

Foreword

The Ministry of Agriculture, Forestry and Fisheries (MAFF) has pleasure in presenting this Master Plan for National Agricultural Research for general reference and guidance. The Master Plan was developed over a twelve month period commencing at the beginning of 2005 and involved many stakeholders in agriculture. Included were staff from MAFF research institutes, MAFF departments, representatives from universities, agricultural schools, the private sector including proprietors of agro-industry and farmers, NGOs and donors to agricultural development. Together, the stakeholders identified the strengths, weaknesses, opportunities and threats (SWOT) of the agriculture sector in Cambodia and the main research institutes serving it. Based on these SWOT analyses, working groups consisting of the representatives from each agricultural sub-sector proposed research programs that Government institutions will coordinate over the next ten years to resolve the identified problems. The whole process of developing research programs and the resulting research projects was a Cambodian Government led initiative and MAFF will continue its strong ownership of the research process into the future.

Cambodian Government research organizations are prepared to implement the new Master Plan with an expanded Government budget for agricultural research. MAFF will continue to cover the recurrent costs of the main research institutes and increase research implementation funds significantly over the next five years. Approximately \$2 million per annum over this period will be provided to implement agricultural research in the sub-sectors of crops, livestock, fisheries, forestry, agro-industry and rubber. These funds will provide the opportunity for the main research institutes and collaborative organizations to develop new technologies in support of more productive, profitable and sustainable agricultural systems. The Government will provide additional funds for training and improving infrastructure to ensure the long term future of agricultural research in Cambodia.

This Master Plan lays the foundation for a relevant, focused and flexible agricultural research system with strong linkages to Cambodian producers and international research organizations and education systems. All will benefit from our nation sharing expertise within the region. Cambodian institutes will expand their involvement in regional networks and collaborative research programs and the Government will develop laws which encourage the exchange of genetic material and intellectual property. Our commitment to the World Trade Organization will also expand the level of agricultural trade to increase market size and promote an environment of closer technical cooperation.

We encourage the use of this Master Plan to help achieve the national agricultural research system vision of “spearheading generation and transfer of improved and appropriate agricultural technologies in collaboration with partners and clients for sustainable development and poverty reduction”.

HE Chan Sarun
Minister
Ministry of Agriculture, Forestry and Fisheries
1 December, 2005

Executive Summary

Introduction

This document describes the structure, processes and activities that are envisaged for the national agricultural research system (NARS) for the period 2006-2015. The Master Plan is the result of a consultative process, most notably the efforts of five sub-sector working groups operating with oversight from a national steering committee. A medium term (2006-2010) action plan is also included and provides more detail on the research, infrastructure development, HRD and other planned activities for the NARS over the initial five year period.

The Master Plan was formulated with the assistance of a steering committee established in 2005 led by the Ministry of Agriculture, Forestry and Fisheries (MAFF) with representatives from the Government sector, Non Governmental Organizations (NGOs), donors and the private sector. Working groups with similar representation for the sub-sectors of crops, livestock, fisheries, forestry, rubber and agro-industry analyzed the strengths, weaknesses, opportunities and threats (SWOT) of the Cambodian agricultural sector. This process was also repeated on a regional basis with meetings in Kandal, Battambang, Kampong Cham and Sihanoukeville.

After identifying the constraints, the sub-sector working groups developed a research prioritization system. Using this system, research programs and projects were formulated to address the identified constraints.

Constraints to agricultural development in Cambodia

Many of the constraints to agricultural development identified through SWOT analyses require the development of technologies through research as well as sustained links to appropriate service providers, information sources and market centers. The working groups and regional workshops identified the main constraints for each of the sub sectors in order of priority is as follows:

- | | |
|-----------|---|
| Crops | (i) improvement to currently used varieties and cultivars, |
| | (ii) improved cultural techniques |
| | (iii) agricultural zoning |
| | (iv) pests and diseases, post harvest technologies |
| | (v) low soil fertility |
| Livestock | (i) improvement to animal husbandry practices |
| | (ii) disease control |
| | (iii) animal breeding |
| | (iv) socio-economics, public health and animal waste management |
| Fisheries | (i) techniques for aquaculture production |
| | (ii) better management and protection of aquatic resources |
| | (iii) socio economics of fisheries |
| Forestry | (i) forest resource management and conservation |
| | (ii) rehabilitation and restoration of degraded forest |
| | (iii) community based management of forest resources |

Agro-industry	(i)	quality, price and services in the market
	(ii)	farming, planning and services in agro-industrial development
	(iii)	food processing and storage
Rubber	(i)	improved selection of rubber clones
	(ii)	physiology agronomy of rubber trees and plantations
	(iii)	chemistry of rubber production

Vision and objectives of NARS

The vision and objectives of the Cambodian NARS to overcome the issues mentioned above are as follows:

Vision A system of excellence spearheading generation and transfer of improved and appropriate agricultural technologies in collaboration with partners and clients for sustainable development and poverty reduction.

Objectives To increase the quantity, quality, and availability of agricultural technologies, methods and policy advice for the efficiency and profitability of agriculture while improving food security, safety, equity, and natural resource sustainability.

Structure for agricultural research in Cambodia

The NARS structure for the period from 2006-2015 involves the following organizations and responsibilities:

1. The Council for Agriculture and Rural Development (**CARD**) chaired by the Prime Minister provides advice to Royal Government of Cambodia (RGC) on the overall rehabilitation and development of the agriculture and rural areas. It advises MAFF directly on RGC policy and has a representative on the Cambodian Agricultural Research Council (CAREC).

2. **MAFF** retains overall responsibility for its departments, general directorates, Forest Administration (FA), Provincial-level organizations and public institutions (including semi-autonomous institutes, SAIs). Funding mobilized by MAFF (including loans) for research institutions will be approved by MAFF and disbursed by the MOF.

3. **CAREC** will be provide leadership in developing vision, concepts and strategies for research and development in Cambodia to directly benefit rural stakeholders. It will coordinate the establishment of three year rolling plans for the sub sector with working groups plus public and private research organizations. The three year plans will be approved by the boards of individual SAIs and CAREC for forwarding to MAFF.

4. **SAIs** in MAFF will develop rolling research plans in collaboration with the sub sector working groups. These will be approved by individual SAI board of directors. The chairs of the SAI boards of directors report to the Minister of MAFF. Research institutes will include those for a) Crops, b) Rubber, c) Livestock, d) Forestry and Wildlife and e) Inland Fisheries. The Government will also give consideration to the future establishment of an institute for marine fisheries. The DAI will continue to conduct studies on agro-industry

5. MAFF will work closely with **NGOs** and the private sector to incorporate their research programs into mainstream activities. Representatives of these sectors on the board of CAREC will ensure non public sector research is recognized on a national level.

6. The participation of the **private commercial sector** in the provision of agricultural research services will be encouraged as well as their involvement in the governance of public sector agricultural research organizations.

7. Collaboration with **international organizations** (IOs) will be encouraged to address problems of common interest. The Cambodian NARS will, for the period of the MP, import suitable technologies from other NARS and IOs.

8. The Cambodian NARS will be concentrate on **applied and adaptive research**.

9. **Facilities** will be shared and occasionally transferred between MAFF departments and public institutions to improve efficiency. Low maintenance infrastructure will be constructed to suit the research program.

10. **Universities and colleges** will be encouraged to link their research to activities in research institutes and qualified personnel in the institutes will provide technical and teaching support to the universities and colleges.

11. **Provincial and local level** needs will become regular features of provincial plans and projects and arrangements will be made for their support as part of the decentralized system of planning and implementation.

12. The Cambodian research program will be based on **client needs**.

12. In the near to medium term (5-10 years), resource constraints are likely to rule out a significant degree of **decentralization of the NARS**. In time, producers as well as **public and private agencies** providing agricultural services in the provinces may feel that they will be better served by having regional or even provincial research stations which could profoundly affect the NARS structure and governance arrangements.

13. RGC gender guidelines regarding **gender and social issues**. The NARS will be pro-active in the employment of at least 30% women in its programs within 10 years. Ethnic groups will also be equitably represented in provincially based research programs.

Research programs and projects

Each of the working groups formulated research programs based on the major constraints stated for each sub-sector mentioned under “Constraints to agricultural development in Cambodia” above. MAFF is committed to supporting agricultural research and has allocated up to \$2 million per annum to the sector for the period from 2006-2010. Crops research will receive 42.5% of the total amount with the remaining funds being allocated on a 21,15,11, 6 and 4.5% basis for livestock, fisheries, forestry, agro-industry and rubber respectively. The allocation of funds to each sub-sector will be reviewed by CAREC in its three year rolling plans.

A majority of these funds will sponsor research projects coordinated through the national agricultural research institutes and departments including CARDI, DAHP

NAHPIC, IFRéDI, FWRSI, RUA and DAI. These organisations will closely collaborate with KCNSA, PLNSA, other Government agencies, NGOs, IOs and the private sector for the projects' effective implementation.

Externally funded research (international and national non-government) to be conducted in collaboration with Government institutes will be selected using selection criteria similar to that for Government funded programs.

Action plan and implementation schedule of Master Plan

An action plan for the implementation of the Master Plan over the medium term (2006-2010) period includes activities; time schedules and budgets for programs of research; infrastructure development; laboratory furnishing and stocking of equipment, necessary vehicles and field equipment; human resources development and research coordination. Cambodian Government funding will "jump start" the medium term period with its injection of funds. It is envisaged that over the 2006-2010 period, an increasing level of funding for research will be provided from external sources and by private enterprise. Some of these funds will be channeled through CAREC.

On-going research projects include a continuation of those with sponsorship from the Cambodian Agricultural Research Fund (CARF), the Australian Centre for International Agricultural Research (ACIAR), the Farmer's Livelihood Improvement Project (FLIP), Consultative Group for International Agricultural Research (CGIAR) centers, bi-lateral and multilateral aid programs, NGOs and the private sector. Planning for most of these programs was not complete for the five year period at the end of 2005. CARF projects for example will operate through to the end of 2007 and not continue. The current eight ACIAR projects will be completed before mid 2008 but a similar number of projects is envisaged to continue throughout the Master Plan period. Small research projects from CGIAR centers and bi or multilateral aid programs will also continue, as will private sector funded research, and regionally funded research programs.

Each of the agricultural sub-sector working groups (for crops, livestock, fisheries, forestry, agro-industry and rubber) prepared projects to address constraints to agriculture identified in the SWOT analyses. Tables matching the research programs and projects with the constraints are presented in the Appendices. One page concept notes for each of the proposed projects to be initially funded by the Government are also included.

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ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
ADRA	Adventist Development Relief Agency
AFSC	American Friends Service Committee
APIP	Agricultural Productivity Improvement Project
AQIP	Agricultural Quality Improvement Project
ASDP	Agricultural Sector Development Project
AusAID	Australian Agency for International Development
BATC	British American Tobacco Cambodia
CAAEP	Cambodia Australia Agricultural Extension Project
CARDI	Cambodian Agricultural Research and Development Institute
CARDI-AP	CARDI Assistance Project
CAREC	Cambodian Agricultural Research Council
CAREP	Cambodian Agricultural Research and Extension Policy
CARITAS	Catholic Agency for Overseas Aid and Development
CDRI	Cambodia Development Research Institute
CEDAC	Cambodian Center for Study and Development in Agriculture
CelAgrid	Centre for Livestock and Agriculture Development
CGIAR	Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CORRA	Council for Partnership for Rice Research in Asia
CRRRI	Cambodian Rubber Research Institute, usually referred to as IRRC in French
CRS	Catholic Relief Services
DAALI	Department of Agronomy and Land Improvement
DAE	Department of Agricultural Extension
DAHP	Department of Animal Health and Production
DAI	Department of Agro-industry
DAM	Department of Agricultural Machinery
DANIDA	Danish International Development Agency
DED	German Development Service
DOF	Department of Fisheries
DPSIC	Department of Planning, Statistics and International Cooperation
EU	European Union
FA	Forest Administration
FAO	Food and Agriculture Organization
FWSRI	Forest and Wildlife Science Research Institute
GDP	Gross Domestic Product
GIS	Geographical Information System
GMO	Genetically Modified Organisms
IARC	International Agricultural Research Centers
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development

IFReDI	Inland Fisheries Research and Development Institute
INIBAP	International Network for the Improvement of Banana and Plantain
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
KCNSA	Kampong Cham National School of Agriculture
LWF	Lutheran World Federation
MAFF	Ministry of Agriculture, Forestry and Fisheries
MEKARN	Research Cooperation For Livestock-Based Sustainable Farming Systems In The Lower Mekong Basin
MOC	Ministry of Commerce
MOE	Ministry of Environment
MOP	Ministry of Planning
MOWRAM	Ministry of Water Resources and Meteorology
MRC	Mekong River Commission
MSc	Masters of Science
MVU	Maharishi Vedic University
NAHPIC	National Animal Health and Production Investigation Centre
NARS	National Agricultural Research System
NGO	Non Governmental Organizations
NWFP	Non Wood Forest Products
PDA	Provincial Department of Agriculture
PFO	Provincial Fisheries Officer
PhD	Doctor of Philosophy
PIF	Provincial Investment Funds
PNSA	Prek Leap National School of Agriculture
RGC	Royal Government of Cambodia
RUA	Royal University of Agriculture
SAI	Semi Autonomous Institutes
SOE	State Owned Enterprises
SWOT	Strengths, Weaknesses, Opportunities and threats
TIP	Technical Implementation Procedure
USAID	United States Agency for International Development
VSF	Veterinaires sans frontiers
WB	World Bank
WTO	World Trade Organization
WVI	World Vision International

1. Introduction

1.1 Objectives

This Master Plan was developed by stakeholders of agricultural research in Cambodia. It is an analysis of the present and projected future research environment to make proposals for strengthening the research system and to define medium and long term goals and objectives. Based on these priorities and on available resources, the Master Plan enables the Government to decide on the best strategy for the evolution of the agricultural research system. The Master Plan indicates the necessary measures to be undertaken by the Government (especially the Ministry of Agriculture, Forestry and Fisheries, MAFF) for the Plan's smooth implementation, particularly regarding research prioritization, institutional and management changes and financial support planning.

1.2 Components of the Master Plan

The Master Plan is composed of three main components. These are:

- Part I A review and assessment of existing policies and strategies for agricultural research and extension,
- Part II Development of a renewed strategy for national research in the medium term
- Part III Identification of the priority research programs based on current and future needs in the agriculture sector

1.3 Formulation of the Master Plan

Existing policies and strategies for agricultural research and rural development were reviewed. The current state of the national agricultural research system (NARS) was examined in terms of institutional setting, research facilities, research staff capacity, service conditions, funding, priorities, organization and management of research, and linkages with farmers and other partners. Representatives of Government research organizations and departments, farmers groups, non governmental organizations (NGOs), private commercial enterprises and donors were consulted to evaluate the agricultural sector's strengths, weaknesses, opportunities and threats (SWOT) in relation to rapidly changing internal and external environments. The consultation process included fielding regional workshops, conducting a series of commodity working group workshops in addition to holding two national workshops and one meeting with the Technical Working Group on Agriculture and Water (Government and donor community). Other public and private sector individuals were also consulted in separate discussions. The results of SWOT analyses of agricultural sub-sectors conducted on a regional and working group level were combined and are presented in Appendix 1.

Structural options employed by other countries were examined and a system was developed for Cambodia which reflects its current needs and future prospects for agricultural development. Major improvements and additions to research linkages were found to be essential for the relevance of future research activities and for widespread

uptake. Accordingly, the plan includes measures to strengthen and add a) links to both small and commercial farmers and b) partnerships with universities, extension services, other development agencies, regional and international research organizations, agro-processing industries and agribusiness. Needs in terms of research personnel, information management systems, and monitoring, evaluation and impact assessment were evaluated and recommendations made.

New research programs and priorities were identified based on current and future research needs with an estimate of the resources required for the medium term period. Gender and environmental concerns were addressed in the design of proposed new agricultural research system and recommended mid term plan. A series of research project proposals were also developed by each sub-sector to submit to Government and non government organizations for sponsorship.

PART I

REVIEW AND ASSESSMENT OF EXISTING POLICIES FOR AGRICULTURAL RESEARCH AND EXTENSION

2. National Agricultural Research Policy

2.1 National policy and strategies, MAFF goals/objectives for the agriculture sector

Resolving problems in the agriculture sector is a key to poverty reduction in Cambodia. More than 80% of the population lives in rural areas and a majority (70% or more) of the nation's labor force is involved in agriculture. Although they have the capacity to produce their own food, 56% of the rural population is below the poverty line compared with 15% in Phnom Penh. (OPCV, 2002; NPRS, 2002; MOP, 2003). The RGC identifies improvements in the agriculture sector as being an important component of national development. As a result, the MAFF is formulating a strategic policy to enhance the agricultural sector based on the RGC Rectangular Strategy (RGC, 2004), the Cambodian Millennium Development Goals (MOP, 2003), the Second Socio-Economic Development Plan (SEDPII, 2001) and the National Poverty Reduction Strategy (NPRS, 2002). The resulting strategy and agricultural development policy is summarized in a recently released report (Agriculture Sector Strategic Development Plan, 2006-2010 (ASSDP, 2005), in which the RGC expressed the desire to be actively involved in:

- 1) Providing Government investment to promote agricultural intensification and diversification.
- 2) Accelerate land distribution and the issuance of land titles within the social land concession framework.
- 3) Upgrade and expand the area possessing irrigation facilities.
- 4) Improve water resource management by establishing and strengthening farmer water user groups.
- 5) Promote agricultural research and extension, agricultural market development, distribution of input supplies such as seed, fertilizers and rural credit.
- 6) Delegate the responsibility of knowledge transfer and information sharing with farmers to the commune councils.
- 7) Direct public investment and encourage private investment in the agriculture sector.
- 8) Continue to develop border and remote areas to improve necessary infrastructure.
- 9) Promote the "one village, one product" movement to encourage creativity and confidence of the rural population.

Policies directed at agriculture and the inclusion of Cambodia into the World Trade Organization (WTO) have implications on the type of research necessary to address such changes in environment. Some of these challenges are summarized in SWOT (Strength, Weaknesses, Opportunities and Threat) analyses presented in Appendix 1 and discussed in section 2.5.

The MAFF strategy to assist the RGC achieve its national development plan is currently under development. A draft of the proposed strategy is presented in the ASSDP (2005) and has been formulated as eight sectoral goals/objectives. These are as follow:

- 1) Improved food security, productivity and diversification.
- 2) Improved market access for agricultural products
- 3) Improving and strengthening the institutional and legislation framework.
- 4) Ensure access of land resources for the rural poor through a process of land reform for land tenure and land market development.
- 5) Create possibilities for poor to access land by improving land tenure security and land markets resulting in a reduction in land disputes.
- 6) Ensure sustainable access to fisheries resources for rural poor be encouraging fisheries reform.
- 7) Promote forestry reform to ensure sustainable forestry resource management and access to forestry resources for rural poor. Increase the proportion of forest cover to 60% by 2010 and increasing protected areas to 1.5 million ha.
- 8) Ensure better management of natural protected areas, including mangrove forests through producing data on land use, forest coverage, infrastructure and geographical divisions between protected areas.

The 8 goals/objectives were formulated to address 39 constraints in the agriculture sector identified by MAFF. Ninety six (96) actions are proposed to overcome the constraints. Within the five year period (2006-2010) for example, the MAFF aims to irrigate an extra 100,000 ha of land; establish farmer development communities in 24 provinces; include 30% women in training courses; implement participatory water management programs to 20% of existing irrigation systems and promote reforestation and rehabilitation of degraded forest areas. Specifically for the research system, MAFF will promote the development of technologies for improvement to the nations poor soils, low productivity of rice and other crops, pest management practices, land suitability for crops and post harvest practices. They will also address the lack of agricultural statistics, poor fish processing techniques, lack of agricultural legislation and legal framework of fisheries, limited fish conservation techniques, the capacity for research and lack of information on the use of forest goods. Improving the capacity of institutions to address these issues will be a high priority for MAFF. The formulation of this master plan is a reflection of that desire. MAFF estimates that US\$117,426,050 of the US\$127,498,050 budget for the 2006-2010 planning period will be spent on improving productivity and diversifying the agriculture sector. The remainder will be used for land reform, mine clearance, fisheries and forestry reform.

The large range of issues addressed in MAFF's strategic plan is reflected in the Ministry's vision and mission statement (see Section 2.2).

The current MAFF policy regarding research and extension is presented in the Cambodian Agricultural Research and Extension Policy (CAREP) statement developed in 1998. The two main tenets of the policy were to:

- a) separate the research and extension functions and provide them with separate budget allocations and,
- b) develop a long term strategy to develop sustainable research and extension policy systems.

Research was fundamentally separated from agronomy during the re-organization of the MAFF in 2000 after CARDI was established. Similarly, CRRI has been separated from the General Directorate of Rubber Plantation. The opportunity remains to separate the IFRReDI from DOF, NAHPIC from DAHP and the FWSRI from FA. None of the institutes possess budget allocations separate from MAFF although CARDI and CRRI have individual allocations for their recurrent costs. The operations of IFRReDI, NAHPIC and FWSRI are included in their respective Department budgets.

Both CARDI and CRRI have Boards of Directors who determine research priorities at the institute level and are responsible for preparing the institute's development proposals. The boards also represent the major research stakeholders. However, during 1999 and 2000 when sub decrees for the Board of Directors were established, there was no mechanism to include Non Governmental organizations on the boards of Government institutes. For this reason, all members of these two institutes are Government personnel and it is difficult for either of the two boards to incorporate opinions from the private sector or to solicit non government funds to assist operate the centers.

CAREP suggests that the existence of a research council composed of Government, private sector, NGOs and other sections of the civil society would help prioritize the allocation of research resources between institutes. A sub decree for the establishment of an agricultural development and research council is currently in draft form with the Council of Ministers for approval.

Slow progress has been made on the development of a long term strategy to develop the existence of a sustainable research and extension delivery system. There has been a) no reduction in the total staff involved in research and extension; b) apart from CARDI, no strategies are in place for cost recovery of some services and c) no delegation of personnel and financial responsibility and accountability to managers of research and extension delivery units. Terms and conditions of employment have also not been drawn up to ensure the retention of high performing, well qualified and experienced staff. However, considerable donor assistance has been provided in human resource development. Qualified persons are filling senior research positions at the research centers, departments and universities. This cadre of trained personnel will play a significant role in the formulation of sound research programs in the future if suitable employment conditions are offered to them (see also section 2.9).

Most CAREP recommendations for the extension system were in place at the beginning of 2005. These included a) basing and managing the extension system in the provinces; b) delivering services to groups rather than to individual farmers and c) encouraging the private sector to be involved. Large companies such as CP Corporation, BATC and the Royal Fertilizer Company all have active extension programs. A Farmer

Cooperative Program under DAE and an Agricultural Marketing Office under DPSIC facilitate interaction between farmers, extension services and researchers and to provide them with information concerning prices and market information. These units are currently under-resourced.

Not mentioned in the policy statement for agricultural research is the role of RUA, PNSA and KCNSA, all of which fall under the responsibility of MAFF. Each of these institutes conduct research during the education of undergraduate and post graduate students. Their research is supplemented by further academic studies conducted at Maharishi Vedic University (MVU) and by NGOs such as CelAgrid and CEDAC. These educational units and NGOs have the potential to play a major role in agricultural research in the future (see section 3.2)

2.2 Vision and Mission of the Cambodian MAFF

The **long term vision** of the MAFF is to ensure:

- Enough and safe food availability for all people
- Poverty will be reduced and the GDP per capita will increase
- Natural resources will be reserved and protected

The **Mission** of the MAFF is to:

“Support the economic growth of Cambodia by providing high quality services which result in a secure, safe food supply, increased agricultural output, and add value on a sustainable and cost effective basis to agricultural, fishing and forest based sectors.”

2.3 Composition of the Cambodian National Agricultural Research System (NARS)

The Cambodian NARS plays a particularly large role in developing techniques for improving productivity of food commodities and diversification within the agriculture sector as identified in MAFFs objectives. It also plays a part in the development of linkages to improve market access for agricultural products, provides options for improving access to fisheries resources and in the development of methods to improve the management and conservation of forests and protected areas.

The current NARS headed by MAFF addresses the challenges in agricultural development by organizing its research along commodity lines. The main research organizations within MAFF are as follows:

- (i) Cambodian Agricultural Research and Development Institute (CARDI) for research into crops (Appendix 2.1 for details).
- (ii) Cambodian Rubber Research Institute (CRRI) for research into rubber (Appendix 2.2).

- (iii) National Animal Health and Production Investigation Centre (NAHPIC) under the Department of Animal Health and Production (DAHP) (Appendix 2.3) for livestock research.
- (iv) Forest and Wildlife Science Research Institute (FWSRI) under Forest Administration (FA) (Appendix 2.4) for forestry research.
- (v) Inland Fisheries Research and Development Institute (IFReDI) under the Department of Fisheries (DOF) (Appendix 2.5) for fisheries research.
- (vi) Department of Agro-industry (DAI) (Appendix 2.6) for improvement in the agro-industry sector.

These institutes lead commodity based research programs in collaboration with the Royal University of Agriculture (RUA) (Appendix 2.7) and the two national agricultural schools (Prek Leap National School of Agriculture, PNSA and Kampong Cham National School of Agriculture, KCNSA). In addition, the MAFF departments of Agronomy and Land Improvement, DAALI; Agricultural Machinery, DAM, Agricultural Extension, DAE and Planning, Statistics and International Cooperation, DPSIC plus some MAFF sections will conduct studies.

Non public sector agricultural research includes that conducted often with multi-lateral and bi-lateral aid by NGOs, private and semi private universities and private enterprises. Aid supported research is generally conducted in collaboration with government organizations, often cutting across disciplines. Included in this category are FAO (Food and Agriculture Organization) IPM (Integrated Pest Management) farmer field schools and IFAD (International Fund for Agricultural Development) or World Bank (WB) funded rural development programs. The Australian funded CARDI assistance project (CARDI-AP) and the Cambodia Australia Agricultural Extension Project (CAAEP) also support research activities through government research institutes and departments.

NGO supported research is conducted both within and outside of the government system. The Cambodia Development Research Institute (CDRI) researches and analyzes socio-economic development issues; the Centre for Livestock and Agriculture Development (CeLAgrid) conducts research related to livestock, forage crops and renewable resource utilization; World Vision International (WVI) and CARE conduct individual social studies for their rural development programs as does the Cambodian Center for Study and Development in Agriculture (CEDAC), and the Adventist Development Relief Agency (ADRA) who also perform agronomic research as part of their agenda. American Friends Service Committee (AFSC), Lutheran World Service (LWF) and Venerinares Sans Frontiers (VSF) have all supported animal health and production programs, some of which involve research into small and large animals.

Private enterprise funded research also partners with government institutions. The CP Group Ltd working with RUA on pig genetics and poultry research is one example. Other companies finance and implement their own research programs. British American Tobacco Cambodia (BATC) (Appendix 2.8) manages its own tobacco research program and the Mong Riththy Group examines the advantages of feeding oil palm waste and cassava as stock feed.

Short descriptions of selected MAFF research institutes (CARDI, NAHPIC, and IFRReDI); one MAFF department involved in research (DAI); one university (RUA) and one private enterprise (BATC) are attached as Appendix 2. Summaries include the organization's mandate, personnel numbers and qualifications, linkages with other organizations, financial support and research programs. The strengths, weaknesses, opportunities and threats of a select number of research organizations are also attached as Appendix 3.

Other Government Ministries conducting research that may influence the development of technologies for agriculture include the Ministry of Water Resources and Meteorology, MOWRAM; Ministry of Environment, MOE and the Ministry of Planning, MOP.

2.4 Vision and objectives of the Cambodian NARS

Vision A system of excellence spearheading the generation and transfer of improved and appropriate agricultural technologies in collaboration with partners and clients for sustainable development and poverty reduction.

Mission To contribute to the improvement of the welfare of the Cambodian people and the conservation of the natural resource base, including soil and water, by increasing the sustainable productivity and sustainable utilization of crop, livestock, fisheries and forestry resources through the enhancement of agricultural scientific knowledge, and the generation, adaptation and transfer of improved technologies, methods and policy advice.

Objective The objective of the Cambodian NARS in the modernization process and in addressing the future challenges of agricultural development is:

To increase the quantity, quality, and availability of technologies, methods and policy advice for the efficiency and profitability of agriculture while improving food security, safety, equity, and natural resource sustainability.

Components of NARS Strategy The Cambodian NARS strategy includes 5 major components as follows:

- i. Improving the efficiency and effectiveness of technology development and transfer through the greater participation of producers in all stages of the research and dissemination process, better targeting of research resources and stronger linkages with all sources of knowledge;
- ii. Broadening the funding base and promoting participation of the private sector in the funding and provision of agricultural research and related services;
- iii. Incorporating social equity, gender and environmental concerns in all aspects of technology development and transfer;
- iv. Increasing and maintaining a knowledge base through applied and adaptive research and through interactions with international institutions for basic and strategic research data;

- v. Strengthening its capacity to implement these strategies in a sustainable manner especially with respect to its ability to attract, develop and retain quality staff, resource deployment and decentralization of activities in service of agricultural development efforts throughout the country.

2.5 Challenges facing Cambodian agriculture

Cambodia's NARS faces a number of challenges over the ten year Master Plan period. These include the development of new technologies to cater for increased competition resulting from the country's admission to the WTO, an acceleration in the distribution of large tracts of land requiring new technologies; an expansion in private sector investment in agriculture requiring a different approach to research; an increased involvement of farmers in the management of community resources; and the promotion of increased agricultural diversity plus the intensification of agriculture placing a heavier load on the research system.

Inclusion in the WTO will open Cambodia to increased competition both in terms of price and quality of agricultural commodities. Local farm produce needs to meet international standards for both domestic consumption and for export. It will also be strategically important for researchers to concentrate on improving the productivity of agricultural commodities in which Cambodia possesses a comparative advantage to its neighbors while ensuring the poor are food-secure. The RGC promotion of "one village, one product" may lead to agro-ecological zone preferences for production, making the research requirements even more specific.

Agricultural commodities identified as having considerable potential for investment by the private sector for export include rice, freshwater fish, rubber, livestock and fruit crops including mangoes and cashews plus silk, sugar palm and bamboo products (MOC, 2002, 2005).

The center of origin of "jasmine" aromatic rice is in the NW of Cambodia and NE of Thailand. The rainfed conditions in this area are conducive to the production of high quality aromatic rice which commands a premium on the international market. To improve production, investment is required in plant breeding and seed multiplication to ensure high quality seed is available for farmers. Increasing production without a resulting loss in grain quality is also a research challenge. This will be particularly the case if Cambodia was to produce rice for the "organic product" market, a market Cambodia is particularly qualified to supply considering the low level of chemical inputs presently applied to the predominant rainfed lowland rice ecosystem. Current production of quality rice is fragmented and suppliers (farmer associations and millers) need to be formed to ensure large quantities of high, consistent quality product reaches the millers. Investment from the private sector is also necessary to improve the milled quality of grain to exportable quality.

The Tonle Sap lake in Cambodia is the largest freshwater lake in SE Asia and covers almost 10% of the country during flood periods. During flood periods, 15-20% of the nation is covered with free standing water. The potential for producing fresh water fish in this environment to supply the expanding global market is very large. Technologies need refining for cage and pond production and management techniques for cage and the natural

resources extended to farmers. Private investment in fish processing is also necessary to meet the high WTO standards.

Cambodia's rubber industry has a known comparative advantage to neighboring countries because of the industry's excellent soil type and rainfall conditions. As a result the potential yields and product quality are high. However, certification of its products on the international market have been slow. As a result, prices for the product have been discounted by 10-15%. Certification is slowly being achieved and the state owned plantations will be divested in 2006 propelling the industry towards higher economic efficiency. Production challenges remain and further research is required to select higher producing clones and develop farming systems to bring higher returns to plantations replanting old trees.

Cambodia's low population density, particularly in the uplands provides considerable potential for increasing livestock numbers to feed the huge regional and global market for live animals. Caged and lot fed animal production in Cambodia is also undeveloped and there is high potential for this industry to grow in the future. Challenges remain in the supply of low cost animal feed and maintaining product quality.

The acceleration of land distribution to private concessions will place increasing pressure on researchers to develop new or adapt existing technologies for use in these areas to improve production and limit resource degradation. The development of sustainable resource management techniques will become increasingly important in the research portfolio. Large areas will become available for fruit and nut tree production particularly mangoes, oranges and cashews, crops that grow particularly well in Cambodia and are known to be of high quality on the domestic market. Mulberry trees can also be grown to supply the manufacture of silk products unique to Cambodia. The challenge will be to prepare these products cost effectively and to high enough standards for the international market. Upland cropping will require more interdisciplinary research than is needed for the lowland ecosystems resulting in the need for closer inter-department and inter research institute collaboration.

The Cambodian climate and many of its soils are conducive to the cultivation of sugar palm. This palm is recognized as being Cambodia's national tree and is ubiquitous to many regions of the country. Cambodia can exploit this palm to produce products "uniquely Cambodian" for tourist consumption and export. Products include hats and baskets from the leaves and sugar and alcohol products from the inflorescence sap. Utilizing the palm products effectively is a challenge for the agro-industrialists.

Cambodia does not possess either a robust agro-processing industry or a strong commercial farming sector. The RGC strategy to encourage private sector investment in agriculture will strengthen non government presence in the industry. The research needs of the private sector may be different to those of the traditional farming community and require addressing. At the same time, the small contributions to research currently forthcoming from tobacco companies, feed mill operators, plantation owners and animal lot centers may increase to reflect private sector interest in agricultural production and processing.

Financing public sector research is a challenge in all countries and Cambodia is no exception. Limited Government budgets will increase the need for public sector research

institutions to be efficient and responsible in its use of public funds. The Government will expect research organizations to produce outputs in terms of increased agricultural productivity and quality. It will become increasingly important for research organizations to not only conduct research and write up reports, but to also to develop strong linkages with extension at the central and commune level, to facilitate the transfer and utilization of the results by farmers and other stakeholders. End users need to be involved in the identification of problems and setting research priorities to ensure the research programs remain client orientated. The process of multidisciplinary working groups setting research priorities employed during the development of this research Master Plan will continue in future iterations of agricultural research Master Plan formulation.

Cambodia's small population and early phase of economic development limits its capacity to conduct cutting edge research. For the next decade at least, Cambodia will rely on external sources for a major number of technical developments. Some of this knowledge will be developed using expensive techniques such as agricultural biotechnology being employed at international research centers, well funded universities and research institutes in other parts of the world. Some techniques can be targeted to solve problems specific to Cambodia if local research institutions maintain good linkages with external research institutes and join regional organizations working on similar problems.

There is considerable scope for achieving productivity improvements in Cambodia through applied and adaptive research. Government funds are expected to support most of these activities. Collaboration with donors, international organizations, NGOs and the private sector will supplement these programs and provide most of the funding for applied and the small amount of strategic research. Government research institutions will ensure they plan to meet these needs of both the large adaptive research and developing applied research programs. Financial requirements, personnel levels, facilities, equipment, linkages and communication technologies necessary for the MAFF and NARS to achieve its vision and objectives over the next ten year period are discussed in the following chapters.

2.6 Agricultural commodities and NARS programs

2.6.1 Crops. Rice production dominates the crop sector in terms of cultivated area, food security and employment generation. Rice cultivation occupies 85% of the 2.7 million hectares of agricultural land in Cambodia. Less than 13% of this area is irrigated and yields are the lowest in SE Asia at 2.1t/ha. Despite the low yields, Cambodia as a nation has been self sufficient in rice since 1995. Improved productivity resulted from a concentrated seven year research effort to improve varieties and farming practices in Cambodia (CIAP, 2001). Production surpluses relate to the wet season rainfall and flood levels. Droughts and floods reduce the level of rice production surplus to domestic needs. In 2000 a surplus was estimated of approximately 40,000 tons of unmilled rice. In 2004-5 the surplus was estimated at 650,000 tons. Most this rice is sold across Cambodia's borders without going through the export licensing system.

Less effort has been put into research on other annual food crops which occupy about 8% of the total agricultural land. Estimated areas cultivated to some selected annual food crops are as follows; maize: 93,000ha, cassava: 26,000 ha, sweet potato: 9,000ha, vegetables: 36,000 ha, and mungbean: 45,000ha (MAFF, 2004). The average yield of maize is 3.3 t/ha and almost all of the production of approximately 300,000 tons is exported

to Thailand and Vietnam where drying facilities are more efficient than domestic sources. Animal feed processors (CP Pty Ltd) often import dried maize grain to make up for shortfalls sourced domestically. There is considerable potential for selling more grain in Cambodia if agro-processing improves. Mungbean and soybean are in short supply for feed mills, as these grains are also exported for drying. Some of the 350,000 tons of cassava harvested is also exported for feed purposes, although much of it remains in-country as human and animal feed. Processing of cassava into flour has considerable commercial potential and once factories are established, more farmers will be encouraged to grow the crop. Sweet potatoes and vegetables are all consumed domestically.

Fruit trees occupied about 3.5% of agricultural land. Areas cultivated to some selected fruit trees in 2003/2004 were; banana: 27,000 ha, cashew: 37,000 ha, coconut: 27,000 ha, and mango: 14,000 ha. All coconuts, bananas and mangos are sold on the local markets, while cashews are equally exported and consumed locally. Cashews from Cambodia are of inferior quality on the international market because of low quality trees and poor processing. There is considerable potential for production increases in this industry with the assistance of applied research. Other fruit trees/crops planted for local consumption include longan, milk fruit, sapodilla, durian, jack fruit, custard apple, orange, coffee, rambutan, guava, and pineapple. Cambodia's competitive advantage over neighboring countries in terms of wage rates and lower land values provides the potential for it becoming a major producer of annual food crops and fruit. Crop diversification will not only help increase farm incomes, but can bring underprivileged groups into the main stream of agricultural development.

Industrial crops (tobacco, jute, soybean, sesame, peanut, sugarcane, etc.) occupy 3.5% of the agricultural land. An estimation of cultivated areas in 2004 is as follows; soybean 52,000 ha, sugarcane 8,500 ha, sesame 32,000 ha, and tobacco 6,400 ha. There is a good opportunity to expand agricultural land, particularly in the upland areas, thus the production of these crops is projected to increase in the future. Yields may also be improved with irrigation and the adoption of improved practices. Exports of industrial crops include sugar, sesame and soybean, although the quality of the products is known to be poor. Improved in-country processing will improve the export prices of all products and encourage more cultivation of the crops.

SWOT (strengths, weaknesses, opportunities and threats) analyses conducted on the sector during 2005 by a special crop commodity working group and by members of working groups formed at regional workshops in Kandal, Battambang, Kampong Cham and Sihanoukeville identified the greatest strengths of the Cambodian cropping sector in general were related to crop area, climate and potential for diversification (see Table A1.1 in Appendix 1 for details). Government policy to support agriculture was also assessed as being a strength. The list of key weaknesses recognized by the working groups is long, but in many cases, may be overcome through implementation of improved and additional linkages between research, extension, marketing and small commercial producers. Researchable topics include the poor performance of local cultivars, limited cropping technologies, lack of agricultural zoning, pests and diseases, low levels of post harvest technologies and low soil fertility. There are also opportunities for improving crop production through an expansion of total cropping and irrigation areas. Threats to the sector are related to incomplete land ownership registrations and changes in land ownership

laws, inadequate rural roads and infrastructure hindering access to markets, increasing costs of farm inputs, storage and handling and natural calamities.

CARDI (Appendix A2.1 for more details) is the leading research institute in the cropping sector and addresses the identified problem of cultivar improvement in rice, maize, tomato, water melon, mungbean, soybean, banana, mango, cassava and cowpea (see Table A4.1 in Appendix 4). The institute also studies the agronomy of a range of crops, farming systems, socio-economics, plant protection, agricultural engineering and soil and water sciences. Adaptive crop research and technical support is provided by DAALI and RUA (Table A.4.5) while BATC studies varieties and agronomy of tobacco (Table A4.6). Other Government and Non Government organizations conducting crop based research include PNSA, KCNSA and CEDAC.

DAALI possesses 12 research stations and development centers spread across a range of ecosystems including the rainfed lowlands, irrigated environments (mainly for rice production), upland crops stations (for maize, legumes etc), a vegetable research station, pepper station and fruit research station. Many of the provinces also possess areas of land on which research may be conducted. Although termed research stations or development centers, the infrastructure is very rudimentary and the land is often utilized only for seed or crop production. However, most of the important ecosystems are represented on Government land and CARDI and other research institutes are able to utilize them for research purposes.

2.6.2 Rubber. Rubber trees were planted on 38,000 ha of the seven state owned plantations producing 26,000 tons of dry latex worth more than \$30.5 million in 2004. Rubber was also produced from a further 11,000 ha of small holder plantations. All rubber trees are located on Cambodia's "red volcanic soils" to the east of the country, mainly in the province of Kampong Cham.

A number of studies confirm Cambodia's comparative advantage for rubber production with its favorable soils and climatic conditions in addition to abundant cheap labor (see Table A3.2 in Appendix 3 for SWOT analysis). There is potential of increasing the area of rubber under production to a total of 150,000 ha, mainly through additional logging and clearing of existing natural forest areas. With reasonable yields, production should increase to 220,000 tons at full development. Significant increases in production are also likely to be achieved by growing improved clones and using better management practices.

State owned enterprises account for 80% of rubber production with the remainder coming from smallholders. This compares with 18% state ownership in Malaysia and 8% in Indonesia. Plans were underway in 2005 to divest Cambodia of state owned rubber plantations. This should free up the market for more investment in the latest technology and also increase the demand for applied and adaptive research activities. Poor efficiency of state owned enterprises (SOEs) is considered to be a major weakness of the rubber sector resulting in a low return in investment. The industry also requires considerable investment for replanting of old trees. Effective replanting will require comprehensive strategic planning and an improvement in extension. A shortage of expertise may limit such developments in the short and medium term (Table A3.2 in Appendix 3).

CRRI conducts research to address the major constraints of the rubber industry. Research includes the introduction of higher yielding planting material to address the low yields, investigations into improved tapping methods, inter-row planting to assist smallholder production and in improving the grade of rubber emerging from processing plants (Table A 4.2)

2.6.3 Livestock. Livestock numbers in Cambodia have steadily increased over the past two decades. In 2003, cattle numbered 3.65 million head, pigs 2.3 million and poultry 16 million. Traditionally, cattle and buffalo are used as draught animals rather than for slaughter. Livestock make up approximately 6.1% of GDP and had a trade value of approximately \$306 million in 2003. During that year production of cattle and buffaloes was approximately 1.9 million head and consumption 1.8 million leaving a surplus of 50-100,000 head for export.

Demand for meat in the nearby countries is projected to increase and it is likely that Cambodia will benefit from this expanding market opportunity (see SWOT analysis in Table A1.3 in Appendix 1). Thailand, Indonesia, and Malaysia are already importing large numbers of live animals. Vietnam also faces a meat shortage and the movement of live cattle across the border between Cambodia and Vietnam is well recognized. In the long term, the prospects for contract growing cattle, pigs, and poultry looks very promising. To achieve this, an integrated agribusiness system based on local crops, livestock, and fishery products needs to be developed. This involves the adoption of new feed crop production systems plus the commissioning of animal feed and fishmeal processing plants to supply animal production units with locally formulated feed concentrates. Livestock sector stakeholders consider that inputs prices for vertically integrated livestock production systems remain internationally competitive (Table A1.3 in Appendix 1) but support services and rural infrastructure need improving to make the system economically viable. Adaptive research is needed to upgrade local knowledge on animal husbandry practices and disease control. Effective transfer of this knowledge to producers through additional and strengthened links is essential.

DAHP/NAHPIC (see A2.3 for details) are unable to address a significant number of livestock production problems with the limited budget they have available for research. Their current research program is limited to small projects on Newcastle disease vaccine and hemorrhagic fever trials and a collaborative project with the Australian Centre for International Agricultural Research (ACIAR) on fasciolosis control (See Appendix A4.3 for details of current research program). In addition, Celagrid investigates livestock feed options.

DAHP possesses one research station for animal research situated at Phnom Thmao south of Phnom Penh. The station is located on typical cattle grazing country and is capable of conducting research on both animal health and production.

2.6.4 Fisheries. Fish is traditionally the main source of protein for most Cambodian people and an estimated 27% of the population catches fish as secondary employment. The country is rich in fishery resources and harvests of fresh water and marine fish in 2003 were estimated at 309,000 and 55,000 tons, respectively. Exports were estimated at approximately \$7.2 million in 2000 (OPCV, 2002). Production has not

increased significantly since that year and most of the production will remain in-country. Approximately 30,000 ton of fish was processed in 2004 and consumed domestically.

Inland and marine captures have stagnated due to high levels of exploitation, conversion of inundation forests into flood recession rice areas, poor management, and continuing environmental degradation. However, growth in sustainable inland fishery production can be achieved through better management and steps to protect aquatic resources together with expansion and improvement of rice-fish farming and aquaculture (Table A1.4 in Appendix 1). Knowledge of fishing communities needs improving for the implementation of laws and regulations to protect the industry. Techniques for aquaculture production must also be developed if modern fish raising practices are to be used.

Marine fisheries research receives little support in Cambodia and catches may be significantly underestimated because a large percentage of it is sold off shore. Only 6,200 tons of fish were processed or converted into fish sauce in 2004 (MAFF, 2004). Anecdotal evidence indicates that over fishing by boats from neighboring countries has reduced marine numbers in recent years. Considerable research is required to substantiate these assumptions and regulations enforced to re-habilitate the industry. The information and motivation needed by both inland and marine fishing communities to achieve progress in these areas will come from technical information centers and research institutes. Effective transfer of this information will require strengthened and additional links to the fishing communities.

IFReDI (Appendix A2.4) hosts a MRC/DANIDA (Mekong River Commission and the Danish International Development Agency) regionally funded research program to address issues regarding sustainability of native fresh water fish populations and fresh water aquaculture. The institute has a small budget for its own research (Table A3.4 in Appendix 3). Its research program is completely funded from MRC headquarters in Lao PDR (Appendix 4.4) and is divided into three parts. Part A assesses Mekong capture fisheries, Part B the management of river and reservoir fisheries and Part C aquaculture and indigenous Mekong species.

Apart from the research facilities at the headquarters in Phnom Penh, both IFReDI and DOF manage research stations. IFReDI operates one research station in Kandal and DOF possesses three stations, two in Kandal and one in Prey Veng.

2.6.5. Forestry. Cambodia's forest resources including non-wood forest products (e.g., rattan, bamboo, wildlife, and medicinal/eatable plants, etc.) are rapidly being depleted. In recent times this has been a result of illegal logging. Approximately 125,242 cubic meters were exported legally in 2004 (MAFF, 2004). More may also have crossed over the borders illegally. With a sound forest policy framework, effective control of forest resources, and proper management and conservation practices, the industry can generate sustainable government revenues of \$25-50 million annually (OPCV, 2002). The establishment of forest plantations with fast growing species and traditional hardwood varieties will enhance the supply. Reforestation will not only supplement the country's forest resources, but provide employment opportunities and increase rural incomes.

Forest reform is a major component of the Royal Government of Cambodia (RGC) rectangular strategy and, as such, the forestry sector will receive an increasing amount of attention from the government over the next decade. Re-forestation is being encouraged

along with the development of an industry for value adding of forest products. Government officials understand well that a reduction in the forest area impacts directly on the national economy through a loss of sustainable income and indirectly via its effects on fisheries and other agricultural pursuits. Weaknesses of the forestry sector (see Table A1.5 in Appendix 1) include a lack of capacity to enforce existing forest law, poor communication, poor collaboration with local users, limited budgetary support and a lack of clarity between forest and social land concessions. There are however, ample opportunities to improve the forest sector (Table A1.5 in Appendix 1) before environmental changes affect the economy. Many of these opportunities require support from a structured research program, installation of an effective extension program and strong and multiple links with forest holders, timber harvesters and adjacent local farming communities.. Threats to the system include high international timber prices driving unmanaged clear cut timber harvesting, expansion of the cultivated area, climate change and uncontrolled forest fires.

Forest Administration (FA) possesses a GIS (Geographical Information System) unit to implement its main activity of administering the forests. The FWSRI, which falls under FA does not possess a large budget to operate a research program and its research in 2004 was limited to a minor role with the Japan funded project on changes in Water Circulation in the Mekong River Basin (Appendix A2.5). The small size of the research program of FWSRI is seen to be a major constraint of the institute (Appendix A3.5)

2.6.6. Agro-industry is an important sub-sector underpinning the economy in Cambodia. Most agricultural products currently are sold and distributed in an unprocessed form as raw materials. Strengthening the agro-industry sub-sector will help farmers and processors improve their incomes and create employment opportunities. The creation of an appropriate investment environment will bring about private sector development. The foremost objective of the Government is to support measures that raise the quality of agricultural produce and promote diversification into new commercially exploitable high value crops and thereby enhance acceptability of Cambodia's products in world markets to absorb its surpluses arising from improved productivity.

An estimated 70% of Cambodia's labor force is involved in agricultural pursuits and local salary levels are low. These conditions are considered to be key strengths of the agro-industry sector along with the fact that there are no official taxes on agricultural production (Table A1.6 in Appendix 1). Opportunities for expansion of the sector through improvements to infrastructure diversification, export plus an increase in the cultivated area are widely recognized. There are however, a number of constraints to the industry that must be overcome or accommodated before large productivity improvements are possible. Many of these relate to general national economic improvements and administration (problems of unofficial charges, transport costs, law enforcement, smuggling, credit). Other weaknesses and threats to the industry may be resolved through improvements in agro-ecological zoning, the development of new production technologies, a reverse in declining soil fertility, resolution to pest and disease problems, an improvement in market information and market access and an expansion in public and private extension capacity. All require prior research and development. These issues are summarized in the SWOT analysis presented in Table A1.6 in Appendix 1.

The DAI is responsible for formulating policies and preparing projects to develop agro-industrial crops and food enterprises (A2.6 in Appendix 2). The department was

established in 2002 and by 2004 had not yet developed a research program for collecting information to formulate the policies. A lack of financial support for such activities is seen to be a major constraint of the DAI (Table A3.6 in Appendix 3).

2.6.7 Non commodity based agricultural research. No MAFF institutes are currently established in Cambodia to conduct non commodity based research. Social sciences, organic farming, farming systems research, gender, agricultural economics and other cross cutting issues are generally handled by individual research organizations. For example, social science studies in the cropping sector are conducted by CARDI, RUA, NGOs or the private sector. Those in the fisheries sector are generally done by IFReDI. The same applies for gender and environmental issues in each discipline. Economic studies in the agriculture sector form part of the mandate of CDRI but the economics of farming practices are regularly part of commodity based research programs.

Agricultural policy is generally formulated at higher levels within MAFF, although DPSIC, other departments and research institutes are expected to heavily support collection of the information necessary for developing policies. Departments within MAFF are also able to interact with other ministries such as MOWRAM and MOE when conducting research on water resources or the environment.

2.7 Collaboration among Cambodian research institutes

The five main agricultural research institutes (CARDI, CRRI, NAHPIC, IFReDI, FWSRI) were established to address constraints to the production of different commodities and do not often interact with each other on a scientific basis. No official linkages exist between them, collaboration being a result of special projects. Examples of such collaboration include research on fish - rice field ecosystems conducted jointly by agronomists and fish specialists from respective departments. These studies resulted in the publication of a hand book on cultivating fish in rice fields (Ricefield Fisheries Handbook, 1997). Other examples include joint studies on animals in the rice ecosystem resulting in the publication of "Livestock in Cambodian Rice Farming Systems" (McLean, 1998). Projects currently in operation or under proposal include interactions with the Forestry Administration and CARDI for agro-forestry with the World Forestry Center, farmer based rodent control with CARDI and the DAE and vegetable production with CARDI and DAALI. The rodent and vegetable projects are both funded by ACIAR. The technical departments and research institutes all collaborate with RUA, PNSA, KCNSA, MVU and other tertiary education institutions to assist student research activities. In addition, contract research is often conducted on behalf of private agricultural research companies by Government research institutes (see section 6.2 for details).

CARDI relies heavily on accessing research station facilities belonging to both DAALI and the provincial centers. Access to land for research on the department's stations is often in competition with the station's seed production activities and formal agreements may be necessary in the future to accommodate research. Collaboration between research organizations is often much stronger at the provincial level. Provincial Department of Agriculture (PDA) staff representing different departments manage to interact on a more personal level and feed farming system data back to centrally based research institutes.

Formal linkages between research institutes and other sections of MAFF are necessary to facilitate the sharing of facilities including laboratories (see section 2.9 for more details). Some operational cost issues will be resolved during implementation of research projects conducted in partnerships with two or more parties. Operational costs will be shared according to the institute's capacity to implement that part of the project. Any resulting income from the research (for example, sale of product) will be divided in proportion to each institutes investment.

2.8 Linkages between research, extension services and farmers

The research institutes currently rely on DAE and a few NGOs to transfer technical information to farmers and to obtain feedback on farmers needs. However, no formal linkages currently exist between the research institutes and the DAE. Most of the research institutes interact with government extension services at the provincial level. CARDI installs trials and demonstrations with the cooperation of provincial and district personnel. CARDI then provides technical back up during the management of the trials and field days to extend the technologies. The DOF, IFReDI, DAHP and NAHPIC also interact with the various PDA in this manner. The Provincial Forestry Administration exists in some provinces. These offices also interact with the PDA on extension matters.

Direct interactions between research institutes and the DAE are generally project based. In 2005, extension material for use by the DAE was under preparation by the DOF, DAHP, DAALI, CARDI and FA. Research/extension projects such as the community based rat control project and the development of a model for the control of fasciolosis in cattle and buffaloes in the Kingdom of Cambodia, both ACIAR funded projects, involve the interaction of technical departments, research institutes and the DAE. A coconut hispine beetle biological control program is underway with collaboration between DAALI, DAE and the University of Forestry and Agriculture in Saigon.

Close collaboration through additional and stronger links between research institutes, commodity dealers, traders, seed producers, millers, manufacturers and other private enterprises are proving to be a productive method of extending technologies to farmers in Cambodia. Private enterprises such as those with commercial incentives already have strong links to selected producers and are making efforts to expand their networks. For example, seed producers through the Agricultural Quality Improvement Project (AQIP) sell seed to millers who, in turn, contract farmers to sow that seed for grain production. The relationship ensures the miller receives a consistent product thereby increasing milling percentages and profitability to all sectors of the industry -seed production, grain production and milled grain sales.

The results of CARDI's work to examine the value of rock phosphate produced in two locations were extended to farmers at the phosphate company expense. Other examples of successful collaboration include IFReDI work with fingerling producers and CARDI interactions with seed producers. NGO's also serve as important facilitators of input supply, particularly in reaching new varieties, practices and technologies. Many agencies (for example the NGOs, SME Cambodia and ACLEDA) have significant credit or linked programs and use these for bridging gaps in input availability.

Since the early 1990s, NGOs have performed a particularly important role in supporting Government departments in the extension of technologies developed by research institutes. They have invested considerably in organizational development and capacity building activities among farmers. Farmers groups, producers associations, credit societies and women's associations are examples of groups developed and supported by NGOs. NGOs work as sources and facilitators of technical information, counseling and provide advice to farmers while drawing upon technical expertise from the research institutes. They are regularly included in research centre training programs to improve their technical skills and are involved with the research prioritization process. NGOs with significant funding to spend on the agriculture sector in Cambodia include WVI, CARE, ADRA, AFSC, LWF and VSF, working mainly on crop and livestock improvements in addition to community issues (see section 2.5). Details of the organizations involvement in the Cambodian agricultural sector are available on the relevant web sites (<http://www.dac.org.kh/affiliates/affiliates-summaries/wvi-c-print.htm>, http://www.careinternational.org.uk/cares_work/where/cambodia/, <http://www.adracambodia.org/>, <http://www.afsc.org/asia/cambodia.htm>, www.lwfcam.org.kh/, www.lwfcam.org.kh/

Researchers benefit from being involved with the development of materials used to extend the technologies. It is often the case that the formulation of "Technology Notes" such as those developed by CARDI may be sufficient to provide feedback to the researchers on the application of the developed technologies. Tech Notes require formulation into an appropriate format for extension to farmers or provincial and district extension officers as is under way with Technical Implementation Procedures (TIPs) being put together by subject matter specialists in research groups with assistance from DAE. Technicians and extension personnel within the MAFF technical departments, the DAE and the research institutions need to work closely together to ensure the technology is made available to farmers. The extension of the research results to farmers should be incorporated into the research project proposals to ensure the research remains relevant.

Linkage mechanisms which will assist develop strong linkages between research and extension include a) surveys of farmers problems conducted jointly by research and extension, b) regular (bi-annual or tri-annual) meetings between research and extension c) regular publication of material provided by research and extension staff d) presentation of jointly developed material at large workshops, e) joint training programs, f) field days.

2.9 Availability of financial and human resources, facilities, equipment and existing information networks for research institutions

Human Resources MAFF employed a total of 8,699 staff members in 2004 (Table A5.1, Table A5.2 in Appendix 5). Staff were located at the central MAFF buildings, departments, research institutes, public institutions and in the provinces. Sixty percent (5186) work in the provincial agricultural offices and the remainder are within the MAFF organization,

mostly located in Phnom Penh. Of the total, 31 (0.3%) have PhDs, 222 (2.6%) Masters, 1551 (17.9%) Bachelors, 2371 (27.3%) diplomas and 4517 (51.9%) possess no degrees or diplomas. A high proportion (43%) of the PhDs are presently working at CARDI and most of 222 MSc graduates employed by MAFF work at the central offices in management or administration works. Only 22 MSc graduates are located in Provincial centers (Table A5.1).

The high number of PhD graduates at CARDI compared with other institutes (Table A5.3) is a result of concentrated financial support in the 1990's to promote crop research by development projects. Most graduates from CARDI and many MAFF departments completed their post graduate studies through research rather than coursework and are experienced in the field as well as academically. CARDI staff numbers and qualifications are adequate to lead crop based agricultural research in the near future. However, training of their staff needs to continue for the researchers to remain current with technical developments. Other Cambodian research organizations need to hire or train personnel with higher degrees to raise the level of research experience. Data from the Department of Personnel and Human Resources Development illustrate the lack of higher degrees in research institutes other than CARDI (see Table 1 below).

Another option to improve the effectiveness of the research system is for smaller research organizations to improve their linkages with those possessing more qualified staff to assist with research design, analyses and reporting. Overall, there are sufficient qualified and experienced staff in MAFF to manage a large adaptive research program in Cambodia if the research is conducted on a collaborative basis. Expertise on experimental design, data collections systems, statistical analysis and report writing methods are transferable across disciplines. In addition, as demonstrated with the CARF program, projects are particularly productive when research institute and educational organizations work together.

Table 1 Personnel qualifications in main research organizations.

Qualification	RRIC	RUA	CARDI	IFReDI	NAHPIC	FWSRI	DAI	Total	%
PhD	1	4	12	3	0	0	4	24	6
MSc	0	33	10	12	1	10	2	68	17
BSc	16	59	13	23	22	13	10	156	38
Diploma	30	11	2	1	4	6	4	58	14
Labourers	13	60	15	4	3	5	0	100	25
Total	60	167	52	43	30	34	20	406	100

The existing Government salary structure of \$20-40 per month is insufficient to retain highly qualified research staff. International NGOs pay \$200-\$350 per month to retain qualified, experienced researchers and \$300-\$450 per month for management staff. This payment level is considered to be reasonable to remunerate all research and management staff. Some Government personnel receive salary supplements or training allowances from projects and development programs. Self-generated funds are also available for salary support at the public institutions of CRRI, CARDI, RUA, PNSA and KCNSA. However, this income stream is not permanent and a longer term solution is required. The Government salary structure is currently under review. In the mean time, staff support programs using non-government resources need to continue until sufficient salary levels are reached.

Agricultural research conducted outside of Government institutes includes that being done by the private sector and NGOs through development projects. Staff at CelAgrid, formerly employed at the University of Tropical Agriculture, supervise Masters degree students and receive grants from international training institutes to support these activities. As mentioned above, NGO staff generally receive higher salaries than government staff. Private, commercial enterprise personnel are also well remunerated.

Administrative facilities Government research institutes for crops (CARDI), livestock (DAHP/NAHPIC), fisheries (IFReDI), rubber (CRRI), teaching (RUA, PNSA and KCNSA) possess good (KCSNA) to excellent (CARDI) buildings to house research requirements. Almost all of these institutions have had new buildings constructed over the past five – ten years. New administrative buildings will not be needed at these institutes for the foreseeable future. Facilities at DAI are limited but adequate for the 25 employees of the department. Extra rooms may need to be sourced at a later date to house an expanded research program.

Laboratory facilities All laboratories currently within MAFF suffer to some degree from a) a shortage in trained staff, b) a lack of equipment, c) poor laboratory facilities to house the equipment and d) a lack of operational funds. The CARDI laboratories for example, are in a new building requiring the installation of fume extraction equipment and safety measures. The institute also does not have trained personnel capable of operating the new equipment on order, nor are there sufficient analytical reagents to conduct the analyses. DAALI has well trained staff but possesses old broken equipment and IFReDI possess the laboratory space but does not have a full complement of equipment. The FWSRI, DAM and DAI possess no laboratory space and no laboratory equipment. Details of the laboratory facilities are presented in Appendix 2.

Laboratory space is available at all MAFF technical departments and research institutes excepting the FWSRI, DAM and DAI. It is not necessary for DAM and DAI to possess analytical laboratories to keep pace with the current level of research at these departments, but some basic equipment will be necessary for FWSRI to operate effectively. This may be limited to microscopes and other equipment for measuring tree growth rates and wood density. Wildlife carcass post mortems can be conducted at DAHP/NAHPIC. The DAI may need to construct laboratories in the future if its research program expands as envisaged.

Both DAALI and CARDI have recently constructed or will soon complete construction of laboratory buildings for analysis of soil, plant tissue, seed, fertilizer and water. Similar facilities are also found at RUA on a smaller scale. Duplication can be avoided and large savings made if samples from all sectors are forwarded to one laboratory for analysis. This also applies for the analysis of pesticides and pesticide residues. DAALI laboratories can service all MAFF requirements including CARDI, DOF, DAHP, Bureau of Agricultural Materials Standards, RUA and other regulatory, research, and educational organizations.

Large expenditure on buildings and equipment over the past decade has not resulted in an efficient laboratory system for research and development. The lack of operational funds constrains the activities of all laboratories in MAFF although CRRI which is able to charge and retain some fees for service in the rubber industry. All other laboratories do not

have sufficient analytical reagents to properly operate their services. Most rely on special project funds to purchase the necessary chemicals. This causes delays, lack of continuity and constant frustration. The lack of operational funds also limits the number of samples passing through the facilities, dramatically reducing the efficiency of their operations. This could be remedied if laboratories are able to charge a fee for service and the fee is re-invested back into the laboratory.

Considerable scope exists for research institutes to increase the sharing of laboratory facilities and other resources. It is currently possible to transfer budget from one department to another in the same ministry using existing RGC regulations to pay for services. However, budget transfers between departments result in delayed materialization into cash for the immediate purchase of reagents and maintenance of laboratory equipment to analyze waiting samples. Cash payments are therefore demanded by many laboratories. For example, the CRRRI is required to pay cash for soil analyses conducted at DAALI laboratories. Standard rates need to be developed for each to facilitate payments and make the system more open. MAFF institutes will rationalize the number of analyses conducted by each laboratory and develop a standard charge system to improve efficiency and reduce duplication of facilities across departments.

Laboratory equipment After the recent equipment purchases by CARDI and DAALI are installed in their laboratories, there will be sufficient laboratory equipment and glassware for almost all standard analyses required in MAFF. Other analyses such as diagnosis of the latest bird flu viruses may be outsourced to the Pasteur Institute, National Institute of Public Health or sent abroad. By late 2005, there will be sufficient equipment in MAFF for diagnosis of most animal and fish diseases, analysis of the quality of water, feed, seed, fertilizers, pesticides and measurement of soils and residues. The number of samples currently analyzed in MAFF laboratories does not necessitate the need for multiple numbers of modern auto analyzers and other expensive equipment unless the level of research or regulation increases dramatically. Details of the recently purchased equipment are presented in Appendix 2.

Information networks can be either manual systems (eg mail, libraries), electronic (telephones, mobile phones, radio, television, pagers) or computerized (eg email, web pages) for communicating information.

On a national basis, Cambodia is extremely under resourced regarding information and communications technology and other information network expenditure compared with the rest of the world. For example, there are only 2 line telephones per 1000 head of population compared with 502 for East Asia and the Pacific, 1.5 computers compared with 19, 119 radios compared with 287 and 8 televisions compared with 266 (World Bank data for 2002).

Despite this poor statistical comparison, Cambodian research institute and extension personnel have adopted the use of the mobile telephone as part of their daily routine. Verbal communication between researchers is therefore not difficult. Most researchers are also computer literate and have access to computers, email and the internet. Breakdowns at institute facilities are compensated by cheap (by international standards) access to the internet at internet cafes found in the capital and Provincial centers.

Although the numbers are small, radio and television coverage is widespread in Cambodia and events at research institutes or advertising of field days and training courses receive good coverage on government controlled and private networks.

Traditional book libraries established in MAFF departments during the early 1990s languish without adequate maintenance although most printed material of interest to the agriculture sector is now housed in a recently established document center at MAFF headquarters. CARDI possesses one of the largest libraries in Cambodia for rice and other agronomic crops. However, digital copies of reports and other information are gaining popularity and will soon replace the expensive hard copies as a means of extending information.

Adult literacy levels are approximately 70% country wide and posters plus handouts are regularly part of extension systems employed in rural Cambodia.

2.10 Experience of other countries for strengthening national agricultural research

By virtue of its recent history, Cambodia has not fully participated in many of the major events relating to agricultural research in the region and more generally in the developing world that have taken place over the last half century. Cambodia has the opportunity to benefit from the experiences of NARS in other countries in selecting approaches and structures that are best adapted to the country's requirements and capacities.

NARS have evolved considerably over the past 40 years. The public sector received heavy support from donors (1960's and 1970's) but because of its high cost, evolved into a decade of farming systems research (1980's). In the 1990's, some donors, notably the United States Agency for International Development (USAID), turned away from the agricultural sector altogether. In recent years, there has been a resurgence of interest in supporting public sector agricultural research among major donors. However, the expectations of donors have changed and they now prefer to support a system involving participation from a number of sources. Chema et al (2003) presented a list of features commonly found in more recent systems as follows:

- (1) The application of a stricter public good argument (privatize when possible) for Government funded research and a separation of research funding, priority setting, and implementation;
- (2) A geographical decentralization and in terms of decision making;
- (3) The involvement of stakeholders in the design, implementation, budget control and possible co-financing of research
- (4) More emphasis on (co-)financing by direct beneficiaries (surcharges, matching grants, etc.); competitive research funds; and
- (5) Strengthening of system linkages between research agencies (national, regional, and international); between research, extension and farmers and between all possible partners in an agricultural innovation process, including civil society organizations, traders, and input and processing industries.

A major lesson from the events of the last several decades is that the governments of developing countries should be very cautious about participating in projects that include considerable infrastructure carrying high recurrent costs. The MAFF will ensure infrastructure development caters for current rather than future requirements.

Cambodia will also develop a system relevant to its size. Cambodia is a small country with a relatively young national agricultural research system in a region (southern and eastern Asia) that features bigger countries with much larger populations and more mature research systems. Ultimately, Cambodia's economy must support its own research services and its GDP should influence the size of the NARS. In 2003 the % of GDP spent on agriculture in Cambodia was estimated at 0.23% (World Bank, 2004). This compares with an average of 0.58% across SE Asia. Based on these figures, the RGC should invest more in development of the agriculture sector. This level of expenditure does not include loan funds and inputs from donors. Operating funds for research are under resourced and can be increased using the current facilities and personnel.

It is much more logical to simply "borrow" improved technologies and practices from other NARS, IARCs and other sources of such information until the government is able to fully support the system. Donors are most unlikely to fund recurrent core expenses to any significant degree (aside from possibly allowing indirect costs in contracts and grants for specific research projects) but may contribute to operational costs.

Bangladesh adapted technologies characterized by the Green Revolution through intensification and the widespread use of improved technologies since there is virtually no additional land available for agricultural production in the country. Elsewhere, experiences strongly suggest that adaptive research should be carried out at the local level with the participation of clients, notably producers, processors, etc.

Decentralization is one means of addressing diversity. However, decentralization requires a strong center to coordinate and lead the research. Thailand and Indonesia provide contrasting experiences on decentralization. Thailand has achieved a fair measure of success in managing a large, quite decentralized system through having a strong "center". Indonesia on the other hand does not have a particularly strong center and the key linkages that are vital to facilitating and sustaining the work of the different components are weak or non-existent.

There have been attempts in several countries, particularly in Latin America and more recently in West Africa, to have NARS become self supporting. Nearly all of these efforts have failed as NARS find it very difficult to make this transition. In general, senior staff in NARS institutions do not possess the knowledge, skills and orientations to market their goods and services and they do not see themselves as being responsible to stimulate a demand for these. The most able staff members that might assist with this transition often are the first to leave. Further, serious efforts to become self supporting often result in a strong shift towards NARS institutions serving commercial agriculture and turning away from serving the needs of the poor.

Developing a constituency of support for agricultural research among stakeholders at the national level is critical to NARS growth and survival. Perceptions are at least as important as the reality, as the decline of support for agricultural research took place in the

1990's despite strong evidence from numerous studies that NARS had made important contributions in several countries

Based on these experiences, a Cambodian NARS will be developed to possess:

- a) a program size scaled to the nations GDP and capacity to implement
- b) a centralized research system based on commodity or discipline,
- c) a research program based on applied and adaptive research
- d) importation of suitable technologies from other NARS, IARCs and research centers
- e) a research program based on client needs,
- f) client involvement in the design and implementation of research programs,
- g) co-financing of research,
- h) strong linkages between research centers and between research, extension and farmers and other stakeholders.
- i) low maintenance infrastructure suited to the research program size
- j) sharing of research facilities

The strategy and structure of the renewed Cambodian NARS is presented in Part II of this report.

Note:

Adaptive research in this document is defined as the field evaluation of the results of applied research. An example is conducting non replicated trials of a rice variety on farmers fields.

Applied research refers to the evaluation of the results of strategic research in typical ecosystems. An example is the replicated evaluation of a wide range of drought resistant varieties on research stations.

Strategic research is the development of technologies directed towards resolving and important issue. An example here is the development of a rice variety for drought affected environments.

Basic research refers to the parameters of strategic research. An example being a study of the elements of a drought resistant rice variety.

PART II.

**DEVELOPMENT OF A RENEWED STRATEGY FOR
NATIONAL RESEARCH IN THE MEDIUM TERM**

**3. Renewed Strategy and Vision for National
Agricultural Research**

**3.1 Changes in external and internal environments affecting
agricultural research emphasis and implementation**

An assessment of the current situation and challenges for Cambodia's agricultural sector is presented in Section 2. Other current issues affecting the emphasis on the type of research conducted and way it is managed includes the following:

- Divestment of the state owned rubber estates during 2006-2007. The divestment will place increasing emphasis on CRRI to generate technologies to increase production from small holder plantations. This will include farming systems research towards generating income from young plantings and improve the techniques for collection and storage of latex. An increased level of funding for the rubber institute is possible if the private companies are requested to pay a levy on the sale of their product.
- Implementation of the Cambodian seed law and strengthening of phytosanitary and sanitary regulations to comply with the WTO will provide more consistent guidelines for seed and plant material trade and research. Plant breeding will thus become more regionalized and diminish the need for Cambodia to make its own varietal crosses.
- The establishment of CAREC early in 2006 will unify the approach taken for agricultural research and oversee the research prioritization process.
- The RGC promotion of "one village, one product" movement places emphasis on the research system to prioritize research based on client needs.
- The RGC policy to increase the delegation of responsibility for knowledge transfer and information sharing with farmers to the commune councils. Researchers will need to involve the commune councils in the research priority setting process and implementation of adaptive research.

3.2 Structural Options for better management and governance of national agricultural research.

Options for the MAFF to restructure include a reversal in the devolution of research and extension resulting in the model initially adopted in the MAFF during the early 1990's when the MAFF departments performed all research, regulatory and extension functions. At the other end of the spectrum is a completely decentralized system of regional/provincial research units governed from a local level (see box).

Public sector options for structure and governance

Structure	Governance
MAFF Departments/Units	Government Ministry
Semi autonomous institutes (SAIs) for commodity sub-sectors	Governing Board and Director
Single National Agricultural Research Institute (NARI) for most research	Governing Board and Director
National Coordinating Council (CAREC)	Governing Board and Director for Council
Research Groups/Units within University Departments	University Department
Semi Autonomous Institutes within University	Governing Board and Director
Decentralized System of Regional/Provincial Research Units	Several options including units of national institutes with varying degrees of deconcentration and devolution

A comparable set of arrangements exists for private sector research organizations. However, in Cambodia as for most developing countries, private sector research is almost exclusively carried out by units that are integral parts of business enterprises. Arrangements for research units in RUA parallel those for MAFF where research capacity is found in discipline based faculties and associated with teaching programs or in collaboration with international organizations or private enterprise.

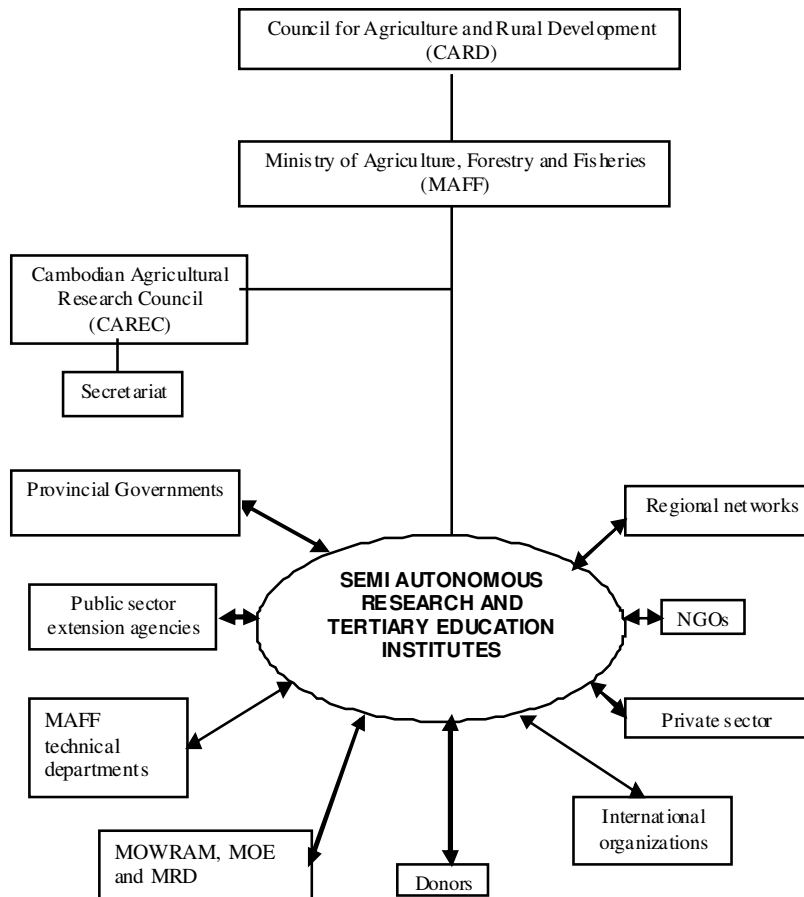
There are several possible arrangements relating to the decentralization of agricultural research services, ranging from provincial/regional research centers that are units of national research institutes through to the concept of forming semi autonomous centers that are controlled by local boards.

Most Cambodian research capacity is found in public sector institutions at the present time, notably MAFF and RUA. There is capacity among the NGOs and private sector organizations and considerable potential exists for these sectors to play a more significant role in agricultural research.

The current Master Plan is developed using the present structure but with modifications to cater for the improvements to the system as discussed in section 2.10. A model is presented in Figure 1 illustrating the research, funding and linkage relationships between the Council for Agriculture and Rural Development (CARD), CAREC, MAFF central departments (planning, administration, finance), provincial offices including PDA, public extension agencies, donors, international organizations, the private sector, NGOs and

regional networks. The need for structural change, if any, will grow out of the experiences of the next five years and the question revisited in future Master Plans.

Figure 1. Public Sector Agricultural Research Structure and Linkages



The new structure involves the following organizations and responsibilities:

1. **CARD**, established in 1994 as a high level (chaired by the Prime Minister) body, holds the responsibility to “set out priorities in the rehabilitation and development of the agriculture and rural areas in accordance with the programs of the Royal Government”. It also plays a role in “coordinating the components of economy, especially between private companies and ministries or government institutions in order to rehabilitate and develop the agriculture and rural areas”. The council advises MAFF directly on RGC policy. Its representative is the vice chairman of CAREC.

2. **MAFF** retains overall responsibility for the Departments (including DAALI, DAHP, DOF, DAI), General Directorates (Department of Rubber Development), Forest

Administration (FA), Provincial-level organizations and public institutions (including RUA, CARDI, PLNSA, KCNSA, CRR). MAFF will provide Government salaries to personnel in all mentioned organizations. These salaries may be supplemented by projects and, in public institutions through self financing activities. Funding mobilized by MAFF (including loans) for research institutions will be approved by MAFF and disbursed by the MOF.

3. **CAREC** will be established by Sub-decree with a vision to “facilitate the development of a progressive, profitable and sustainable agriculture sector” by “stimulating research investments by both the Government and industry for the benefit of the rural sector”. Its main responsibilities amongst others, are to (i) provide leadership in developing vision, concepts and strategies for research and development in Cambodia to directly benefit rural stakeholders; (ii) communicate priorities for national research to Government, semi government and non government organizations to ensure the effective utilization of resources for agriculture; (iii) coordinate agricultural research work of Government ministries and institutions, international organizations plus the donor, private and NGO sectors; (iv) coordinate the acquisition, distribution and utilization of public and private resources plus international assistance for agricultural research and development in Cambodia. As part of (iv) CAREC will establish a competitive grant scheme into which public and private funds may be invested for research purposes.

A secretariat will be established to conduct the day to day operations of CAREC. Some of these activities include the coordination of working groups in the different sub sector (commodity) groups to assist establish three year rolling plans for the sub sector. The three year plans will be approved by the board of CAREC and forwarded to MAFF. Each of the research institutes will be on the working groups to ensure collaboration in the development of research plans compatible with their institutes.

4. **Semi autonomous research institutes** in MAFF will develop rolling research plans in collaboration with the sub sector working groups. These will be approved by individual SAI board of directors. The chairs of the SAI boards of directors report to the Minister of MAFF. A major proportion of the funding for Government research institutions will be provided from RGC budget. Other potential sources are discussed in section 6.2. Research institutes will include those for a) Crops, b) Rubber, c) Livestock, d) Forestry and Wildlife and e) Inland Fisheries. The Government will also give consideration to the future establishment of an institute for marine fisheries. The DAI will continue to conduct studies on agro-industry

5. MAFF will work closely with **NGOs** and the private sector to incorporate their research programs into mainstream activities. Coordination of activities will be on a commodity level and in the provinces. Representatives of these sectors on the board of CAREC will ensure non public sector research is recognized on a national level. MAFF may contract NGOs or private sector to conduct research where their own resources do not match those of other collaborating organizations.

6. The participation of the **private commercial sector** in the provision of agricultural research services will be encouraged as well as their involvement in the governance of public sector agricultural research organizations.

7. Collaboration with **international organizations** will be encouraged to address problems of common interest. MAFF will make available existing research facilities (infrastructure, research stations, areas for field trials etc), while partner research institutes will provide scientific leadership, finance and salaries of their scientists and operating costs.

8. **Facilities** will be transferred between MAFF departments and public institutions to improve efficiency. Facilities may include land, buildings or equipment as with the establishment of the transfer of buildings to establish the DAI. Facility sharing between institutes will also be increased. This will involve the development of clear guidelines for sharing of operation costs through consultation with relevant stakeholders. Opportunities exist for the operation of only one soils laboratory (in either CARDI or DAALI), one pesticide residue laboratory (DAALI), one fertilizer laboratory (DAALI or CARDI), one seed laboratory (CARDI), one animal health laboratory (DAHP/NAHPIC) utilizing the facilities of the Pasteur Institute, one fish laboratory (IFReDI), one rubber laboratory (CRRI) and one forest ecology laboratory (DOF and FWRSI).

9. **Universities and colleges** will be encouraged to link their research to activities in research institutes and qualified personnel in the institutes will provide technical and teaching support to the universities and colleges.

10. **Provincial and local** level needs will become regular features of provincial plans and projects and arrangements will be made for their support as part of the decentralized system of planning and implementation.

11. In the near to medium term, resource constraints are likely to rule out a significant degree of **decentralization of the NARS**. However, as provinces gain greater governance autonomy through decentralization and deconcentration they will propose and fund an increasing proportion of research of strategic importance to their region. Funds from the region will support adaptive research in farmers fields and eventually subsidize core activities of the institute. In time, producers as well as public and private agencies providing agricultural services in the provinces may feel that they will be better served by having regional or even provincial research stations which could profoundly affect the NARS structure and governance arrangements.

12. RGC gender guidelines regarding **gender and social issues**. The NARS will be pro-active in the employment of at least 30% women in its programs within 10 years. Ethnic groups will also be equitably represented in provincially based research programs.

3.3 Non commodity based agricultural research in the new structure

There are no plans for establishing new institutes to study issues that cut across commodities. Cross cutting research such as that required for the development of agricultural policy, agricultural economics, organic farming, water resources management, farming systems research, environmental impacts of agricultural development, gender and technology transfer will, in the main, be undertaken by current research bodies including the university system and departments within MAFF. For example social science research on crops will be performed by CARDI and for food processing issues by the DAI. Gender

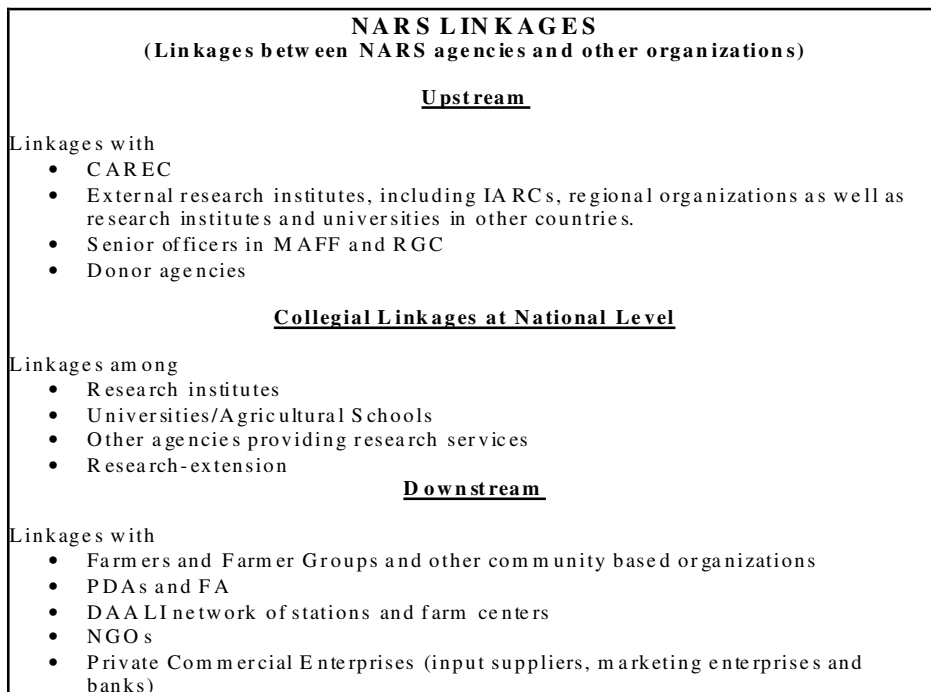
studies, agricultural economics, farming systems research and technology transfer issues will also fall under current discipline based organizations although considerable interaction between institutes will be required to facilitate the formulation of comprehensive recommendations.

Research on general agricultural policy may be conducted by the DPSIC or contracted out to other agencies through CAREC. Contributions from all commodity based research organizations will be expected during the formulation of new policies.

Linkages with other ministries will be necessary to perform research in some disciplines. For example, water resources research by crop specialists will require interaction with MOWRAM and environmental impact studies with the MOE. Both CARD and CAREC should facilitate cross ministerial research. These linkages can be formal or informal established for project purposes only.

3.4 Linkage options for the national agricultural research system

Approaches to develop and/or strengthen system linkages include those which may be termed: i) upstream with the policy makers, donor agencies and the sources of information and technologies in external agencies; ii) collegially among research organizations; and iii) downstream with public and private providers of agricultural services and farmers themselves (see box).



Note: National Agricultural Research System (NARS) agencies are primarily government organizations working in collaboration with the private sector.

Upstream Linkages

CAREC: CAREC will play a major role in agricultural research policy formulation, planning, monitoring evaluation and impact assessment. It will develop its linkages through its board of directors, and via regular meetings with working groups and research organizations.

External research institutes Formal linkages that currently exist with regional and international research institutions for advanced technology and information include participation in networks, collaborative projects, student and staff exchange programs, development of the “sister university” concept, conferences and sharing of library facilities.

CARDI personnel have developed good linkages with research organizations through networks. Networks include the International Network for the Improvement of Banana and Plantain (INIBAP) and the Council for Partnership for Rice Research in Asia (CORRA) while CeAgrid is in the livestock based sustainable agriculture in the lower Mekong basin (MEKARN). Such networks expand exchange of information through newsletters, short term training courses, personnel exchange and joint research programs.

Collaboration with international organizations will be encouraged to address problems of common interest. MAFF can make available existing research facilities (infrastructure, research stations, areas for field trials etc), while partner research institutes provide scientific leadership, finance and salaries of their scientists plus operating costs

Projects between Cambodian and international institutes such as ACIAR and CIRAD often develop research programs that result in personnel from respective organizations visiting each others countries for part of their activities. Under ACIAR funded research for example, Australian scientists visit Cambodia for field research activities and Cambodian researchers travel to Australia for laboratory analysis and training. These types of relationships can often lead to student places for Cambodians in Australian institutes to update their knowledge.

Student and staff exchange programs often develop through collaborative projects but may also form part of a sister organization approach. Either way, the result is an improvement of technology flow between institutions.

Attendance at conferences is a common method of facilitating the flow of technology. As conferences are generally associated with networks, institutes and societies, joining of such organizations for Cambodian research personnel will be encouraged by their respective research organization.

Senior officials in MAFF and RGC: Good connections with senior officials in MAFF are critical to achieving better coordination at policy and national planning levels. The major functional linkages between research institutes and MAFF departments will be downstream directly with PDAs and regional FA offices via regional/provincial network of adaptive research teams/agricultural stations (see below). CAREC will play a prominent role in the linkages with senior decision makers by ensuring that RGC policies are communicated to and observed by public sector research agencies as well as making NARS agency concerns known to the RGC.

Donor agencies: The RGC/donor joint Technical Working Groups can potentially play a vital role in promoting the benefits of agricultural research and source funding for NARS activities.

Collegial Linkages at National Level

Close relations among the NARS agencies and between NARS agencies and the DAE will be strongly encouraged. Capacity is expected to remain limited for some time. Thus, many research programs will require collaboration between two or more research agencies including universities and agricultural schools. All research programs will remain closely linked to the DAE to assist their programs remain client based.

CAREC is a key player in promoting these linkages and addressing issues of common interest, particularly at the national policy level. CAREC will host workshops and symposiums on agricultural research policy and other issues of common interest. It will also administer a grants and contracts program in which collaboration among research agencies will be actively encouraged.

Downstream Linkages

Producers and Producer Groups: In most instances, linkages between research agencies and producers/producer groups will be indirect via a range of agricultural service providers (most notably PDAs (often through the DAE) as well as NGOs, input suppliers, etc). However, research agencies will continue to interact directly with limited numbers of producers/producer groups via agricultural/farming systems research programs aimed at i) understanding existing systems, opportunities and constraints (using participatory rapid reconnaissance techniques); ii) identifying and testing improved technologies and practices (using participatory/action research approaches); and iii) monitoring, evaluation and impact assessment activities.

A network of regional or eventually provincial farming systems research or adaptive research teams operating out of DAALI stations will provide advisory services and training in adaptive research to service providers and farmer groups in their regions/farmer groups. These teams will help give substance to the participatory adaptive research and technology testing dimensions of farmer field schools.

A program will be initiated to encourage farmer groups or clubs to engage in the field testing of new technologies and participate in the provision of the inputs associated with new technologies they adopt (e.g. production of improved seed, planting materials, livestock and fingerlings).

Regional and Provincial Extension services: PDAs, Cantonment FAs and other agricultural service providers will be enjoined to include adaptive research and linkage/information services they require in their provincial extension plans. Funding may become available from Provincial Investment Funds (PIF) for approved activities. PIFs are an initiative of decentralization and deconcentration and encourage provinces to plan strategically for activities that will benefit the province or region. PIFs were allocated to extension programs in 2004 and in the future, may be used for research on localized problems. They will be largely restricted to adaptive research, training and information services at the provincial level.

NGOs: Participation of NGOs in agricultural research will be actively encouraged in the following ways:

- MAFF will actively encourage the development of a set of partnerships between NGOs and MAFF research institutes, focusing primarily on the provision of adaptive research and information services as well as feedback on the progress of development activities. In support this effort, MAFF has established the Department of International Cooperation which will promote collaboration between MAFF departments and International NGOs.
- NGO representatives will be included on the boards of research institutes and CAREC and in any special working groups addressing matters of concern to the NARS.
- NGOs involved in agricultural research will be full members of CAREC and recipients of the services provided by the Council.
- NGOs will be encouraged to participate in competitive grants and contracts programs administered through CAREC and make proposals for any awards for which they have the interest and requisite capacities.

Gender and ethnic groups: Women's groups will be directly approached by sub sector working groups to ensure their technology development concerns are met. At least 30% of training courses will be attended by women and in provinces possessing different ethnic groups these groups will be targeted for attending workshops and training courses. Linkages will be developed with these groups through provincial centers.

Private Commercial Enterprises: Input suppliers, notably retailers at local level, have a vested interest in promoting new technologies. A special program will be designed and implemented to provide input suppliers with training and information on the technologies associated with the inputs they are selling. In addition, MAFF research institutes and PDAs will administer a program designed to increase farmer group participation in the production of improved inputs and the sale of these to input suppliers.

Banks will be encouraged to work with NARS agencies to address concerns about the credit worthiness of most agricultural producers. The ACLEDA bank for example has a good history of business planning and recently received an international award for excellence. Farmer clubs/farmer field schools could engage in technology testing as precursor to a loan (or even as a requirement for a loan).

3.5 Possible use of and access to agricultural biotechnology

Biotechnology includes any technique that uses living organisms or substances from organisms to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses (Cohen, 1994). Traditional biotechnologies include fermentation using enzymes and micro organisms and traditional breeding techniques are commonly used in Cambodia. Biogas production is under research and development with Celagrid and biogas units are sold for power generation in locations isolated from grid delivered electricity. Biotechnology used for making yoghurt, brewing beer, composting and making vaccines are common practices in rural and industrial centers of Cambodia and will continue to be so.

Traditional breeding techniques are employed at CARDI for the development of new rice varieties. High yielding varieties are crossed with traditional Cambodian varieties to improve production in specific environments. These traditional techniques are limited to species that are sexually compatible. It is envisaged that Cambodia will rely on regional plant breeding programs for a majority of its germplasm requirements in the medium term and a high level of resources will not be invested in traditional breeding techniques for non rice crops. It may be necessary for Cambodian farmers to pay for some of this genetic material as does the Mong Riththy Group purchasing oil palm hybrids from Costa Rica.

Biotechnology has the capacity to expand the range of traits beyond those found in sexually compatible species. Modern techniques complement traditional breeding methods by speeding up the process. Some use recombinant DNA techniques to transfer genes from one species to another. Laboratories for such techniques are not found in Cambodia nor are there trained staff to operate them. However, transgenic crops possessing pest resistance from toxin producing genes introduced from the bacteria *Bacillus thuringiensis* or Bt genes are imported into the country. There are a range of crops on the market with the potential to reduce pesticide applications. Another potentially useful genetically modified crop for Cambodia is the betacarotene enriched rice referred to as Golden Rice which, if eaten, will partially alleviate widespread vitamin A deficiency in Cambodia. These are often referred to as Genetically Modified Organisms (GMOs). Cambodia does not prevent the importation of GMOs but has guidelines from the implementation of MAFFs policies and material standards claiming the right to refuse importation. It is very unlikely that Cambodian research organizations will engage in transferring genes from one species to another within the decade but may be instrumental in the design of programs in international research institutes to address Cambodian-specific problems.

Tissue culture is used for conservation, generation of plants from small pieces of tissue, and rapid replication of one line of genetic material. The practice is employed at CARDI to regenerate banana and plantain plants rapidly. Tissue culture will also be useful in the future for transferring disease free material across borders.

Cambodia has benefited from the use of agricultural biotechnology, particularly from traditional rice breeding techniques, fermentation and more recently from biogas production. Unless external funding sources are located, research in this field will receive a low priority for the next five years. It is possible that agricultural biotechnology may become a more important part of public research institutes after 2010. The use of more advanced biotechnology research such as the production of genetically modified organisms (GMOs) requires expensive laboratories and heavy investment in human and financial resources. Cambodia is unlikely to afford this type of research prior to 2015. In the meantime, the Government will undertake risk assessment, develop bio-safety measures and set up a regulatory framework for such research.

3.6 Strategies for human resource development

Achieving the vision of a productive and successful NARS to address a changing environment outlined in section 3.1 requires an adequate compliment of skilled and motivated staff. The summary review of the Cambodian NARS in Appendix 2 clearly shows that current realities are seriously at variance with the conditions required for a successful set of national research organizations. Public sector agencies are constrained by

the existing government salary structure and management practices as well as by shortages of resources to the point that only CARDI, CRRI and IFRDI among the MAFF institutes have substantive research programs at the present time. Personnel in these institutes receive above award salaries allowing them to concentrate on research related duties. Agricultural universities and colleges also supplement salaries through income derived from recently introduced student fees. Active research programs are limited to RUA but these activities are generally funded from outside. Private sector salaries are much higher than found in the public sector and research is well funded. Research programs generally form only a small part of the companies overall activities.

The pool of qualified staff is small in some research institutes. As presented in Table 1, there is a shortage of post graduate qualifications in all the major research organizations apart from CARDI. MAFF will ensure that each of the research institutes have sufficiently qualified personnel by targeting staff for training and that qualified staff are retained. Expanding the number of trained staff in the research institutes may be achieved by sponsoring staff to study for Masters degree training at RUA (or even for PhDs at private universities). MAFF will promote specific research staff members to take advantage of post graduate training programs offered by USAID, AusAID, JICA and the EU plus at CGIAR centers on condition that they return to the research institute for set period. As part of its mandate, CAREC will provide extra impartiality to the process by taking responsibility for interviewing prospective applicants for higher degree training.

The RGC recognizes that attractive and competitive conditions of service for senior staff are essential to the success of the research institutes. The SAI organizational structure discussed in section 3.2 will allow the setting of a reasonable salary structure and more generally enable conditions required for successful research programs. The pace of implementation of this strategy will continue to be tempered by financial realities.

It will be the responsibility of the boards and management teams of the individual SAIs to define the conditions of service that they feel are required to achieve these conditions. The rewards of success will be in positive reputations that will enable the organizations to sustain themselves.

Another option for expanding or reducing the researchers at a given institute is by contracting for services as research funds become available. A core of informed staff will be required at the institute to set guidelines for contracted staff. In western society a ratio of 70/30 permanent to contracted staff is recognized to be a manageable level. However if a large pool of qualified staff exists, this ratio may be much lower.

Attractive conditions of service and facilitating environments are not simply a matter of salaries. Research leaders need to be committed to providing rewards and recognition for staff members with outstanding performance. These rewards may be in the form of travel to conferences, small financial incentives, promotion opportunities, public recognition or a combination of all these. The rewards need to be closely linked to performance in terms of innovation or other impact forms.

A gender-positive recruitment policy will be followed to ensure reaching the RGC target of 30% women in the Government workforce within a ten year period. Women will be provided equal opportunity to attend national and international training opportunities. Various ethnic groups in Cambodia will also be represented in research priority setting

programs, implementation of research, particularly in the provinces and inclusion in training courses.

All supporting staff including technical officers, laboratory staff and other assistants require incentives to be productive members of research programs. Technical staff are often overlooked and low morale at this level often leads to gross inefficiencies in the form of absenteeism and low productivity. Expanding training opportunities to include technical staff, combined with accelerated promotion for the best performers can lead to significant improvement in performance of research programs.

PART III

PRIORITY RESEARCH PROGRAM AND ACTION PLAN

4. Methods and procedures to identify priority areas

4.1 Vision and objectives for research in crops, fishery, livestock, forestry, agro-industry and rubber

4.1.1 Vision and objectives for research in crops

Vision

Achieving a nation that produces high quality and safe crop produce in a sustainable manner for self-reliance and export.

Objectives

Building capacity to achieve food security and food safety for Cambodian people using a crop and ecosystem approach involving interdisciplinary research and through the development of partnerships that lead to increased crop productivity, improved livelihoods and better nutrition.

4.1.2 Vision and objectives for research in livestock sector

Vision

Improving livestock production through exploitation of animal breeds, better management of key diseases, sustainable production of animal feed, expanding exports of livestock products to international markets, and capacity building in livestock research and services in rural areas.

Objectives

To ensure a sustainable growth of livestock production to i) Meet local demand for meat products, ii) Production of safe food products, iii) Provide food security for rural households, iv) Prevention of infectious disease spread in stock, v) Reduce the level of key diseases in animals, vi) Develop policy guidelines for control of key diseases, vii) Increase livestock productivity, viii) Promote suitable breeds for specific regions, v) Develop new breeds with high performance and resistance to key diseases and adverse environments, ix) Improve processing of animal products, and x) Exploit raw materials for use in animal production

4.1.3 Vision and objectives for research in fisheries sector

Vision

Improve the livelihoods of fishery stakeholders through sustainable use of aquatic resources.

Objectives

Improving fishery production through expanding aquaculture and better management of fishery resources by fishery research to ensure the sustainability of aquatic resources.

4.1.4 Vision and objectives for research in forestry sector

Vision

Provision of appropriate technologies for enabling the sustainable use of forest resources with an optimum contribution to poverty reduction of rural people.

Objectives

To achieve a sustainable growth of forestry production via;

1. Sustainable use of forest resources which include proper management of forest resources, conservation of forest ecosystem, and biodiversity.
2. Restoration/rehabilitation of degraded natural forest and logged forests
3. Community-based management of forest resources in contribution to poverty reduction, food security, and livelihood of the rural people.

4.1.5 Vision and objectives for research in agro-industry sector

Vision

To enhance agro-processing and agribusiness in Cambodia.

Objectives

To improve the livelihoods and income of the local people through employment creation, expanding production to meet local demands and improving product quality for international market

4.1.6 Vision and objectives for research in rubber

Vision

Achieving a productive natural rubber industry in Cambodia through research and exchange of information and knowledge on rubber production.

Objectives

To assist rubber planters and other stakeholders in Cambodia to expand their rubber production in a profitable manner *via* an improvement on planting materials, chemistry technology, cultural practices and management.

4.2 Criteria and methods for priority setting

Priority setting is the process of defining a research portfolio that is consistent with the country's agricultural policy, the research organization's mission and the research program's objectives. Priorities are normally set in the light of limited resources, increasingly diverse research needs, and growing demands for transparency in resource allocation. (Planning Agricultural Research: A Source Book. ISNAR, 2001).

Criteria that guide priority setting for the Cambodian NARS are also derived from the goals and objectives of the research organizations as discussed in Appendix 2. The criteria and the resulting priorities may change over time in response to adjustments in national policies. Further, the programs and projects themselves are revisited periodically to determine whether progress is consistent with expectations. The methodology used for priority setting and review of the system are both discussed below.

4.2.1 Methodology and approach for priority setting

The following points were utilized to guide decisions on resource allocations for research in the Master Plan.

1. **Highest priority to adaptive research and information services in support of on going and prospective development activities:** Each of the commodity working groups set guidelines for their respective sub-sector for the percentage of resources (funds and staff time) that will be devoted to adaptive research and information services/linkages in support of development activities.
2. **High priority to concluding on-going research activities:** On-going research activities will be allowed to continue and at least reach a reasonable stopping point that will allow it to produce results. Providers of research services will comply with the requirements of existing contracts and grants.
3. **No new programs/projects to be initiated unless full funding has been secured.** Further, all new programs are to be screened for consistency with the overall priorities, notably the guidelines on adaptive research and information services.
4. **Review existing plans and priorities of the research institutes, universities and other research service providers.** The planning and priority setting methodologies were harmonized as much as possible by the commodity working groups to afford comparisons across the sub-sectors. However, most of the formal priority setting was done at the sub-sector and specific commodity levels.
5. **MAFF/RGC to make a determination on the level of support that it is able to sustain for the core operating budgets to specific institutes.** This determination provides a rough indication of the scale of the research activities that can be considered and the allocations across sub-sectors for the next research period.
6. **The allocation of resources will be guided by a long term vision.** PDAs and other service providers will be encouraged to think beyond their immediate needs and anticipate what might be needed for specific commodities and parts of the country 5 and 10 years from now. The future agenda can provide guidance for both adaptive and applied research.

7. For applied research possibilities, the working groups made the following determination:

- a. What information and research activities related to the topic already exist in the region or beyond? Is additional research by Cambodia necessary?
- b. Where can the research be undertaken most effectively and efficiently?
- c. Does the necessary staff and facilities to undertake the research already exist in Cambodia or is investment in physical resources, training and TA required?

MAFF will support mainly applied and adaptive research. As a general rule, all basic or strategic research undertaken by Cambodian research organizations should be fully supported (except core operating expenses) from sources other than the government budget. Staff time should be allocated to basic or strategic research only if is not required to meet the requirements of commitments in adaptive research and information services in support of development activities.

Consideration should be given to the skills of available research staff in the design of research programs and projects. Animal scientists cannot substitute for plant breeders and visa versa. Some redeployment or even retraining may be required for scientists to move from one investigative field to another. Additionally, research programs that are clearly not high priority should not be sanctioned simply because staff with the requisite skills are available.

Criteria for priority setting: After taking into consideration the above 7 points, the commodity working groups developed 10 criteria for setting agricultural research priorities. These criteria were then applied to each proposal. Proposals were scored by all working group members according to its impact. If the scores were equal for two or more proposals, an averaged ranking system was used to separate the pair. Criteria considered to the most important were as follow:

1. Does the research reflect Government policy?
2. Will the research have direct impact on the country's economy?
3. Will the results of the research improve food security?
4. Is there capacity for the research staff to implement the research program?
5. Can the clients easily adopt the improved technology?
6. Will the research be inexpensive to conduct?
7. Can the research be conducted over a reasonably short period?
8. Will the research create jobs and reduce poverty?
9. Is the program gender affirmative and lead to social equity?
10. Will the research improve the environment?

The evaluation methodology and scoring systems used during the research prioritization process by the working groups is presented in Appendix 6.

The criteria can also be used in a modified form for prioritizing commodities and subjects between and within sub-sectors. An example of this is illustrated in prioritizing which crop sub-sector should receive the most attention (see Section 5.0). Similar priority setting criteria will be used in the future.

4.2.2 Research planning

Research planning throughout the Master Plan period will have the following features:

1. **Review of criteria and methodology for planning and priority setting:** The criteria used priority setting are designed to reflect RCG policy objectives and will only be adjusted as changes in these objectives make that necessary. This determination was made by MAFF in the first instance with an emphasis of funding on crops research (see Table 2 in Section 6.2). CAREC will translate new policies into a revised set of criteria and weights and communicate these to commodity research networks and individual research organizations. The CAREC secretariat will draft the revisions that will then be circulated to research networks and organizations for comment before being formally considered for endorsement by the Council. These criteria will guide the decisions on competitive grants and contracts administered through CAREC as well as resource allocations generally for the NARS. The CAREC secretariat will also be responsible for monitoring and assessing planning and priority setting approaches and making adjustments as deemed necessary.
2. **Three year rolling plans for each research organization/commodity network:** The medium term plan has an initial 5 year prospective. However, this is a rather long perspective, given the large number of uncertainties associated mainly with resource availability. Each public sector research organization will prepare three year plans, which will be essentially identical to the first three years of the medium term plan and cover the period 2006-08. These plans will be reviewed by the CAREC secretariat and by the concerned CAREC commodity networks before being submitted to the Council for endorsement and transmission to MAFF/CARD. The secretariat will coordinate the results of the planning activities at the organization and sub-sector network levels to ensure consistency and will prepare a summary plan covering the entire sector. This will be a document that is formally reviewed by the Council and transmitted to MAFF/CARD. The timing will be phased so as to allow the plans to be used in decisions on annual resource allocations by RGC. Thereafter, the three year rolling plan will be reviewed annually and revised to include the addition of the next year (2009 in the first instance). The three year rolling plan approach is already in use by CARDI.
3. **Adjustment of national research plans:** The adjustments of national research plans of individual research organizations and networks will consider the following issues:
 - a. **Changes in RGC policies:** As reflected in adjustments in criteria (discussed above). Due attention will also be given to any communications from the three joint Technical Working Groups concerned with the agricultural sector.
 - b. **Prospective resource availability:** The RGC is committed to providing adequate core operating budget support for the research institutes and universities. However, the resources available to support research could well change dramatically from year to year, as new funding for competitive grants and contracts comes on and existing programs are completed. The

CAREC secretariat will review the situation annually as part of the program review exercise and make recommendations for adjustments in plans, as appropriate.

- c. ***Resource allocation guidelines between applied research, adaptive research and other services:*** These may be adjusted in the light of changes in RGC policies and resource availability.
4. **Procedures for planning adaptive research and associated services at the regional and provincial levels:** Annual revisions of plans at the provincial level will be made in accordance with the procedures for decentralized planning employed by PDA and other public sector agencies. The reviews will take new information generated by agro-ecosystem analysis into account in a fashion that is consistent with annual extension planning. However, the procedures will be modified to make them more forward looking for purposes of planning research activities.
5. **Reviews of services for NGOs and private sector organizations:** Review and revision of existing plans for services provided to NGOs, private commercial firms and farmer groups will be made in accordance with the contracts, memoranda of understanding and procedures agreed upon with these agencies and groups. New projects and programs may be added, but these will require the incorporation of these activities into the national plans of the research organizations involved and those of associated CAREC commodity network(s) as well as the endorsement of the national leadership of the concerned research organization(s).
6. **Stakeholder participation in research planning:** The participation of stakeholders in research planning will be in accordance with procedures employed by the individual research organizations and CAREC sub-sector networks. Guidelines for broader participation in research generally will be developed by the CAREC secretariat in its first year of operation, but the application of these guidelines will be the responsibility of the individual organizations and sub-sector networks. Participation will include representation on governing boards in the case of SAIs and encompass the range of linkage arrangements discussed in sections 2.8 and 3.4. Producers, particularly poor and disadvantaged groups, are generally under represented in these formal processes. An effort will be made to at least partially correct this deficiency through utilization of feed back from the agro-ecosystem analyses. An interactive information system serving farmer groups directly and via service providers will be piloted during the medium term plan period and could serve to enhance communications with large numbers of farmers on their research requirements.

5. Formulation of priority research programs for the sub-sectors:

Identification and formulation of priority research programs for the sub-sectors of crops, fishery, livestock, forestry, agro-industry and rubber

5.1 Identification of priority research programs

Sub-sector working groups composed of MAFF personnel, NGOs, commercial sector representatives, donors and a farmer identified a list of researchable problems identified in SWOT analyses conducted earlier. SWOT analyses were a compilation of those completed by each sub-sector working group and incorporating similar studies done at regional meetings. Ten criteria were used to set priorities for research as presented in section 3.2 and Appendix 6. These criteria were used to a) prioritize sub-sectors of the cropping program for research and b) prioritized programs within the sub-sectors. These were identified as follows:

Crops

Research areas/programs	Project	Priority
I. Rice-based farming systems	Improvement of rainfed lowland rice production in Kampong Speu and Kampong Chhnang	1
	Improving rice-based farming system for rainfed lowland rice farmers	2
	Increasing productivity of irrigated rice in Cambodia	4
	Improving rice production chains in Cambodia	8
II. Upland farming systems	Improving the productivity and sustainability of farming systems for upland areas	3
	Improvement of soybean production in northeast and northeast regions of Cambodia	7
	Enhancing cassava production in upland areas of Cambodia through varietal improvement and crop management	11
III. Conservation and utilization of selected plants	Collection and maintenance of ornamental plants suitable for propagation in Cambodia	12
	Genetic diversity and distribution of mulberry in Cambodia, its ex-situ conservation, and productivity improvement	13
IV. Vegetables and maize	Integrated approaches to improve the quality and yield of Cambodian vegetables	5
	Improving maize productivity and corn kernel quality through varietal improvement, appropriate crop management practices, and post harvest technologies	6
V. Fruit and industrial crops	Improving yield and quality of selected fruit crops (banana, mango, and orange) through cultural management and post-harvest technology	9
	Improving cashew productivity and nut quality via varietal selection and post harvest technology	10

Livestock

Research areas/programs	Research projects	Priority
Feed management	1. Appropriate technology for improving feed quantity and quality for ruminants	2
	2. Appropriate techniques for using local feed resources for pig and poultry production	1
	3. Feed quality control and nutrition	5
	4. Feed processing technology	7
Animal disease control	1. Vaccine production and quality control for Newcastle, <i>Haemorrhagic septicemia</i> (HS), <i>Avian influenza</i> (AI), and other important infectious diseases	3
	2. Epidemiology, diagnosis, and control of foot and mouth disease (FMD)	8
Breeding program	1. Genetic improvement of ruminants	16
	2. Poultry production and quality enhancement through breeding	17
	3. Development of appropriate breeds for local adaptation and market demand	12
	4. Production of crossbreeds between local and exotic breeds	13
	5. Introduction and development of dairy cattle	14
Socio-economics	1. Supplies, demand, and marketing study in livestock	15
	2. Cost and benefit study	18
Zoonosis and public health	1. Meat quality control management	4
	2. Development of meat quality standards	10
	3. Human risks associated with pet diseases	19
Animal waste management	1. Animal farm management study	11
	2. Development of biogas plants using animal waste	6
	3. Reduction of farm pollution and its environmental impact	9

Fisheries

Research areas/programs	Research projects	Priority
Fish seed and aquaculture development	1. Improving farmer's livelihoods through fish and freshwater prawn culture in rice fields and flood plains	4
	2. Improving feeds and feeding of <i>Channa micropeltes</i> and <i>C.striatus</i> through domestication and breeding	6
Biology, habitat, conservation and resource management	1. Improvement of fisheries productivity in the Cambodian Mekong Basin	1
	2. Protection and conservation program for endangered fish species	2
Socio-economics	1. The socio-economic impact of fisheries community development in Tonle Sap region	3
	2. Socio-economic study on inland fish cage culture in Cambodia	5

Agro-industry

Research areas/programs	Research projects	Priority
Agro-business (quality, price, services and market)	1. Quality and safety for fruit and vegetables in marketing chains and public awareness	1
	2. Packaging and storage techniques for fruit and vegetables	3
	3. Rural micro credit in the development of agro-business	8
Agro-industrial development (farming, planning and services)	1. Extension services and market information	2
	2. Promotion of areas suitable for construction of agro-processing plants	4
	3. Promotion of locally made products	6
	4. Improvements to contract farming	7
Food processing	1. Storage and processing of food	5

Forestry

Research areas/programs	Research projects	Priority
Forest resource management and conservation	1. Growth and yield modeling of the main forest species	13
	2. Assessment of biodiversity richness and potential for genetic conservation	11
	3. Demand and potential supply of timber and non-timber forest products	6
	4. Potential use of currently un-described tree species	9
Rehabilitation and restoration of degraded natural forest and logged areas	1. Stand structure analysis for adaptive rehabilitation of degraded natural forest	8
	2. Study on CDM (clean development mechanism)	12
	3. Introduction of fast / medium growing species into the rehabilitation of logged over forest areas	7
	4. Research on forest succession of shifting cultivation and logged over forest areas	10
Community-based management of forest resources	1. Market and economic value of forest resources in contribution to poverty reduction of local people	3
	2. Wood and non-wood forest products (NWFP) as resources for handicraft development in contribution to poverty reduction of local people	4
	3. Development of community forestry in expectation for livelihood improvement of local farmers in NE Cambodia	2
	4. Forest based enterprise development for future livelihood improvement of local people	1
	5. Introduction of agro-forestry into the development of community forestry projects	5

Rubber

Research area/programs	Research projects	Priority
Improved selection	1. Increasing natural rubber productivity in Cambodia <i>via</i> improved selection and multiplication of rubber clones.	1
Exploitation and physiology	2. Exploiting rubber physiology to enhance its production in Krek and Peam Chang plantations	2
Agronomy	3. Direct sowing and biomass production based cropping systems between rows of rubber trees	3
Chemistry technology	4. Small-scale experiments on processing of constant viscosity rubber and air-dried sheet rubber and determination of agronomical factors affecting their quality	4

6. Resource Requirements for Priority Research Programs

6.1 Funding policies and strategies

MAFF encourages SAI's and other Public Institutions to generate funds in support of their activities. However, given that special attention must be given to poverty alleviation; the needs of disadvantaged groups and areas; and preservation of the environment, a majority of the funding for Government members of NARS will continue to remain a public responsibility of the RGC. Producer associations, NGOs and private commercial enterprises are definitely encouraged to participate in the provision and support of agricultural research services. This participation is an essential part of the government's policy of better ensuring that agricultural research institutes and other public agencies address the needs of their clients.

The RGC will provide research institutes with adequate core operating budget required for the implementation of the research programs outlined in the Master Plan. This support will enable institutes to offer competitive conditions of service to research and professional staff as well as covering the direct and indirect costs of a core set of research programs. Research institutes, universities and schools of agriculture will be encouraged to apply for grants and contracts, as these are consistent with their missions and capacities.

Support for adaptive research and research related services (training, advisory assistance, information systems) required as complements to agricultural development activities at the provincial, district and commune levels will be made available through the existing decentralized planning and funding mechanisms already in place for DAE and other public sector agencies. These services may receive a degree of subsidy from the core operating budgets of the research institutes during the initial 10 year period in order to enable the institutes to offer these services to PDAs and other agricultural service providers at reasonable prices. However, as the volume of these services expands, the institutes gain experience, and economies of scale are realized, it is the policy of the RGC that clients should in time pay for the full costs of these services.

Research institutes, universities and schools of agriculture will be encouraged to continue to diversify their funding portfolios and seek support from a range of potential sources, as discussed in section 6.2. It is anticipated that an increasing portion of this funding will come in the form of competitive contracts and grants. CAREC will have the responsibility and capacity to administer these contracts and grants. It will also be charged with assisting public and private sector providers of agricultural research services in locating funding by bringing funding possibilities to their attention and offering training and advisory assistance in the preparation of proposals for support.

6.2 National and international sources of financing

Funding sources for agricultural research are becoming increasingly diversified in many countries as the NARS adapt to reforming their research agenda (See box in Section 3.2). In the past, donors supported agricultural research primarily by funding Ministries of Agriculture. The new arrangement is for donor funding to be directed through a number of government and non government entities. This is illustrated in Cambodia by an ADB grant to CEDAC to implement agricultural development activities with DAALI as the project director. AQIP, funded by AusAID is another example where funding is provided to a company for developing a seed production system. In addition the competitive grant scheme of the Cambodian Agricultural Research Fund (CARF) provides funds to non government and government organizations. Future donor research funding may pass through MAFF, producer associations and possibly via provincial governments.

Current and potential sources of support include the following:

- Government budget
- Donor funds
- Levies
- Development projects
- Collaborative research
- Grants
- Contracts
- Income from sales of goods and services
- Provincial Investment Funds (PIFs)
- Clients, including producer groups, agricultural service providers and associations
- Endowments

Accessing government budget allocations will be the main source of funds for Cambodian research organizations for the first five years of this Master Plan. Recurrent costs of the institutes will continue to be funded by the MAFF. In addition, approximately US\$2 million per annum have been made available to support research program operations for the next five years. Initially, the ministry directed that 42.5% of these funds will be allocated to research on crops and the remaining 57.5% to be split between fisheries, livestock, forestry and agro-industry as shown in Table 2. CAREC will provide MAFF with prioritized funding policies in future years.

Table 2 MAFF research funding allocation

	\$000'	%
Crops	850	42.5
Livestock	420	21
Fisheries	300	15
Forestry	220	11
Agro-industry	120	6
Rubber	90	4.5
Total	2000	100

Donors funding of research has been significant in some sectors of Cambodian agriculture in the past. The MRC, for example, fully funds a majority of the fresh water fisheries research conducted at IFReDI and has been doing so for a number of years (see Appendix 1 for details). The proportion of funding of this type will diminish over time as the research institute's capacity to design and resource its own research improves. This type of funding will be replaced by collaborative funding.

Levies on products are sources of funds in other countries. These are usually imposed on commodities. For example wheat growers in Australia pay a small percentage of their harvest to support research into improving wheat production. A levy on the sale of rubber may provide funds for research once the industry is divested from the Government.

Collaborative funding such as provided by ACIAR is developed with the agreements of two Governments or between one research institute and another (possibly a CGIAR center such as IRRI) to tackle a common problem. The research program is identified collaboratively and both provide resources to the venture. Often the Cambodia may only need to provide in-kind resources but benefit significantly from the research and associated training.

Grants for agricultural research are offered by government and non governmental organizations, special funding bodies and international research centers. Cambodian researchers can avail themselves of many of these sources, although considerable amount of work needs to be done beforehand in preparation. International grants can be applied for on the internet and by directly approaching issuing centers. It is also proposed that a competitive grant scheme be set up under CAREC through which funds may be deposited for general applications from the wider scientific community or to address a particular researchable problem at a specified institute. Competitive grant schemes are discussed in section 6.3.

Contractual work provides an extra source of income for government research organizations. Agricultural chemical companies, for example, pay for trials to be conducted on Government research stations or on-farm under government supervision to register products or for adaptive research purposes. Scientific services may also be contracted. For example, CARDI recently providing detailed soils information for an irrigation project in Kampong Thom.

Sales of goods and services include the sale of seed and other products from research stations, the provision of training services, information, books and use of seminar rooms, laboratory space or analyses. The price of these goods and services need to cover overheads plus a small profit margin for the research organization.

As mentioned in Section 3.4, PIFs are a possible source of funds for research on localized problems. They will be largely restricted to adaptive research, training and information services at the provincial level

Clients, including producer groups, agricultural service providers and associations provide mainly "in kind" support via participation in adaptive research-related activities, but scope for financial support in case of cash crops (cost recovery) and input supply in particular may be a useful tool for the public sector. Millers, for example may assist the installation of on farm trials if the produce is made available to the mill.

Endowments provide long term support for charitable organizations and educational organizations in developed countries. This type of assistance to research organizations in Cambodia is unlikely in the short term but may become significant in the future..

6.3 Competitive grants

Competitive grant systems are common in developed countries. The USA, Australia, Britain for example all have bodies for disbursing funds on a competitive basis. Many of these are driven by agricultural industries themselves. This system is illustrated by the Grains Research Development Council in Australia which receives most of its funds from a grain levy placed on farm production. In less developed countries a majority of the funds in competitive grant systems are from donor sources. In Papua New Guinea, a donor funded Agricultural Innovations Grant Facility assists activities that, in particular, disseminate existing research information that will directly benefit villagers.

In Cambodia, the CARF was established to provide Cambodian scientists further training and experience in sourcing research funds from competitive grants and managing the projects. The Research Trust Fund is open to Government, university or colleges and NGOs based in Cambodia which have a clear ability and mandate to implement research. Acceptable proposals need to be in the areas of crop production, protection and post harvest technologies, livestock production and health, natural resource management, farming systems, farm economics, rural socio-economics and aquaculture in farming systems. Grants of up to \$10,000 per annum are awarded for projects which may span over 1-3 years.

Cambodia does not have a trust fund that meet the requirements necessary to receive contributions from a number of different donor organizations. However one will be established under the auspices of CAREC. Establishing a transparent system through which the competitive Cambodian Agricultural Research Grant system will operate is essential for both the contributors and recipients of the funds. The fund needs to possess a strong governance structure and clearly identified objectives, priorities, expected results and desired long term outcomes. A suggested governance structure includes a board of directors, a secretariat and a technical advisory committee.

7. Action plan and implementation schedule: Activities, time schedules and budgets

The successful implementation of the agricultural research Master Plan over the medium term period (2006-2010) is dependent on the formulation of research programs targeted towards resolving problems that are of national strategic importance. The research programs require sufficient funding, human resources, facilities and equipment to be implemented plus possess an efficient administration and monitoring and evaluation system to be fully effective. A timetable for their implementation is presented in Table 3

Table 3 Timetable for implementation of agricultural research Master Plan

		Year				
		1	2	3	4	5
Activity		2006	2007	2008	2009	2010
Research						
1.	Ongoing local research program	—————	—————	.....	.....	.....
2.	On-going regional research	—————	—————	—————	—————	—————
3.	Implementation of MAFF funded program	—————	—————	—————	—————	—————
Infrastructure development						
1.	Completion of CARDI laboratory construction	—————	—————	—————	—————	—————
2.	Construction of DAALI laboratories	—————	—————	—————	—————	—————
3.	Possible buildings for DAI, FWRI, CRRI, DOF, FA and IFReDI					.....
Laboratory furnishings and equipment						
1.	Furnishing and equipping of CARDI laboratories	—————	—————	—————	—————	—————
2.	Furnishing and equipping of DAALI laboratories			—————	—————	—————
3.	Further equipment for NAHPIC, IFReDI, CRRI, FWRSI and RUA			.....	.....	.....
Vehicles, computers and other field equipment						
1.	All programs to purchase necessary vehicles and field equipment from MAFF funds	—————	—————	—————	—————	—————
Human resources development						
1.	Post graduate training (MSc and PhD)	—————	—————	—————	—————	—————
2.	Short term training courses	—————	—————	—————	—————	—————
Research coordination						
1.	Establishment of CAREC and committee	—————	—————	—————	—————	—————
2.	Competitive grant scheme operating		.....	.....	.....	.....

————— Funded activities
 Unfunded activities

7.1 Research

7.1.1 Externally funded research

Externally funded research activities

As mentioned in Section 4.2.1, highest priority will be given to the conclusion of funded on-going research activities and to the implementing of adaptive research programs. The timelines for current ongoing research activities are presented in Table 4. Many of these activities are in the final years of implementation. Of particular note is the completion of CARF funded activities prior to the end of 2007. Some of the ACIAR funded programs are also due for completion within the first two and half years of the Master Plan medium term period. However, unlike the CARF, ACIAR will continue to fund a collaborative research program into the foreseeable future.

CGIAR studies and donor funded programs such as those coordinated through GRET will continue as will private funded research activities (BAT Cambodia and Mongriththy as examples). These programs are often planned on a short term basis in response to current issues.

Some activities, particularly for MRC/DANIDA and the EU are included in the program as regional projects. These activities will need close coordination by collaborating Cambodian organizations to maximize resource effectiveness between projects and programs. Development projects may also support research to resolve provincial problems.

Externally funding research sources

Most ongoing agricultural research activities at the beginning of 2006 were funded by AusAID (including CARF), ACIAR, MRC/DANIDA, CGIAR centers, DED and the EU. CARF funding will terminate by the end of 2007. However, support is expected to continue for the other activities described in Table 3. Research directly funded by CARF amounts to approximately \$172,000 over the initial two years (2006-2007) of the Master Plan period (see Table 5 for details). The program will consist of 7 or 8 projects with total funding of approximately \$1.2 million per annum. These funds will cover in-country costs, expenditure in Australia and travel between both countries. Funding is also expected from the CGIAR centers plus bilateral and multilateral aid programs to support agricultural research during this period. Development projects such as the Economic and Social Re-launch of Northern Provinces (ECOSORN) and the smallholder Livestock Production Programme (SLPP) will provide small contracts for conducting research to resolve project related issues.

Considerable interest from donors to contribute to a competitive grant scheme set up under CAREC indicates a bright future for the continuation of external funding to agricultural research in Cambodia. The fund will however, need to provide proof of impartiality and be fully accountable for its finances. Such a scheme will fund a similar range of activities as in the successful CARF.

Table 4 Ongoing externally funded research activities (2006-2010)		Year				
		1	2	3	4	5
Code	Project Title	2006	2007	2008	2009	2010
CARF Funded						
APHEDA73	Fish feeds	█				
CARDI90	Rice Grain Quality	█				
CARDI87	Soil Nutrient Dynamic	█				
CARDI89	Rice Pests (PRODUCE)	█	█			
CARDI84	Banana Practice & Management		█			
CARDI88	Watermelon	█	█			
CARDI83	Banana Improvement	█	█			
DAALI179	DBM	█	█			
DAALI78	Coconut Beetle	█	█			
KCNSA95	Rice Production Assessment	█	█			
MVU74	Cattle Nutrition	█	█			
PLNSA97	Ground nuts	█	█			
RUA71	Dragon Fruits	█	█			
RUA72	Rice SRI	█	█			
RUA106	Edible Saprophytic Mushrooms	█	█			
RUA77	Kg.Thom Fisheries	█				
FLIP funded						
ACIAR funded						
ASEM/2000/109	Farming systems research for crop diversification in Cambodia and Australia	█	█			
ASEM/2003/012	Improving the marketing system for maize and soybeans in Cambodia	█	█			
CIM/2003/030	Improving understanding and management of rice pathogens in Cambodia	█	█	█		
LWR/2001/051	Assessing land suitability for crop diversification in Cambodia and Australia	█				
FIS/2003/003	Stock structure of two important Mekong river carp species	█				
CIM/1999/048	Increased productivity of rice based cropping systems in Lao PDR, Cambodia and Aust.	█				
ASI/2002/099	Development of a model for the control of fasciolosis in cattle and buffaloes.	█				

Table 4 continued Ongoing externally funded research activities (2006-2010)						
Code	Project Title	Year				
		1 2006	2 2007	3 2008	4 2009	5 2010
GRET Funded						
GRET 1	Rice cropping systems study					
CGIAR direct funded programs						
CIAT 1	Improving yield and quality in cassava					
INIBAP 1	Propagation of good banana varieties					
DED funded programs at RUA						
DED 1 & 2	General funding to Faculties of Forestry and Agronomy					
MRC/Danida funded regional studies						
A	Assessment of Mekong Capture Fisheries					
B	Management of reservoir fisheries					
C	Aquaculture of indigenous Mekong species					
EU Regional studies						
EU1	Production in aquatic peri-urban systems in Southeast Asia					
EU2	Open sources for weed assessment in lowland paddy fields (OSWALD)					
Private enterprise research (BAT Cambodia as an example)						
Fertilizer trials	Understanding response of tobacco to different rates of applied fertilizer					
Variety trials	Evaluation of different tobacco varieties in Cambodia					
Other trials	Curing trials					
Project sources of funding for research by contract (as examples)						
Rural dev't	Economic and Social Re-launch of Northern Provinces (ECOSORN)					
Livestock	Smallholder Livestock Production Programme (SLPP)					

— Planned activities

— Opportunity for research activities

— FLIP Farmers Livelihood Improvement Project funded by CARDI-AP

Table 5. Financial details of external project support for Government Institutes (2006-2010)

Project No.	Recipient org.	Year					Total
		1 2006	2 2007	3 2008	4 2009	5 2010	
CARF							
CARDI90	CARDI	9966					9966
CARDI87	CARDI	9999	9999				19998
CARDI89	CARDI	9950	9958				19908
CARDI84	CARDI	4995	4994				9989
CARDI88	CARDI	9936	9957				19893
CARDI83	CARDI	5000	5000				10000
DAALI179	DAALI	9726					9726
DAALI178	DAALI	6566	6566				13132
KCNSA95	KCNSA	7278	10576				17854
PLNSA97	PLNSA	6585	3200				9785
RUA71	RUA	3165	2630				5795
RUA72	RUA	7720	7720				15440
RUA106	RUA	5341	2914				8255
RUA77	RUA	2357					2357
Sub total		98584	73514				172098
GRET	CARDI	5000	5000				10000
CIAT	CARDI	2000					2000
INIBAP	CARDI	3000	3000				6000
DED 1	FA	4200					4200
DED 2	FA	4000					4000
Sub total		18200	8000				26200
BAT Cambodia	Private	13,000	13,000	13,000	13,000	13,000	65,000
ACIAR							
ASEM/2000/109	CARDI	X	X				
ASEM/2003/012	MOC/CDRI	X					
CIM/2003/030	CARDI	X	X	X			
LWR/2001/051	CARDI	X					
FIS/2003/003	MRC, Cambodia	X					
CIM/1999/048	CARDI	X					
ASI/2002/099	DAHP/CARDI/DAE	X					
Other projects		X	X	X	X	X	
Project sources							
ECOSORN	Various	X	X	X	X	X	
SLPP	DAHP/NAHPIC	X	X	X	X	X	
Regional studies	Various	X	X	X	X	X	
CGIAR centers	Various	X	X	X	X	X	
EU, MRC etc	Various	X	X	X	X	X	

X Funding available but not exclusively for research in Cambodia

Other potential funding sources include applying for research funding under a number of international bodies such as the EU (<http://www.delttha.cec.eu.int/en/index.htm>) and the Asia Wide Fund (http://europa.eu.int/comm/europeaid/projects/asia/asia-wide-programmes/update_dec2004.pdf).

7.1.2 MAFF funded research

Research activities

Working groups consisting of representatives from MAFF, other Government agencies, NGOs, IOs, private sector (including farmers), and donors formulated research priorities, research programs and research projects to resolve problems in the sub-sectors of crops, livestock, fisheries, rubber, forestry and agro-industry. Some of these projects will be supported directly by MAFF.

A timeline for the implementation of the selected projects is presented in Table 6 and funding allocation in Table 7. These projects were developed to resolve problems in the individual sub-sectors identified in the SWOT analyses presented in Appendix 1. A summary of the constraints within the sector, the research program designated to resolve that problem, the beneficiaries of any technologies emerging from the research, research objectives, action required for its implementation, research goal, research project title, responsible agency/collaborator and the financial cost of the research are presented in descriptions of the Government funded sub-sector programs in Appendix 7. These tables (Table A7.1-A7.6) summarize the approach to the design of research projects to resolve issues of national importance. They also note the agencies who will take prime responsibility for implementing the research and the financial commitment required for the activities.

Outlines of the proposed research projects are presented in Appendix 8. These one page concept notes provide the proposed project title, a list of the beneficiaries, objectives of the project, the project contents, expected outcomes, some methods to be employed for conducting the research, gender and environmental issues, a list of implementing agencies, expected international cooperation and a budget for the period of the project. Agencies responsible for implementing the projects possess more details of each proposal.

Government research funding

Government sponsored research will constitute a majority of the studies conducted in Cambodia throughout the initial 5 year planning period as discussed in section 6.2. A majority of these funds will sponsor research projects coordinated through the national agricultural research institutes including CARDI, NAHPIC, IFRDI, FWRSI, RUA and DAI. These institutes will closely collaborate with KCNSA, PLNSA, other Government agencies, NGOs, IOs and the private sector for the projects' effective implementation. Details of the responsible agency and project collaborators are presented in Appendix 7 and Appendix 8.

MAFF is committed to covering all recurrent costs for operating the research institutes and departments during the Master Plan period. The extra costs associated with

the expanded research program will be derived from the budget allocated to each institute or organization as stated in the project proposal budget. These issues are discussed further under the sections on vehicles, computers and other field equipment.

7.2 Infrastructure development

Major construction of facilities in support of research and research training planned for the 2006 – 2010 period includes buildings at CARDI and DAALI. At CARDI, the construction of seed processing and training facilities will be completed during 2005/2006. DAALI was also developing soil, pesticide and seed analysis laboratories during 2005-2006. No other major construction at the main MAFF research institutes was planned at the end of 2005.

A majority of the research project proposals detailed in Appendix 8 do not call for a high degree of laboratory analyses and it is possible for the institutes to share facilities to maximize efficiency as discussed in section 2.9. The expanded research program may, however, require the utilization of extra office space for field data collation and analysis. Shortages of these facilities are particularly evident in the DAI, FWRSI, IFRDI and NAHPIC. These institutes and some departments may need to collaborate with other organizations to effectively conduct their studies. The DAI also requests the establishment of research institutes with their own laboratory facilities. This will require an extra budget allocation.

7.3 Laboratory furnishings and equipment

Extensive refurbishment is planned for the CARDI and DAALI laboratories described in section 7.2. These refurbishments will allow both organizations to analyze soil samples, seed and in the case of DAALI, pesticide residues. No other large purchases of equipment were planned at the end of 2005. Small pieces of equipment will need to be procured using the research funds budgeted for the operation of research projects.

7.4 Vehicles, computers and field equipment

Extra vehicles (four wheel and motorcycles), computers and other small pieces of equipment are needed for the research organizations to implement the research programs and projects presented in Appendix 8. Planning for their purchase and operation will be on a research program basis.

7.5 Human resources development

The mid term (2006-2010) plan for agricultural research developed by the sub-sector working groups took into consideration the level of personnel required for each project. All projects were designed to take adaptive research approaches and do not require large numbers of highly qualified researchers. Selection criteria for proposed projects take into account the immediate needs of the sub sector commodities, capacity to implement (facility and human resources) and financing prospects. The current 31 PhDs, 200 MSc and 1046 BSc (at 2004 levels) have the capacity to implement the adaptive

research program proposed in Appendix 8. Fifteen (15) PhD, 16 MSc and 148 BSc graduates in CARDI and DAALI will work with RUA, PLNSA and KCNSA plus the private sector to manage a majority of the crops research program. Other lead organizations also possess qualified staff with the capacity to oversee the research projects. Research experience in FWSRI will be supported by the large number of master degrees in the FA and IFRoDI and DOF will join scientific forces if necessary. Where an imbalance in the number of post graduates is found in the smaller programs (rubber and livestock in particular) more assistance may be required initially from stronger research organizations or from international sources to design the research activities and assist with the statistical analysis plus reporting of the trial results.

During the initial five year period, short term training activities are included in the design of the research projects. Activities include short term training courses, technical exchange and study tours. (Table 6).

Table 6. Human resources development for agricultural research

	Year				
	1	2	3	4	5
Training program	2006	2007	2008	2009	2010
Formal short term training courses
On-the-job training	
Technical exchange
Field visits
Study tours	
Conferences and symposiums		
Donor funded post graduate courses					

Short term training courses will be arranged directly by individual research centers and collaboratively with other research programs. CAREC will take a lead role in the organization of collaborative short term training courses. MAFF will not embark on a self financed program of long term training to increase the number of post graduates in the system for the initial five year period.

On-the-job training will include assigning qualified personnel to research programs within the same organization, between collaborative organizations within the same working groups and across disciplines where skills can be transferred. Where possible, personnel from international collaborative research programs will also be requested to work closely with the researchers.

Technical exchange will be primarily through collaboration with neighboring countries with whom Cambodia has close relations and high costs are not involved. Exchanges are currently particularly strong between provinces in the NW of Cambodia and provinces in NE Thailand. Similar relationships are also strong between provinces bordering Vietnam in the SE of Cambodia.

Adaptive research programs require a considerable number of trips to the field. These trips will enhance the capacity of field staff when experienced personnel take the effort to impart their knowledge informally. Initially, the more experienced staff members will need to work hand in hand with the field staff to improve their skills.

Study tours to similar environments are a means of allowing field staff in addition to senior researchers the opportunity to discuss their programs with personnel in foreign countries. Initially trips will be made to Thailand and Vietnam to environments are similar to those in Cambodia. Trips further a field will follow in later years.

Program research results need to be written up and discussed with peer groups. The best venue for this is within conferences and symposia organized on a local level and internationally. Annual conferences to discuss the previous years results and plan for subsequent years will be part of the overall strategy for review. Attendance at international conferences will be based on merit.

Over the longer term the number of post graduate trained staff will need to be increased. If a general guide is followed of having 10-15% of PhDs and 20-30% of MSc graduates amongst the technical staff in each research organization by the end of 2015, institutes will need to attract or train 20-30 PhDs and 50 MScs over the Master Plan period if staff numbers remain at 2004 levels. Most additional higher degree graduates will be located in the universities, and in rubber, fisheries, livestock and forestry. The percentage of post graduates working in research will need to increase further as programs turn from adaptive to applied and strategic research in 10 to 20 years time.

The training of 20-30 PhDs and 50MSc level research staff over a ten year period will require the Department of Personnel and Human Resource Development at MAFF to target personnel from selected research organizations to apply for academic scholarships offered by Government and non Government organizations. For example, Australia offers 20 post graduate scholarships each year. Japan, EU, the USA and other countries offer similar training schemes at Universities in their respective countries. MAFF may also sponsor candidates to study at local universities to improve their academic qualifications. Sponsorship of research personnel to short term courses and to attend seminars and conferences will assist develop and maintain linkages with international research and academic organizations plus keep personnel current with recent scientific developments.

Retaining qualified and skilled personnel at the research organizations will require the implementation of incentive schemes as discussed in section 3.6

Contracting personnel services (see Section 3.6) is another option for sourcing the necessary number of researchers for short and medium term research programs. Contracting will allow an expansion and contraction in the number of research staff members in relation to the level of available funds. This strategy assumes that an adequate pool of qualified personnel is available at the time of employment.

7.6 Research coordination

An outline of the research coordination process under the renewed strategy is presented in section 3.2. The ongoing research programs funded by CARF, ACIAR, GRET, CGIAR, DED, MRC, EU, BAT and other organizations will continue as presented in Table 3 under current coordination processes. This research will be reconsidered by the working groups under CAREC in the next three year plan. The MAFF funded program presented in Tables 7 and 8 will be coordinated by the implementing agency presented on the research concept notes. Collaborating

organizations will refer to the main implementing agency for resources. The implementing agency will submit proposals to MAFF for funding of individual projects. Funds deposited in the CAREC managed competitive grant scheme will be directly disbursed by CAREC. The first step in research coordination of the MP is the formation of CAREC and formalization of sub-sector working groups for research prioritization.

Table 7. Implementation schedule of projects with funds mobilized by MAFF.

Code	Project Title	Year				
		1 2006	2 2007	3 2008	4 2009	5 2010
Crops						
Cr1	Improvement of rain fed lowland rice production in Kampong Speu and Kampong Chhnang					
Cr2	Improving rice based farming system for rain fed lowland areas					
Cr3	Increasing productivity of irrigated rice in Cambodia					
Cr4	Improving rice production chains in Cambodia					
Cr5	Improving the productivity and sustainability of farming systems for upland areas					
Cr6	Improvement of soybean production in NE Cambodia					
Cr7	Enhancing cassava production in upland areas of Cambodia through varietal improvement and crop management					
Cr8	Collection and maintenance of ornamental plants suitable for propagation in Cambodia					
Cr9	Genetic diversity and distribution of mulberry in Cambodia, its ex-situ conservation, and productivity improvement					
Cr10	Integrated approaches to improve the quality and yield of Cambodian vegetables					
Cr11	Improving maize productivity and corn kernel quality through varietal improvement, appropriate crop management practices and post harvest technologies					
Cr12	Improving yield and quality of selected fruit crops (banana, mango, and orange) through cultural management and post harvest technology					
Cr13	Improving cashew productivity and nut quality via varietal selection and post harvest technology					
Livestock						
Li1	Appropriate technology for improving feed quantity and quality for ruminants					
Li2	Appropriate techniques for using local feed resources for pig and poultry production					
Li3	Feed quality control and nutrition					
Li4	Feed processing technology					
Li5	Appropriate control of Newcastle Disease in Pursat province					
Li6	Epidemiology, diagnosis, and control of foot and mouth disease (FMD)					
Li7	Genetic improvement of ruminants					
Li8	Poultry production and quality enhancement through breeding					

Table 7 cont. a		Year				
		1 2006	2 2007	3 2008	4 2009	5 2010
Code	Project Title					
Ll9	Development of appropriate breeds for local adaptation and market demand					
Ll10	Production of crossbreeds between local and exotic breeds					
Ll11	Introduction and development of dairy cattle					
Ll12	Supplies, demand, and marketing study in livestock					
Ll13	Cost and benefit study					
Ll14	Meat quality control management					
Ll15	Development of meat quality standards					
Ll16	Human risks associated with pet diseases					
Ll17	Animal farm management study					
Ll18	Development of biogas plants using animal waste					
Ll19	Reduction of farm pollution and its environmental impact					
Fisheries						
Fi1	Improving people's livelihoods through fish and freshwater prawn culture in rice fields and flood plains					
Fi2	Improving feeds and feeding of <i>Channa micropeltes</i> and <i>C. striatus</i> through domestication and breeding					
Fi3	Improvement of fisheries productivity in the Cambodian Mekong Basin					
Fi4	Protection and conservation of endangered species					
Fi5	The socio-economic impact of fisheries community development and management in the Tonle Sap region					
Fi6	Socio-economic study on inland fish cage culture in Cambodia					
Forestry						
Fo1	Growth and yield modeling of the main forest species					
Fo2	Assessment of biodiversity richness and potential for genetic conservation					
Fo3	Demand and potential supply of timber and non-timber forest products					
Fo4	Potential use of currently un-described tree species					
Fo5	Stand structure analysis for adaptive rehabilitation of degraded natural forest					
Fo6	Study on the effect of solar stoves on the reduction of wood fuel use					
Fo7	Introduction of fast/medium growing species into the rehabilitation of logged-over forest areas					

Table 7 cont b		Year				
		1 2006	2 2007	3 2008	4 2009	5 2010
Code	Project Title					
Fo8	Research on forest succession of shifting cultivation and logged-over forest areas					
Fo9	Market and economic value of forest resources in contribution to poverty reduction					
Fo10	Wood and non-wood forest products (NWFP) as resources for handicraft development					
Fo11	Development of community forestry in expectation for livelihood improvement of local farmers in NE					
Fo12	Forest based enterprise development for future livelihood improvement					
Fo13	Introduction of Agro-forestry into development of community forestry projects					
Agro-industry						
Ai1	Quality and safety for fruit and vegetables in marketing chains and public awareness					
Ai2	Packaging and storage techniques for fruit and vegetables					
Ai3	Rural micro-credit in the development of agribusiness					
Ai4	Extension service and agro-business information					
Ai5	Promotion of areas suitable for construction of agro-processing plants					
Ai6	Promotion of locally made products					
Ai7	Improvements to contract farming					
Ai8	Storage and processing of food					
Rubber						
Ru1	Increasing natural rubber productivity in Cambodia via improved selection and multiplication of rubber clones					
Ru2	Increasing rubber productivity in Cambodia by improving tapping systems					
Ru3	Direct sowing and biomass production based cropping systems between rows of rubber trees					
Ru4	Small-scale experiments on processing of constant viscosity rubber and air-dried sheet rubber and determination of agronomical factors affecting their quality					

Table 8. MAFF research fund (\$000') allocation by project (2006-2010)

	Project No.	Year					Total
		1 2006	2 2007	3 2008	4 2009	5 2010	
Crops	Cr1	129	158	157	178	207	829
	Cr2			49	69	72	190
	Cr3		56	68	79		203
	Cr4	110	96	83	84	77	450
	Cr5		65	52	52	48	217
	Cr6		62	52	52	48	214
	Cr7	129		98		90	317
	Cr8	115	99	83	84	77	458
	Cr9	112	96	83	84	77	452
	Cr10	110	96	83	84	77	450
	CR11	58	48	42	42	39	229
	Cr12				42	38	80
	Cr13	87	74				161
		Total	850	850	850	850	850	4250
Livestock	Li1	23	21	16	18	18	96
	Li2	20	18	18	18	18	92
	Li3	20	17	17	17	17	88
	Li4		22	21	22	22	87
	Li5	20	20	20	20	20	100
	Li6	65	54	54	52	34	259
	Li7	20	14	14	12	14	74
	Li8	20	14	14	14	14	76
	Li9	47	34	23	23	24	151
	Li10	20	14	14	14	14	76
	Li11			23	24	35	82
	Li12	30	35	33	31	36	165
	Li13	25	20	20	20	20	105
	Li14	20	20	20	23	23	106
	Li15		29	29	29	29	116
	Li16	22	23	20	20	20	102

Table 8 cont.		Year					
	Project No.	1	2	3	4	5	
	Li17	22	20	20	20	20	102
	Li18	21	20	20	20	20	101
	Li19	25	20	20	20	20	105
	Total	420	420	420	420	420	2100
Fisheries	Fi1	53	53	53	53	53	265
	Fi2	53	53	53	53	53	265
	Fi3	61	61	61	61	61	305
	Fi4	35	35	35	35	35	175
	Fi5	50	50	50	50	50	250
	Fi6	48	48	48	48	48	240
	Total	300	300	300	300	300	1500
Forestry	Fo1		30	22	33	33	118
	Fo2	20	18				38
	Fo3	46	18	22			86
	Fo4			22	33	33	88
	Fo5	30	30	20			80
	Fo6	36	36	20			92
	Fo7			26	30	26	82
	Fo8				36	40	76
	Fo9				35	58	93
	Fo10	20	30				50
	Fo11	37	25	25			87
	Fo12			28	30	30	88
	Fo13	31	33	35	23		122
	Total	220	220	220	220	220	1100
Agro-industry	Ai1	60	40	20	30	60	210
	Ai2		25	10			35
	Ai3			20	20		40
	Ai4	30	20	20	30	20	120
	Ai5	30	15			20	65
	Ai6		20	10		10	40
	Ai7			20	20		40
	Ai8			20	20	10	50
	Total	120	120	120	120	120	600
Rubber	Ru1	8	17	22	25	25	97
	Ru2	5	15	24	27	27	98
	Ru3	7	18	24	28	28	105
	Ru4	70	40	20	10	10	150
	Total	90	90	90	90	90	450
	Grand total	2000	2000	2000	2000	2000	10000

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