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Report of GARD Consultancy

Evaluation of Soils Inventories

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University of Wisconsin-Madison

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GARD REPORT #22

EVALUATION OF SOILS INVENTORIES

BY

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UNIVERSITY OF WISCONSIN-MADISON

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I. INTRODUCTION

The Terms of Reference for this short-term mission called for focusing on four activities: to select and identify "benchmark" upland soils; to review progress of the ongoing soil characterization study; to work on the development of the Gambian soil mapping program and of a land classification scheme; and to review the groundwater monitoring network designed to study water table fluctuations and salinity behind (up-stream) salt water intrusion barriers.

As much of the work involved field problems, a good deal of time was spent on trek. Two trips were made to Bakendik on the North Bank to review both upland crop lands and lowland rice areas. Salt water intrusion barriers and water retention structures utilized for rice production were studied at Somita, Kwinella, Tendaba, Sintet and other locations. Upland sites near Basse, Kuntaur, Sare Sofi, Kanjabina, and Old Yundum were also visited. The purpose of the visits to upland sites was to develop a sense of how farmers "classified" the soils they farmed and then to determine the relationship of their observations to the soil taxonomic scheme currently extant in The Gambia.

Similarly, the rice growing sites were visited in order to understand more clearly the rice ecology classification and to study the soils which are found in the various rice producing areas. In addition, salinity is a particularly complex problem and an effort was made to determine the nature and extent of salt problems associated with areas flooded behind recently-constructed, water retention and/or salt intrusion barriers.

Both enroute to The Gambia and on the return trip, stops were made at the Land Resources Development Center (LRDC) in London to try and track down raw data from the LRS-22 study which was missing from the data set at the University of Wisconsin-Madison. Bill Posnett, who is the agency's Information Director, was very helpful and made available all files still in their possession. Successful meetings were also held at LRDC with Dr. J. B. Williams who was the author and principal investigator for Soil-Water Studies of The Gambia (Technical Study 3).

II. HISTORICAL DATA ON SOIL TYPES

Data on the so-called hydromorphic soils is the most complete both because much of the original material was retained in The Gambia and because recent sampling efforts have been focused on those soils. The

data on upland soils are, unfortunately, rather incomplete and seem to exist in bits and pieces. Files borrowed from LRDC filled in a number of gaps; additional materials provided by Saihou Taal were also extremely helpful as they contained valuable summary information on the upland soils. Still missing, and of great import, are the mechanical analysis data developed by the Yundum Soils Lab for the LRDC study. Correspondence files obtained from LRDC were very valuable in providing insight into the questions and concerns of the soil mappers during the course of the soil survey.

III. IDENTIFICATION OF BENCHMARK SOILS

Certainly, the most complex issue to be addressed was the question of the identification of benchmark soils. The concept is indeed sound in that it seeks to pinpoint those soils within cluster areas which are utilized for crop production and which have chemical and physical characteristics similar to those of other soils widely used for agriculture in The Gambia. In the course of field visits, farmers were queried as to the differences they recognized between soils and as to how those differences affected cropping and management decisions. Once these representative or benchmark soils are identified, experimental work can be focused on them. An important underlying assumption to this, as a part of the cluster areas concept, is that these benchmark soils are widespread so that information derived from work on them can easily be extended to other parts of the country.

Interviews with farmers seemed to confirm the benchmark soils concept. They clearly differentiated between soils, and although their descriptions tended often to be in terms of color differences, they were generally referring to some soil physical property which appeared to influence either how they managed the soil or how they cropped it. For example, "dek" soils tended to be those where the fine-textured subsoil materials were close to the land surface (around 25 cm). Because of this, and because the surface materials themselves were densely packed, tillage of these soils was difficult. Soils with up to 50 cm of sandy materials on top were generally considered by farmers to be good for groundnut production both because the coarse-textured surface materials make lifting easier and because the relative proximity of the finer-textured materials to the surface significantly improves soil moisture relations. Soils with somewhat restricted natural drainage are considered by most farmers to be good sorghum soils.

Though not documented in the Gambian setting, the thickness and texture of the surficial soil materials appear to be important factors because of their influence on soil moisture. Fine-textured materials (clays, sandy clays, etc.) do not allow water to infiltrate easily so that much of the precipitation which falls on them tends to run off across the land surface and is thus lost for plant growth. In

addition, water which does infiltrate these materials is often held by the soil particles at tensions which exceed the plant's ability to extract that water.

On the other hand, water infiltrates coarse-textured materials (sands, loamy sands, etc.) rather easily so that precipitation can be captured and held for plant growth. The problem with coarse-textured materials is that water moves through them rapidly and will, if not stopped, move out of the rooting zone before plants can utilize it. In Gambian soils, the presence of a finer-textured layer beneath coarse-textured materials is important because it slows water movement and effectively holds it for plant growth. This is of critical import during those periods in the rainy season when the rains stop for periods of up to two weeks. A soil which consists of 50 cm of sandy loam materials over clay will, if it is reasonably moist to begin with, support plant growth for a ten-day to two-week period without additional precipitation. During this period, plants should not be subject to undue moisture stress.

In the interviews conducted, there appeared to be a certain universality in the farmers' concepts about soils. This would seem to suggest that management and cropping practices developed in the cluster areas would have wide applicability to Gambian agriculture in general. Upland soils in The Gambia simply do not vary that much. Natural fertility is extremely low. The differences that do exist are physical in nature and are primarily related to the thickness of the sandy loam/loamy sand coverings and, to a lesser extent, on the texture of the subsoil (clay loam and sandy clay loam vs. sandy clay and clay). This latter notion, namely that of the physical make-up of the soil, becomes the basis for the concept of the upland benchmark soil. In a general sense then, the upland, benchmark soil can be defined as differing thicknesses of coarse-textured materials overlying finer-textured materials.

IV. SOIL FERTILITY

Compilation of soil characterization data currently underway at U.W.-Madison shows conclusively that the upland soils are universally deficient in major plant nutrients (nitrogen, phosphorus and potassium), that their organic matter contents are negligible and that they have extremely low cation exchange capacities. These data suggest that soil fertilizer recommendations should, for the present time, be based primarily on varietal needs and yield expectations. Reviews of existing data by U.W. soil scientists conclude that the leveling-off of yield curves apparent in plot data is probably more a function of soil moisture than of fertility and/or varietal characteristics.

There is some evidence to suggest that manuring and fallowing may enhance soil fertility. In the case of manuring, since most of the

waste is raked up and burned before crops are planted, the effects on fertility are minimal. There may be some additions from the urine and some potassium may be added from the ashes. It may be, however, that the most positive effects from this practice of tethering animals in a relatively small area are due to the actions of the dung beetles which burrow up through the soils from relative depths to the soil surface. Their tunnels may be valuable conduits for moving water to the subsoils and recharging them after the long dry period.

Likewise, with fallowing, the relative increases in yields observed on fields that have been idle are probably a function of improved soil moisture rather than increases in soil fertility. Root systems of plants which grow during the fallow period serve to improve aggregation of both surface and subsoil materials. The resultant improved soil structure allows increased infiltration and percolation of precipitation which, in turn, improves crop responses. One answer, of course to this line of thinking, is that even though the amounts of plant nutrients added through manuring and fallowing is small, nutrient levels are inherently so low that every little bit helps. This is certainly true, but in the long-range strategy for agricultural production, these additions should probably be considered as insignificant. Clearly, further research work should be undertaken both by soil fertility specialists and soil water experts to quantify the overall impacts of these practices.

V. MAPPING OF BENCHMARK SOILS

Among the researchers, some confusion still exists about the concept of the benchmark soils. An attempt to clarify that particular problem follows. The soil map of The Gambia prepared as a part of LRS-22 was completed at a scale of 1:125,000 and the map units used were soil associations. These are, by definition, groups of soils which have similar characteristics and which occur in repetitive patterns on the landscape. In the process of developing the legend for this map, soil series were described and combined to make up the map units, but because of the scale of the map, those series were only broadly defined. Correspondence reviewed in the LRDC files clearly indicates that the soil surveyors were concerned about the lack of definition of the series they were mapping, but finally decided that those definitions were adequate for the scale involved. It is interesting to note that Hill, in his 1968 soil survey of the Western Division (which was done at a scale of 1:50,000), defined many soil series which were simply combined in the LRS-22 map to fit the broader descriptions used in that later inventory.

Last year, detailed soil surveys were completed at a scale of 1:10,000 for some villages which are the focal point for farming systems work in The Gambia. Mapping at this scale simply pushed the existing series concepts too far. Everything ends up mapped as Charmen or some other single soil series yet farmers in the villages

can - and did - describe differences in the soils. The problem is clearly not an easy one to solve, but two approaches should be pursued. First, the review of soils data currently underway at U.W. should examine the upland soils with an eye towards establishing additional soil series to meet the needs of the type of mapping legend required for mapping at a larger scale (1:25,000).

Secondly, a working definition of benchmark soils which is relevant to local farming systems should be developed. The following are proposed as upland benchmark soils: 25 cm of coarse-textured materials over fine-textured materials, 50 cm of coarse-textured materials over fine-textured materials, 100 cm of coarse-textured materials over fine-textured materials and |100 cm of coarse textured materials. These groups do not have regular series names but rather are designed to include more than one soil series.

This clearly does not solve all the problems involved but will do for now. The development of a map legend for work at 1:25,000 will result in more soil series being recognized in The Gambia than there are now.

For example, the better-sorted surfaces of some of the soils on the North Bank have sealing problems. Whether these soils should be defined as separate soil series or as phases of existing series or of series yet to be defined remains to be seen. Questions of the importance of soil color and soil mottling (characteristics which form the basis of the LRS-22 classification scheme) need to be resolved. Work at U.W. will resolve these and other questions. In The Gambia, field work in the cluster areas should proceed, utilizing the broad, "generic" classification scheme suggested above.

M.S. Sompo-Ceesay has proposed a "Land Evaluation for Rainfed Agriculture in The Gambia". This proposed system is very similar to benchmark soil classification scheme suggested above and work is currently underway by F. Madison and L. Ward Good at U.W. to tie the two concepts together. Suggested revisions will be submitted to Mr. Sompo-Ceesay for his review and comment.

VI. RICE ECOLOGIES

In order to understand more clearly problems associated with rice production, all of the so-called "rice ecologies" were examined in some detail. The upland Tandako setting is unique and provision has already been made for its study in a leased area near Old Yundum. After visiting many rice-growing sites, it appears that the most pressing areas requiring study at the present time are the Bolons which have been modified by the construction of salt water intrusion barriers and water retention structures. These structures have proven to be very popular and are being installed at many locations.

The program, however, appears to be at a fairly critical juncture in that the effects of water retention need to be examined in some detail. It is clear, for example, that the first waters retained become saline as salts are removed from the soils. In at least one reported instance, the saline waters backed up into the rice-growing areas which had previously been unaffected by salt problems. The addition of sluice gates to salt water intrusion barriers currently under construction should help to solve these problems by allowing the rapid release of salty waters. Management of the sluice gates should be carefully monitored to assess their effectiveness. It is possible, particularly in newly developed areas, that waters may have to be released more than once to insure adequate salt removal.

More importantly, however, the hydrology of the areas behind the structures should be studied. The effects of ponding water on water table elevations in the Bolons is extremely important. The installation of structures at Somita has, in fact, made more land suitable for rice production, but some of the lands which are producing rice are not those originally identified for production. Rice is being grown in the palm tree fringe around the wetland which is probably due to a raising of the water table caused by the water ponded behind the salt water intrusion barrier and the other water retention structures. Also, it would appear that there are areas of soils (either acid sulfate or extremely saline soils) behind the salt water intrusion barriers which will never produce rice. This is not a fault of the construction of the structures but rather seems inevitable. It is not a major problem, but these areas should be identified and the villagers informed so that time and effort will not be wasted in attempting to grow rice there.

Groundwater monitoring networks should be established, both to identify changes in water table elevations associated with the wet and dry periods, and to determine the extent of subsurface intrusion of saline water and its possible impact on rice production. It may well be that late in the rainy season, or perhaps during extended dry periods during the rainy season, salt water intrudes through the groundwater and saturates the soil which will adversely affect plant growth. It is important, therefore, to understand the extent and movement of saline groundwater in the Bolons. Definition of the salt-free period, i.e., the number of days between the time that the salts are leached from the surface soils by rainwater and the time that the salts reappear (probably in the groundwater) is certainly critical in some rice-growing areas.

Much of this work will be handled initially by Tom Remington, and it is suggested that primary attention for groundwater monitoring be focused this year and next on the rice-growing area at Somita. An effort which was not successful was made during the consultancy to install monitoring wells at Somita. It was determined that wells could be installed once the proper equipment was obtained. A monitoring network for the rice-growing area was designed and well locations identified. Equipment needs were spelled out and hopefully,

wells can be installed without too many problems. A portable conductivity meter will be obtained and shipped to project staff for this effort. Once wells are installed and developed, water table elevations should be determined on a monthly basis, and perhaps even biweekly during the rainy season. Measurements of salinity at increasing depths in the aquifer should be made at the same intervals. In addition, effort should be made to determine the transmissivity of the aquifer materials and, if possible, detailed soil profile descriptions written at each of the monitoring well installation sites.

It is appropriate for the rice research program to focus on these problems associated with the construction of water retention structures. Definition of the groundwater hydrology of the Bolons, as well as an understanding of the movement of salts both in surface and groundwaters, will tie together well with the cultural rice program which will look at rice varieties, different planting techniques and fertilizer application strategies. Hopefully, the hydrology of the Bolons is similar throughout The Gambia so that results of this monitoring effort will have wide applicability. All of this proposed work seems to fit in well with the farming systems concepts.

VII. THE FUTURE OF SOILS RESEARCH IN THE GAMBIA

Collaboration between the Rice Research Program and the Soil and Water Management Unit (SWMU) is crucial. Follow-up work on the new and/or revitalized rice-producing areas is of critical import to the long-range success of the Unit. Varietal, fertilizer, and pesticide recommendations developed by the research staff can be effectively disseminated to the rice growers by these trained people. Again, it is worth pointing out that this highly successful construction program is clearly at a point where critical back-up work needs to be done in order to understand its value and effectiveness.

Several meetings were held with Harvey Metz of SWMU, Gambian soil scientists and a technical advisor from the U.S. Soil Conservation Service regarding the future direction of the soil survey program in The Gambia. A long-term plan was developed to project completion of a detailed soil survey (at a scale of 1:25,000) of the entire country. Manpower and equipment needs were identified, and the time required to finish the survey was estimated. Details of this exercise are included in the trip report of the SCS technical representative (Horace Smith) and will not be repeated here. It was agreed that in the short term, efforts should be made to increase, if possible, the number of hectares mapped per man per day and the number of days spent in the field each year.

An important result of these meetings was that agreement was reached on the scale to be used for soil maps. Final maps will be produced at a scale of 1:25,000, utilizing the Mark Hurd 1982 orthophotography. The SWMU will acquire that photography as soon as

funds are available. Mapping at a scale larger than 1:25,000 is relatively futile, both because map units appropriate for use at larger scales cannot be defined at this time, and because the uniformity of the landscape in The Gambia simply does not require the increased intensity of mapping. The soil survey of The Gambia, when complete, would be printed on about 80 sheets roughly the size of the 7.5 minute topographic maps used in the U.S.

At the present time, the Soil Survey Unit is involved in contract mapping primarily for OMVG and, to a lessor extent, for GARD and other projects. Given existing manpower and financial constraints, this work should continue to be the main focus of the Unit. Since only a minute portion of the country has been mapped, the location of the Unit's activities is not particularly important. At the completion of the OMVG contract, the majority of the alluvial or hydromorphic soil areas will be mapped. Work could then begin in earnest on the upland soils. Changes in national priorities or other factors obviously could redirect the soil survey effort. With an eye toward the future, provision should be made for upgrading the staff currently working on soil survey. B.S. training and special short courses are called for.

Progress on the compilation of soil characterization data at U.W. was reviewed with the interested parties in The Gambia. It was clear, particularly after many soil profiles were examined in the field, that the study should focus on problems associated with the definition of the upland soils. The hydromorphic or alluvial soils wnich are, perhaps, more interesting have been worked on in much more detail, and the series which are being mapped are much more clearly understood. All available and useful data on Gambian soils will be collected, organized and automated; their classification will be developed.

VIII. TRAINING

It is critical at this juncture that John Fye spend a short period of time at U.W. with the researchers involved. It is important to go over with him the criteria to be used in the classification of the soils and for the creation of new soil series. Suitable forms for the description of soils in the field should also be developed. During his stay at Madison, Mr. Fye will be given the opportunity to participate in field reviews of ongoing soil surveys with both the U.S. Forest Service and the U.S. Soil Conservation Service. As head of the soil survey, he needs to be exposed to the organization and structure of soil survey operations.

IX. SUMMARY

In summary, it appears that all of the soils data that still exist have been collected with the exception of the mechanical analysis data

from Yundum. As might be expected, a fair amount of the data from the LRS-22 and Western Division studies has been lost, but enough remains to characterize the major units and to identify areas where new soil series need to be defined, described and sampled. The soil characterization work is scheduled to be completed in the spring of 1988.

ANNEX 1

TERMS OF REFERENCE

NAME:	Dr. Fred Madison
DATES:	May 12 - May 30, 1987
SPECIALIZATION:	Soil Science
COUNTERPARTS:	Staff of the Resource Management Task Force and Soil and Water Management Unit.

SPECIFIC ACTIVITIES:

1) Work with the Cropping Systems and Research Management Task Force and Soil and Water Management Unit in the characterization and selection of benchmark soil fertility and cropping systems research.

2) Discuss with SWMU the initial results of the systematic review of soil profile characterizations completed during the Gambian soil mapping exercise.

3) Review with Tom Remington the details of the proposed monitoring of the SWMU-built dikes.

4) Work with the SWMU in developing priorities for soil mapping and land classification programs.