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R E P O R T

AN EVALUATION OF THE ALL-INDIA CO-ORDINATED RESEARCH PROJECT ON AGROFORESTRY OF I.C.A.R.

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Consultant Report by

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Consultancy Report submitted to
WINROCK INTERNATIONAL
NEW DELHI

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Figure 1: Location of AICRP-AF Centers

EXECUTIVE SUMMARY

1. This report pertains to an evaluation of the All India Coordinated Research Project on Agroforestry of the Indian Council of Agricultural Research (ICAR). The evaluation mission involved field visits to a few coordinating centers, discussion with a large number of officials. and participation in the four-day All India Workshop at Navsari, Gujarat.

2. The Project, initiated in 1983-84 has at present 31 coordinating centers all over India. Coordinated by a Project Coordinator at New Delhi, the Project has a total staff deployment over 250, including about 70 scientists, belonging to the various participating State Agricultural Universities and ICAR institutions. The technical program consists of three sub-projects: I. D & D survey, II. Collection and evaluation of germ plasm, and III. System management studies.

3. Given the infancy of agroforestry research world-wide and the institutional constraints, the project has made considerable impact on convincing the agricultural scientists the importance of trees in farming systems, and encouraging them to undertake research on tree-involved farming systems.

4. However, the Project has some obvious shortcomings and deficiencies as well. For example, the D & D surveys seem to have been undertaken without a thorough understanding of the philosophy and rationale of D & D; as a result, the surveys have, at the most, only identified some of the trees in existing farming systems. The germplasm collection and evaluation have been done arbitrarily; but, nevertheless, some good results have been produced from this exercise. The so-called system management studies undertaken under sub-project III have been limited to a few "stereotyped" trials, in some cases, even without clear definitions of objectives and time-frame. It needs to be reiterated that some of these deficiencies are because of the newness of agroforestry research.

5. Administratively the project needs more efficient coordination. For accomplishing this, regional coordinators may be appointed at different regions, and a full time coordinator (instead of the present position of Assistant Director-General-cum-Coordinator) with adequate staff and support facilities (e.g., computers) at the headquarters. Besides, socio-economic scientists should actively be involved in the project.

6. The D & D should evolve into a "Recurrent Diagnosis", the procedures for which for each center may be worked out locally based on the general framework provided from the headquarters. Such diagnosis should be extended to marginal lands and other communal lands with agroforestry possibilities.

7. Multipurpose tree evaluation should be intensified at all centers, with due emphasis being given to exploiting indigenous species. Initial screening and evaluation of trees should precede detailed, statistically laid-out field experiments involving them.

8. Agronomic crops also need to be studied for their amenability for agroforestry.

9. There should be better coordination between the Project and other agroforestry research activities such as by the country-wide National Agricultural Research Project and State Agricultural Universities.

10. Serious efforts may be made for facilitating better interaction among project scientists at regional, national and international levels, and for publication of research results in appropriate scientific and technical media.

11. Research in agroforestry should extend to more detailed investigations of the "why" and "how" types of studies.

12. The creation (designation) of "Apex/Regional Centers" of agroforestry research is strongly recommended.

13. A matrix of geographic and agro-ecological zones is proposed for coordinating agroforestry research.

14. A few technology thrust areas of agroforestry research, in which U.S. collaboration with Government of India could be strengthened are:

    i. systems analysis and modeling;
    ii. biotechnology research and application;
    iii. development of expert systems for technology dissemination as well as research coordination; and
    iv. advanced agroforestry education and academic collaborations.

1. INTRODUCTION

This report pertains to an evaluation of the on-going All-India Coordinated Research Project on Agroforestry (AICRP-AF) of the Indian Council of Agricultural Research (ICAR). The evaluation is based on the consultant's field visits to a few research sites in different parts of India, discussion with relevant officials of ICAR and State Agricultural Universities (SAU), and participation in the Fourth All-India Biennial workshop and Symposium on Agroforestry held at the Gujarat Agricultural University, Navsari Campus on 8-11 January, 1990. The consultant's itinerary is given as Annexure-I and a list of individuals with whom substantial discussions were held is given as Annexure-II. An invited paper entitled "Agroforestry research in India: present trends and future directions" was presented by the consultant to the above-mentioned All-India Workshop at Navsari on 10 January, 1990; an extended summary of that paper is given in Annexure-III.

2. OBJECTIVES OF THE MISSION

The objective of the consultancy was to review the progress of research under the All-India Coordinated Research Project on Agroforestry of the ICAR.

Specifically, the scope of work was to:

- review the progress of research under the All-India Coordinated Research Project on Agroforestry;
- assist in formulating the plan of work for the next two years;
- participate in the biennial workshop-cum-symposium on Agroforestry at Navsari, Gujarat, January 8-11, 1990;
- visit a few selected research centers at Mannuthy, Coimbatore, Jhansi, etc.

3. THE PROJECT

The All-India Coordinated Research Project on Agroforestry (AICRP-AF) was initiated by ICAR in collaboration with various State Agricultural Universities (SAU) during the financial year 1983-84. At present there are 31 coordinating centers spread all over the country (Fig.1), 23 SAU centers and 8 ICAR centers. Plans are that during India's VIIIth Five-Year Plan, all SAUs (at present 26) will have one AICRP-AF center each.

The revised set of objectives of AICRP-AF (December, 1989) are:

1. to survey existing AF systems and create data bases in respect of AF systems in the country.

2. to generate technologies for higher biomass production from farm lands, marginal lands and other degraded lands.

3. to select and improve multipurpose trees (MPTs) and nitrogen-fixing trees (NFTs) for different farming systems.

4. to optimize fuel, fodder, and small timber production from farm lands, community lands and degraded marginal lands.

5. to integrate and optimize the production of woody biomass from arable farming systems.

6. to develop suitable methods of breeding and propagation of elite trees and provenances through conventional as well as tissue culture techniques.

7. to develop suitable agroforestry models for different watersheds and degraded lands.

8. to develop post-harvest technology and forest utilization for the welfare of rural people.

The project is managed and coordinated by a Project Coordinator (PC) located at ICAR headquarters in New Delhi; he is also the Assistant Director-General (ADG) of ICAR in charge of agroforestry. A full-time person (Dr. S. Chinnamani) was appointed to this combined position in May, 1988; till then, the Coordinator's responsibilities were being handled by other ICAR officials in addition to their other designated duties. At the headquarters, the Project Coordinator is assisted by one scientist (two positions have been sanctioned) and one administrative assistant (sanctioned:2). The staff at the coordinating centers are deployed by the respective centers; consequently, staffing pattern and strength vary considerably at different centers. At present, the project has a total staff deployment of 69 scientists, 92 technical, 23 administrative, 69 supporting, and 11 auxiliary personnel (total 264). The 31 coordinating centers are grouped, somewhat arbitrarily, into six agroclimatic zones: Himalayan Hill Zones -- two (East and West), Gangetic Plains, Humid and Sub-Humid, Arid and Semi-Arid, and Tropical Zones.

The technical program of the on-going project consists of three sub-projects:

I. Diagnostic and Design (D&D) Survey;
II. Germplasm collection and evaluation;
III. System management studies.

The D&D survey is aimed at appraisal of existing farming systems and agroforestry practices. The second sub-project aims at collection and evaluation of promising species and cultivars for fuel, fodder, and small timber (trees and shrubs). The third sub-project

consists of various experiments at different centers, aimed at devising appropriate management practices for different agroforestry systems. Experiments/species under sub-projects II and III are different at different centers, but sub-project I is based on a uniform pattern modeled on the International Council for Research in Agroforestry (ICRAF)'s D&D approach.

4. REVIEW OF PROGRESS

The progress of the Project attained during 1987-1989 at all the 31 participating centers has been reported in a document presented at the biennial workshop at Navsari (Biennial Progress Report for the All India Coordinated Research Project on Agroforestry, 1987 - 1989; compiled and edited by S. Chinnamani; assisted by O. P. Sharma; ICAR, New Delhi; January 1990; 184 pp; mimeo.). The report contains the Project Coordinators summary statement of progress, and summary of results from various centers. Additionally, written reports of progress from various centers were distributed during the workshop.

There are great variations in the extent of work done at different centers. No work has been reported from some centers; it is not clear whether this means that no work has been done at all, or no work was reported. But substantial amount of work has been reported from some centers. Based on the consultant's field visit to some centers, it is felt that more than what is being reported in these reports are being done at these centers.

It is neither necessary nor appropriate to quote all these voluminous results here. An overall evaluation of the project's progress, based on what has been seen and heard, is more relevant and feasible for this mission. This is attempted in the following section.

5. EVALUATION OF THE ON-GOING PROJECT

5. 1. ADMINISTRATIVE AND ORGANIZATIONAL

This is a massive project with 31 centers (with plans for more centers being added) spread over the entire length and breadth of the country (Fig.1). The scientific coordination and administration is handled by Project Coordinator, with the help of a very minimal staff, located in New Delhi. The PC is also the Assistant Director-General in charge of agroforestry.

The project's progress is monitored and activities coordinated through correspondence, PC's visits to centers, and all-India workshops which take place once every two years. It is obvious that there are physical limits to what an under-staffed ADG-cum-PC -- even if it is such an extremely capable and competent person like Dr. Chinnamani -- can accomplish in effectively coordinating the activities of such an enormous project.

5. 2. TECHNICAL

5. 2. 1. Sub-Project 1: Diagnosis and Design (D&D) Survey

D&D is one of the most mis- (or, inadequately) understood research approaches to agroforestry in the Indian context. The philosophy and rationale of D&D have been amply illustrated by ICRAF, but it seems that these ideas have not been transferred to or understood by most of the project personnel. One of the main reasons for this could be that most of the scientists of the project are biological scientists with practically no interaction with social scientists. Another reason may be that base-line data on many of the farming systems are already available in India, and naturally, the scientists assigned the task of D&D would be

wondering as to why similar data should be collected all over again. As a result, most of the D&D exercises have been limited to identifying the trees in existing farming systems, with practically no emphasis being given to understanding the role of these trees, let alone investigating as to how such trees could advantageously be used for mitigating some of the diagnosed (if at all they are properly diagnosed!) land-use constraints. The second "D" of D&D (referring to design) seems to have been totally left out of the D&D exercises reported so far.

5. 2. 2. Sub-Project II: Germ-Plasm Collection and Evaluation

Among the three sub-projects, this is the activity that can in the long run set the stage to bring about the greatest contribution to agroforestry development in India as well as elsewhere. The present project's program encompasses planting a few species at each location, hopefully with the idea of evaluating them in terms of their adaptation, growth, productivity, and amenability to agroforestry. Species selection has been done very arbitrarily: this is understandable, because when the project started, there was practically no other way to decide on the species except to go by the experience of people who have been working in related scientific fields locally and elsewhere. Fortunately, several of the species that have been selected are of proven adaptability to local conditions and acceptability to local farmers and farming systems. Neem (Azadirachta indica), "Kherji" (Prosopis cineraria), Dalbergia sissoo, Acacia spp., Casaurina spp. and several other useful MPTs have thus been included in these efforts. And, this is a remarkable effort indeed.

However, the criteria and objectives of tree evaluation need to be properly defined, or re-defined. In agroforestry literature, one of the oft-repeated roles of trees is their soil-improvement potential, and tree evaluation criteria have been developed based on this perception. In India fertilizers are comparatively cheaper (as compared with many other developing countries) and fertilizer use and soil fertility management are of a somewhat higher level (again, compared to other

developing countries). Therefore, in mixed AF systems, the role of MPTs should be more in terms of their productivity function than soil-fertility improvement per se. However, under wasteland development schemes where block plantings of MPTs are being recommended, both the productivity and fertility-improvement potentials of MPTs should weigh equally.

The seriousness with which MPT selection, and eventual tree-improvement, programs are undertaken at present leave much to be desired. One of the most striking features in all MPT plots is the remarkable variations in form and shape of the MPTs planted from the same seedlot or source; the variations are more striking in relatively under-exploited species such as Acacia spp. as compared with "exotics" such as Casuarina and Leucaena. This variability only shows the wealth of germ-plasm resources from which selection and improvement could be undertaken, and calls for such actions expeditiously.

5. 2. 3. Sub-Project III: System Management Studies

This is the sub-project that is expected to produce results of direct and immediate applicability. Different types of experiments have been undertaken in various centers with different degrees of pattern on the type and nature of experiments under similar agroclimatic zones. Some of the most common experiments are intercropping studies involving trees and crops, tree plus grass (silvopastoral) systems, and tree management (mostly espacement) studies. A few studies that fall outside this general pattern of "routine" studies include the organic matter decomposition studies reported from Pantnagar center and soil conservation and sand-dune fixation studies at Rajasthan.

The consultant got the impression during presentation of research results from various centers at the Navsari workshop that the objectives and time-frame of various experiments are not clearly defined in some case.

5. 3. OVERALL COMMENTS

1. Considering the newness of agroforestry, its potentials in the Indian context, multidisciplinary and complex nature, and the comparatively low levels of research activities in the subject in the world, the Agroforestry initiatives in India, of which the AICRP-AF has a pivotal position, has accomplished remarkable progress. Quantitative evaluation of the accomplishments by whatever criteria may not be convincing. But the greatest accomplishment has been that many agricultural scientists now consider trees and other woody perennials as essential and researchable components of farming systems. Given the disciplinary orientation and single-commodity focus of most agricultural scientists, this has been no mean an achievement. If this momentum can be sustained, much more can be accomplished at a much rapid rate in the years to come, which could be beneficial not only for India by also for other developing countries. Every effort should be made to facilitate these accomplishments.

2. Publication of research results is an area in which the project does not seem to have made much efforts and therefore progress. There is a wealth of information on different aspects of agroforestry lying in various research records of the scientists and research stations. Unless concerted efforts are made to synthesize these results and publish them in appropriate scientific and technical media, these results will remain unknown and unavailable to the rest of the scientific and farming community nationally and internationally, and India would be missing the potential advantage of leadership in agroforestry research world-wide.

3. An important aspect that has so far been ignored in the studies (Sub-Projects II and III) is the agricultural component of agroforestry. This is a characteristic of agroforestry research not only in India, but everywhere else in the world. However, it is time that deserving attention is given to studying shade tolerance, varietal differences in amenability to agroforestry, management requirements, and a whole range of such issues concerning the agricultural components of agroforestry systems. This is particularly important because most of the crop varieties used in agroforestry systems have been bred and or otherwise developed for their production in monocultural systems.

4. Yet another characteristic of agroforestry is the lack of uniformity in the use of terminologies. This, again, is not unique in the Indian context. But, in India we find a proliferation of terms describing different combinations of agroforestry, e.g., silvi-pasture, horti-silvi, agri-horti, agri-silvi-horti, and so on. These terms are used differently not only in different centers of AICRP-AF, but even by the same scientists in different contexts. This consultant's view is that since agroforestry is still in its emerging and evolving phase, some of this "confusion" is inevitable; as time progresses, these issues will be sorted out and a set of common words and terminologies will emerge. However, this coordinated project should make a beginning in the use of uniform terminologies, starting with agroforestry as a single, rather than a hyphenated, word, as it is written almost universally.

6. RECOMMENDATIONS

6. 1. ADMINISTRATIVE AND ORGANIZATIONAL

1. The positions of ADG (AF) and PC (AF) should be delinked; there should be separate individuals for these two jobs.

2. Coordination needs to be decentralized. There should be Regional Coordinators for each of the designated ecological regions. If this is not feasible immediately, a beginning of decentralization may be made by appointing two Regional Coordinators, one for the Himalayan and Gangetic Plains regions, and the other for the central and southern regions of the country.

3. There is a glaring lack of involvement of social and economic scientists in the planning and implementation of this project. This deficiency should be rectified as soon as possible. If it is infeasible to have a social scientist at each center, the involvement of such scientists may be ensured at the regional level in project planning, implementation and evaluation.

6. 2. TECHNICAL

6. 2. 1. Sub-Project I: D&D Survey

The importance of having a mechanism for not only pre-project diagnosis of constraints, but also continuous monitoring of the adoptability of technology innovations by the clientele was stressed by most participants during the Workshop discussions. Taking this (as well as the deficiencies of the way in which D&D has so far been undertaken) into account, it is recommended that:

1. D&D should more appropriately be called and undertaken as "Recurrent Diagnosis".

2. Diagnosis should be extended to different types of lands: farmlands, marginal lands and other wastelands, and community lands and other common lands,

so that the needs and aspirations of land-holding as well as landless farmers could be considered.

3. Recurrent diagnosis should be a location-specific exercise; individual centers may develop or refine their own diagnostic procedures based on a general framework developed by the PC's unit.

6. 2. 2. Sub-Project II: Germ-Plasm Collection and Evaluation

1. MPT collection and evaluation activities should be intensified at all centers, with serious attention being given to identifying promising phenotypes among individual species.
2. Emphasis should be given to exploring the potential of underexploited indigenous MPTs, several of which are already known to local farmers, and, sometimes, scientists.
3. Methodologies and criteria for MPT evaluation need to be developed more systematically. It is, however, recognized that this is an area in which agroforestry research lags behind all over the world (because of the newness of the subject and complexities of the problems). International institutions such as ICRAF, with which the project has close working relationship, can hopefully lend some assistance in the matter.

4. Social values of indigenous MPTs should be an important criterion in their selection and evaluation.

5. Tree productivity factors in terms of multiple products (fodder, fuelwood, small timber, etc.) may be considered along with site-improving qualities of trees in evaluation criteria.

6. Cash generation capacity of some MPTs is now being exploited by some (mostly, resource-rich) farmers. Rather than denigrating these tendencies, systematic studies may be undertaken to make such practices more popular and bring them within the management capabilities and options of small farmers as well.

6. 2. 3. Sub-Project III: System Management Studies

1. The objectives of each experiment needs to be stated clearly and understood by the researchers.

2. Management studies for each center need to b .dentified based on recurrent diagnosis, and prioritized, so that based on resources availability, they could be taken up in progression.

3. There should be a defined time-frame for each experiment, and there should be no hesitation to close down experiments after their term.

4. Repetition of similar experiments at different centers of the same region may be avoided, which can be accomplished through proper regional planning and coordination.

5. Centers that have better infrastructure, and resources, and longer history of research in agroforestry may be encouraged to undertake more intensive studies on selected topics. A strategy for accomplishing this is outlined in section 7. 1. 2. of this report.

6. Statistical designs and evaluation procedures need to be standardized. The present trend of going ahead straight away with statistically designed

experiments with several replications and other requirements using species on which practically very little information is available is resource-inefficient. Short-term observational trials including species and provenance evaluation should precede full-fledged experiments in randomized block designs, split-plot experiments, etc.

7. Long-term monitoring of sustainability parameters outlined separately (Annex. III) should be undertaken from well laid-out and managed experiments in, at least, selected centers, of say, one in each region.

6. 3. ON-GOING PROJECTS AT CENTERS VISITED

6. 3. 1. Kerala Agricultural University (KAU)

1. The project site may be shifted from the present place Thiruvizhamkunnu, 120 km away from KAU headquarters (and the nearby Kerala Forest Research Institute -- KFRI). The place is in a relatively remote location so that it is difficult to get the staff stationed there on a continuing basis. Locating the project nearer KAU, Vellanikkara will enable KAU Forestry faculty and students, as well as scientists of KFRI, to have better involvement in project activities. The Dean Agriculture, Director of Research, and the Special Officer-in-charge of Forestry College of KAU (who is also in charge of the AICRP-AF) are all very much in favor of such a change. Sufficient land is reported to be available on Vellanikkara campus to accommodate the project.

2. Indigenous (or locally adapted) MPTs such as Pterocarpus marsupium, Macaranga peltata, Thespicia sp., Moringa oleifera, Pongamia pinnata, etc.

need to be studied in detail to understand their characteristics, select promising lines, and describe appropriate management systems for these on farm lands.

3. There is an on-going controversy in Kerala about the environmental desirability of Acacia auriculiformis, which has been found to be the most promising among introduced MPTs in social forestry programs, but is alleged to be environmentally undesirable (moisture competition and depletion, incompatibility with crops in farming systems, etc.). The project has this species under evaluation; but more serious and focused efforts may be made to settle the controversy by either proving or disproving the alleged undesirable attributes of this, otherwise desirable and potentially promising, species.
4. No effort should be spared to appoint and keep the scientists in position for implementing the project. KAU has a strong contingent of US-trained forestry faculty - two of them at the University of Florida, Gainesville -, who are enthusiastic and capable of undertaking agroforestry research. Their involvement in the project may be ensured; shifting the project site to KAU headquarters as recommended above will facilitate this to a great extent.
5. There are also scientists in Vellayani campus of KAU who are extremely interested and who have had past experience in agroforestry research (Dr. C. Sreedharan, Dean; and Dr. M. Achuthan Nair, Assoc. Professor, Agronomy). The possibility of involving them in this project, may be by undertaking some of the experiments at Vellayani campus, may be examined.

6. 3. 2. Tamil Nadu Agricultural University (TNAU), Coimbatore/Mettupalayam

TNAU with its relatively long-standing experience in agroforestry research, good infrastructure, and capable leadership and direction may be designated as a

Regional (Apex) center for Agroforestry Research (the philosophy of Regional Centers is explained in section 7. 1. 2.).

6.-3. 3.IGFRI and National Research Center - Agroforestry (NRC-AF), Jhansi

The NRC is designated to be the lead institution in AF research in the country. There is a long way to go before the Center assumes this capability and role. All aspects of recommendations mentioned in the following sections apply especially to the Center.

7. FUTURE DIRECTIONS

The following recommendations are made in the hope that they will be useful in chalking out future strategies for AF research in India under the auspices of ICAR.

7. 1. ADMINISTRATIVE AND ORGANIZATIONAL

1. The need for delinking the positions of ADG (AF) and Project Coordinator of AF project, as well as establishing Regional Coordinators has already been emphasized earlier (section 6. 1).
2. There should be greater decentralization in planning, implementation and coordination of the project. In order to facilitate greater in-depth studies in the most resource-efficient manner, some centers, may be one each in the six existing ecological regions may be designated as Apex (Regional) Centers. These apex centers could be the focal points for periodic meetings, exchange and dissemination of scientific and technical matters of regional significance, and research training of regional scientific staff. These apex centers could

also be the locations for undertaking "more-than-the-routine" type of studies, for example, the "how" and "why" types of experiments (see section 7. 3 for explanation of these terms).

3. Social and economic scientists may be involved in the planning and implementation of AF experiments; as a beginning, at least each regional (apex) center should have such scientists.

4. There should be better coordination of efforts between NARP (National Agricultural Research Project) and State Agricultural Universities research, both of which have substantial components of AF research outside the purview of AICRP-AF.

5. There should be more and better facilities for interaction and exchange of ideas among scientists working in the project. The proposed Regional Centers could facilitate the accomplishment of such interactions.

6. Publication of research results by the project scientists, in national and international scientific media, should be strongly encouraged.

7. The project should make serious efforts to facilitate the use of a set of uniform agroforestry terminologies (see section 5. 3. 4.).

7. 2. TECHNICAL

7. 2. 1. Studies on Agronomic Crops in Agroforestry Systems

Such studies should be included in Sub-Projects II and III as explained in section 5. 3. 3.

7. 2. 2. Evaluation Criteria

Productivity, sustainability, and adoptability are the three basic attributes of all agroforestry systems (see Annexure III for explanation of these terms). Evaluation criteria of agroforestry innovations should include all these three considerations.

7. 2. 3. Levels of Research

Agroforestry research falls under three levels:

WHAT : What happens if a certain technology or treatment is used in a certain way?

WHY : Why the things that happen do happen?

HOW : How a system works, i.e., understanding the processes involved.

Most of the on-going experiments are productivity-orientated and are of the "what" type; these are expected to give immediate research results for use by development workers and farmers. These results are, however, location-specific and therefore not extrapolatable. The "why" and "how" experiments that are scientifically-orientated alone can explain the reasons for the observed behavior. Agroforestry research should move on to these stages. However, it may not be necessary for all the centers to embark upon such experiments -- that is where the role of Apex Centers becomes important. Besides, "what" experiments need to be established and monitored to identify researchable "why" and "how" topics.

7. 2. 4. Sustainability Studies: Systems Modeling and Analysis

Soil-related parameters are an important group of topics (in addition to other ecological and economic factors) in sustainability studies. These also present appropriate themes for the "why" and "how" experiments.

Considering the infancy of AF research and diversity and complexity of factors, it is recommended that the systems analysis approach may be adapted for these studies. Essentially, it will involve conceptualizing a model of the system to be studied (a system here need not necessarily be a land-use system; it is an entity defined by its boundaries and operational parameters, e.g. a soil ecosystem, a tree/crop interface system, etc.); compartmentalizing the system into its components; defining the processes of the factor(s) being studied within the system; monitoring the input, output, and turnover processes (within the system) of the factor, and then evaluating, synthesizing and predicting the effects of changing the quantity or intensity of the factor on the overall performance of the system. Systems analysis approach has been applied extensively in nutrient cycling, plant behavior, integrated pest management and other ecosystem studies. Microcomputers will be an essential tool in such studies.

The advantage of this approach is that it will enable us to identify the gaps in our knowledge, and the areas in which efforts should be focused to gather the missing information. It also allows a holistic analysis of the whole system which no amount of individual component research can provide.

As mentioned earlier, such systems modeling and analysis approach need to ge undertaken only in a few select centers; to start with, a few areas (e.g. nutrient cycling) on which relatively more data are available may be selected for such studies.

7. 2. 5. A Matrix of Geographic and Agro-ecological Zones for Coordinating Agroforestry Research

For implementing this project, the country has been divided into six agro-ecological zones, albeit arbitrarily. The characteristics of the country are such that each geographic region has many agro-ecological zones. For example, arid and/or semi-arid zones can be found all over the country; so also the humid/sub-humid and other zones. And similar agro-ecological zones in different geographic regions have somewhat similar characteristics. In consideration of these, it may be desirable to have a matrix with geographic regions as the columns and a few well-defined agro-ecological zones as the rows. This could be a scale-neutral matrix in the sense that the number of entries along columns and rows could be as many or as few as deemed practical. Each or any cell of this matrix may be singled out for an evaluation of what is already known or done, leading to identification of research on items that have quick-return ("what" type) as well as those that need detailed studies ("why" and "how" types). Since some experiments are already in progress in several centers, this may amount to synthesizing and grouping the available information for each of the designated cell of the matrix. This approach will enable us to identify gaps in the existing network of research sites, and avoid duplication of efforts. The summation of rows and columns will give a total picture of agroforestry activities in different geographical and ecological regions.

The matrix can easily be computerized, and the format could be used for coordination of any number of defined parameters such as staff deployment, seed supply, equipment, budget, or whatever.

7. 3. NEW THRUST AREAS

Some of the new directions that a US-supported Agroforestry Research Program should consider are listed briefly.

7. 3. 1. System Modeling and Analysis

The importance and essential concepts have already been outlined (7. 2. 4.).

7. 3. 2. Biotechnology Research and Application

Great opportunities exist in exploiting germ-plasm variability among indigenous of otherwise locally adapted MPTs. As a part of the germ-plasm evaluation and selection Sub-Project of AICRP-AF, several promising lines or individual trees are being identified in different centers. Modern biotechnology methods have a great role to play in evaluating and rapidly multiplying such elite plants.

7. 3. 3. Informatics: Expert Systems

Microcomputer based expert systems is an area that is getting popular in disseminating knowledge-based information systems to development workers and trainers. For example, the prototype of a knowledge-based Agroforestry Expert System (AES) has recently been developed with this consultant's involvement. Such tools would be useful in the hands of institutions such as India's 100+ Krishi Vigyan Kendras. The possibility of developing such Expert Systems for different cells in the earlier-mentioned (7. 2. 5.) geographical-matrix needs to be examined seriously.

7. 2. 4 . Agroforestry Education and Training

Indian and US institutions could collaborate more actively in developing educational and training programs in agroforestry. USAID-supported Forestry Faculty Training is already on-going. Additionally, training at PhD levels may be

supported. The University of Florida, Gainesville, for example, has an Agroforestry Program that allows graduate students to undertake their field research in an appropriate developing country. Indian SAUs and other AICRP-AF centers could be excellent centers for hosting such scholars. The scholars could concentrate on some of these new technology-thrust areas such as biotechnology, expert system development and computer-simulated systems analysis models based on their field studies in such centers. Such an arrangement would be relatively cost-effective (as compared to full-time faculty involvement), facilitate faculty - faculty interactions between collaborating institutions, and furthering research of the "why" and "how" types.

Short-term research training opportunities in agroforestry also need to be intensified. Such training should be imparted on selected technology - thrust areas (listed above), to enable the Indian scientists to get acquainted with the latest techniques in the respective fields in US institutions, who, upon return to India could disseminate the skills acquired to their colleagues through short-term training courses organized at the Regional (Apex) Centers. This program is very similar to the on-going activity under the Indo-US collaboration.

8. CONCLUDING REMARKS

AICRP-AF is a massive activity: spread over 31 coordinating centers throughout the length and breadth of the country, and working on such a new activity, the project is indeed a bold initiative. In spite of some institutional constraints and technical difficulties, the Project has made some notable accomplishments. Mistakes may have been made and all expectations may not have been fulfilled. But these should in no way belittle the significance of the accomplishments. If nothing else, a section of the traditionally discipline- and commodity-oriented agricultural scientists have now accepted trees and other woody perennials as essential components of farming systems and as researchable items. Thus a

major impediment to agroforestry research has been overcome. If this momentum is sustained, further results will be faster and more substantial.

- To sustain this momentum and develop more and more productive, sustainable, and adoptable technologies, the efforts need to be strengthened, not only in volume, but also in quality. Modern scientific tools and techniques are becoming available at an alarmingly fast rate; agroforestry research in the 1990s should be "modernized" to benefit from these opportunities.

The potentials offered by agroforestry are enormous, especially in the Indian context. But unless more systematic and scientific investigations are undertaken, agroforestry will not get very far from the present state of anecdotal statements and unsubstantiated hypothesis. Indian scientists and institutions have much to offer in the development of scientific agroforestry not only for India, but also for the rest of the world. This project is a very good vehicle for accomplishing this, and external donors like US-AID will be doing a great service to the cause of development of agroforestry world-wide by supporting these Indian activities, especially in specialized areas of technology thrust.

ACKNOWLEDGEMENTS

I would like to acknowledge the help and support of many people during the course of this mission. A list of people with whom I have had substantial interaction is given in Annex II. In particular, I would like to thank Dr. S. Chinnamani, Assistant Director-General and Project Coordinator, Agroforestry, ICAR; Dr. Deb Roy, Director, National Research Center for Agroforestry, Jhansi; Dr. S. Jayaraj, Vice-Chancellor, Tamil Nadu Agricultural University, Coimbatore; Dr. M. Achuthan Nair, Associate Professor of Agronomy, Kerala Agricultural University, Vellayani; Dr. A.P.S. Ahlawat, Joint Director of Research, Gujarat Agricultural University, Navsari; Dr. Maharaj Singh, Senior Agricultural Scientist, Winrock International, New Delhi, and Dr. J.S.P. Yadav of USAID New Delhi, for their time, interactions, invaluable assistance, and excellent arrangements for the various field visits. Special thanks goes to Mrs. S. Bhat and Mr. Srinivasan of Winrock International's Washington, D.C. and New Delhi offices, respectively, for their excellent coordination of logistical arrangements.

ACRONYMS AND ABBREVIATIONS USED

ADG	Assistant Director-General
AF	Agroforestry
AICRP-AF	All India Coordinated Research Project - Agroforestry
D&D	Diagnosis and Design
ICAR	Indian Council of Agricultural Research
ICRAF	International Council for Research in Agroforestry
IGFRI	Indian Grassland and Fodder Research Institute
KAU	Kerala Agricultural University
KFRI	Kerala Forest Research Institute
MPT	Multipurpose tree
NARP	National Agricultural Research Project
NFT	Nitrogen Fixing Tree
NRC-AF	National Research Center - Agroforestry
PC	Project Coordinator
SAU	State Agricultural University

Annexure I

CONSULTANT'S ITINERARY

26 Dec 89:	Departure, Gainesville, Florida, USA (2:40 p.m).
28 Dec 89 :	Arrival, Trivandrum, Kerala, India (11:30 p.m) - (flight delay at Bombay, India).
29/30 Dec 89:	Private (holidays).
31 Dec 89 :	Trivandrum, Meeting with the Dean, Agriculture, Kerala Agri. University. Travel (by train) to Trichur (1:00 - 8:00 p.m).
01 Jan 90 :	Visit Kerala Agri. University headquarters at Vellanikkara and Agroforestry project site at Thiruvizhamkunnu (120 km) along with KAU officials. Travel to Coimbatore (by road) (5:00 -8:00 p.m).
02 Jan 90 :	Visit Tamil Nadu Agri. University headquarters at Coimbatore, and AF project site at Mettupalayam (35 km) along with TNAU officials.
03 Jan 90 :	Discussions at TNAU, Coimbatore; travel to Madras (air) (en route to Delhi).
04 Jan 90 :	Travel to Delhi (delayed/disrupted flight due to bad weather) (6:00 a.m - 5:00 p.m).
05 Jan 90 :	Discussions at the office of Winrock, New Delhi, and at ICAR headquarters; Attend the meeting of Indo-US Sub-Project on Agroforestry Research at ICAR headquarters.
06 Jan 90 :	Visit National Research Center on Agroforestry on the campus of IGFRI, Jhansi, along with the Director of the Center (6:00 a.m - 11:00 p.m).
07 Jan 90 :	Preparation of paper for the Navsari Workshop (Annex III). Travel, along with Dr. M. Singh, Winrock, New Delhi (by train) to Navsari, Gujarat, dep. 5:00 p.m.
08 Jan 90 :	Arr. Navsari (11:00 a.m); Workshop. Attend a special group meeting convened by the Dy. D.G. ICAR (8:00 - 10:00 p.m).
09 Jan 90 :	Field visit (8:30 a.m - 8:30 p.m).

10 Jan 90 :	Workshop. Present the paper (Annex III). Group meeting to discuss AF program development at Navsari campus, Gujarat Agricultural University (8:00 - 9:30 p.m).
11 Jan 90 :	Workshop at Navsari. Chaired the morning session. Departure for New Delhi (by train) 1:00 p.m (along with Drs. M. Singh and J.S.P. Yadav).
12 Jan 90 :	Arrival in Delhi (11:00 a.m). Winrock Office; Report preparation; Meeting with USAID officials. Final debriefing.
13 Jan 90 :	Travel back to Gainesville, Florida (dep. 3:00 a.m; arrival in Gainesville 6:00 p.m).
20/21 Jan 90:	Report finalization at Gainesville, Florida (as agreed earlier with Winrock/India, New Delhi).

Annexure II

PRINCIPAL CONTACTS

Note: During the mission, the consultant had the opportunity to meet with a large number of scientists and experts involved in agroforestry research and development. Special group meetings were organized for the consultant at the various centers he visited. Moreover, more than 60 scientists involved in the All India Coordinated Research Project of AF in different parts of India were present in the Navsari Workshop. Understandably the names of all these individuals are not given here; instead a select list of individuals with whom the consultant had substantial interactions is given.

WINROCK INTERNATIONAL, NEW DELHI

1. Dr. A. Colin McClung, India Coordinator
2. Dr. Maharaj Singh, Sr. Agricultural Scientist
3. Mr. P.S. Srinivasan, Administrative Specialist

USAID/AGRE, NEW DELHI

1. Mr. John Becker, Office Director
2. Dr. J.S.P. Yadav, Program Specialist (RC&Mgt)

ICAR, NEW DELHI

1. Dr. I.P. Abrol, Dy. Director-General
2. Dr. G.B. Singh, Asst. Director-General (Agronomy)
3. Dr. S. Chinnamani, Asst. Director-General & Coordinator (AF)
4. Dr. O.P. Sharma, Scientist (Agroforestry)

IGFRI, JHANSI & NATIONAL RESEARCH CENTER FOR AGROFORESTRY, JHANSI

1. Dr. Punjab Singh, Director, IGFRI
2. Dr. R. Deb Roy, director, NRC-AF
3. Dr. P.S. Pathak, Head, Agrosilvopasture Division, IGFRI

KERALA AGRICULTURAL UNIVERSITY, MANNUTHY

1. Dr. C. Sreedharan, Dean, Agriculture
2. Dr. M. Aravindakshan, Director of Research
3. Mr. V.R.K.Nair, Officer-in-charge, College of Forestry
4. Dr. M. Achuthan Nair, Assoc. Professor, Agronomy, Agri. College, Vellayani

TAMIL NADU AGRICULTURAL UNIVERSITY, COIMBATORE

1. Dr. S. Jayaraj, Vice-Chancellor
2. Mr. Kumaravel, Dean, Forestry
3. Dr. S.P. Palaniappan, Dean, Agriculture
4. Dr. C. Surendran, Professor & Head, Forestry Research Station, Mettupalayam

GUJARAT AGRICULTURAL UNIVERSITY, NAVSARI CAMPUS

1. Dr. Bhakta, Campus Director
2. Dr. B.S. Chundawat, Principal, College of Forestry & Horticulture
3. Dr. K. Janakiraman, Director of Research & Dean, Post-graduate studies
4. Dr. A.P.S. Ahlawat, Jt. Director of Research
5. Dr. A.H. Shah, Principal, College of Agriculture

NATIONAL AGRICULTURAL RESEARCH PROJECT (NARP), NEW DELHI

1. Dr. S.P. Ghosh, Director (met in Navsari)

Annexure III: Paper delivered at the All-India Agroforestry Workshop, Navsari, Gujarat, India; 10 January 1990.

AGROFORESTRY RESEARCH IN INDIA
PRESENT TRENDS AND FUTURE DIRECTIONS

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Organized research in agroforestry is a relatively new effort in India, as in other parts of the world. In simple terms, there can be two approaches to agroforestry : taking trees and shrubs to farms, and taking crops and/or animals to forests and other wooded areas. The former is more feasible and pragmatic under Indian conditions for a variety of reasons. It is therefore very appropriate that the ICAR, the central agency for agricultural research and education in India, has taken a lead role in agroforestry research. A brief evaluation of the nature and levels of research in agroforestry conducted in India at present, based on my rather limited familiarity with these activities, and some suggestions for future directions shall be the subject of this short presentation.

Categories of on-going research :

The main categories of agroforestry (AF) research that are being conducted either under the auspices of the All India Co-ordinated Research Project on Agroforestry or otherwise can be categorized as follows :

(1) Component research
- 1/ Multipurpose tree evaluation and management
- 2/ Nitrogen-fixing trees; soil improvement by trees.

(2) Systems research
- 1/ Various forms of intercropping
- 2/ Tree fodder and silvipastoral systems
- 3/ Alley cropping and other forms of Zonal AF
- 4/ Multipurpose woodlots for wasteland development
- 5/ Diagnostic surveys.

Contd..

Evaluation :

How can we undertake a scientific evaluation of these efforts and their results ?

The three basic attributes of AF are said to be productivity, sustainability and adoptability. Productivity refers to production or output, within a defined period of time, of the desired product, not only of the agricultural components, but also of the tree and animal components. The most common tree products include fuelwood, fodder, food, timber especially small timber. Sustainability refers to the protection or service functions of AF. It has been variously defined; but for the purpose of the discussion here, sustainability can be considered as the maintenance of production over time without degradation of the natural resource base on which that production is dependent. In addition to purely agronomic criteria, economic, social, and ecological factors need to be taken into sustainability considerations; moreover, sustainability, like productivity, is defined with a tim-frame. The third characteristic of "adoptability" refers to the extent to which the suggested innovations are accepted and adopted by the targetted clientele (in this case, mostly farmers).

Judging from these criteria, we can see that most of the AF research efforts in India address mainly the productivity issues; some (e.g. nutrient cycling, soil improvement, wasteland reclamation, etc.) address the sustainability issue, though peripherally. The adoptability issues are seldom tackled except in the D & D surveys most of which, again, have been done in a rather cursory manner.

On the productivity front, attention has been focussed on a few tree species, and quite undertandly so. Now we need to think about extending the component productivity studies (screening, evaluation, management, improvement) to the agricultural components as well. Additionally, special attention has to be given to exploiting the potential of indigenous trees that have been essential components of local farming systems since time immemorial. Among the multipurpose trees that have so far been tried selection for vigour, form and other desirable characterics may be undertaken.

Contd..

As far as sustainability issues are concerned, the soil-related factors are of utmost importance. N fixation, organic matter dynamics, synchrony in nutrient use by the tree and the crop components, soil-moisture availability, soil conservation and amelioration etc. are some of the topics that need to be looked into. Similarly, there are also adverse interaction efforts such as competition for light, moisture, and nutrients, allelopathy and other forms of chemical and biochemical interactions; these also have to be investigated.

As mentioned earlier, adoptability of AF innovations also needs serious attention. It could be argued that AF research has not reached the level of taking research results to the farmers, and therefore it is too early to consider such issues. But social scientists would argue that they should be an integral part of research planning right from the very beginning, rather than being late entrants.

Levels of agroforestry research :

What, then are the levels and mechanism for tackling these issues ? AF research can be considered to fall under three levels "What", "Why" and "How"

WHAT : What happens if a certain technology or treatment is used in a certain way ?

WHY : Why the things that happen do happen ?

HOW : How a system works, i.e. understanding the processes.

Often it is difficult to distinguish between the "Why" and "How" experiments.

Most of the on-going experiments, being productivity-oriented, are the "What" type; these are expected to give immediate research results to development workers and farmers. These results are, however, very location-specific, and therefore not extrapolatable. The "Why" and "how" experiments, which are more scientifically-oriented alone can explain the reasons for the observed behaviour, and the processes involved. We need more of these efforts in order to lend scientific credibility to agroforestry and make the results extrapolatable. The sustainability issues of agroforestry outlined earlier could be the research topics for such experiments.

Contd.

Organizational strategy :

It is neither feasible nor necessary that all centres embark upon all experiments with equal intensities of research. There could be some "apex" centres with (existing or built-up) infrastructure and capabilities to undertake detailed investigations to deeper depths on selected problem areas. Each of the broad agro-ecological regions should have one of these regional apex centres to tackle the group of problems that are most characteristic of that region. For example, in the semi-arid and arid regions, the thrust area could be tree fodder and silvipastoral system; agroforestry approaches to soil conservation could be the thrust area in highlands and slopping areas; in humid lowlands, multistorey combinations and role of agroforestry in soil fertility improvement could be the thrust areas. Results from such apex centres could then be tried out in other centres with similar problems and potentials more for verification of results than for detailed investigations. Such a matrix of geographical regions and ecological regions could be the basis of a resource efficient and result-oriented approach to AF research in the next phase.

Research, especially AF research is an iterative and evolving process. It should and can not exist in isolation from other related activities such as education and training and extension. Research education linkage is particularly important and extremely feasible under Indian conditions given the linkages between ICAR and Agril. Universities. Commendable efforts are being undertaken in strengthening AF education and training in India. These activities must be closely linked with the AF research projects.

The greatest accomplishment of this project is that trees are now accepted (by agricultural and animal science scientists) as essential components of farming systems. This has been a remarkable change in attitute. To sustain this momentum and devise more and more productive, sustainable, and adoptable technologies, we need to strengthen our efforts. The potential offered by AF is enormous, but unless we embark upon more systematic research of the "how" and "why" type, AF will continue to be riddled with anecdotal statements, unsubstantiated hypotheses, and wishful thinking. India and Indian scientists have much to offer to the rest of the developing countries in this area. The world at large is looking up to us for leadership; let us assume that and do it well.

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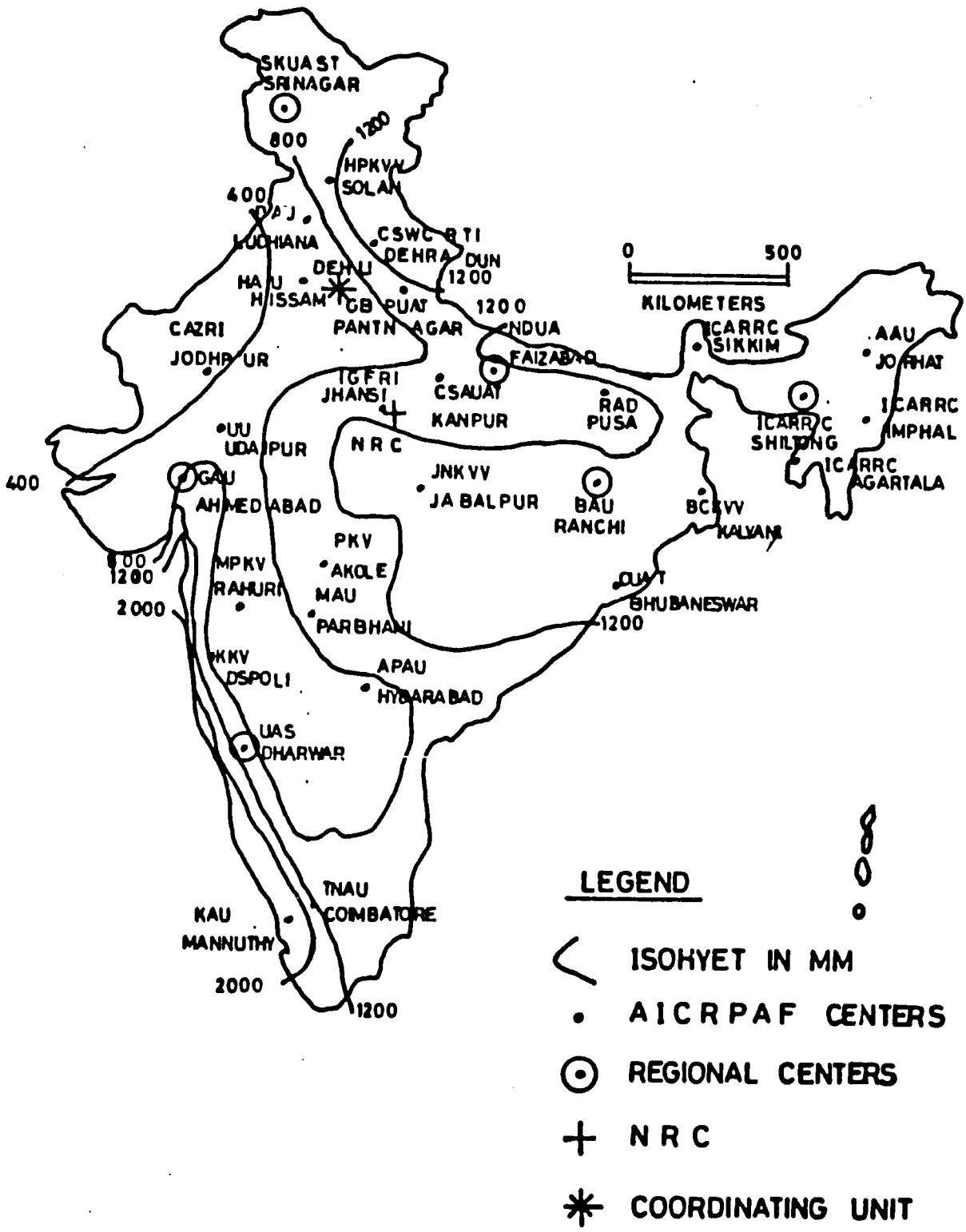

Figure I: Location of AICRP-AF Centers in Different Rainfall Zones.