉ
OUALLAM
TILLABERY
SIMIRI
CANTON OF TONDIKANDIA
CANTON OF LIMANAN
BONKOUKOU
14°
NIGER
DAMANA
CANTON OF TAGAZAR
TÁBLA
BALAYARA
KARMA
RIVER
NIAMEY
HAMDALLAYE
LIBORÉ
N'DOUNGA
DANTIANDOU
KOURÉ
SAY
12°
ADMINISTRATIVE DIVISIONS
BOUNDARY OF ARRONDISSEMENT
BOUNDARY OF CANTON
BOUNDARY OF PROJECT
ADMINISTRATIVE POST
SEAT OF CANTON
SEAT OF ARRONDISSEMENT
SCALE - 1 : 1,000,000

PLUVIOMETRIC DATA

RT = Rainfall Total in mm. for each year

D = Number of Days of rainfall per year

Station	1975		1974		1973		1972		1971		1970		1969		1968		1967		1966	
	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D
Niamey	667.5	65	474.7	44	370.7	37	430.2	45	570.4	45	450.6	45	645.9	53	447.0	56	813.0	55	565.0	51
Niamey (airport)	689.5	60	500.0	49	395.0	38	342.6	47	456.5	47	476.9	44	609.6	62	543.6	59	868.4	68	506.0	53
Ouallam	349.5	28	285.5	26	289.5	28	352.1	29	394.0	26	353.0	27	334.2	33	340.0	25	564.3	45	699.2	43
Mangaize	329.8	29	248.3	25	222.6	17	283.5	21	327.3	23	272.6	26	363.7	28	357.1	31	407.2	32	302.0	28
Filingue	263.0	33	357.3	23	215.7	19	283.9	23	380.0	27	320.0	15	339.3	24	352.0	17	608.6	34	306.9	21
Toukounous	407.6	40	275.2	23	150.2	20	283.2	25	262.7	24	312.4	25	310.8	36	366.1	27	384.3	39	422.3	35

Station	1965		1964		1963		1962		1961		1960		1959		1958		1957		1956	
	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D	RT	D
Niamey	661.5	54	705.3	56	557.7	51	663.1	48	699.2	54	628.0	55	652.7	66	621.9	55	607.9	58	414.0	50
Niamey (airport)	728.4	58	854.4	62	473.5	55	740.4	57	633.6	60	561.0	60	617.4	75	523.2	51	732.7	82	540.6	59
Ouallam	619.0	36	553.0	34	502.2	33	574.5	30	43913	28	393.2	25	549.8	31	476.0	33	588.7	39	567.3	30
Mangaize	363.8	30	590.7	41	287.3	30	-		464.7*	27	370.0	26	579.6	30	551.8	33	540.0	38	438.8	29
Filingue	602.8	33	475.0	34	467.4	29	501.2	29	464.7	27	370.0	26	579.6	30	551.8	33	540.0	38	438.8	29
Toukounous	580.8	39	544.8	40	324.2	30	387.9	37	456.2	34	316.6	39	576.5	45	505.0	40	335.9	46	342.4	38

* No figures available for month of May.

difference in rainfall between contiguous areas or those on the same latitude is striking. The different annual rainfall totals for the meteorological stations in the city of Niamey and at the Niamey airport (only 10 km away) serve as an example. The monthly distribution of rain also fluctuates substantially, as does the amount of rain which falls at any one time.

The distribution of rains is another primary consideration. Ideally, rains should fall at regular intervals so as to best promote crop growth, and too much rain should not fall at any one time. Irregular rainfalls, whereby rains are separated by long dry periods, can impede crop growth. In parts of Niger in 1975 farmers were forced to plant their millet several times, because heavy early rainfalls were not succeeded at regular intervals; the first seeds planted had failed to germinate.

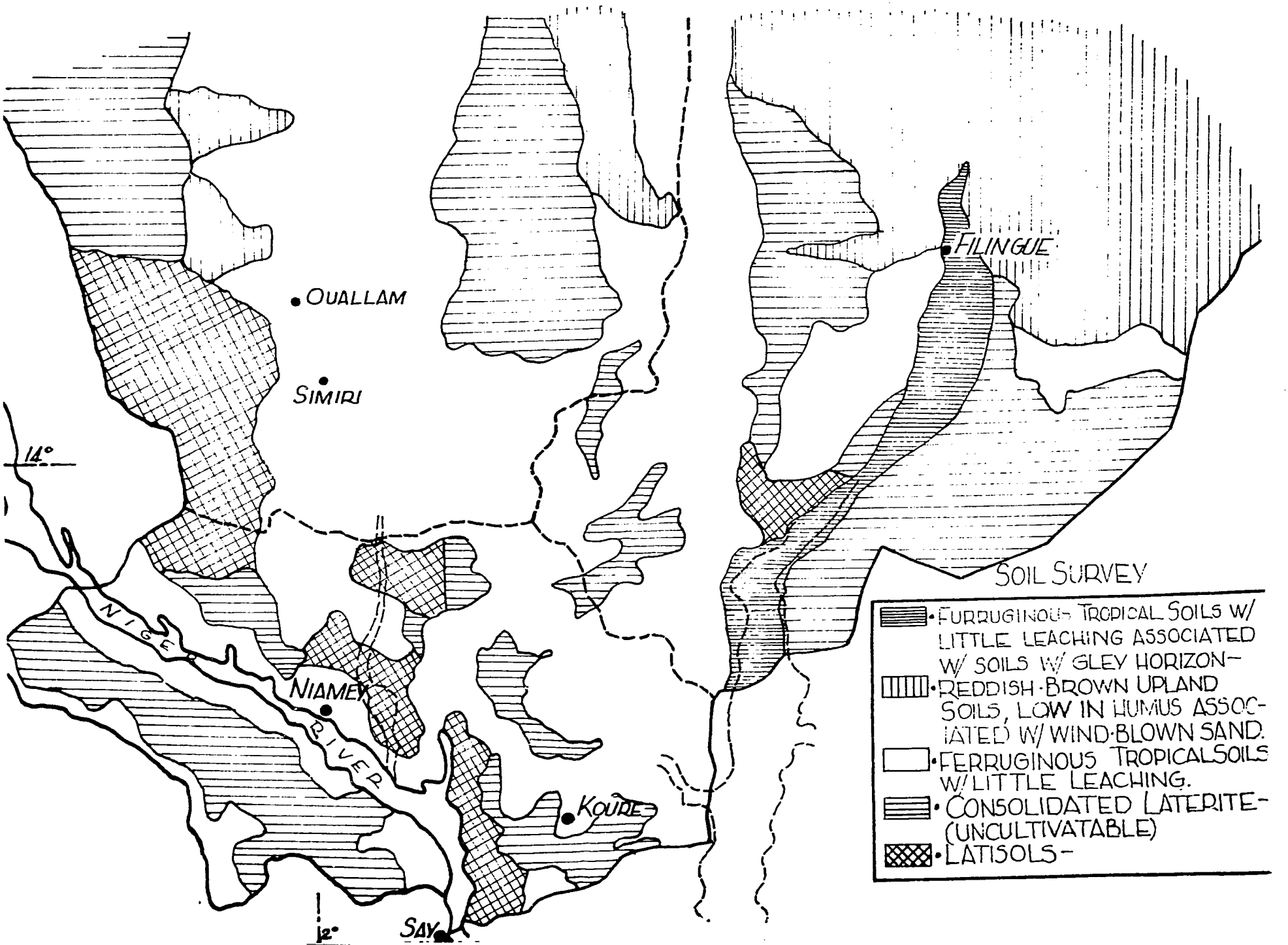
The project zone is composed principally of a low plateau at an average of 260 to 290 meters above sea level. Other notable regions in the project area include the river valley (averaging 200 to 220 meters above sea level) and the Dallol Bosso (210 to 220 meters). The Dallol Bosso is a large valley in the east of the project area extending from North to South. It was dug by an ancient river which no longer flows. It varies in width from 5 to 19 kilometers, and it contains the richest soils in the project area outside of the river valley.

About half of the surface of the project zone is made up of tropical ferruginous soils. These soils are only slightly leached, and they are low in humus and exchangeable bases. They are light, no deeper than one meter, lacking in phosphorous, and of low fertility. They are suited to millet cultivation.

Somewhat less than a quarter of the soils in the project area are of the lateritic cuirass variety in which hard stone comes right up to the surface. Hence, these soils are uncultivatable, and the regions in which they are found are uninhabited. This type of soils is found particularly on the western side of the river.

In the northern sector, there are reddish brown upland soils, which are low in humus and associated with wind-blown sand. These soils are sandy, fine in texture, shallow and capable of supporting sparse pastures.

The soils in the low-lying Dallol are of yet another type. They are water-retentive and relatively rich in gley and organic matter. There are numerous mares, some of which are permanent, which are fed by streams dropping into the Dallol from bordering plateaus and hills. It has been estimated that the permanent standing bodies of water cover about 1500 hectares.


OUALLAM
SIMIRI
FILINGUE
14°
NIGER
RIVER
NIAMEY
KOURE
SAY
12°
SOIL SURVEY
• FERRUGINOUS TROPICAL SOILS W/ LITTLE LEACHING ASSOCIATED W/ SOILS W/ GLEY HORIZON-
• REDDISH-BROWN UPLAND SOILS, LOW IN HUMUS ASSOCIATED W/ WIND-BLOWN SAND.
• FERRUGINOUS TROPICAL SOILS W/ LITTLE LEACHING.
• CONSOLIDATED LATERITE- (UNCULTIVATABLE)
• LATISOLS-

Due to its relative fertility the Dallol Bosso has a higher population density, and it tends to attract the more progressive farmers in the area, who practice diversified production. In addition to traditional millet cultivation, they practice arboriculture, market-gardening, and rice production.

Aside from the mares in the Dallol Bosso and around Ouallam, there are no other bodies of water. The Niger river does not have any permanent tributaries on the northeast side. There is, however, ample water under the surface which can be reached by wells, which are generally deeper than 20 meters.

In general, the soils of the project area are of low fertility, containing little or no humus, phosphorous and other minerals, and exchangeable bases. The Southern zone is suitable for millet and sorghum production, whereas the Northern zone is adaptable for grazing and limited millet production.

B. DEMOGRAPHIC CHARACTERISTICS

The Southern zone of the project area is much more heavily populated than the Northern zone. Its rate of population increase is 2.7% to 3%, which also exceeds that of the Northern zone (1.9%). The active farm population in the arrondissements of Niamey, Ouallam and Filingue (310,790) is greater than the nomad population (70,334). The population density is heaviest along the Niger river and in the Dallol Bosso. This is to be expected in light of the superior soils and accessibility of water in these areas (the water table is high in the Dallol).

A rough population breakdown into ethnic groups is as follows: Djerma, 50%; Hausa, 30%; Peul, 12%; Tuareg, 6%; Other, 2%. The principal ethnic groups are the Djerma and the Hausa. Both these groups are sedentary farmers who cultivate millet as their staple. The Djerma are most prevalent in the Niamey and Ouallam arrondissements, or more precisely in the Djermaganda, rugged area of Continental Terminal devoted to subsistence production. The Hausa are found in the Filingue arrondissement, particularly in and around the Dallol Bosso.

The Tuareg and Peul are both nomadic and sedentary or semi-sedentary. The nomadic Tuaregs herd their animals around the northern zone in search of pasture and water. In contrast, the migration of the nomadic Peul is transhumant, or on a north-south axis. During the rainy season the Peuls graze

their herds in the Northern zone of the project area where farming is not practiced and where seasonal rainfall provides adequate pasture and surface water. Once the harvest is over and the dry season has begun, the Peuls migrate to the South in search of better grasslands and in order to forage for millet stubble in already harvested fields. As their herds exhaust available pasture in their southward grazing, the Peuls continue to press south, sometimes out of the project area. The extent of this movement depends, of course, on the quantity of rainfall and grass available during any given year. In addition to the nomadic pastoralists among the Tuaregs and Peuls found in the Northern zone of the project area, there are more sedentary and semi-sedentary Tuaregs and Peuls as one moves to the South.

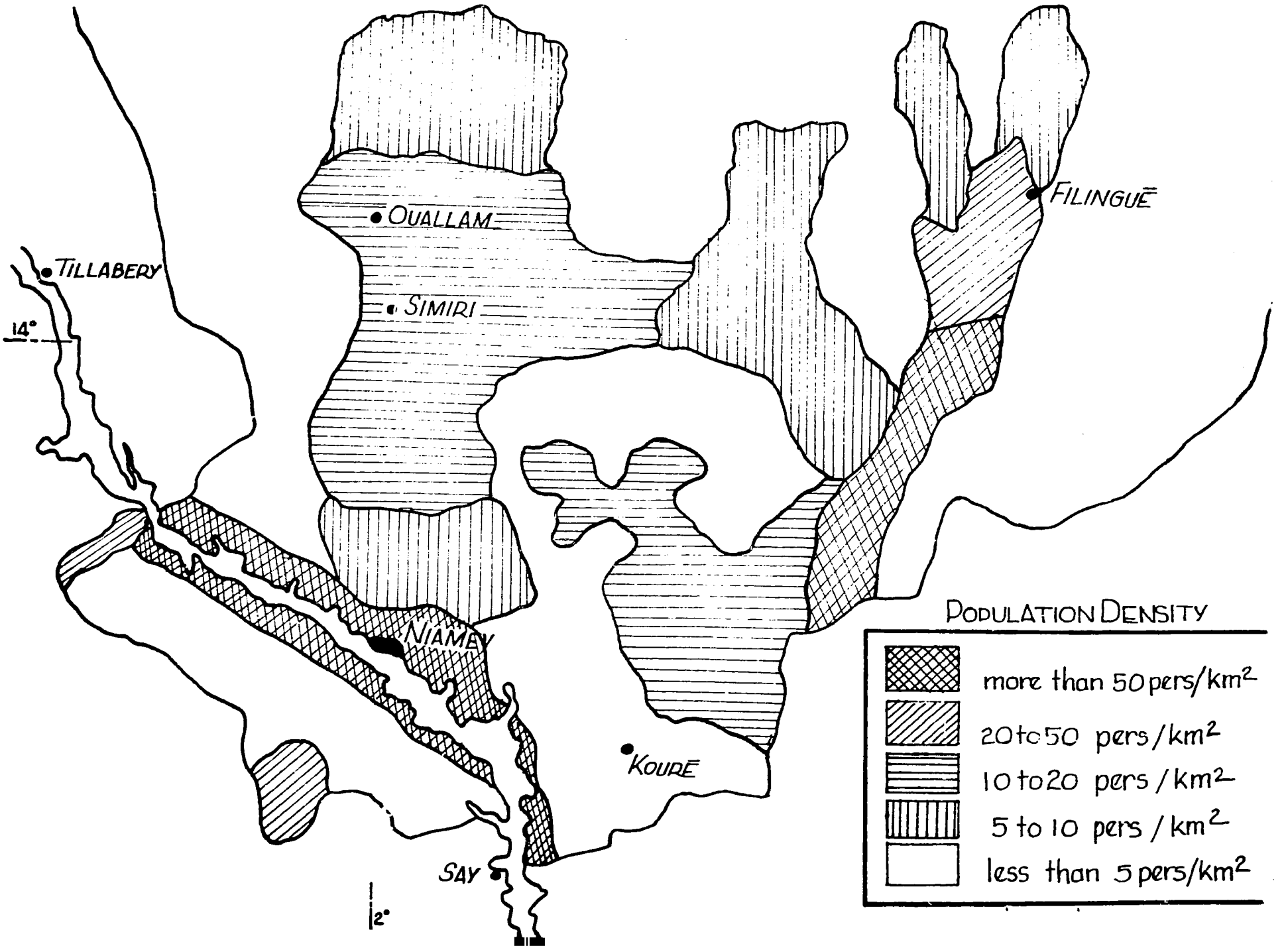
The most prevalent emigration pattern in the project zone is for able-bodied Djerma men to migrate to coastal countries, particularly Ghana and Ivory Coast, in search of more or less permanent jobs in the cities or on cocoa and coffee plantations. This movement to the coast can also be a temporary phenomenon, whereby unoccupied males work as unskilled laborers during the dry season. As the rains are about to recommence, these seasonal migrants return to work in the fields of the project zone. Many young males also migrate to Niamey in search of off-season employment. The exact figures for these migratory waves to Niamey and the Coast are unknown, though let it suffice to say that this migration is significant.

C. ECONOMIC ACTIVITY IN THE PROJECT ZONE

1. Agricultural and Livestock Production.

There is little diversification in crop production in the project area. Millet is the most widely cultivated grain, and it is the staple for all the ethnic groups. Ninety percent of the area cultivated in the project area is devoted to millet cultivation, which amounts to an average of 380,000 hectares a year. Before the drought the Niamey Department produced enough grain so that surpluses could be exported to deficit regions of Niger; now not enough grain is produced to supply local needs.

Most of the farms have no more than six hectares under cultivation. Cultivation is done entirely by hand, as traditional farming practices have not changed for centuries. As the population has increased, soil fertility has declined and the period during which fields lie fallow has been shortened or eliminated. In addition, wind and water erosion carries away tons of topsoil every year. Thus, the need for soil reconstitution has become a serious problem.


OUALLAM
SIMIRI
TILLABERY
14°
FILINGUÉ
NIAMEY
KOURÉ
SAY
2°
POPULATION DENSITY
more than 50 pers/km²
20 to 50 pers/km²
10 to 20 pers/km²
5 to 10 pers/km²
less than 5 pers/km²

Millet can be successfully cultivated in low-grade soils when there is at least 350 mm of rainfall. The millet grown in the project area is a late maturing variety which has a vegetative cycle of 90-110 days. Since the late 1960s a decreasing area has been under millet cultivation in the Niamey Department. Total production and yields per hectare have also declined.

Niebe (cowpeas) are usually intercultivated with millet, and it is sown after the principal crop has been planted. It has been increasingly cultivated in Niger, although the area cultivated in the project area has fallen off in recent years (especially in the Quallam arrondissement). Production in tons and yields per hectare have varied.

Sorghum, unlike millet and niebe, is generally grown in the southern zone of the project area where rainfall is relatively abundant and around mares or irrigated areas. It requires greater rainfall and richer soils than millet. During the last seven years the area under cultivation, total production and yields have varied.

Rice, manioc and sweet potatoes are also grown in the project area. Production, surface cultivated and yields have remained constant for rice. Those for manioc and sweet potatoes have fluctuated around a constant level, dropping significantly during the worst years of the drought. In addition, small quantities of Bambara groundnuts, vegetables, melons and fruit are grown in the project area.

Cultivation of these basic grains is greater in the southern part of the project area than in the northern zone. The northern limit of cultivation varies according to the annual rainfall and its distribution. As a rule, dry land farming is not possible in areas with less than 350 mm of rainfall per year. The 350 isohyete fluctuates substantially on a north-south axis, varying as much as 100 kilometers each year to year. If the rainfall totals for the last fifteen years are averaged, it is found that the 350 isohyete lies just south of Mangaize and Abala.

While farming is practiced more heavily in the southern zone than in the northern zone, livestock production is more heavily practiced in the northern zone. There the sandy and less fertile soils are best adapted for the grazing of cattle, camels, sheep and goats. The legal dividing line between farmland and pasture, as decreed by the government of Niger before the drought is the 350 mm isohyete. During the growing season, herders are supposed to move north of the 350 mm isohyete, i.e., out of the cultivatable areas. Of course once the harvest has been completed, nomads, particularly the Peuls, are allowed to migrate south so that their cattle can graze on the fodder remaining in the fields, in turn fertilizing them with manure.

Cattle are sold at the principal beef markets of Baleyara, Mangaize and Abala and sent south to be consumed. More cattle appear on the market at certain times of the year than others, particularly when taxes fall due in the middle of the dry season and at the beginning of the rainy season, when herders buy provisions before migrating in search of pasture and water. The total quantity of livestock dropped markedly during the drought years, but herds are presently being slowly reconstituted.

2. Supplemental Income Generating Activities.

Supplemental family income is generated in a number of ways. In the handicrafts, local artisans, as well as some nomads and farmers, produce leather goods, silverwork, cloth, pots, clothes, blankets, skins, mats, baskets, hats and ropes. Making mud bricks, millet stalk fences and straw huts and roofs can also generate income. Women can draw and carry water, sell vegetables and spices grown in small plots, and prepare food for other families in order to earn money. Nomads sell milk to obtain cash and their belongings (clothes, pots, skins) during hard times.

Another income generating activity is off-season unskilled labor in Niamey or in coastal countries such as Ghana and Ivory Coast. As mentioned early, many young Djerma males migrate south after the harvest, hoping to find work and accumulate cash which can be sent or taken home. Other income generating activities include shop ownership, petty commerce and the repair of vehicles, bicycles, motor scooters, radios and watches. There are also some masons, carpenters, blacksmiths, traditional wells specialists, chauffeurs and merchants. Aside from the production of handicrafts, one could say that supplementary generating activities in the project area are limited.

3. Forestry.

Eaux et Forets, the forestry division of the Ministry of Rural Economy, directs several forestry projects, particularly the gao reforestation and green-belt programs. The gao (Acacia albida) projects are located in Abala (116 hectares) Banibangou (52 hectares), which are actually north of the project area, and in Tabla (150 hectares) and in Kone Kaina (200 hectares), 25 kilometers along the road to Quallam from Niamey. The former two projects have been completed, whereas Peace Corps volunteers will supervise first year planting in the latter two once the rains become regular in 1976 (July). The goal of the reforestation program is to plant trees in farmers' fields which will serve as windbreaks, thus cutting back on soil erosion. Also the leaves of gao drop off during the dry season and enrich the soils.

The green-belt projects proposed for 1976 feature the mechanically-aided establishment of 400 hectares of trees around Niamey. This will complete a one kilometer band begun in 1965 with partial USAID funding. The current project is being funded by FAC, the French Cooperation, for $190,000. The planting of green-belts of 50 hectares around the arrondissement centers of Filingue and Ouallam is still in the planning stage.

4. Private and Public Industries.

In the project area (outside of Niamey and away from the Niger River) there are no private industries and little in the way of public industries. SONERAN (la Societe Nigerienne d'Exploitation des Ressources Animales) operates a cattle ranch of 110,000 hectares at Ekrafane, which is north of Abala and near the Malian border. Five mechanically-powered small bore wells, reaching depths of 800 meters, provide water for the 10,000 head of cattle. The ranch produces 1500 tons of beef, 600 of which is exported.

5. Commercialization Within the Project Zone.

No cooperative organizations exist in the project zone outside of those in the river valley. Agricultural products are commercialized through the vehicle of traditional markets and OPVN (Office des Produits Vivriers du Niger), a state-run purchaser, stocker and seller of grain. The markets in the project area are:

Filingue Arrondissement:	Filingue, Baleyara, Bonkoukou, Damana, Gao Kabe, Sanam, Chimbarkawa, Eza.
Ouallam Arrondissement:	Ouallam, Mangaize, Guesse, Dabre, Beneberi.
Niamey Arrondissement:	Niamey, Namaro, Boubon, Kolo, Libore, N'Dounga, Diankindi, Doguel, Aoula Koura, Karma, Dantiandou.

Important cattle markets are located in Niamey, Chimarkawa, Ayerou (west of Mangaize, on the Niger River), Abala, Baleyara, Filingue and Mangaize. In order to reach these markets, cattle have to walk considerable distances. The primary cereals markets are in Niamey, Filingue, Baleyara and Gotheye (on the western bank of the Niger).

The following table shows the marketing and consumption figures for the Department of Niamey from 1969 to 1974. Little, except for rice, has been commercialized since the drought. Even the quantity of rice and percentage of the rice crop marketed have also fallen off since 1972. The last three years have been deficit years for grain production in the project area, so virtually everything produced has been consumed.

MARKETING and CONSUMPTION TRENDS for the MIAMBY DEPARTMENT

Figures are in TONS Source: Ministry of Rural Development, Agricultural Statistics

CROP	1974-75		1973-74		1972-73		1971-72		1970-71		1969-70		
	M	C	M	C	M	C	M	C	M	C	M	C	
Millet	4458	222,972	- 0 -	245,163	73,357	334,944	36,380	312,370	132,860	161,370	166,488	256,313	
Maize	808.6	33,150	- 0 -	24,137	3197	54,849	13,660	5850	13,700	12,745	30,693	49,774	
Sorghum	1.7	47,468	- 0 -	9637	14,188	37,259	10,000	29,300	14,720	23,180	17,314	45,193	
Rice	5123.9	24,[illegible]26	14,000	31,606	23,069	5171	25,000	1400	22,400	13,[illegible]	22,797	10,292	
Onions	- 0 -	28,310	- 0 -	24,641	5241	10,725	x	x	10,220	17,115	16,335	6569	
Sweet Potatoes	- 0 -	1422	- 0 -	642	318	213	900	420	319	340	195	198	

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II. AGRICULTURAL AND LIVESTOCK PRODUCTION IN THE PROJECT ZONE

A. Small Farm Systems.

1. Some general observations

Most of the farmers in the project area cultivate millet, sometimes along with niebe, on holdings averaging six hectares in area. Village lands are divided among the heads of families, although there are some instances where land is rented. In the latter case, 10% of the harvest is reserved for the landowner.

Farming in the project area is done exclusively by hand, with the use of rudimentary implements. Clearing of fields is accomplished by burning off brush and cutting down trees with small hatchets. Planting is performed with hoes. Djerma farmers use long-handled hoes, whereas the Hausa employ short-handled ones, bending at the waist to dig holes for the seed. Holes are generally dug about two steps apart in rows, and a small handful of seed is dropped into each hole before covering it over. When the farmers weed, they use a long-handled tool with a semi-circular blade called iler. It is most effective in loose, sandy soils. When grain is harvested, the farmers use one to two foot long knives to cut the millet stalks. Animal traction for pulling plows and carts is virtually nonexistent, although donkeys and camels are sometimes used to carry the sheaves of millet from the fields (or firewood from the bush).

Millet seeds are stored in above-ground granaries which do not prevent rats and field mice from entering. They are planted after the first major rain by everyone available, usually sometime in May or early June. The entire family assists in the planting. While the men and older boys work with tools, the women and children put the seeds in the holes and cover them over. The first weeding takes place about 15 days after the planting, or before the weeds reach 10 centimeters in height. At this point farmers can plant niebe between their rows of millet, for the young millet plants have sufficiently matured. A second weeding occurs about two weeks after the first one. The men and boys harvest the millet, although some of the boys may, by that time, be in school and unable to assist. Clearing of the fields is also a male activity, although women and children can help by carrying away bushes and small trees.

Almost all of the farmers allow nomads to graze their animals on their fields after the harvest. This is a symbiotic relationship in which the nomads are able to provide pasture for their animals, while sedentary farmers benefit from the manure droppings. Sedentary farmers also graze their animals on

the millet stubble. This traditional use of manure is not wholly effective, for much of its value is lost while lying exposed on the surface. Few farmers know how to use it as compost or as a fertilizer which is put under the ground during the planting. Moreover, few farmers have access to chemical fertilizers or pesticides, both because of their cost and inadequate supply and distribution.

2. Four Typical Small Farm Systems: Microcosmic Studies.

The typical sedentary farmer in the southern zone of the project area is Djerma, and he cultivates about six hectares of millet using traditional practices. This means that he does not irrigate, prevent wind and water erosion, nor use animal traction. Cultivation and water-drawing are done by hand. The millet is cultivated extensively (i.e., the seeds are planted far apart) and often intercropped with niebe. Sorghum is also grown for the rainfall in the southern-most regions is sufficient. As a supplemental source of income, farmers own a small number of goats and sheep, or perhaps a cow or two if they are better-off. Women are permitted to cultivate small plots on which they grow piment, gumbo, calabashes and melons. After the harvest, many of the able-bodied men migrate to the coast in search of off-season employment as laborers on cocoa or coffee plantations or in large cities.

The sedentary farmers of the Northern zone of the project area, particularly the Hausa in the Filingue arrondissement, cultivate millet over larger surfaces than farmers of the southern zone. More land is farmed because of the likelihood that many of the millet plants won't survive the harsher climate of the northern zone, which is characterized by inadequate and irregular rainfall, sandier soils and greater wind erosion (on account of little vegetation). Yields of millet per hectare and total production are less than they are in the southern zone. The 1975 millet crop in the northern zone was virtually non-existent, due to the irregular distribution of the rains and the damage wreaked by locusts, caterpillars and rodents. In good years, however, the farmers produce enough to sell at cereals markets.

The most progressive farmers in the project area are found in the Dallol Bosso or around the small number of permanent mares in other areas. These farmers cultivate millet and sorghum more intensively than other farmers in the project area and their yields per hectare are greater. The farmers in the Dallol benefit from a high water table and some 1500 hectares of permanent mares, which allow them to irrigate and cultivate plots of manioc, sweet potatoes and vegetables. Around their gardens they use live fencing to prevent animals from damaging their crops. Also, they sometimes plant fruit trees. In sum, the

farmers of the Dallol often practice year-round mixed cultivation, concentrating on their gardens once the millet or sorghum is harvested.

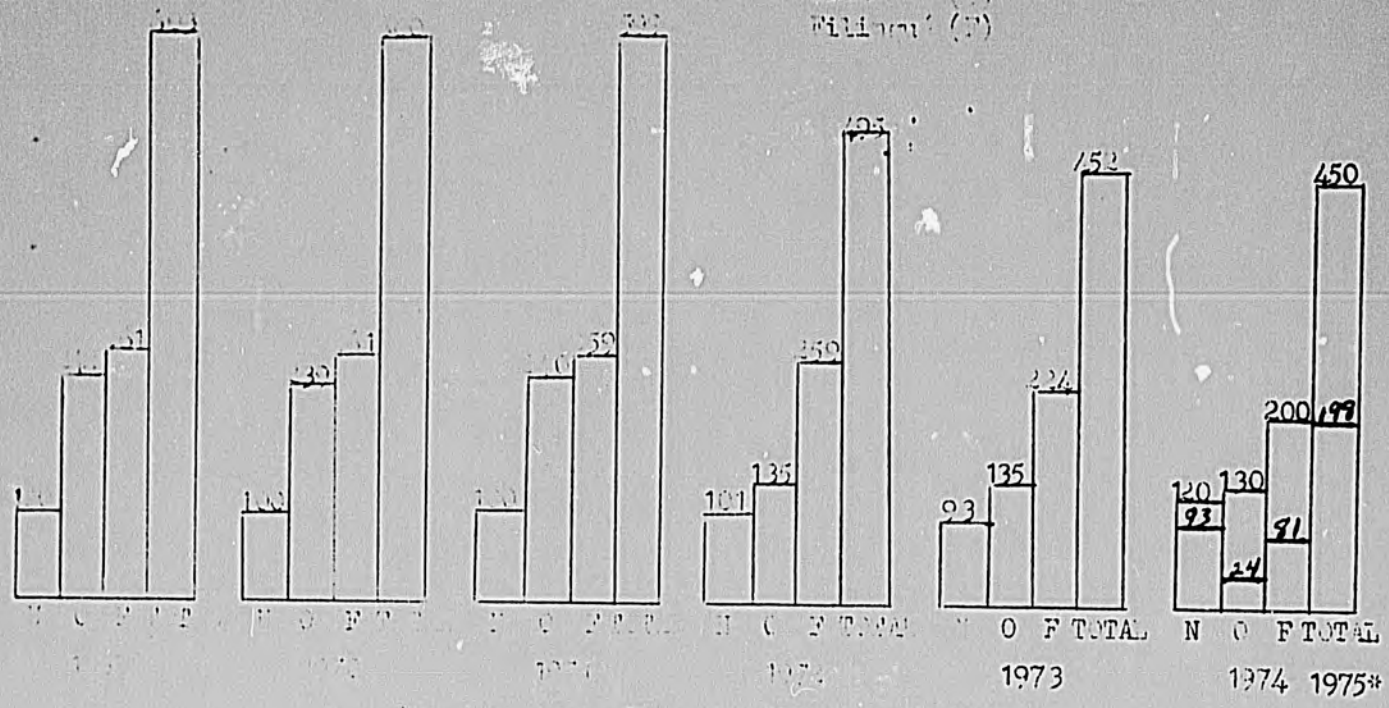
A last small farm unit is that of the sedentary or semi-sedentary Peul or Tuareg, who are most often located in and on the fringe of the southern part of the Dallol Bosso. Since the sedentarization of the nomads is a relatively recent phenomenon, many of the sedentary Peuls and Tuaregs farm mediocre lands, the best fields already having been taken or used previously by the Hausa or Djerma. Hence their total production and yields per hectare are inferior to other farmers'. During the rainy season, the heads of Peul and Tuareg families cultivate millet, while sending their sons or younger brothers northward with the family animals to search for pasture and surface water. Or if the family herd is small, it can find adequate pasture and water in the general area of the farm. After the harvest the herd returns to the family fields, staying there throughout the dry season and enriching them with manure. During the dry season milk and some cattle are sold to the sedentary Djerma and Hausa in order to purchase millet (if it's necessary). The men are often paid to care for other farmers' cattle, and the women earn money by pounding millet for other families. On the whole, the sedentary Peuls and Tuaregs are far less progressive farmers than their Djerma and Hausa neighbors in the Dallol. In trying to maintain two ways of life simultaneously, those of livestock raising and farming, they do not devote their best energies to either of them.

B. AGGREGATE CROP PRODUCTION

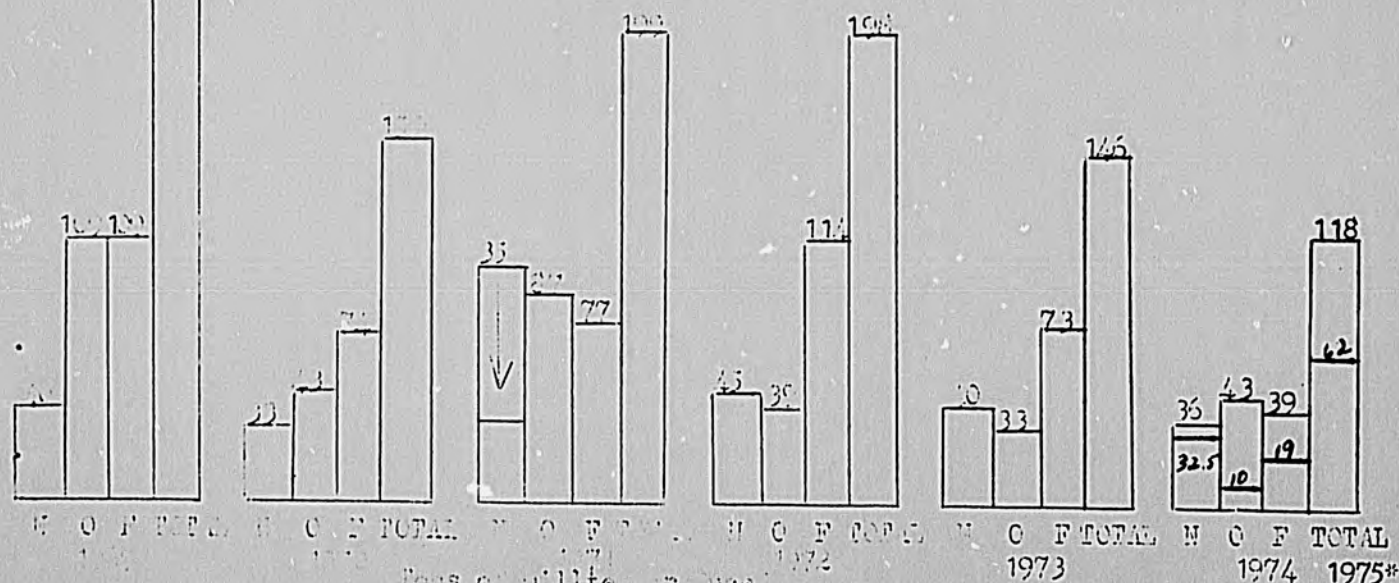
The following productivity charts show the total surface area given to the production of millet, sorghum and niebe and the quantity of each produced in the arrondisssments of Niamey, Ouallam and Filingue. From the millet productivity charts one can conclude that the surface area cultivated in millet and the total production have fallen off significantly since 1969, a year of abundant rainfall. Yields per acre have also decreased.

The surface area devoted to the cultivation of niebe, a crop of secondary importance, has declined. Since 1973 the total production of niebe has remained constant. Hence, yields per hectare have risen slightly, despite a significant drop between 1972 and 1973.

For sorghum, a minor crop in the area, the surface area cultivated has remained constant, although there was virtually no crop in 1973, the worst year of the drought. Total production decreased drastically during the drought. The quantity produced in 1973 was one tenth the quantity produced in 1971. Ever since this nadir production has increased steadily. Yields have been variable.



Sorghum area given as millet production in thousand hectares.



Tons of millet, sorghum and fingermillet.

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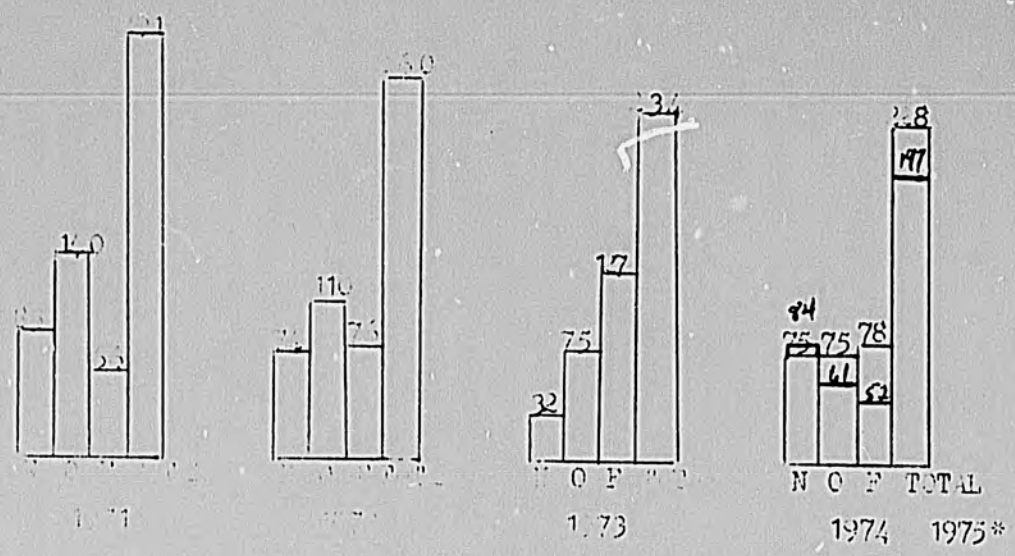
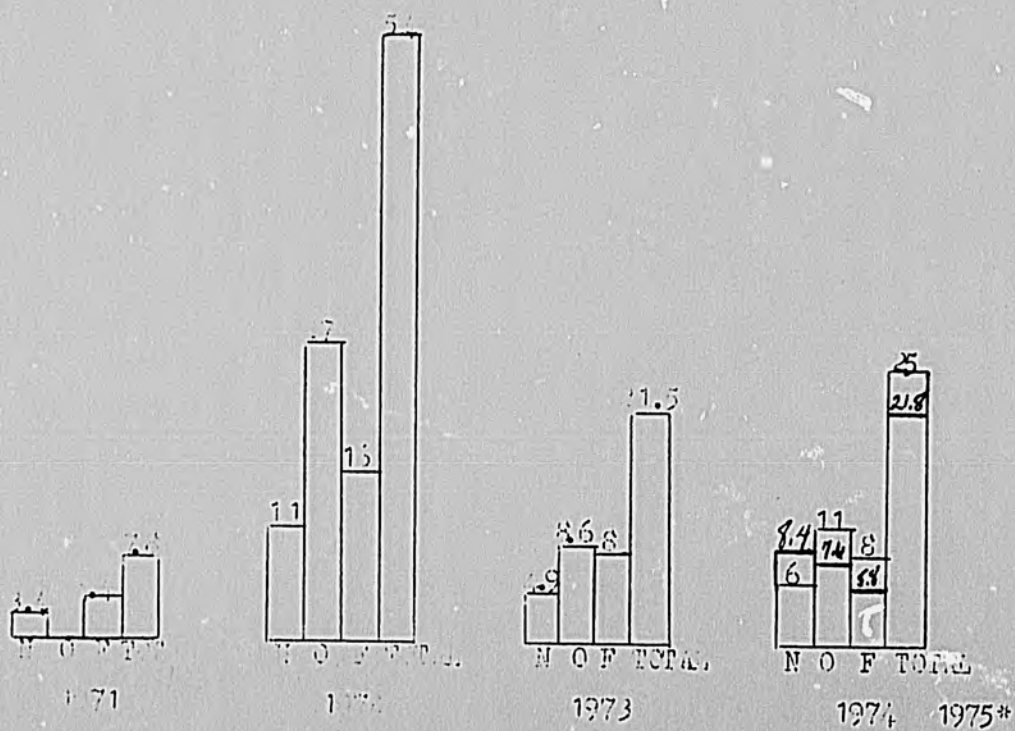
Niebe production chart: Niger (N)
Mallam (O)
Wilingai (F)



Surfaces are given to niebe production
in thousand hectares.



Tons of niebe produced
in thousand tons.

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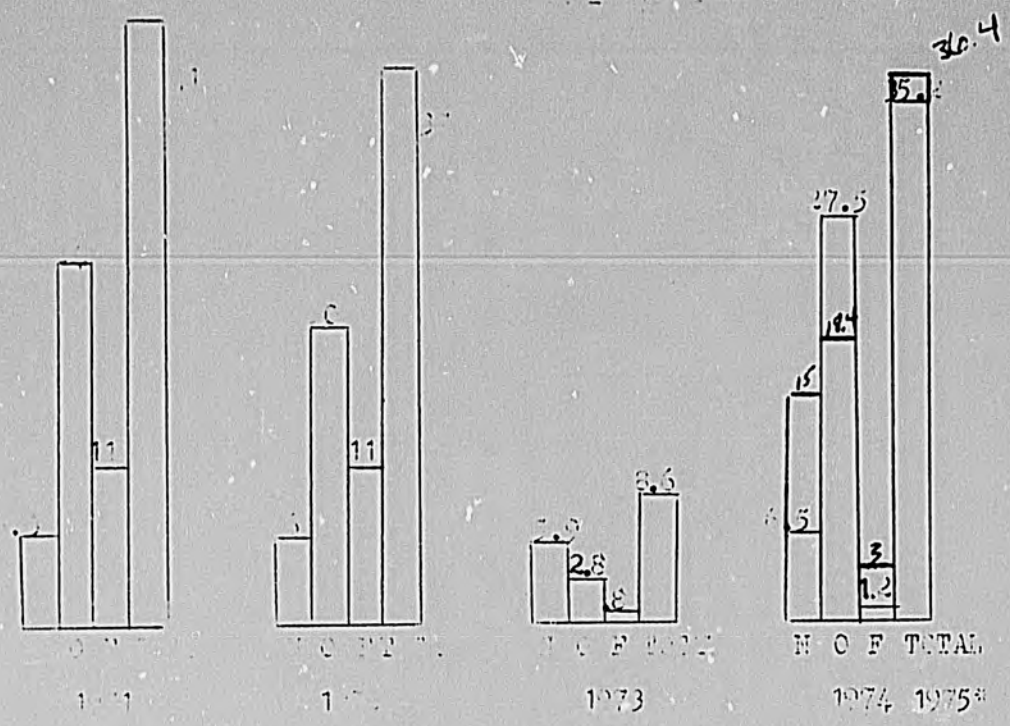
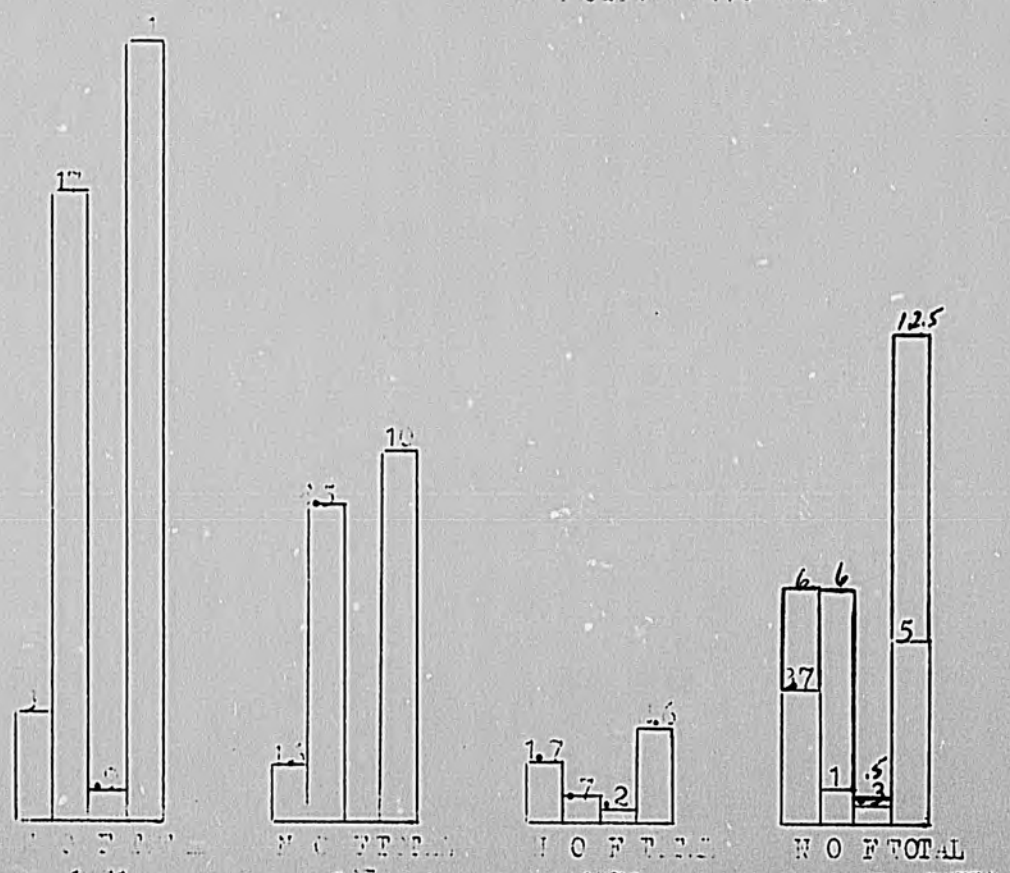


[illegible] to [illegible] production
in thousand metres.



[illegible] production
in thousand tons.

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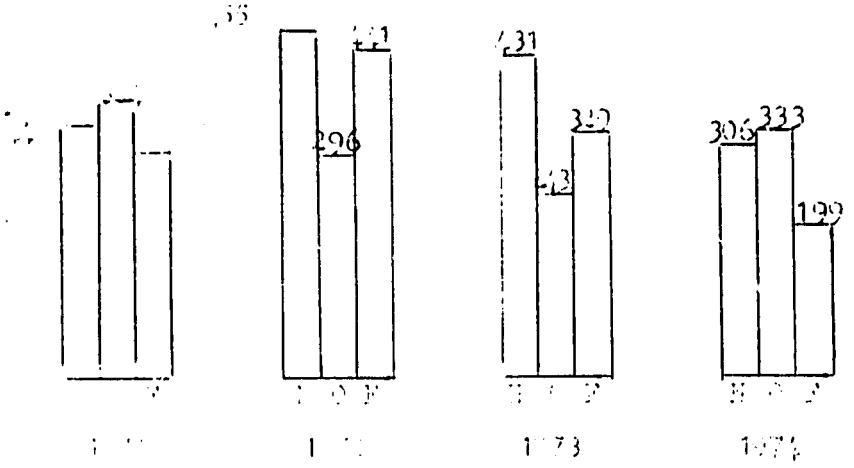
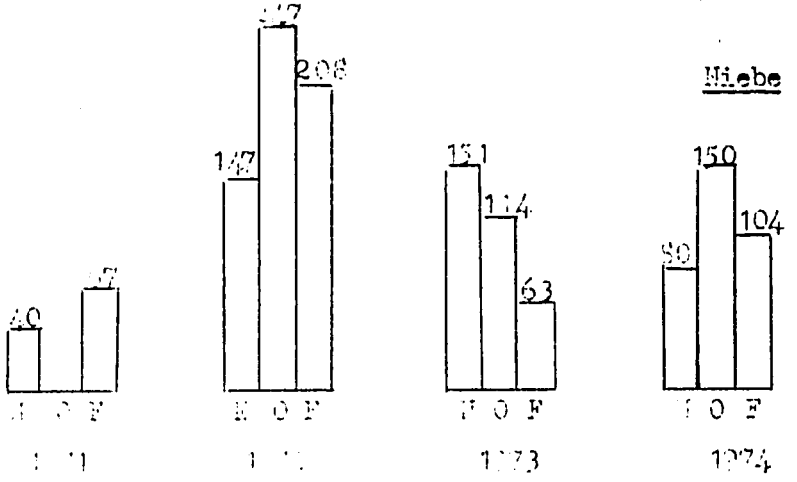
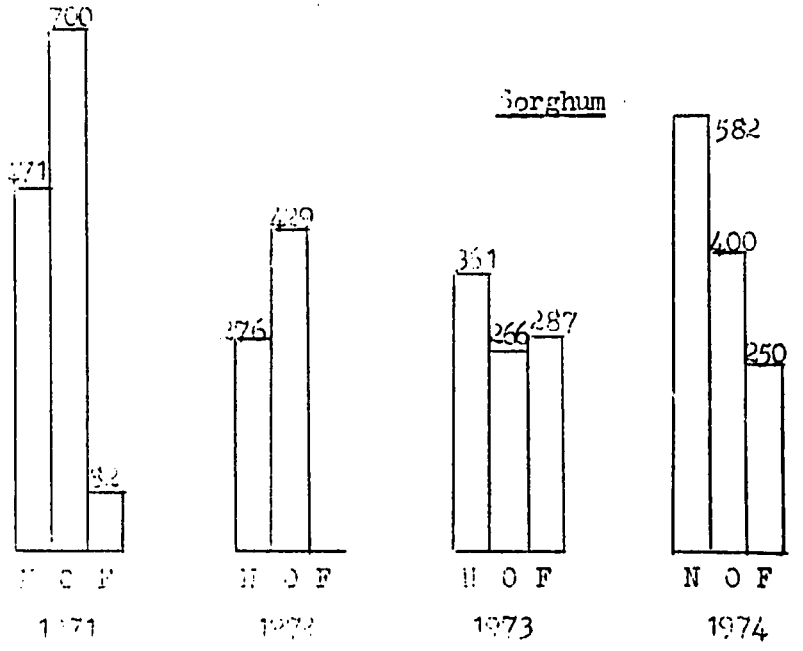
Silvopasture productivity scale: Money (N)
Cullum (O)
Fillingim (F)







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Other crops produced in the project area include rice, manioc and sweet potatoes. The surface area under rice cultivation has remained more or less constant, as have production levels and yields. The drought led to a decreased cultivation of manioc and sweet potatoes, as well as decreased total production and yields, but these have returned to pre-drought levels in the last two years.

C. LIVESTOCK PRODUCTION

1. Animals within the Project Zone and their Commercialization.

Tables 1 and 2 show the total numbers of each type of livestock in the arrondissements of Niamey, Ouallam and Filingue. The figures in Table 1 are taken from a 1974-75 census conducted by the Department of Niamey. The figures are quite low, for the census was taken at the end of the drought, at which point herds were at their lowest levels in years. In addition, rural inhabitants, particularly the nomads were reluctant to state the actual strength of their herds, for before the drought they were taxed on the basis of the number of head. In recognition of these two factors, the Livestock Service (Service de l'Elevage) at the Departmental level estimated the numbers of animals in each arrondissement. Hence their estimates are substantially greater than those figures obtained by census, especially for the arrondissement of Filingue, which has a large nomad population dispersed within a vast land area.

TABLE 1 Livestock Total for the Arrondissements of Niamey, Ouallam and Filingue. Source: Department of Niamey census 1974-75.

Arrond.	Cattle	Sheep	Goats	Camels	Horses	Donkeys
Niamey	35,134	11,733	17,601	618	1722	1477
Ouallam	27,166	12,814	50,762	4474	2718	3195
Filingue	28,706	10,968	23,812	5651	2853	3219
Total	91,006	35,515	92,175	10,743	7293	7891

TABLE 2 Livestock Totals for the Arrondissements of Niamey, Ouallam and Filingue. Source: Livestock Service, Dept of Niamey Estimates, 1975.

Niamey	60,000	20,000	30,000	1500	2500	2200
Ouallam	50,000	15,000	60,000	5000	4000	3000
Filingue	117,000	48,000	38,000	10,000	7000	9000
Totals	227,000	83,000	128,000	16,000	13,500	14,200

Table 3 shows the total number of each type of livestock offered for sale at the major livestock markets in each arrondissement in 1975. This information was obtained by 6 livestock agents who regularly visited approximately 45% of the beef markets in the three arrondissements. The totals are greater than the livestock service's estimates, because a good percentage of the animals were counted more than once. Livestock raisers may have brought their animals to several different markets in order to obtain the best price possible for them.

TABLE 3 Marketing of Livestock
Livestock Totals for the Arrondissements of Niamey, Ouallam and Filingue. Source: Livestock Service, Department of Niamey, 1975.

Arrond.	Cattle	Sheep	Goats	Camels	Horses	Donkeys
Niamey	32,710	67,090	61,248	3308	1395	1094
Ouallam	6,744	20,662	18,936	4766	125	572
Filingue	24,582	62,061	71,186	15,972	1805	4477
Totals	64,036	149,813	151,370	24,046	3325	6143

2. Livestock Ownership and Production in the Northern Zone.

The two principal livestock holding groups are the Peul and the Tuareg. The Tuaregs graze their animals primarily in the Northern zone of the project area. Their herds consist of Azawak cattle, which are resistant to the hot climate and require little water, camels, sheep and goats. In contrast, the Peuls practice a transhumant migration, i.e., seasonal nomadic movements on a north-south axis. Their herds are also mixed, consisting of long-horned Bororo cattle, sheep and goats. For both ethnic groups herds can range in size from ten to 800 animals. Usually there are about twice as many goats and sheep as cattle and camels.

Nomadic Peuls and Tuaregs were formerly reluctant to sell their animals, particularly their cattle for the number of animals that a herder possesses has always been a measure of his wealth. During the drought this reluctance to sell proved disastrous. Nomads waited too long before selling their cattle, at which point the animals were too weak or diseased to be saleable. This is not to mention those who died from under-nourishment. However, the nomads' reluctance to sell has diminished in recent years, because of the herders' need to acquire millet and other staples. In addition to selling their animals outright, the nomads sell cow's milk to sedentary farmers, many of whom do not own cows. (Rather than consuming cow milk, Peuls drink goat's milk).

3. Animal Traction and On-Farm Fattening of Beef in the Southern Zone.

Sedentary farmers generally keep goats and/or sheep and occasionally cows. They usually have about five or six of each of the former, which are herded by younger members of the family. When farmers need money, they can sell their animals. Cattle are regarded as a very sound investment by farmers, for they can always resell them for substantial sums of money.

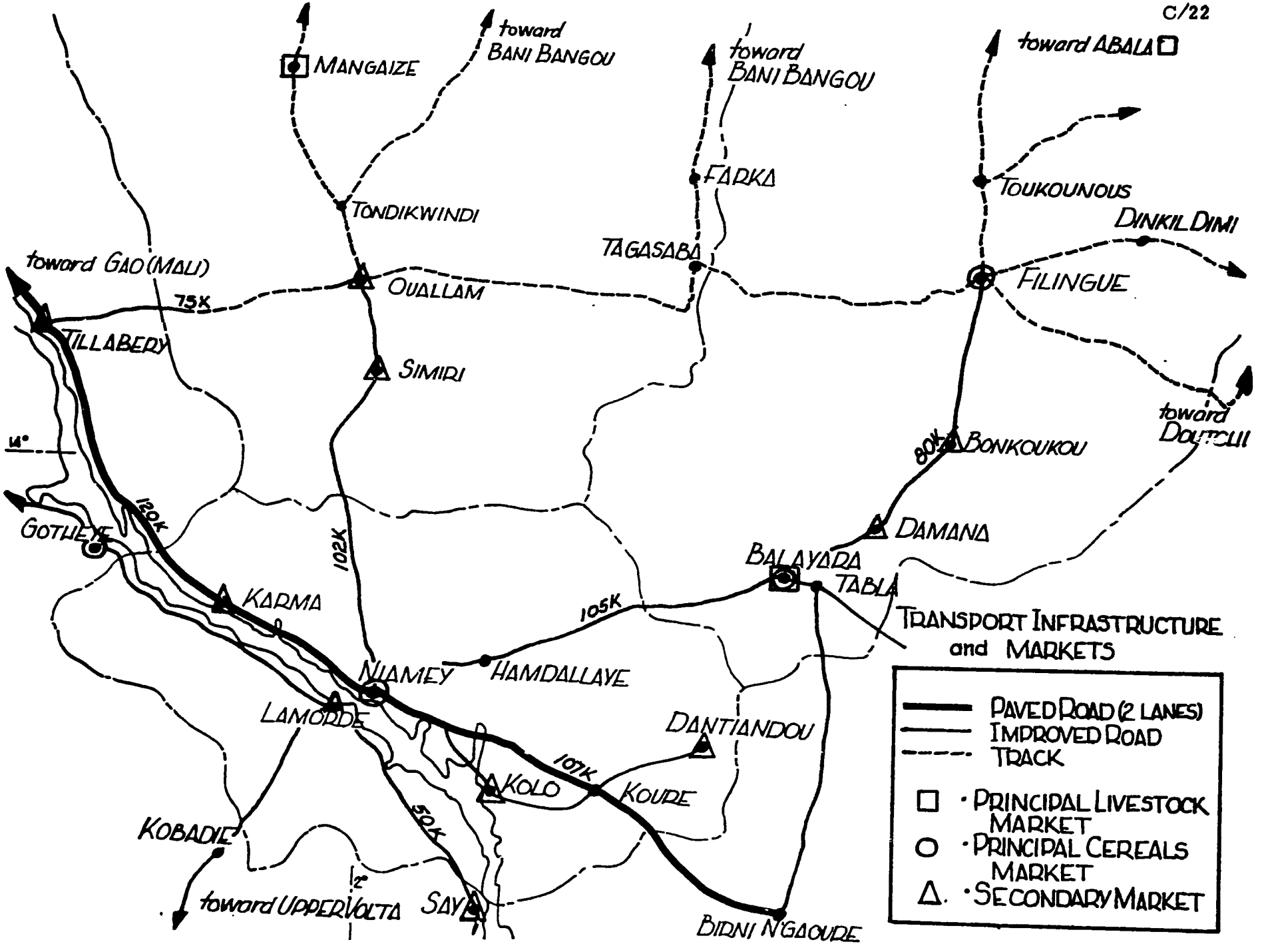
Animal traction, whether for drawing plows, carts or water is virtually unknown among farmers. The Djerma have little knowledge about how to train and use animals. Moreover, a trained cow capable of working with a plow or a cart costs between $170 and $210, a high sum for peasants in an area where annual per capita income is about $50. Plows and carts are also expensive and could only be bought on medium-term credit. Another obstacle to animal traction is that sedentary farmers in the project area do not clear their fields before planting in such a way which permits the use of a plow. Stumps and roots of small trees and bushes must be removed before a field can be plowed, and farmers here cut away surface growth at the beginning of each year in preparation for planting. At this time the peasants lack the knowledge and the tools to do this.

D. CONSERVATION MEASURES

Both zones in the project area are plagued by extensive soil and water erosion. Unchecked winds and heavy rains carry off tons of topsoil annually. The problems of introducing conservation measures are imposing. The Nigeriens have little or no experience with conservation. They have been exposed, however, to measures for combatting wind erosion through windbreaks and water erosion through the construction of terraces on inclines. Reforestation projects in Abala and Banibangou have been plagued by inadequate rainfall and indifference on the part of villagers who have shown little interest in keeping animals out of the plantations. The rural population has never thought in terms of 10 to 20 years trajectories, the period necessary for the maturation of a gao tree.

E. PRIMARY AGRICULTURAL PROCESSING

The conversion of millet grain into flour is done entirely by hand by women. First, the millet heads are thrashed in order to obtain the grain, which must also be separated from the chaff. Then the grain is placed in a wooden mortar and pounded by women using shafts and then cooked into an edible mush. Other food-stuffs are either directly prepared or pounded before eating. Much of the rice grown along the river is processed at a plant in Tillabery, which is outside the project zone.


TRANSPORT INFRASTRUCTURE and MARKETS
PAVED ROAD (2 LANES)
IMPROVED ROAD
TRACK
· PRINCIPAL LIVESTOCK MARKET
· PRINCIPAL CEREALS MARKET
· SECONDARY MARKET
toward GAO (MALI)
TILLABERY
GOTHEYE
MANGAIZE
toward BANI BANGOU
TONDIKWINDI
OUALLAM
SIMIRI
KARMA
NIAMEY
HAMDALLAYE
LAMORDE
KOBADIE
toward UPPER VOLTA
SAY
KOLO
KOURE
DANTIANDOU
BIRNI N'GAOURE
BALAYARA
TABLA
DAMANA
BONKOUKOU
FARKA
TAGASABA
toward BANI BANGOU
toward ABALA
TOUKOUNOUS
FILINGUE
DINKIL DIMI
toward DOUTCHI
75K
120K
102K
105K
107K
80K
50K
14°
12°

Potentials for introducing new technologies of agricultural processing are limited, as the rural population is accustomed to dietary habits which have not changed for centuries and which require little or no processing. Millet is increasingly processed in 2 1/2 horsepower mills in the larger towns, however. The use of these mills will continue to spread, although their cost is prohibitive for most Nigeriens. Women who have their millet processed by a small mill will have more time which they can devote to income-raising schemes, such as cultivation of small plots.

III. INFRASTRUCTURE AND SERVICES

A. RURAL ROADS NETWORK

The major routes in the project area are the bituminous national road linking Niamey and Tillabery and Dosso and the laterite roads running from Niamey to the arrondissement centers, Ouallam and Filingue. The latter two are practicable during the entire year, as they are regularly maintained by the Department of Public Works with funds coming from the national level.

There are several secondary routes in the project area.

1. Ouallam to Mangaize, partially improved from Ouallam to Tondikiwindi - neither maintained nor practicable during the rainy season.
2. N'Dounga to Dantiandou - well-defined though unmaintained track.
3. Ouallam to Tillabery - partially improved, though impracticable from during the rainy season.
4. Filingue to Abala - unmaintained, virtually impassable during the rainy season.

Tertiary routes running from Ouallam to Filingue, Filingue to Rwafi, Toukounous to Sanam, Tondikiwindi to Bani Bangou and Tagasaba to Bani Bangou are little more than tracks in the sand, barely passable under the best of conditions.

The rural roads network is an obstacle to development of the project area. Aside from the major roads, little money is spent to maintain rural roads, for funds must come from the arrondissement as opposed to the national level. The Minister of Transport has estimated that 50% of the villages of 2000 people or less in Niger have no roads connecting them to the exterior. And if roads do link villages to larger towns they are seldom maintained.

Even more striking is the fact that the two northern towns of Mangaize and

Abala, which are the sites of principal cattle markets, are not well linked to potential southern markets. The improvement of the roads connecting Ouallam to Mangaize and Filingue to Abala should be a high priority. In addition, an all-weather road linking Ouallam and Tillabery needs to be constructed, for rice and fish from the Tillabery area could be traded for cattle from the Ouallam arrondissement. The present road has been improved but it still remains unpracticable during the rainy season.

Road construction in Niger is done by private French (SATOM, SFEDTP) and Canadian firms. The potential for enlisting local labor in construction projects is not great, not because the villagers aren't willing to help, but because road construction is capital intensive in the Sahel. Given the sandy soils, low areas washed out by rainfall, runoff, and general difficulties of road construction in the project area, capital intensive methods involving the use of dump trucks, graders and rollers are far more effective than a crew of peasants hauling in laterite and tamping down the surface with hand tools.

B. VILLAGE WATER SUPPLY

OFEDES (Office des Eaux de Sous-Sol or the Agency of Underground Water Sources) has installed cement wells in each of the arrondissements according to this breakdown: Filingue, 265; Ouallam, 163; and Niamey, 147. Two-thirds of these (about 400) are probably in the project area. In addition, there are eleven small-bore wells in the project area, which are mechanically pumped units ranging in depth from 150 to 800 meters.

As there are approximately 700 villages in the project area, it is possible that as many as 250-300 villages are not served by cement wells. There are other areas where land is cultivatable and villages could be established, but lack of accessible water keeps these areas uninhabited.

One of the organizations funding OFEDES well construction is the World Food Program for Niger, which provides food for village laborers in a 217 well construction project for all of Niger. OFEDES projects are also financed by UNICEF and UNDP (United Nations Development Program) which have donated funds for the construction of 67 wells in the Filingue and Ouallam arrondissements. FED funded the construction of 20 wells in Ouallam in 1975 as part of a long-term 350 wells construction program for all of Niger. In 1975 USAID financed the construction of 12 wells along cattle tracks leading to southern markets. Finally CWS (Church World Services) has begun a two year program (1975-76) to install 40 ABI hand pumps in cement wells.

Among well-digging outfits in West Africa, OFEDES has a good reputation, despite its high costs of construction (60,000 CFA a meter for cement wells

which is reduced by 40% if local labor is used). With the aid of international donors, it appears as if OFEDES can construct enough wells to meet the increased demand for clean, year-round water supplies. Uncontaminated wells are, of course, essential for the improvement of health conditions. And keeping the wells uncontaminated requires regular maintenance. OFEDES periodically cleans out wells at the expense of the arrondissement which, for lack of funds, does not always maintain wells as frequently as should be done.

An increased water supply can also aid herders and farmers who want to raise more animals for traction and for the market. It appears that dry land irrigation outside of the Dallol Bosso (where wells range from two to 10 meters in depth), is unfeasible, for the water must come from depths of 20 to 75 meters.

C. HEALTH FACILITIES

In the city of Niamey there is one hospital, five dispensaries, one maternity ward and four PMI centers (Maternal and Infant Protection). Outside of Niamey there are two medical centers, in Ouallam and Filingue, which provide maternal and child care, tuberculosis treatment, and basic dispensary services. Fourteen rural dispensaries are located in the project area according to this breakdown by arrondissement: two in Ouallam, six in Filingue and six in Niamey.

In addition to medical centers and dispensaries, there are two mobile units in the bush which give vaccinations against smallpox and measles, treat cases of syphilis and leprosy, and intervene in epidemic areas when necessary. These two units serve the entire Niamey Department, which includes three arrondissements outside the project area. They are able to cover one arrondissement per year. Matrones (midwives who are not qualified to diagnose) and secouristes (first-aid personnel) are also sent out to villages after receiving two weeks of training in Niamey. They are able to give advice to women (generally after the women have delivered), dress wounds, send people to dispensaries when their wounds become infected, treat malaria and diarrhea, and instruct villagers in basic hygiene, water treatment and sanitation.

In Niamey there are training facilities for training doctors (University of Niamey), qualified nurses (ENSP, the National School of Public Health), midwives and social workers (aides sociales). In addition, there is a two-year program for forming certified nurses in Zinder. Seven years are required to train doctors, three for midwives and qualified nurses, and two for aides sociales, who spend one year at ENSP and another under the guidance of

Animation. Generally, qualified nurses, midwives and aides sociales are sent to medical centers, whereas certified nurses are usually in charge of dispensaries.

As to be expected, health coverage in the project area is inadequate. There is a lack of medicine, facilities and qualified personnel. In the project area outside of Niamey, there are only two qualified nurses and nineteen certified nurses, while five midwives, two aides sociales, 450 secouristes and 200 matrones serve the entire Department. Despite the increasing number of health personnel in the field, there are only two doctors capable of diagnosing all types of illnesses presently serving rural areas for the entire Department.

The thrust of health programs in the Department is to counter basic problems in hygiene and nutrition and diseases of high incidence, particularly malaria and diarrhea. There is a flavoquinization program for the prevention and suppression of malaria among children from 0 to 6 years of age. The health personnel in the area are qualified to deal with these common health problems. Treatment of tuberculosis, meningitis, leprosy and veneral disease is not adequate though.

Exact statistics for health coverage, i.e., the number of people who are annually treated at health centers and dispensaries or by matrones and secouristes in the villages, are not available. For infants from 0 to 3 years of age, it is known that 47 children per 1000 in the Niamey Department receive treatment against malaria, diarrhea and malnutrition. Given this inadequate coverage, over 30% of the children between 0 and 5 are malnourished, and many are close to being malnourished.

D. EDUCATIONAL FACILITIES

In the project area outside of the city of Niamey there are only two secondary schools (of the first cycle) one in Ouallam and the other in Filingue. The following table shows the numbers of primary schools, students, classes and teachers, and classrooms according to their type of construction, in the Filingue arrondissement and that part of the Niamey arrondissement in the project area.

TABLE 1 Primary School Statistics

Arrond.	Schools	Students	Teachers & classes	Mud brick	Mixed mud-brick/cement	Cement
Niamey	31	2707	68	37	4	31
Filingue	41	5043	124	55	32	37

Source: Primary School Inspection, Department of Niamey 1975-6 School Year. Figures were not available for the Ouallam arrondissement.

In addition to these formal schools, there are numerous Koranic schools in rural villages which offer religious instruction in Arabic.

The rural areas have inadequate educational coverage. The percentage of school age children who are actually in school (the scolarization rate) is only 13% for all of Niger, 21% for the Niamey arrondissement and 16% for the Filingue arrondissement. There are not nearly enough teachers, facilities and funds to expand the educational system in the project area. Recruitment of primary school teachers is low, for teaching at this level is considered an unattractive career. Basic conveniences and electricity are not available in villages with primary schools, and many of the posts are isolated. In addition, nearly 40% of the teachers have had no special training for primary school teaching, or have not completed secondary school studies.

In order to meet the demands of primary education and to solve the problem of a lack of qualified teachers, the government of Niger, in cooperation with the French, has experimented with educational television. Televisions, classrooms and monitors have been placed in 150 villages in the Niamey Department as a substitute for traditional primary schools. Preliminary indications are that students educated by television are substantially stronger in oral French than their counterparts educated in a traditional classroom setting. They have had problems, however, adjusting to the traditional system once they have completed the educational television program. Although educational television is an exciting and imaginative possibility, certain imperfections have to be worked out, and the cost of financing this system, without foreign donations, is prohibitive for the Nigerien government.

Niger has one of the lowest literacy rates in the world. For tax-paying adults in rural areas in Niger, the literacy rate is an infintesimal 0.1%. In order to alleviate this, the Government of Niger began an Alphabetization program in 1962 in order to instruct adults how to read and write in their local languages and how to communicate simply and effectively in oral French. In the project area there are 21 literacy centers outside of Niamey: 4 in Ouallam, 9 in Filingue, and 8 in Niamey. Less than 4% of villages in the project area are affected. Formerly instructors used to be primary school teachers, but their attitude was found to be lacking and their attendance irregular. So they were replaced with local instructors, generally those who formerly attended primary school. They are chosen by the students of the center and paid 5000 CFA a month.

One problem with the Alphabetization effort is that many adults discontinue their studies before the end of the program. Thus, actual percentage of students that begin studies who become literate is low, generally less than 15%. When asked why they drop the program, students usually answer that they prefer to learn how to speak, read and write French rather than to read and write their local language. They stated that French was the language of the "patron", i.e., the official language used by administrators and those in positions of power and influence.

Television alphabetization and presentation of demonstrations concerning health, livestock raising, farming, hygiene, etc., have been more successful. For a four month period in 1973, adults were taught to read and write their local languages at five television centers. In addition, educational television sites are used to present 18 programs concerning new practices in health, nutrition, farming, sanitation, water supply, reforestation, education and other pertinent topics concerning the daily life of the people. The eighteen different programs are periodically aired in the local languages and reported to be enthusiastically received.

E. RURAL ELECTRICITY

Electricity is unavailable in rural areas, although the town of Filingue has a limited electrification program. Electricity is available until 2000hr. in a small number of homes and public buildings (dispensary, secondary school, administrative offices). Parts of Ouallam are electrically wired, but electricity is rarely available.

F. RURAL COMMUNICATIONS

In Niger there is one newspaper ("The Sahel") and one radio station, both directed by the government. The newspaper is widely read in the major towns, but it does not reach the villages, as almost everyone in rural Niger is illiterate. The impact of the radio broadcasts is far greater, however, in a country with a strong oral tradition. One of the first things that a peasant buys when cash is available is a radio, so that he can listen to a wide range of broadcasts in one of several local languages.

Many of the programs are very appropriate for development. Broadcasts in the major local languages include programs on health, nutrition, agriculture, livestock raising, animal traction, adult education, reforestation, the role of women, the Samaria, the problems of youth, urban problems, etc. Sunday afternoons are devoted to theater in which plays dramatizing daily problems, centering around changes in roles and practices brought about by developmental process, are broadcast. The Samaria, village-level youth organization, can

reinforce these themes by acting out plays in the villages.

The "Voice of the Sahel" broadcasts are one-way presentations of the government's goals and ideas in which there is no possibility for a dialogue with the rural population. Hence, radio serves as a propaganda tool for the government, whose impact can not be underestimated given the widespread psychological phenomenon of immediate acceptance by the rural population of whatever is said over the radio.

In addition to programs and plays broadcast over the "Voice of the Sahel", there are two broadcasts a week (Thursday and Sunday evenings at 8:30) presented by Radio Clubs of Niger. These also touch on the problems of daily life and development. Government agencies prepare programs in which they explain why they want the peasants to adopt new techniques of livestock raising, crop production and marketing, exploitation of mares and water sources, etc.

Trained animateurs call together Radio Club audiences for collective listening sessions in posts throughout the country, There are five centers (which are provided with radios and loudspeakers) in the Niamey Department, two of which are in the project area. After listening to a thirty-minute broadcast, the animateur directs a discussion for at least an hour in which he follows a set format. Different groups in the village (chosen according to age, sex or occupational role) are questioned and allowed to express their opinions about the ideas presented in the broadcast. Often a representative of the governmental service which prepared the broadcast will field questions and further explain the new practices and programs presented. At the close of these discussions, the animateur, encourages the listeners to make a decision about whether to adopt the practices discussed and solicit the government's aid if necessary.

Unlike the "Voice of the Sahel" broadcasts, the peasants who attend the Radio Club sessions can criticize and discuss the programs and new methods of doing things which have been presented. They can offer counter-proposals on the basis of their knowledge and experience in the field which must be addressed by the involved governmental agencies (particularly by their representative on the spot) if they hope to insure successful implementation of their proposal. Admittedly, the Radio Club broadcasts are propagandistic in that the governmental services are trying to encourage the adoption of new practices and behavior, but this element of dialogue between the government and the peasant makes Radio Clubs a rich developmental aid, for the feedback obtained from the peasants can be used to design programs which are feasible

and responsive to the needs of the rural population, thus making acceptance of new practices by the people highly probable. Limited funds and trained personnel to guide listening and discussion sessions pose a problem though.

IV. SOCIAL SYSTEMS WITHIN PROJECT ZONE

A. Major Tribal Groups

The major tribal groups within the project area are the Djerma, the Hausa, the Peul and the Tuareg. The Djerma occupy the Southern zone as sedentary farmers, and they are the most populous group (50%) in the project area. The heart of Djerma country is the Djermaganda, a plateau composed of Continental Terminal in the Ouallam arrondissement. The Hausa (30%) are also sedentary farmers found in the Eastern region of the project area, particularly in and around the Dallol Bosso, extending from Baleyara to the northern edge of the project area. Whereas the Djerma are found essentially in the arrondissements of Niamey and Ouallam and the southern part of the Filingue arrondissement, the Hausa are generally not found outside the Filingue arrondissement.

The Peul (12%) and the Tuareg (6%) contain both sedentary (or semi-sedentary) and nomadic elements. Peuls are scattered throughout the project zone, with the sedentary and semi-sedentary ones in the southern part of the Dallol Bosso around Baleyara and Bonkoukou and near the river. Nomadic Peuls occupy the Northern zone during the rainy season and for some time after (as long as there is good pasture and accessible water), but move to the Southern zone or out of the project area during the dry season. The Tuaregs are found in the extreme north of the project area, towards the Malien border. In contrast, their sedentary and semi-sedentary counterparts occupy areas in and just outside of the Dallol Bosso, starting south of Baleyara and extending north to Filingue.

B. The Djerma.

Among the Djerma all the village lands are owned by someone, whether they are cultivated or not. All lands have known proprietors, and the amount of land that a man possesses is an important criteria of wealth. Lands are passed on by inheritance. Often a landowner lets his land out to those outside the family, who repay him with a part of the harvest.

In Djerma villages the chief has the final decision-making power. He can convoke a council of village elders in order to discuss important matters, or he can rely on the advice of a few close associates. Often there is a land chief who arbitrates in cases of land disputes among villagers and whose agreement is necessary if someone wants to farm unused land. If there isn't a land chief in the village, then land tenure decisions are made by the chief.

The more progressive farmers in Djerma villages are men who have travelled to other areas, particularly to the southernmost parts of Niger and to the coastal countries. They have seen other agricultural techniques used successfully, and they are potential modernizing leaders in the villages who might serve to diffuse new practices. New practices might also be spread by those who have been to school in places other than their native villages, where different methods are practiced. The danger here, however, is that the peasants consider students inexperienced and ignorant in their domain of farming. Hence, their advice would probably be ignored.

Work in the village is divided according to age and sex. Beginning at ages 6 to 8 children help out in the fields by carrying off branches during the clearing, placing seeds in holes and covering over the seeds during the planting, and caring for the animals owned by the family. Mature youths are able to manipulate heavy tools during all phases of cultivation and they are also allowed to cultivate small plots of spices, vegetables and peanuts, although they don't actually own the plots. They also run small enterprises on the side, such as cooking, poultry raising or water carrying. Djerma women are able to influence family decisions through discussions, although the final decision-making power rests with the family heads. They make the important decisions concerning what is to be cultivated when, where and how and decisions involving the ways in which additional family revenue can be earned.

The basic farming unit is the family, which can often include married sons of the family head. The sons own their own land, but they must first cultivate the family's common fields, i.e., those fields belonging to the family head. His power seems to be substantially less than that of a Hausa family head. Besides this intra-family cooperation, there are many examples of cooperation between families, particularly when a family is short-handed during planting, weeding or harvesting and needs additional laborers to complete the work rapidly. In addition, there are collective work sessions called Boogu, where villagers, particularly members of the Samaria participate. The Samaria are organizations of young men and women ranging from ages 12 to 30.

When a Djerma needs money, he sells one of his goats or sheep or a valued possession. If he is unable to or refuses to do this, he can usually get money from his extended family. Or he can obtain cash from other villagers on the condition that he repays the lender with a little interest or provides him with some service such as helping in house construction or field clearing. Curiously, the Djerma have no word in their language for interest, which would indicate that it is a foreign concept. The charging of interest is practiced among the Hausa. Local level credit associations do not exist so the potential for forming formal credit associations in Djerma villages cannot be determined. The Djerma do, however, have a strain of individualism, reflected

in their systems of land tenure and family organization, which might impede cooperation among different families and the formation of cooperatives and credit unions.

A possible social/cultural constraint to the adoption of new practices by the Djerma might be the weight of tradition. The rural population of the Djermaganda has a reputation for stubbornness and unreceptivity to innovation. Djerma farmers have cultivated millet for centuries using rudimentary methods which have kept them slightly above subsistence. Practices are deeply ingrained, and it will take in-the-field demonstrations of the superiority of new practices to persuade traditional farmers to change their methods. Unable to gamble as they are never assured of living comfortably above subsistence, the Djerma will have to see evidence of the advantages of new practices before attempting to use them. Any constraints to poorer segments of Djerma communities receiving benefits of new practices, which would probably involve additional expenses, would be economic rather than social or cultural.

B. The Hausa

In contrast to the Djerma whose lands are all parcelled up and accounted for, the land in Hausa areas belongs to those who cultivate it, pending on the approval of the village head. Hence, property ownership comes from usage. There are, of course, inherited lands, but these are cultivated permanently or allowed to lie fallow fo short periods. This foreshortening of the fallow period stems from landowners' fears of losing their land to opportunistic neighbors. In areas where fields have not been cleared, farmers must demand permission from the village or canton chief in order to extend their area under cultivation.

Decisions in Hausa villages are made by family heads (Maigida). These heads manage the Gandu or collective fields and distribute the Gamana, fields which are conceded to individuals for personal use. The Maigandu or holders of private plots are usually sons or younger brothers of the family head. They spend four or five days a week working for themselves and the other days working in the Gandu. The Maigida are obliged to pay taxes for the family, feed the family during the dry season and the growing season, and pay social expenses such as marriage. The actual evolution of this system of joint collective and personal tenure is towards the dissolution of the extended patriarchal family into separate households concerned with their privately-owned fields.

Married Hausa women are granted small personal plots which they cultivate with their sons. With any money earned from agricultural production, they

are able to buy animals, stock up on grain and pay expenses for social events. They are required to buy cooking utensils, manage their compounds, prepare young women for marriage and care for children until they are able to work in the Gandu. Young men prefer salaried work in the fields of wealthier neighbors, which pays 200 to 350 CFA a day, to working in the Gandu. If they refuse to work in the latter, however, they lose their rights of inheritance to it.

Hausa villages have arbitrators who intervene in disputes. These men (called cadi) are religious leaders trained in Arabic who run the village Koranic school, attend marriages, baptisms and prayer sessions, but their counsel is respected in other domains. Village or canton chiefs usually judge land cases.

As with the Djerma, labor is divided according to age, sex and difficulty of the work. Collective work (Gaiya) are also performed by young Hausa, especially through the vehicle of the Samaria. These works involve clearing and plan cultivating of fields, digging of traditional wells and other projects which benefit the entire village.

There is no system of formalized credit among the Hausa. If they need money, they sell animals or tap family resources. If they have to obtain money outside the family, they can borrow money at exorbitant rates of interest from local usurers. Collective pooling of money, particularly among women and young men, enables each member of a group to buy expensive items in a rotational manner. This tradition of pooling resources bodes well for the formation of credit-granting organizations which might enable farmers to buy costly materials such as plows or carts.

Hausa farmers generally appear to be more progressive than Djerma farmers. They have adopted the cultivation of cash crops such as peanuts and cotton in other areas of the country; they are also receptive to new practices introduced by agricultural extensionists and animation. As with the Djerma, carefully planned and tactfully-presented demonstrations of new practices, along with proof of their effectiveness, will be necessary to persuade farmers to change their ways.

Despite the existence of financial pools, a social/cultural constraint to the formation of credit associations might be the entrepreneurial verve of the Hausa, accentuated by successive lean years. Recent poor harvest and diminished family income may have made farmers reluctant to grant credit to others on reasonable terms, for there are high risks of lending in such an uncertain environment where a substantial return on an investment is not always possible.

D. The Peul

The Peul in the project area are of two types: nomadic and sedentary or semi-sedentary. The nomadic Peuls specialize in herding, whereas the sedentary ones farm and raise animals. The nomadic Peuls make transhumant migrations, moving northward after the rains have begun and as surface water and pasture become available (in July) and returning southward once mares and pasture have dried up (anytime from late October through early January).

The nomads are grouped into administrative units which contain from ten to fifty family camps. Half of these camps are composed exclusively of the nuclear family, including the family head, his wives and their children. Another type of family camp is the extended household, which includes all of the elements of the nuclear family plus the wives and children of the head's sons. A third form of family organization is the extended family unit, which includes all of the former plus married brothers and half brothers of the family head. The head of the family is entrusted with the direction of the family herd, including those animals which are not his own (his wife's or his married daughters'). The larger nomadization units are conducted by 'arDo, the heads of primary lineages.

At the beginning of the rainy season, the heads of family camps meet formally with the 'arDo and decide on their itineraries. At these meetings a form of collective decision-making takes place. The participants render traditional justice and discuss what routes they will take on their northward trek and where they meet for the annual worso, which is several days of celebrating marriages and the naming of children. The nomadization unit is broken down into small groups of family camps which take different routes north in order to utilize most effectively scarce water sources and pasture. About midway through the rainy season, the nomads regroup for the worso. Then they return south along northern valleys to their habitual dry season water points.

During the dry season, the nomads circulate amongst four to ten water points, which are either wells or water sumps. In addition, most Djerma and Hausa farmers permit nomads to graze their animals on farm lands after the harvest. In this way the nomads' animals fertilize the farmers' fields with manure. Also during the dry season the nomadic Peuls frequent markets, especially those at Baleyara and Bonkoukou. They come more in order to meet friends and relatives than for commercial reasons. The nomads are forced to sell cattle in the middle of the dry season, when taxes are due, or before heading north (in June or July) so they can buy clothes, salt and millet. From the standpoint of rational commercialization, this practice is unsound, for the

cattle are often thin and weak and there is too large a supply of them on the market at one time. Hence, the prices at which they sell are low. Cattle are generally sold at the principal beef markets of Abala and Baleyara or at Filingue and southern markets such as Dogondoutchi and Gaya. Finally, the nomads receive millet during the dry season in exchange for milk or beef or as remuneration for fertilizing fields.

Sedentarization of the Peuls has effectuated significant changes of life-style. Heads of families, along with their wives and young children, do not make the traditional transhumance. They stay on fields in the southern zone of the project area in order to cultivate, while the head's older sons or younger brother migrate north with the family herd. This herd is substantially smaller than those of exclusively nomadic Peuls. After the harvest the young men return south to allow the animals to graze on and provide manure for the family's fields. Some sedentary Peuls graze smaller herds by having young males of the family lead the cattle around constantly in the area of the family's fields, carefully avoiding cultivated land.

Sedentary Peuls differ from Djerma or Hausa farmers in that they live in the fields with their animals during the dry season. Peul villages are spread over a larger area than those of the Djerma or Hausa. From time to time the villagers move in search of more fertile fields, a better water supply and greener pastures. Sedentary Peuls can acquire additional income by caring for the cattle of Djerma or Hausa farmers or by selling animals.

A problem in transmitting new practices to the Peuls is their recalcitrance to accept anything new. An increasing number of Peuls have become sedentary or semi-sedentary on account of tragic losses of cattle during the drought, and it will be necessary to at least localize them in order to impart new techniques. The trend from nomadization to increasing sedentarization will cause considerable dislocation and stress, which might prolong the period of adaptation. During this stressful period, many Peuls may not be receptive to government efforts to reach the rural population.

The nomadic habits of the Peul frequently lead to accidents occuring in the fields of sedentarized Djerma and Hausa farmers. For example, a group of Peul families may begin its northern transhumance a bit late and their cattle might destroy recently planted millet as they pass through farmers' fields. Or in years when northern water sources have dried up or pastures have been exhausted early, Peul cattle have damaged unharvested crops on their return south. Even when reparations are paid to the injured parties, which is not always the case, relations between the nomads and the sedentary population

are strained. Nomadic Peuls who are forced to sedentarize in the future may not be well-received by neighboring Djerma or Hausa farmers.

Since many of the sedentary Peuls have only recently become sedentarized they are less progressive in their agricultural practices than the Djerma or Hausa. In the event that agricultural extension agents are sent to regions heavily populated by sedentary Peuls, they had better be Peul, for a Djerma or Hausa agent might aggravate relations strained by grazing accidents and the crowding of cultivatable land. Traditionally, Peuls have not received visiting merchants at their villages or wells, which might be an indication of their receptivity to the proselytizing of new practices by extensionists or livestock agents.

E. The Tuareg

As with the Peul, the Tuaregs are becoming increasingly sedentarized. Both groups suffered tremendous losses during the early 1970s, as their herds were decimated for lack of pasture and water. Almost all of the sedentarized Tuaregs farm in the Dallol Bosso region, where there have been more and more property conflicts with the overcrowding that has occurred in recent years. Like the sedentary Peuls, sedentary Tuaregs cultivate millet, generally on less fertile lands than the Djerma or Hausa. Unlike the Peul, the Tuareg augment their income through the sale of handicrafts. They also sell milk and beef to neighboring farmers. Last, the raising of livestock on or near the farm creates a reserve capital whose profits seem greater but less certain than those of agriculture.

Most of the sedentary Tuaregs are Bouzous, or lower caste Tuaregs who served as slaves for Tuareg nobles. Since the Bouzous have been accustomed to laboring as herders, artisans and farmers for the noble class, they have adapted more readily to sedentarization. They presently farm, raise camels, transport goods and conduct commerce for the nobles, sell cola, tobacco and handicrafts, and perform manual labor for others.

The remaining nomadic Tuaregs roam about the northern zone of the project area. They do undertake the north-south transhumance, but it is on a minor scale compared to the seasonal migrations of the Peul. During the dry season they remain in the northern zone, grazing their animals around several wells or a particular deep small bore well which serves as a base of operation. During this period pasture becomes very scarce.

The animals in Tuareg herds are owned individually but managed collectively. Women and children own animals which are acquired as gifts at birth, while they are growing up, and at special ceremonies such as marriage. Common

herds are formed by the animals of the extended family, which includes the family head, his brothers and their wives, and all their sons and their spouses. Animals are sold at the principal beef markets cf Abala, Mangaize and Baleyara, especially during the dry season. The revenue is used to purchase such Tuareg staples as tea, sugar, tobacco, millet and cloth. On the whole, the Tuaregs seem less hesitant to sell their animals than the Peul. They also have a reputation for being more open and adaptable than the Peul.