A CRITICAL ASSESSMENT OF RESEARCH ON SELECTED ENVIRONMENTAL RESOURCES IN TANZANIA: AGROFORESTRY AND WATER MANAGEMENT

JOHNSON M.R. SEMOKA (Lecturer Sokoine University of Agriculture)

ABSTRACT

A critical evaluation of past research and current projects on agroforestry and water management in Tanzania is presented. In agroforestry 22 research projects focusing on aspects such as selection of trees species for agroforestry, the role of agroforestry in soil fertility maintenance and amelioration of unfavorable soil conditions and developing appropriate systems of tree-crop combinations have been undertaken. Some of these projects are still in progress. In soil water management few studies have been undertaken focusing on the soil-plant-atmosphere continuum. Fragmentary and some site specific data on components of this continuum have been obtained.

It is recommend that research programmes in both areas be strengthened. In agroforestry research activities should be extended assess the contribution of roots and mycorrhizal associations of trees to soil fertility maintenance, include indigenous trees species in the selection of multipurpose tree species for use in agroforestry and assess the role of agroforestry in soil conservation.

In soil water management a coherent list of broad research topics has been proposed to enable the development of a more meaningful research programme. In both areas, differences in agroecological zones should be considered in planning and executing research projects to enable efficient utilization of resources by avoiding unnecessary duplication. In addition both areas require increases in funding and training of personnel. Finally efforts to disseminate the technologies developed to farmers should be intensified.

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1.0 INTRODUCTION

Research on environmental resources from the viewpoint of the Ministry of Agriculture encompasses three broad areas namely soils, water management and agroforestry. This paper presents a critical review of two of these components namely agroforestry and water management and proposes programmes for the future.

2.0 AGROFORESTRY

Agroforestry is a collective name for all land use systems and practices where woody perennials are deliberately grown on the same land management unit as crops and/or animals, either in spatial mixture or in sequence. To qualify as agroforestry there must be both ecological and economic interactions between the woody and non-woody components (ICRAF, 1983).

2.1 Land use systems

Agroforestry, in the broad context defined above encompasses many land use systems. Excellent reviews on this aspect have been published (Nair, 1984; 1987; 1989). The prominent agroforestry systems are summarized in Table 1. The major systems are:

(i) Agro-silvicultural system in which crops are grown together with trees as for instance in shifting cultivation with improved fallows, the corridor system of cultivation used in Zaire or the Chagga homegardens in Kilimanjaro region.

(ii) Silvo-pastoral system in which trees and shrubs are allowed to grow on grasslands for grazing e.g. the Acacia dominated grasslands in Kenya, Ethiopia and Somalia.

(iii) Agro-silvo-pastoral system which is basically the inclusion of livestock in (i) above.

In essence the above systems represent the traditional forms of agroforestry and have been in existence for many years.

However during the past 15 years agroforestry has received great attention by scientists and the research efforts have received a substantial momentum since the establishment of the International Council for Research in Agroforestry (ICRAF) in 1977. ICRAF has collected much of the known information on agroforestry and is developing new areas of research. The main focus being the development of sustainable systems

Table 1: Some example of prominent agroforestry systems in Eastern and Central Africa (Source: Nair 1987 Modified)

Major Systems	Subsystem/practice	Example in Eastern and Central Africa
Agroforestry systems	Improvement fallow in shifting cultivation.	Gum gardens of Sudan
	The Taungya	The shamba system
	Hedge row intercropping	The corridor system of Zaire
	Multipurpose trees and shrubs on farmlands	The Chagga homegardens (Tanzania). Nyabisindu sytem (Rwanda)
	Proteinbank (cut and carry fodder production)	Very common
Silvopastoral	Trees and shrubs on pastures	The Acacia dominated system in Kenya, Ethiopia and Somalia
Agrosilvopas toral systems	Woody hedges for browse, Mulch, green manure, soil conservation etc.	Common variants of the shamba system
	Homegardens (large number of herbaceous and woody plants with or without animals)	Chagga homegardens (Tanzania)) Nyabisindu system (Rwanda))

2.5 Previous work and current research projects

Appendix 2 gives previous studies on soil water management which have been reported while appendix 3 gives on going research projects on soil water management. The list given in appendix 2 is not exhaustive as it does not include publications in journals and papers presented in conferences and symposia. Most of the work summarized was conducted at Sokoine University of Agriculture (SUA) and its forerunner the University of Dar es Salaam. All the studies investigated some aspect of the soil-plant-atmosphere continuum. One project, during the reporting period was conducted at the Uyole Agricultural Center (UAC) Mbeya for a degree dissertation. This was part of work which was initiated at UAC during the mid 70s to develop appropriate techniques for soil and water management for the southern highlands areas of Tanzania. The research was however discontinued in the early 80s. Important findings were obtained from the studies but in general the studies were limited in scope and thus the utility of the results in terms of providing answers to soil water management problems was limited.

The other research institutes visited namely Mlingano, Selian and Lyamungu and the Department of Irrigation of MALD do not have research projects on water management. The Soils and Fertilizer Use Research Program (Haule, 1988) hardly mentions research on soil water management. The program is concentrated on three areas; soil survey and land evaluation, soil testing laboratories, and soil fertility and management.

3.0 CRITICAL EVALUATION AND SUGGESTIONS FOR THE FUTURE AGROFORESTRY

3.1 Fulfillment of objectives and scientific advances

As is evident from Appendix 1, a number of experiments on agroforestry have been initiated. However since these experiments require long term assessment of their effects on the land use system, only a few of them have generated conclusive results. Several papers have been published by the agroforestry researchers at SUA (Lulandala 1985; Lulandala and Hall 1987, Chamshama 1989). Efforts are now underway to validate the generated technologies in farmers fields and encourage adoption. The results from the experiments at Mlingano ARI are expected to be summarized in the coming year. For the remaining trials, about 1-3 years are still required before definite recommendations can be drawn. Therefore although progress has been made much remains to be done.

Many of the studies in progress are testing only a few tree species. With the exception of the SADCC-ICRAF-MALD agroforestry project based at Tumbi ARI in which many cultivars of several tree species are being tested, the other projects are concentrating on two or three tree specie with the most preferred 'candidate' being *Leucaena leucocephala*. Considering the many ecological zones on which agroforestry interventions have been suggested, it is necessary that large numbers of species are evaluated. Special efforts should be made to include evaluation of indigenous species and cultivars.

Organizational and design aspects of agroforestry research also require considerable improvement. Currently basically the same types of experiments are conducted almost everywhere. This is not an efficient way of utilizing scarce resources. It is recommend that each zone be assigned specific roles relevant to problems pertaining to that zone. This will avoid duplication of efforts and concentrate on real issues. Also the Agroforestry Coordinating Committee should clearly specify their research objectives and have these documented.

3.4 Suggestions for future development of the research

Research projects

Most of the research projects reviewed address some aspect of the soil fertility maintenance role of agroforestry e.g. its contribution to soil organic matter, nutrient cycling and to a lesser extent the N_2 fixing capabilities of the trees used. Other aspects need to be added to the research topics e.g.

- the contribution of root and mycorrhizal systems of trees to soil fertility
- effects of specific tree species on soil properties
- search of indigenous trees with agroforestry potential.

In addition agroforestry research in Tanzania should be extended beyond soil fertility maintenance to encompass soil conservation. More trials should be initiated in semi arid and other marginal areas to assess the contribution of agroforestry in these ecologies.

3.5 Personnel

Although the number of researchers doing agroforestry is relatively large their effectiveness is diminished because most of them spend only a small percentage of their time on agroforestry research. Every large project

SUA has now changed and it is hoped that things will change in the research institutions as well.

The second problem is the absence of a clearly defined research agenda, so much that even the few studies that have been undertaken do not fit into a well organized and planned programme.

4.4 Suggestions for future development of the research

The first recommendation is to take deliberate efforts of developing manpower in this field. Concerted efforts by both the research institutes and SUA should be taken to develop specialists on this field as soon as possible. Secondly those available should be efficiently utilized to initiate and execute a comprehensive research program on this field. The research agenda should be well defined. The first step should involve defining the objectives of the research in this field which could broadly be as follows:

- To develop techniques for efficient rainwater management.
- To develop farming practices that increase soil moisture conservation and the storage of runoff.
- To develop technologies to support sustained production under irrigation.

The following are examples of research topics or projects to fulfil the above objectives:

- Analysis of rainfall data on daily, weekly and monthly frequencies.
- Develop technology to increase, a) water intake, b) moisture storage capacity and c) efficiency of stored moisture for crop production.
- Techniques for soil moisture conservation
- Techniques for rainwater harvesting
- Mechanical measures for the conservation of rainwater
- Control of conveyance (seepage and evaporation) losses
- Utilization of harvested water to supplement in irrigation
- Water balance studies for rainfed and irrigated crops.

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Title and description of research	Year started (duration)	Institution	Source of funds	Researcher(s)
8. Maize-Leucaena spatial distribution. Objective: to determine the effect of the spatial distribution of Leucaena rows on maize yield and provision of organic matter for soil and yield improvement.	1984 (6 yrs)	Mlingano ARI, Tanga	MALD	A.E.T. Marandu D.S.K. Shirima
9. Leucana-maize intercropping to optimize production of fuel wood and poles and maize. Objective: to determine a suitable spacing for the intercropping with the intention of producing Leucaena poles and fueld wood.	1986 (4 yrs)	Mlingano ARI, Tanga	MALD	A.E.T. Marandu D.S.K. Shirima
10. Citrus sinensis intercropped with maize or cowpea. Objective: to determine the effects of species interaction on yield and disease infestation.	1989 (1 yr)	Mlingano ARI, Tanga	MALD	A.E.T. Marandu D.S.K. Shirima
11. Evaluation of the performance Leucaena Leococephala provenances/varieties on fooder and wood production, under Tumbi, Tabora conditions. Objective: to select suitable Leucaena varieties for use in agroforestry in Tabora region.	1998 (yrs) Kibaha	Tumbi ARI, Kibaha	MALD D.S.K. Shirima E. Sabas	N.M. Lema
12. Alley cropping experiment. Objective: to select suitable plant species for alley cropping under Tabora conditions.	1990	Tumbi ARI Kibaha	MALD	N.M. Lema D.S.K. Shirima
13. Dual purpose crops for fooder, wood and improvement of soil fertility. Objective: to screen pigeon pea accessions that have potential for soil fertility improvement, fooder production, fuel wood production and grain production.	1988 (2 yrs)	Tumbi ARI SADCC-ICRAF	SADCC - N.M. Lema TZ GOVT.	M. Karach E. Sabas

Title and description of research	Year started (duration)	Institution.	Source of funds	Researcher(s)
19. Assessing appropriate spacings of Leucania in alley cropping. Objective: to establish the spacing of Leucaena for optimum yield of both trees and crops.	1986 (4 yrs)	UAC UAC	FINNIDA	J.A. Kamasho G. Ley
20. Sukuma agro-pastoral research programme. Overall objective: to develop agroforestry technologies to enhance soil fertility and increase the supply of fodder and wood for fuel and building materials.	1987 (5 yrs)	Mwanza & Shinyanga RIDEPS		CIDA
21. Soil erosion control and agroforestry project (SCAP) in Lushoto district, Tanzania. Objectives: to test the effects of leguminous fodder bushes and agroforestry trees and grass lines on macro-contour lines on the control of erosion maintenance of soil fertility.		Tanga RIDEP	TZ GOVT. & GTZ.	
22. Role of trees and shrubs in livestock feeding in the HADO areas		LPRI, Mpwapwa	SAREC	P. Masaoa C.M. Shayo D.G. Mlay V.G. Rushalaza

Appendix 4: Major research projects on soil Management water management.

	Year started (duration)	Institution	Researcher(s)
1. An investigation into cultivation methods for controlling soil moisture in the semiarid tropics.	1987	SUA	P.S. Makungu
2. Subsoil compaction effects on soil structure and yield of maize on an Oxisol at Morogoro.	1988	SUA	B. Kayombo
3. Prediction of effective rainfall for beans on freely drained soils.	1989	SUA	S.Y. Thadei
4. Development of a simulation mosdel for quantifying the need for irrigation and predicting available workdays for field operations under different soil and climatological conditions.	1990	SUA	H.O Dihenga N.I. Kihupi P.S Makungu
5. Improving soil water availability and efficiency of utilization by crops in the rainfed semi-arid zones of Tanzania.		SUA	A.R. Kashasha H.F. Mahoo B. Kayombo H. Hatibu G.I. Mlay
6. Technical evaluation of the use natural commenting materials for lining irrigation channels.		SUA	HF. Mahoo B. Kayombo

Appendix 5

FIGURE 2
An Example of a Logical Framework

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or sector goal: Provide universal education geared to needs of Temasek	Measures of goal achievement: (a) Degree of shortage/surplus in various professions	(i) Questionnaires to major industries (ii) Comparison of number of students graduated with objective in 10-years plan	Assumptions forachievirig goal targets: Ability of economic sector to provide jobs predicted in 10-year plan
Project purpose: 1. Meet the educational needs of rural	Measures of purpose achievement: (a) Number of students from rural and urban areas proportionate to the population of potential students (b) Research and course directions in School of Agriculture	(i) Demographic data (ii) Opinions of leaders of rural interests groups	Assumptions for achieving purpose: Ability of primary and secondary schools in rural areas to provide students with an adequate foundation for tertiary education