ON FARMERS' FIELDS:

PORTRAIT OF A NETWORK

SIMON CHATER AND VIRGILIO CARANGAL

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Foreword

In 1989, U Tin Aung, a regional manager of the Myanma Government's Agricultural Service, accompanied the coordinator of the Asian Rice Farming Systems Network on a visit to an area in the south of his country where deepwater rice is grown. During the visit, he listened while his companion embarked on a lively discussion with farmers about the rice-fish production system practiced by Vietnamese farmers.

In this system, a large earthen bund, some 3-4 meters wide, encloses a ricefield. The bund is bordered by a canal, which is used to raise fish. By building the bund, the farmer improves the control of water, enabling two crops of rice to be grown each year instead of one, nearly doubling farm income at a stroke. The bund also serves as a raised surface on which to grow fruit trees and upland crops, increasing cash income still further. And the fish produced in the canal increase the supply of protein for the family, as well as providing a large surplus for sale.

A few weeks later, U Tin Aung attended the network’s planning meeting held at Hat Yai, Thailand, where the merits of rice-fish systems were again discussed. He was able to join other participants on a visit to field sites in the Phatthalung area, where network researchers were testing a modified version of the Vietnamese system. Impressed by what he saw, he decided to try the system out in his own country. On his return home, he set about organizing adaptive research, which was quickly followed by multilocation testing and demonstration, then a full-scale production program. The system was an instant success with farmers, who in less than 3 years, have adopted it on more than 4000 hectares of land.

People sometimes criticize networks, accusing them of being little more than a talk shop — “too much net and not enough work.” Yet, as this example shows, networking at the international level can make a powerful contribution to the transfer of technology between countries. Within countries too, a networking approach can unite people who would not normally work together, forging new alliances not only between different disciplines within crop production but also between whole sectors previously separated by departmental barriers — crop and livestock production, fisheries, and forestry.

Launched in 1974, the Asian Rice Farming Systems Network enjoyed a 20-year lifespan under continuous funding from the International Development Research Centre (IDRC) of Canada. The stability of the network and its operations over this long period makes it an excellent case study on the effectiveness of networking as a vehicle for conducting agricultural research and disseminating its results. This publication documents some of the network’s experiences, highlighting the achievements but also describing the problems. We hope it will make a useful contribution to the global debate about networking, as this becomes the modus operandi for an increasing amount of agricultural research worldwide in the closing years of our century.

George Rothschild
Director General

In the beginning

In 1974, a Filipino plant breeder with an impressive track record in the administration of public-sector national agricultural research joined IRRI's Multiple Cropping Program. The task of the new staff member, Dr. Virgilio Carangal, was to launch the Asian Cropping Systems Network (ACSN).

A changing world

The network was born at an auspicious moment in regional agricultural research and development.

In research, an important new movement was making its voice heard. To complement conventional disciplinary research, in which new technology was generated on the research station, remote from the world of the producer, the apostles of cropping system research preached a new approach that placed the farmer at the very center of the research process. The two hallmarks of this approach were its multidisciplinarity, involving the social as well as that biological sciences, and its holism—taking whole production systems, rather than merely components of them, into account when designing new technology and studying its effects. Central to its methodology was the revolutionary idea of braeking down the research station fence—taking research onto farmers' fields and involving farmers directly in the design and evaluation of new technology

Exciting changes were also taking place in development. By 1974 the new, short-stemmed varieties of rice bred at IRRI during the mid-to-late 1960s were sweeping through South and Southeast Asia, transforming the outlook for agriculture and economic developlnent. The progress of the new technology felt like a race against time. Less than a decade previously, media images of the starving in India had evoked fears of mass starvation on a regional scale, leading to uncomfortable discussion of the principles of triage—the decision as to who should be chosen to survive on the "raft of humanity." Many countries still had rice deficits. As late as 1972—only 2 years before the network was founded—the Government of the Philippines had declared a rate of emergency to prevent food riots in Manila and other major cities.

Against this background. IRRI's scientists were keen to capitalize on the new opportunities, created by technology, to intensify and diversify crop production. At the same time, there was an urgent need to find out how cropping systems research—all very well in theory—could actually be applied. It was to pursue these aims that IRRI established theACSN.

Why a network?

Familiar today, the concept of networking was new in 1974. ACSN broke new ground Institutionally, being one of the first organizations of its kind in the international agricultural research community. It has since been widely imitated.

The networking model is a simple one. A central research institute, usually at the international level, serves as a "hub," providing expertise and facilities and fulfilling a coordinating function that enhances the conduct of research at each national "node" (see Fig. 1). The concept is similar to that of a bicycle wheel with its spokes. As the network strengthens, the nodes begin to interact with one another directly instead of thought the hub, which gradually becomes less crucial in sustaining operations. Eventually the nodes in turn become hubs

"Participation of Malagasy scientists in ARFSN enabled them to share and exchange their experiences with scientists from other countries. This contributed immensely to the development of improved cropping systems."

— **Francois Rasolo,** director general
National Center for Applied Research in Rural Development (FOFIFA), Madagascar

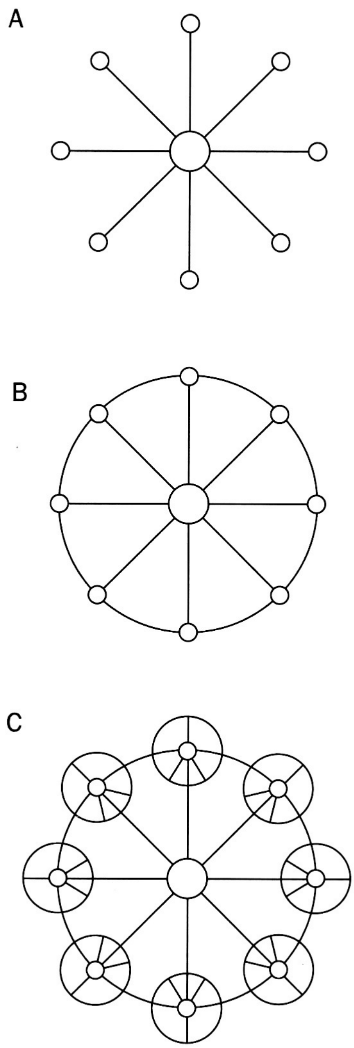


Fig. 1. Types of networks.

for "networks within networks," or subnetworks, which develop at the national level.

For an international research institute such as IRRI, networking offers a more cost-effective means of working with multiple national partners than do intensive, one-on-one relationships. The institutions taking part are able to economize by sharing research inputs (such as seeds), methods, facilities, and results. They can avoid duplicating each other's research and can capitalize on each other's strengths, with each member taking the lead in areas of comparative advantage. The network also serves as a mechanism for organizing training and exchanging information. Eventually, as the nodes get stronger, the international center should be able to work itself out of a job, having fulfilled its mandate to strengthen national research

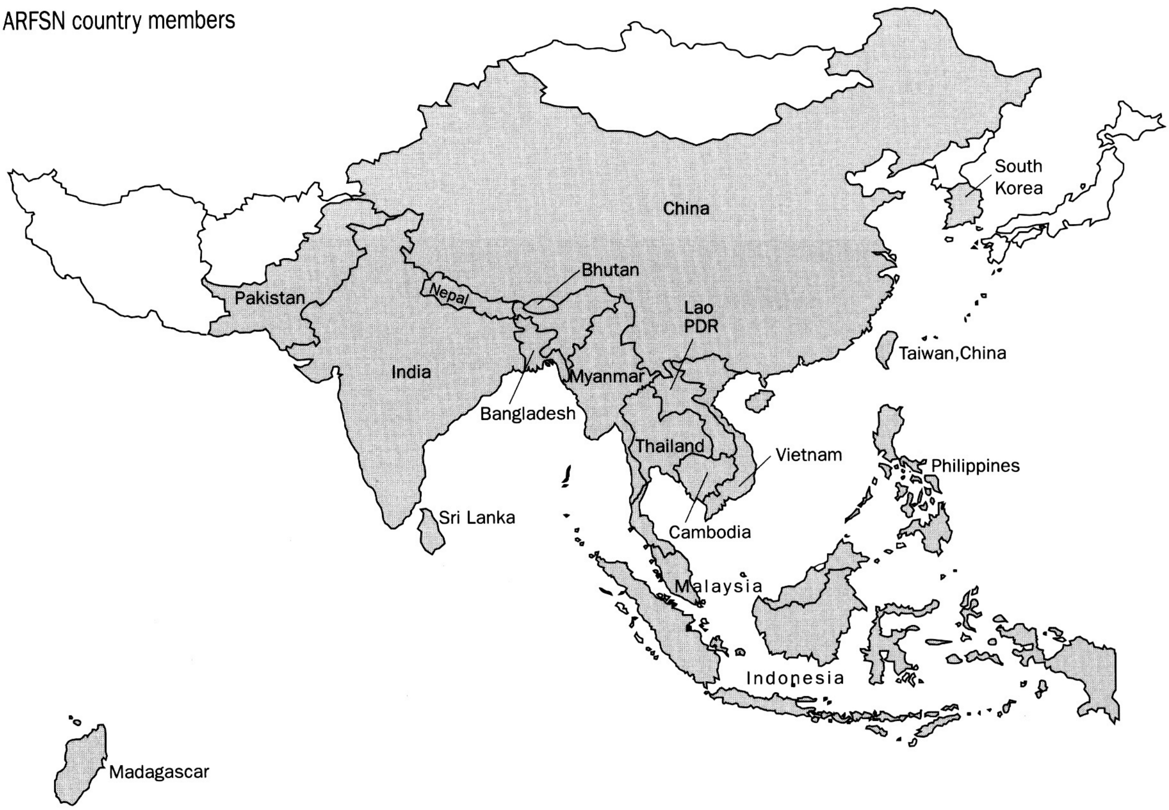
How ACSN operated

IRRI and the International Development Research Centre (IDRC) took steps at the start to ensure that national researchers would have a strong sense of ownership of ACSN. The only management mechanism was the Asian Cropping Systems Working Group, set up in 1975 to review and guide activities. This had a representative from each participating country, but no chairperson. As a result, its meeting, which were held twice a year at first, then annually, had a pleasantly informal atmosphere.

Being a member of the network meant, first and foremost, sharing information with other members. The unrestricted exchange of information was an explicit operating principle. Each country sending a representative to the annual group meeting, or to the network's workshops and conference, had to present a paper and participate actively in discussions. With IRRI support. the network published full proceedings of each and every meeting and workshop held over its 20-year life-span. The quarterly newsletter, *Rice farming systems technical exchange,* provided another forum for information sharing.

Group meetings were hosted by each country in turn, giving members an opportunity to visit

ARFSN country members



and learn from each other's field research. Meetings generally opened with a keynote address given by a minister of agriculture or other high-ranking official. Inviting such people to meetings was one of several ways in which the network forged links with policymakers and kept them aware of the importance of research and its contribution to national development.

Early meetings of the group provided the forum for hammering out the methodology of the clopping systems approach to research. The first two meetings, in 1975, were spent developing the conceptual framework (see page 11). Subsequent meetings held detailed discussions on each phase in the research process, and on such subjects as farmer participation, links between research and extension, and economic analysis.

Country representative at the group's first meeting strongly endorsed the idea of conducting research on farmers' fields. The rapid growth of the network, from 4 founding members to 12 within the first 5 years and finally to 17 by 1993, attested to the demand for a cropping systems approach within national systems. It was made possible by the generous donor funding available at that time.

National research teams in each country conducted on-farm research at key sites representing the major rice-growing ecosystems. By 1981, when the network was at the height of its operations, the number of sites had risen to more than 50 in 10 countries in South and Southeast Asia. Detailed planning of research at these sites took place at planning meetings, held annually for each ecology. Monitoring tours—visits to research sites by group, of network scientists—were organized to evaluate technology and encourage its transfer across national boundaries.

Throughout its life, IRRI contributed to the network in two major ways. It funded the position of a full-time network coordinator. It also provided technical support, mainly through its interdisciplinary Cropping Systems Program.

An evolving concept

The Asian Cropping Systems Network, later to become the Asian Rice Farming Systems Network (ARFSN), was the first in the world to put a farming systems approach to research into practice. The network's evolution was a microcosm of the development of conceptual thinking about agricultural research worldwide over the past two decades.

From multiple cropping to cropping systems research

The network arose out of the work of IRRI's Multiple Cropping Program. This program had explored the potential for growing extra crops each year where only one (or two) had been grown before.

Two technologies made this possible. The first was the early-maturing varieties of rice bred by IRRI's plant breeders. Varieties such as IR28, IR30, and IR36 reached maturity in 100-110 days, compared with up to 150 days for traditional varieties.

The second was the dry-seeding of rice. Instead of raising seeds in a nursery and then transplanting them to puddled ricefields in the traditional manner, farmers could plant directly into dry soil in their fields before the rains set in. In this way, they could save labor and plant several days earlier, adding to the advantages gained by using early-maturing varieties.

Bringing forward the harvest date in these ways would, in theory at least, allow farmers to plant and grow another crop—sometimes two extra crops—before the season ended.

This strategy was a vital part of the struggle to end hunger in Asia. While new high-yielding rice varieties could be combined with fertilizers and pesticides to raise yields, increasing the number of crops grown intensified the use of land, bringing about a massive (though one-off) leap in output.

At first, IRRI's scientists applied this strategy mainly to irrigated rice. There were plenty of opportunities for double- or even triple-cropping rice in the high-potential irrigated areas on which the Institute focused most of its early research. Then, as researchers turned their attention to rainfed areas, it became increasingly clear that the strategy both could and should apply to other crops as well. In these areas—and to a lesser extent in irrigated areas too—rice was but one of several important staples, including cassava, sweet potato, maize, and mungbean. Farmers' traditional rotations in both types of system provided ample evidence that these other crops were necessary, whether to make better use of scarce water resources or to ward off pests and diseases or to preserve soil structure and fertility. In addition, they diversified the family's diet and its sources of income, helping to spread risk.

Studying these systems increased scientists' awareness of another important difference between farmers' fields and their own plots on the research station. Farmers grew crops not as sole crops. in the modern Western style, but as mixtures—broadcasting or sowing alternate rows of two or more crops in the same field, either at the same time (intercrops) or with staggered planting dates (relay crops).

These were important perceptions from a methodological as well as a technological viewpoint. Seeing the rice crop as but one among many in a system of interacting components provided the rationale for adopting a cropping system's approach to research. As a single-commodity institute, IRRI was aware of its need for a safety mechanism that would prevent it from "pushing" its commodity at the expense of others into areas or systems to which it was not suited. The Multiple Cropping Program, which had conducted its first on-farm experiments in the early 1970s, signaled its growing commitment to the systems approach by changing its name to the Cropping Systems Program in 1973.

This evolution in thinking was well under way by the time ACSN was formed. Accordingly, intensification and diversification received equal emphasis in its initial statement of objectives. The new network thus had a mandate to test and introduce not just new rice varieties but other crops too, in a range of patterns and mixtures. This was to provide an important impetus to the building of its collaborative relationships, which were to span a wide range of commodity institutes and universities at the national level.

From cropping to farming systems

Bringing in livestock

In Asia, rice is not just a human food. It is also a major source of animal feed, providing straw and bran in addition to grain. The plant breeders responsible for the Green Revolution in rice had un-intentionally downplayed the importance of these residues. It was feared that their short-stemmed varieties, so critical to eradicating human hunger, had reduced the ability of many farmers to provide for their livestock.

Likewise, most of the so-called food legumes used in farmers' rotations were in fact dual-purpose—used to feed animals as well. And among the options for diversifying farming systems, forage legumes beckoned as an attractive, under-researched alternative to food crops because of their ability to benefit soil structure and fertility at the same time as providing a protein-rich feed for livestock. Their introduction would support improved smallholder dairy production, which offered major opportunities to farmers with access to Asia's rapidly growing urban markets.

A further underresearched area was the contribution made by livestock to the crop sector through the provision of traction and manure, both of which constituted important alternatives for smallholders to the use of modern, high-cost inputs.

As these concerns surfaced during the late 1970s, national researchers began to look for international support in their efforts to integrate research on livestock with that on crops. In the absence of a dedicated international focus on livestock in Asia, they turned to IRRI and ACSN.

Commodity research institutes frequently experience tension between the drive of the farming systems group to expand the areas covered by research in the interests of a holistic approach and the more conservative views of the commodity specialists, who wish to concentrate resources on the core mandate of the institute. At IRRI, a concern for the feed value of rice residues when defining breeding objectives appeared legitimate, although it was not always included in the objectives. Research on such areas as animal traction and forage legumes, however, was judged to lie beyond its purview.

Operating outside the orbit of IRRI, ACSN was free of such inhihitions. Discussions on integrating the livestock component began during the 1982 meeting of the working group. A year later, the group took a formal decision to expand activities to include animal production research.

By virtue of being a network rather than an institute, ACSN had been able to respond to an emerging need flexibly and promptly. In both this and other areas, it could build on the strong capacity of individual national institutions in areas for which IRRI had no mandate.

Breaking down barriers

At its 1983 meeting, the working group decided to move into two other new areas of research: agroforestry and rice-fish systems.

Agroforestry was a new name for an age-old practice—that of growing trees and crops together in farmers' fields. As a science, it had been given international recognition only in 1978 with the creation of the Nairobi-based International Council for Agroforestry Research (ICRAF). Research on agoforestry sought to solve the problems of soil erosion and declining soil fertility, at the same time as creating greater self-sufficiency in products such as firewood and building materials. The introduction of multi-purpose trees would also increase income-earning opportunities for the poor.

Systems combining the production of rice and fish were once common in Asia, but had been largely displaced by the advent of modern rice-growing technology, with its vast increase in the use of agrochemicals. Reintroducing such systems offered exciting opportunities to improve nutrition and incomes, as well as benefiting human health and the environment.

The decision to conduct research in these "new" fields showed considerable foresight. It reflected a concern for sustainability and equity several years before these concepts became explicit objectives of the international research community. It also reflected ACSN's determination to play its part in integrating agriculture, forestry and fisheries—sectors often separated at the ministerial level by watertight administrative barriers. It was to be some years before the World Commission on Environment and Development (1987) was to make a plea for moves of just this kind.

"Sectoral organizations tend to pursue sectoral objectives and to treat their impact on other sectors as side effects. Hence, impacts on forests rarely worry those involved in guiding public policy or business activity in the fields of energy, industrial development, crop husbandry, or foreign trade. Many of the environment and development problems that confront us have their roots in this sectoral fragmentation of responsibility. Sustainable development requires that such fragmentation be overcome."

With responsibility for the disappearance of fish from farmers' ricefields laid firmly at the door of the Green Revolution, these words carried special resonance for IRRI. Despite the obvious relevance of rice-fish systems to the Institute's mandate, some of its scientists remained skeptical of their potential for several years after the network had begun its own work on them. Not for the first time, ACSN was able to propel IRRI's research in a new direction.

To reflect its expanded focus, ACSN members decided to change the network's name to the Asian Farming Systems Network. When IRRI's Board of Trustees learned of this proposal it asked that the word "rice" be included in the network's title—a reflection of its concern over the mandate issue. The network thus became the Asian Rice Farming Systems Network, or ARFSN.

Understanding ecosystems

Given the growing importance of the environmental issues surrounding agriculture, the ecosystem provides a more appropriate organizing principle for research than does the commodity.

Put simply, if the notice on the research program door says "Cassava," that program's scientists will tend to measure their achievements narrowly, in terms of increased cassava production. If it says "Humid Zone," they are more likely to conduct research that balances the need to produce more food with the need to prevent deforestation and erosion. Freed from a compulsion to "push" cassava, they will base their research on a more objective assessment of the zone's suitability for a broader range of commodities and uses.

These ideas, commonplace today, had yet to emerge when ARFSN was founded. Yet the network was an "early adopter" of the ecosystems orientation in research, helping to promote this approach throughout Asia and at IRRI.

By the time the network was created, IRRI scientists had identified the four main ecosystems in which rice is grown—the irrigated, rainfed lowland, rainfed upland, and deepwater rice ecosystems. They saw these ecosystems as crucial determinants of cropping patterns and practices, and hence as the basis for analyzing the opportunities for intensification and diversification as well as for breeding new rice varieties.

IRRI and ARFSN's researchers selected the locations for on-farm research as representative of these ecosystems. These key sites, as they were known, served as the launching pad for new technology designed for a larger target area. In several

cases, the sites remained constant as the scope of research expanded, presenting opportunities to integrate efforts across sectors.

ARFSN's successful use of key sites was one among several factors influencing the reorganization of its host institute. By the end of the 1980s, there was a consensus that, for the reasons given above, a single-commodity institute such as IRRI needed a strong ecosystems orientation at the program level. IRRI's new set of programs, inaugurated in 1990, focuses on the four major rice-growing ecosystems of Asia, with a single cross-cutting program to deal with issues common to more than one of them.

Within the rainfed ecosystems, IRRI is now adopting what it calls a consortium approach to building research partnerships. Essentially, this means bringing together partners from different sectors to work in the same location. Although the range of partners sought has broadened, now including NGOs alongside national institution in the public sector, the key site approach to networking taken by ARFSN in the 1980s can be seen as the direct precursor of the consortium model.

Equity issues

Balancing objectives

Like its host institute, ARFSN was intended to benefit resource-poor farmers. This group can be subdivided into two broad categories. Farmers in high-potential areas with reliable water supplies, fertile soils and easy access to markets are often still poor by European or North American standards, but they tend to be better off than more subsistence-oriented farmers in remote areas with poor soils and less predictable rainfall.

Of the two groups, the former is more willing to risk investing in new technology. Research targeted toward this group therefore stands the best chance of promoting large increases in production and hence economic growth. However, the latter group exerts a legitimate claim on research resources on the grounds of equity — the desire that research should benefit the poorer members of society.

In selecting project sites, ARFSN's leaders sought a balance between growth and equity objectives. Some projects aimed to achieve a rapid impact in higher potential irrigated areas; others tackled the more difficult problems of rainfed agriculture, particularly in the uplands and flood-prone ecosystems. The choice of country, or of target area within a country, could also be used as a rough means of deciding whom to benefit. A site in the Hill country of Nepal, for instance, was more likely to benefit poor farmers than one in the fertile Terai plains. Similar discretion could be exercised in the choice of head, middle, or tail reaches of an irrigation system.

Increasing income-earning opportunities

Creating new opportunities for poor people to raise their incomes became an important research objective in the 1980s, complementing the previous emphasis on subsistence.

The development of research on crop-livestock systems enabled ARFSN researchers to try out new enterprises, such as poultry production among underprivileged groups. As we have seen, research on agroforestry and rice-fish systems fulfilled a similar function.

Incorporating gender issues

In 1983, women accounted for an estimated 60-80% of the person-hours devoted to the production and processing of rice and other crops in Asia. Yet their contribution remained invisible in national statistics and largely ignored in both research and development. In some societies, women were not even regarded as farmers.

That same year, IRRI's then director general, M.S. Swaminathan, convened an international conference on "Women in Rice Farming Systems." The conference was a first for the international agricultural research community and took IRRI into the lead in addressing gender issues in agricultural research. One of its recommendations was that IRRI should organize a network on this theme in the Asian region.

The Women in Rice Farming Systems (WIRFS) program was born some 2 years later. The program's aims and operations made it suitable for inclusion in ARFSN. Once again, the network had proved the ideal organizational form for accommodating an important emerging concern in regional research and development.

Conclusion

Throughout its 20 years, ARFSN showed itself both willing and able to adapt rapidly to changing research needs. As an organizational form, the network coped well with the paradigm shifts that have characterized the farming systems approach to research.

A learning experience

A major challenge for ARFSN was to solve the methodological problems surrounding the conduct of on-farm research—to answer the question "How do we do it?"

Developing a conceptual framework

An early achievement was a clear definition of the cropping systems research process and its links with development (see Fig. 2). The phases of the process seem obvious to us today. At the time, they were new concepts essential to the development of a common language and approach among national and international researchers.

The process begins with the selection of a target area—the province or district in which new technology is to be disseminated. Researchers may play a part in this, but the choice rests ultimately with national planners and policymakers, who set the objectives for national development. The target area is then described, using secondary data wherever possible.

Next comes the selection and description of key research sites—the locations where technology is to be developed and tested. These sites must be representative of the target area and its ecosystems. They may also reflect economic and social criteria, such as farm size or access to markets. Logistics too play a part—sites that can be reached easily from the research station lower the costs of research and allow better links with station-based scientists.

At the design phase, scientists formulate a detailed plan of the cropping patterns and varieties or other innovations they will test with farmers. They present their proposals to farmers for discussion with them at meetings. The proposals are based on the characteristics of the site identified.

This leads directly to the testing phase, in which farmers provide the land and labor to tr-out the new technology on their fields, using inputs supplied by the researcher. At harvest, researchers measure the yields and compare them with those obtained using the farmers' traditional system. They also calculate the net gain in farmers' incomes achieved by using the new technology. More detailed studies may be carried out on other factors important in increasing productivity and incomes, such as fertilizer rates, cultivation tech-

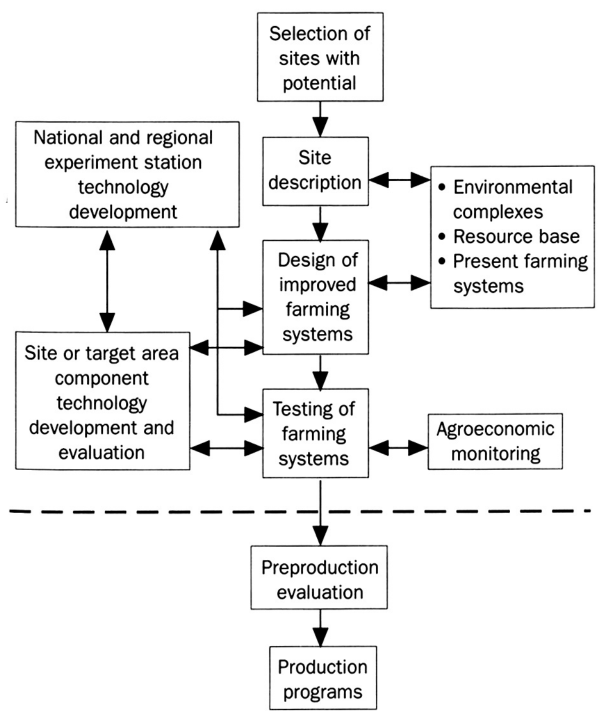


Fig. 2. Conceptual framework for rice farming systems research and extension.

niques. and weeding practices. These studies are known as component research.

Subsequent phases of the process concern the transfer of results from the site to the rest of the target area. In multilocational testing, the hypothesis that the new cropping pattern or technology is superior to the farmer's existing system is tested at a larger set of locations. This prepares the way for a pilot testing program, leading into a full-scale production or development program. During these phases, the resources required to support the adoption of technology—seeds, credit, fertilizer—are marshalled and delivered to farmers. Extension services play an increasingly important role, while researchers limit themselves mainly to monitoring the adoption of technology and evaluating its impact.

Trial and error

In the rush to develop and spread new technology during the early days of cropping systems research, mistakes were macle that would probably not be repeated today. Research on the introduction of a rice - sorghum - sorghum system in the Philippines provides a typical example. Initial results looked promising, with farmers showing rapid adoption in the first few months of field trials, but the new varieties of sorghum ran into trouble after harvest. They did not thresh well when farmers used their traditional manual method—a problem that had been overlooked by scientists, who had carried out threshing mechanically on the research station. Moreover, with their high tannin content, the new plants completely failed the acid test of any new technology—its acceptability to consumers. Plant breeders still considered the sorghum an animal feed rather than a human food and had developed the varieties with scant regard for their cooking qualities, digestibility, and taste.

Such experiences helped to convince scientists of the need for thorough on-farm research, conducting post harvest as well as agronomic operations with full farmer participation. They also showed the importance of interaction between on-farm and on-station research, particularly between plant breeders and social scientists.

The late 1970s saw intensive collaboration between IRRI's Cropping Systems Program and ARFSN as both sets of researchers grappled with the prolems of methodology development. Most of these problems concerned the role of farmer participation in making research more efficient and effective.

Farmer participation

Researchers soon agreed on the value of farmer participation in site description. This lesson was learned the hard way through early experiences in the Philippines, notably in the Cagayan Valley of northern Luzon. Here the climatic data used by researchers had failed to detect the area's susceptibility to severe floods and sudden dry spells. Had they been consulted, farmers might have revealed these conditions. In the event, the only outcome of 3 years of on-farm research was the conclusion that the "promising" early-maturing varieties tested by the project were wholly unsuitable for the target area.

A more difficult issue was the role of farmers in technology design. This remained limited at first, with many researchers arguing that the nature of the challenges faced by IRRI and ARFSN made farmer participation in this phase inappropriate. Averse to taking risk, farmers would not wish to test innovations with which they were unfamiliar, such as new crops and cropping patterns. The early work of the Multiple Cropping Program was thus prescriptive rather than participatory in nature. It used a package approach, recommending whole new systems rather than presenting a range of optional, stand-alone components.

Two early experiences of the network, at sites in the Iloilo and South Cotaboto provinces of the Philippines, helped persuade researchers to adopt a more flexible approach. The rapid adoption of dry seeding together with multiple cropping at these sites had been widely touted as one of the few successes of rainfed agricultural development in Southeast Asia. However, an impact study revealed that adoption was in fact neither uniform (within or across farms) nor complete (in the sense of the full package of practices being adopted). Dry seeding had not been adopted by

poorer farmers with low labor availability, nor by those in drier areas with less predictable rainfall. Farmers had used lower than recommended levels of inputs, halving fertilizer rates and using herbicide sparingly.

The most important lesson drawn from this experience was that farmers experiment with technology just as much as researchers do. They do not adopt whole packages but prefer instead to adapt and modify components according to their resources and needs. This is especially true in highly diverse production systems where the conditions for cropping are unpredictable.

These perceptions marked the beginning of a gradual change in attitude toward farmers' innovations and their role in technology design. While researchers remained confident—unlike some of today's practitioners—that research had something to offer farmers, they became more aware of the potential for transferring farmers' existing practices and more open to the idea of making small changes to the farming system rather than seeking to impose radical new systems.

Another outcome of the Iloilo experience was a change in the way researchers perceived the function of on-farm research. Viewed during the early days as little more than a link between station-based research and extension, research on farmers' fields now came to be seen as a vital part of technology generation, creating a "feedback loop" in what had previously been unidirectional linear process. The results of on-farm research would be useful primarily to researchers in the first instance, and not necessarily to farmers and extensionists.

A further realization was that blanket recommendations to farmers, of the kind frequently made by both researchers and extensionists in the past, were often misdirected. Recommendations had to be better tailored to suit varying sets of conditions within a target area.

Debate on the testing phase centered on who should manage and implement the experiment. On-farm research requires a delicate trade-off between statistical rigor, which can only be achieved through tight control, and the participation of farmers, which implies their freedom to alter treaments as they wish. This problem is still unresolved today. In a recent cattle fattening study in the Phillippines, scientists were unable to detect any differences in performance between farmers in the control group and those following an improved management scheme. Farmers in the control group had wanted to compete with their colleagues and had simply adopted some of their improved practices.

Experience in the late 1970s suggested strongly that trials managed and implemented entirely by researchers did little to foster farmers' sense of ownership of the results, and since this was a key aim of the testing phase, the balance of opinion tipped gradually in favor of farmer implementation. This had the added advantage of making research more economical, since Farmers supplied their labor as well as their land. At most key sites, some trials were not only implemented but also managed by farmers, with researchers restricted to the role of observers.

Other issues that arose during the testing phase concerned the terms of farmer participation and the degree of risk farmers could be expected to bear. It was felt that farmers should not have to pay for the higher levels of inputs used with improved technologies. On the other hand, they were not guaranteed against crop failure. The optimum plot size for testing new cropping patterns appeared to be around 1000 m^2—large enough to attract attention and form a marked contrast with the farmers' traditional system, yet not so large as to make them feel the experiment to be too risky. Farmers were allowed to keep the produce after harvest.

Besides studying farmers' modifications to introduced technology, scientists learned to spend part of the evaluation phase looking out for indigenous solutions. This was particularly important if the introduced technology was not proving as popular as hoped with farmers. Thus, in one network project, researchers searching for a cure for erosion turned to the use of grass contour strips—a simple low-cost solution devised by farmers—when their own more complex hedgerow intercropping system failed to appeal (see page 25).

Other issues

The need to understand farmers' production systems before attempting to intervene in them was a basic tenet of farming systems research. In the early days, large and elaborate surveys were used for this purpose. These were expensive in both time and money, often amassing data that were never properly analyzed. One international scientist, presenting a graph of household labor allocations at a meeting back in the 1970s, is alleged to have boasted that the graph represented 150,000 data points. Cost considerations rule out such an approach today. The past 2 decades have seen a shift to the use of shorter, less formal survey techniques such as rapid rural appraisal as donors and government have increased the pressure to produce results more quickly.

An important principle to emerge from experience with production programs was that a system approach should apply just as much to the transfer of technology as to its development. Extension is not the sole requirement for successful transfer, but simply one among a range of ingredients such as the provision of credit, adequate infrastructure, good pricing policies, and so on. Consequently, links with policymakers began to assume growing importance for research managers.

Synthesis

In the early 1980s, IRRI published the manual. *A methodology for on-farm cropping systems research* (Zandstra et al. 1981), which distilled all that the teams working at ARFSN and IRRI research sites had learned over the previous decade. The manual takes the reader through the various phases of research, providing background information, basic concepts, specific guidelines, and some useful tools.

On publication, it was distributed to all network participants. Fifteen years later, it is still being widely used throughout Asia.

While ARFSN had succeeded in defining the methods for cropping systems research, those for on-farm livestock and agroforestry research proved more elusive. These fields are intrinsically more complex. with the result that standardized approaches are more difficult to establish. Moreover, ARFSN scientists lacked technical support from IRRI in these areas, which lay beyond its mandate

On farmers' fields: the network in action

In the course of research spanning 20 years at more than 50 sites in Asia, ARFSN scientists studied the problems of Farmers and worked with them to find solutions. This chapter presents some of their work.

Intensifying and diversifying crop production

Designing and testing technology to intensify and diversify crop production in Asia was one of the two major tasks for which ARFSN was originally established. To fulfill it, the network organized research at key site representing the region's major rice-growing ecosystem: irrigated systems, rainfed lowlands, rainfed uplands, and flood-prone systems.

"Participation in network activities has had a great impact on the growth of crop production in Myanmar."

—**U Tin Hlaing,** deputy minister of agriculture
Myanmar

"The RDA-ARFSN collaborative farming systems approach has had a tremendous impact on the practices of rice cropping farmers and greatly influenced the research directions of RDA...We greatly appreciate the contribution of ARFSN to the advancement of Asian rice farming."

—**Young Sang Kim.** director general
International Technical Cooperation Center,
Rural Development Administration
Republic of Korea

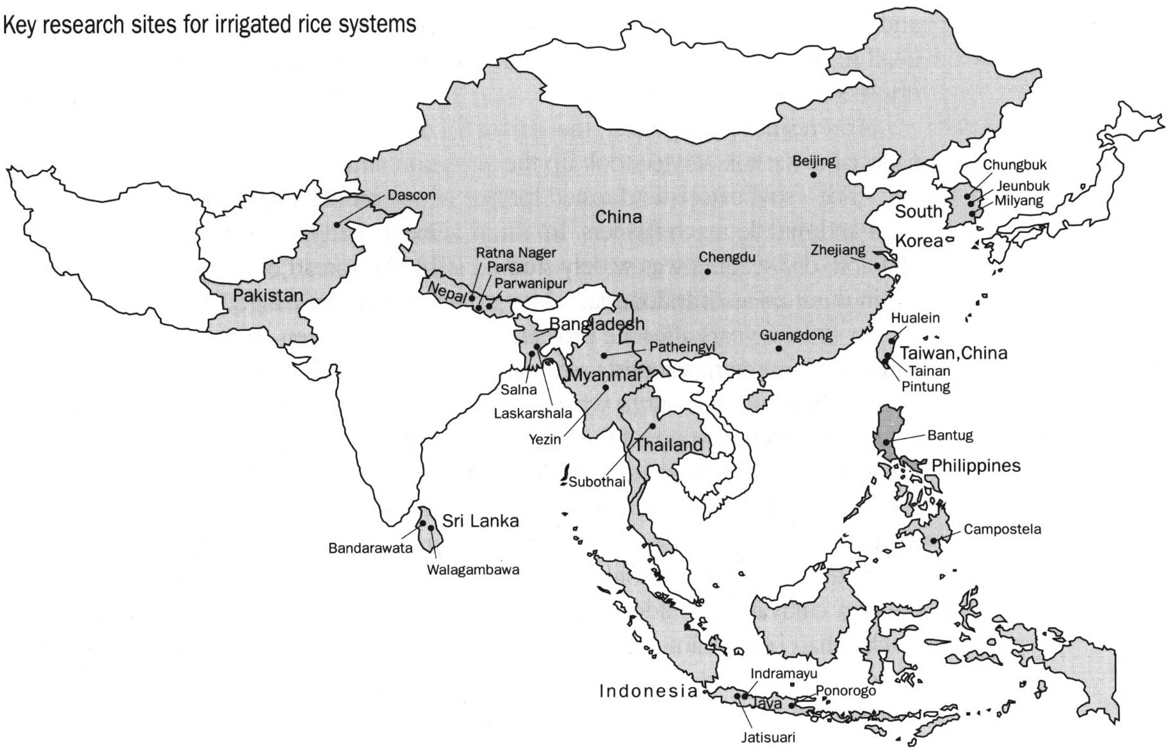
Irrigated systems

Approximately 55% of the world's rice is irrigated. Cropping intensity and farmers' incomes are generally higher in irrigated than in rainfed areas. The key factors at work are year-round access to reliable water supplies and effective control of water.

However, these factors do not apply universally. Farmers at the tail end of irrigation systems are often deprived of their fair share of water by wasteful users upstream. Growing numbers of irrigation systems are experiencing chronic water shortages as industrial and domestic' demand increases. In the Philippines, an estimated 70-80% of the country's irrigated area no longer receives sufficient supplies during the dry season to grow a second rice crop

Indonesia: rice production doubles
One of ARFSN's most successful projects was in the densely populated Indramayu area of West Java. Here rice production doubled in less than a decade, owing to the combined effect of increases in cropping intensity and yield. The area devoted to growing a

Key research sites for irrigated rice systems



dry-season crop grew by 13,000 hectares.

Scientists from Indonesia's Central Research Institute of Agriculture first arrived in the area in 1975, when they selected sites in the Rentang and Jatalihur irrigation scheme to conduct on-farm research on new crop varieties and cropping patterns.

In the course of site characterization, the scientists divided the scheme's command area into areas with irrigation water for 10, 7, and 5 months of the year, representing the head, middle, and tail reaches respectively. In the middle and rail reaches, the percentage of farmers planting only a single rice crop during the year was higher, reflecting their scarcer and less reliable water supplies.

Figure 3 shows the cropping patterns introduced by the project. The scientists decided to try out dry seeding for tail reach farmers, for whom early harvesting of the first rice crop was critical if the second and/or third crops in the pattern were not to fail.

The farmers tested these patterns on their fields over a 3-year period. The results clearly reflected the inequitable distribution of water. The highest rice yields were obtained from the transplanted rice - rice - soybean system, which was widely adopted by farmers in head reaches. In these areas, the continuing availability of irrigation water following the first rice harvest allows farmers to transplant their second rice crop (walik jerami) without further land preparation, increasing turnaround times markedly and so boosting subsequent harvests. At US$ 1,242, farmers' incomes for this pattern were substantially higher than for any pattern tested in the middle and tail reaches. The highest income in a tail reach was US$524, obtained from dry seeded rice - rice - cowpea.

As a result of the project, the national extension service took up the rice - rice - soybean pattern tested for head and middle reach farmers. In addition, dry seeding was widely studied in other areas of Indonesia.

In 1984, 6 years after the project had ended, network scientists returned to the scheme to find out to what extent farmers had adopted the technologies tested. They found that farmers in all reaches had gradually intensified their cropping patterns. In 1975, before the project began, only 21% of the area cultivated in middle and tail reaches had been planted to two crops of rice a year, and no land had been triple-cropped in 1984, 46% of the area was double-cropped and a further 18% was planted to three crops. The area planted to a single rice crop had fallen from 64 to only 27%.

Improvements in cropping intensity and yield had doubled rice production and increased dry-season cropping by more than 33%. These improvements had been made possible partly by the spread of early-maturing varieties and partly by quicker turnaround times between crops, caused by the introduction of tractors. In middle and tail reaches, the use of dry seeding had also contributed. However, once tractors became available, farmers had been able to dispense with dry seeding as their turnaround times improved.

This project demonstrated the effectiveness of IRRI's new technology in improving farmers' livelihoods. But it also revealed the important effect of water distribution the cropping patterns farmers can adopt and hence on their incomes.

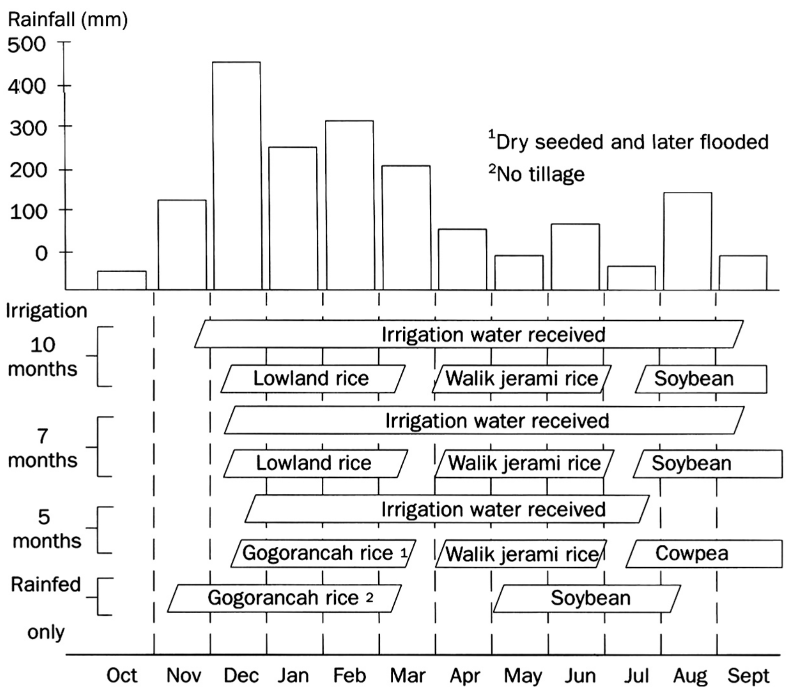


Fig. 3. Rainfall distribution and introduced cropping patterns at Indramayu, West Java, Indonesia, 1975-78.

The Philippines: fine-tuning technology

Farmers adopting new technology often need the assistance of researchers in finding out what management practices lead to the best results. This is particularly true when new crops are introduced. The cropping systems approach adopted by ARFSN, combining detailed component research with the testing of cropping patterns on farmers' fields, proved admirably suited to this task.

In 1984, ARFSN launched a project in the village of Bantug, Nueva Ecija, Philippines. Bantug lies in the service area of a tubewell. Farmers in this area classify their land as *turod,* which is slightly elevated, with soils that are lighter textured and more easily drained, or *lungog*—lower lying land prone to more prolonged waterlogging, with heavy soils. Farmers generally grew a single rice crop on turod land, whereas lungog land was more often double-cropped. The average number of crops a year grown at the site before the project began was only 1.4.

The project's scientists designed two new cropping patterns for the site—one each for lungog and turod areas. For the higher lying turod areas, they recommended rice - maize - mungbean, using the new early-maturing IR42 varierty of rice and modern high-yielding hybrids of maize suitable for use as feed grain.

Maize was a new crop to farmers, who were unaware of its agronomic requirements. At first, they did not allow their fields to dry out sufficiently before tilling them. The use of local implements on wet soils meant that large clods were not broken up, with the result that the seeds could not be properly covered. Other problems were drought in fields too far from the pump and waterlogging in fields close to irrigation ditches or adjacent to flooded ricefields.

The scientists responded to these problems with intensive component research. They found that the high moisture losses from tilled soils meant that it was better not to till at all when planting maize by hand. Mechanized planting, using an invented T-seeder or a plow seeder developed by IRRI, did not seem to offer any great advantage over manual seeding. The drought problem could be overcome by increasing the frequency of irrigation. Dibbling fertilizer after emergence, rather than applying it in the furrow at planting, increased yields dramatically.

Maize yields increased steadily as farmers became more familiar with the crop. The best yields, of around 6.9 t/ha, were obtained using more frequent irrigation (five or six times in the season) and higher rates of nitrogen application at 80-120 kg/ha. By 1987-88, average yields were 5.6 t/ha.

The net income from the rice - maize - mungbean pattern was US$1130/ha—a mammoth 600% increase over the income from a single rice crop and 200% higher than from rice double-cropping. Over the 4 years of the project, the benefit-cost ratio was 2.59. That is, for ever· extra peso they spent, farmers gained 2.59 pesos.

A fitting side-effect of the improved system was a sharp increase in the percentage of farmers paying their irrigation fees. Farmers growing maize could afford to do so, whereas those growing rice alone could not.

Because of the initial problems they experienced, project farmers did not immediately expand the area they devoted to maize beyond the 1,000-m^2 trial plots. But once component research had solved the problems, rates of adoption rose quickly. From an original 1.2

ha, the area devoted to maize rose to 10.8 ha in 1988-89, then doubled to 20.5 ha the following year. With the aid of a new credit scheme, production is now spreading beyond the research site.

The scientists used a geographic information system (GIS) to identify other areas in the province where rice - maize and rice - maize - mungbean could be introduced (see page 47). Nearly 80,000 ha were defined as highly suitable for the new patterns.

Rainfed lowlands

About a quarter of the world's rice area consists of rainfed lowlands. Yields are lower and less stable than in irrigated systems, and farmers tend to be poorer. Designing technologies for rainfed systems is more difficult than for irrigated systems—and fewer improved technologies have been adopted by farmers.

Rainfed lowland areas may be loosely divided Into those considered favorable and unfavorable. Favorable areas are those having at least four consecutive wet months in a year.

The Philippines: the need for stability

Drought-prone during the dry season and flood-prone during the rains, when it is frequently visited by typhoons, the Tumauini area of Isabela Province in the Philippines typifies the less predictable and sometimes extreme weather conditions faced by farmersin the unfavorable rainfed lowlands.

At the start of ARFSN's project here in 1983, farmers derived most of their food security and income from maize. They also grew a single rice crop, which they established in the traditional way, by transplanting.

The scientists throught they could introduce two cropping patterns that had been successfully tested elsewhere—mungbean followed by dry- seeded rice (DSR), and DSR followed by wet-seeded rice. (When rice is wet seeded, the land is prepared and flood-ed as normal, but instead of transplating, farmers broadcast pregerminated seed directly onto the puddled wet soils.)

The technology looked promising in on-farm trials. A farmer's annual income from a single rice crop was US$378/ha. The mungbean - DSR pattern increased it to US$444, while the rice double-cropping system more than double it, to US$907.

Encouraged by these results, the researches teamed up with the extension service to implement a pilot production program in the province's Tumauini, Upi, and Gamu areas. Once again, the results were highly encouraging. In Tumauini, the returns to investment w ere 140% for mungbean - rice and 120% for rice - rice.

Key research sites for rainfed lowland systems

However, an impact study conducted in 1989-91 revealed lower than expected productivity levels and cropping intensities on farmers' fields. The on-farm trials and multilocation testing had coincided with a period when weather conditions had been reasonably favorable. But with the return of less predictable conditions, namely, late onset of rainfall and drought, the technology had proved insufficiently stable to earn widespread acceptance. Predictably, farmers who had adopted it were those best placed to take risks—the medium- to large-scale farmers with higher incomes.

The study concluded that, until researchers were able to make the improved system more stable, maize would remain the primary source of income for farmers in the region. As in northern Luzon, the project had provided an object lesson in the need for more careful site characterization, involving farmers rather than relying on climatic data alone. It had also shown just how difficult it is to devise technology that will benefit the poorer segments of the farming community.

Thailand: targeting resource-poor farmers

Thailand is usually considered one of Asia's success stories. Political stability, good economic policies, a thriving agricultural sector, and a surge in tourism have combined to bring income growth rates of 7% or more over the past 20 years.

But, as so often happens when growth occurs rapidly, many of the poorest have not benefited. In the remote, predominantly rural Phayao Province, household income still averages only US$636 a year—just over half the average for Thailand as a whole. The majority of the province's aging rural population is engaged in rainfed farming. Yields are dogged by unreliable rainfall and poor soils. Floods or droughts occur every 2 years.

ARFSN's project in the province began in 1983, when scientists from the Farming Systems Research Institute selected two sites for on-farm research. One was in the village of Amphoe Dok Kham Thai, which suffers from Severe drought. Farmers in this village cannot even be sure of one rice crop a year. A second, somewhat more favorable site was chosen in another village, Amphoe Mae Jai, Farmers here are able to grow crops such as garlic or soybean on lower lying land in the dry season. In upland areas, the most common cropping patterns are maize as a single crop or maize followed by mungbean.

The scientists designed two new cropping patterns for Amphoe Dok Kham Thai and six for Amphoe Mae Jai. After 2 years of testing, mungbean - rice emerged as the most promising pattern for both locations. This pattern was recommended for multilocation testing, which took place in Phayao and Chiang Rai provinces in 1985-86, after which a pilot production program covering four provinces was launched.

During the pilot production stage, mungbean - rice was adopted on more than 58 ha in Phayao Province. By 1991, this had expanded to 1607 ha. Throughout this period, the average yield of mungbean remained low—around 0.3 t/ha. The only farmers obtaining larger yields were those cultivating small plots, which they were able to tend better.

These low yields meant that the net income advantage of the new system was also low—only about US$69 over the traditional system. Nevertheless, most farmers continued planting mungbean because it brought them other benefits. These included improved soil fertility, higher rice yields, and easier land preparation.

DSR, which had given good performance at the testing stage. also performed wel1 in multilocation trials, leading to higher yields at all locations. As is typical for this technology. adoption fluctuated greatly in response to rainfall: when rains are plentiful farmers play safe, resorting to their traditional practice of transplanting. Adoption rates increased somewhat when an improved mechanical seeder became available. Predictably, the main disadvantage of dry seeding was that it led to more weeds in the rice crop.

> "Thailand owes much of its progress...to the member countries, and we hope to exchange more information and material among the group."
>
> —**Yukti Sarikaputhi,** director general
> Department of Agriculture, Thailand

Despite their aversion to taking risks. farmers showed enthusiasm for the project and a determination to better their lot. They frequently took the initiative in obtaining and testing new technology, and also experimented to adapt and improve it. One farmer traveled more than 600 km to Kasetsart University in Bangkok to buy Khampaengsaen mungbean varieties, which he had found to be better than the Utong 1 variety supplied by the research term. A group of farmers organized themselves to buy their own thresher, since the one introduced by the research team did not work well. Most farmers tried several different ways of controlling weeds. They found thorough land preparation and the alternate use of dry seeding and transplanting to be effective.

An impact study confirmed the difficulty of introducing technology to benefit the poorest members of society. It revealed that adopting farmers generally had larger farm and higher incomes than nonadopters. Thirty percent of adopters had savings in the bank. compared with only 20% of nonadopters.

Rainfed uplands

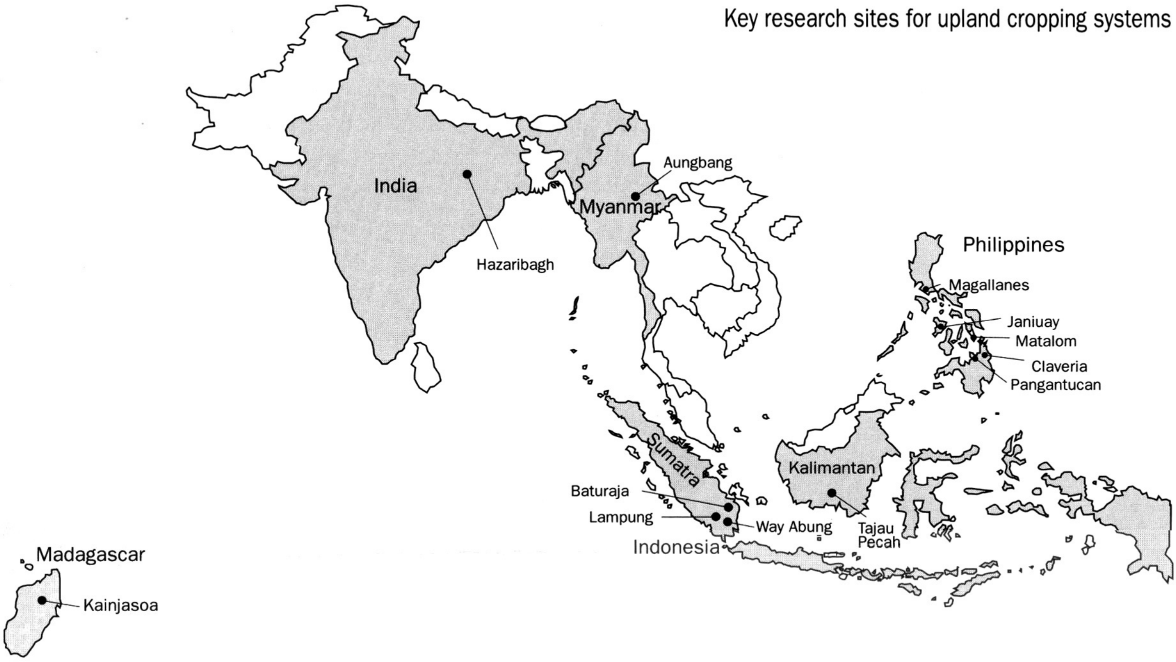
Farmers worldwide grew about 17.3 million hectares of upland rice in 1991—more than 10 million of them in Asia. Yields were very low, averaging 1 t/ha or less. Most farmers still grow traditional varieties without using chemical inputs.

Many of Asia's poorest farmers live in the uplands. Their farming systems are highly diverse, with tree products and livestock often playing as important a part in family Farm income as annual crops. Rice is grown mainly in association with other crops such as cassava, maize, sweet potato, and mungbean. Soil erosion and declining fertility can be major problems.

Upland rice areas are often mountainous, with a high percentage of steeply sloping land. They do, however, vary in altitude, from highlands of 2500 meters to gently sloping areas only a few meters above sea level. The defining feature is not altitude but the fact that rice grows on well drained soils free of standing water.

The Philippines: transferring farmers' innovations

Imperata cylindrica (cogongrass) is known to most researchers and farmers as a pernicious weed. But farmers at Matalom, Leyte, Philippines, see it differently. Grown in grass strips along



the contours in the traditional upland rice-coconut cropping system, it helps to control erosion while providing a low-cost livestock feed

Researchers at the site first noticed these uses of the weed during a baseline survey conducted in 1987. The survey, by a team from the Visayas State College of Agriculture, drew attention to the area's high rainfall and many sloping fields, with the consequent risks of erosion and declining soil fertility. It also noted that around 35% of farmers a ready practiced some form of erosion control, many of them using *I. cylindrica*.

The researchers' first response was to design and introduce a hedgerow intercropping system. They asked farmers to rank 102 tree and shrub species for their suitability for livestock feed, mulching, and erosion control. The farmers selected *Leucaena leucocephala* (ipil-ipil) and *Gliricidia sepium* as promising species for all three purposes,

This system proved a failure when it was tested on farmers' fields. Farmers found the management of *L. leucocephala* and *G. sepium* too labor-intensive and decided to omit them. They soon reverted to what many of them had been doing already—simply allowing *I. cylindrica* and other weeds to form a perennial grass strip along the contour.

The experience transformed the project's approach. The scientists gave up trying to transfer a package of innovation from elsewhere and began instead to look for single innovations from within the existing system that would provide farmers with a range of simple. low-cost options.

Some farmers were observed growing the perenial grass vetiver (*Vetiveria zizanioides*) to hold the soil along the dike of lowland fields. In 1990, the team asked 10 other farmers to test the adaptability of vetiver to upland acid soils. Farmers visiting the project were shown slides of the grass and taken to the trial area. Those interested were supplied with seeds. By 1993, more than 100 farmers were using vetiver with other species in contour strips.

One farmer, in Altavista village, had invented a new cropping pattern. He intercropped maize with rice bean (*Vigna umbellata*), a legume that accompanies maize well without competing with it. The researchers provided a further eight farmers with seeds of both crops so that they could evaluate this innovation. The new pattern was an instant success, spreading to more than 100 farms by 1993.

The difficulty of creating modern technologies that are superior to traditional ones had first become apparent when the researchers tried to introduce new upland rice varieties. The most popular local variety is Lubang, a tall-growing late-maturing red rice that cooks well and is delicious. Under the low levels of fertilizer application likely to be used by local farmers, Lubang outperformed 744 other upland rice lines from IRRI's collection. In some trials, it even performed as well as improved varieties when moderate amounts of fertilizer were used. Lubang is well adapted to the acid soils typical of the uplands.

Further confirmation came when the team tried to relieve the drudgery endured by women Farmers when they weed crops. In Matalom, women provide at least half the labor for weeding upland rice and well over half for weeding other crops. They use a traditional weeding tool that requires them to squat. The researchers asked the women to test several new types of tool, including a light pull-type hoe without teeth. This reduced the time taken by 28%. However, neither it nor the other introduced tools eliminated the weeds completely, whereas the traditional tool did. Not surprisingly, when the women ranked the various tools, the results showed that they preferred the traditional one.

The researchers were able to score one success, however. One of the most labor-intensive tasks in Matalom is the pounding of rice, which is done by women and children using a pestle and mortar. To ease the task, a micro rice mill dev eloped by IRRI and the Philippine Rice Research Institute was introduced and evaluated through the local women’s association (see page 43). Use of the mill reduced the time spent pounding from 26 minutes to under 2 minutes/kilogram. The recovery of rice grain was higher than with hand pounding, and the mill gave finer rice bran—better for feeding to animals. The women agreed that the mill was a worthwhile investment and have been making full use of it ever since.

India: combating drought

The village of Meru near Hazaribagh, lies in the hilly uplands of Bihar—one of India’s poorest states. Its population of 6000 is a mix of different ethnic and religious groups, mainly Mahato and Muslim, but also several others. Pressure on the land is extremely high. Nearly 50% of the population are landless agricultural laborers, and 36% of the farms are less than 1 ha in size. Landholdings are fragmented, tyically consisting of four to five plots scattered in different parts of the village.

Drought is the major problem facing farmers. Its causes are complex. Erratic rains with long dry spells between them are the main factor, but the low water-holding capacity of some soil types and high weed infestation also play their part. Runoff is high on steeper slopes—and this also causes erosion.

Attempts to sink wells are fraught with risk. The costs are high, water tables are deep—and the unlucky speculator is as likely to hit solid rock as a reliable water supply. Social and economic factors compound the difficulties. The small size and fragmented nature of landholdings make investment in a well unprofitable for the individual owner. With many ethnic groups unwilling to work together, building canals to connect unirrigated areas to wells owned by higher caste people is out of the question. Forming a cooperative of neighboring farmers to share investment costs and management tasks is equally impossible. Credit is sometimes available from the wealthier members of society, but only at extortionate interest rates.

The inhabitants of Meru must look elsewhere for solutions to the problem of water scarcity. Thanks to a network project of the Central Rainfed Upland Rice Research Station, they are now able to do so. Project scientists and farmers explored two alternatives—water harvesting and improved crop management.

Water harvesting—Starting on two farms in the neighboring village of Handio, the scientists persuaded villagers to dig ponds and build valley check reservoirs—dams that block small valleys. Some 16 structures of either kind were completed in the course of a single summer, using family and communal labor.

Farmers put the extra water to good use, increasing their cropping intensities from under 100 to 160% on the upper slopes and from 150 to nearly 250% on lower lying land. Many farmers planted vegetables during the dry season, boosting cash incomes considerably. Some planted tomato during the summer rains. Besides increasing cropping intensity, the irrigation water stabilized the yields of rice and other staple food crops during the main cropping season.

The new water supplies prompted three farmers to start raising fish. Others began applying animal manure to their dry-seasson vegetable crops—a practice not followed previously because the returns to traditional crops did not justify the labor required to collect dung from distant grazing lands. Some farmers also began to stall feed their livestock. thereby eliminating the collection problem altogether.

Crop management—Drought cannot be overcome—no one can compel the skies to open—but it can be circumvented. That is, its worst effects can be avoided or at least mitigated through judicious management. Understanding the pattern of drought is the first step.

Thanks to the efforts of the Indian Meteorological Department, Hazaribagh is fortunate in having accurate meteorological records dating back over a long period. Using these records, scientists analyzed the timing, duration, and severity of drought in the region over a 75-year period, from 1913 to 1987. They also conducted a detailed analysis of the main cropping season in each year over the most recent quarter century.

The scientists begin by defining three 7-week periods termed as the initial, intermediate, and terminal stages of rice growth. They then calculated the mean dates at which the monsoon began, its average duration, and the probability of drought during each growth stage.

They found that the monsoon normally began on 18 June, but that the starting date caried considerably, from 2 June to 6 July. Dates on which the monsoon ended ranged from 9 September to 28 October, with the most likely date being 11 October. There is a 99% probability that at least 666 mm of rain will fall during this period—harely enough to grow a rainfed rice crop. Almost 90% of monsoon rain falls between 18 June and 9 October, a period of under 4 months. This makes the season a short one, especially if farmers are growing traditional long-duration varieties of rice, which may take up to 150 days to mature.

An average 10.4 weeks during the rice-growing season were without rain. Of these, 3.8 weeks occurred during the initial youth stage, 2.0 weeks during the intermediate stage, and 4.6 weeks during the terminal stage. Even in years of plentiful rainfall, up to 4 rainless weeks could occur during the season.

The crucial finding was that drought is more likely during the initial and terminal stages of growth than during the intermediate stage. The effect of drought at these stages can be a1tered by manipulating sowing dates and selecting shorter duration crop varieties.

Farmers normally start preparing their land for sowing rice in the third week of June, once they are sure the monsoon has set in. In years of continuous rain, this leads to delayed sowing and a waste of soil moisture, as the soil may by then be too wet to work. In these years, the rice crop is more likely to suffer from terminal drought.

The scientists tried dry seeding on 7 June, before the onset of steady rains. They used early-maturing upland rice varieties RR167-982 and RR165-1160, comparing these with traditional varieties such as Brown Gora and Kalinga III. They obtained significantly higher yields from the early-maturing varieties.

Predictably, however, dry seeding incurred another problem—that of weeds,which emerged with the first showers of rain, at the same time as the rice crop. Some farmers lost an estimated 77% of their rice crop to weeds.

Research is continuing on various agronomic practices for dealing with weeds. The most encouraging results so far have been obtained by sowing in furrows, which has the additional advantage of beiing a further technique for avoiding drought. Seeds placed at a depth of 3-5 cm are better able to survive a dry period because the upper 5 cm of soil dries out quickly but the subsoil retains moisture far longer. Sowing in furrows also protects seeds from birds and requires lower seeding rates than broadcasting.

Several farmers in the study villages have now switched from broadcasting to furrow sowing. They have also modified the traditional plow, removing its iron shear so as to open up shallower furrows, of only 5-6 cm depth. The improved cultivar RR167-982 is gradually gaining acceptance, and farmers are bringing forward their planting dates.

Flood-prone systems

Farmers in South and Southeast Asia grow approximately 10 million hectares of flood-prone rice, which is about 18% of the world's total. There are three kinds of such rice: deepwater rice, tolerating depths of 50-100 cm; floating rice, found in water up to 400 cm deep; and tidal wetland rice, which can survive submergence in salt water for short periods.

The area devoted to flood-prone rice is gradually decreasing in most countries, as the control of water im proves and farmers modernize their production systems.

Vietnam: helping farmers to modernize

The Mekong Delta of Vietnam is a huge area of swamp and waterway. Its two main products are fish and rice. Both have been a way of life for the region's inhabitants for centuries. But nom farming systems in the delta are changing. Water control is improving as the government constructs new canals, leading to a rapid decline in the area of traditional flood-prone rice. In its place, farmers are planting new, early-maturing high-yielding varieties. Increasingly, they are able to grow two or more crops a year instead of the traditional one.

Thanh Thang Village, in Thot Not District, lies in the middle of the Mekong Delta. Farm size around the village has reduced rapidly in recent

years, and 30% of the farms are now under half a hectare in size. As farms become smaller, cropping intensity increases. About 37% of the district's rice area is grown to one rice crop a year, 57% to two crops, and 5% to three. When two rice crops are grown, farm-

ers plant before and after the months in which floodwaters are deepest (September to November).

Rice is so important in the Mekong Delta that it has a special regional institute devoted to it. In 1980, scientists from the Cuu Long Delta Rice Research Institute selected Thanh Thang as a site for ARFSN's on-farm research project. The aim was to evaluate the area's existing highly productive cropping patterns for their potential use elsewhere. These patterns included rice - rice, groundnut - maize/deepwater rice, rustic tobacco - maize/deepwater rice, and groundnut - kenaf. In addition, one new pattern, groundnut - rice, was tested.

The reasons why farmers switch from deepwater rice to modern varieties were plain to see. Modernizing their systems brought in a harvest of 4 t/ha or more, twice if not three times a year, whereas the traditional single deep-water crop normally yields about 2.5 t/ha. However, it remains to be seen whether the intensified system is sustainable in the long term.

The study found that farmers who had modernized used high levels of chemicals on all their crops. Levels of nitrogen ranged from 227 to 382 kg/ha. Pesticide use, at 4.23-7.71 kg ai/ha. was alarmingly high. An early recornmenciation of the project was to introduce integrated pest management, enabling farmers to reduce these levels.

To see if they could improve still further on farmers' yields, the team tested several new rice varieties. A variety called OM90-2, developed at the Cuu Long Research Center, broke through the 5-ton barrier in the preflooding period, while still yielding a respectable 4.5 t/ha in the second season.

Several modern technologies used by farmers were documented and recommended for use elsewhere. They Included rice double cropping with improved varieties and the use of maize and other nonrice crops as a relay crop with floating rice.

India: intensifying land use

Eastern India has approximate 2.06 million hectares of and that is deeply flooded during the monsoon season from July to November. Until recently, this land was used almost exclusively for a single crop of deepwater rice yielding less than 1 t/ha. When the floodwaters receded during the dry winter season, the fields remained fallow.

In 1989, a term from the Narendra Deva University of Agriculture and Technology launched a project at the village of Ghagraghat, in Uttar Pradesh. The scientists began by introducing improved varieties of deepwater rice. When accompanied by simple improved management practices such as increased fertilizer application and timely sowing, these led to signiticant field gains.

The highest yields of rice were obtained by sole cropping, but when deepwater rice was relay cropped with maize, farmers' incomes rose to a new high of US$177/ha. The relay cropping system also appeared more stable than the sole rice pattern, since it was unlikely that both components would fail.

Next the scientists turned their attention to the underexploited winter season fallow. The land dries out rapidly once the rice crop has been harvested, so the period in whisch a further crop can be grown is short. For this reason, the scientists decided to broadcast the third crop immediately after the rice harvest, without recultivating. They tested linseed, lentil, mustard, and sesame. The maize + rice - linseed pattern produced the highest net income, which was US$326 ha.

Finally, the scientists added fish to the system. A stocking density of 6,000-10,000 fingerlings per hectare of various species, including catla (*Catla catla*), *Labeo rohita,* and *Crrhinus mrigala,* produced an additional net return of US$l67/ha.

Moving out of rice

As the Green Revolution gathered momentum, most Asian countries became surplus rice producers. Many of them introduced policy measures to persuade farmers to diversify out of rice into other crops. In Taiwan, China, and Bangladesh, ARFSN supported government programs to this end.

Taiwan's program was one of the most successful. The country was one of the first in the region to experience a rice surplus as incomes rose and consumption declined sharply in the early 1980s. In 1984, the government launched a 6-year ricefield conversion scheme. This scheme had a research component in which promising alternative cropping patterns were tested and demonstrated in different regions.

In the decade to 1992, total rice production fell by 35%, while the area devoted to upland crops rose more than tenfold, from 10,500 to 127,600 ha. Large areas of rice were replaced with maize, sorghum, vegetables, fruits, and flowers. The new cropping patterns saved water, improved soil fertility through the use of legumes, and reduced the incidence of diseases and pests in the rice crop. The program also had a useful knock-on effect in increasing the demand for agricultural machinery, which can more easily be used for nonrice crops. The government set up 393 upland crop mechanization centers to help farmers mechanize.

Varietal selection and testing

Soon after it was founded, ARFSN started evaluating the germplasm of nonrice crop for its compatibility with rice. This activity was impoetant for developing new cropping patterns. It complemented the work of ARFSN's sister network, the International Network for the Genetic Evaluation of Rice (INGER), which fulfilled a similar function in rice.

Over the years, ARFSN built strong links with leading national plant breeding institutes in Asia. Institutes that had previous operated only at national level began to assume a regional role. Next door to IRRI, the Institute of Plant Breeding (IPB) at the University of the Philippine Los Baños supplied genetic materials for mungbean, soybean, and groundnut. The Thailand Field Crops Research Institute (FCRI) and the Indonesian Central Research Institute for Food Crops (CRIFC) also provided materials.

Collaboration at the international level was no less inportant. Materials for cowpea and soybean were supplied by, the International Institute of Tropical Agriculture from its headquarters in Ibadan, Nigeria. The Asian Vegetable Research and Development Center (AVRDC), based in Taiwan, provided improved mungbean and soybean varie- ties. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), near Hyderabad in India, collaborated in the screening of pigeonpea, groundnut, and sorghum lines. Maize varieties from the International Maize and Wheat Improvement Center (CIMMYT) in Mexico were evaluated by several countries. IRRI contributed to these efforts by multiplying the seeds of elite lines and cultivars and sending them to network collaborators.

Through these links, the network was able to make a strong contribution to the exchange of genetic material in South and Southeast Asia. Between 1982 and 1990, more than 1,700 sets of various nonrice crops were distributed to 15 collaborating countries in the region. Pooling the genetic resources of national and international institutions provided a powerful stimulus to the development of improved cropping patterns.

Several countries released new varieties as a result of these efforts. Countries lacking in critical mass to breed their own varieties of specific crops benefited especially, receiving promising materials developed by their colleagues in stronger national programs. Progress was most noticeable in food and dual-purpose legumes—an area that had not received priority in the past because the lion's share of most countries' limited resources had been devoted to the staple food grains.

In some cases, national breeding programs were reoriented to identify or develop varieties. that fit into a cropping system rather than simply performing adequate as a single crop. The chief characteristic of interest here was early maturity. since crops raised in a sequence must often be grown and harvested within a sharply defined period. Any delay infringes on the needs of the nest crop in the cycle. The pursuit of early maturity in mungbean, soybean, and groundnut received fresh impetus through ARFSN, whose participants were

Making Wheat Worthwhile

RICE – WHEAT PATTERNS are extremely important in the high-potential irrigated systems of Pakistan, India, Bangladesh, Nepal, and China, where both crops are part of the staple diet and, in some cases, significant export commodities. These countries participated in an ARFSN project to test an improved rice - wheat pattern combining inputs from INGER, India, and the International Maize and Wheat Improvement Center. A common problem in the traditional version of the pattern is that the wheat tends to be planted late because the rice harvest is delayed.

Combined with the introduction of zero tillage to reduce turnaround times, the shorter-duration rice varieties distributed through the project made wheat a more reliable crop for farmers to grow. In the Shakhot area of Pakistan, for example, wheat yields rose by 32% to 2.5 t/ha when Basmati 385, a new early-maturing rice variety, was introduced, allowing sowing dates to be brought forward by 16 days. Yields of rice also increased, and the net returns to the whole system went up by 7% or US$40/ha.

also able to confirm to IRRI's own scientists that the early-maturing rice varieties distributed through INGER were effective.

At both international and national institutes, some breeders had been slow to realize that most upland crop are not monocropped but intercropped—grown in the same field and at (more or less) the same time as other crops. Intercropping requires special attention to the timing of a crop's establishment—too early or late. and it may steal light, nutrients, and moisture from its companion or successor. Rooting behavior and the habit of the crop—the shape into which it grow—are also important, for similar reasons. This too is an area that ARFSN was able to influence, promoting breeding programs for coconut-based intercropping systems in the Philippines, for maize- and rubber-based systems in Vietnam, and for maize- and cassava-based systems in Indonesia.

ARFSN also promoted a new emphasis on the value of the crop reside for animal feed. This applied to both cereals and food legumes. Breeders at IRRI began once again to develop medium-height rice varieties, instead of the dwarf varieties characteristic of the Greaan Revolution. The network also succeeded in increasing the attention paid to the special needs of the rainfed lowlands, which have different soil conditions than the uplands.

Getting it together: crops and animals

Animals are integral lo small-scale farming in Asia, providing tractive power to cultivate the land, dung to fertilize it, and a means of transporting crop surpluses to market. They are an important supplementary source of income—sometimes even the dominant one—for many resource-poor farmers, particularly women. The quality and quantity of feed is the major constraint to increased production.

Researchers in the region have devised many improved technologies for animal production, but most farmers regard them as too expensive, risky, and complex to adopt. Technology has been designed mainly for large-scale intensive commercila system. Most smallholders, in contrast, raise a small number of animals in the backyard, using minimum levels of purchased inputs.

The Philippines: building an integrated system

"Farmers have learned a lot. They are raising animals better—moving from a low rate of weight gain, of around 100 grams per day, to over 500 grams per day," says Dr. Cesar Sevilla, animal scientist with the crop-livestock research team of the University of the Philippines Los Baños. In 1984, the team began research under an ARFSN project at field sites in Santa Barbara and Magallanes, in the country's Cavite Province.

Finding the right cropping pattern—Most farmers in the dry rainfed lowlands of these regions grow only one rice crop a year, leaving the land falllow after the harvest. A few rise a crop of mungbean on residual soil moisture following the rice harvest.

Livestock—mostly cattle for beef production and draft—are an important secondary enterprise. They gain weight during the rainy season, but tend to lose it during the dry season, when feed is scarce. Their diet consists mainly of low-quality ricestraw.

The spread of early-maturing rice varieties in recent years has created the opportunity to grow a second crop after rice. However, project scientists soon realized that, despite the importance of livestock, farmers' most urgent priority was to increase their food security. The needs of the animals would not take priority over those of the farm family.

The team therefore began by introducing in–proved dual-purpose varieties of mungbean and cowpea. In these crops, the bean provides human food while the pods and leaves form a protein-rich supplement for animals. The higher yielding varieties had been developed by the IPB of the University of the Philippines Los Baños.

Cowpea yeilded well, but the market for the crop was poor. Mungbean, however, proved highly popular. After only 2 years, about 67% of project farmers grew the crop, compared with only 10% at the start of the project. By 1993, adoption was 100%. Growing a crop when none had been grown before raised farmers' incomes by 50-180%.

Although the pods of mungbean can be fed to animals, the crop's occupation of previously fallow land had the short-term effect of reducing feed supplies, because animals were barred from what had once been dry-season grazing. At the height of the dry season, when alternative supplies were scarce, this was a serious snag.

The next step was therefore to introduce a forage crop into the system. These crops provide a nutritious protein-rich feed for consumption during the dry season and help to improve the digestibility of other more fibrous feeds, especially rice straw. They can also be used for green manuring, thereby enriching the soil for the next rice crop. In this way, they serve to integrate food crop and livestock production.

Again, farmers will not usually adopt forage legumes if these take up time and space that could be used to produce food crops. The solution is intercropping — growing the food and forage crops together in patterns and combinations that allow each to flourish.

The scientists and farmers tested three forage crops—siratro (*Macroptilium atropurpureum*), sunn hemp (*Crotalaria juncea*), and desmanthus (*Desmanthus virgatus*). The dual-purpose legumes and a forage crop were planted simultaneously in alternate rows approximately 25 cm apart.

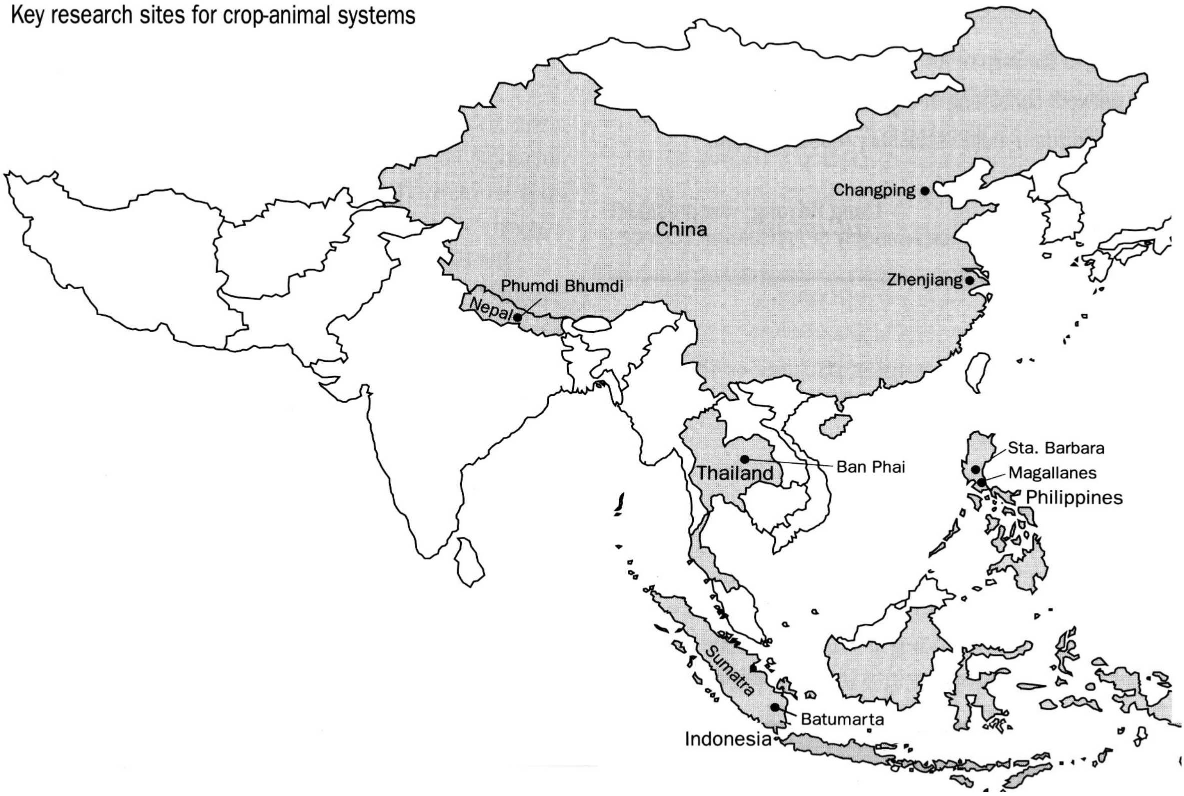
The desmanthus failed altogether, proving too sensitive to survive the high temperatures and drought conditions of the dry season. The sunn hemp also proved unsuitable, growing so rapidly that it shaded the cowpea and mungbean, the yields of which fell to levels lower than those achieved under sole cropping.

The siratro, on the other hand, established slowly but eventualy formed a dense green cover. It proved the ideal companion crop for mungbean, offering it little competion while it grew yet spreading well after the bean was harvested. The fodder yields of mungbean were not affected by intercropping. And its grain yields even improved slightly, from 1.03 t ha when sole cropped to 1.09 t/ha when intercropped with the siratro.

The siratro provided four clippings for feeding to cattle, each with a yield of 3 t/ha, and a further 2.5 to 3.5 tons from the last regrowth, which was used as green manure for the following rice crop.

During the next season, rice grain yields were significantly higher in plots that had previously

Key research sites for crop-animal systems



been planted with legumes—both dual-purpose crops alone and dual-purpose crops intercropped with forage species. The plots to which green manure had been applied had the best yields of all. The amount of rice staw available for feeding animals also increased.

The Bureau of Agricultural Research in Manila is now testing the improved rice - mungbean + siratro system in other provinces. Each province sent two representatives to a 2-week training course held at the Department of Agriculture to introduce the system. The main impediment to more widespread adoption is the shortage of siratro seed.

Dual-purpose animal uses—The promising results obtained with the improved cropping system encouraged the reseachers to seek other ways of improving the efficiency of animal production. These included the introduction of a dual-purpose cow for calf production and traction.

Setting cows to plow the land would save farmers time and money by removing the need to keep oxen as well. Research elsewhere has shown that a little light exercise, taken each day on easy soils, can increase rather than reduce milk production in lactating cows.

The project is now testing the draft power and stamina of cows at two stages of pregnancy, 3 and 6 months. Cows cannot plow during late pregnancy, so the scientists are trying to ensure that this period does not coincide with the peak demand for traction at the start of the cropping season. This is done by synchronizing all mating to take place between February and April.

Stage of pregnancy so far appears to have had no significant effect on the cows' work performance. This is probably because draft power is related primarily to body weight, which actually increases during pregnancy. However, the pulse rate of working cows at 6 month of pregnancy was significantly fuster than at 3 months, suggesting that if work becomes too strenuous it may affect the physiological well-being of the fetus.

Several farmers haw volunteered to test the dual-purpose cow system on their farms, combining this with the improved cropping system. Their

> "Thanks to the help of ARFSN, we established a national FSR network consisting of eight provinces/municipalities and organized a multidisciplinary research team."
>
> —**Liang Keyong,** vice-president
> Chinese Academy of Agricultural Sciences

willingness to test a complex package of this kind testifies to their trust in the project as a source of worthwhile innovations.

China: triticale takes over

A quarter of Beijing's milk comes from Changping Country, which lies just outside the city limits. With its intensive irrigated systems, the area manages to be highly productive despite having a harsh climate, prone to drought in winter and spring and flooding in summer and autumn. The average temperature is only 11.5 °C and frost may occur nearly half the year round.

Much of the county's dairy herd is in the hands of the state or of cooperatives. The major barrier to increasing dairy production is the shortage of maize and sorghum silage. Cropping intensity in the uplands is already high—200%—so there is little potential for increasing silage production there. The best hope lay in introducing silage crops during the winter season in the lowlands, where paddy rice is the main and often the only crop grown during the year.

In 1986, ARFSN launched a project to introduce triticale for silage production. Yields under irrigation at Yantan Township were very high (50 t/ha), with the result that net income from the system was US$ 1,421—some 114% more than for single-cropped rice and 44% more than for wheat-rice.

The scientists conducted a feeding trial in nearby Baifong village. There was no significant difference in milk production between cows fed on maize silage and those fed on triticale silage. The nutritive value of triticale even appeared superior, leading to improved crude protein and fat contents in the milk. Lactose percentage remained the same.

In 1988, the results of the feeding trial attracted theattention of the Beijing Municipal Bureau of State Dairy Farming Management, which organized visits to the research site for dairy farm officials and farmers. The bureau decided to introduce triticale into its many dairy farms throughout the Beijing region.

By 1993, the area devoted to triticale was about 2,600 ha—more than 60% of the total area devoted to winer silage crops. Average yields were 32 t ha, while net incomes were US$207/ha, US$131 higher than from barley. The crop has been adopted not only in the lowlands but also in the uplands.

Triticale has sincebeen introduced and tested in 15 other provinces or municipalities throughout northern China. There has also been some introduction in the south of the country. The area of these pilot introductions outside Beijing is about 223 ha.

The research has led to the reorientation of China's triticale breeding program. Previously, the emphasis was on breeding varieties for human food. Now it is on dual-purpose varieties suitable for silage production as well. The Chinese Academy of Agricultural Sciences (CAAS) has recently released several new v arieties for silage production.

Bring back the fish

Rice - fish system are traditional in China and Southeast Asia, where farmers have, for centries simply allowed freshwater fish to multiply in their fields during the long period of flooding. Such systems were once widespread, but had been largely displaced by the advent of modern rice-growing technology. The chemicals used in modern systems proved poisonous to fish, with the result that many farmers simply gave up producing fish altogether.

Besides increasing incomes and improving nutrition on farm, raising fish in ricefields brings environmental benefits. Chief among these is a large reduction in the use of pesticides, made possible because the fish eat certain pests of rice, including the notorious stern borer. Soil structure and fertility also seems to improve, although the mechanisms at work here are not well understood.

The most cheering news of all is that rice yield actually increases when fish are present. Farmers have ofetn claimed that this is so, but until recently scientists did not believe them. Now a growing number of studies in different countries is proving the farmers right. Network research in Thailand, China, Indonesia, and India shows yield gains ranging from 6 to 26%.

Asiar has vast potential for increasing Fish production in ricefields. In Indonesia, out of 6.23 million hectares of irrigated rice, only aboout 6% are now used to produce fish. China alone has about 1 million hectares devoted to rice - fish—the. largest area in the region—but the potential, in this huge country, is about four times this amount. India has a further 2 million hectares on which rice-fish systems could be introduced.

Indonesia: learning from the farmer

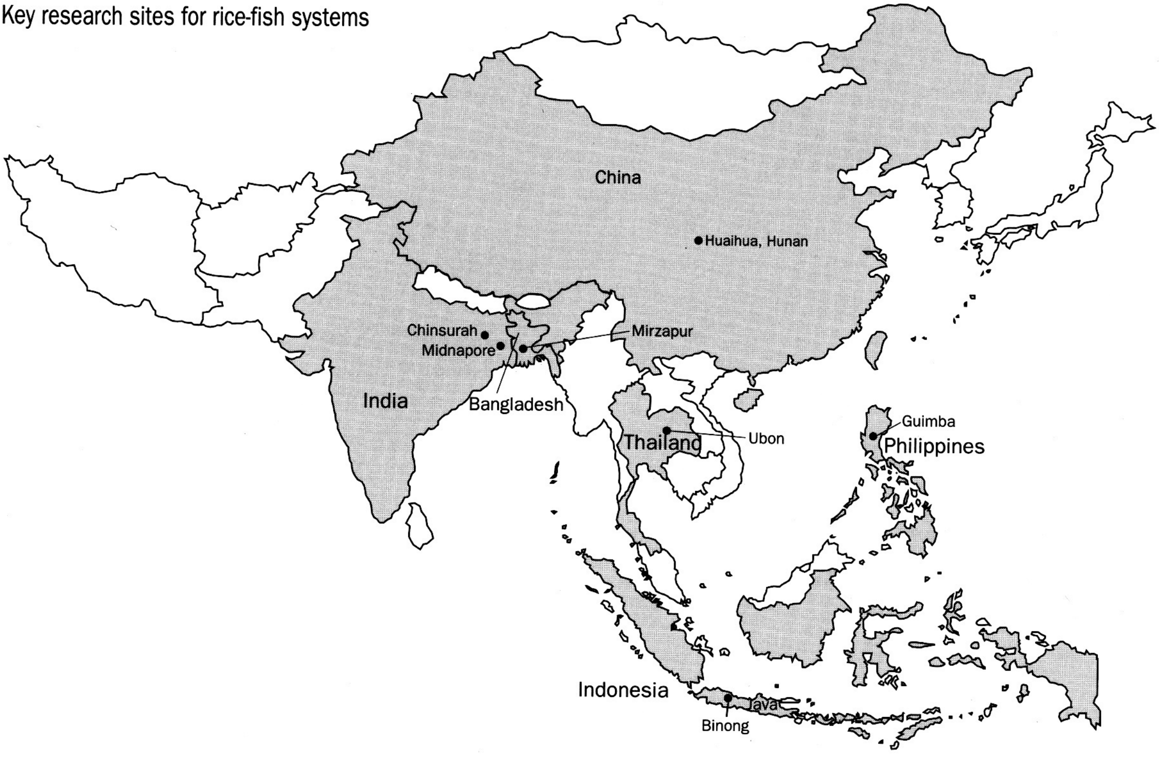
When Indonesia's. scientists heard about rice - fish production, they decided to launch a project in an area where farmers already practiced such a system. They wanted to learn from farmers before designing systems for extension in other parts of the country. A joint team from the Sukamandi Research Institute for Food Crops and the Research Institute for Freshwater Fish chose a site at Nangerang village in the densely populated Binong subdistrict of Subang, West Java.

Fish culture had first been introduced to the district in 1979. At that time the extension service had advocated the use of modern crop varieties in a sole cropping system in which a fish "rotation" followed two successve rice crops. By 1987, when ARFSN's project began.about 15% of irrigated ricefield were being managed in his way. But a small percentage of more innovative farmers had modified the system to an "intercropping" pattern combining rice with fish simultaneously. This pattern was repeated twice, then followed by a sole fish phase. The two systems can be repeated as: rice-rice-fish (recommended by extension), and (rice + fish) - (rice + fish) - fish (developed by farmers).

Despite, the ingenuity of farmers, diagnostic. surveys had revealed several opportunities for improving their practices. Many farmers provided little or no feed for their fish, stoked fingerlings that were too small, did not provided a trench, and did not allow a sufficiently long growing period.

The scientist decided to test all the systems found on farmers' fields, including a rice double

Key research sites for rice-fish systems



cropping system without fish, which served as a control. To improve on farmers' efforts, they added a further component to the already complex "intercropping" system, namely duck. In this system, a bamboo fence is erected around the rice plot, and 25 ducks per hectare are allowed to enter 2 weeks after transplanting the rice. The ducks are removed again shortly before the rice grain ripens.

Figure 4 shows the systems tested and the average yields of each component. For components other than rice, the value of the yield is converted into an equivalent amount of rice.

The first year's results showed the intercropping system with duck to be the most productive, providing a rice yield equivalent of more than 20 t/ha per year—half a ton above its nearest rival, which was the same system but without duck. Interestingly, the duck component appeared to increase rice yields just as the fish component did, and probably for the same reasons, namely better control of weeds and insect pests. The system with duck was also the most profitable, providing farmers with a net annual income of US$1,498/ha, some 8% more than the intercropping system without duck, and an impressive 50% higher than the income from rice double cropping. Extra cash from selling duck eggs amounted to US$83/year.

In the second year, the scientists tested three managenent levels—varying fertilizer rates. the stocking density and size of fingerlings, and the width of the trench used. Intensifying the fish component did not depress rice yields, which ranged from around 12 to 14 t/ha. The highest rice yields were again obrained in the system with cluck, which provided farmers with a record-breaking US$2,000 ha.

In 1990, the provincial government of West Java launched a production program covering 20,000 ha and involving 17 districts. The success of this program encouraged the national government to follow suit with a full-scale production program at the national level. In 1991-92, this program reached an estimated 46,000 ha in 14 provinces. The target area was expanded still further the following year.

To assess the project's impact, two Indonesian economists studied 60 farmers in the Subang District

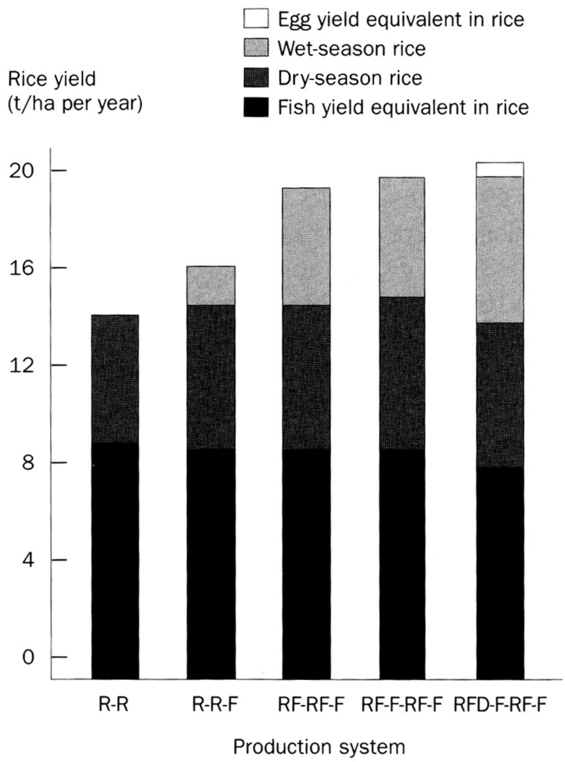


Fig. 4. Total rice yields in rice monoculture and rice - fish systems in Mangerang Village, Binong Subdistrict, Indonesia, 1988-89 wet and dry seasons.

in 1989-90 and 1990-91. The farmers represented the two main types of fish system, rice - rice - fish and (rice + fish) - (rice + fish) - fish, and the rice double-cropping system. The duck innovation was stil under research, so its impact was not assessed.

The economists found that farmers who had introduced fish had been able to cut back on their use of fertilizers and pesticides. The intercropping system, for example, consumed only 153 kg of triple superphosphate/ha during the wet season of 1989-90, compared with 225 kg/ha for rice double-cropping. The amount of herbicide used fell dramatically, while that of insecticide was also reduced.

Rice yields were up to a third higher in all systems with fish in all four seasons covered by the impact study. For the intercropping system, the yield advantage reached an monishing 38% on several farms during one wet season. When fish yields were converted into rice-yield-equivalents, the total yield of the intercropping system was 50% higher than that of the rice double-cropping system.

Besides having tremendous yield advantages, sytem with fish also demanded less labor. The main savings were in need and insect control—tasks which the fish largely took over. Farmers were able to make repeated sprayings with pesticides a thing of the past. In the rice - rice - fish system, farmers also reported easier land preparation.

Interestingly, adopting farmers were smaller than nonadopters, having a farm size of only 0.7 ha compared with just over 1 ha for farmers practicing rice monocropping. These larger farmers spent more on chemical inputs—and on dried fish to feed the family, which they may well have purchased from adopting farmers. Thus, in a small way rice - fish systems help to close the gap betwen rich and poor.

The impact study brought to light one prob lem that could prevent more widespread adoption, not just in Indonesia but across Asia. Even more than rice production, fish - rice system depend on reliable and abundant supplies of water. Adoption in Binong had been cramped because of the chronic shortages experienced in the commaand area of the district's two major irrigation systems. Similar shortages plague a growing numher of irrigation system throughout the region, especially in the drier and poorer areas that stand to benefit most from fish production.

China: prize-winning adaptive research

In 1989, the government of China's Hunan Province awarded a prize for advances in science and technology to a research team from the province's Soil and Fertilizer Institute. The team had collaborated with the local extension service in the testing and promotion of production systems combining rice, fish, and azolla in ridge fields. The area covered by the systems had increased from zero to more than 175,000 ha.

The extension effort was preceded by a brief phase of adaptive reseach in which scientists compared improved rice single- and double-cropping system including fish with the conventional nonfish systems used by farmers.

Both the improved and the conventional systems inclucled azolla—an aquatic fern that fixes atmospheric nitrogen. In the improved systems, the azolla sewed as fish feed, as well as providing organic fertilizer for the rice crop. In the conventional systems, more azolla was available to nourish the rice.

Predictably, the scientists obtained the highest rice yields from the rice - rice/azolla system. This provided more than 13 t/ha, reflecting the effect of the azolla. But yields of rice fell only slightly when fish were added to the system, maintaining levels of around 12.8 t/ha. In economic terms, the system wirth fish was the clear winner, hinging net returns of' US$1,897/year, 60% higher than from rice - rice/ azolla.

The system with fish included trenches as well as ridges. Trenches subtract from the area available for rice but are important for intensifying fish production. Before extending the system to farmers, scientists had to find out what field layout gave the optimum trade-off between fish and rice production. In one experiment, they varied the trench width while keeping that of the ridge constant. In another, they tried different ridge widths. Considering the yields of both rice and fish and the economic returns to each, they established recommended widths of 80 cm for ridges and 40 cm for trenches.

"ARFSN created and facilitated exchanges of ideas, experiences, research methodologies, materials and results, as well as the transfer of technologies."

—**A. Syarifuddin Karama,** director
Centre for Soil and Agroclimate Research
Indonesia

"We learned from other Asian countries' scientists, we shared our research results with them and improved our research level."

—**Wang Lianzheng,** President,
Chinese Academy of Agricultural Sciences

Different fish exploit slightly different niches in the rice ecosystem, feeding off different soil organisms and insect pests of the rice crop. For this reason, it is advantageous to raise a mixture of species in the same pond or trench. The scientists tested three species of carp in different proportions — all of them native to the traditional rice - fish systems of China. A mixture of 50% grass carp. 30% Lotus carp. and 20% Hunan Crucian carp gave the highest yield, at nearly 2 t fish/ha.

Another variable tested was stocking density. High densities are not necessarily best, because the survival rate of fingerlings and the rate at which they gain weight decline with increases in population. In this case, the fish yield at the highest stocking density, 30,000 fingerlings/ha, was only 5% higher than the yield at the next level down, which was 22,500. And at a stocking density of 15,000 ha, the survival rate was 30% higher than at 22,500.

The adaptive research phase culminated in a set of recommendations, after which the technology entered multilocation testing in collaboration with the extension department. Where farmers already practiced rice double-cropping, a rice - rice/fish/azolla system was introduced: this was simplified to rice - fish/azolla for areas where singles-cropping was the rule.

Trials over nearly 100 ha in 37 counties of the province showed average rice yields of 13.4 t/ha in double-cropping areas. In other words, farmers outdid the results obtained in on-farm research, enjoying a 6% gain over the conventional rice-rice system On top of this, at little extra cost, they had the added bonus of fish yields amounting to an average of 795 t/ha,

Farmers' net annual incomes were US$749/ha higher than in the conventional rice - rice system Expenditure on fertilizers and pesticides fell by US$23/ha, while cash crops planted on the banks around the ricefield and around refuse ponds added a further US$47/ha to incomes.

Not surprisingly, the technology proved extremely popoular with farmers, who began adopting it like wildfire. The research team had earned its prize.

Benefiting women

Considering the immense contribution made by women to Asian Agriculture (Fig. 5), it is sobering to reflect that less than a decade ago, no conscious efforts had been made to target research and extension efforts for their benefit.

IRRI's Women in Rice Farming Systems (WIRFS) Program, which formed part of ARFSN, was established to rectify this omission. The program has two objectives. It aims to play a direct part in the development and testing of technology that will benefit rural women in Asia. But it also aims to work itself out of this role in the longer term by instilling an awareness of women's needs in national research and extension systems, equipping them to meet those needs themselves.

To aid its studies and help it identify priorities, the WIRFS team classifies the technologies that can benefit women as being of three basic kinds: labor-saving, knowledge-based, and livelihood-oriented. Their use can be combined to powerful synergistic effect.

Labor-saving technologies

Women perform almost all the tasks concerned with rice production and consumption except land preparation. In traditional systems, they raise the seedlings in nurseries and transplant them to the flooded fields, where they must spend many hours stooping with their arms immersed up to the elbow in muddy water. They weed the crop on emergence, and again as many as three or four times before it is ripe. Then they harvest the crop, transport it to the homestead, thresh it, and store it. Finally, they pound and cook the rice grain, usually twice a day, for their families.

The challenge for researchers is to devise technology that will reduce the time and effort women must devote to these tasks. Agricultural engineers from IRRI and the Philippine Rice Research Institute (PhilRice) have come up with several labor-saving technologies, including an ultralite transplanter, a micro rice mill, and a rice husk stove.

Ultralite transplanter—All the tasks associated with rice production are laborious, but none is

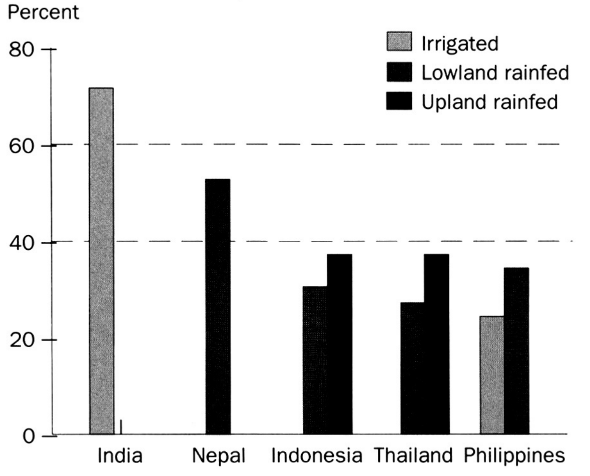


Fig. 5. Female contribution to total labor Input in rice cultivation in five Asian countires

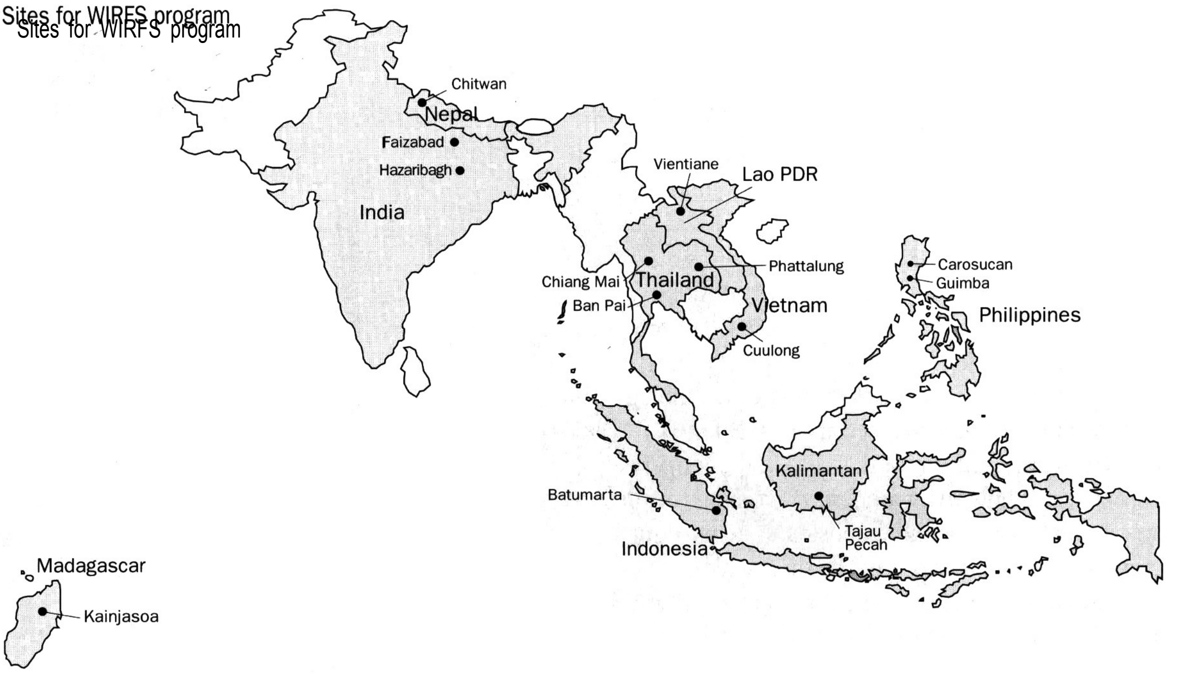
more so than transplanting, which requires constant stooping when done manually. According to Indian research, many women rice farmers suffer back injuries while transplanting.

The mechanical transplanters developed during the 1980s are too heavy for women. During a visit to IRRI in 1989, Devaki Jain, a prominent Indian feminist, challenged the Institute to design a light, weight model.

The result is the ultralite transplanter, a four-row portable machine weighing just 10 kg. On-farm testing showed that women using the ma-chine could achive a fourfold gain in the speed of their fieldwork, taking only 1 hour to transplant 40 m^2 instead of 4 hours when the task is done manually.

IRRI's researchers are now attempting to improve on the current model for ruggedness, reliability, and accuracy. They have designed an "extra-ultralite" model for use on small plots and in rugged terrain. Attempts are being made to low-er the investment costs, which are still too high for individual farmers.

Micro rice mill—Women and children using a pestle and mortar to prepare food are a common sight in and South and Southeast Asia. The task is strenuous and time-consuming. Pounding a kilogram of rice takes at least an hour.



Now, for little more than the cost of a television, women can make the job a lot easier. An agricultural engineer at PhilRice has come up with an improved portable micro rice mill, based on a Chinese design adapted by IRRI. Women using the mill find they can process a whole sack of rice within an hour—a 50-fold gain in efficiency. They also gain by having easy access to milling byproducts such as rice bran, which are important feeds for their pigs and poultry.

The mill costs around US$500 and can be bought and managed cooperatively at the village level. It runs off mains electricity, but an engine-driven model is also available to cope with power outages. Manufacturers trained by IRRI have now gone into mass production.

Rice husk stove—In many parts of Asia. rice husk is burnt and thrown away, despite being a potentially valuable fuel. Often in the very same village, women responsible for cooking the family's daily meals must spend many uproductive hours fetching fuelwood.

To make better use of rice husk, agricultural engineers at IRRI and PhilRice have developed a new type of cooking stove. The stove is made of cheap, locally available scrap metal and can be ignited by burning paper, dry leaves or straw, without using kerosene.Women are now evaluating several different models in villages in Central Luzon, Philippines. Their tests so far indicate that the stove is easy to start and boils a liter of water in 5 minutes.

In Vietnam, about 3.2 million tons of rice husk are produced each year as a product of rice milling. That amount could cook around 1.6 billion family meals, according to WIRFS estimaites. The rice husk stove thus has considerable potential for taking the pressure off fuelwood resources in Asia's remaining forest areas.

Knowledge-based technologies

Many women performing agricultural task lack vital skills. The problem grows worse daily as men move out of farming to seek better paid work in cities. They leave women to take over jobs traditionally done by them, such as land preparation or applying checmicals to crops.

A survey of two villages in central Thailand revealed that women were aware of the harmful effects of pesticides on their health and on the environment. However they failed to follow even the most elementary safety measures, such as washing their hands after applying pesticides, and were unable to identify banned chemicals. In both Vietnam and Thailand, open pesticide bottles were found lying beside public wells, where playing children could easily have emptied their contents into the village water supply. In Indonesia, empty pesticide bottles were sold back to stores for recycling.

Under a training scheme organized by Thailand's Department of Agriculture and Extension, women were taught to remedy these shortcomings. The scheme also introduced them to the principles of integrated pest management. According to the trainers, the women proved more responsive, than men usually do to concepts such as biocontrol. They now visit their fields every day to check for the presence of natural enemies of key pests. Many have given up the use of pesticides altogether.

Seed handling is another area in which increased knowledge would benefit women. Asian farmers tend to buy new or certified seed only every 4-5 years. In the intevenins years, a part of the harvest is reserved as seed for the next crop—a task for which women are often responsible, Training them to select the most viable seed can greatly increase yields. Skills such as growing seeds in a specific area of the field, identifying wild plants, eliminating weeds, recognizing diseases, and cleaning seed are simple to acquire and easily passed on to others.

Astonishingly, this kind of training has never been carried out before. Seed technology is so elementary that researchers have attached little importance to it. Under a training scheme organized by ARFSN, women from the village of Guimba in Nueva Ecija, Philippines, were trained in the field and then invited to visit IRRI's. Seed Unit, where they learned to detect specific diseases. Now, there are plans to extend the scheme, first to Vietnam and then to other countries.

Livelihood technologies

To better their lives, women need new opportunities to increase their incomes. Typically, women in rural Asia earn cash by processing farm produce

"I would like to express my gratitude to IRRI. This institution has, through the WIRFS collaborative network, taken the lead in research with gender analysis as a new perspective in farming systems research, training and extension."

—Ibrahim Manwan, director
Central Research Institute for Food Crops
Indonesia

or running a small livestock enterprise such as poultry or swine. In theory. introducing technology to make these operations more profitable should benefit them.

In practice, this often proves surprisingly thickely. Women are empowered through improved enterprises only if they make the management decisions, control the sales, and are free to decide how to spend the extra cash. If the new venture turns out to be a real money-earner, it is difficult to prevent men from getting in on the act, especially if they are working less hard than women in the first place and therefore have more time on their hands.

Thailand: poultry raising—An ARFSN project in Thailand illustrares these pitfalls perfectly. In 1987 a team of socioeconomists from Chiang Mai University conducted a surveyin collaboration with the national Farming Systems Research and Development Unit (FSRDU) on villages in the Amphoe Phrao area. The team was on the lookout for possible interventions that might benefit women.

The survey revealed just how much harder womer worked than men. Husband and wife labored about equally on cropping activities—1,025 hour for women and 1,190 hours for their husbands. Inputs to livestock were also about equal between the sexes. But women put in an average of 920 hours a year on housework, compared with only 37 hours spent by men. To fulfill their many roles, they often spead their attention and energy over several task simultaniously. The survey suggested that there was considerable potential for increasing women's incomes by improving traditional poultry pro duction. Raising poultry was already an important income-generating activity for women, but the poor productivity of local breeds, coupled with high incidence of pests and diseases, kept profitability low.

The bug advantage of the traditional system wad its low labor requirement. The women avoided

a conflict with their other duties by feeding the birds while cooking, thereby doing two jobs at the same time. They spent an average of only 30 hours annually caring for the birds.

The project set about introducing an "improved" system. A more productive breed of hen, the Red Rhode Island, was introduced for egg laying, while a crossbreed between this and the native male was introduced for broiler production. The families received a starter flock consisting of 1 cock, 7 hens, and 50 chickens, plus the credit needed to buy feed. FSRDU staff provided advice and vaccinations where necessary. Two management regimes were explained to the families—one for layers and one for broilers. which were to be kept in separate pens.

The new enterprise proved risky—mortality rates remained high—but profitable for most households. However, it required about 10 times as much labor as the traditional system. Chief cause of the increase was the fact that, since the birds were no longer free roaming, women could not feed them while preparing the morning and evening meals.

Project staff noticed that, in virtually every household, men began assisting in poultry keeping—something unheard of in the traditional system. While women spent up to 317 hours per year or the new enterprise, their husbands spent even longer. The men put in the extra time only partly to ease their wives' workload: they were also interested in the income-earning potential.

Asked how they felt about this situation, the women said they were happy to have their hushands help them feed and care for the poultry. Indeed, as the benefits were equally shared in the family, they thought it only fair that they should do so. In the few households where men did not share the work, the women complained that the improved poultry enterprise took up too much of their time, suggesting they would drop it once the project ended.

Originally intended to benefit women, the project gradually switched to working with both sexes. In the end, the project workers shrugged their shoulders over this, accepting the involvement of men as a fait accompli and agreeing to

alter the aims of the project to include men as beneficiaries alongside women.

The Philippines: glutinous rice—Another poject to improve women's livelihood was more successful. This project, at Carosucan, Philippines, combined the use of labor-saving technology with improvements to a traditional food processing enterprise.

Each year, the women of Carosucan increase their incomes during October and November by selling a delicacy called durumen. The main ingredient of durumen is glutinous rice, which farmers grow in small plots beside their main rice crop Asked about the problems they faced, the women cited the shortage of glutinous rice and the many hours of hard work needed to process it.

The WIRFS team set about solving both these problems. Working with IRRI scientists, they introduced IR65, a modern early-maturing glutinous variety—developed by IRRI. This can yield up to 5 t/ha, compared with 3 tons for the local variety. In 1986, 22 farmers grew IR65 on test plots side by side with traditional glutinous rice varieties such as

Imelda, Milagrosa, and Waray. Average yields were 16% higher, and the crop was harvested between 10 and 30 clays earlier.

To speed up processing, the team introduced a rice huller developed by IRRI's engineer. This cut the time needed to remove the husks from 50 kg of rice from to hours down to 1.5. It also reduced winnowing time by half.

The scientists then asked five women who made durumen to take part in a teat to find out whether the smell and taste of IR65 were accept able. IR65 and four other varieties were cooked and wrapped in coconut leaves in the traditional way. According to the women, the Waray variety had the most appetizing smell, but IR65 was comparable to both Waray and Imelda in terms of taste.

A random survey conducted in 1990 showed that the number of farmers growing IR65 had increased to 42, while the area planted had risen from 0.91 to almost 4 ha. The average gross returns to processing had risen by 42% in the peak months of September and October.

All 21 women processors interviewed had used the rice huller. They confirmed that they had benefited in terms of less time spent winnowing and pounding, and larger amounts of durumen processed. The women spent the time they saved mainly on fetching more glutinous rice to process from other villages and on cooking and marketing more durumen. They also spent more time gathering feed for their pigs. The extra cash earned went on food, clothing, and hired labor for harvesting. Some families brought land or construction materials. One even brought a television set.

These findings are encouraging. Some radical feminists (mostly from developed countries) have accused IRRI of creating unemployment among women thought the introduction of labor-saving technology. This study shows that women put any extra time they can save to highly productive use, leading to gains in family farm income and a rise in living standards. New technology can sometimes reduce the income-earning opportunities for hired laborers, but in this case it had the opposite effect.

Applying new tools

One of ARFSN's roles was to make the research process more efficient by introducing new tools and methods to natioanal participants. Two areas showed particularly rapid progress: the extrapolation of research results and the management of data in cropping systems research.

Extrapolating results

Extrapolating the results of research means identifying specific areas or sets of conditions in which new technologies can be recommended for broader use. The task of defining these recommentiation domains, as they are called, is vital if the extension srvice is to target subsequent production programs accurately and avoid expensive mistakes.

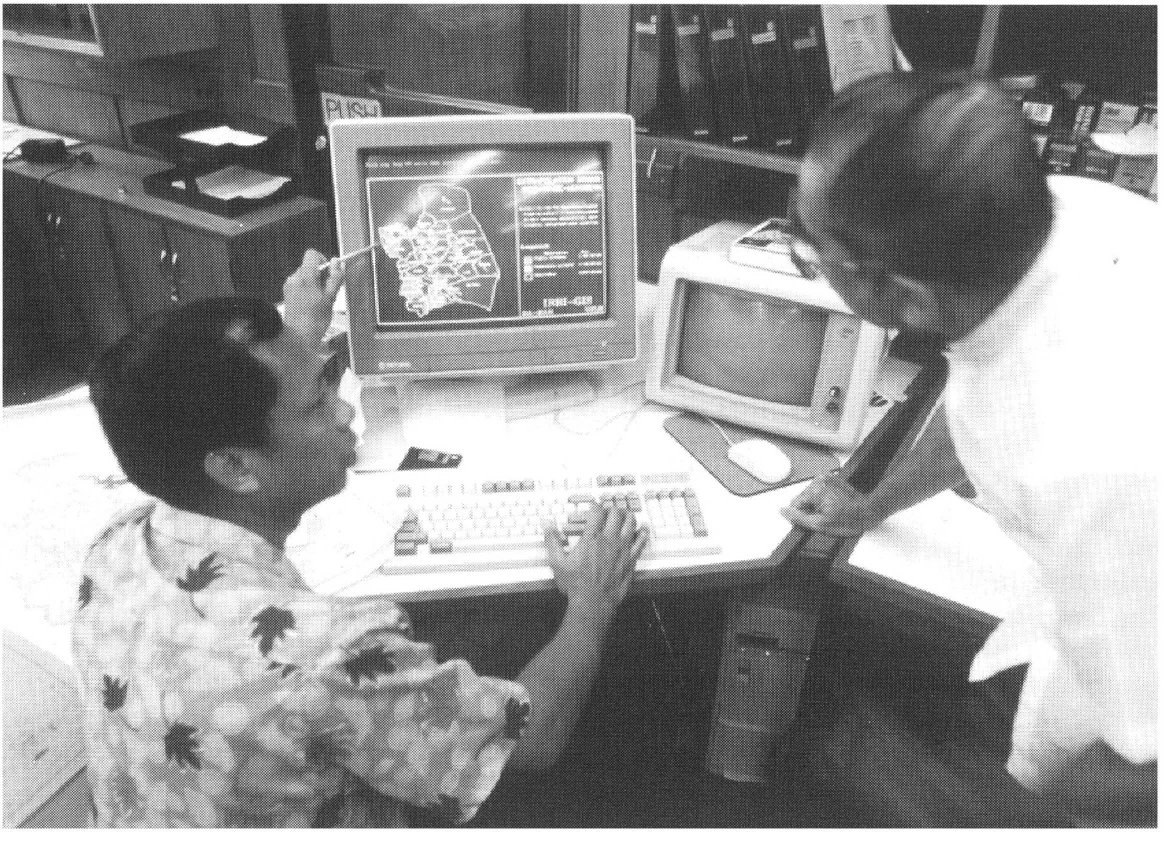
A frequent problem in extrapolation is integrating the various sources of data required. To take an imaginary example, a certain crop variety needs 300 frost-free days per year. In addition, thc crop suits only those farmers with abundant supplies of irrigation water and easy access to markets. Data on frost incidence are available from the national meteorological office. On request, the irrigation department comes up with a report describing the reliability of water deliveries to the head, middle, and tail reaches of the region's irrigation systems.

And market access can be determined by proximity to main roads and location within a 50-km radius of the regional capital.

The problem is not how to obtain these data butt how to fit them together to define the recommendation domain and represent it graphically. Formerly, a great deal of labor would have been expended on the manual production of maps on tracing paper. The map of frost incidence would have been overlaid on a rough map of the irrigation systems, perhaps with hatching to indicate those areas considered favorable. Details of main roads and major towns and cities would also have been added by hannd. If the cartography section was fully occupied working for the director general—and it usually was—much would have depended on the amateur drawing skills of the researcher, not to mention his or her ability to hold the tracing paper still. And, after all the effort, the final product would be static, not dynamic: any change in the data available would mean going back, literally, to the drawing board.

These clumsy methods are now a thing of the past. The advent of geographical information systems (GISs) allows researchers to digitize data and overlay them on the computer screen. The result can be produced on a laser printer, providing a color map that shows the required Information clearly. The system is easy to update: when new data on, say, the supply of irrigation water become available, they can simply be entered and the new recomendation domain printed out within minutes. And the method can quickly be applied to different areas—adjacent to the research site, in a neigboring province, or even in a completely different country.

To introduce regional researcher to these systems, ARFSN and IRRI organized a workshop at IRRI in May 1990. Seven member countries then sent staff and data to IRRI headquarters to make use of its GIs facilities and expertise, while five took steps to acquire the necessary hardware and software to support their own GIS.



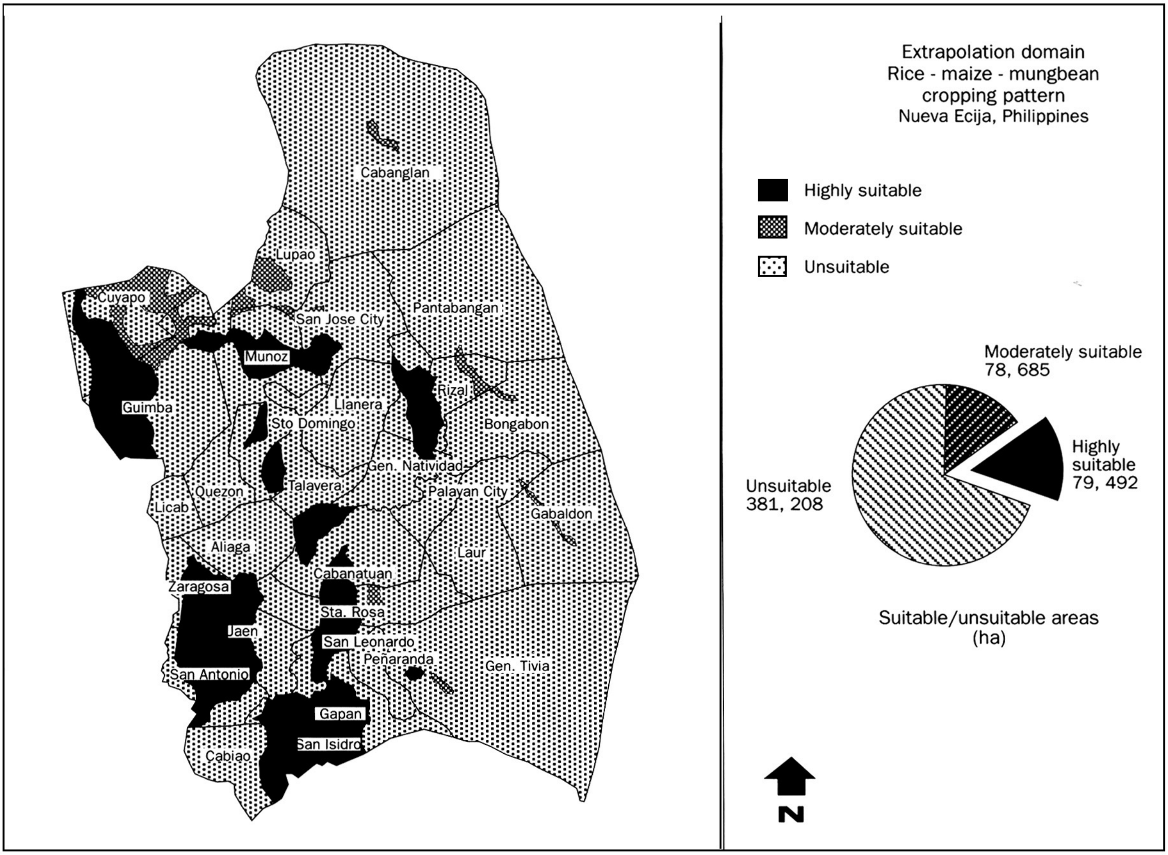


Fig. 6. An example of the usefulness of GISs—four microcomputer-generated thematic maps (soil types, geomorphology, climate, and groundwater availability) are overlaid to determine the suitability of a rice - maize - mungbean cropping pattern.

A case from the Philippines illustrates the way in which GIS systems are now used by national researchers. The researchers needed to define the recommendation domain for an improved rice - maize - mungbean system in Nueva Ecija Province. The system had been tested in field trials for 4 years. It was clearly applicable in areas with good rainfall, but not in drier areas in the south of the province. In addition, the slope of the land had to be sufficiently gentle to avoid erosion, and enough moisture had to remain in the soil at the end of the season to grow the third crop.

The researchers used a microcomputer to generate four thematic maps—one each for soil types, geomorphology, climate, and groundwater availability. The maps were then overlaid to give the result shown in Figure 6.

Data management

Cross-site analysis and comparison are important advantages of networking because they increase both the validity of results and the efficiency with which they can be obtained. The yields of a crop variety that does well across many sites with varying rainfall can be pronounced stable with greater certainty than if the results had been obtained at only one location. Replicated across locations, the trial captures performance under different rainfall conditions in a single year rather than having to be repeated for several years running. This allows the earlier dissemination of results.

However, to secure these advantages, two conditions have to be met. First, the objectives of research at different sites must be sufficiently similar for comparison to be worthwhile. Covering so many different topics. ARFSN's research often did not meet this condition. Second, standardized methods of data collection and analysis must be used to make comparisons valid.

In 1990, ARFSN launched an initiative to improve the management of network data. The initiative focused on cropping systems research—an area in which method and objectives were felt to be sufficiently clearly defined to make cross-site comparison both possible and desirable.

Network members designed six standard forms for recording data. The forms cover daily climate, description of research site, conditions on farmers' fields, cropping operations, economic data, and harvest details. These forms were used in conjunction with a software package developed by IRRI for data collection and processing.

The software, known as IRRI-OFT, has five modules, taking researchers through each step in the research process, from specifying the variables to be measured, through data collection and entry using the purpose-designed forms, to data analysis and information retrieval. The data analysis module computes statistics, compares the results from improved technology with those obtained by farmers, draws the researcher's attention to variables that explain the differences, and highlights any unexpected results.

Researchers are currently testing the package at two sites each in Indonesia, Thailand, and the Philippines. They will be able to feed their results directly into a GIS to obtain recommendation domains for specific crop models (see Fig. 7).

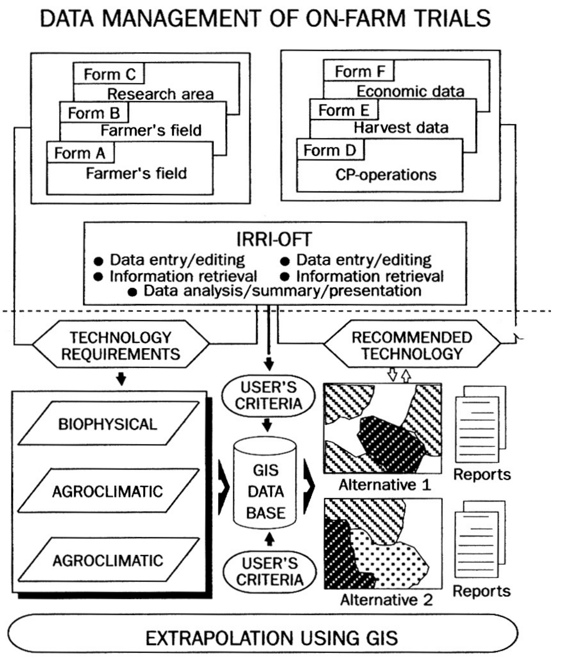


Fig. 7. Enhanced data management of technology extrapolation system.

Changing lives

What lasting differences did ARFSN make? What is its legacy? Reflect ing its two main objectives, ARFSN changed the lives of two major groups of people. First, national re-searchers, who now conduct research quite differently to the way they did 20 years ago. Second, the small-scale farmers of Asia, whose production practices and standard of living benefited by the innovations to which they were introduced. A third group of people, the urban consumers of rice and other crops, also benefited, through cheaper food prices.

The institutional legacy

ARFSN strengthened the conduct of national research in three ways. Through its training programs, it built a cadre of staff committed to the systems approach to research. It helped to integrate the work of different groups within national research system. And, it institutionalized the farming systems approach at the national level throughout Asia.

Investing in the future

As head of the Farming Systems Research Division of' the Bangladesh Rice Research Institute (BRRI), Nizam Uddin Ahmed is an enthusiastic advocate of the farming systems approach to research.

In 1976, Dr. Ahmed attended the Cropping Systems training course at IRRI. Funded under a USAID-IRRI project, he went on to complete an MS degree in 1979 at the University of the Philippines Los Baños. He then returned to his country, taking up the post of senior scientific officer with the then Cropping Systems Division of BRRI. A Ph D from the University of Florida, funded under the same project in 1987, further embellished his career by equipping him with the necessary qualification to apply for his current position.

Group training. Dr. Ahmed was one among more than 600 national scientists from 16 Asian countries to receive training through ARFSN between 1974 and 1993. The network began organizing group training courses soon after it was founded, when a 4-month course in cropping systems research replaced the multiple-cropping course previously offered by IRRI. The new course covered the whole cycle of research, from selecting target areas and sites to organizing pilot production programs. Conducted partly in the field, the course provided hands-on experience in describing sites, diagnosing farmers' problems, designing technology, and implementing trials.

Marking the broaddening of its mandate, ARFSN began complementing this course with a 2-month course on socioeconomic research in 1983. In 1989, the two courses were combined into a single farming systems course, which covered livestocks and agroforestry techniques in addition to crops.

Other, more specialized courses followed as new needs arose. These covered such subjects as rice - fish farming systems, varietal improvement and testing of upland crops, gender analysis. the use of GISs, and data management in on-farm research.

With their strong emphasis on training the trainer, the courses proved an effective means of spreading skills at the national level (see box). Most countries col1aborating with ARFSN started their own courses on cropping or farming systems research. National scientists trained at IRRI and/or

"Scientists from collaborating countries benefited from ARFSN's training events and workshops. The network helped them keep abreast of new developments in rice-production technology."

—**Qasim Chatha,** national coordinator
Pakistan

Training the trainers: the case of China

TRAINING THE TRAINERS is a powerful means of achieving a multiplier effect through training.

In 1993, ARFSN organized a 4-month training Course on adaptive research with a farming systems perspective for Chinese scientists participating in a World Bank project to revitalize the national extension system. Held at IRRI, the course gave instruction in the training skills that would enable participants to run their own courses in the future. Five-person multidisciplinary teams from each of five southern provinces attended. Afterwards, the teams returned home to plan and execute in-country courses for subject matter specialists at the prefecture and county levels.

A Similar Course was conducted the following year for northern provinces. Within a few years, China will have large numbers of agronomists able to develop location-specific recommendations with farmers.

under the network organized the courses or gave instruction. Course materials usually included modules developed and disseminated by IRRI. Training in a farming systems approach spread beyond rice to include other commodities.

Individual training. ARFSN frequently sponsored or organized specialized training for individuals. This consisted mainly of on-the-job training in various disciplines required for component research or pilot testing. Between 1979 and 1988, some 70 young Asian scientists were trained in entomology, weed management, plant pathology, and varietal improvement. In addition, the network often acted as a catalyst in securing opportunities to pursue advanced degrees at Asian or developed country universities.

Integrating national systems

ARFSN helped to create more integrated national research systems in several ways. By conducting joint projects on the ground it broke down barriers between different sectors. It brought universities into the mainstream of development-oriented research. And it strengthened the links between research and extension.

Cross-sectoral research—Several countries integrated their crop and animal research as a resul of their exposure to this idea through ARFSN activities. Among them was Pakistan, which conducted on-farm research on both food and forage crops at the same locations, while simultaneously investigating the potential of buffalo for both draft and milk production. This project was inspired by similar work in the Philippines.

Five countries—China, Bangladesh. Vietnam. Indonesia. and the Philippines—formed cross-sectoral committees or subnetworks at the national level whose role was to plan and implement projects that integrated research across several sectors (see page 55).

Involving universities—Durig the 1970s, universities in Asia came under pressure to contribute more practically to national development. The farming systems research movement gave them the opportunity to do so.

On foundation, ARFSN acted quickly to tap the underexploited resources of universities for problem-oriented on-farm research. The University of the Philippines Los Baños was a strong participant at both the national and regional levels from the outset. Thailand's Kasetsart and Khon Kaen universities also collaborated at an early stage, launching projects at two key sites that served as a laboraton for methodology development.

The most important contribution made by the universities lay in the social sciences—often an area of weakness in conventional commodity research institutes. A typical example is the input provided in Thailand by Chiang Mai University to the work of the Farming Systems Research Institute at Amphoe Phrao. The team working in this village had no economist, with the result that labor allocations and other social and economic factors were poorly understood. The university conducted a socioeconomic baseline study, drawing attention, among other things, to the roles of women and to the potential for involving them in increased poultry production—an opportunity the team subsequently sought to make the most of (see page 45).

Links between research and extension—Early practitioners of the farming systems approach were driven by a strong desire to close the gap between research and extension—perceived as a major weakness of station-based research.

ARFSN was able to strengthen the links in the field between research and extension wherever it had collaborative projects on the ground (see box). It was less successful in establishing cooperation at the departmental level and in countries or areas where it did not have projects. And it was seldom able to institutionalize links so that these were sustained in the longer term, once projects ended.

Institutionalizing the farming systems approach

Many donor-funded projects with a short timespan leave little trace behind them. Once the project ends and funding is withdraw, participants revert to their old ways.

ARFSN was different. Through its strong emphasis on training and collaborative research over a 20-year period, it brought about a sea-change in the way national research institutions and systems operate.

Stronger links help extend technology

AMONG THE WORLD'S developing regions, Asia has relatively strong extension services. ARFSN was frequently able to capitalize on these to achieve maximum impact from its small collaborative field projects.

At Phayao, in Thailand, scientists selected the research sites in consultation with extension workers, who also helped to characterize them. The research team evaluate various cropping patterns and technologies, identifying mungbean - rice and dry-seeded rice as the most promosing. It organized field days for farmers and extension workers shortly before harvesting. Three 1-day training sessions were held for subdistrict extention workers from different districts and provinces where multilocation testing was to take place.

As a result of the pilot phase at Phayao, the area devoted to dry-seeded rice grew from 7 ha in one province in 1982-83 to 1,484 ha in four provinces in 1986-87.

Virtually all the countries participating in ARFSN have espoused a farming systems approach to research. Some, such as the Philippines and Indonesia, made esplicit policy declarations to this effect. Many started new programs or divisions. Two countries—Thailand and the Philippines—launched new farming systems research institutes. In some countries, a farming systems approach to research was adopted, but without a major reorganization.

There is no firm evidence to suggest that any one of these measures is more effective than the others for institutionalizing the farming systems approach. While launching a new program or institution ensures a clean break with the disciplinary or commodity-based approaches of the past, it is vital that these new structures be provided with adequate budgets and properly trained staff to fulfill their tasks. This did not always happen in the countries participating in ARFSN—and in these circumstances it is tempting to conclude that the farming systems approach is more effective as an underlying philosophy than as an organizing principle in research.

More encouraging evidence of successful institutionalization lies in the number of national universities that now offer courses in farming systems research and development. Among the first to do so was the University of the Philippines Los Baños, which now has a course at both the graduate and undergraduate levels. Thailand's Chiang Mai and Khon Kaen universities, which began systems-oriented research in the late 1970s, offer a range of courses, including an MS degree. Some of these courses are taught in English and are open to applicants from other Asian countries as well as Thais.

Another encouraging sign is the foundation of the Asian Farming Systems Association, which held its first meeting in Bangkok in 1990. The association was organized to bring together scientists working on rice-based farming systems with those adopting a systems approach to other commodities. Membership is through subscription. Many members are former ARFSN collaborators, and most of the officers were members of the Asian Rice Farming Systems Working Group.

Professional societies are really a form of networking. Through their levies of membership dues, they are more likely to prove self-sustaining than donor-funded networks. In the past, professional groups have usually organized themselves along disciplinary lines. The emergence of the Asian Farming Systems Association shows not only that such groups may form at international level within the developing world but also that they may take a multidisciplinary form more suited to today's research and development needs.

In many couuntries, it is difficult to distinguish the influence of ARFSN from other factors that led to the adoption of a farming systems approach. The case of Bangladesh provides the clearest example of the network's catalytic role. It also shows how international networks can help to integrate national research systems by stimulating the formation of additional networks at national level (see box).

"ARFSN helped the Bangladesh Rice Research Institute pioneer farming systems research in Bangladesh. I congratulate ARFSN scientists on their relentless efforts to bring about positive changes in poor farmers' communities, not only in Bangladesh but throughout Asia."

— **Mamunur Rashid,** director general
Bangladesh Rice Research Institute

"The farming systems perspective has been institutionalized by the Department of Agriculture in its pursuit of agricultural development in the countryside. Farmer participation is made real in such an approach."

— **Manuel Lantin,** undersecretary for research, training, and field operations
Department of Agriculture, Philippines

Rural development

ARFSN also changed for the better the lives of thousands of rural people in Asia. It shares the credit for this with the researchers who generated new technology (only some of whom were members of the network) and the policymakers, extensionists, and others who helped to disseminate it.

Growth

Reporting to a meeting held in 1993 to review ARFSN's research in China, the president of the Chinese Academy of Agricultural Sciences estimated that, over the 5 years since the project began, new technologies had been extended to an area of 1 million hectares, bringing a total increase in farmer's incomes of about US$52 million. This

Bangladesh: network within a network

BANGLADESH WAS ONE of the founder members of ARFSN and the first Asian country to start reorganizing its commodity research to accommodate a systems perspective. This it did with the creation of a Cropping Systems Research Division within the Bangladesh Rice Research Institute (BRRI) in 1974. A year later, BRRI began on-farm research at two locations in the irrigated and rainfed lowlands, where multidisciplinary teams applied the methodology developed by ARFSN. Other sites were later added, to cover the deepwater, rainfed lowland, and irrigated rice ecosystems. Dubbed a "miniature IRRI" by one observer, BRRI had a strong emphasis on ecosystems right from the start.

From BRRI, the farming systems approach spread to other institutes. With the involvement of the Bangladesh Agricultural Research Institute (BARI), the core of the public-sector national research system became committed to promoting the approach, through both its own programs and those of other institutions and sectors. Institutions as diverse as the Bangladesh Jute Research Institute (BJRI), the Bangladesh Agricultural University (BAU), and the Bangladesh Water Development Board were soon enthusiastic practitioners. An interesting feature of the Bangladesh experience was the early involvement of nongovernment organizations (NGOs), with CARE, HEED, and the Mennonite Central Committee adopting the approach in the late 1970s.

By 1979, an informal network linking these institutions at the national level had formed. The network organized a training course to develop standardized methods and common data formats. By 1980, the country had 30 research sites at which a cropping systems approach was being applied. In that year, the network's efforts gained the recognition of the Bangladesh Agricultural Research Council (BARC), which coordinates all agricultural research in the country. The council formalized the network and created a coordinating committee to steer its program. The statement of the network's objectives developed by the committee clearly reflects the influence of ARFSN and IRRI, emphasizing farmer participation, interaction between system components, the need for socioeconomic research, and the develop ment of better links between research and extension.

In 1984, BARI established an On-farm Research Division to consolidate all the on-farm research that was by then being separately conducted by its various programs and projects. This was a large division with around 500 staff scattered about the country. The division inherited a network of around 200 trials. A process of rationalization followed, in which a reduced number of trials were grouped at 11 cropping systems research sites and 82 multilocation testing sites.

When ARFSN broadened its scope in 1983, Bangladesh did likewise. The Bangladesh Livestock Research Institute (BLRI), the Bangladesh Forest Research Institute (BFRI), and the Fisheries Research Institute (FRI) all joined the national network, which changed its name to become the National Coordinated Farming Systems Research Program (NCFSRP). An animal scientist joined each on-farm research team. BRRI, BARI, and BLRI launched collaborative research on forage crops, which ran alongside the food crop research at key research sites. Mirzapur, a deepwater rice area, became one of the key sites for research on rice - fish systems.

The national network had thus become the mechanism for cross-sectoral cooperation, breaking down the barriers between the country's different ministries and institutions.

Research on gender issues was launched by BRRI's Cereal Chemistry Division, which hosted a workshop on gender roles in rice farming in 1990. The workshop recommended the incorporation of gender issues in all national research. This call was taken up by BARC, BARI, BAU, and the NGOs. Many of the women in these institutions had already participated in IRRI-sponsored events with a gender component.

figure alone is more than seven times the total budget of ARFSN over its 20-year life-span.

With its highly organized research and extension system, good infrastructure and vast expanses of arable land, China provides what is perhaps the most dramatic example of the network's impact on production. Nevertheless, many other countries have reported similar results, albeit on a smaller scale. In Indonesia, for example, rice production in the densely populated Indramayu area of West Java doubled in less than a decade as a result of the ARFSN project in that area.

Both between and within countries, ARFSN played an important part in technology transfer. Often, the flow was two-way: in the case of the Philippines, for instance, the idea of rice-fish farming entered the country from Indonesia. while the intensification of rice production. Which began at Iloilo and other locations, spread to other countries.

At local level, cropping patterns in which both components were already familiar to some farmers in the area, such as rice double-cropping or rice - mungbean, often proved more popular than more radical production systems involving new crops. In these cases, the network acted more to speed up a process of adoption that was already taking place than to introduce new technology.

Equity

ARFSN, like IRRI's Multiple Cropping Program, was most effective in transferring technology in areas where water supplies were predictable and farmers could obtain the necessary inputs easily. In the less favorable rainfed areas—particularly the uplands—the record of technology adoption following network activities is less impressive. Even here, however, there were signs of slow but steady progress in many projects. Farmers in the poverty-stricken Bihar State of India adopted both new crops (vegetables) and new technology for their existing rice crop once project interventions had increased their water supplies. And it should not be forgotten that, in poorer areas, the benefits of project activities cannot be measured in purely monetary terms. Producers in the poor Amphoe Phrao Province of Thailand continued to adopt mungbean despite its apparently negligible contribution to family farm income.

As we have seen, ARFSN's sponsors intended its research to benefit low-income producers—an aim broadly met by targeting research across a range of ecosystem. Evidence from several projects shown how difficult it is to reach the very poorest members of this group—those who put themselves most at risk when they adopt new technology. In both Isabela Province of northern Philippine, and Amphoe Phrao Province of northern Thailand, adopters were larger farmers with higher incomes and savings in the bank. This pattern was repeated in many other projects. Only in fish-rice systems was there some evidence of a technology that could benefit smaller farmers.

The network's clearest contribution to meeting equity objectives came through its attention to gender issues. While it is still too early for this work to have achieved broad impact, research results show clearly that a combination of labor-saving technology and improved livestock or crop enterprises, such as poultry or glutinous rice, could act powerfully to improve women's lives. Training in areas such as seed selection and integrated pest management also shows great promise, with a strong potential impact on human health and well-being.

Sustainability

ARFSN's impact on the sustainability of production is less easy to discern. Its early projects, conceived before environmental concerns had gained their current prominence, were content with measuring short-term gains in crop yields and farmens' incomes. Few attempted to assess trends in productivity over the long term, or the effect of new technology on the natural resource base.

ARFSN played a leading part in the intoduction of food or dual-purpose legumes to many areas. It also helped introduce forage legumes in a few countries. Some network projects were among the first in Asia to test agroforestry components and systems such as hedgerow intercropping. These projects undoubtedly helped to conserve and enhance soil resources, although the precise amount of nitrogen fixed was seldom measured.

Conclusion

The Asian Farming Systems Working group held its 24th and last meeting in the Republic of Korea in September 1993. Funding for ARFSN ceased in 1995. What was achieved? And what should happen next?

National programs in Asia now have a firm grasp of the technologies currently available for increasing food production. Remaining opportunities to disseminate these technologies more widely lie mainly in the rainfeed and upland areas. Improving the links between research and extension will help to realize these opportunities.

All participating national programs now posses skills in a farming systems approach to research. A new generation of researchers and policymakers has grown up convinced of the value of that approach. More needs to be done to integrate the social sciences into the research process, and to develop techniques and methods for taking sustainability and equity issues into account in the design and evaluation of technology.

Looking ahead, it is clear that increasing and sustaining food production must remain a major objective of national and international research in Asia. In the past 3-4 years, the Philippines has once again begun to experience rice shortages. Its population, currently 65 million, continues to grow at 2.5% annually. Similarly frightening statistics are repeated in most countries across the region.

Increasing the number of crops grown in a year is a "one-off" means of intensifying production—it can never be repeated. Future gains in output will have to come from less obvious sources and may be far more difficult to realize and sustain.

Yet the future is not without hope. Approaches to achieving productivity gains have undergone a quiet revolution in the 2 decades since ARFSN was born. The genetic potential of the crop and its biosphere is now more than ever seen as the key resource, with the prospects of raising the yield "ceiling" of the rice plant through a radical redesign improving daily. Instead of encouraging farmers to increase their use of pesticides, researchers are now investigating ways of doing without them altogether. Research on natural means of restoring soil fertility is seeking solutions to the problems of overdependence on chemical fertilizers wrought by the Green Revolution.

Asia is becoming wealthier, with many countries achieving growth rates that are the envy of Europe and North America. Under these circumstances, it is right that the region should shoulder an increasing share of the costs of its agricultural research. As it does so, it will need stronger and more efficient research institutions at national and regional levels. With its emphasis on training and on fostering collaboration between different countries, ARFSN has played a key part in building a stronger regional research capacity—one that is equipped to meet the challenges of the 21st century.

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