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WARDA's Strategic Plan: 1990-2000

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West Africa Rice Development Association
Bouaké, Côte d'Ivoire
June 1988

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WARDA's Strategic Plan: 1990-2000

Document approved by the
Technical Advisory Committee of the CGIAR
at its 45th meeting, Rome,
14–22 March 1988

West Africa Rice Development Association
Bouaké, Côte d'Ivoire

What is WARDA?

The West Africa Rice Development Association (WARDA) was founded in 1970. It is an inter-governmental association of 16 African countries and one of the 13 international agricultural research centers whose activities are coordinated by the Consultative Group on International Agricultural Research (CGIAR).

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Preface

This strategy document marks a turning point in WARDA's development. In 1986 the CGIAR agreed to support the Association on the same basis as the other centers in the system. Support was to be conditional on TAC's approval of our strategic plan, and on organizational changes that would bring WARDA's governance, structure and program into line with current CGIAR characteristics.

These organizational changes are part of a deeper process of change in the Association's status. When, in 1973, WARDA first applied to the CGIAR for funding, it was as an intergovernmental association established to stimulate and assist national programs in adaptive research (1), as well as to promote regional rice development and trade. While it will retain a regional focus, WARDA is now a fully fledged CGIAR center with a mandate for technology generation.

Thus readers of our strategy document will find that it voices many of the same concerns as those expressed by our sister institutes. Like them, we confront the major challenge of designing technology that preserves the natural resource base at the same time as increasing output; like them, we seek to be a center of excellence, strengthening the capacity of national research while retaining our primary research focus on issues that transcend national boundaries; like them, we ask ourselves how best to cooperate with the many and diverse entities needed to make agricultural research in developing countries a success. Indeed, a key word in our document is partnership, as WARDA seeks to forge collaborative relationships with these other entities.

Partnership . . . a key word for WARDA.

Forming productive working relationships with our research partners, although vital, is not the only ingredient necessary for WARDA's success. Our ability to develop as an institute in the years ahead will depend critically on the support we receive from donors. Two major kinds of support are needed.

First, core funding is as crucial to the development of a coherent program at WARDA as it is at any research institute. Our core funding must increase rapidly if we are to build the institutional capacity necessary to tackle our difficult mandate effectively. Special project funding, while welcome in some instances, can lead to a loss of focus.

Secondly, a key concern for WARDA in the immediate future will be to provide its scientists with the facilities they need to achieve the standard of excellence expected of a CGIAR institute. We at WARDA hope that this strategy document will inspire TAC and our donors with the confidence to support our program by funding the construction of a new main research station and headquarters for WARDA at Mbé Valley, near Bouaké in Côte d'Ivoire.

WARDA formulated its strategy mainly through the efforts of its own staff, complementing these with external inputs from those most closely concerned with its work.

This final version of our strategy document was approved for submission to the CGIAR's Technical Advisory Committee (TAC) by the Program Committee of WARDA's Board of Trustees, acting on behalf of the full Board. The committee met in The Hague on 8 February 1988. TAC endorsed the strategy without comment at its 45th meeting in Rome, 14-22 March 1988.

Eugene Terry, Director General
20 May 1988.

Heinrich Weltzein, Chairman,
Board of Trustees
20 May 1988.

WARDA's formal mandate

WARDA's formal mandate, which remains unchanged since the Association's original constitution of 1970, states:

> The Association shall assist the governments of member states to achieve operational cooperation in the pursuit of the following aims within the countries of West Africa:
>
> (a) the promotion of rice production;
>
> (b) the increase of the quantity of rice produced;
>
> (c) the improvement of the quality of rice produced;
>
> (d) the encouragement of production and the use of varieties suited to the conditions of these countries and to existing and prospective demand;
>
> (e) the exploration, introduction and extension of rational production methods adapted to the conditions prevailing in these countries;
>
> (f) the promotion and implementation of measures for effective phytosanitary controls in relation to rice;
>
> (g) the improvement of systems of storage and processing as well as of marketing of rice, both within these countries and with respect to the external trade in rice.

In pursuit of these aims the Association is to undertake or promote the following activities:

> (a) encouraging, coordinating and undertaking as necessary basic and applied research programs in the scientific, technical, economic and sociological fields;
>
> (b) collecting, analysing and disseminating information on methods applied, experience gained and results obtained, both within and outside West Africa;
>
> (c) organizing and arranging for conferences, seminars and training facilities, securing fellowships and establishing or assisting in the establishment

of advisory services and training and extension facilities;

(d) elaborating requests for special financial and technical assistance and receiving and administering separately such financial and technical assistance (including movable and immovable property, services, grants and loans) as may be made available under the appropriate programs of the United Nations, the specialized agencies, and other organizations or governments desirous to support the aims of the Association;

(e) providing, as appropriate, regional rice research and development facilities;

(f) carrying out or promoting any other measures or activities at the regional as well as the national levels for the purpose of developing rice production and marketing in West Africa.

1. BACKGROUND

Economic and technical

Evolving a strategy for WARDA's future was no easy task. The rice situation in West Africa is both complex and dynamic. Complex because rice is grown in a wide variety of West African ecosystems, many of whose characteristics are peculiar to that region; dynamic in the sense that the amount grown in any one of them depends critically on government policies, and these are subject to abrupt change.

Nevertheless, as we have developed our strategy, one thing has remained abundantly clear. New technology to increase the efficiency and sustainability of West African rice production is needed urgently. We must strive to improve the land and labor productivity of the region's smallholder rice farmers, while preserving the resource base on which their future livelihood depends.

As recent studies by both IFPRI (2)* and WARDA (3) show, the share of rice in West Africa's consumption of food grains is rising at 4% a year, faster than that of any other food crop except wheat, as consumers switch away from the region's traditional staples, maize, millet and sorghum. In the past 20 years per capita consumption of rice in West Africa has doubled from 12 to 24 kg. If this trend continues 24% of Sahelian cereal consumption will come from rice by the year 2000, a prospect which raises questions as to the adequacy of current research resource allocations to this crop.

At present, governments are meeting the escalating demand for rice largely through imports, which have risen by 250% in volume during the past decade. These imports act in two ways to widen the gap between domestic supply and demand still further. First, they arrive in the region at subsidized prices against which Africa's smallholder farmers find it hard to compete. Secondly, they fuel demand by broadening it across social classes: the new consumers of rice are not just the region's more prosperous towndwellers, but belong also to its lower-income groups.

Rice imports: up by 250% in the last 10 years.

* All the acronyms used in this report are spelt out in full on page 65.

Recent policy changes in two of West Africa's major rice producing countries are designed to reduce rice imports, thereby saving scarce foreign exchange and improving incentives to domestic producers. The strict limits imposed on rice imports in Nigeria and Côte d'Ivoire should translate into increased employment and incomes in rural areas. A distinguished international commission (4) summarizes this relationship as follows:

> When countries with untapped agricultural resources provide food by importing more, they are effectively importing unemployment. By the same token, countries that are subsidizing food exports are increasing unemployment in food-importing countries. . . . Shifting production to food-deficit countries, and to the resource-poor farmers within those countries, is a way of securing sustainable livelihoods.

While such trade policies can significantly improve incentives to domestic producers, it is crucial that short-term production responses do not occur at the expense of the longer-term productivity of the resource base. Given limited opportunities for increasing yields by applying modern technology, farmers attempt to increase production by extending the area under cultivation. In the forest zone this leads to shortening fallow periods and declining soil fertility. The deforestation of upland watersheds also causes erosion, drought and flooding, further reducing productive potential.

When inappropriately applied, modern technology can further threaten the long-term sustainability of production. Poorly designed and badly implemented irrigation systems result in waterlogging and salinization; and waterlogging in turn leads to iron and aluminium toxicity. Continuous applications of nitrogen and phosphorus fertilizers without adequate run-off control can create serious water pollution problems. Over-reliance on chemical control can lead to the resistance of insects to pesticides.

In short, under current technical conditions, the production of rice in West Africa's fragile ecosystems is probably less sustainable than that of other crops, such that an immediate ban on imports to stimulate domestic production might serve only to worsen an already serious predicament.

The production of rice must be made more sustainable.

Thus, a major effort is needed to make rice a more sustainable crop, or at least to shift its production to the

region's more robust ecosystems. Until new technology is available to bring about a sustainable increase in domestic output, governments will be forced to depend to some extent on imports. The dangers of such dependence, for national food security, have been illustrated recently by sharp fluctuations in the price and availability of rice on the international market. Such instability can have political as well as economic repercussions.

WARDA's task will be to help national scientists and policy makers work together to provide West Africa's rice farmers with more and better choices, both technical and economic. Rice must take its rightful place within West Africa's mixed cropping systems, but only on certain conditons. The two major requirements of new rice technology for the region are that it simultaneously:

- increases land and labor productivity;
- helps preserve the agricultural resource base.

WARDA's strategy must meet these requirements.

Institutional

NARS have limited facilities and manpower with which to deal with the very wide range of problems confronting rice production in West Africa. Allocations to rice have to be defended against the rival claims of other crops or livestock. The case for more research on rice is gaining ground, but for historical reasons rice is still not receiving its due share, given its rapidly growing importance in the region.

The case for more regional research on rice is gaining ground.

The work of NARS is supported by WARDA and by other IARCs within the region and outside it. In addition, specialized institutes in the developed world make contributions in specific areas. Besides WARDA, the main IARCs contributing to rice research are: IITA, which has programs on rice in mixed farming systems; IRRI, which coordinates an International Rice Testing Program (IRTP) in which West African countries participate; and CIAT, which has made important contributions to the development of improved dryland rice varieties. Among the developed country institutes operating in the region, CIRAD and ORSTOM (France) are active in the collection and enhancement of genetic resources, as well as other aspects of rice research and development.

Various other international, national and regional organizations either provide funds for WARDA's research or use its results. These organizations, together with the IARCs and specialized institutes mentioned above, are listed in Annex List A1. Most of the funds used for rice research in the region, including WARDA's own, come from donor agencies in the CGIAR.

WARDA is unique in being an intergovernmental association as well as an IARC.

WARDA is thus only one of the many institutes concerned directly or indirectly with increasing rice production in West Africa. However, it is unique in being an intergovernmental association as well as an IARC. Some characteristics of the Association's 16 member countries are given in Annex Table A1.

Lessons of the past

Perhaps the main lesson that has been learnt from rice research in West Africa so far is that technology from outside Africa is seldom applicable within it. FAO (5) comments:

> It has been proposed that Asia's green revolution technology can be transferred to Africa. This is not generally correct. The new varieties of rice and wheat that formed the basis of the green revolution in Asia yield well only when irrigation or reliable rainfall provide sufficient moisture. Irrigation is too limited in extent and generally too costly for staple food production, and some 40% of the currently cultivated area suffers from unreliable rainfall.

In addition, smallholder farmers in West Africa rarely have access to the levels of inputs used elsewhere in the world. Fertilizer use is particularly low. The limited financial resources of both farmers and governments in West Africa suggest a strategy to develop technology that economizes on the use of external (or purchased) inputs.

Research must benefit the rice farmer, not merely the rice crop.

As a result of these limitations, the dissemination of improved germplasm has not so far met with much success. Some of the varieties distributed have not only been environmentally and economically unsuitable, but also ill matched to the tastes and cooking requirements of consumers.

Past research has tended to treat rice in isolation from other crops. We must not forget that West Africa's rice

producers are predominantly mixed crop farmers, intercropping or rotating rice with other crops. Future research must seek to benefit the rice farmer, not merely the rice crop.

Factors determining rice ecosystems

An obstacle to concentrating rice research effectively in West Africa is the number of different rice ecosystems and the difficulty of distinguishing between them. The factors that determine ecosystems are climate, soils and landscape position.

With respect to climate, three broad zones can be distinguished in West Africa: the Guinean zone (total annual rainfall averaging > 1200 mm), the Sudanian zone (total annual rainfall averaging 600-1200 mm) and the Sudano-Sahelian zone (total annual rainfall averaging 400-600 mm). Within these zones, factors such as temperature and the amounts and distribution of rainfall create further distinctions.

The potential for rice production in each climatic zone is modified by soils. Infiltration, drainage and run-off influence water availability. The fertility of the soils, their structure, and the presence or absence of any toxic elements further determine to what extent the rice yield potential can be met.

Within the broad climatic and soil classes it is the position of the rice field in the landscape that defines the ecosystem. Depending on the physiographic source of water, a range of landscape positions can be described, as part of a continuum that extends from the top of the slope, down to the valley bottoms and river floodplains.

Resulting from the interactions of climate, soils and landscape positions, a large number of rice ecosystems can be distinguished (6). Although the differentiation of rice ecosystems must continue to be subject to research, for operational purposes WARDA has grouped these ecosystems into four major rice growing environments.

West-Africa's major rice growing environment is the upland/inland-swamp continuum.

The major environment in terms of area, number of farmers involved and overall production is the upland/inland-swamp continuum found in the Guinean and southern Sudanian zones. Rice in this environment may grow under rainfed, partially saturated or flooded conditions. The second environment occurs in the Sudano-

Sahelian zone (hereinafter referred to as the Sahel), where rice is grown under irrigation in large government schemes. Essentially, this zone is semi-arid with strong seasonal winds ranging greatly in temperature. A third environment consists of mangrove or former mangrove swamps, found mostly along estuaries. After mangrove trees have been cleared, swamps become viable rice environments, though subject to a growing season which depends on the pressure of freshwater floods to hold seawater from the riceland. A fourth environment consists of the floodplains of inland rivers and lakes. The rice grown here is known as deepwater or floating rice. This cultivation system is one of the oldest in West Africa.

2. WARDA's STRATEGY

In this section we describe WARDA's strategy in response to the rice production needs of its region. First we define WARDA's goal, then its operational mandate and other structural elements of the strategy.

WARDA's goal

WARDA's goal is to provide and strengthen a growing West African capability in the science, technology and socio-economics of rice production that will improve and sustain the livelihood of smallholder farm families, increase the opportunities for rural employment and contribute to increased food security in the region.

Operational mandate

WARDA's formal mandate is given at the outset of this document. It has remained unchanged since the Association was founded in 1970. In the 1986 deliberations between the CGIAR and WARDA's member states the formal mandate was seen as providing a satisfactory basis for an IARC with a regional focus.

Our formal mandate is more specific than that of other centers in the CGIAR system. It names a single crop on which to work and a clearly defined region in which to operate. However, it does not identify the Association's target and client groups, nor does it select the rice species, products and growing environments on which to concentrate. Furthermore, the formal mandate lists a wide range of possible activities in support of rice production and trade in WARDA's region, a range which is too broad for an organization of WARDA's current size and strength to tackle comprehensively. Finally, although it mentions research, our formal mandate does not adequately delineate the scope of research and the approach to be used.

Thus, while TAC has indicated that WARDA's formal mandate need not be altered, it has requested us to develop an operational mandate that clearly states our priorities. We will now outline these priorities and, where necessary, discuss the reasoning behind them.

Rice growing environments

As we have seen, WARDA recognizes four major rice

growing environments in West Africa, namely the upland/inland-swamp continuum, the Sahel, the mangrove swamps, and the deepwater/floating rice environment.

Our research program will focus on the first three of these. We exclude the deepwater/floating rice environment on the grounds of its diminishing size and low potential impact on production.

Our three priority rice growing environments are the upland/inland-swamp continuum, the Sahel and the mangrove swamps.

We select the upland/inland-swamp continuum as our first priority environment because it is here that the vast majority of the smallholders who constitute our target group (see below) grow rice. At the upper end of the continuum, the potential for impact on yields may be relatively small, but because of the large numbers of producers involved the overall potential for impact on output is large, provided production can be sustainable. At the lower end of the continuum, the potential for impact on yields is greater, but human disease risks may slow down the development of inland swamps (see Section 3).

We select the Sahel as our second priority environment on the grounds of both human need and potential impact. Nowhere in Africa is the need for rapid increases in food production greater than in this environment, where per capita consumption of the major cereals has fallen by 15 kg since the early 1960s (2). Once varieties have been found that will perform well under the Sahel's unique environmental conditions, the potential for impact will be high provided water management problems can be solved. Returns to the considerable investments in dams and irrigation schemes already made by governments must be maximized (see Section 3).

We select the mangrove swamps as our third priority environment. Here the potential for impact on yields is fairly high, but the overall impact on output is likely to be relatively low because of the difficulties of bringing extra land into cultivation. The need for technology to reduce labor inputs and improve yields is considerable among the relatively small numbers of producers involved (see Section 3).

Rice species

Two main types of rice are grown in West Africa: *Oryza glaberrima*, selected from indigenous predecessors more than 2000 years ago, and *O. sativa*, extensively introduced from Asia only during this century. We will con-

centrate our breeding program mainly on the higher yielding *O. sativa* varieties, incorporating useful traits from *O. glaberrima* where necessary. We will cooperate with ORSTOM, IBPGR, CIRAD, IRRI and IITA in the collection and medium-term storage of traditional varieties of both types, including hybrids.

Rice products

By far the most important use of rice in West Africa is as a human food. WARDA's breeding program will therefore concentrate on improving the quantity and quality of rice grain for human consumption. Other uses to which the rice crop or its residues could be put, such as mulch and livestock feed, will nonetheless be evaluated and will be reflected in breeding goals whenever they begin to assume economic importance.

Target group

WARDA's target group will be the resource-limited smallholder farm family growing rice as a food crop. We select this group because it already accounts for an estimated 90 to 95% of rice producers in West Africa and will clearly continue to be the region's foremost group of producers in the short to medium term. WARDA will design technology primarily to meet the needs of this group. However, we may also develop technology using higher input levels for other target groups if economically and socially justified. Within the farm family the needs of women, who frequently provide most of the labor for rice cropping, will receive special attention.

We will target research on the smallholder farm family, with special attention to the needs of women.

Client group

WARDA's clients – i.e. those whose needs it exists to serve – will be the NARS of its member states. NARS normally include:

- the national agricultural research insitute(s);
- agricultural universities and university departments;
- agricultural training colleges;
- agricultural research departments within ministries;
- policy and marketing organizations or units;
- extension services.

We will assist NARS scientists through research, communication and training.

It is the rice scientists within the NARS who are the main users of WARDA's research and services. Theirs is the long-term responsibility for generating technology to increase West African rice production. WARDA exists primarily to strengthen their ability to do this. Other major users within the NARS include the leaders of national research and extension services, responsible for

guiding and managing national programs, and government policy makers, responsible for decisions affecting the economic environment in which rice development takes place.

Activities

WARDA will restrict its activities to research, communications and training. The Association will catalyze the planning of regional rice research, and will act as a clearing house for new rice technology or other initiatives proposed for West Africa by institutes outside the region or by other IARCs within it. We will provide some support services for national research, communications and training.

Research scope

WARDA's research program will concentrate primarily on germplasm improvement, crop and resource management and socio-economic constraints, but will include work on post-harvest technology where appropriate.

The goal of work on germplasm improvement will be to develop improved germplasm for our three major rice growing environments. The main disciplines involved will be plant breeding, plant genetics, plant pathology, entomology, soil chemistry, cereal chemistry, food science and agricultural economics.

The goal of work on crop and resource management will be to maximize sustainable output through a better understanding and manipulation of the physical and biological factors affecting crop performance. The main disciplines involved will be soil science, crop agronomy, plant protection, agricultural engineering and agricultural economics.

The goal of work on socio-economic constraints will be to find ways of increasing technology adoption, in addition to analysing national policy options.

Research approach

WARDA's research program will be organized in interdisciplinary projects, defined in terms of the desired outcome of the research. All projects will involve both the biological/physical and the social sciences, with social and economic analysis being a built-in feature. In the early years at least, projects will generally aim to develop low-input technology, i.e. technology which makes minimal demands on scarce capital and manage-

Low-input technology will be stressed in the early years.

ment, and which exploits the steepest portion of the response function, such that returns are high and assured.

In response to farmers' needs identified through diagnostic research, technology will be generated on the research station and then tested in farmers' fields. Once technology has been generated, subsequent on-farm research will be restricted in scope to assessing the suitability and likely impact of the technology. This work will be done collaboratively with NARS (see page 40).

Mission statement

WARDA will conduct and promote research to improve the technical and economic options available to smallholder farm families in the following three West African rice growing environments:

- **as a first priority, the upland/inland-swamp continuum;**
- **as a second priority, the Sahel;**
- **as a third priority, the mangrove swamps.**

This research programme will:

- **develop improved rice varieties;**
- **develop improved production methods;**
- **find ways of reducing post-harvest losses;**
- **assess and increase the acceptability and impact of new technology;**
- **investigate issues affecting technology adoption and analyse national policy options.**

Through this research program, and related communications and training activities, WARDA will seek to strengthen the rice research capabilities of NARS.

Institutional values

The values held by an institute cannot be transferred from elsewhere. They must evolve internally through the interaction of people and events, as guided by the vision of the institute's leadership, such that they permeate the organization as a whole. This strategy document reflects WARDA's current values and lays the basis for their future evolution. Those values have been

evident in the way in which the strategy was developed – through a collaborative effort that valued the contributions of WARDA's own staff, as well as those of NARS, other IARCs and donors.

Our four institutional values are relevance, excellence, integrity and partnership.

Our first institutional value is relevance to the well-being of West African farm families. At its heart lies a problem-oriented approach to research that places the farmer, not the scientist, at the center of the research process. Central to this process is the search for information that will lead to increased understanding of rice producers, consumers and others related to the region's rice economy.

Our second institutional value is uncompromising commitment to scientific excellence. This requires recruiting and rewarding skilled and imaginative scientists, and providing them with challenging goals, coherent direction and efficient support.

Our third institutional value is organizational integrity. This value involves ensuring that all WARDA's operations – administrative and fiscal as well as scientific – are harmoniously, responsibly and efficiently executed, to the standards expected of an IARC.

Our fourth value is partnership. WARDA has made collaboration with other organizations – the entities of member states, other IARCs and specialized institutes – the cornerstone of its research, communications and training program. In this way the Association will continue to reflect its unique original nature as an expression of collective interest.

3. RESEARCH PROGRAM

Whereas the multi-commodity centers in the CGIAR system typically organize their programs around individual crops, a single-commodity center such as WARDA can obtain a narrower focus that will heighten the chances of success by bringing critical mass to bear on the problems of individual environments. The rice growing environment will therefore be the focal point of our three research programs.

WARDA's narrower focus heightens the chances of success.

We therefore begin this section by describing our three chosen rice growing environments and assessing their potential*. Next, in order to provide a rational basis for selecting our major research projects within each program, we describe the main constraints in each environment.

On this basis we then list, in order of priority, the projects to be tackled initially by each program. Our selection is provisional: diagnostic research and discussion with NARS over the short term will lead to a sharper definition of priorities. In addition, the order of priority can only be approximate at this stage, due to the interrelated nature of the constraints addressed in each project.

Upland/inland-swamp continuum

Description

West Africa's undulating landscape leads to diverse ecosystems in close proximity. Farmers frequently cultivate in more than one ecosystem at once, growing a range of crops at different levels on the same slope. Within a farm, individual production units often overlap ecosystems. IITA (7) summarizes:

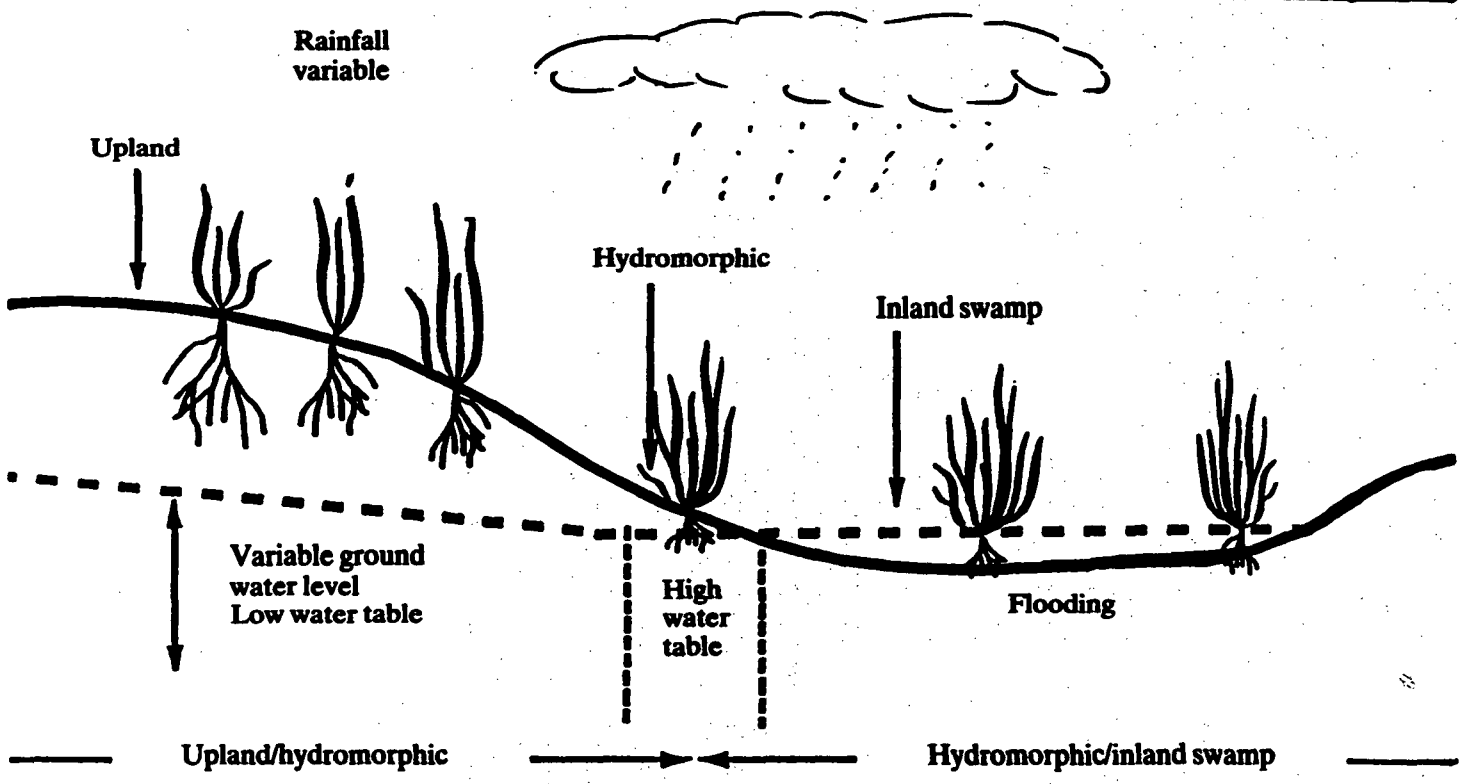
> Despite the analytic value of distinguishing the various rice ecologies, it is important to remember that farming systems frequently cut across them. The same farm will often include upland crops and an inland valley swamp and/or an area of hydromorphic soils.

This diversity of ecosystems we call 'the upland/inland-swamp continuum' (Figure 1). The continuum

The continuum: a highly variable environment with a diversity of ecosystems.

* More detailed assessments of current and future production in each environment are shown in Annex Tables A2 and A3.

Figure 1. Upland/inland-swamp continuum.



varies through both space and time. Through space it ranges from upland areas in which the rice crop is strictly rainfed, through slopes on which it is groundwater-assisted, down to swamp areas in which it is flooded. Through time it changes from one year or season to the next, as rainfall patterns or land management alter the supply of water.

For rice cropping purposes, the continuum contains two distinct types of land, the uplands and the inland valley swamps, and a third less well defined one, the hydromorphic zone, which lies between the other two. This third, transitional zone is usually fairly narrow and highly variable, but there are areas in which it is broader and somewhat more stable. Farmers cultivating in the hydromorphic zone have evolved management practices that address its fluctuating water regime.

Where the hydromorphic zone is narrow and highly variable, it is impractical to treat it separately for rice breeding purposes. Under these circumstances the breeding strategy for the continuum is twofold: first, varieties can be bred for swamp conditions, and these will not perform well under upland conditions; secondly, varieties can be bred that will yield well under strictly rainfed conditions and which may perform even better when assisted by groundwater, as in the part of the hydromorphic zone adjacent to the uplands.

This twofold strategy makes sense from the farmers' viewpoint. When hydromorphic and upland areas are closely interwoven the boundary between the two is constantly shifting. The depth of groundwater fluctuates and is often unknown to the farmer at the time of planting. Farmers cannot therefore plant different varieties for each area. Conversely, farmers planting in inland swamps are less subject to uncertainty since, although the swamp expands and contracts in response to rainfall, seedlings are transplanted only where there is standing water. Some varieties bred for swamp conditions will in any case perform well in the wetter hydromorphic areas that fringe the swamps. A separate breeding strategy for this ecosystem is therefore practicable.

The breeding strategy may be twofold or threefold.

Where the hydromorphic zone is broader and less variable, the breeding strategy becomes threefold, since farmers cultivating such land can rely on more stable conditions and can therefore plant varieties specially adapted for them. However, for the purposes of our own research we refer to two ecosystems in the con-

tinuum: the upland/hydromorphic ecosystem and the hydromorphic/inland-swamp ecosystem.

Irrigated land also occurs within the continuum*. Irrigation can be introduced at any point in the continuum, although it is most likely to occur at or near swamp level. The only characteristic that differentiates this zone from the rest of the continuum is partial or complete control over the water regime. Under these less variable conditions, greater yield stability can be expected from varieties bred for high performance.

The West African farmer is traditionally a dryland farmer, using dryland techniques to grow a range of crops so as to spread risk. However, farmers have recognized the advantages of the wetter part of the continuum for growing rice, with the result that production is shifting towards these areas. How far this shift will extend into the underutilized inland swamps will depend on farmers' perceptions of the human disease risks of working in such areas, as well as on their access to land and on the costs of developing it. Several countries in the region, and especially Nigeria, plan major developments of their wetlands.

The upland/inland-swamp continuum is found throughout large areas of West Africa. About 70 to 80% of the smallholders who will form WARDA's target group (see Section 2) already grow rice on some 2 million ha of land within the continuum. Such land will be more easily exploited in the savannah and savannah-forest transition zones, where slopes are gentler, than in the forest zone, where they are steeper.

Containing about 70-80% of the region's smallholders, the contiuum has vast potential.

Potential

The potential for increased production from the continuum is vast, but markedly different for its ecosystems. Much will depend on whether the current shifting cultivation system can be replaced with more stable alternatives in the uplands, and on the speed with which complete or partial water control can be introduced in the wetlands.

In the upland/hydromorphic ecosystem, very large areas, amounting to some 1.5 million ha, are already cultivated and there is still room for considerable expansion. If we assume that the area under cultivation will

* Henceforward in this document we refer to such land as 'the irrigated humid zone'.

continue to grow at the same rate as during the past 10 years, it will reach about 2.16 million ha by the year 2000. If modest gains in average yield, from 1 t/ha today to 1.3 t/ha by the millenium, can be achieved over this expanded area, annual output would rise by some 1.3 million tons by the year 2000.

In the hydromorphic/inland-valley swamp ecosystem, on the basis of past trends and current development efforts we believe the non-irrigated area under cultivation should rise from 530 000 ha today to 760 000 ha by the millenium. (It may rise faster than this if human disease risks decline). If average yields can be increased to 2.5 t/ha from their current low level of about 1.4 t/ha, annual output in the year 2000 will be about 1.15 million tons higher than it is today.

The irrigated area in the continuum is at present some 119 000 ha. In view of the extensive development efforts currently under way in Nigeria and other countries, we expect this to rise rapidly, reaching 185 000 ha by the year 2000. Given the better performance of higher yielding varieties under the more stable conditions obtained under irrigation, we believe average yields can rise to 3.5 t/ha from their present level of 2.8 t/ha. If this happens, annual production will increase by some 314 000 tons by the year 2000.

The total gain in annual output from the continuum as a whole by the year 2000 would thus amount to some 2.79 million tons, an increase of more than 100% over the current annual output of approximately 2.56 million tons.

Constraints

Many socio-economic constraints to increased rice production in West Africa affect all the rice growing environments; others are environment-specific. In this section on the upland/inland-swamp continuum, the cross-environmental socio-economic constraints are described in full, as well as those specific to this environment. Under the Sahel and mangrove swamp environments, only those specific to each will be described.

The most important constraints for upland rice are associated with stability and sustainability.

Physical and biological. Under each environment, we have assessed the major physical and biological constraints. In each instance, this assessment is provisional. It is based partly on the literature and partly on the judgement of our own and NARS scientists. These judgements are presented in Tables 1 and 2 and are

similar to those of the IITA planning group presented in Annex Table A4. The latter table also quantifies and values the losses associated with each constraint.

Under upland/hydropmorphic conditions, the most important group of physical and biological constraints are those associated with the stability and sustainability of rice production, mainly water stress, blast, and adverse soil conditions, including low and declining fertility, poor water retention and erosion. As Herdt and Riely (8) have pointed out, introducing genetic resistance to any one of these problems would probably improve productivity only marginally, since the others would still hold yields down.

Another important constraint in this ecosystem – as in all others – is weeds, the shortage of labor for weeding being one of the main reasons why shifting cultivation continues to predominate despite the ecological damage it causes. Among the diseases, leaf scald and brown spot appear important, as well as blast. Insects, and especially stemborers and diopsis, form a third important group of constraints.

Under hydromorphic/inland-swamp conditions, the outstanding group of constraints are adverse soil conditions, especially iron and aluminium toxicity, with manganese toxicity and low soil fertility also important. Weeds are again a major problem, frequently associated with the inadequate management of water. Among the diseases, RYMV appears the most serious, but a number of others are also significant, including blast.

Socio-economic. The technical, economic and social constraints to West African rice production are legion. In most cases, they are not only common across environments but also affect the agricultural sector as a whole rather than just rice production. Many socio-economic constraints are not researchable in themselves, but affect the choice of research approach to physical/biological problems.

Tractors: unlikely to become widely available.

West African farmers lack appropriate tools to clear and prepare the land for rice planting. Land clearance is especially difficult where vegetation is thick and tree-stumps need to be removed. Land preparation, including levelling and bunding, is constrained by unfamiliarity with appropriate techniques. The use of animal traction is hampered by the shortage of trypanotolerant cattle in the coastal zone. Tractors are unlikely to become widely

available in the West African region within the foreseeable future (5).

Table 1. Provisional assessment of the importance of physical constraints to increased rice production by ecosystem in West Africa.

Importance in:	Upland/inland-swamp continuum			Sahel	Mangrove swamp
Type of constraint	Upland	Hydro-morphic	Inland swamp		
Rainfall:					
Deficient	+++	+++	+	++	++
Excessive	+	+	+	–	+
Unreliable	+++	+++	+	++	++
Temperature/humidity:					
Excessively hot/dry	–	–	–	++	–
Excessively cold	–	–	–	+++	–
Wind:					
Cold, dust-laden	–	–	–	+++	–
Strong	+	+	+	+++	++
Sunshine:					
Insufficient	+	+	+	–	++
Soil:					
Low fertility	+++	++	++	++	++
Poor water retention	+++	++	–	–	–
Erosion	+++	+	+	++	–
Acidity	++	+	+	+	+++
Iron toxicity	–	+	+++	+	++
Iron deficiency	++	+	–	–	–
Manganese toxicity	–	+	+++	+	+
Aluminium toxicity	–	+	+++	+	++
Salinity	–	–	–	++	+++
Tidal movement:	–	–	–	–	+++

Notes:
+++ = major constraint; ++ = important constraint;
+ = locally important/minor constraint;
– = negligible/non-existent constraint.

In the upland/hydromorphic ecosystem of the continuum, rice, like other cereal crops, is generally sown broadcast, increasing the amount of seed required to ensure establishment. Row planting can be carried out using the traditional hoe, but there is a shortage of labor required to perform this task, and more efficient forms of appropriate technology are needed.

Both farmers and scientists need to learn more about appropriate cropping patterns and mixtures. Lack of knowledge is also a constraint in areas such as cropping

density and crop geometry, the use of appropriate nursery and transplanting techniques, and the choice of appropriate planting dates for specific crop mixtures. Understanding these factors is important for protecting crops against drought, diseases, pests and weeds.

Table 2. Provisional assessment of the importance of biological constraints to increased rice production by ecosystem in West Africa.

Importance in:	Upland/inland-swamp continuum			Sahel	Mangrove swamp
Type of constraint	Upland	Hydro-morphic	Inland swamp		
Diseases:					
Blast	+++	++	++	++	+
Leaf scald	+++	++	++	++	++
RYMV	–	+	+++	+	++
Brown spot	++	++	++	+	++
Sheath blight	+	++	++	+	+
Sheath rot	+	+	+	+	+
Stem rot	+	+	+	+	+
Pests:					
Gall midge	+	++	++	++	+
Stemborers	+++	+++	+++	++	++
Rice bugs	++	++	++	+	++
Spider mite	–	–	–	+++	–
White flies	–	–	–	++	–
Diopsis	++	++	++	–	+
Termites	++	–	–	–	–
Nematodes	++	++	+	+	++
Crabs	–	–	–	–	+++
Birds	++	++	++	++	++
Weeds:	+++	+++	++	++	++

Notes:
+++ = major constraint; ++ = important constraint;
+ = locally important/minor constraint;
– = negligible/non-existent constraint.

Lack of improved varieties combining appropriate resistance/tolerance characteristics with high efficiency in converting chemical nutrients represents a major constraint. Where improved varieties have been developed, their effectiveness is inhibited by the low seed production capacity of West African countries, thought to be meeting less than 10% of demand at present. Poor seed handling and the mixing of improved seed with other varieties reduces performance after a few generations. Where traditional varieties are well adapted to the

specific soil and water characteristics of the continuum, farmers may grow more than one variety on the same field. Research must take into account the resulting complexity of field operations.

Harvesting is slowed down by a lack of efficient tools, but mechanization is unlikely to be widely introduced during the next decade (5). Inefficient technology also hampers the threshing, drying, storage and milling of rice.

Labor: a constraint in nearly all production systems.

Farm labor shortages and low labor productivity constrain output in nearly all subsistence production systems. Tasks such as land preparation, planting, weeding, bird scaring and harvesting are delayed or performed inefficiently because of the conflicting demands of other crops, sometimes with disastrous consequences. Labor shortages are accentuated by urban migration, which drives up hiring costs. Farming is increasingly the pursuit of the elderly and the young. Increasing school attendance is reducing the labor contribution of the latter group. Raising the productivity of labor is essential if West Africa is to produce more rice at prices competitive with imports.

Women frequently lack access to resources.

Women, who in several production systems provide most of the labor for growing rice, often do not control the cash obtained by selling surpluses. This discourages them from growing more than is needed for family subsistence. When new land is developed, as in inland swamps, women may lose their traditional land rights. Women frequently lack access to resources, especially credit, and are habitually left out of development projects and extension efforts organized by and for men.

A number of other social and economic factors may constrain the adoption of new technology at farm level. They include the cooking characteristics and palatability of new varieties, the remoteness of farmers from markets, their wish to minimize risk, and their lack of cash with which to buy inputs. There is also a lack of suitable organizational structures through which new technology can be introduced to groups of farmers.

The supply of inputs is constrained by macroeconomic and institutional issues. A major problem is the high cost of high-technology imports. In the late 1970s and early 1980s, imports of agricultural machinery and pesticides fell in real terms, while those of fertilizers stagnated (5). Falling prices for some of West Africa's

export crops and deteriorating terms of trade in general and in the mid-1980s are likely to accentuate these trends over the next decade.

Another factor constraining both the availability of inputs and the marketing of surpluses is lack of infrastructure, including roads, vehicles, input supply centers and grain storage facilities. In some West African countries, the under-population of rural areas reduces the feasibility of making infrastructural investments pay, at least over the short term.

Subsidized imports discourage domestic production.

Many African governments have kept domestic rice prices down through a policy of subsidized imports. While fuelling demand, this has acted as a disincentive to domestic producers, especially those near the major urban centers of distribution. Alternative policies include banning or curtailing imports (including food aid), raising producer prices for rice and/or other cereals, curbing rice consumer subsidies and increasing expenditure on rice research and development. More needs to be known about the effects of implementing these options before the right combination of interventions can be selected (2).

Human health: a major constraint in the inland swamps.

Human health problems can be a major constraint to rice development in the inland swamps. The main disease risks to which rice farmers are directly exposed include schistosomiasis, river blindness and malaria. Long-term control methods for schistosomiasis are still poorly developed, but a drug (Mectizan) has recently been developed to prevent river blindness (9), while some progress has also been made in the development of a vaccine against malaria. WARDA will strongly encourage other organizations to address these problems.

Shortage of the labor and other resources needed to control grain-eating birds is a major constraint across all rice growing environments. In particular, the risk of bird attack discourages farmers from planting early maturing varieties. It also hinders the use of staggered planting dates, which would otherwise help to relieve labor bottlenecks. While WARDA itself will not undertake research on bird control methods, we will encourage other organizations to work on this problem.

Priority projects

Our program for the upland/inland-swamp continuum will initially comprise projects for the development of:

1. Improved soil fertility techniques, involving the incorporation of organic matter and nitrogen fixation and combining the latter with the use of rock phosphates (for both ecosystems) and azolla (for flooded areas) and with the application of commercial NPK fertilizers where appropriate.

2. Alternative, more sustainable cropping systems such as intercropping and rotation, including alley farming, to replace shifting cultivation (for the upland/hydromorphic ecosystem).

3. Short- and medium-cycle varieties combining tolerance to drought with stable resistance to blast, leaf scald and stemborers (for the upland/hydromorphic ecosystem).

4. Varieties combining tolerance to toxic soil conditions with resistance to RYMV, stemborers and blast (for the hydromorphic/inland-swamp ecosystem).

5. Improved water control methods, such as bunding and levelling (for the hydromorphic/inland-swamp ecosystem), and water harvesting/run-off management systems (for the upland/hydromorphic ecosystem).

6. Improved techniques for weed control (for both ecosystems).

7. Improved small- to medium-scale irrigation schemes (for the hydromorphic/inland-swamp ecosystem).

Sahel

Description

The Sahel must be considered as a separate environment because of its management system and its proximity to the desert, both of which create special conditions.

Most rice in the Sahel is produced under government development projects on large irrigated areas in which it is the only crop grown in the rainy season. Individual holdings generally remain small, however, and farmers may cultivate other crops outside the irrigation scheme during the rainy season, and within it during the dry season.

The needs of the Sahel require further study.

From the point of view of crop improvement, the needs of the Sahel require further study. At least two rice crops a year could be grown in this environment, the first during the rainy season and the second during the cold or hot dry season. High-input varieties from Asia can perform well during the rainy season, although performance stability, adaptability and acceptability remain problematic. Improving the management of water will doubtless improve yield stability. However, initial indications are that Asian varieties do not perform well during the cold dry season, since they are not adapted to the Sahel's large diurnal temperature fluctuations and cold, dust-laden winds. More testing is needed, using photoperiod-insensitive cold-tolerant varieties planted earlier in the season.

In the absence of suitable varieties, farmers at present prefer to grow vegetables or other profitable cash crops (even wheat) during the cold dry season. Whether they would switch to rice if more suitable varieties became available would depend largely on the policy and market environment. Where markets are remote from irrigation schemes rice is an easier crop to store and transport than are vegetables, which require rapid but delicate handling. A switch to rice might well occur in a number of countries where dry-season rice cropping has already been tried with little success. At any rate, farmers should have the option of growing rice, should this appear less risky and more profitable.

Potential

The potential for expansion in the Sahel's irrigated area is huge, but is unlikely to be met in the near future because of the high costs of land development following dam construction. An irrigable area of approximately 2 million ha lies along the Sahel's major rivers and in the Lake Chad basin. Of this, only 5% (some 111 000 ha) was estimated to be in use in 1985. The recent completion of the Diama and Manantali dams in Senegal and Mali makes available a further 375 000 ha, but unless additional funds for land development are provided less than 10% of this is likely to be brought into cultivation by the year 2000. Together with expected increases in other Sahelian countries, this would bring the total area cultivated to about 155 000 ha by that year.

Expansion will be slow, but yields could rise substantially.

Despite this slow expansion, the potential for increased output from this environment is fairly high. We assume that under favorable management conditions average yields could rise to about 3.5 t/ha from their current

level of about 2.8 t/ha. If, in addition, by the year 2000 two crops a year are grown on 10% of the expanded area, this would lead to an additional output of some 286 000 tons a year.

Constraints

Physical and biological. The most important physical and biological constraints in the Sahel are climatic, especially cold, dust-laden winds, which discourage farmers from growing a second crop of rice during the cold dry season. Dry atmospheric conditions can also cause post-harvest losses, as brittle rice grains shatter during milling.

Climatic constraints are severe.

Weeds can be a problem in this environment, again associated with poor water management. Among the pests, losses to spider mite can be especially severe during the dry season, while white flies have also been a major problem. A number of diseases, such as blast and leaf scald, are important. Various adverse soil conditions also constrain yields, including salinity, which affects large areas in river deltas.

Socio-economic. In addition to the general socio-economic constraints discussed earlier, the major one in the Sahel is the management of water. Whereas Asian farmers have centuries of experience in irrigation, the technique is relatively new to African farmers. Over-sophisticated equipment that is difficult to operate and maintain has compounded the problem. Inadequate initial assessment of water resources, neglect of overall watershed management (leading to sedimentation) or poor drainage (leading to salinization) have been further problems (5). In addition, problems of social organization and human conflict have been a major impediment.

Water management is a major socio-economic constraint.

Other socio-economic constraints in the Sahel are broadly similar to those in other environments. Remoteness from markets or lack of infrastructure inhibit cash cropping to some extent. The labor input of women may be constrained by their need to walk increasingly long distances to fetch firewood.

Priority projects

Our program for the Sahel will initially comprise projects for the development of:

1. More productive and sustainable water management practices, and the requisite social organizational mechanisms.

2. Improved soil fertility management practices, including the use of azolla, legumes and rock phosphates.

3. Varieties resistant to blast and stemborers (for wet-season cropping).

4. Varieties with cold and heat tolerance, resistance to white flies and spider mite, and tolerance to saline conditions (for dry-season cropping).

Mangrove swamps

Description

Affected by the movement of the tides, the mangrove swamps form a third distinct rice growing environment. Nearly all mangrove swamps enjoy a salt-free period during the rainy season, as freshwater floods wash the land. This period shortens, from over 6 months to under 4, with increasing proximity to the sea, but is generally long enough to allow farmers to grow a rice crop.

Both salinity and sulphate acidity constrain production in the mangrove swamps, leading some farmers to abandon their plots. Reduced rainfall in the Sahel in recent years has accentuated these problems.

Rice plots in the mangrove swamps are often remote from villages and difficult to work. Cultivation is predominantly manual at present, using low-yielding varieties. About 35% of the 100 000 farm families that grow rice in this environment also farm in adjacent inland swamp and upland areas. Under these circumstances, labor allocations to mangrove swamp rice are often insufficient, with the result that the area cultivated by each family tends to be smaller than in other environments. However, this is partly compensated by the fact that the mangrove swamps are generally more fertile than other environments, with yields currently averaging 1.8 t/ha. Soil fertility in the mangrove swamps is naturally maintained by regular deposits of silt.

WARDA's work with NARS has already led to the release of new varieties.

As regards breeding, WARDA's work with NARS has already led to the release of new varieties adapted to some of the environmental stresses of the mangrove swamps. Current research is leading to a better understanding of the special soil toxicity problems of this environment, including acidity, salinity, and iron, aluminium and manganese toxicity. The variable length

of the salt-free growing season implies different selection criteria within a single breeding program. Farmers who also cultivate plots in the uplands and inland valley swamps prefer late maturing varieties that allow them to complete weeding and harvesting elsewhere before allocating labor to these tasks in the mangrove swamps.

Potential

Of a total of 1.2 million ha of mangrove swamps along the West African coast, rice is currently grown on about 193 000 ha. Mangrove swamps contribute significantly to rice production in only 5 of WARDA's 16 member countries. It was the Temne people of Sierra Leone who first developed such land along the Scarcies rivers during the nineteenth century (10). Most of the mangrove swamps now cultivated were cleared by individuals, but a few relatively large areas were developed with government assistance during the colonial era, using empoldering to hold back the sea and improve land drainage. Because of the high labor requirements and costs of clearing and maintaining such land today, the area under cultivation is unlikely to expand between now and the year 2000. This may be just as well since, for ecological reasons, mangrove swamp development should not exceed a certain proportion of the overall resource.

The area under culitvation is unlikely to expand.

The potential increase in output from this environment is therefore limited. Using a combination of new varieties and techniques to increase labor productivity, we believe average yields can increase from their current levels to around 2.2 t/ha by the year 2000. If the area under cultivation remains stable, this will lead to an additional annual output averaging some 77 000 tons.

Constraints

Physical and biological. The major constraints in the mangrove swamps include lodging and silting, caused by tidal movements. Adverse soil conditions, especially acidity and salinity, but also iron, aluminium and manganese toxicity, are also very important.

The major constraints are lodging and silting.

Weeds are a major constraint, especially in swamps further from the sea. Crabs are by far the most damaging pest, but stemborers and rice bugs are also important. Among the diseases, blast, brown spot and others can all be severe.

Socio-economic. In addition to the general socio-economic constraints discussed earlier, the most important one in the mangrove swamps is labor shortages. As we have

Labor shortages are the most important socio-economic constraint.

seen, plots are often remote from villages, making access difficult and increasing the time spent travelling to and from them. The many mangrove swamp farmers who also cultivate land in the adjacent upland and inland-swamp areas tend to devote more resources to these areas. The special difficulties of clearing and maintaining land in the mangrove swamps discourage farmers from cultivating such land. Owing to urban migration, hired labor is scare and therefore expensive. As a result, farmers often either get into debt or ignore their mangrove swamp plots. Other socio-economic constraints in the mangrove swamps are broadly similar to those in other environments.

Priority projects

Our program for the mangrove swamps will initially comprise projects for the development of:

1. Production techniques that will increase labor productivity.

2. Management techniques that will minimize losses caused by salinity, acidity and weeds.

3. Improved varieties resistant to lodging and silting and tolerant of saline and acid soil conditions.

4. Methods for controlling crabs.

4. COMMUNICATIONS AND TRAINING PROGRAM

West Africa is not a scientific desert: most of the region's NARS are already carrying out an active agricultural research program. However, as we have seen, resources tend to be spread too thinly over too large a range of crops. As a result, trained manpower in rice science is especially scarce: only 3 of WARDA's 16 member countries have more than two full-time rice scientists; another 11 have only one or two, while the remaining 2 have none. And the manpower need is qualitative as well as quantitative: West African NARS urgently need better trained rice scientists who are in touch with farmers' needs, familiar with existing rice technology, and equipped with the up-to-date techniques required to develop new technology.

The few rice scientists West Africa possesses often work in comparative isolation. They lack access to information about each other's activities, and about relevant research elsewhere in the world. They also lack the means for telling others about their own research findings and problems.

Trained manpower in rice science is especially scarce.

The purpose of WARDA's communications and training activities will be to address these needs.

Communications activities

In keeping with its mandate to strengthen the use made of new and existing technology by NARS, communications activities will be a major component of WARDA's program. The immediate priorities will be to establish an integrated information dissemination service to link NARS scientists in West Africa with each other and with relevant research elsewhere, and to build a strong collaborative publishing program that will ensure the two-way flow of information between WARDA and NARS scientists in the region. Additional staff and equipment are needed urgently to address these priorities.

Communications activities will be a major component of our program.

The integrated information dissemination service will offer the following:

- selective dissemination of information, based on research profiles established for individual rice scientists;

- question-and-answer service, including data base searches on specific topics, on request;
- provision of quarterly lists of current titles in various fields;
- provision of photocopies of articles or other documents on request;
- compilation and dissemination of specialized bibliographies;
- exchange of literature with African and other libraries;
- support for the dissemination of national research results;
- provision of library loan services to WARDA and collaborating NARS staff.

Through these services, West African rice scientists will have access to data bases elsewhere in the world, including AGRICOLA, AGRIS, CABI and TRADIS. We will participate in regional, as well as international, information sharing and networking systems.

Lack of a capability in publishing our documentation is a major problem.

Lack of a capability in publishing, as in documentation services, is a major problem in the NARS of WARDA's mandate region. Additional publishing outlets at regional level can be provided by WARDA more cost-effectively than by individual NARS acting at national level. The publications we propose to produce, and their audiences, are:

- the WARDA *Annual Report*, for donors and senior NARS staff;
- WARDA's *Research Highlights*, for donors and senior NARS staff;
- the WARDA *Technical Newsletter*, for collaborating NARS staff, other rice scientists and trainees;
- manuals, for trainees, collaborating NARS staff and other scientists;
- tape/slide presentations, for trainees, collaborating NARS staff and other rice scientists;
- the proceedings of meetings hosted and/or sponsored by WARDA, for meeting participants and other scientists or policy makers;
- occasional papers, for planners, policy makers and rice scientists in West Africa.

WARDA's *Technical Newsletter* will facilitate the two-way flow of information.

Manuals, tape/slide presentations, and the WARDA *Technical Newsletter* will be compiled jointly with NARS. The latter publication will serve as an outlet for national as well as WARDA research results, facilitating the two-way flow of information between NARS, and

between NARS and WARDA. In the longer term, we may seek support for the publication of an African rice research journal. We will aim to publish all our serial publications in both English and French.

WARDA's publications and documentation services will be provided free-of-charge to all WARDA clients and stakeholders, with special emphasis on reaching scientists within the region, and other rice scientists in Africa. In the longer term, we will seek to set up marketing arrangements for our publications outside Africa.

We will encourage copublishing of WARDA or other relevant publications in African or other languages when appropriate. Similarly, we will continue to translate into French and to disseminate within the region materials originating from outside it, and particularly training materials from IRRI, ensuring that these are first adapted for relevance to West Africa.

We expect WARDA's mailing list to be computerized and to grow significantly from its current level of 3000 names. We envisage some use of the mass media for outreach in the longer term, but this will grow only as WARDA's research starts to generate more technology. Meanwhile, we will exhibit WARDA's publications at bookfairs and professional meetings.

Training activities

Training activities will consist of group and individual training. Group training is currently well developed at WARDA, taking the form of regional or national conferences, workshops and seminars, as well as the short courses offered regularly at the Association's Training Center at Fendall in Liberia. Individual training, on the other hand, has received less attention. As well as continuing its group training activities, WARDA will therefore seek to build up its individual training program over the coming years. The program will comprise the following elements:

We will seek to build up our individual training program.

- post-B.Sc. on-the-job training as a WARDA research assistant;
- thesis or dissertation research involving practical work in one of our environmental research programs;
- postdoctoral research using advanced techniques and facilities available at WARDA headquarters;

- visiting and associate scientist programs for existing NARS staff wishing to strengthen their collaboration with WARDA.

Individual training will be used to help build the collaborative research program. On-the-job training for young graduates will consist of a 2- or 3-year period spent assisting WARDA's scientists, with those showing most promise being selected for subsequent Ph.D. support, where appropriate at an African university. WARDA will serve as a 'broker' to identify and help generate scholarship support for such individuals. Training for graduates already registered for a Ph.D. will also include practical work carried out in one of WARDA's research programs. In this way, we will subsequently develop close links with the former trainee's national program.

Our group training activities will address the needs of staff already working within national research institutes, extension services or development programs. Besides meetings, group training activities will consist of short courses designed to:

- impart the research techniques needed for effective WARDA/NARS collaborative research;
- enhance familiarity with new and existing rice production technology;
- increase trainer development skills, and other skills related to communications and the dissemination of new technology.

In group training there will be more emphasis on research techniques.

The main trainees on group courses so far have been extension staff, research assistants and technicians. In future there will be increased emphasis on research-related training for NARS staff. In the short to medium term, we will adapt course content so as to place more emphasis than at present on research techniques. The purpose will be to increase the ability of NARS to participate fully in collaborative research. In the longer term, as more technology is generated, we expect the balance to swing back towards production-related training. This training will be directed towards key extension personnel as well as scientists, and will seek a multiplier effect through the concept of training the trainers.

Group training in adaptive research methods will be an important mechanism for strengthening the relevance of NARS research and promoting the dissemina-

tion of low-cost technology. Course content will reflect the conditions under which farmers operate, and particularly their access to inputs.

Both group and individual training will be supported by training materials. These will take the form of manuals and visual aids. An early priority will be to prepare manuals on a number of technologies now ready for transfer. In the medium term, we hope to make WARDA a center for the development of rice training materials for West Africa.

In the medium to long term, group training will increasingly take the form of in-country courses organized and taught by NARS staff. WARDA's role will be restricted to the provision of jointly developed training materials and of specialized expertise not yet available within NARS.

Group training will increasingly take the form of in-country courses.

5. COLLABORATION WITH NARS

Collaborative research

Each research station will act as the center for collaborative research in its environment, generating technology and coordinating its testing by NARS*. We will seek to strike a balance between strategic/applied research, conducted centrally, and adaptive research, conducted largely through collaborative research networks. As strategic/applied research generates new technology, so must the capacity of NARS to adapt it be strengthened. Each network will therefore be supported through training and communications activities, in addition to visits and meetings.

Much of the work done in networks will consist of testing new varieties for their suitability to local environmental and economic circumstances. However, since improved germplasm is not the only ingredient necessary for improving production, we will encourage network participants to test and adapt any new relevant technology that both meets farmers' needs and lies within their resources. Essentially, this will be low-input technology designed to increase the efficiency of production while preserving the resource base on which future production depends.

We will encourage network participants to test any relevant new technology that meets farmers' needs and lies within their resources.

A network approach will also be used to test technology developed outside the region for its appropriateness within it. WARDA will continue its participation in IRTP-Africa, gradually assuming responsibility for the coordination of all West African activities within the program.

It is not now possible to specify in detail how research responsibilities will be shared between ourselves and our national partners. We expect responsibility for adaptive and applied research to shift increasingly to NARS as their capacities strengthen. Strategic research, on the other hand, will continue to be carried out mostly by WARDA in collaboration with other IARCs or specialized institutes. We will aim to increase NARS capacity for such research on problems which are country-specific. As the region's stronger NARS assume res-

We expect responsibility for adaptive and applied research to shift increasingly to NARS.

* For a definition of NARS, see page 13.

ponsibility for strategic and applied research, WARDA will work in collaboration with them.

Table 3 shows how WARDA and NARS expect to collaborate in rice research and support activities for West Africa. Much will depend on the existing national capacity in any given field, and this will vary over time. The table is therefore a guide-line, not a prescription. As we have already seen (Section 4), trained manpower is generally scarce in the region at present, and WARDA will need to step up its training in research techniques to meet the more urgent needs in areas of collaborative research.

Table 3. A framework for WARDA/NARS collaboration in rice research and support for West Africa.

	NARS group*		
Area	A	B	C
Research:			
Germplasm improvement	+	++	++
Crop/resource management	+	++	++
Socio-economics	+	+	++
Germplasm testing	+	+	+
Support:			
Seed dissemination	+	+	+
Training	++	++	++
Information	++	++	++
Bilateral projects**	+	+	+

Key:
+ = WARDA participation in specific complementary activities
++ = WARDA has leadership role

Notes:
*NARS classified as follows:
Group A: countries with more than 2 full-time rice scientists
Group B: countries with 1 or 2 full-time rice scientists
Group C: countries with no full-time rice scientists
Group A comprises 3 of WARDA's 16 member states, Group B 11 and Group C 2.
**Rice research and development projects between member countries and donors, for which WARDA provides technical support.

Linkages

Because it was originally conceived as an intergovernmental association, WARDA's links with NARS have

WARDA's well established links with NARS will be strengthened still further in future.

long been well established. They will be strengthened and used still more effectively in the future. Mechanisms for ensuring effective links will exist at various levels within the Association. They will include:

- political liaison through WARDA's Council of Ministers;
- contact through WARDA's Directorate of International Cooperation;
- meetings between WARDA and NARS leaders to evaluate past or plan future research;
- meetings between NARS and WARDA scientists to discuss the implementation of research and compare results;
- missions for conducting aspects of collaborative research, such as data analysis, germplasm collection, etc;
- contact through WARDA's integrated information service;
- contact through WARDA's training program*;
- studies arranged through WARDA's visiting or associate scientist programs.

Whenever necessary, WARDA staff will participate in collaborative research at a NARS location. WARDA's research stations will provide a suitable location for larger collaborative programs with host country NARS, provided these strike a reasonable balance between tackling regional as opposed to purely national problems.

* All trainees will be automatically added to WARDA's mailing list.

6. COLLABORATION WITH OTHER RESEARCH INSTITUTES

Collaborative research

Table 4 shows how we expect to collaborate with our major international research partners. Specific areas of collaboration will include:

- with IITA, breeding and testing of varieties for the hydromorphic/inland-swamp ecosystem within the upland/inland-swamp continuum, and crop and resource management studies across the continuum, with special emphasis on the adaptation of alley farming to upland rice cropping systems;
- with IRRI, testing of existing and new Asian varieties in the Sahel and humid zone irrigated systems, joint development of a Sahel-based breeding program and coordination of IRTP-Africa;
- with CIAT/CIRAD, development of varieties adapted to the upland/hydromorphic ecosystem within the continuum, especially those tolerant to drought;
- with IIMI, technical and training requirements for improved water management in the Sahel and humid zone irrigated production systems, and the hydromorphic/inland-swamp ecosystem within the continuum;
- with IFDC, improvement of soil fertility in the upland-hydromorphic ecosystem, with special emphasis on the use of African rock phosphates;
- with IFPRI, analysis of macro-economic factors affecting government policy and the adoption of new technology in all rice growing environments;
- with IBPGR/ORSTOM/IITA/IRRI, collection and evaluation of rice species in all environments.

We will also seek opportunities for collaboration with ILCA, on the introduction of animal traction, with ICRAF, on the use of trees and shrubs in agroforestry systems, and with ICIPE, on the control of insects. We will seek similar opportunities to collaborate with national institutes worldwide, whenever these have specialised areas of expertise that complement WARDA's program.

IITA: a key research partner for WARDA.

IITA is a key research partner for WARDA by virtue

of its location in West Africa and its programs on rice and mixed cropping systems. In the course of recent meetings between teams of scientists from the two institutes, agreement was reached on the division of collaborative activities over the short term. While responsibility for varietal improvement will be transferred to WARDA, IITA will retain leadership in a number of areas concerned with crop and resource management, in which it has a special advantage.

Details on how tasks will be shared between now and 1990, when IITA will phase out its varietal improvement program, are given in Annex Tables A5 and A6.

Table 4. A framework for international collaboration in rice research and support for West Africa.

	Institutes						
Area/environment	WARDA	IITA	IRRI	IFPRI	IIMI	CIAT	CIRAD
Research:							
Germplasm improvement							
Continuum	++	+	+	−	−	+	+
Sahel	++	−	+	−	−	−	−
Mangrove swamps	+++	−	+	−	−	−	−
Crop/resource management							
Continuum	+	++	−	−	+	−	+
Sahel	++	−	+	−	+	−	+
Mangrove swamps	+++	−	+	−	+	−	−
Socio-economics							
Continuum	++	+	+	+	−	−	−
Sahel	++	−	+	+	−	−	−
Mangrove swamps	++	−	−	+	−	−	−
Germplasm testing	+++	−	−	−	−	−	−
Support:							
Training	++	+	+	+	+	+	+
Information dissemination	++	+	+	+	+	+	+
Bilateral projects*	++	−	−	+	+	−	+

Key:
− = No direct activity: WARDA to act as clearing house
+ = Participation in specific complementary activities
++ = Leadership role
+++ = Leadership role and sole responsibility

Note:
*Rice research and development projects between member countries and donors, for which WARDA provides technical support.

Linkages

Various mechanisms will ensure effective links between WARDA and its research partners in the CGIAR system as well as specialized institutes elsewhere in the world.

As our operational mandate states, WARDA will serve as the clearing house for intercenter rice research activities in West Africa. This will act as a mechanism for avoiding the problems of overlap and the overloading of NARS noted by some observers of the CGIAR system (5).

WARDA will serve as the clearing house for intercenter rice research in West Africa.

Since much of our work will be carried out collaboratively with IITA and IRRI, periodic meetings will be held to discuss progress.

A WARDA-IITA liaison officer is already stationed at WARDA. We would welcome the early posting to WARDA of more scientists from both IRRI and IITA to facilitate collaborative work in priority areas. To ensure that there is no duplication of effort between the three centers, WARDA will act as the convenor of discussions on all initiatives relating to rice research in West Africa proposed by these institutes.

Links with the other IARCs with which WARDA will collaborate will be established and maintained through the usual channels. In some instances, long-term collaborative research arrangements will be sought. One such arrangement has already been discussed with IFPRI, who may outpost a staff member with WARDA to work on economic policy issues when our new headquarters are operational. In other instances, short-term inputs through consultancies and the secondment of staff will suffice. Meetings to discuss joint efforts will be held whenever necessary.

As regards institutes in the developed world, one collaborative research programme, conducted with CIRAD and covering upland rice, is already in place. We may seek further programs of this nature. WARDA's collaborative work with developed world institutes will usually emphasize specialized aspects of strategic research in which WARDA lacks expertise. Contract research arrangements will be made where necessary. Short-term inputs through consultancies and the secondment of staff will also be sought.

Collaboration with developed world institutes will emphasize strategic research.

Given WARDA's regional focus, there will be little need for the Association to consider outposting its staff to other IARCs. Where appropriate, we may seek to send either WARDA or NARS staff to other IARCs or to developed world institutes for short periods of training or collaborative work in specialized areas, however. Because of their superior facilities, IITA and IRRI may prove especially helpful to us in this respect over the next few years.

7. PROGRAM IMPLEMENTATION

Management structure

Our new organizational chart is shown in Figure 2. Under its Council of Ministers and Board of Trustees, WARDA will be managed by four directors, reporting to the Association's Director General. The four directorates will be Research, Administration and Finance, Communications and Training, and International Cooperation.

Organization of research

Research programs will be organized around rice growing environments.

We plan three research programs organized around our three major rice growing environments. Each will be based, but not exclusively conducted, at a single research station. Thus:

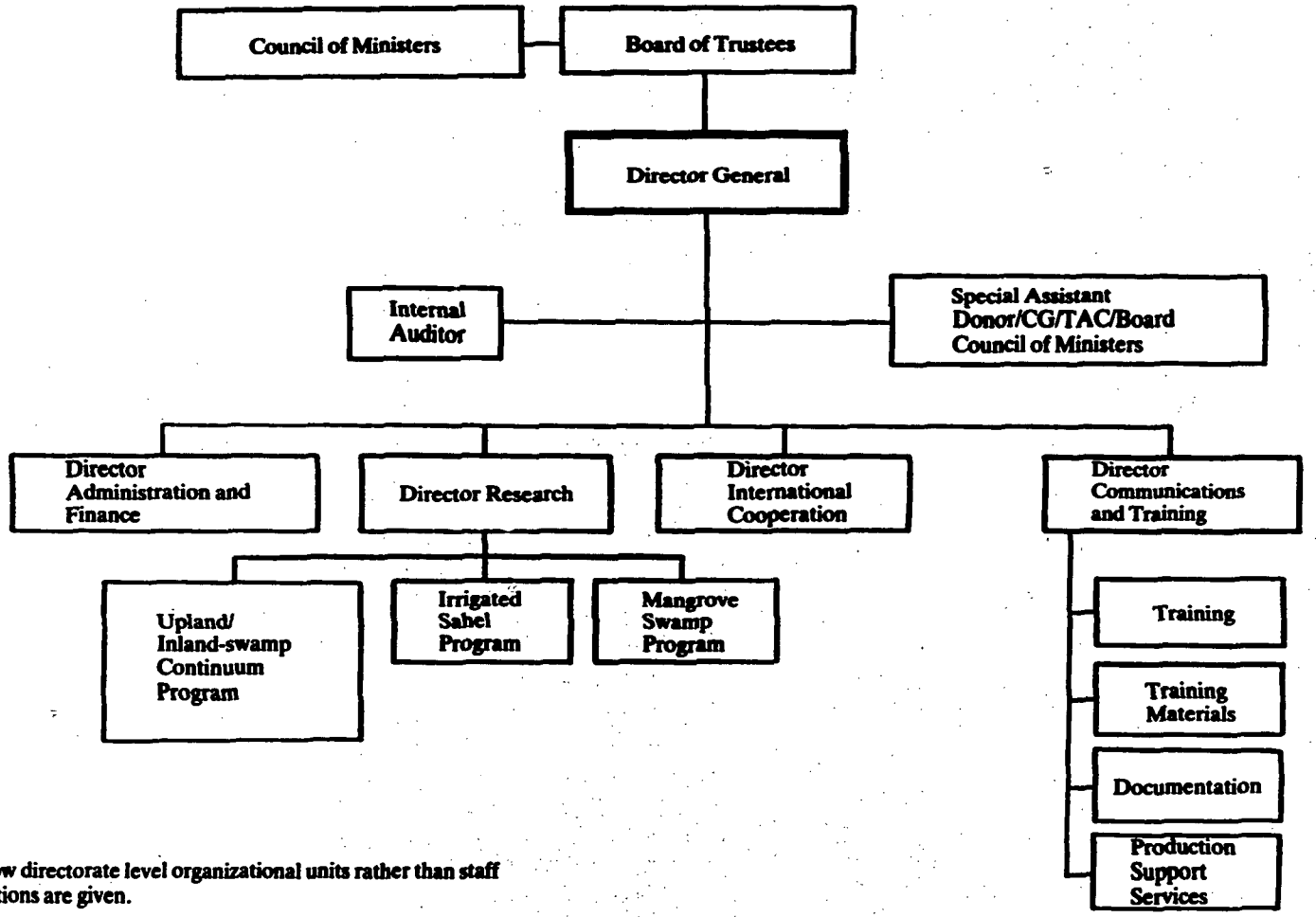
- our Upland/Inland-swamp Continuum Program will be entered at our new main station at Mbé Valley, near Bouaké, Côte d'Ivoire in the savannah-forest transition zone, but the program will include work in the humid forest zone to be undertaken at Suokoko in Liberia;
- our Sahel Program will be based at our existing St. Louis station in Senegal;
- our Mangrove Swamp Program will be based at our existing Rokupr station in Sierra Leone.

Satellite stations will be used to address other specific agro-ecological factors. Figure 3 illustrates potential relationships between these satellites and our major programs.

Each multidisciplinary research program will have a station-based program leader, reporting to the Director of Research at headquarters. Program leaders will be supported by a farm manager, responsible for station maintenance and operations, and an administrative officer.

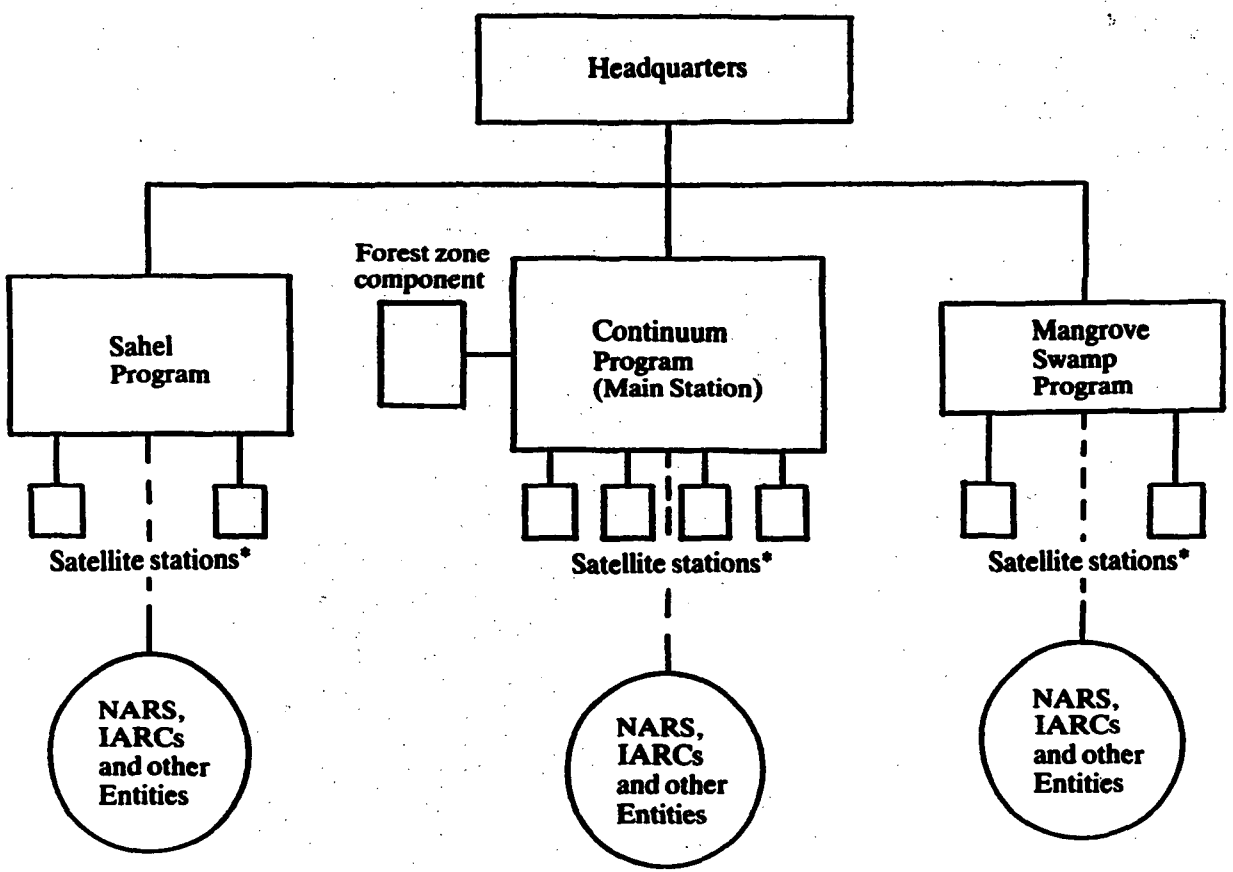
As we have seen, each program will consist of a number of projects. These will be subdivided into component tasks, each having its own budget and clearly delineated objectives to be achieved within a limited

*Figure 2. Organizational chart of WARDA, 1988.**



*Below directorate level organizational units rather than staff positions are given.

Figure 3. WARDA's future research operations.



*Number to be determined by research needs and resources.

time period. Tasks may comprise one or more experiments, each with its own plan and publication schedule. Individual scientists will be responsible for one or more tasks, on which they will report progress annually. During the annual evaluation process scientists will demonstrate how their work has contributed to the overall aim of the project.

Through this structure we expect to:

- integrate the work of different disciplines by providing them with a common goal;
- foster a sense of purpose in the individual scientist that will transcend his or her professional disciplinary interest.

Scientists will be guided by the leader of their environmental program, but they will also belong to disciplinary working groups that will cut across programs. Disciplinary groups will not have formal organizational status but will serve, through the office of the Director of Research, as an important means of integrating and enhancing the work of the different programs. Specifically, disciplinary groups will help WARDA to:

- maintain the quality of research by providing mechanisms for peer review and advice;
- ensure the flow of knowledge, technology and methods between programs.

Research staff will give and participate in regularly held research seminars to broaden their understanding of key areas of WARDA's work and to sharpen their professional skills.

Quality control

Mechanisms for ensuring the quality and relevance of research will include:

- evaluation by farmers and studies of their adoption rates;
- joint planning/evaluation of research with NARS, at an annual West African Rice Review meeting;
- establishment of research plans with clearly defined and justified objectives, and publication schedules;
- annual evaluation of research projects, including published results, by a Research Committee chaired by the Director of Research;
- periodic evaluation by the Program Committee of WARDA's Board of Trustees;
- External Program and other reviews commissioned by TAC or donors.

Research will be evaluated through an annual West African Rice Review meeting.

Support services

As we have seen, the testing and adaptation of new technology will form one of the major components of WARDA's collaborative research with NARS, in addition to collaborative work in applied and strategic research with those countries whose capacity is stronger. Based at headquarters, WARDA will provide various services in support of this research. Primarily, these will include the collection and storage of germplasm, and various disciplinary support services in fields such as entomology, virology and pathology to underpin our plant breeding work, in addition to the production and distribution of breeder seed*, and assistance in data analysis.

Other services will also be provided, including laboratory analysis of soils and plants, advice in areas such as post-harvest technology and seed multiplication, and the identification of training needs. However, WARDA's resources are limited, and we will take care to ensure that providing these other services does not detract from our ability to focus on our primary objective, the generation of new technology and its dissemination to NARS.

Thus, we see our service functions as closely harnessed to our network activities. Services to institutes within the region will not be provided for their own sake, nor in isolation from the collaborative research effort. Follow-up to the provision of services will be the responsibility of the Directorate of International Cooperation.

WARDA will respond to requests for seed or for information coming from NARS outside West Africa, though West Africa will be its major program focus.

We see our service functions as closely harnessed to our network activities.

Phasing of activities

WARDA's strategy is scheduled to become operational in 1990, and will span the 1990s. For planning purposes, we have divided the decade into two 5-year periods.

Between now and 1990 WARDA will be in a transition phase, during which we will prepare to implement our strategy by establishing links with our international and national research partners, and by seeking donor funding. We will also be entering the first phase of the construction of our new main research station and head-

Our strategy becomes operational in 1990.

* WARDA will arrange access to plant quarantine facilities so as to ensure compliance with IAPSC regulations.

quarters. Research during the transition period will continue as already planned, but with increased emphasis on constraint diagnosis. At Bouaké, increased resources will be devoted to the hydromorphic/inland-swamp ecosystem. Group training activities will continue at the Fendall Training Center, pending the completion of studies which will clarify its future role.

Individual training in research skills and emerging technology will be increased, and manpower studies will be carried out to identify training needs and provide the direction of future training activities. Headquarters activities (research, communications, administration and finance) will continue as planned, but will be relocated in temporary facilities at Bouaké as soon as possible. Communications activities will be backstopped with extra staff and facilities.

By 1995 we aim to have an expanded program and an operational headquarters.

By the end of the first 5-year period, we expect research activities to have expanded considerably in our priority environment, the upland/inland-swamp continuum. We also hope that construction of our new main station and headquarters will have been completed. Communications activities should also have expanded and our training program for individuals should be well established. Responsibility for adaptive research should have shifted significantly towards those NARS whose capacity has been sufficiently strengthened.

During the second 5-year period, WARDA will intensify its applied/strategic research, using the critical mass of staff and facilities by then available at the new main station and headquarters. Collaborative research network activities will also be further expanded during this period. Towards the year 2000, WARDA should begin to be able to move further upstream in the research spectrum, relinquishing responsibility for some aspects of applied research. However, progress in the move upstream will depend on the development of NARS capabilities. Group training activities at headquarters will probably decrease, as NARS take greater responsibility for in-country courses.

Resource allocation

Research, support and administration

In its resource allocations WARDA will aim for a ratio of 60:20:20 between research, support activities (including communications, training and international cooper-

ation) and administration. We hope to strengthen activities considerably in both the research and the communications/training departments. We do not expect allocations to differ greatly between the two 5-year periods.

Research programs

Within research, the allocation of resources to different environments is depicted in Figure 4.

The current allocations are 70% to the upland/inland-swamp continuum and 15% each to the Sahel and mangrove swamp environments.

By the start of the first 5-year period, these broad allocations will be the same, but within the continuum the share devoted to the hydromorphic/inland-swamp ecosystem will have risen from 5% to 30%, reflecting our increased emphasis on research for this ecosystem, in view of its relatively high potential (see Section 3). The share of allocations to the uplands will be reduced accordingly.

Seventy per cent of our research resources will go to the upland/inland-swamp continuum.

Allocations to all environments, but particularly to the mangrove swamps, will be reviewed at the end of the first 5-year period. Those for the second 5-year period are therefore somewhat more tentative. Depending on the outcome of the review, they will probably shift as follows: overall resources for the continuum will decline to about 65%, although those devoted to the hydromorphic/inland-swamp ecosystem could rise slightly as breeding activities progress; resources for the Sahel might increase somewhat, to reflect the growing importance of this system and the need to test new varieties adapted for Sahelian conditions; the allocation to mangrove swamps will doubtless decline, reflecting a shift towards NARS of activities in applied/adaptive research in this environment.

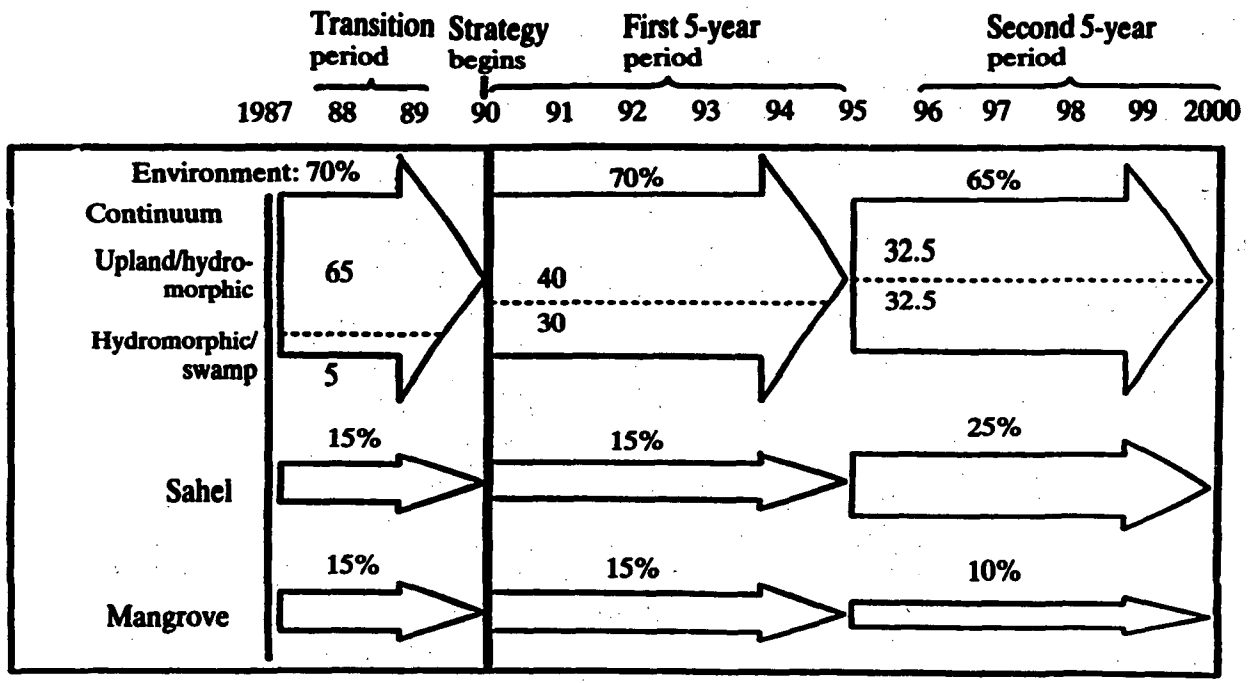
Capital development and staff needs

WARDA's most urgent need is for a new main research station and headquarters from which to operate. Facilities at the St. Louis and Rokupr stations also need upgrading. Satellite research stations and other research facilities will be needed, and further major equipment needs will be encountered as the research program develops.

Our most urgent need is a new main research station and headquarters.

We project a minimum staff requirement of 32 profes-

Figure 4. Approximate allocation of research resources at WARDA, 1987-2000.



sionals at the outset of the first 5-year period. The ratio of researchers to technical support staff is currently very low. We expect it to increase to a level nearer that of other CGIAR institutes as WARDA's program grows. Besides support staff, WARDA's professionals will be complemented by additional resources such as post-doctorals, visiting scientists, etc. Staff needs will increase sharply as research expands in our priority environment, the upland/inland-swamp continuum.

8. MEASURES OF PROGRESS

WARDA's stakeholders will evaluate the Association's performance in terms of the extent to which they feel it achieves the goal defined at the outset of Section 2. As the CGIAR impact study (11) has shown, it is impossible to measure accurately the multiple effects of the IARCs' work, especially where this is reflected in an enhanced national research capacity. Any assessment of WARDA's performance will therefore be partly subjective.

The extent to which research results are translated into widespread production gains depends on factors beyond the influence of research institutes (12). Impact on regional rice production will not, therefore, be the prime measure of WARDA's success, although the results of on-farm trials will give important clues to the potential for impact of new technology.

The products of research are new knowledge as well as new technology; the product of communications and training activities is an enhanced national research capability. In the absence of methods for quantitatively measuring these products or their effects, an important indicator of WARDA's performance will be the perceptions of our clients, the NARS, regarding the extent to which we have helped them acquire their own expertise to develop new technology and adapt it to the needs of farmers.

NARS perceptions will be an important indicator of WARDA's success.

Many participants in agricultural research and development, including donors, scientists and national planners, tend to underestimate the time it takes to achieve impact through research. According to ISNAR/SPAAR (12), it takes 3 to 5 years to import and adapt technology, and 10 years at least to generate new technology. Once new or adapted technology is available, a further period must be allowed for its adoption. The impact of IARCs on national research capabilities is also likely to take far longer to materialise than is usually allowed for.

In view of these considerations, and the very different stages our various research programmes will have reached, we propose the following criteria for evaluating WARDA's performance in the year 1995:

- on farm trials in the mangrove swamps have established potential impact of new technology;

- new varieties for the upland/hydromorphic ecosystem have been released;

- a sustainable upland rice cropping system to replace shifting cultivation is being tested through collaborative research;

- breeding activities for the Sahel environment and the hydromorphic/inland-swamp ecosystem have reached a satisfactory stage;

- improved water management methods have been developed for flooded ecosystems;

- NARS feedback on the effectiveness of collaborative research and on the value of WARDA's training and communications activities is positive;

- links for on-farm research are established with national and regional programs;

- WARDA and IFPRI have started assisting in the analysis of national rice policy options;

- WARDA's administration and management have been developed to the standards of other CGIAR centers;

- WARDA's main station and headquarters are built and operational;

- information on initial research results and on researchable constraints is documented and available to member countries and donors;

- WARDA is becoming recognized as a center of scientific excellence.

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Annex

List A1. Major international-regional organizations concerned with WARDA's work.

1. Other IARCs

International Institute for Tropical Agriculture (IITA)
International Rice Research Institute (IRRI)
Centro Internacional de Agricultura Tropical (CIAT)
International Center for Insect Physiology and Ecology (ICIPE)
International Irrigation Management Institute (IIMI)
International Fertilizer Development Center (IFDC)
International Service for National Agricultural Research (ISNAR)
International Food Policy Research Institute (IFPRI)
International Board for Plant Genetic Resources (IBPGR)
International Council for Research on Agroforestry (ICRAF)
International Livestock Center for Africa (ILCA)

2. Donor/development agencies/countries*

Food and Agriculture Organization of the UN (FAO)
United Nations Development Program (UNDP)
International Bank for Reconstruction and Development (IBRD)
United Nations Environmental Program (UNEP)
Gesellschaft für Technische Zusammenarbeit (GTZ)
United States Agency for International Development (USAID)
Canadian International Development Agency (CIDA)
International Development Research Center (IDRC)
Swedish Agency for Research Cooperation (SAREC)
Rockefeller Foundation
Belgium
France
Japan
Netherlands
Germany (FRG)
African Development Bank (AFDB)

3. Other developed country institutes

Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) (France)

* Actual 1987 donors only.

Office pour la Recherche Scientifique et Technique Outremer (ORSTOM) (France)

4. Regional organizations

Economic Community of West African States (ECOWAS)
United Nations Economic Commission for Africa (UNECA)
Organization of African Unity (OAU)
Comité Inter-états de Lutte contre la Sécheresse (CILSS)

Table A1. WARDA's member states: population, area and principal working language for research purposes, 1985.

Country*	Population ('000s)	Area ('000 ha)	Language†
Benin	4056	11262	F
Burkina Faso	6925	27420	F
Chad**	n.a.	128400	F
Côte d'Ivoire	9808	32246	F
The Gambia	717	1130	E
Ghana	13473	23854	E
Guinea	5928	24586	F
Guinea Bissau	892	3612	P
Liberia	2191	11137	E
Mali	7685	124000	F
Mauritania	1885	103070	F
Niger	6312	126700	F
Nigeria***	95864	92377	E
Senegal	6524	19619	F
Sierra Leone	3423	7174	E
Togo	2929	5679	F

Notes:

*The only country in West Africa that is not a member of WARDA is Cape Verde Islands, which grows no rice.

**Chad is a member country although it is not strictly speaking part of West Africa. Its inclusion is justified by the similarity of its rice growing environments to those of the other Sahelian member states.

***Nigeria is the 'giant' among member states. Its population of 95 million is seven times that of Ghana, West Africa's second most highly populated country, and 50% of the region's total.

†Out of our 16 member countries 10 are francophone, 5 are anglophone, and in 1 the main foreign language spoken is Portuguese, but French is fairly widely understood.

Table A2. Rice areas, yields and production by ecosystem in West Africa, 1980–84.

Environment	Area ('000)	Area (%)	Yield (t/ha)	Production ('000 t)
Continuum:				
Upland/hydro.	1490	57	1.0	1490
Hydro./inland sw.	530	20	1.4	742
Irr. humid zone	119	5	2.8	333
Sahel	112	4	2.8	313
Mangr. swamp	193	7	1.8	347
Deepw./floating	190	7	0.9	171
Total	2631	100	–	3396

Table A3. Rice areas, yields and production by ecosystem in West Africa, by the year 2000***

Environment	Area ('000) ha	Area (%)	Yield (t/ha)	Production ('000 t)
1. Yield as now, area changed				
Continuum:				
Upland/hydro.	2160	59	1.0	2160
Hydro./inland sw.	760	21	1.4	1064
Irr. humid zone	185	5	2.8	518
Sahel	155	4	2.8	434
Mangr. swamp	193	6	1.8	347
Deepw./floating	190	5	0.9	171
Total	3643	100	–	4694
2. Area as now, yield changed				
Continuum:				
Upland/hydro.	1490	57	1.3	1937
Hydro./inland sw.	530	20	2.5	1325
Irr. humid zone	119	5	3.5	416
Sahel	112	4	3.5	392
Mangr. swamp	190	7	2.2	418
Deepw./floating	190	7	0.9	171
Total	2631	100	–	4659
3. Area and yield changed				
Continuum:				
Upland/hydro.	2160	59	1.3	2808
Hydro./inland sw.	760	21	2.5	1900
Irr. humid zone	185	4	3.5	647
Sahel	155	5	3.5	542
Mangr. swamp	193	5	2.2	425
Deepw./floating	190	5	0.9	171
Total	3643	100	–	6493

Notes:

*Yield gains represent the average increases we believe achievable over each environment as a whole.

**Assumptions made as follows: No change in areas devoted to mangrove and deepwater/floating rice; area changes for other environments based on changes in the past 10 years; yield increases based on Asian figures, adjusted downwards for Africa; no yield increase in deepwater/floating rice environment; main research efforts concentrated on the upland/inland-swamp continuum and on irrigated rice; the cropping intensity of rice will remain the same; only one crop a year grown on irrigated land.

Table A4. Intensity, yield loss and value of production foregone attributable to rice production constraints in West Africa.

Constraint	Intensity (0–9)	Yield loss (kg/ha)	Value (US$ million)	% of total value
Diseases:				
Neck blast	3.67	22.31	5.65	4.02
Blast	3.33	19.12	4.84	3.45
Grain discoloration	3.33	19.12	4.84	3.45
Sheath blight	2.67	17.00	4.31	3.06
Sheath rot	2.83	14.68	3.72	2.65
Brown spot	2.83	14.33	3.63	2.58
Leaf scald	2.00	11.95	3.03	2.15
Yellow mottle virus	2.17	8.23	2.08	1.48
Bacterial leaf blight	0.33	0.53	0.14	0.10
Physiological efficiency:				
Processing	8.00	42.47	10.76	7.65
Fertility	4.67	29.23	7.40	5.27
Stand establishment	4.67	27.34	6.92	4.93
Erosion	2.67	25.54	6.47	4.60
Water management	4.67	14.47	3.66	2.61
Grain quality	2.00	10.62	2.69	1.91
Insects:				
Storage insects	4.00	21.24	5.38	3.83
Stemborers	3.33	17.79	4.51	3.21
Diopsis	3.17	15.22	3.85	2.74
Stink bugs	2.00	10.62	2.69	1.91
Gall midge	1.00	2.30	0.58	0.41
Other pests:				
Birds	7.33	40.01	10.13	7.21
Weeds	6.50	39.30	9.95	7.08
Rodents	3.17	20.81	5.27	3.75
Crabs	0.83	3.08	0.78	0.56
Soil factors:				
Tillage	7.67	43.27	10.96	7.80
Mineral availability	2.17	15.85	4.01	2.86
Iron toxicity	2.33	10.24	2.59	1.85
Acidity	1.33	6.89	1.75	1.24
Salinity	1.67	5.47	1.38	0.98
Iron deficiency	0.33	3.19	0.81	0.58
Temperature and water:				
Submergencce	2.17	9.97	2.53	1.80
Drought	1.00	9.58	2.43	1.73
Low temperature	1.17	1.87	0.47	0.34
High temperature	0.83	1.34	0.34	0.24
Total	–	555.00	140.55	100.00

Source: Adapted from IITA planning group responses (using intensity method), in refs. 7 and 13.

Table A5. WARDA/IITA collaboration in germplasm collection and varietal improvement for the hydromorphic and inland swamp portions of the continuum over the transition period (1988-90).

Component	Tasks	Responsibility	
		WARDA	IITA
Germplasm resources	Collection	+	+
	General characterization	+	
	Storage		
	–short- and medium-term	+	
	–long-term		+
	Evaluation for tolerance/ resistance to		
	–drought	+	
	–iron toxicity	+	
	–flooding		+
	–blast		+
	–RYMV		+
	–stemborer	+	
	–diopsis		+
	–gall midge		+
	–storage insects	+	
	–soil acidity		+
	Utilization		
	–in crosses	+	
	–for advancement	+	
Varietal development	Drought		
	–screening	+	
	–root study/selection	+	
	Iron toxicity		
	–survey	+	
	–screening methods	+	
	–screening activities	+	
	–plant/soil analysis		+
	–enhancement	+	
	–inheritance studies	+	
	–agronomic characteristics	+	+
	Dry-season adaptability	+	
	Soil-acidity		
	–screening	+	
	–study of acidity effects	+	
	–screening methods/symptom typification	+	
	–yields	+	+
	Other toxicities/deficiencies		
	–screening	+	
	Flooding		
	–tolerance at different growth stages and water depth		+
	–recovery after different submergence periods		+
	Diseases		
	–blast		+

– RYMV		+
Insect pests		
– stemborers	+	
– diopsis		+
– gall midge		+
– storage insects		
identification	+	
rearing techniques		+
screening for resistance	+	
Grain quality		
– physical characteristics	+	
– chemical characteristics		+
– cooking characteristics	+	

Table A6. WARDA/IITA collaboration in crop and resource management and socio-economic studies in the hydromorphic and inland swamp portions of the continuum over the transition period (1988-90).

Component	Tasks	Responsibility	
		WARDA	IITA
1. Cropping patterns	Environmental characteristics of benchmark sites		+
	Evaluation of existing cropping systems	+	
	Design/testing improved cropping systems		+
2. Weed management	Appraisal of problems	+	
	Biology/ecology		+
	Control methods		
	– chemical	+	+
	– manual	+	
	– cultural	+	+
3. Soil fertility	Study of		
	–acidity	+	
	– nutrient deficiencies/ losses/toxicity	+	
	Management		
	– biological fertilization	+	
	– chemical fertilization		+
	Soil fertility maintenance		+
4. Integrated pest management	Studies on		
	– influence of cropping pattern/cultural practices	+	
	– pest control methods	+	+
	– influence of pesticide application		+
5. Socio-economics	Study of micro-environment	+	
	Technology evaluation		+
	Technology adoption/impact		+
	Macro-economic analysis	+	
6. Water management	Swamp inventory/classification	+	
	Study of water regime		+
7. Small tools	Inventory	+	
	Evaluation/adaptation	+	
8. Post-harvest technology	Identification of constraints	+	
	Consumer preferences	+	+

Acronyms and abbreviations

AFDB	African Development Bank
AGRICOLA	Agricultural on-line access (USDA)
AGRIS	International Information System for Agricultural Science and Technology
CABI	Commonwealth Agricultural Bureaux International
CIAT	Centro Internacional de Agricultura Tropical
CIDA	Canadian International Development Agency
CILSS	Comité Inter-états de Lutte contre la Sécheresse
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (France)
CGIAR	Consultative Group on International Agricultural Research
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organization (of the UN)
FRG	Federal Republic of Germany
GTZ	Gesellschaft für Technische Zusammenarbeit
ha	Hectare
IAPSC	Inter-African Phytosanitary Council
IARC	International agricultural research center
IBPGR	International Board for Plant Genetic Resources
IBRD	International Bank for Reconstruction and Development
ICIPE	International Center for Insect Physiology and Ecology
ICRAF	International Council for Research on Agroforestry
IDRC	International Development Research Center
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IIMI	International Irrigation Management Institute
IITA	International Institute for Tropical Agriculture
ILCA	International Livestock Center for Africa

IPM	Integrated pest management
IRRI	International Rice Research Institute
IRTP	International Rice Testing Program (coordinated by IRRI)
ISNAR	International Service for National Agricultural Research
kg	Kilogram
NPK	Nitrogen, phosphorous and potassium
NARS	National agricultural research system
OAU	Organization of African Unity
ORSTOM	Institut Français de Recherche Scientifique pour le Développement en Coopération
p.a.	Per annum
RYMV	Rice yellow mottle virus
SAREC	Swedish Agency for Research Cooperation
SPAAR	Special Program for African Agricultural Research
t	Tons (metric)
TAC	Technical Advisory Committee (of the CGIAR)
TRADIS	Tropical Resources for Agricultural Development Information Systems
UN	United Nations
UNDP	United Nations Development Program
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environmental Program
USAID	United States Agency for International Development