Developing sustainable rice production systems in Cambodia: An Australian contribution[1]

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Abstract
Australia recently made a contribution to the development of sustainable rice production systems in Cambodia through the Cambodia-IRRI-Australia Project (CIAP). This paper describes the difficulties faced and progress made in establishing a process through which technologies could be developed and evaluated on a national level. Commencing operations during an environment in which Cambodia was initially politically isolated, research resources and farm inputs were difficult to obtain. Sustainable farming systems technologies were therefore initially based on utilizing locally available products for crop improvement. As the country adopted an open market policy, imported goods become more readily available and these were included in the recommendations. Development of sustainability of other project activities were also pursued. Cambodian researchers were sponsored through higher degrees in Australia and returned to continue the research programs along with their colleagues in Cambodia. An income generation scheme was also developed to assist future operations of the nations new agricultural research institute.

Key Words
Cambodia, IRRI, rice, sustainable, research, IPM.

Introduction

In 1986,a representative from the Cambodian Ministry of Agriculture, Forestry and Fisheries (MAFF) invited scientists from the International Rice Research Institute (IRRI) to visit Cambodia and assist with research and training needs. Political isolation of Cambodia at the time excluded the country receiving assistance from the World Bank, Asian Development Bank, major UN development organizations and through direct bi-lateral aid from western countries. Despite international pressure not to do so, the Australian Government agreed to fund initial studies of the Cambodian MAFF proposal through IRRI's IndoChina program. The Cambodia-IRRI-Australia Project (CIAP) soon emerged from this small pilot project. IRRI accepted its first "post war" Cambodian agriculturalists for rice production courses in 1987 using CIAP funds (IRRI, 1988). An IRRI representative and small team were assigned to reside in-country the following year to help set up a national agricultural research system designed to include components of human resources enhancement and technology development (IRRI, 1990). Three extra phases of the project followed, all increasing in size and scope. The CIAP goal remained constant throughout the different phases of the project: "To increase rice production and the productivity of rice based farm production systems." After the project developed and promoted technologies that assisted Cambodia become self sufficient in rice in 1995, increased emphasis was placed on development of sustainable whole farm production systems. More importantly, however, CIAP encouraged the establishment of agricultural research capacity in Cambodia and the word "sustainability" within the project became the catchcry for the promotion of both rice based farming systems and for the future of in-country technology development.

Context and rationale of project in Cambodia

Cambodia was a major rice exporting nation in the 1960's during a period of political stability following independence from the French in 1953 (Helmers, 1996, Nesbitt, 1996). In 1964/65 rice exports exceeded 500,000 t/year and Cambodia was considered as being a rice bowl of SE Asia. Its capital, Phnom Penh was also a cultural magnet with the population enjoying a good quality of life. This encouraging production trend of increasing yields and area under crop soon reversed itself as the country became embroiled in the war against communism. By 1975, when Phnom Penh finally fell to the communist Khmer Rouge, the area under rice had declined by 77% and rice production had decreased by 84% of the 1970 level. During the Pol Pot (Khmer Rouge) era (1975-79) the country was further devastated through mass dislocation of the population. Intellectuals were persecuted and 25% of the population perished. By 1980 there was a dire shortage of qualified personnel to help rejuvenate the shattered economy. Only 40 of the 400 pre-war

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qualified agriculturalists remained in the country at this time and most of the research infrastructure was destroyed. Cambodia faced annual rice shortfalls ranging between 50,000 and 200,000 tons during the 1980's. The green revolution had virtually passed by Cambodia and its farmers continued to use traditional practices, many of which had been in operation for over a thousand years. To make matters worse, the Pol Pot policy of dislocating the farmers from their accustomed ecosystems resulted in many of the traditional rice varieties being lost. Cambodian farmers desperately needed access to improved technologies. However, there were few technicians capable of developing or adapting higher yielding practices for Cambodian conditions, a national technology evaluation system was non existent and agricultural extension was under-resourced. CIAP developed objectives to overcome these constraints. Its objectives were as follows:

a) To enhance the capacity in Cambodia to develop technologies in support of rice based farming systems,
b) Improvement of the quality and quantity of research conducted in rice based farming systems to provide improved household food and income security,
c) Development of a research system and the capacity of the system to conduct and manage agricultural research and training.

Over the following years, the project design included components of technology development, farming systems and the development of a research system. Each component possessed a number of sub-components. Technology development included plant varietal improvement, integrated nutrient management, integrated pest management and agricultural engineering. Farming systems included an understanding of the system (with social sciences), development of farming system methodology within the research fraternity and a component of on-farm agronomic diversification.

Re-establishing a research system in Cambodia after years of neglect and destruction required concentrated effort on developing human resources capable of conducting and managing a research program, on the development of the system itself and rehabilitation of sufficient infrastructure capable of supporting the programs.

The project was directed by its main sponsor, AusAID, to be cost effective and asked to develop an efficient management system which possessed an appropriate level of gender sensitivity, used a collaborative approach, was environmentally conscious and had an effective monitoring and evaluation system. Most project activities were conducted over a thirteen year period from the beginning of 1989, although there were a small number of training courses and diagnostic surveys conducted prior to that year. Approximately US$24.65 million was invested in the project. These funds were well spent as the project outputs and impact were considerable (Raab, 2000; Norris, 2001; Norris et al, 2001; Urwin and Wrigley, 2001; Young et al, 2001).

Major Project Outputs

Technology development

Plant varietal improvement At the commencement of the project, IRRI plant breeders were conscious of the fact that Cambodia still possessed a wide diversity of genetic material in the countryside, particularly within the rice population. To conserve this diversity, rice germplasm was collected over a five year period from 1989 resulting in 2,500 varieties being stored in Cambodia with duplicates at the rice gene bank in the Philippines. A collection of 500 accessions stored earlier in the Philippines was returned to Cambodia in 1988. Some varieties, lost during the war, were returned to farmers. Four single line isolates were developed from the collection and released as high yielding traditional rice varieties. A total of 34 photo period and non photoperiod sensitive varieties were released before the project terminated at the end of 2001. By this stage, a viable seed production system had been established in collaboration with other organizations.

Integrated nutrient management A soil classification system developed in the 1950's by a USAID soil scientist (Crocker, 1962) was initially used by scientists in Cambodia to formulate soil improvement recommendations. This pedological system soon proved to be inadequate and an in-house agronomic soil classification system was developed and used to formulate soil improvement recommendations for the major rice growing soils. The soils were then mapped to assist identify factors limiting rice production and for the establishment of policies for the sustainable farming of each soil type (White et al, 1997).

Integrated pest management Surveys conducted during the 1980's indicated that pests were not a major problem in Cambodian rice fields. This appeared to be an ideal opportunity for the introduction of integrated

pest management techniques before pest incidence increased. AusAID were brave enough to support the implementation of such a program and an IPM team was assigned to the project in 1995. By the end of 2001, IPM techniques were developed and recommended for 11 key pests, a museum of insect, weed, rodent and snail pests was established, pest distribution maps developed and a national pest forecasting program established. Participatory rodent control methods and a golden apple snail eradication program were also in operation.

The agricultural engineering team extended improved on-farm water harvesting techniques in addition to developing labor efficient crop establishment techniques and post harvest improvements. Land levelling proved to be economical in some environments and was promoted where funds were available for equipment hire and fertilizer purchases.

Farming systems

Integrating each of the above technologies into productivity improving systems was achieved only after a number of baseline surveys and in-depth studies of household consumption and income were completed. A system was also developed to incorporate Government, Projects, NGOs and other agents of extension into the research process. Much of this research was conducted in a participatory approach with extension agents.

In the late 1980's and early 1990's when chemical fertilizers were in short supply, the use of Sesbania rostrata and other green manure crops were promoted along with applications of rock phosphate. In later years, as the market economy was adopted and relatively cheap imported goods become available, these recommendations were supplemented with a range of options for farmers to improve their overall farming system.

Although initially outside the project's mandate, CIAP research agenda expanded into non rice crops by placing greater emphasis on increasing whole farm production. Activities included research into legume based farming systems, varietal evaluation of mung bean and soybeans and land remodelling to reduce the effects of flooding and drought. The project goal changed to meet these challenges when Cambodia became net exporter of rice in 1995. Further agronomic diversification was promoted after collaborative work with the Asian Institute of Technology (AIT) and the Cambodia-Australia Agricultural Extension Project (CAAEP) developed rice fisheries and animals in the rice ecosystem manuals to encourage agricultural diversity under challenging conditions (Gregory, 1997; McLean, 1999).

Project sensitivity towards developing sustainable farming systems was enhanced through its collaboration with the non governmental organizations in Cambodia, many of whom operated at the grass roots level in the provinces. NGO's were able to organise the farmers into groups to discuss issues of sustainability of farming systems against the traditional practice of continued rice production.

Development of research system

(a) Human resources development

Training needs assessments were conducted regularly during the project and updated as the capacity for research and extension improved. Short courses were provided directly by project personnel and through qualified agencies within the country. Short, medium and long term training was also provided abroad. As a result, between 1987 and 2001, over 7000 training opportunities were provided to more than 1700 individuals. Twelve PhD graduates from Australian universities now lead the agricultural research system in Cambodia.

(b) System development

By the end of the project, a national agricultural research system was established, being directed by the newly established Cambodian Agricultural Research and Development Institute (CARDI) and operating through MAFF technical sections and provincial agricultural offices.

(c) Infrastructure

Almost all research facilities were completely destroyed between 1975 and 1979 during implementation of the "year zero" policies of the Khmer Rouge. It was not until CIAP established an office in Cambodia in 1988 that support for research infrastructure rehabilitation was forthcoming. Buildings on 14 research

stations across 9 provinces were constructed and assistance provided to stock the buildings with basic research essentials. Land for establishment of CARDI was allocated by the Cambodian Government in 2000 and funds were allocated by the Australian and USA Governments for construction of buildings and the provision of equipment. CARDI assumed responsibility of agronomic research at the end of 2001.

Project impact

Towards the end of the life of CIAP (end of 2001) five impact studies were conducted to determine the effect the project had on Cambodian agriculture. Studies included evaluations of human resources development and information dissemination, the interactions CIAP had with the NGO community, environmental impacts, gender and finally the impact the project had on the Cambodian economy.

Human Resources Development and information dissemination

The large number of training opportunities (over 7000) provided by the project had an extremely strong impact on technical personnel within the MAFF. This knowledge capital, widely acknowledged by the UN, NGOs, government officers and private enterprise, provided the basis for most farmer training courses held in Cambodia during the 1990's. The project also provided reference material from its library, pest management laboratory, soils laboratory and plant breeding plus engineering offices.

CIAP – NGO interactions

CIAP had a very strong impact on the institutional capacity of NGOs by training Cambodian NGO staff members, the formation of a technical group responsible for information dissemination (resulting in the formation of the Cambodian Society of Agriculture) and through extensive technical backstopping. NGOs played a key role in disseminating and adapting CIAP technology for use by farmers. NGOs have key access to farmers problems at the grassroots level and provided feedback to CIAP on the requirements for research.

Environment

The main source of environmental degradation the Environmental Impact Assessment team could determine CIAP had on Cambodian agriculture was the fact that the genetic diversity of rice in Cambodia was in danger because there was a rapid adoption of project released varieties. In addition, the reviewers considered that farmers could over or miss-use fertilizers and result in the contamination of ground and surface water supplies. Conservation of Cambodian rice was a concern for all project personnel because they could foresee Cambodian farmers adopting a smaller number of higher yielding rices and losing the diverse range of traditional types. Project plant breeders placed considerable emphasis on collecting a complete set of Cambodian rice varieties for long term storage in the event of this happening. The agronomic soil classification system also allowed targeted fertilizer recommendations, thereby reducing pollution of ground and surface water sources. It was also considered that the pre-emptive IPM program reduced the adoption and use of pesticides. Adoption of other project recommendations resulted in improved agro-diversity, increased fish numbers in the paddies and reduced greenhouse gasses.

Gender

Women's labour requirements intensified when the farm adopted CIAP's high yielding rice varieties (HYV) and improved single line isolates of traditional rice (CAR) varieties. More work was also involved with extra fertilizer applications, improved seed storage techniques and knowledge intensive activities like IPM. Demand for women's labour decreased by land levelling and direct seeding. Conversely, farm diversification recommendations hold tremendous potential for improving the economies of female headed households.

Agriculture was generally not the first choice for women to study in Cambodia and there was never a high ratio of women technicians employed by government and non government organizations. Despite this, women's participation rates in CIAP courses were well above Government ratios and the project personnel list possessed higher women workers ratios than the Government.

Economic impact

Financial rates of return for rice production are traditionally low in Cambodia. However, a financial model of investment in dry season rice production using CIAP technology resulted in a financial return of 36%. A similar model for early wet season rice resulted in a financial rate of return of 45%. The major costs included in this model were farm operating costs and labour. When research, extension and on-farm

investment costs were included, the calculated economic rate of return was 32% for the full life (1987-2020) of the project evaluation period. Despite the apparent low rate of return for the farmers investment, rice production in Cambodia increased by 50% over the length of the project, mainly due to farmers adopting CIAP recommended technology. The extra production resulted in net financial benefits to Cambodian farmers estimated at US$1.3 billion. Extra animal production and improved population health benefits were not included in this calculation. Most importantly, the project achieved its goal of developing technologies that all Cambodian farmers could potentially benefit from. Further technologies continue to be developed at the newly established CARDI and more improvements to agricultural productivity are forthcoming.

Sustainability

CIAP's goal of increased agricultural production and productivity was achieved after improved technologies were released to and utilized by the farming community. This resulted in Cambodia becoming self sufficient in rice production by 1995 and the country has exported rice each year since then. A vast improvement has already been made to food security in a major proportion of Cambodian farm households. Sustaining project gains over the medium and long term is dependent on a number of factors. These are described below.

Human resource development, expertise retention and attraction to research

An impact study on human capital development in CIAP (Raab, 2000) conducted in 2000 considered that the 1700 persons trained over the length of the project will continue to have an impact on technology development well into the 21st century. This will result from the extension of existing or the development of new technologies. Personnel trained in the early years of the project now hold senior positions in provincial and central government offices and use their knowledge to train younger staff members. The multiplier effect is considered to be six fold, dramatically expanding the effects of the training.

All CIAP trained personnel remain in Cambodia supporting the development of agriculture. Some personnel shifted focus from research to extension or development work but directly or indirectly still assist the spread of CIAP developed technologies. Replacement of this expertise and attraction of researchers to CARDI is currently being assisted by a new project supporting CARDI management (CARDIAP) funded by AusAID, funds from an ADB loan and funds from CARDI income generation projects. Supplements to the low government salaries will remain an important component of these projects to attract and retain staff possessing a high degree of research expertise.

Technology development

Technology developed by CIAP is presently increasing the production and productivity of rice based farming systems by more than A$100 million per year and will continue to do so as the technology is extended to more farmers. The gains made to date will never be lost. Refinement of these technologies and development of new technologies will be made through the now existing national agricultural research system with CARDI as its headquarters.

Extension

Provision of an efficient knowledge delivery system remains a key to the success of the agricultural research system. Fortunately for CARDI, the establishment of the Department of Agricultural Extension, and projects to support it ensure CIAP and CARDI developed technologies will effectively reach the farmers. CAAEP and the Agricultural Quality Improvement Project (AQIP), both AusAID funded projects remain lead agencies in agricultural extension, seed production and post harvest quality control.

Environmental and economic sustainability of technologies

A conscious effort was made to ensure project developed technologies were environmentally and economically sustainable before being releasing to stakeholders. Initially, for example, the nutrient recycling work relied on the use of locally available inputs such as green manures, farm yard manure and applications of rock phosphate. When the markets opened up and chemical fertilizers became available, soil improvement recommendations were expanded to cater for a wider range of social groups. Recommendations remained targeted to soil type and are therefore sustainable in an environmental sense. More laborious but less expensive technologies remained a core of the recommendation schedule for poorer farmers. The same principles applied to the range of varieties and recommendations for water security, agronomy and IPM.

Germplasm conservation
The range of rice varieties available in the farming community will diminish as CIAP recommended varieties spread onto a larger number of farms. Loss of this germplasm is protected through the existence of a germplasm center at CARDI. The collection is stored in a number of low cost domestic freezers which are easy to maintain and do not require a constant supply of electricity. Thus the collection is reasonably secure. To be doubly sure, a duplicate set of varieties is kept in long term storage facilities at IRRI headquarters in the Philippines.

Seed production
Ongoing supplies of seed of CIAP released varieties are essential to ensure sustainability of project benefits. This seed production may become the responsibility of commercial seed producers leaving the development of new varieties to research institutions.

Infrastructure
Buildings constructed by CIAP at CARDI and on provincial research stations were all built to operate on a minimum overhead. Offices at CARDI, for example, with their high ceilings can be cooled using fans with electricity provided by a smaller generator rather than cooled by more expensive air conditioners. Farm operations on all stations can also be conducted with local methods on small budgets. Extra construction at CARDI is planned under an ADB funded project. In general, sustainability of the research system in not a problem if government personnel remain interested in developing technologies and operational funding continues to be forthcoming from both Government and non government sources.

Finances
CARDI cannot survive on government funding alone, but it's financial security is assured for at least five years past the beginning of 2002. Support is being provided by ADB for infrastructure, research and general operating costs and the Government provides government level salaries and some research plus operating costs. AusAID will assist with salary support, management training and some research costs while CARDI will generate additional funds through the business unit. Planned income generating activities include seed production, contract research, training and personnel services. Smaller fund sources include collaborative research programs with institutes and projects. Included in this category are activities with UN agencies, international organizations including IRRI, bi and multi-lateral aid programs and ACIAR.
Farmers also require an improved level of affordable credit to facilitate the purchase of farm inputs and allow the family to pay for unexpected expenses including family health bills. A number of micro credit facilities have opened up in rural areas in the past few years reducing the cost of borrowing for poor farmers, thereby improving the chances of farmers adopting more profitable modern farming practices.

Local and overseas technical support
CARDI will need to maintain strong linkages with local and overseas organizations to retain an up to date and focused research program. It already has collaborative projects with UN agencies, NGOs, bi and multi-lateral aid agencies in Cambodia, and projects with ACIAR, IRRI and the Asian Vegetable Research and Development Center (AVRDC). Technical support from these organizations will provide good direction for specific research projects and will need to be carefully managed by CARDI to ensure the research program does not become too fragmented and donor driven. IRRI will open an office at CARDI to maintain close collaboration between the two organizations.

Research priority setting to maintain relevance
Setting relevant research priorities is a constant challenge for all research institutes, particularly those with limited resources. CARDI will need to strike a balance between complying with Government directions, generating income and satisfying donors.

Capacity to respond
Maintaining research relevance will require CARDI to continue to respond to the changing environment. This process will be assisted by maintaining a flexible personnel management system at CARDI allowing staff to transfer between internal and external projects. A reduction in the capacity to respond will make it difficult for CARDI to maintain a relevant research program.

Political awareness
CARDI has maintained a particularly high level of political awareness since it's inception in 1988. During his speech at the institutes inauguration ceremony and on other occasions, the Prime Minister promised not to neglect his "baby", thereby ensuring the long-term sustainability of institute.

Conclusions
A long term commitment is necessary when providing assistance to research into sustainable farming systems for a developing country. In addition to financing the development of technologies themselves, support may also be needed to assist operation of organizations within the research system. This was the case in Cambodia where the whole agricultural system was devastated by war and a long period of political isolation. Evaluation of technologies in the field was often a slow process because most subsistence farmers were risk averse. Farmers often did not produce enough food for their own households and, in the case of food crops, gaining short term yield benefits needed to be balanced against the adoption of more expensive but sustainable medium and long term practices. Because most Cambodian farm family members were involved in agricultural activities, many operations were gender specific. Gender preferences were therefore of importance during problem identification and technology development. Despite these constraints, farmers adopted technologies developed by CIAP to various degrees and national rice based farm productivity increased significantly. This was not at the expense of the environment and targeted technologies reached a range of social levels within the farming community. Australian funds assisted Cambodia establish CARDI which will continue to develop more productive and sustainable farming systems. Future technology development activities are now in well trained Cambodian researcher hands, all of whom wish to maintain strong linkages with Australian research institutions.

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