Research Need Assessment and Agricultural Research Priorities for South and West Asia

The Asia-Pacific Association of Agricultural Research Institutions
International Crops Research Institute for the Semi-Arid Tropics
National Centre for Agricultural Economics and Policy Research

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Abstract

Despite the impressive gains in food production, food security, and reduction in rural poverty in South Asia in recent times, problems such as degradation of natural resources, water scarcity, and low productivity persist in the region. The threat of marginalization of agriculture and livelihoods of the poor looms large in South and West Asia, where agriculture is the dominant economic activity. The emerging global challenges, paucity of resources, and the need for greater and quicker impacts now compels organizations to prioritize research. This workshop was organized as part of APAARI, ICRISAT, and ICAR's ongoing effort to establish a demand-driven research agenda based on a participatory approach. The objective was to identify research priorities based on gap analysis by national programs. Representatives of five South and West Asian countries (India, Sri Lanka, Bangladesh, Nepal and Iran), CGIAR institutes, donors, NGOs, farmer associations, agricultural universities, and the private sector presented their research needs and emerging challenges, on the basis of identified critical gaps and alternative approaches for addressing these. This book is a compilation of the country papers presented, and spells out specific priorities at macro-, meso-, and micro-levels under the broad themes of genetic improvement, natural resources management, and socioeconomic and policy research.

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Proceedings of a Workshop
held at ICRISAT, Patancheru
7-8 October 2004

Edited by
MCS Bantilan, Mruthyunjaya, CLL Gowda and GV Anupama

The Asia-Pacific Association of Agricultural Research Institutions

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Preface

Agricultural research is no longer what it used to be a few years ago. Today, emerging global challenges, paucity of funds, competing demands and the need for greater and quicker impacts propel organizations to prioritize research. Rampant poverty, low productivity, degradation of natural resources, water scarcity and a host of global issues jostle for urgent attention. They threaten the very fabric of our lives.

The threat of further marginalization of agriculture looms large in South and West Asia, where agriculture is the dominant economic activity. In this context, stepping up public investments in agricultural research and technology development assumes great significance. However, this calls for a more focused approach to research rather than a sprawling one.

This book - APAARI, ICRISAT, and ICAR's ongoing collaborative effort to establish a demand-driven research agenda based on a participatory approach - reports on priority research interventions for South and West Asia. The result of a workshop, it sets out to identify research priorities at the micro level based on gap analysis by national programs. It builds on APAARI's previous attempts to promote collaborative research among member institutions and encourage the establishment of cooperative research and training programs in accordance with regional, bilateral, or national needs and priorities.

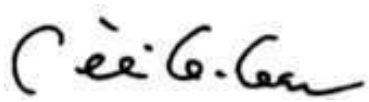
Representatives of five South and West Asian countries (India, Sri Lanka, Bangladesh, Nepal and Iran), CGIAR institutes, donors, NGOs, farmer associations, agricultural universities and the private sector have presented their research needs, emerging challenges, identified research gaps and spelt out activities that need to be taken up to bridge these gaps. The overall aim is to enhance productivity, profitability and employment in agriculture, which are vital for improving the well-being of the poor. There is a deliberate narrowing down of local priorities within the ambit of broad priorities for a more focused approach to research need assessment.

The book spells out macro, micro and zonal priorities under the broad themes of genetic improvement, natural resource management (NRM) and socioeconomic and policy research. Under genetic improvement, diversi-fication with emphasis on legumes, genetic resource management including postharvest technology, value addition and agri-business-marketing aspects were identified as crucial issues. In NRM, integrated watershed management, soil fertility/health management, and salinity/quality of water were seen as being important. Under socioeconomics and policy, higher investment on infrastructure, marketing, credit, and pricing came out as priorities.

I acknowledge the power of partnerships here. Without working together, without a common thread running through our

efforts, our work would be meaningless. Also, this exercise will be complete when we catalyze policymakers for enhanced support to R&D in agriculture in general and priority areas under different agroecosystems.

Food and nutrition security, risks and vulnerability, inadequate resources and so many others look like insurmountable problems. Meeting them head on is a challenge we face today. With the best efforts on all sides, I am sure we can do it together.



William D Dar
Director General
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Welcome Remarks

William D Dar

As Director General of ICRISAT, I extend a warm welcome to all the participants at this workshop, which is part of APAARI, ICRISAT and ICAR's ongoing collaborative efforts to establish a demand-driven research agenda.

ICRISAT aims to alleviate rural poverty in Asia. As part of its research integration process, it was agreed to formalize the establishment of a Future Harvest Alliance of 15 centers of the Consultative Group on International Agricultural Research (CGIAR) with the objective of enhancing the efficiencies of centers and partners as a group. The purpose of the exercise was to reinforce the notion that collective action is the key to tackling major global issues. ICRISAT has always explored such alliances that enhance partnership. I have been elected Chair of the Center Directors Committee (CDC) of the CGIAR and will be holding this position for one year starting January 2005. I believe this is a good opportunity for the centers to work together along with APAARI towards a common goal - that of improving the lot of the poor small farmer in South and West Asia.

The CGIAR's Science Council has listed ten systems priorities with the intention of developing a more cohesive and better focused research program. They are as follows:

1. Conservation and characterization of genetic resources
2. Genetic improvement of specific traits
3. Improved water management and use in agriculture
4. Better management and use of forests and forest landscapes
5. Better soil and land management and use
6. Improved production and processing systems for high-value commodities
7. Enhancing resource efficient and equitable forms of livestock sector growth
8. Improved management and use of aquatic resources
9. Policy and institutional innovation to reduce poverty and hunger and to enhance competitiveness of small holders
10. Strengthening national and regional capacities for agricultural research and rural institutions

The aim of the systems priorities is for the 15 CG centers to align themselves within this consolidated research focus. In the case of South Asia, we need to look at priorities/subpriorities within these 10 priorities. This consultation will have a tremendous impact since it will clearly identify the research needs; thereafter a focused approach can be formulated for better results.

I would like to dwell on hunger, a global tragedy in which 852 million people still go to bed hungry every night! The seven basic recommendations made by the Millennium Task Force on Hunger to the UN Secretary-General Kofi Annan aim to reduce hunger by 2015. The Task Force recommends:

- Move from political commitment to action
- Reform policy and create an enabling environment
- Increase agricultural productivity for food insecure farmers
- Improve nutrition of vulnerable groups with chronic and hidden hunger
- Reduce vulnerability of the acutely hungry with productive safety nets
- Make markets work for and increase income of the food insecure
- Restore and conserve natural assets of the food insecure

We should be able to institutionalize our research and development efforts within these recommendations. Steps are being taken in all directions to better the lives of the poor. The UN Secretary-General is making efforts to increase the budget to fight hunger and malnutrition. An annual budget of $1 billion is being projected for the CG system as against the present $460 million, to be increased to $500 million in 2005.

Let us not forget that it is in South and West Asia that most of the poor live. We owe it to the poor in these regions to show them the way to a better future.

Introduction

Cynthia S Bantilan

The countries of South and West Asia have significantly benefited from investment in agricultural research, in particular through the adoption of high-yielding crop varieties, soil fertility management methods, efficient use of water, and integrated pest and disease management. Having said that, the need to focus and set research priorities cannot be overemphasized, as these countries have limited resources for agricultural research for development. The extensive consultations organized by APAARI in collaboration with ICRISAT and ICAR in 2001 and 2002 helped identify broad research priorities for agricultural research and development. Ranked in order of importance are the research areas on cereals, livestock, horticulture crops and plantation crops. The sectoral priorities identified for the region were summarized as follows:

Sector	Priority research themes
Crops	1. Development of crop varieties for • Tolerance to abiotic and biotic stresses • Improving crop yield ceilings in irrigated areas • Better product quality, nutrition and value addition • Dual purpose (food and fodder) crops 2. Short-duration varieties of rice and wheat to incorporate other crops, especially legumes in cropping systems 3. Diversifying production systems 4. Improving input use efficiency through ICM, IPM, INM, precision farming, etc. 5. Improving cropping systems for higher yields through pest management, natural resource conservation, and integration with livestock and trees 6. Sustainable seed and technology transfer systems 7. Small farm mechanization
Horticulture	1. Postharvest handling, value addition through processing and storage 2. IPM and INM in orchards, vegetables and floriculture 3. Improving root stocks and rapid plant propagation methods in fruit trees 4. Integrated management for off-season vegetables, flowers and peri-urban cultivation

Continued

Sector	Priority research themes
	5. Development of varieties for better quality, nutrition, and shelf life and suitable for processing
	6. Protected cultivation of vegetables and flowers
	7. Development of arid (hot and cold) horticulture
Livestock including poultry	1. Technological options for sustainable crop-livestock systems
	2. Improving nutrition through • Quality of crop residues and removal of anti-nutritional factors • Strategic supplementation • Development of improved varieties of fodder crops and feed balance
	3. Animal health: • Epidemiology, diagnosis and vaccine production for major diseases based on biotechnology • Disease-nutrition interactions • Genetic resistance to major diseases
	4. Characterization and improvement of local breeds through selective breeding
	5. Factors influencing adoption and impact of improved technologies
	6. Market development, product processing and biosafety of products, with focus on smallholders
	7. Socioeconomic and environmental impact of crop-livestock systems, including pastoral systems
Fisheries	*Coastal*
	1. Sustainable management of coastal systems and marine protected areas
	2. Sustainable management of marine shrimp farming (feed, nutrition, health and seed distribution), including effluent management
	3. Crab and ornamental fish culture
	Inland
	4. Genetic improvement for growth enhancement and disease resistance
	5. Fish health management, particularly for intensive culture of fish and crustaceans

Continued

Sector	Priority research themes
	6. Deepwater rice-fish, fresh water prawn culture
	7. Integrated fish farming, and open water culture-based fishery
	8. Cold fish water culture
	General
	9. Postharvest issues, and biosafety of seafood products
	10. Socioeconomic issues, environmental impact analysis and institutional issues pertaining to aquatic resources and aquaculture
Forestry	1. Sustainable management of second-growth forests
	2. Inventory, evaluation and development of forest resources
	3. Tree and forest health management
	4. Promotion and management of agroforestry
	5. Improvement of medicinal and aromatic plants
	6. Market development for non-timber and minor forest products
	7. Policy and institutional issues in forest management
	8. Ecotourism and landscape forestry
Natural Resource Management	1. Conservation of genetic (crop, livestock, fish, tree), water and land resources
	2. Improving efficiency of the distribution and use of irrigation water (policy, technology and institutional issues)
	3. Technological and institutional options for harvesting and use of rainwater (e.g. watershed management)
	4. Sustainable land use, organic recycling and soil fertility management
	5. Reclamation of degraded/sodic lands, control/management of saline and arsenic-contaminated water
Socioeconomic	1. Poverty mapping and investment priorities
	2. Market integration and trade liberalization with focus on smallholders
	3. Risk management
	4. Empowerment of women and labor migration
	5. Policy and institutional aspects of agricultural R&D

Source: These are based on recommendations of working groups formed during the expert consultations.

This workshop on "Research need assessment and prioritization of agricultural research for development in South and West Asia" was conceptualized to address the recommendations made during the two stakeholder consultations on the Asia Pacific held in July and November 2001 and a General Assembly meeting of APAARI in December 2002. The overall assessments of the working groups during these consultations led them to recommend that local priorities under the broad categories listed above need to be determined based on an assessment of research requirements of the countries in the region, and also according to the needs and goals of the research system. These specific needs should be brought to the attention of the national agricultural research systems, CGIAR, nongovernmental organizations, civil societies and other concerned partners so that they can be addressed.

An important suggestion that is being pursued for this workshop is undertaking a gap analysis and study of research needs following a bottom-up approach, with active participation from stakeholders such as farmers, NGOs, farmer organizations, development workers and extension agents. Grassroots level perspectives are essential to understand the resource base and agroecological situations, infrastructure and farming systems as well as the local experiences and opportunities. A participatory elicitation process assures identification of specific research gaps and potential opportunities, taking into account the relevance of the problem as well as the ownership and accountability of the local implementer.

Thus, the workshop has the following objectives:

- To identify research needs based on gap analysis by national programs in South and West Asia.
- To synthesize the regional research needs and priorities for South and West Asia and draw up a set of recommendations on research priorities that may influence the global research agenda.

The workshop was organized to facilitate the development of country papers among participating countries in South and West Asia, including Bangladesh, India, Iran, Nepal and Sri Lanka. A framework underpinning the research need assessment and gap analysis was designed to guide the exercise. All five countries responded positively and developed their analysis according to the following outline:

- agricultural scenario analysis;
- significance of agricultural research for development in the NARS;
- emerging agricultural research challenges;
- research needs-evidence from micro-studies by agroecologies, sectors, classes of farmers, and research themes;
- gap analysis - comparison of research needs and current efforts;
- steps required to bridge the gap - role of research institutions, extension agencies and development department; and
- implication on agricultural research priorities.

The set of five country papers produced through this consultation exercise is an important milestone. A synthesis of these assessments in different ecologies, and subsectors (crops, horticulture, animal

science, fishery, forestry, natural resource management and socioeconomics) provides a basis for research institutions whereby they can examine their research portfolios and address the research gaps in future national research programs.

The active participation of the IARCs, NGOs, farmer organizations and the private sector also enhanced the process of identifying the priority needs by commodity and agroecology, both regionally and internationally. The brainstorming meeting benefits not only the national programs in South and West Asia, but also APAARI, GFAR, and the CGIAR centers by achieving a better programmatic focus and a more participatory identification of priorities. Ultimately, the above assessments and recommendations help the donor communities and decision makers plan their funding, human resource development, policy formulation, and development programs and other interventions.

Research Prioritization Initiatives by APAARI - Genesis for the Present Exercise

Rajendra Singh Paroda[1]

This section presents a detailed background of the research priorities initiative, highlighting the objectives, functions, strategies and action plan of APAARI, and featuring the major issues for consideration that include gap analysis, implications of the existing network, development of new proposals and partnerships, and funding strategy. The vision of APAARI is to promote agricultural research for development in the Asia-Pacific region and facilitate it through novel partnerships among NARS and other related organizations so that it contributes to sustainable improvements in the productivity of agricultural systems and to the quality of the natural resource base that underpins agriculture. This will help enhance food and nutrition security, and economic and social well-being. The main objective of APAARI is to encourage the establishment of appropriate cooperative research and training programs in accordance with the identified regional, bilateral, or national needs and priorities. The key functions include promoting collaborative research among member institutions. The strategies are regional collaboration on priority programs and action plan is to form networks and consortia.

The important expert consultations APAARI had in the recent past include

- Priority setting by NARS in the Asia-Pacific region, 1996
- Management and strengthening of research networks in the Asia-Pacific region, 1997
- Research management mechanisms of NARS, 1998
- Development of APAARI Vision 2025, 1999
- Strategies to implement APAARI Vision 2025, 2000
- Development of a regional agricultural information system, 2000
- Regional priority setting for agricultural research for development in the Asia-Pacific Region, 2001
- Status of biotechnology in agriculture in Asia and Pacific, 2002
- Development of second phase of the Asia-Pacific Agricultural Research Information System (APARIS), 2002
- Strengthening ofresearch partnerships through networks and consortia, 2002
- Strengthening regional agricultural information system and research networks, 2003
- Postharvest technologies for ensuring food security and value addition for enhanced income, 2004

The goals of APAARI as envisioned in Vision 2025 are

- Harnessing agricultural science for better future
- Engineering (capacity building) the NARS
- Growth-oriented and responsive governance

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The following mechanisms will be used to achieve these goals: Partnership, networking, information and communication technology, human resource development, improving research management, publication enhancement for technology transfer, setting strategic directions, policy dialogue and advice, impact assessment, and sustainability of APAARI's efforts.

APAARI is planning to implement its Vision 2025 through various expert consultations on different strategies. The various issues for consideration are

- Gap analysis: identifying gaps between present collaborative efforts and regional needs/priorities
- Implications for existing regional networks and regional collaborative programs
- Development of new proposals for regional and/or global partnerships
- Funding strategy through resource sharing by the stakeholders and mobilizing additional funding from donors
- Guidelines for developing new proposals

The earlier priorities identified were:

- Technology: biotechnology, post-harvest technologies, integrated pest management (IPM) and information and communication technology (ICT)
- Crops: soybean, mungbean, lentil, cotton, minor fruits and vegetables
- Forestry: agroforestry
- Livestock: improvement and conservation and disease management
- Natural Resources Management (NRM): soil conservation, soil fertility management, water management

Networks have to be formed based on regional relevance, after identifying common regional priority issues. Knowledge, materials, research responsibilities and costs need to be shared - weaker NARS can benefit more through regional collaboration. The catalytic role of International Agricultural Research Centers (IARCs) needs to be understood. The objectives of APARIS are

- Advocacy to promote ICT/ICM in agricultural research for development (ARD)
- Capacity building in weaker NARS
- Integration of national, regional and global information resources

APAARI is sharing knowledge through

- Three ICT/ICM expert consultations for members and National Information Nodal Points (NINP)s, and one training of NINPs from Least Developed Countries (LDCs);
- APAARI homepage and publication dissemination;
- ARD-related databases;
- APAARI on CD (including 20 success stories);
- ARD information gateway and experts database;
- Regional status report on ICT/ICM in ARD; and '
- active participation in regional and international agricultural information networks.

Under the theme of biotechnology, the main issues are ethics, food and environmental safety, economic consideration, intellectual property rights (IPR) and diverse stakeholder

involvement and the following strategies have been followed:

- Asia-Pacific consortium on agricultural biotechnology (APCoAB), an APAARI initiative established in January, 2004
- First steering committee meeting held on 8 April 2004 at Bangkok, Thailand to finalize road map and work plan

APCoAB activities include policy advocacy, research networking, capacity building, and dissemination of information. APCoAB serves as a neutral platform that works as a facilitator with the involvement of all stakeholders, which include public institutions, international centers and organizations, private sector and foundations, NGOs and farmers' organizations. The mission of APCoAB is to help achieve the mission of harnessing the benefits of agricultural biotechnology for the achievement of society in the Asia-Pacific region. The main issues considered here are

- Agricultural productivity and environmental safety
- Ethics and biosafety
- IPR and access
- Capacity building
- Partnership - public and private
- Public awareness

The vision of APCoAB is "to enhance the benefits of biotechnologies for the sustainable agricultural development in the Asia-Pacific region, through greater stakeholder partnerships, improved policy environment, enhanced capacity building and greater public awareness".

The main research functions of APCoAB are

- Services-oriented focal point
- Research prioritization involving all stakeholders
- Facilitating promotion of ag-biotechnologies through partnership initiatives

It plays an advisory role to policy makers on biosafety issues of GMOs and other biotech products, forms policies for the exchange of material and technology, facilitates public awareness, and conducts training programs/awareness campaigns on biosafety, bioethics and related issues, and issues related to IPRs, patenting, and benefit sharing. It provides basic information and links with other Web sites, and disseminates knowledge and information at all levels based on scientific information in a reader friendly way.

APAARI proposed an expert consultation on postharvest technologies for improved food security and enhanced income through value addition at Bangkok on 1-2 December 2004.

The objectives of the current exercise are stated to be

- Identification of clearly defined research gaps
- Identification of necessary partnerships to address the research gaps
- Well-defined work plans and responsibilities
- Resource mobilization within NARS and CG centers
- Ensuring policy support
- Proposals for donor funding

Research Need Assessment and Prioritization of Agricultural Research for Development: India

Mruthyunjaya[1], LM Pandey[2] and AK Jha[2]

1 Introduction

The last four decades have witnessed impressive gains in food production, food security, and reduction in rural poverty in developing countries, thanks largely to the use of modern technology, high-yielding varieties (HYVs), intensive use of irrigation, and fertilizers. However, there has been a skewed distribution of such gains. Low productivity, water scarcity, degradation of natural resources, widespread poverty, globalization and World Trade Organization (WTO) issues are threatening to further marginalize agriculture and the livelihoods of the poor. Since agriculture is the dominant economic activity in these countries, it is vital to enhance productivity, profitability and employment in agriculture for improving the well-being of the poor. In this context, stepping up public investments in agricultural research and technology development assumes critical significance.

Given the limited resources available for public research investments; competing demands including research investment demand; and the need for greater, wider, and quicker impacts; it is essential to prioritize research. APAARI, after developing broader research priorities for member countries in the Asia-Pacific region, felt that a critical gap analysis is needed for a clear and comprehensive assessment of research needs that require attention on a priority basis. In earlier studies, APAARI had prioritized broad research themes covering soil and water management, commercialization and diversification of production systems, market integration, livestock (including health and nutrition), mapping of poverty, and sustainable seed and technology systems. However, it was felt that subsequently local priorities under these broad research themes need to be identified, based on research need assessment studies in the member countries of the region and also according to the needs and goals of the research system. These should be given focused attention by national agricultural research systems (NARS), international agricultural research centers (IARCs), and nongovernmental organizations (NGOs). Such need assessment and gap analysis studies have to be bottom-up group exercises involving farmers, NGOs, farmer organizations, research, extension, development workers, etc. The present study on India (limited to

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28 of 602 districts) has been designed by following these broad directions. The objectives of the study are to:

- provide a scenario analysis of agriculture in India vis-a-vis the rest of the globe,
- highlight the significance of agri-cultural research for development, particularly in the context of emerging challenges,
- identify research needs at micro-level,
- attempt research gap analysis-research needs vs. current research efforts,
- prioritize the research gaps, and
- suggest strategies to bridge the prioritized research gaps through involvement of research institutions, extension agencies, and development departments.

2 Agriculture in India: Scenario analysis

World

The global scenario has changed substantially in the past few decades. World population is projected to be about 11 billion by 2050. It is projected that the food grain production has to increase by 185% to meet the needs of the population, and this will have to come through a 100% productivity increase and 85% increase in area. However, high volatility in world commodity prices, restricted movement of genetic materials (including knowledge on account of the emerging IPR regime), strict food quality standards, and fall in investment in CGIAR institutions are some of the hard realities to be faced that will create obstacles to achieving these goals. It is predicted that hundreds of millions will remain food insecure and millions of children will die of malnutrition if environmental degradation goes unchecked. Globally, productivity losses due to soil erosion, nutrient depletion, and salinization are 0.1-0.2% per year. By 2025, almost two-thirds of the world population will live in water-scarce regions in developing countries. Owing to climatic changes, heat waves, heavy precipitation events, floods and droughts are projected to increase. Today only about 15 plant species and 8 animal species supply 90% of our food. Heavy biodiversity loss is predicted.

South Asia

The South Asian countries comprising Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka, although they have similar sociopolitical institutions and economic, agricultural, and governance systems, differ considerably in terms of their population size, geographical area, and economy. They are all classified as low-income countries. All these countries, although they have improved their economic performance in the 1990s, are facing the problems of unchecked population growth, higher percentage of population below the poverty line (particularly in rural areas), and the fact that a significant proportion of women and children are malnourished (Mruthyunjaya et. al. 2003). Despite all these odds, these countries have made tremendous progress in terms of achieving self-sufficiency in food grain production. Another notable achievement has been the increase in milk production, which has increased more than three

times during the last 3 decades. Notwithstanding these achievements crop yields are still low in the region, productivity of agricultural workers is also very low, fertilizer consumption is moderate, level of mechanization is low, there is limited area under irrigation without any further scope of expansion, and per capita availability of land is declining. Furthermore, all these countries are facing the problems of declining farm size, creation of limited or no additional employment opportunities in agriculture, natural resource degradation, and management and new challenges from the global developments in trade. Institutional and policy responses to address these issues have also been either inadequate or almost ineffective. Research intensity is very low in these countries (except India) with expenditure of less than 0.3% of the AgGDP on agricultural research and education (Mruthyunjaya et. al. 2003). Since agriculture is the dominant activity, agricultural development holds the key to overall economic development and prosperity in these countries. Agricultural research should play a central and pivotal role in this task.

India

India, by virtue of its size and relatively advanced development, holds a key position among the South Asian countries. Agriculture has been and will continue to be the lifeline of the Indian economy. The country is not only self-sufficient in food, but also commands a strong position in world markets for some commodities. This has been possible through the uptake of modern technology combined with supportive policies and the hard work of Indian farmers. As the largest private enterprise (single largest industry) in India (>10 crore farm holdings), agriculture contributes nearly one-fourth of the national gross domestic product (GDP), sustains the livelihood of about two-thirds of the population, contributes about 13% of total national exports, and is a major supporter of agro-based industry. Agriculture is also a social sector where critical concerns like food and nutritional security, employment and income generation, and alleviation of poverty are addressed. The agriculture sector acts as a bulwark in maintaining food security and in the process, national security as well. The allied sectors are horticulture, animal husbandry, dairy, and fisheries, and in the context of emphasis on diversification, they are important in improving the overall economic conditions and health and nutrition of the rural masses. Besides, the rural areas are the biggest markets for a variety of consumer goods, including consumer durables.

No doubt, the direct effect of agriculture on GDP has fallen from around 50% during the 1940s to 24% during 2003. But in the future, as average agricultural incomes increase, the indirect effects of agricultural income on nonagricultural growth, particularly the industry and service sectors, will become progressively stronger as the bulk of the incremental income in rural areas will be spent on nonagricultural goods and services and not on food. One of the major concerns, however, is that the proportion of people dependent on agriculture has not come down along with fall in its share in GDP.

Small farms dominate Indian agrarian structure. During 2000-01, nearly 81% of the farms were small farms (<2ha) and this is projected to be 83% in 2010-11. India has about 16% of the world's population as against 4.2% of the world's water resources and 2% of the world's geographic area. It has about 108 million ha degraded land. Postharvest losses are enormous (estimated to be 25%) and only 2% of the agro-produce is estimated to be processed. The value addition is only 7%. There has been continuous decline in public investment in agriculture from 1995-96; decreasing from 1.6% of GDP in 1993-94 to 1.3% in 2000-01.

During the 1990s (1989-90 to 1999-2000), the growth rate of crop production declined from 3.72% per annum to 1.21% per annum. In the same period, the growth rate of food grain production declined to 1.92% per annum from 3.54% per annum. Similarly the growth rate of productivity in food grains decelerated to 1.32% as compared to 3.33% per annum. Furthermore, during the years 2000-01 to 2003-04, wide fluctuations in annual agricultural GDP growth rate has been observed. For example, it was negative during 2000-01 (-0.1%) and 2002-03 (-18.18%) whereas it was positive during 2001-02 (8.18%) and 2003-04 (21.01%). The period of bad monsoons, thought to be a thing of the past, appears to be reemerging. Furthermore, studies have indicated widening of regional and socioeconomic class disparities. Agricultural development has been unable to address this issue. Thus, the challenge for Indian agriculture is not only raising productivity and profitability, reducing instability and increasing resource use efficiency, improving equity, and improving quality, but also in meeting demands for increasing agricultural commercialization and diversification. Furthermore, on account of increasing stress and uncertainty owing to the world trade regime under WTO including IPR and SPS (sanitary and phytosanitary measures) issues, Indian agriculture is under tremendous pressure. All-round depressed prices, combined with successive droughts and floods, inadequate and ineffective extension, credit and other service and support systems have shattered Indian farmers, particularly in the last 4-5 years. The National Agricultural Policy (NAP 2000) envisages a growth rate of 4% per annum in agriculture in the next few years. This growth rate, never realized earlier, demands considerable scientific and technological input. It is generally held that agricultural research, institutions and policies are the drivers of change. The Indian agriculture research system as well as its policies must respond to these complex national and global problems. Replicating past achievements in today's changed and more complex environment will require increase in the effectiveness of the public expenditure in the research and extension system. Doing business as usual will not be appropriate for attaining such a goal. Enhancing productivity, resource use efficiency, using cutting edge science, creating state-of-the art experimental facilities, and above all producing and maintaining a stock of first-rate human resources to service knowledge-intensive agriculture has become critically important.

3 Agricultural research for development

Advances in agricultural science and technology have played a critical role in alleviating hunger and rural poverty in India, like elsewhere in the world. Agricultural practices of today came about through increased scientific and technological knowledge that led to mechanization, improvements in cultivars and management practices, and improved plant nutrient and crop protection technologies. These practices resulted in both increased food supplies and higher incomes. For example, with the introduction of HYVs of rice, wheat and other staple cereals, yields begin to rise; they increased even more as fertilizer use along with irrigation became common, beginning with the Green Revolution in the mid-1960s. The impact on productivity of these practices has been enormous. In 1968, there were just 2 rice-growing districts in the country accounting for 10% of the rice area and producing more than 2 mt ha^{-1}. But in 2002, 44% of the rice-growing districts (of a total of 103 districts) were realizing yields more than 2 mt ha^{-1}. The Green Revolution followed by white, yellow, blue and other revolutions have significantly raised productivity and income, reduced prices, and enhanced nutrition of the farmers (Acharya and Chaudhari 2001). The incidence of rural poverty substantially declined as agricultural growth and the purchasing power of the rural households rose. Such a growth in food production and agricultural growth in India has been driven by significant public agricultural research expenditures by successive governments.

Overall public research funding for agriculture in India grew at 3.16% in the 1970s, 7.03% in the 1980s, and slowed to 4.61% in the 1990s. Closely following this trend, agricultural research expenditure as a share of AgGDP increased significantly during the 1960s and 1980s, but remained around 0.3% during the 1990s. Thus, there appears to be a clear case of under-investment. China, a country of comparable size and stage of development, spends 0.43% of AgGDP on research (Pal and Byerlee 2003).

Although India has one of the largest research systems in the world, the public sector still under invests relative to other developing countries. In the late 1990s, India invested 0.31% of agricultural GDP in research; if not as much as China at 0.43%, significantly lower than the average for all developing countries of 0.62% (Pardey and Beintema 2001). Industrialized countries spent a much higher figure - 2.64% of agricultural GDP - on agricultural research, reflecting their relatively higher tax base, smaller agricultural sector in relation to the economy, and often politically powerful farm lobby groups.

However, India appears to be catching up with the rest of the world in terms of growth rate of overall spending on agricultural research. Over the period 1986-95 the growth rate of spending was higher at 5% than for all developing countries, and comparable with the rest of Asia, which had a relatively high growth rate. One notable feature of spending for agricultural research in India is that growth rate has accelerated through the 1990s, in contrast to a worldwide slowdown and even decline in some countries. If India can continue

this trend, research intensity in the country could reach the average for all developing countries in the next few years (Pal and Byerlee 2003).

The NARS in India has evolved over the years and now comprises 189 institutes/projects under the Indian Council of Agricultural Research (ICAR), 100 private and voluntary organizations (VOs), 34 agricultural universities, farmers organizations, 23 general universities having agricultural faculties, related scientific organizations/ departments, and more than 105 scientific societies involved in agricultural research. The total number of scientists in the Indian NARS exceeds 25,000 (ICAR/DARE 2000).

Many studies have empirically shown impressive performance of the system with annual rates of return to investment in research ranging from 35% to 155% (Evenson et al. 1999). Notwithstanding these achievements, the NARS is having to deal with the following issues and problems (Mruthyunjaya 2000):

1. Increasing household food and nutritional security and reducing poverty
2. Complex and demanding research agenda of sustaining natural resources, enhancing product quality, and ensuring food safety
3. Development of knowledge- and skill-intensive agriculture
4. Lowered agricultural research intensity
5. Organization & Management (O&M) system sickness and second generation issues in institutional development
6. The realization that the agricultural research system needs to be reoriented in the changed context is not shared by all
7. Facilitating and enabling rules, procedures, incentives and rewards, autonomy, flexibility, human resource and O&M support

The NARS have profoundly changed in the developed countries during the last 25 years. In the majority of the developed countries, the changing role of the government, public administration reform, and the shifts in agricultural policies have induced institutional changes in the NARS. The most important changes that have taken place are:

1. The mandate has moved away from the traditional productivity focus towards issues of wider social interest such as the environment, animal welfare, and food safety.
2. Increased emphasis has been given to client orientation, and demand-driven and decentralized planning of agricultural research.
3. Emphasis is given to improved efficiency through consolidation, separation of agricultural research policy formulation and execution, and use of more private sector-like management principles.
4. Public funding of agricultural research has become more competitive.

A comparison of organization of NARS in developing countries and developed countries (Paroda and Mruthyunjaya 1998) showed that NARS in the former are in the process of transformation whereas NARS in developed countries are more independent, autonomous, effective, and efficient.

Recognizing the importance of such changes elsewhere, ICAR has also emphasized O&M reforms, particularly during the National Agricultural Technology Project (NATP) period (1998-2004) by stressing on competitive grant programs, greater focus on applied production research system research, and targeting research institutes to mobilize greater financial resources through commercialization. However, it is strongly realized that India should also move towards a market-oriented economy with focus on high-technology fields such as biotechnology and information and communication technology (ICT), besides stress on food and nutritional security. Thus, a further round of reforms aimed at changing the NARS into an internationally competitive, state-of-the-art, merit based, "quality oriented" organization with the core goals of (i) increasing the research output and the adoption of that output, (ii) upgrading research staff competence and provision of increased resources, and (iii) focus on breakthroughs in cutting-edge areas like biotechnology are necessary and being focused on in the proposal for the next phase of NATP.

It is also strongly felt that these issues have to be resolved and ICAR, being the premier apex body, should take the lead in addressing these problems jointly with other partners of NARS, regional organizations like APAARI and IARCs at the earliest.

4 Emerging challenges in agricultural research

By 2020, India's population is likely to be around 1.3 billion, and its contribution to overall employment is not likely to increase significantly. With opportunities for area expansion being almost exhausted, the required additional food output of 4 to 5 million mt annum^{-1} will have to come primarily through increased productivity. The challenge to increase productivity growth is more acute now than ever before, as all favorable factors have been exhausted. For instance, by the year 2020, to meet the projected demand, the productivity must increase to the level of 2.9 mt ha^{-1} for rice, 3.92 mt ha^{-1} for wheat, 1.33 mt ha^{-1} for coarse grains, 1.2 mt ha^{-1} for pulses, 28.4 mt ha^{-1} for vegetables and 24.1 mt ha^{-1} for fruits. In other words, the average yields at national level are required to be increased by 56% for rice, 62% for wheat, 36% coarse cereals, 116% for pulses, 104% for vegetables, and 134% for fruits by 2020. The production of livestock and poultry products must be improved by 136-157% by the year 2020 (Paroda and Kumar 2002).

Such a trajectory of high growth rates has to be achieved while keeping sight of environmental impacts as immense biotic pressure is already felt on India's natural resources. In the Green Revolution belt, intensive agriculture is now seen as a major cause of the problems of soil salinization, groundwater pollution, nutrient imbalances, and environmental degradation. In the fragile and marginal environments including vast rainfed areas, rising biotic pressure and the lack of soil management systems and inputs to realize the optimum potential of land threaten the sustainability of agriculture. The consequence of these is degraded lands, loss of biodiversity, soil erosion, waterlogging, pollution of water resources, deforestation, and overall

environmental pollution and diminishing farming efficiency resulting in falling productivity. Changing consumption and demand patterns and new market and trade opportunities have provided impetus to greater diversification of farming systems with emphasis on horticulture; animal husbandry; milk; poultry; fisheries; nonfood crops like fibre mushroom, spices, and condiments; medicinal and aromatic plants; and agroforestry. In the context of diversified agriculture, value addition postharvest technology, agri-business, credit, market, food safety, and quality assurance and customized policy support assume critical significance (Kumar and Mruthyunjaya 2003). Similarly, (lack of) availability of energy will become a crucial factor in the future. More research and development on power and energy has to be emphasized. Research on alternate bio-energy resources such as bio-diesel, alcohol, fuel cell technology, and gasification of biomass should receive serious attention.

Knowledge becomes central to advancing in agriculture, but increasing difficulties are seen in free flow of knowledge in the future on account of the emerging IPR regime. Therefore, human resources development (HRD) programs to plan and train more manpower in frontier areas and re-orient education to develop entrepreneurship should receive priority attention. Similarly, innovations in technology dissemination should receive attention, as the public extension system is largely inadequate and ineffective. The main challenges before the agricultural research system are water crisis, soil degradation and fatigue, genetic erosion, increasing biotic and abiotic pressure, slow pace of diversification, high postharvest losses, inefficient energy management, inadequate markets and unfavorable trade, increasing knowledge lag, and non-customized policy support.

5 Research needs: Evidence from micro-studies

In the backdrop of the agricultural scenario at the global, South Asian and country levels, addressing the specific challenges stated above through agricultural research requires identification of research needs at the farmer's level. Such research needs were assessed during the implementation of a mega World Bank supported project (NATP) at micro-level in 28 districts of 7 states of India while preparing strategic research and extension plans (SREP). It may be of interest to see how this model was conceived and executed for further action. The location of the selected districts in different major agroecosystems as classified under NATP is provided in Fig. 1.

SREP methodology

Selection and training of extension personnel

A number of multidisciplinary teams of extension personnel were identified from government departments like Agriculture, Horticulture, Soil Conservation, Animal Husbandry, Fishery, etc, and also from Agricultural Universities, NGOs, and Krishi Vigyan Kendra (KVK) for preparing SREP. These identified officers were trained by National Institute of Agricultural Extension Management

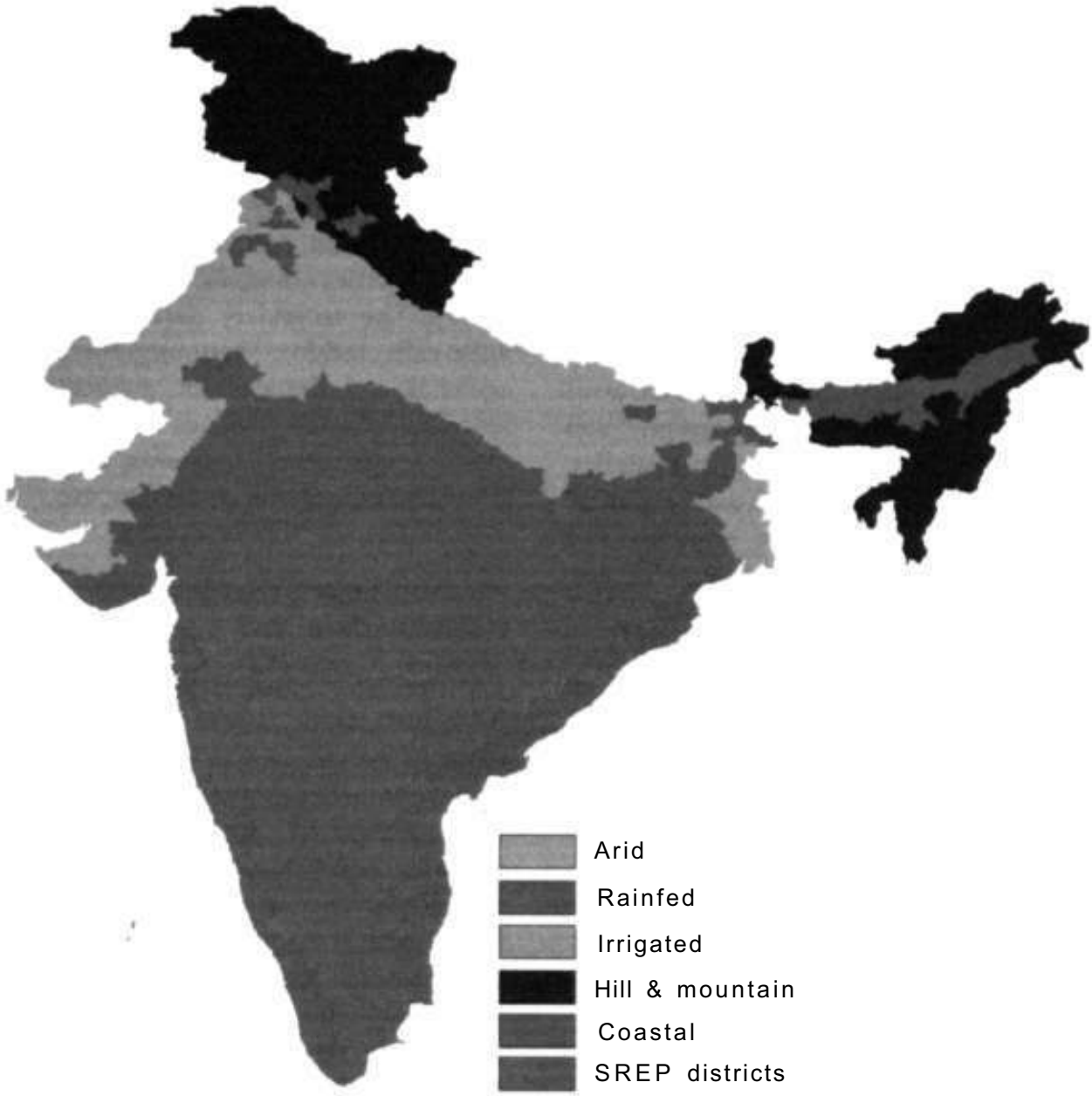

Figure 1. SREP districts under different agroecosystems in India.

(MANAGE) experts for collection of information and the preparation of SREP.

Identification of states, districts and major agroecological situations

The Department of Agriculture, Ministry of Agriculture, Govt. of India decided to select seven states based on the broader considerations of variations in states with respect to agroecologies as well as development perspectives. For instance, the agroecologies like irrigated as well as developed state (Punjab), hill and mountain (HP), coastal (east), irrigated and rainfed (AP), arid, irrigated, horticulturally important and coastal (west) (Maharashtra), potential

for development but not visible (Bihar & Orissa), and tribal farming (Jharkhand) were considered.

The selection of the districts within the state was left to the respective state governments. The states selected the districts on the basis of availability of institutional facilities as well as local agroecological and crop/ enterprise variations.

The secondary data on district level information on rainfall topography, soil type, etc. were gathered from various line departments, publications, and periodical reports of Government agencies and used for identifying the agroclimatic zone of the district. Each district was further divided into agroecological situations (AES) using information on rainfall, topography, soil type, etc. Such situations varied from 2-6 in each district. As can be seen in Table 1, there are 25 agroclimatic zones represented by these 28 districts. The details of AES under each selected district/ agroclimatic zone are given in Table 2.

Field survey and techniques used for participatory rural appraisal

For collection of data at grassroots level, representative villages were identified from each AES, which represents the agroclimatic zone of the whole district. A multidisciplinary team was formed from trained personnel for each representative village. The team visited representative villages and collected primary data with the help of participatory rural appraisal (PRA).

The tools and techniques used for PRA included social mapping, resource mapping, transact walk, matrix ranking, seasonality, trend analysis, Venn diagrams, and wealth ranking.

The field visits were used to understand field problems, and social and economical backgrounds of the villagers and villages. The components of the farm women, landless women, and women engaged in other activities were also covered in the survey. The secondary data on villages were collected from various government agencies and department publications, revenue officials, village department officers, agricultural assistants, teachers, gram sevaks, anganwadi sevikas, etc.

Verification and analysis of collected data

The primary data collected during field visits were checked with various farmers' groups in the village and also through verified information available from published sources and from different departments. The farmers from representative villages and consultants from State Agricultural Extension Management and Training Institute (SAMETI) and MANAGE were also involved in the review and verification of data. The technological gaps were identified in each AES for different crops grown and enterprises taken on the basis of perception, experience, and wisdom and discussed with farmers for reasons and solutions, both local and external.

Finalization of SREP

A one-day district level workshop was organized, in which findings of the field experiences were discussed and shared with farmers from representative villages, district level officers, scientists

Table 1. Details of selected districts.

S.No.	State	District	Agroclimatic zones	Major crops
1	Himachal Pradesh	Kangra	Submountain & low hills subtropical, mid-hill subhumid, high hill wet subtemperate (AES 6)	Wheat, mung, paddy, ragi
		Hamirpur	Submountain low hill (AES 4)	Wheat, maize, paddy
		Shimla	Subhumid hill to temperate (AES 5)	Wheat, maize, paddy, millets, pulses
		Bilaspur	Submountain low hill-subtropical (AES 4)	Wheat, maize, vegetables, paddy
2	Punjab	Gurdaspur	Hilly-semi hilly-undulating-central plain (AES 5)	Wheat, paddy, maize
		Faridkot	Southwestern region (AES 3)	Wheat, paddy, cotton, pulses
		Sangrur	Central-western plain (AES 4)	Wheat, paddy, maize
		Jalandhar	Central-undulating plain (AES 2)	Paddy, wheat, pulses, maize
3	Bihar	Munger	South Bihar alluvial plain (AES 4)	Wheat, paddy, maize
		Patna	South Bihar alluvial plain (AES 4)	Wheat, paddy, maize
		Muzaffarpur	Northwest alluvial plain (AES 5)	Paddy, wheat, pulses, oilseeds
		Madhubani	Northwest alluvial plain (AES 5)	Paddy, wheat, pulses
4	Jharkhand	W.Singhbhum	Southeastern plateau (AES 3)	Paddy, maize
		Dumka	Central & northeastern plateau (AES 4)	Paddy, maize, pulses
		Jamtara	Eastern plateau & hills (AES 4)	Paddy, maize, pigeonpea
		Palamau	Western plateau (AES 5)	Paddy, maize, wheat
5	Orissa	Ganjam	East & southeastern coastal plain & northeastern ghat (AES 8)	Paddy, mung, ragi
		Koraput	Eastern ghat highland-Southeastern ghat (AES 7)	Paddy, small millets, maize, oilseeds, pulses
		Khurda	Southeastern coastal plain (AES 6)	Paddy, pulses, groundnut
		Sambalpur	High rainfall-rainfed	Paddy, pulses, oilseeds
6	Andhra Pradesh	Prakasam	High-moderate-scanty rainfall (AES 6)	Paddy, pigeonpea, tobacco, cotton
		Kurnool	Scarce-rainfall zone (AES 4)	Groundnut, sunflower, cotton, paddy
		Adilabad	North Telangana (AES 6)	Jowar, cotton, paddy
		Chittoor	Southern zone (AES 5)	Groundnut, paddy, sugarcane
7	Maharashtra	Amravati	Assured to high rainfall zone (AES 5)	Cotton, jowar, wheat, pulses
		Ratnagiri	Very high rainfall zone (AES 6)	Paddy, pulses, groundnut
		Ahmadnagar	Ghat hilly-plain transition-scarcity (AES 3)	Jowar, bajra, pulses
		Aurangabad	Assured-scarce rainfall zone (AES 5)	Jowar, cotton, pulses, oilseeds

Numbers in parentheses indicate number of agroecological situations defined within the districts

Table 2. Agroecological situations of SREP districts.

S.No.	State	District and agroclimatic zones	Agroecological situations within the districts
1	Andhra Pradesh	Chittoor (Southern zone)	1. Red sandy loam 2. Red soil irrigated dry - northeast monsoon influenced 3. Red soil - southwest monsoon influenced 4. Clay loam 5. Red sandy loam irrigated
2	Andhra Pradesh	Kurnool (Scarce rainfall zone)	1. Noncommand, high/normal rainfall, black soils 2. Noncommand, high/normal, rainfall, red soils 3. Noncommand, low rainfall, black soils 4. Noncommand, low rainfall, red soils
3	Andhra Pradesh	Prakasam (High-moderate-scanty rainfall)	1. Medium to deep black soils with canal irrigation NSP & KWD 2. Medium to deep black soils under tankfed and lift irritations 3. Medium to deep black soils under rainfed conditions 4. Red sandy soils under canals, wells and tankfed irrigation 5. Red sandy soils under rainfed conditions 6. Coastal sandy loams with irrigated and rainfed conditions
4	Andhra Pradesh	Adilabad (North Telangana)	1. Black cotton soils-rainfed-high rainfall 2. Black cotton soils medium rainfall 3. Red soils-rainfed-medium rainfall 4. Irrigated tanks 5. Irrigated canals 6. Life irrigation-wells/borewells
5	Bihar	Muzaffarpur (Northwest alluvial plain)	1. Upland rainfed saline 2. Upland irrigated 3. Upland rainfed 4. Midland irrigated 5. Low land-chaur/monn
6	Bihar	Munger (South Bihar alluvial plain)	1. Diara 2.Tal 3. Plain 4. Hilly

Continued

Table 2. *Continued.*

S.No.	State	District and agroclimatic zones	Agroecological situations within the districts
7	Bihar	Madhubani (Northwest alluvial plain)	1. Eastern flashflood affected kamala-kosi zone 2. Middle south plain zone 3. Middle north undulated zone 4. Western waterlogging zone
8	Bihar	Patna (South Bihar alluvial zone)	1. Tal (Waterlogging, heavy-textured soil) 2. Diara (undulated light textured land) 3. Jalla (peculiar situations, water stagnation problem) 4. Irrigated plain (well-irrigated plain land) 5. Rainfed plain (nonirrigated plain land)
9	Himachal Pradesh	Hamirpur (Submountain low hill)	1. High altitude gravelly sandy clay loam 2. Medium altitude sandy clay loam 3. Medium altitude gravelly sandy clay loam 4. Low altitude sandy loam
10	Himachal Pradesh	Shimla (Subhumid hill to temperature)	1. High hill (H1) 2. Mtd hill-1 (M1) 3. Mid hill-2 (M2) 4. Mid hill-3 (M3) 5. Low hill-1 (L1)
11	Himachal Pradesh	Bilaspur (Submountain low hill-subtropical)	1: Govind Sagar's basin soil areas 2. Valley areas 3. Changer areas 4. Mid-hill areas
12	Himachal Pradesh	Kangra (Submountain & low hills subtropical, mid- hill subhumid, high hill wet sub-temperate)	1. Rainfed moderately plain zone 2. Riverbed, high temperature, low rainfall areas 3. Rainfed, subtropical changer area 4. Moderate rainfall, irrigated area 5. High rainfall, acidic soils, hailstorm-prone area 6. Grassland, meadow and other areas
13	Jhar-khand	Palamau (Western plateau)	1. Upland rainfed light soil 2. Upland rainfed heavy soil 3. Medium rainfed light and heavy soil 4. Irrigated medium heavy soil 5. Sot (low land) rainfed gray yellowish heavy soil

Continued

Table 2. *Continued.*

S.No.	State	District and agroclimatic zones	Agroecological situations within the districts
14	Jharkhand	Jamtara (Eastern plateau & hills)	1. Upland (tar)-eroded soil-rainfed 2. Medium land-sandy loam-rainfed 3. Medium land-sandy loam-tank irrigated 4. Lowland-alluvial soil-rainfed
15	Jharkhand	West Singhbhum (Southeastern plateau)	1. Kolhan Porahat upper plateau rainfed moderately high & forestry based 2. Kolhan lower plateau rainfed moderately high & forestry based 3. Kolhan comparatively plain and rainfed
16	Jharkhand	Dumka (Central & north-eastern plateau)	1. Upland rainfed 2. Midland rainfed 3. Midland irrigated 4. Lowland irrigated
17	Maharashtra	Amravati (Assured to high rainfall zone)	1. Hilly marginal land, heavy rainfall and high altitude 2. Medium to deep soil and assured rainfall 3. Shallow to medium soil, assured rainfall and plain topography 4. Plain area deep soil and assured rainfall 5. Plain area, shallow to medium soil, assured rainfall and command irrigation
18	Maharashtra	Ratnagiri (Very high rainfall zone)	1. North coastal 2. South coastal 3. North plateau 4. South plateau 5. North hilly 6. South hilly
19	Maharashtra	Aurangabad (Assured-scarce rainfall zone)	1. Low rainfall, light to medium soils 2. Low rainfall medium to heavy soils, non-CADA area 3. Assured rainfall medium to heavy soils 4. Assured rainfall hilly terrain 5. Command area heavy soils

Continued

Table 2. *Continued.*

S.No.	State	District and agroclimatic zones	Agroecological situations within the districts
20	Maha-rashtra	Ahmadnagar (Assured-scarce rainfall zone)	1. Command area with unassured irrigation and medium soils 2. Command area with assured irrigation and medium soils 3. Command area with assured irrigation and light soils 4. Noncommand hilly zone with shallow soils 5. Noncommand transition zone with medium to shallow soils and well and lift irrigation 6. Noncommand area with medium soils and well irrigation 7. Noncommand with medium soils and rainfed 8. Noncommand area with shallow soils and rainfed
21	Orissa	Ganjam (East & southeast-ern coastal plain & northeastern ghat)	1. Coastal alluvial noncommand 2. Coastal alluvial noncommand 3. Coastal alluvial saline 4. Rainfed laterite 5. Rainfed red and laterite 6. Block, medium rainfall and irrigated 7. Alluvial low rainfall and irrigated 8. Laterite, moderate rainfall and irrigated
22	Orissa	Koraput (Eastern ghat high-land-southeastern ghat)	1. High elevation, high rainfall & noncommand 2. High elevation, medium rainfall & noncommand 3. High elevation, low rainfall & noncommand 4. Medium elevation, medium rainfall, & noncommand 5. Low elevation, medium rainfall, command 6. High elevation, medium rainfall, command 7. High elevation, medium rainfall, & noncommand
23	Orissa	Khurda (Southeastern coastal plain)	1. Noncommand laterite 2. Coastal alluvial noncommand 3. Coastal alluvial saline noncommand 4. Black alluvial noncommand 5. Coastal alluvial command 6. Black alluvial command

Continued

Table 2. *Continued.*

S.No.	State	District and agroclimatic zones	Agroecological situations within the districts
24	Orissa	Sambalpur (High rainfall-rainfed)	1. High rainfall laterite soil noncommand 2. Tableland canal irrigated 3. Tableland rainfed 4. Undulating submountainous tract rainfed 5. Plateau rainfed
25	Punjab	Gurdaspur (Hilly-semi hilly-undulating-central plain)	1. Undulating rainfall with loamy sand soil 2. Tube well irrigated with clay loam soil 3. Tube well irrigated with alkaline soil 4. Tube well irrigated with loamy soil 5. Canal irrigated with sandy loam soil
26	Punjab	Faridkot (Southwestern region)	1. Faridkot Hathar-sadiq-sandy plain 2. Faridkot: Uttar-dhudhi-sandy loamy 3. Jaitu area: sandy loam to loam
27	Punjab	Jalandhar (Central-undulating plain)	1. Central plan region I 2. Central plan region II
28	Punjab	Sangrur (Central-western plain)	1. Plain topography, tube well and canal irrigation, sandy loam soil with saline sodic in nature 2. Plain topography, tube well irrigated supplemented by canal water, sandy soil 3. Plain topography, tube well and canal irrigation, sandy loam soil with sodicity 4. Plain topography, tube well and canal irrigated, flood-prone area, sandy loam soil with saline sodic in nature

from SAUs, KVKs, NGOs, etc. and observers from SAMETI and MANAGE to obtain their feedback for suitable improvements in research and extension gaps and SREP.

6 Gap analysis

The major agroclimatic zones and crops of the pilot districts are provided in Table 1. The research needs and gaps by agroecologies are displayed in Table 3 (Annexure I). It can be seen from Table 1 that wheat, maize and paddy are the three major crops in the selected districts of HP, Punjab and Bihar. Besides paddy, pulses, oilseeds, and cotton are the major crops in the selected districts in Orissa and Andhra Pradesh whereas in Maharastra, jowar is also an important crop besides cotton and pulses. However, there were other enterprises that were

taken up by the farmers in different AES of the selected districts. It may be noted that districts in arid agroecosystems were not selected under the SREP project and therefore, this exercise does not provide insights on this important ecology, which forms around 8% of the net cultivated area of India (Saxena et. al. 2001). This is one of the limitations of this study. .

In Table 3 (Annexure I), the research needs are provided along with the gaps. It may be noted that, as desired, research needs have been identified and stated in a focused manner for immediate action. The gap analysis is attempted by looking into the research portfolio of one of the largest recent projects in India, the World Bank-funded NATP. All the state research institutions including private institutions participated in this project under different modes of research. It was envisaged that the research needs felt by farmers was explored during this project and therefore, a comparison of research needs with the research portfolio of this project should provide a broad picture of the gaps that exist at the moment. The most ideal way would have been to look at the research portfolio of all the research institutions in the country (relevant districts) to see whether the gaps find place in their projects, but this was not possible for lack of time. However, it is strongly felt that comparison with NATP is least objectionable as it provides not only information about gaps but also an opportunity to address these gaps in future, particularly in the next phase of NATP.

Nine themes have been identified for the purpose of research prioritization, and major gaps exist in genetic improvement, NRM, IPM, and integrated pest and nutrient management (IPNM). It may be recalled that in the earlier study of broad priorities, six themes were identified, namely soil and water management, commercialization and diversification of production systems, market integration, livestock, mapping of poverty, and sustainable seeds and technology systems. The identified gaps, if classified under this scheme, mostly fall under the themes of sustainable seeds and technology systems, livestock, and commercialization and diversification of production systems, in that order. As regards different ecologies, research gaps are largest in hill and mountain and irrigated agroecology followed by coastal and rainfed agroecologies. Although NATP is a project of great opportunities for bridging the research gaps, the analysis indicates that many gaps still exist at least from the point of view of needs at the farmer level. It may be inferred from this that the process and mechanism of reflection of research needs in the research agenda are still not perfect and require improvement. Perhaps, as it generally happens, the selection of the research projects under NATP was more through scientists' perception/wisdom than farmers' felt needs.

7 Bridging the gap

The gaps identified can be bridged through participation of research institutions, extension agencies, and development departments. As can be seen through the success stories in NATP under Innovations in Technology Dissemination (ITD) component, the Agricultural Technology Management Agency (ATMA) model exemplifies a

workable but participatory mechanism for continuous effort in bridging the gap. It may be noted that after identification of gaps, a research and extension strategy involving all the concerned agencies was finalized to bridge the gaps. The research strategy included re-synthesis of the technological package as per farming situation, strengthening of on-farm research and strengthening of on-station research. Similarly, the extension strategy involved improving the productivity and income of the existing enterprises and commodities, diversification and intensification of existing farming systems, improving sustainability in production and income, improving the financial sustainability, strengthening of farmer organizations, strengthening of marketing infrastructure, and strengthening of private institutions for extension. For each one of these strategies, different crops/ commodities/tasks, suitable unit size, unit cost, number of units, and total cost were identified, and the agency implementing the strategy on a pilot scale was defined and directed to implement the task. As regards research strategies, it was impressed on research institutions (SAUs and ICAR institutions) that they should address long-term issues utilizing their own funds. In respect of short-term issues like on-farm field trials, limited financial support was extended to KVKs by ATMA.

Although SREPs were prepared well with all details and involvement of all the concerned people, many practical difficulties were experienced while implementing them. Some of these difficulties arose on account of not fixing the relevant targets (like area to be covered) for tasks to be performed; alternative options were not explored and assessed while deciding on activities; production constraints/ gaps were mostly identified and addressed while ignoring processing, marketing etc; only linkage between research and extension agencies was visualized but not the broad spectrum of issues and agencies involved in rural development; etc. These limitations must be overcome in the next phase for effective functioning. This requires improved coordination, understanding, and functional mode of action of all concerned. Fully realizing the potential of the ATMA model for decentralized agricultural planning, the Government of India proposes to implement the model in 250 districts of India during the 10th Five Year Plan (2002-07).

8 Implication on agricultural research priorities

The research gaps identified need to be systematically prioritized using the methodology of constraint analysis, which involves estimation of yield loss and value loss considering target domain, intensity, and frequency of occurrence of the problem - constraints are prioritized in accordance with the value loss. For want of time, this was not done in this exercise. In the instant exercise, relating to 28 districts, the ATMAs have to analyze economic significance of the identified gaps using standard tools. Depending on the resource availability and the mandate of the consortium institutions, the research gaps must be addressed by the research institutions, extension gaps

by extension agencies, and development gaps by development agencies. In this paper, we have highlighted only the research gaps. It may be noted that in the project, extension and development gaps were also studied and suggestions made for redressal.

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Research Need Assessment and Prioritization of Agricultural Research for Development: Sri Lanka

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1 Sri Lanka's agricultural sector

The fundamental challenges facing agricultural development in Sri Lanka are first to increase domestic food production in a sustainable manner to feed the gradually increasing population, and second, to increase the volume of exports of both traditional as well as the nontraditional commodities, to increase foreign exchange earnings. The present population is 19.25 million, which is expected to increase by an additional 5 million in the next 30 years, and food production has to be geared to meet the consequent increase in demand. To achieve the required level of production, the domestic agricultural sector has to be revitalized. As expansion of land area is limited, the only way to achieve this is by intensification of current agricultural production through use of modern technologies. Agricultural intensification must undergo a paradigm shift from current practices to orient the production-utilization chain to meet the new challenges. This will require development of new technologies that are applicable under local conditions.

At the same time, we should not ignore our continuous commitment to less glamorous but essential programs such as reducing postharvest losses, focusing on renewable energy, agrarian reforms, and empowering small-scale producers and rural women in agriculture. Hence, both the public and private sectors need to play an active role focusing on agricultural research and technology development. This is a formidable challenge and requires appropriate policy and program interventions to mobilize human, physical and financial resources.

The share of agriculture in GDP was 19.5% in 2002 and 15.5% in 2003. Direct employed population in agriculture, livestock and fisheries was 35%, while those dependent on the agricultural services sector expands the figure to 70% in 2003. There has been a shift of agricultural labor to industry due to low profitability of agriculture as well as diversification of the national economy. This sector has shown poor growth due to a number of factors such as the open economic policies that have permitted uncontrolled import of consumer goods after trade liberalization.

Agriculture has been the dominant sector and mainstay of the economy since 1948. It consists mainly of rice and other field crops, vegetables and fruit crops; agricultural crops for export; forestry; plantation crops (mainly tea, rubber, coconut and spices); fisheries;

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and livestock; and the newly emerging floriculture, environment-controlled agriculture, and organic agriculture.

The area under rice cultivation has declined over the last two decades due to urbanization; lack of labor, irrigation water, and incentives for cultivation; and marketing of high value product diversification. The current area under paddy is about 820,000 ha, of which only half is cultivated in the *yala* (dry) season due to lack of water for irrigation. Abandoned paddy lands are a common feature in rural areas. Approximately 32,200 ha of paddy lands were abandoned in 1998, which had a negative influence on paddy production. The high cost of production in peri-urban areas also deters farmers from cultivating rice. The best option for increasing rice production would be to pay more attention to the main production areas, while diversifying the marginal paddy lands. The adoption of HYVs covering over 90% of the paddy-cultivated areas of rice has increased the average yield up to 3.8 mt ha^{-1} (2003) from 1.6 mt ha^{-1} in 1962 (Table 1).

Table 1. Rice extent and production, 1952-2003.

Year	Extent (ha)	Paddy production (mt)	mt ha^{-1}
1952	478, 292	603,000	1.26
1962	621,570	1,001,000	1.61
1972	726,238	1,312,000	1.81
1982	844,648	2,156,000	2.55
1992	803,174	2,340,000	2.91
1999	877,000	2,855,000	3.26
2000	877,994	2,958840	3.37
2001	798,000	2,695,000	3.38
2002	852,000	2,860,000	3.36
2003	817,000	3,071,000	3.76

Sources: Central Bank report. 2002, 2003.

The yield potential of these varieties ranges from 10 to 12 mt ha^{-1} and the realizable yield under farmer conditions is only one third. Bridging this yield gap will be a good option to increase the national rice yield. Batalegoda Rice Research Institute is currently conducting a hybrid rice program jointly with Chinese scientists to further enhance paddy yields. The yield increment is expected to be 15-20% of the existing paddy yield. However, hybrid rice production must be carried out continually to maintain superior parental lines. The National Policy for rice is to achieve self-sufficiency and use the surplus grains for rice-based industries.

In most of the other field crops (chilly, onion, potato, groundnut, soybean, green gram, black gram, maize, cowpea, etc.) production was lower than the previous decade (Table 2). In 2003, production was 40% less than in the previous year (Central Bank Report 2003). These crops face massive competition from cheaper imports, which have discouraged the farmers from growing them (Table 3).

The cultivated area of these crops has also gradually reduced due to low profitability. The low yields are also associated with the cultivation of low-yielding varieties and use of substandard management practices. Use of high-yielding hybrid seeds and planting materials, postharvest processing, storage, value addition and marketing have been completely neglected in these crops. High quality seeds and planting materials, improved technology, and

Table 2. Annual production of major field crops, 1999-2003.

(Figs, in mt)

	1999	2000	2001	2002	2003
Kurakkan	4807	4849	4196	4701	5267
Maize	31471	31052	28755	26417	29645
Sorghum	138	121	50	148	201
Green gram	13825	11695	9716	10324	10605
Cowpea	12106	12121	9839	10436	12900
Soybean	797	648	622	1156	2957
Black gram	6730	5420	5127	5094	5941
Gingelly	4775	4598	4205	4070	5485
Groundnut	6540	7065	6461	8737	6587
Potato	27171	48409	57681	88709	71744
Red onion	42648	42502	36863	35334	35513
Big onion	62729	36560	31966	31560	32301
Chilli (green)	60031	55860	49042	46349	461181
Chilli (dry)	15008	13965	12261	11587	11548

effective delivery systems are crucial to improve the productivity of these crops.

The vegetable sector also faces the problems of lack of superior seeds and planting materials, poor management systems, high postharvest losses, and lack of proper marketing mechanisms, all of which adversely affect sustainable productivity and supply of quality products to the market. The high cost of inputs such as fertilizer and agro-chemicals have aggravated these problems. The use of hybrid seed technology will be crucial to develop this sector, but research in this direction has only just begun. The vegetable sector has immense potential for export; hence the National Policy aims at improving the production systems and investments on high tech precision agricultural techniques to encourage the production of exportable vegetables.

Sri Lanka produces very small amounts of fruits compared to other Asian countries. At the same time, Sri Lanka imports large quantities of fruits such as grapes, oranges, apples, dates, and pears. Of the 20 common fruits, 12 have been prioritized for research and development (R&D); these are shown in Table 4.

The total area under fruit cultivation is about 100,000 ha, with an annual production of 560,000 t. Postharvest losses in fruits are relatively high compared to those of other developed countries, and in some cases such as papaya, losses exceed 40%. Fruit production is not satisfactory due to use of inferior varieties, poor quality planting materials, poor management, high incidence of pest and diseases, low quality produce and inadequate storage. Development of dwarfing rootstocks and hybrid fruit trees and high density planting of compact trees can form the basis for developing the fruit sector. As the National Policy states, the fruit sector will be expanded on a commercial basis to develop a fruit industry for promoting exports.

Table 3. Import of field crops, 1999-2002.

	1999		2000		2001		2002	
	Quantity '000 mt	Value '000 Rs.	Quantity '000 mt	Value '000 Rs.	Quantity '000 mt	Value '000 Rs.	Quantity '000 mt	Value '000 Rs.
Chillies	20.36	1,293,705	23.36	1,327,406	25.82	1,520,001	25.29	1,675,140
Big onions	83.99	1,640,735	117.50	1,501,538	110.18	1,749,368	130.11	1,900,173
Red onions	2.06	48,033	5.94	107,444	2.73	64,782	1.82	57,373
Maize (seed)	66,669.00	620,514	7,864.00	75,348	69.00	1,466	7.00	1,456
Maize (Other)	58,956.00	494,738	115,248.00	1,088,006	157,334.00	1,794,638	945,883.00	12,046,754
Gingelly	1,091.00	27,214	1,031.00	27,604	845.00	28,051	303.00	11,138
Soybean	1,820.00	37,179	2,972.00	61,828	3,166.00	80,393	3,512.00	98,612
Green gram	7,528.00	183,330	6,767.00	172,548	8,717.00	271,434	7,121.00	223,083
Black gram	4,928.00	99,524	7,332.00	17,082	7,891.00	225,054	6,939.00	223,850
Groundnut	4,348.00	158,402	4,382.00	172,266	4,990.00	210,160	5,494.00	233,318

Source: Division of Agricultural Economics, Department of Agriculture, 1999-2002

Table 4. Annual production of major fruit crops, 1999-2003.

(Production in mt)

	1999	2000	2001	2002	2003
Banana	397272	403404	366900	280628	395964
Cashew	5200	4610	5304	5335	5489
Lime	3530	3879	3952	3240	5087
Mango	71150	71123	75733	80393	82595
Orange	3000	3328	3331	3510	3159
Papaya	17468	15806	1711	17102	19267
Passionfruit	527	872	601	1139	453
Pineapple	40783	43254	53243	53040	50895

Source: Division of Agricultural Economics, Department of Agriculture, 1999-2003.

The floriculture sector in Sri Lanka, mainly comprising private firms, has made rapid progress in the last two decades by entering into the export markets. There are about 50 export-oriented nurseries that have been organized with the assistance of the Export Development Board, which offers attractive incentives to the exporters. The main products exported are ornamental foliage plants, cut flowers, flower seeds, flower buds, aquatic plants, landscaping plants and tissue-cultured plants. The National Policy promotes expansion of this sector for local and international markets with financial and infrastructure supports coupled with several incentives.

Overall agricultural production has declined in the last decade and its performance has been unsatisfactory. As a result, food imports have been gradually increasing and export earnings are used for purchasing these imports. The expenditure on food imports in 1995, which was around Rs. 26 billion (US$ 33 million) increased to Rs. 48 billion (US$ 53 million) in 2003. This trend must be reversed by enhancing domestic food production. Thus, the key issue of sustainability will revolve round and depend on the small farmers, who constitute 70% of the population. To uplift the farming community, cooperation of all agricultural research institutions, universities and the private sector will be required. Ironically scientific advances such as biotechnology are coming at a time when the farming community is not able to adopt them due to high cost and complexity of new technologies or information. A shift of labor has occurred from agriculture to industry and youth avoid farming, preferring to look for better employment in the cities. The agricultural labor, which was 50% of the population, has declined to 35% in 2003. Attracting youth to farming through modern technologies will be a path that must be pursued if domestic agricultural production is to be improved. If agriculture is innovative, intellectually attractive and financially rewarding, it will attract youth. It is here that agricultural research will be called upon to play the important role of developing and disseminating user-friendly technologies to develop a vibrant agriculture sector.

2 National agricultural policy

Since Independence, the NAP has remained almost unchanged, with emphasis on self-sufficiency in essential foods (mainly rice) and dependent on traditional exports such as tea, rubber, coconut and spices for earning foreign exchange. The NAP 2004-2010 has taken a different direction toward increasing domestic food production and self-sufficiency, with the primary aim of reducing widespread poverty in the rural and estate sectors. Pockets of extreme poverty exist in some regions, reaching levels as high as 37% (Central Bank Report 2003). The present policy also focuses on household food and nutrient security, sustaining environment and natural resources and expanding rural employment. This is a direct reflection of the widening disparities in income between the urban and rural areas.

3 National agricultural research policies

Agricultural research has made substantial contributions to the overall productivity growth since Independence. However, the most significant growth occurred following the Green Revolution with the development of high-yielding rice varieties, which cover over 95% of the sown area at present, reflecting the high investment made on rice research. Rice yield increased from 1.5 mt ha^{-1} in 1960 to 4.0 mt ha^{-1} in 2004. No such significant breakthroughs have been made in the case of other crops. In all cases, including the plantation sector, crop-livestock-resource management research has been less successful. The use of high external inputs to exploit the potential of crops has been fast, often leading to land degradation with consequent environmental pollution. There is no doubt that agricultural research will have to play a more dominant role in the future due to increasing population and scarcity of land and water, and to be competitive under the prevailing open market policies and trade liberalization. Agricultural research will have to respond to the new challenges by generating technologies to increase productivity of the agricultural sector.

Despite the past investments on public sector research, the Sri Lankan NARS is uncertain of future funding to address demands of the agricultural sector, mainly due to lack of priority-setting mechanisms, inefficient management of available resources and insignificant output. Therefore, agricultural productivity has to be increased through various institutional innovations for which farsighted research policies will be required. This is a complex task. The research policies should complement the overall goals and objectives of the NAP of Sri Lanka and reinforce and fill the gaps in R&D that constrain enhanced agricultural production. In this effort, the roles of the state and the private sectors are equally important.

The Sri Lankan NARS consists of 12 main research institutes/departments that operate under six Ministries: Agriculture & Livestock, Plantation Industries, Environment and Natural Resources, Fisheries and Ocean Resources, Tertiary Education, and Training and Cooperatives. Research and development investment as a proportion of the agricultural GDP, as in

the other developing countries, has been low with hardly any increase over the past 25 years. The research investment in the developed countries now approaches 5% when compared to 0.6% in the developing countries, an almost ten fold difference. The Sri Lankan annual recurrent agricultural research expenditure in the year 2000 was Rs. 905 million with a research investment of only 0.52%. Strategically, it is necessary to attract more funds to NARS for research by convincing policy makers, while also canvassing for funds from other sources. Although the NARS has developed sufficient capacity, it has not performed well and a decline in quality is observed. Research institutes currently lack commitment and hard work in the existing poor research environment, and increased motivation and commitment will determine the effectiveness of NARS. Consequently the impact of research at farm level is insignificant. Therefore, the bottomline for revitalizing the agricultural sector is to attract funds to the level of 1.0% of agriculture GDP to reinvigorate the NARS.

The main national agricultural research policies focus on research prioritisation, capacity building in the agricultural sector, financing, improving the efficiency of NARS, international linkages and policy research (Anon 2003). Due to the changes in the national agricultural policies, mandates of the research institutes have also drastically changed from production with emphasis on yield increases to postharvest processing and value addition. The role of the private sector has diminished to a considerable extent with emphasis on farmer organization as the focal point for implementation of production programs. The fund allocation for agricultural research is based on the above priorities rather than on research projects. The focus is on cutting edge research in areas that have immediate impact such as biotechnology, plant breeding, postharvest technology, and labor-saving machinery and equipment.

4 Prioritization of agricultural research programs/projects, 1996-2003

As a basic input for research planning, agricultural commodities were prioritized on the basis of their economic importance. The task was carried out in two distinct steps. The first was the definition of the national agricultural development strategy in terms of selected objectives, indicating their relative importance by assigning a weight to each of them. Five objectives were selected and they were weighted as shown in Box 1.

The next step was to assess and prioritize these commodities on the basis of their capacity to contribute to the attainment of the development objectives identified.

The first approximation of a ranked listing of commodities was obtained by applying a formal priority setting methodology (weighted objectives methodology) to commodities for which data on past performance was available. The list was then discussed and revised, taking into consideration factors such as the potential for future development of these commodities, potential for an effective contribution

Box 1. Weights of the objectives.

S. No.	Objective	Percentage Weighting
1.	Income and employment generation	30
2.	Generation of foreign exchange	24
3.	Economic efficiency	18
4.	Satisfaction of future domestic demand	18
5.	Satisfaction of nutritional requirements of low income groups	10

from research in the medium term, and the availability of trained scientists at the various research institutes. In this process extensive discussions were held with the Department of Agriculture whose research encompasses a large number of commodities.

5 Prioritization of agricultural research programs/projects 2003-2006

The following priority research areas have been identified for 2003-2006 after several rounds of stakeholder consultations. This procedure enabled many of the stakeholders to comment on the previous procedures attempted at prioritization of research programs, and to give advice and suggestions. The priorities are client-oriented and demand driven; hence the findings are expected to lead to implementable solutions. They are as follows:

- Plant breeding/genetic improvement of commercially important crops and underutilized crops
- Hybrid seed development
- Biotechnology
- Conservation and utilization of genetic resources
- Integrated pest management
- Biopesticides and biofertilizers
- Irrigation water management
- Soil fertility management
- Intensive crop production systems
- Agroforestry and NRM
- Fruit and floriculture development
- Food technology, postharvest processing and value addition
- Livestock improvement/breeding
- Integrated farming systems
- Aquaculture and fisheries
- Ornamental fisheries
- Labor-saving machinery and equipment
- Agricultural marketing
- Agricultural information and communication technology
- Socioeconomic and policy issues

Research prioritization at the micro level has been attempted through holding cluster meetings for different crops (e.g. Cinnamon Cluster, Organic Agriculture Cluster, controlled environment agriculture cluster). In this process the stakeholders (cultivators, researchers, extension agents, marketing

agents, wholesalers, processors and exporters) of individual crops were called for a brainstorming session to identify the gaps in research. Their immediate problems were discussed and researchable problems identified. This is a direct procedure that can be used for specific crops or agricultural systems such as environment-controlled agriculture and organic agriculture or plantation crops such as tea, as the interest groups are homogenous and crops are grown extensively in specific regions. It is not applicable to farmers involved in growing the several crops spread over different ecosystems.

Sri Lanka has been classified into three major agroecological regions and several subregions, mainly based on rainfall and factors such as major soil groups, terrain and land use patterns. These are: Dry zone (DL: low country 650-1100 mm), Intermediate zone (IL: low country 1100-1400 mm, IM: mid country 1100-2000 mm, and IU: upcountry 1400-2400 mm) and Wet zone (WL: low country 1700-3200 mm, WM: mid country 1400-3300 mm and WU: upcountry 1800-3100 mm). The major crop research institutes (Rice, Horticulture and Field Crops Research Institutes) have prioritized research for each ecological region (Fig 1).

These research priorities are listed below in brief.

Rice Research and Development Institute

The two major problems in rice production are low productivity and high cost of production, which make rice cultivation an uneconomical enterprise. High production costs are associated with high cost of labor and power amounting to 70% of the total cost. Low productivity is mainly attributed to varying levels of biotic and abiotic stresses in different rice production ecosystems in the country (Abeysiriwardene 2004).

The research thrusts identified are as shown in Box 2.

Box 2. Identified research thrusts for rice research.

Research thrust	Gaps in research
Variety improvement (Countrywide)	• Identification of varieties for different ecosystems, dry, wet and intermediate zones, • Development of varieties resistant to blast, bacterial blight, gall midge and brown plant hopper • Incorporation of tolerance to salinity and iron toxicity • High yield and quality • Improvement of nutrient quality of grain in all varieties aimed at higher milling and quality cooked rice
Plant protection	• Breeding for resistance and development of IPM packages
Agronomy	• Fertilizer use and water use efficiency of crops

Figure 1. Agroecological regions of Sri Lanka.

Horticultural Crop Research and Development Institute

The major research issues are the lack of improved varieties of vegetables and fruit for local consumption and export. Varietal improvement through selection and breeding is the main area of research required. In addition, plant protection is given priority to produce fruits and vegetables with minimum use of pesticides; hence development of biopesticides and biofertilizers is a major research activity. Postharvest processing is another area receiving special attention with reference to vegetables and fruits (Kudagamage 2004). (Box3)

Box 3. Research thrusts for horticultural research.

Research thrust	Gaps in research
Vegetables (Central region, mid-country)	• Varietal development, hybrid seed development in selected vegetables • IPM packages • Breeding and multiplication of sweet potato and root crops • Soil fertility management, fertilizer usage and bio-fertilizers
Vegetables (Central region, upcountry)	• Exotic vegetable production (Potato, cabbage etc) • IPM packages • Postharvest storage
Vegetables (Northwestern region)	• Low country vegetable production packages • Breeding for high yield
Fruits (Central region)	• Papaya and durian improvement • Artificial flower induction for off-season production, Under-utilized fruit improvement • Processing and value addition to fruits and vegetables
Fruits (Central region, upcountry)	• Development of temperate fruits: strawberry, pear and mandarin
Fruits (Western region)	• Germplasm collections and breeding • Crop management systems • Hybrid variety development
Fruits (Northwestern region)	• Banana: germplasm collection and evaluation, and agronomic studies • Pineapple: agronomic studies, Anona mutation breeding

Field Crop Research and Development Institute

This institute is engaged in dry zone agriculture mainly growing coarse grains, pulses, fruits and local vegetables. Water conservation and augmentation is a main emphasis in agricultural production due to irregular rainfall. Low yields, severe pest and diseases attacks and marketing are the main problems faced by the subsistence farmers in the dry zone (Samaratunga 2004) (see Box 4).

Further analysis of the ongoing research programs in terms of future needs highlighted that there are many other emerging unidentified gaps in research that are not addressed by the research institutes. This has arisen due to lack of research focus based on demands of the stakeholders. Prioritization of these based on stakeholder demand and availability of resources is of crucial importance to enhance agricultural production and improvement of farmer incomes. These areas are listed below.

Box 4. Research thrusts for field crop research.	
Research thrust	Gaps in research
Field crops (Dry zone)	• Development of coarse grains (maize, sorghum, millets) • Agronomic packages and pest management • Development of hybrid maize with high-quality protein • Postharvest processing and storage of coarse grains, • Development of high-yielding, pest-resistant varieties of chilly • Development of high-yielding and seed setting varieties of onion • Development of high-yielding, pest-resistant varieties of pulses
Fruits (Dry zone)	Mango, banana, grapes: • Agronomic studies • Postharvest storage • Value addition to fruit products • Marketing studies

- Marketing and market intelligence
- Postharvest processing and value addition
- Collection, conservation and evaluation of genetic resources
- Crop improvement using conventional and modern biotechnologies
- Land use planning, classification and land demarcation based on suitability
- Augmenting water resources, water harvesting and water management
- Integrated pest management, biopesticide use
- Natural resources management, mainly soil conservation and prevention of land degradation
- Agroforestry development and crop diversification
- Dairy cattle breeding and integrated farming systems
- Improved feed resources and utilization of local feeds
- Underutilized crops and domestication of selected species
- Development of SMEs with farmer participation

These gaps cover the whole production-consumer continuum, hence a holistic approach to research prioritization is needed. These issues must be prioritized by the concerned institutions as multidisciplinary, interinstitutional research projects. As several institutions are involved in the implementation of these projects, a mechanism for coordination has to be developed. As the agricultural research system in Sri Lanka is dispersed over several ministries, interministerial coordination is essential in resource allocation for successful implementation of these projects.

Taking all these facts into consideration, the Ministry of Agriculture and the State Council is in the process of developing a strategic national research plan and a human resource development plan to consolidate the NARS on a long-term basis.

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Research Need Assessment and Prioritization of Agricultural Research for Development: Bangladesh

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1 Introduction

Agriculture is the mainstay of the Bangladesh economy, contributing to about 25% of GDP (Table 1). About 70% of the people are directly engaged in agriculture. Since the performance of this sector affects overall progress of the economy and the livelihood of a majority of the population to a large extent, modernization and growth of agriculture has always been a national priority for Bangladesh.

Table 1. Total agricultural production as percentage of GDP.

Year	Current price	Constant price (base = 1984-85)
1991-92	34.47	36.86
1992-93	30.47	35.92
1993-94	29.69	34.58
1994-95	30.88	32.77
1995-96	28.96	32.24
1996-97	29.34	32.41
1997-98	28.65	31.58
1998-99	29.24	31.55
1999-00	25.51	27.53
2000-01	23.31	25.15

Source: BBS, 1994, 1998, 2001.

Agriculture has the potential to reduce food deficit as well as shortage of industrial raw materials, and also to provide employment opportunities with reasonable income that will help improve the standard of living of the majority of poor people living in the villages. The growth potentials of the major crops and other agricultural commodities are two to three times higher than the present levels of production, thus offering substantial scope for increase in productivity. With this increase in productivity and income as well as self-reliance in food, a more desirable socioeconomic and institutional framework could emerge as part of the development process. Thus the country's progress and prosperity primarily depends on agricultural development.

The agro-based industrial development of the country again largely depends on the raw materials obtained from the agriculture sector, such as

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sugar, food, jute, textile, tea and leather. Agriculture accounts for about 87% of all exports (Hasanulla et al. 1996). Agricultural development is thus crucial for the enormous, rapidly-growing population to maintain a minimum level of living and to procure enough food, and to provide labor and capital to the very poorly developed industrial and service sectors of the economy.

The research system, however, still suffers from a number of weaknesses that tend to reduce its efficacy in supporting further growth and its sustainability. There is ample scope for improvement to make the research system more relevant and responsive to the needs of a highly productive, sustainable, intensive and diversified agriculture. In particular, the research system needs to re-examine its focus and re-order its priorities; avoid fragmenting its efforts; change its approach from a commodity-based to a farming system or integrated production system approach; and strengthen its planning, programming, monitoring, evaluation and coordination of research activities in different centers. It should also strengthen its linkages with the extension system. In short, agricultural research should be given proper attention for overall development of agriculture. The present study, therefore, includes the following objectives:

i) To provide a scenario analysis of agriculture in Bangladesh;
ii) To highlight the significance of agricultural research for development, particularly in the context of emerging challenges;
iii) To identify research needs at micro-levels;
iv) To attempt research gap analysis for research needs vs. current research efforts;
v) To prioritize the research gaps; and
vi) To suggest strategies to bridge the prioritized research gaps through the involvement of research institutions, extension agencies, and development departments.

2 Agriculture in Bangladesh: Scenario analysis

Agriculture provides employment

Agriculture is the largest employer in Bangladesh. Since 1974, the absolute numbers in the employed sector, both male and female, have increased by 70% even though the percentage declined from 79% in 1974 to 64% in 2003. Moreover, agriculture is by far the largest employer of women. In 1995-96, 79% of the total number of employed women 15 years or older worked in the agriculture sector. In addition to persons employed directly in agriculture, significant numbers work in industries dependent on agriculture.

Agriculture provides food

Rural agriculture dominates the economy of Bangladesh because it produces 96% of the food. Bangladesh has recently achieved near self-sufficiency in rice, the dominant food staple, in spite of the land holding structure dominated by small and marginal farmers, and the growing pressure of population on limited land resources. Although the area under rice has remained stagnant at around 10 to 11 million ha, rice production (in paddy units) has increased from 16 million tons in 1972 to 27 million tons in 2000-01 (Table 2). This implies a growth rate

of 6.96% per year, much faster than the growth in population. The per capita availability of rice from domestic production has increased substantially in recent years.

Rice dominates agricultural land use in both seasons (kharif and rabi). Since 1983, the agricultural land use has declined by almost 1 million ha. It is essential therefore that research continue to develop technologies to increase productivity from each hectare sown to rice and other minor crops. The farmers have adopted modern varieties to increase their income (Table 3). The yields of HYVs were found higher than low-yielding varieties in the farmers' fields (Table 4).

Contribution of non-agriculture sectors

The livestock and fisheries sectors experienced substantial increase in physical output as well as in prices relative to other agricultural produce. These sectors were highly neglected in the past but have been given considerable emphasis in recent years as there are huge untapped potentials in these sectors. These will generate on-farm and off-farm income earning opportunities together with the development of rural nonfarm economic activities. The income from fisheries grew by 7.8% per year in the 1990s compared to 2.3% during the previous two decades. The income from livestock activities picked up in the 1980s and continued to grow at a robust rate of 7.3% in the 1990s (Table 5). Only the forestry subsector grew at a moderate rate of 3.8% per year. The share of livestock, fisheries, and forestry in agricultural incomes was only 20% during 1973-74, but they contributed nearly 44% to agricultural incomes by 2000-2001 (BBS 2001).

In recent decades, significant changes have taken place in the structure and composition of agriculture in Bangladesh: First, agriculture's share of GDP has dropped from 51% in 1973/74 to 25% in 2000/01. While the share of the crop sector in GDP has diminished from 19% in 1990/91 to 14% in 2000/01, the contribution of fisheries has increased from 4.5% to 6.2% during the same period. Also, while the crop sector output growth was less than 1% per annum during the early 1990s, it has risen to over 4% toward the end of the decade. Some of the noncrop subsectors such as fisheries, livestock, and forestry have demonstrated accelerated growth rates.

Second, the number of farmers holding land increased from 10.1 million in 1983/84 to 11.8 million in 1996. If this trend continues, the total number of farmers in the year 2005 is likely to surpass 13 million. Consequently, the average farm size has declined from 0.81 ha in 1983/84 to 0.61 ha in 1996. As this trend continues average farm size is likely to be reduced to 0.34 ha by the year 2015.

Third, the degree of fragmentation and subdivision of agricultural holdings will increase, implying that there will be more and more small farms. In 1983/84 small farms (up to 1 ha) constituted about 70% of total farms and accounted for about 29% of total farm area, but these proportions rose to 80 and 41% respectively in 1996. While the number of small farms has actually increased at 2.7% annually, the number of medium and large farms has actually

Table 2. Area, production, and growth rates of various crops.

(Area in ha, Production in tons)

	Rice		Wheat		Maize		All Cereals		Pulses		Oilseeds	
Year	Area	Prodn	Area	Prodn	Area	Prodn	Area	Prodn	Area	Prodn	Area	Prodn
1990-91	10439676	17852000	599190	1004000	3109	3040	11150607	18937000	728340	523000	569636	448000
1991-92	2636190	6804230	574895	1065050	3600	3000	10931522	19395525	721893	519155	540065	439550
1992-93	10185020	18340000	637247	1176000	5060	7000	10921862	19590000	713360	517000	534008	449000
1993-94	9985425	18042000	615385	1131000	6400	15000	10697976	19245000	709312	530000	558704	472000
1994-95	9925911	16833000	639676	1245000	9940	29075	10660324	18148000	710526	534000	529150	453000
1995-96	9945749	17687000	701215	1369000	10125	32000	10740081	19126000	698381	524000	555061	471000
1996-97	10182186	18882000	708097	1454000	13672	40690	10982186	20402000	689474	525000	554251	478000
1997-98	10267206	18862000	804858	1803000	14938	65279	11161538	20731000	684211	519000	561538	483000
1998-99	10119838	19905000	882591	1908000	18494	84880	11091093	21878000	547368	416000	402429	448000
1999-00	11545619	24906880	832773	1839980	20390	120000	12398782	26866860	498381	384000	436437	406000
2000-01	11574834	26758750	772992	1673280	25530	152384	12373356	28584414	473684	366000	421053	385000
Mean	9709787	18624805	706265	1424392	11933	50213	11191757	21173073	652266	487014	514757	4484414
CV(%)	25.00	52.00	1.07	3.42	0.08	0.52	6.33	33.13	0.99	0.66	0.64	0.31
Growth rate(%)	5.89	6.96	3.97	6.61	21.24	40.99	1.08	3.60	-4.11	-3.36	-2.86	-0.89

Note: Growth rates are calculated by OLS Semi-Log functions.
Source: BBS 1994, 1998, 2001.

Continued

Table 2. *Continued.*

(Area in ha, Production in tons)

	Potato		Vegetables		Fruits		Tea		Sugarcane		Jute	
Year	Area	Prodn	Area	Prodn	Area	Prodn	Area	Prodn	Area	Prodn	Area	Prodn
1990-91	123887	1237000	171660	1090000	167611	1447000	47773	46000	191161	7681940	583806	5302000
1991-92	127850	1379320	173905	1100340	169488	1444605	47678	45230	187405	7445615	588348	5273190
1992-93	129555	1384000	70040	362000	171255	1448000	47773	49000	184767	7506525	500405	4919000
1993-94	131174	1438000	71255	369000	173684	1460000	47773	51000	180881	7110740	478543	4453000
1994-95	131579	1468000	73684	388000	176518	1467000	47773	52000	180180	7445650	559919	5311000
1995-96	131984	1492000	182186	1213000	180567	1458000	48178	48000	174522	7165090	458704	4074000
1996-97	134008	1508000	195951	1291000	182591	1490000	48178	53000	175658	7520540	507287	4866000
1997-98	136437	1553000	200810	1307000	184615	1495000	48583	51000	175223	7378710	577733	5824000
1998-99	244939	2752000	231579	1483000	185425	1430000	48583	56000	173947	6950925	478138	4475000
1999-00	243123	2933320	246994	1560175	182115	1404315	48583	51588	170393	6910060	408097	711000
2000-01	249099	3215570	255789	1588260	191547	1484310	48583	56722	168960	6741690	448178	821000
Mean	162149	1850928	170350	1068343	178674	1457112	48133	50867	178463	7259771	508105	4184472
CV(%)	0.55	7.50	0.713	4.90	0.078	0.277	0.004	0.038	0.07	3.10	0.63	18.12

Note: Growth rates are calculated by OLS Semi-Log functions.

Source: BBS 1994, 1998, 2001.

Table 3. Rate of adoption of high-yielding varieties of different crops.

Crop	Adoption rate (%)
1. Wheat	100
2. Potato	75
3. Maize	98
4. Tomato	70
5. Summer tomato	31
6. Radish	33
7. Mung bean	56
8. Kazi Peyara (Guava)	31
9. Okra	40
10. Mustard	40
11. Eggplant	20

Source: Survey Reports, Agril. Econ. Div, BARI, Gazipur, 2000-03.

Table 4. Yield gap between high-yielding and low-yielding varieties in the farmers' fields.

Crop	HYV (kg ha^{-1})	LV (kg ha^{-1})	Percent increase over LVs
Wheat	2910	734	582
Maize	10500 (hybrid)	6280 (composite)	67
	6280 (composite)	2250 (LV)	179
Eggplant	6444	3117	107
Radish	58500	37000	58
Tomato	40710	20433	99
Potato	5630	2720	107
Mustard	1088	976	11
Mung bean	1040	609	71
Chickpea	1820	791	130
Black gram	1089	806	35

Source: Survey Reports, Agricultural Economics Division, BARI, Gazipur, 1992-2001.

Table 5. Long-term growth of agriculture and economy.

Sector	1973-74 to 1989-90	1989-90 to 2000-01	1973-74 to 2000-01
1. Agriculture	2.6	3.5	3.0
Crop	1.7	2.5	2.0
Forestry	3.8	3.8	3.8
Livestock	5.2	7.3	6.0
Fisheries	2.3	7.8	4.5
2. Non-Agriculture	6.0	6.2	6.1
Gross Domestic Product	4.1	5.3	4.6

Source: Estimated from BBS, Statistical Yearbook of Bangladesh and Monthly Statistical Bulletins.

fallen over the years. This means that the future agriculture of Bangladesh will be dominated by even smaller-sized farms, which are unlikely to remain economically viable. There is a need for eventually evolving a new form of production mechanism that will integrate small-scale production with the private sector, providing technologies, credit, extension, and marketing services.

Fourth, while the average farm size has declined, average homestead area per rural household has increased from 0.08 acre in 1983/84 to 0.09 acre in 1996. This may mean that opportunities for home-based production systems have increased.

3 Agricultural research for development

The economy of Bangladesh draws its strength and stability mostly from agriculture, so efficient management of agriculture is very crucial for socio-economic development. Increased productivity of agriculture requires the continued support of useful, timely, and relevant modern agricultural research. This led to the development of a NARS, which uses the tools of modern science to help farmers in the productive use of natural resources. The Bangladesh Agricultural Research Council (BARC) was established through the Presidential Order No. 32 during April 5, 1973 to provide impetus to more dynamic research in agriculture (including livestock, fisheries and forestry).

BARC is the apex organization for the NARS in Bangladesh. It has the responsibility of strengthening the national agricultural research capability through planning and integration of resources, and is the umbrella under which the entire Bangladesh agricultural research effort is now coordinated. This involves collaborative activities of several government ministries like Agriculture, Forests, Livestock and Fisheries, Education, Industries and Commerce. BARC's mandated work areas are as follows:

- Planning, developing, and funding agricultural research programs;
- Establishing a system of priorities for agricultural research and providing

mechanisms for updating these priorities;

- Providing and updating the mechanism for assessment of progress and updating the programs;
- Coordinating and evaluating agricultural research programs;
- Studying the human resources position in agricultural research and developing appropriate training programs;
- Liaising with other countries in matters of scientific research;
- Holding national and international conferences, seminars, and work-shops;
- Publishing and disseminating scientific information, transfer of technology, and monitoring,
- Exploiting scientific principles, especially recent advances in frontier sciences, in order to create technologies that will enable agricultural production to increase by means that are both efficient (more output from the same or less input) and sustainable (without degrading the natural resources required by the production systems); and
- Exploiting advances in management sciences to improve both the effec-tiveness and efficiency of research resource use.

BARC also collaborates with other organizations like extension departments, universities and development institutes in the country, and with several regional and international organizations around the world committed to poverty alleviation and rural development.

BARC is the coordinating body of the ten NARS agricultural research institutes (ARIs):

i) Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur
ii) Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur
iii) Bangladesh Jute Research Institute (BJRI), Sher-E-Bangla Nagar, Dhaka
iv) Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka
v) Bangladesh Forest Research Institute (BFRI), Chittagong
vi) Bangladesh Sugarcane Research Institute (BSRI), Ishurdi, Pabna
vii) Bangladesh Tea Research Institute (BTRI), Srimangal, Sylhet
viii) Bangladesh Fisheries Research Institute (BFRI), Mymensingh
ix) Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh and
x) Soil Resources Development Institute (SRDI), Sher-E-Bangla Nagar, Dhaka

Each of the primary institutions in the NARS has a specific mission and is involved generally with a wide range of applied and adaptive research activities. These are complemented by educational support in the form of workshops and seminars for scientific personnel; in-service training for supporting staff and field-days; and related efforts to communicate research recommendations to extension agents, farmers, and other users of information. Another innovation during the past decade has been the strengthening/establishment of the

network of regional research stations and substations under these institutions. These units work on regional and local problems and also conduct studies on the adoption of new technology in different agroecological areas.

A related development is the expansion of participatory on-farm research in which researchers work with local farmers who try out new practices under actual farming conditions. This ensures that new technology is practical for adoption by farmers. The on-farm trials help bridge the gap between technology generation and adoption. The linkage with extension service organizations provides the potential for the two-way flow of communication. Researchers evaluate new findings through the extension network so that they will reach farmers, who can then put them to practice. In turn, farmers can use the extension network for feedback to help researchers become more aware of the real problems they are facing.

Several studies were conducted in the NARS Institutes on the impact of research and extension in several crops. Foreign exchange savings or earnings were also calculated for different crops. The annual rate of return to investment in maize research was found to be 23%, ranging from 11% to 29%. In addition to generating economic benefits to farmers in the form of higher incomes and to consumers in the form of lower product prices, the research and extension on maize varieties released after 1987 saved Tk. 291.59 billion ($5.02 billion) in foreign exchange (Table 6). Without the research and extension activities

Table 6. Impact of investment to research and extension.

Crops	IRR(%)	Range of IRR (%)	Benefit Cost Ratio	Foreign exchange saving (billion Taka)
1. T. Aman Rice	59	48-73	1.74	127.00
2. Boro/Aus Rice	28	0-43	1.67	65.00
3. Wheat	32	27-41	41.00	7.90
4. Potato	41	31-51	11.00	-
5. Jute	15	12-22	11.95	3.30
6. Sugarcane	16	11-27	NA	4.00
7. Maize	23	11-29	11.00	291.59
8. Tomato	57	44-70	10.30	-
9. Radish	19	14-28	3.03	-
10. Mungbean	29	7-45	5.41	4.34
11. Kazi Peyara (Guava)	29	23-35	22.23	-
12. Okra	27	17-46	2.68	-
13. Mustard	26	17-30	3.74	11.14
14. Eggplant	49	33-35	5.20	-

Source: Survey Reports, Agricultural Economics Division, BARI, Gazipur, 1998-2001.

that were responsible for the additional maize production, Bangladesh would have had to import maize equal to this value to satisfy domestic demand. A similar analysis was also done for the other crops mentioned in Table 6. These types of studies indicated the benefits of agricultural research for overall development in agriculture sector.

4 Emerging challenges in agricultural research

Agricultural research has contributed significantly to the development of agriculture and the economy of the country, but it still has to meet many challenges for agricultural development in the coming decades.

Food and increasing population

The projected population for Bangladesh by the year 2025 is about 169 million, which would require about 27.8 million tons (Mmt) of rice (equivalent to 41 Mmt paddy) to feed the population. This is about 21% higher than the production level of 2000. This increasing demand has to be met from the limited and shrinking land resources. Bangladesh Government has developed a NAP for the development of agriculture to meet the emerging challenges.

Food security

Food security for all means that each individual has access to food securing adequate calorie and protein intake. Increased food production is a necessary but not sufficient condition for sustained improvement in household food security and nutrition in Bangladesh. So, the government has taken it as a prime responsibility to ensure food entitlement for everybody in the country. New production systems are needed in which the complementarity of crops and livestock and fish production enterprises are captured to increase as well as diversify income sources for women in the homestead areas.

High variability in rainfall

The annual average rainfall of the country ranges from 1194 mm to 34543 mm. The uneven distribution of monsoon rains over different parts of the country tends to lead to periodic drought and flood situations. Therefore, high variability of rainfall is the single environmental factor which influences the fluctuations of crop yields in different parts of the country.

Flood and drought

Flood is a common feature that severely affects Bangladesh and causes crop losses every year. Periods of drought occur frequently during the kharif season. Moreover, rabi seasons are virtually rainless. Drought annually affects about 2.3 million ha in the kharif and 1.2 million ha in the rabi season.

Salinity

Over 30% of the net cultivated area is in the coastal zone, of which nearly 1 million ha is salinity-affected. The high but somewhat unpredictable intensity of salinity during the rabi season, coupled

with associated tillage problems, makes cropping difficult during that period.

Cyclones and tidal waves

Cyclones and tidal surges are also common in the coastal area and they cause severe loss to the crops and lives. Salinity and tidal submergence tolerant rice varieties and appropriate cropping pattern with proven soil reclamation methods need to be developed to increase the cropping intensity of the coastal saline area.

Soil fertility

Soil is the medium of all agronomic activities. Erosion and depletion of soil fertility are the two main causes of low productivity of soil in Bangladesh. Within the last one decade, over a million ha (11.1%) of cropped land disappeared mainly due to creation of infrastructures for the increasing population and river erosion. It is estimated that the net sown area decreased by 1% from 1990/91 to 2000/01 and single cropped area decreased by 12% in the same period (Table 7). The situation is alarming because more food needs to be produced from less land.

Maintaining germplasm

Plant genetic resources (PGR) are precious new materials which breeders use to develop improved new varieties. BARI, BRRI and BJRI maintain substantial samples of germplasm in gene-banks of many accessions. Germplasm characterization as well as genetic preservation is an important activity of these institutes.

Hill agricultural research

Large areas of the hill tracts have been denuded of trees by mismanagement and unlawful tree cutting. Because the hill has been denuded, topsoil has eroded, which worsens the land productivity problem.

Table 7. Land utilization under forest and other crops from 1990-91 to 2000-01.

(Area in ha)

	Area		
Land Type	1990-91	2000-01	% Changed
1. Forest	1900000	2627935	38
2. Single cropped area	3295547	2891093	-12
2 Double cropped area	3900405	4167206	7
3. Triple cropped area	981377	1026721	5
4. Net sown area	8177328	8085020	-1
5. Total cropped area	14082591	14305668	2

Source: BBS, 1994,1998,2001.

Rural infrastructure development

The increased network of rural roads linked with peri-urban and rural growth centers facilitates movement of people as well as agricultural inputs and produce. It also leads to the establishment of shops, repair workshops, hotels and restaurants on roadsides. It is axiomatic that the aggregate volume of local nonfarm activities in various trades, services, production, and consumption will increase with improvement of infrastructure.

Crop diversification

With rice occupying almost 81% of the cropped area followed by wheat (5%), only about 20% of the cropped area is devoted to a range of other crops. Therefore, crop diversification with other crops like wheat, maize, oilseeds, pulses, fruits, spices, jute, cotton, etc should also be included in the cropping system.

Agricultural diversification

Agricultural diversification, e.g., commercial poultry farming and pond fishery in the private sector has also pushed up nonfarm activities in rural areas. Backward linkages in poultry farming include activities such as preparation of poultry feeds, and manufacturing and marketing of poultry feeding and poultry rearing equipment. Forward linkage activities include marketing of poultry products from production points to urban and peri-urban centers. Pond fishing also generates rural nonfarm activities in production and marketing of fingerlings and fish feeds, manufacture of fishing equipment and fishing net, and processing and marketing of fish.

Re-application of biomass

Available data indicate that the re-application of biomass such as rice stalks and animal wastes to cultivated lands has dropped drastically. The organic matter content of some arable lands has dropped to below 1% as compared to the minimum of 3% required to sustain productive capability. Hence efforts are needed to collect and compost the biomass to produce organic manure for replenishing soil health.

Poverty alleviation and malnutrition

About 50 million people are categorized as poor in Bangladesh, where poverty is manifested in several ways, including low income, inadequate calorie intake, poor health and low level of educational attainment, and limited access to social services. The incidence of hard-core poverty is higher among agricultural households. Reduction in poverty is critical to food security. Moreover, enhancing the ability to buy food contributes to the sustainability of accelerated growth in agriculture.

5 Research needs: Evidence from micro studies

There are 30 agroecological zones (AEZs) in Bangladesh and agriculture research stations and substations of BARI and BRRI are located in different parts of the country based on the AEZs so that

the regional problems can be addressed as per the specific need of the areas.

Crop subsector

During the past two decades, the total production of food cereals increased steadily from 18.94 million tons in 1990/91 to 28.58 tons in 2000-01 at a growth rate of 3.60% per annum (Table 2). Per capita grain production rose from 137.6 kg to 207.7 kg. The principal sources of growth came from Boro and Aman rice and wheat. The major source of growth in rice production was the shift of area from local rice varieties to HYVs or expansion of HYV rice onto newer areas.

Productivity of pulses and oilseed crops remained stagnant during the 1990/91-2000/01 period despite a significant increase in production during this period. Productivity in sugarcane also recorded a consistent downward trend. The area under jute decreased at 2.4% annually during the 1990/91-2000/01 period but production remained static despite considerable year-to-year variation and the productivity decreased by 15.61% annually over this period (Table 2). Of all noncereal food crops, potato showed an impressive growth in its aggregate production. From 1990/91 to 2000/01, the area under potato increased at 101% and production at 160% annually (Table 8).

Table 8. Change of area and production of different crops from 1990/91 to 2000-01.

	1990-91		2000-01		% Changed	
Crops	Area (ha)	Prodn (tons)	Area (ha)	Prodn (tons)	Area	Prodn
1. Rice	10439676	17852000	11574834	26758750	10.87	49.89
2. Wheat	599190	1004000	772992	1673280	29.01	66.66
3. Maize	3109	3040	25530	152384	721.16	4912.63
4. Sugarcane	191161	7681940	168960	6741690	-11.61	-12.24
5. Pulses	728340	523000	473684	366000	-34.96	-30.02
6. Oilseeds	569636	448000	421053	385000	-26.08	-14.06
7. Spices and condiments	147368	319000	253441	397000	71.98	24.45
8. Potato	123887	1237000	249099	3215570	101.07	159.95
9. Jute	583806	5302000	448178	821000	-23.23	-84.52
10. Fruit	167611	1447000	191547	1484310	14.28	2.58
11. Vegetables	171660	1090000	255789	1588260	49.01	45.71
12. Drugs & narcotics	87045	125000	122144	164158	40.32	31.33

Source: BBS, 1994, 1998, 2001.

Between 1990/91 and 2000/01, the aggregate production of vegetables increased from 1.09 million tons to 1.59 million tons recording an annual growth rate of 10.22%. The growth performance of all principal fruit crops decreased. Between 1990/91 and 2000/01, the area under fruits increased at the rate of 1.23% and production at 0.04% (Table 2). Among the major fruits, the area and production of banana, mango, and jackfruit are much higher than others.

Enhanced productivity should come from increased emphasis on hybrid varieties and super rice varieties that would be available in the first decade of the 21st century. Biotechnology can support the conventional crop improvement process by eliminating the natural barriers to hybridization among distantly related plants. It would also reduce the time lag needed to develop new breeds.

Livestock subsector

Inadequate diets and poor animal health are the major constraints to sustaining recent rates of production growth in the livestock subsector. For commercial poultry enterprises, quality feeds are imported but for large ruminants, crop by-products are the major source of feed. Research to improve the nutritional quality of crop by-products will help to sustain the recent growth of animal production as well as increase crop values.

Fisheries subsector

Fish catches from open water capture fisheries have consistently declined. It is, however, projected that the shares of fisheries sector in total agricultural output will grow from 10.8% in 1992 to 13.2% in the year 2010 (Mandal and Asaduzzaman 2002).

Yield gaps in pond culture of fish are in the range of 50% or more. Perhaps this gap can be easily overcome in the near term if certain measures are taken. Ponds can be stocked with fast growing breeds and species, and pond management can be improved (better water quality, feeding rates, disease control, optimal stocking ratios) to increase output.

Forestry subsector

The share of forestry in agricultural GDP stands at around 10%. At present, medium to dense forests cover 2.62 million ha and on a per capita basis, every person has 40 m^2 of state forest. Besides, there are about 0.30 million ha of private homestead tree-covered land and 0.68 million ha unclassified state forest. Put together the share of forest area comes to just 5-6% of total land area. By any standard, this ratio is grossly inadequate to provide a basis for longer-term ecological security.

The present emphasis of forest research is on developing plantation techniques for various fast-growing exotic species to meet the demand for fuel wood. Physiological research on several mangrove species is underway and vegetative propagation techniques for 15 mangrove species have been developed. Rapid propagation techniques for bamboo need to be developed.

Socioeconomics research

Socioeconomic study is an integral part of each research. It helps to collect and

analyze agricultural production and resource data and generate the analyses required to set research priorities and evaluate impacts of research expenditures. An essential part of socioeconomic research is databases, including from primary and secondary sources. Primary data collection skills including data management and analytical capacity should be developed, in which expected costs and returns are discounted to present values to update commodity priorities. In the near term, research priority setting as well as very broadly-scoped impact studies that estimate returns to research and extension are the most pressing needs. Collaborative research work will broaden the capability in this area, which needs to be strengthened further.

Farm category

Agriculture is an economic activity based on land. Since land resources are limited, agricultural development necessarily aims to increase the productivity of land. In Bangladesh, almost one-third of the households do not own any cultivable land and 17% own only up to 0.2 ha (Hossain and Shahabuddin 1997). Measures need to be taken to improve the livelihood of the people who do not own any land and constitute the vast majority of the poor. It was found that the small, medium and large farm holdings were 70%, 25% and 5% of the total during 1983-84, whereas by 1995-96 these were 80%, 18% and 2% respectively, i.e., the small farm holdings are increasing and medium and large farm holdings are decreasing. There are also differences in technology adoption and use of inputs as well returns from crop cultivation among the farm categories.

Export markets

Bangladesh's current share of global trade is only 0.1% and this is dominated by imports, rather than exports. Dairy products, sugar and edible oils are the major imports. Export markets are largely limited to tea, jute, hides and skins, although significant progress has been made in shrimp exports in recent years. Exports could be enhanced by:

i. Establishing specialized agro-export processing of zones, linked with required support services including quality control facilities.
ii. Establishing national quality standards, with modem quality control laboratories.
iii. Further development of communication and port facilities, more airfreight space for perishables, and efforts to increase access of the international cargo flights.

Soil and water management

The rate of depletion of soil and water resources has increased during the past few decades and as a consequence, nutrient deficiencies are a major cause of declining crop yields. To reverse the trend, SRDI, BARI and BINA have collaborated in the Thana Nirdeshika Program. SRDI has completed land and soil resource surveys of 418 thanas. The area serviced by irrigation can be extended from the present 40% of the cultivated area to more than 80%. To achieve this, irrigation efficiency must be improved so that the available limited water can be distributed over a larger area. The Bangladesh Government has formulated NAP and Irrigation Policy where soil

improvement and efficiency of overall irrigation management, supplementary irrigation, and impact of irrigation have been given emphasis.

Commercialization

Agricultural commercialization would be a key avenue for transforming the largely subsistence-oriented farming by providing new opportunities for growth in horticulture and promotion of export-oriented processed food products. There are emerging signs of commercial elements in Bangladesh agriculture. Further growth of agriculture and rural economy as a whole largely depend on the commercialization of agriculture.

Agricultural mechanization

Due to gradual decrease of the availability of draft animal power, the use of power tiller for land preparation, threshing, irrigation, transportation, etc. is increasing. Mechanization must facilitate cropping intensification by overcoming peak demands for labor and draft power. Mechanization will increase overall demand for labor but not displace it. Farmers' cooperatives and credit support may be considered for the purpose. The Bangladesh Government has given emphasis for agricultural mechanization.

6 Gap analysis

There are different constraints and limitations in agricultural research that hamper the enhancement of yields, and certain requirements to be fulfilled for minimizing yield gaps. Some of these constraints and requirements are discussed below.

Soil-related problems

The organic matter (OM) content of most Bangladesh soils is low and different studies show that it is declining alarmingly. More than 50% of our cultivated soils have OM content below the critical level (1.5%). Besides, there are deficiencies of sulfur in almost 4.0 million ha and of zinc in 2.0 million ha of arable land. Salinity, soil erosion, micronutrient deficiency, waterlogging, and alkalinity are some of the problems that limit the yield gains and productivity.

Irrigation-related problems

Insufficient and inefficient irrigation facilities are major causes of low crop yield. Prices of irrigation appliances and inputs are also high. Availability of spare parts, fuel and electricity for low lift pumps and deep tube wells and timely and efficient operation of both public and private irrigation projects need to be ensured. Irrigation regulatory rules and regulations are to be formulated and enforced for efficient use of scarce irrigation water. The high cost of irrigation discourages the farmers - subsidized irrigation would encourage them to bring more areas under irrigation.

Research-extension linkages

Effective extension service could help farmers reduce the gap caused by different constraints and create appropriate physical and social infrastructures to achieve a more rapid rate of growth and development, which would result in

better levels of living. Strong research-extension and research-extension-farmer linkages should be developed for continuing technology identification, field variation, suitability assessment, adaptive modification, and packaging for large-scale dissemination. At present, there are District Technical Committees (DTC), Regional Technical Committees (RTC) and National Technical Committees (NTC) for dissemination of improved technologies in which the scientists and the extension personnel work jointly. Another important fact is that there are too few extension workers (Block Supervisors) at the field levels - one reason for this being lack of accommodation. Improved facilities would ensure the presence of more extension workers at the field level.

Feed for livestock

Feed scarcity is a major constraint to rapid growth of livestock and better livestock health. Poor animal health constrains animal survival, high reproduction rates, and high growth rates.

Land resource constraints

BARC has developed a geographic information system (GIS) that is used to estimate areas prone to drought, salinity, inundation, and ephemeral flooding. GIS can be used to analyze, summarize, and display many features of land and soil. Other GIS applications are preparing maps of available soil P and S status. The Soil Resource Development Institute is also responsible for soil testing and land zoning program, and maximum utilization of land for crdps by AEZs. Bangladesh Government has a Land Policy for this purpose.

Exploitable yield gap

There are wide gaps between the potential and realized yields for all crops in Bangladesh because of poor crop management, gap in technological know-how, and other socioeconomic constraints. The yield gap averages about 1.6 mt ha^{-1} for rice and 2 mt ha^{-1} for wheat. The yield gaps for Aman rice, onion, lathyrus (Khesari) and turmeric were found to be very high (Table 9). It is essential to minimize this yield gap by improving farmers' knowledge base, addressing farmers' socioeconomic constraints related to HYV cultivation, and appropriate technology transfer and input support for increasing overall production of the country.

Enhancing crop improvement

Conventional breeding systems can play a key role in enhancing the yield potential of crops but the availability of biotechnology tools could accelerate the transfer of genes from one species to another. This would open up new opportunities for developing HYVs that can produce high yields in varied agroecological zones. Germplasm enhancement to increase yield potential will be needed to bring more efficiency in breeding program.

Integrated crop management

Farmers need to follow the proven integrated crop management technol-ogies for higher yields. Location-specific

Table 9. Potential and existing yields.

(Figs in mt ha^{-1})

Crop	Potential yield	Attainable yield	Yield in farmers' fields	Yield gap
Aus rice	9.00	4.00	3.50	0.50 (14)
Aman rice	9.00	6.75	4.00	2.75 (68)
Boro rice	9.00	7.00	4.80	2.20(46)
Wheat	4.00	3.00	2.12	0.80 (38)
Mustard	1.50	1.00	0.73	0.27 (37)
Groundnut	2.20	1.70	1.26	0.44 (35)
Onion	14.00	10.00	4.10	3.90(95)
Turmeric	30.00	22.00	3.10	18.90(610)
Lentil	1.65	1.20	0.75	0.45(60)
Mungbean	1.17	0.88	0.68	0.20 (29)
Blackgram	1.50	1.12	0.76	0.36(47)
Khesari	1.63	1.21	0.84	0.79 (94)

Source: BARI Annual Reports & Field Surveys, 1990-2003.

Figures in parentheses represent the percentage of yield gap in the farmers' fields to the available yields.

AEZ-based production management technology packages for different crops should be developed and disseminated so that farmers can utilize these technologies easily. The Bangladesh Government has a Crop Production Policy where all issues relating to crop cultivation are well addressed.

Timely supply of quality seeds

Farmers keep their own seed for most of their crops. The supply of high quality seeds by the Bangladesh Agricultural Development Corporation is limited to 4% for rice, 22% for wheat, and 5% for potato. NGOs are also supplying some quantities of seeds. The present supply of quality seeds is only 6%, which is much less than the total requirement. The private sector covers only 14% and government sources 86% of the total seed requirement (Table 10). Timely availability and supply of ample quantity of quality seeds of desired varieties need to be ensured. The National Seed Policy promotes seed production and distribution.

Balanced and integrated use of fertilizer

Organic matter content of soil is very low and farmers seldom use balanced doses of chemical fertilizers. Farmers need to be trained and motivated to apply balanced

Table 10. Seed production and requirement, 2003-04.

(Figs, in mt)

Seed	Supply*			Requirement	Deficit**
	Govt	Private	Total		
Aus rice	20624 (94)	1246 (6)	21870	337750	315880 (7)
Aman rice	12446 (97)	336 (3)	12782	79200	66418 (19)
Maize	160 (24)	500 (76)	660	980	320 (206)
Jute	367 (36)	650 (64)	1017	4560	3543 (29)
Oilseeds	247 (93)	20 (7)	267	9033	8766 (3)
Pulse	125 (68)	60 (32)	185	18182	17997 (1)
Vegetables	14 (2)	614 (98)	628	1923	1295 (48)
Seed potato	9123 (72)	3625 (28)	12748	430500	417752 (3)
Total	43106 (86)	7051 (14)	50157	882128	831971 (6)

fertilizer doses in appropriate time as per requirement of the soil and crop.

Technology for biofertilizers

Biofertilizer is a cost-effective and renewable source of plant nutrients to supplement the chemical fertilizers. Bangladesh has made considerable progress in the development of bio-fertilizer technologies for lentil, chickpea, mungbean, cowpea, groundnut, soybean, and *dhaincha* production. Yield due to adoption of biofertilizer ranges from 15% to 200% in different crops, besides improving chemical fertilizer use efficiency. Steps may be taken for large scale manufacturing of inoculums in the country with the help of private sectors.

Integrated pest management

The main aim of IPM is to adopt environment-friendly plant protection measures that harmonize with other crop husbandry practices for attaining higher crop productivity. Farmers' training should be organized for improving the knowledge base of the farmers about the ill effects of chemical insecticides. A system should be implemented for managing different pests with minimal use of pesticides. The farmers should be encouraged to use IPM technologies like the use of poultry refuse and mustard oilcake, bishop traps and pheromone traps, grafting of tomato and eggplant, solarization, and sawdust burn for vegetable cultivation. Zones for insecticide-free vegetables should be developed and they can be linked up with exporters. The Government has a National IPM Policy to control pests and diseases to maintain ecological balance as well as grow healthy crops.

Nonconventional food crops

Cultivation of nonconventional food crops like yams, aroids, beans (e.g. bush bean, French bean, sword bean, winged bean, velvet bean), aquatic food crops

(e.g. lily, lotus, ghechu), and buckwheat can be popularized for enhancing of farmers' incomes. The extra income can subsequently be used for buying inputs for the major cereals, pulses and oilseeds.

Tenant-cum-absentee farmers

Absentee farmers do not take proper care of their lands or crop production management, which tends to reduce soil fertility, crop yield and quality. On the other hand, tenant farmers are often uninterested or reluctant to follow good management practices such as the use of high quality seed and recommended doses of fertilizers as they retain only 33-50% share of the produce. The system should be changed by suitable policies to enable peasants to own the land.

Agricultural credit and farmers' security

Most poor farmers cannot afford the high management expenses at different stages of crop production. Short-term credit at reasonable terms and conditions need to be provided to the needy farmers - this can be realized after crop harvest. Crops should be insured to save farmers during severe crop loss due to unpredicted natural calamities. It is necessary to expand the Grameen Bank scheme to cover most of the poor farmers in different Thanas.

Human Resource Management Information System (MIS)

The development of professional scientific human resources is an important factor for receiving the full benefit of technological innovations. Human resources are the main assets of a scientific institute, and well-educated, competent scientists who are trained well have high potential for enhancing agricultural development in the country.

Agribusiness

Agribusiness refers to the business that deals in agricultural produce, including the trading of raw materials used in the agroprocessing industry. The agribusiness industry benefits from research and development when it improves the competitiveness of its products. Agroprocessing and food processing industries need to be established at appropriate locations to utilize additional produce during peak harvesting time, which will minimize loss of perishable items and add value to the produce.

7 Agricultural research priorities

The research gaps identified by each research institute need to be noted and prioritized for implementation. There is tremendous scope for contribution of agricultural research to the development of HYVs and production technology packages that will help farmers increase production. Some possible areas of contribution could include:

i. Developing high-yielding varieties and hybrids with drought resistance, salinity tolerance, and flood tolerance
ii. Crop management practices and farm tools and machinery

iii. Different poverty alleviation and income generation programs
iv. Agro-based processing industries
v. Improved nursery, breeding, and hatchery management of carps
vi. Improved technologies for the production, storage, and distribution of seeds
vii. Cost benefit analyses of modern vs. traditional technologies for different crops
viii. Identification of constraints to marketing of different crops and suggestions for improvement
ix. Soil improvement programs
x. Cattle breeding and cattle feeding programs
xi. Plantation technique for forest

It is imperative that production per unit of land, labor, and water must increase dramatically if the growing demand for food is to be met by the agricultural sector. Other challenges like food security, crop diversification, environmental sustainability, poverty alleviation, and agricultural diversification must also be addressed for optimal agricultural development. Farm mechanization, commercialization of agriculture, and rural infrastructure development need to be emphasized. At the same time, all factors relating to yield gaps must be tackled seriously. The collaborative work of national institutes must be developed and the technologies they develop should reach and be applied in the farmers' fields through research-extension and research-extension-farmer linkages. To achieve these essential goals, new production technologies and other measures must be developed. It is the obligation of the NARS to develop the majority of the technologies required to modernize the agriculture sector.

Development of scientific and professional human capital is another important determinant for harnessing benefits from technological opportunities. There should be a clear policy framework for implementing an HRD program that especially addresses lacunae in high-technology areas. In order to realize the maximum benefit from the manpower resource, there is also the need to create a proper working environment conducive for the scientists so that they can give their best to the country. The incentive and reward system should be restructured in a way that inspires creativity, promotes excellence and sustains scientists' morale.

Further growth of agriculture and rural economy as a whole will depend largely on policy reorientation e.g. agricultural diversification, carefully selected input subsidies, output price support, credit supports, production of high value crops, processing and value addition of food crops, export of crop and noncrop products such as vegetables, spices, and shrimp.

Policies need to be streamlined to increase incentives for the private producers, marketers, processors, and distributors so-that they respond quickly to domestic as well as international market opportunities.

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Gap Analysis and Agricultural Research Priorities in Nepal

SL Maskey[1], HK Manandhar[2] and D Gauchan[3]

1 Introduction

Nepal is an agricultural country with two-third of its population of 24 million engaged in agriculture, predominantly subsistence level of farming. Despite continuous efforts in agricultural research and development, poverty alleviation and food security have been the two major challenges facing the country. At present, 38% of the population lives below the poverty line. The agriculture sector is often blamed for not meeting the challenges in the name of less available technology and ineffective technology delivery system. However, the fact is that the overall impact of agricultural research and development in the country has been greatly affected by the rugged topography, poor infrastructure (road, communication, electricity, market, etc.), small land holding size, limited arable land, low income, and high commodity prices in hills and mountains compared with *terai* and urban areas (Fig 1).

As Nepal's economy is largely agrarian, agriculture-led growth strategy is the only option for the country's broad-based economic development. This has been well stipulated in the Agriculture Perspective Plan (APP) and the current Tenth Five Year Plan (2003-2005) (NPC, 2003a), the latter focusing on poverty reduction strategy program (PRSP) (NPC, 2003b) through economic growth, equity and good governance. At the end of the Tenth Five Year Plan, it is envisaged to reduce the poverty level to 30% with an economic growth rate of 6.2% or to 33% with an economic growth rate of 4.3%. The objectives of the Tenth Five Year Plan are:

- Increased agricultural production, productivity and incomes for achieving food security and reducing poverty.
- Sustainable agricultural production through extension of adaptive research, protection and use of agricultural biodiversity and wider use of on-farm research.
- Promotion of agro-based industries and agro-business with effective

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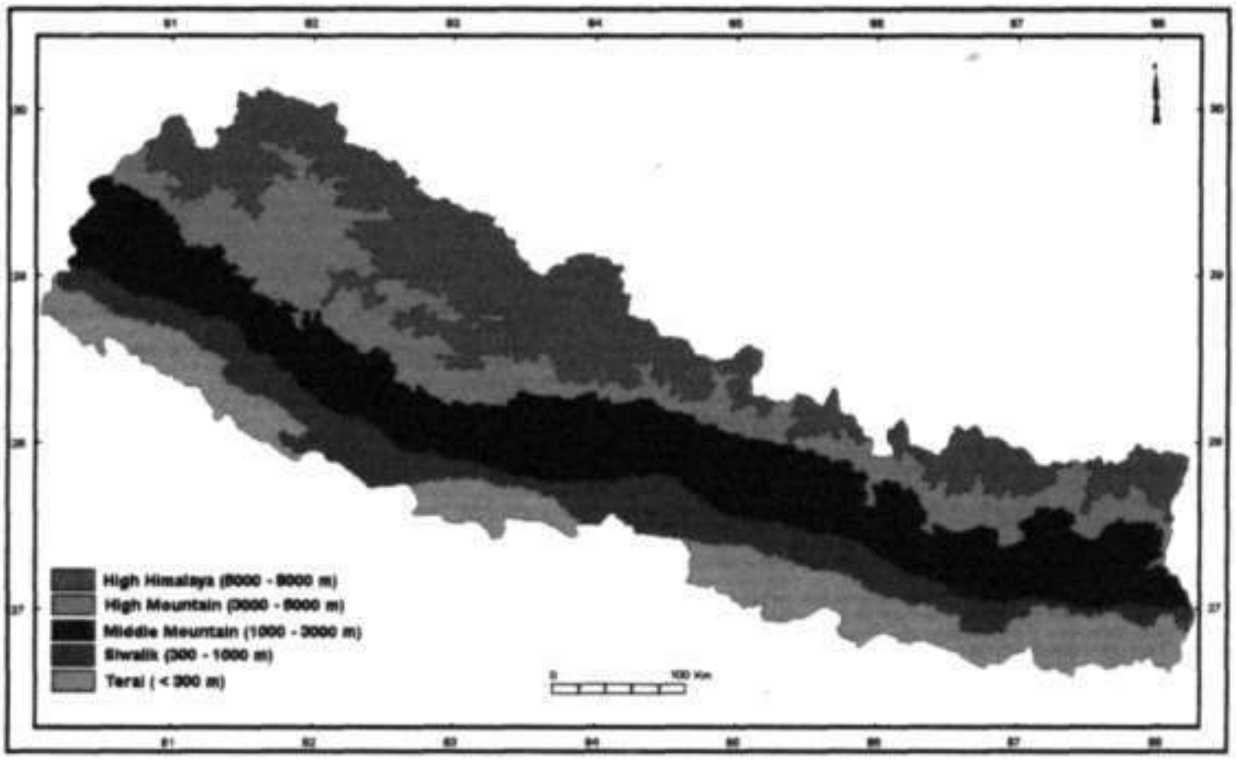

Figure 1. Physiographic regions of Nepal.

Source: Soil Science Division, NARC

participation of private and cooperative sectors.

2 Agriculture scenario

Agriculture is the mainstay of the Nepalese people. It presents the highest potential for growth and poverty alleviation, as the vast majority of people, and especially of the poor, lives in rural areas. Agriculture accounts for 39% of the GDP and 66% of the employment. Crops, horticulture, livestock and fisheries share 41%, 31%, 26% and 2% in GDP, respectively. Crop coverage is dominated by rice (35%), followed by maize (20%), wheat (16%), cash crops (10%), legumes (7%), minor crops (7%), and horticultural crops (5%). Area coverage by improved varieties of rice is 74%, by maize 69%, and by wheat 91%.

Productivity of most of the crops is far below their yield potential. Despite the increasing trend of rice, maize, wheat and potato yields (Table 1), the national average is below 50% of the attainable yield. Two-third of the agriculture is under rainfed conditions. Agriculture growth rate is 2.3%, which is slightly above the population growth rate of 2.24%.

The overall national production and requirement of cereals is more or less in balance (+80,022 mt). The total requirement is 4,463,027 mt. However, the production of cereals in different geographic regions has led to food deficit in mountain (-73,560 mt) and hills (-330,908 mt), and surplus in *terai* (484,490 mt) (Table 2). This has caused severe food and nutrition

Table 1. Growth rate of major crops of Nepal, 1993-2003

(Figs. in kg ha^{-1})

Year	Rice yield	Maize yield	Wheat yield	Potato yield
1993/1994	2410	1663	1470	8352
1994/1995	2124	1688	1508	8593
1995/1996	2391	1681	1550	8475
1996/1997	2455	1659	1607	8998
1997/1998	2417	1711	1610	8356
1998/1999	2450	1678	1695	9244
1999/2000	2598	1765	1793	9644
2000/2001	2703	1800	1806	10182
2001/2002	2745	1829	1886	10902
2002/2003	2675	1877	2009	10925
Growth rate %	3.57	2.67	1.85	2.44

Source: MOAC 2003

Table 2. National requirement of cereals, 2001/2002.

Belts	Population (millions)	Total edibles (million mt)	Requirement (million mt)	Balance (million mt)
Mountain	1.702	0.251	0.329	-0.735
Hills	10.344	1.750	2.082	-3.309
Terai	11.363	2.542	2.057	0.484
Nepal	23.408	4.543	4.463	0.0800

Source: Marketing Development Directorate, Department of Agriculture

insecurity for people in the remote hills and mountains.

3 Emerging challenges in agricultural research

Agricultural research in Nepal has changed over the last 15 years, having become more complex and challenging. Apart from increasing food production by narrowing the yield gap the present issue for Nepal is also to conserve valuable natural resources while sustaining agricultural production. Conventional thinking about agricultural research as a public good has changed and the involvement of nongovernmental and private sectors as partners in developing and promoting technologies has become today's demand. Some major strategic challenges are:

- Wide gaps in crop yields, research knowledge, information and linkage
- Partnerships in technology development and dissemination
- Socially responsible research agenda

- Commercialization of agriculture
- Environmental concerns
- Institutional rationalization
- Diversification of funding resources
- Globalization (World Trade Organization (WTO), The South Asia Free Trade Agreement (SAFTA), etc)

4 Agricultural research strategies

Nepal's current agricultural research and development scenario has evolved over the past 50 years. In the past, agriculture research was limited to sectoral and subsectoral research. It lacked a coherent, holistic and national system approach and the research remained mainly within the public domain. It was only in 1991 that the Government of Nepal, realizing the importance of agricultural research to the national economy, created the Nepal Agricultural Research Council (NARC) as an apex institution for policy coordination and implementation of agricultural research and development in the country.

NARC has developed its 20-year vision (NARC, 2001 NARC Vision 2021), which outlines a broad strategy for addressing the agricultural research needs of Nepal. The vision provides broad policy guidelines and direction for implementation of the program and activities of the agriculture, livestock, and natural resource research in Nepal over the 20 year-period of 2002-2021. It is a rolling plan, and so will require refinement and modification to address the changing needs of the agricultural research system in Nepal as demanded by the national policies and priorities.

The NARC vision focuses on poverty reduction through effective and efficient utilization of scientific information in agriculture and natural resources. The major agricultural research priorities as envisaged by NARC vision include field crops, horticulture, livestock, fisheries, and related natural resources issues, and socioeconomic aspects of the farming systems, price analysis and marketing, on-farm water management, agroforestry, gender, and above all, policy research.

For the implementation of its vision NARC has recently drafted a strategic plan (NARC 2004) that includes:

- Demand-driven and appropriate technology developed for priority client groups and fed into uptake networks.
- Demand-driven agricultural policy, trade, marketing and socioeconomic research conducted and fed into uptake networks.
- Coordination and networking enhanced to maximize the impact of agricultural research.
- Ability of NARC to achieve its objectives improved.
- Mandated direct services delivered appropriately.

NARC is promoting adaptive and applied research programs that are need based and demand driven. Priority has been given to research topics generated from village level workshops participated by researchers, extension workers, development agencies, and farmers' groups and supported by Regional Technical Working Groups (RTWGs).

5 Research priorities

Presently NARC is allocating its research resources in priority themes and commodities identified by the long-term Agricultural Perspective Plan (1997-2016) of His Majesty's Government of Nepal and the NARC Vision 2021. The priorities identified by the APP are:

- Major food crops: Rice, maize, wheat and potato
- High value crops and commodities: Citrus, apple, off-season vegetables, vegetable seed, sericulture and apiculture
- Dairy production: Animal nutrition, high-value fodder crops
- Development of soil fertility and shallow tube-well farming system
- Human resources development
- Development of a strong outreach research system
- Development of scientific research information system
- Development of close cooperation with other agencies of agriculture research

NARC Vision 2021 and the new NARC Strategic Plan have identified the following major research areas in Nepal:

- Hybrid varieties and breeds
- High value commodities
- Postharvest storage, handling and value addition
- Comparative advantage technology
- Biotechnology
- Policy, socioeconomic and market research
- Gender-related research

6 Research needs

There is a need for development of location-specific demand driven technologies employing system based participatory approach for improving the livelihood of the rural poor. NARC has identified research needs in the following commodities and research themes:

Food crops: High-yielding disease- and stress-tolerant varieties, including hybrids; high quality and nutrition-rich varieties; product specific varieties; low cost and resource conservation technologies (zero/minimum tillage).

Fruit crops: Orchard management, postharvest handling, processing and marketing, hybrid varieties.

Vegetables: Hybrid varieties, off-season production, integrated crop management, processing and product diversification.

Livestock: Dairy research and product diversification; crossbreeding for meat, milk and other products; low cost feed technology and animal health.

Fisheries: Enhancement of productivity of pond aquaculture; conservation and utilization of wet land/ghol; genetic improvement of aquaculture species for sustaining production and productivity; standardization and development of low cost feed and fish health.

Socioeconomic and policy research: Identification and analysis of comparative advantage commodities, research on marketing and value addition of high value crops, technology adoption, diffusion and impact studies, research prioritization, and policy analysis.

Biodiversity, genetic conservation and utilization: Diversity assessment, ex situ and in situ conservation, conservation cost-effective technologies, and value addition through breeding and nonbreeding approach.

Natural resource management: Agroforestry, sustainable soil and water management.

7 Gap analysis

The gaps in yield, knowledge, information and linkages and research are as follows:

Yield gaps

Generally, productivity (farm-level yield) of most food crops and livestock is low and falls below 50% of the attainable potential. The case is the same for priority crops like rice, wheat, maize, and potato. For example, the experimental yield of maize is 5 mt ha^{-1} and the national average is only 1.8 mt, while the attainable yield is 3.5 mt, which is two times more than the average yield. Similarly, the experimental yield of wheat is 4.8 mt ha^{-1} and the national average is only 1.8 mt, while the attainable yield is 3.2 mt. Figure 2a and b show the yield gaps for maize and wheat.

Knowledge, information, and linkage gaps

Knowledge and information gaps exist at different levels among scientific communities of different disciplines, between scientists and extension/ development agencies and between scientists and farming communities and agro-entrepreneurs. This is evident by the limited focus of research themes on the livelihood of rural poor, and lack of effective program level linkages and participatory research with farming communities and private sectors.

Research gaps

At present, the research program has given very little attention to the broad natural resources issues, technology adoption and impact studies, gender issues, market price analysis, policy research, water management, and agroforestry, postharvest operations, and value addition research. There is a need to shift the present focus of research from commodity and farming systems

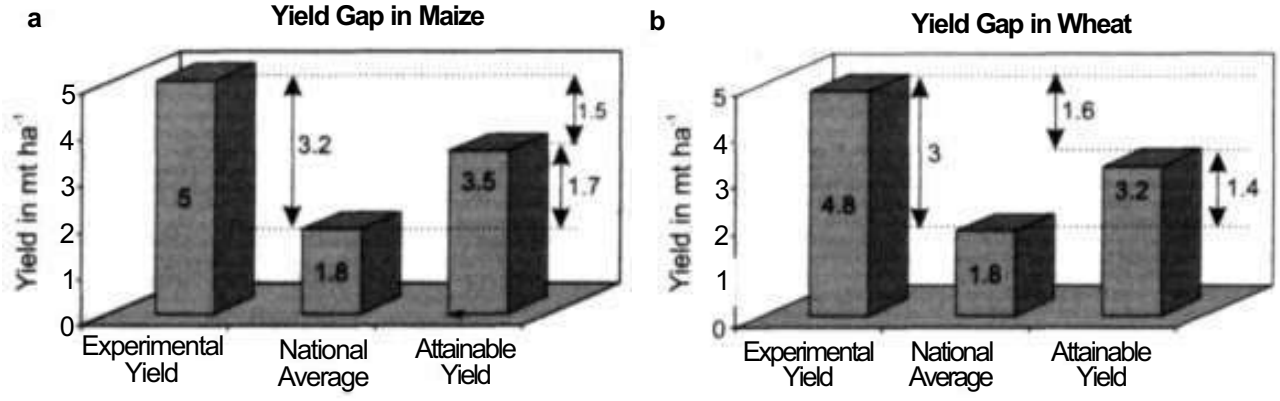

Figure 2a and b. Yield gap in maize and wheat.

(which focus on the components and structure of the on-farm activities) to the enhancement of the rural livelihood of poor people in which technologies developed and recommended need to fit into the livelihood strategies of the farming households. This shift is also imperative to meet the country's poverty alleviation goal as envisaged by the Tenth Five Year National Plan. Research and technology development need to meet the needs of small-scale, marginal, and resource-poor farmers and agroentrepreneurs who constitute the majority of the rural community and face their own specific set of problems and constraints in securing their household food requirements and undertaking commercially oriented activities. This is especially pertinent to those belonging to the deprived and minority ethnic groups. Technological development and dissemination need to be sensitive to the conditions of rural women whose contribution is often greater than that of men in the production, storage, processing, and marketing of crops and livestock products, and in the collection, utilization, and management of natural resources. Under the new strategy, agricultural research will be focused in such a way that gender concerns are properly accounted for while conducting research.

Steps needed to bridge the gaps

- Adequate investment in research and development with diversified funding sources
- Establishment of national level data/information knowledge bank (technology data bank, web page etc)
- Multidisciplinary participatory and livelihood-focused research approach
- Use of biotechnological tools for the speeding up of technological advances
- Integrated crop/breed management
- Collaboration among key stake-holders for research prioritization and implementation
- Upscaling and delivery of research-generated and locally developed technologies

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Research Need Assessment and Prioritization of Agricultural Research for Development: The Islamic Republic of Iran

Mohsen Mohsenin[1]

1 Introduction

Today, the global community faces serious challenges. Spiralling population growth, degradation of natural resources, water shortage, hunger, and poverty are among the complex issues that challenge the developing countries. In most of these countries, the most efficient way to solve these problems is to strengthen the agriculture sector. Sustainable agricultural growth is essential for improving the welfare of the vast majority of the poor in the developing countries who depend on agriculture. Even those who do not live in rural areas depend heavily on increase in agricultural productivity to lift them out of poverty. Thus, both urban and rural poor consumers depend heavily on the efficiency and productivity of farmers. Farm productivity and production costs largely determine the prices of basic foodstuffs, which account for 60-70% of total consumption expenditures by low-income groups. Consequently, significant reduction in poverty will hinge to a large extent on the collective ability of farmers, governments, and agricultural specialists to stimulate and sustain broad-based agricultural growth.

Overwhelming evidence from both the developed and developing world demonstrates that agricultural science and technology development is essential for agricultural growth. Public investment in research plays a vital role in this context.

The objective of this paper is to study the research needs, identify the research gaps and prioritize agricultural research activities in Iran within the broad research themes specified by APAARI.

2 Agriculture in Iran

Agricultural GDP

Agriculture is the second most important economic sector of Iran after the petroleum oil sector. It accounts for more than 25% of the GDP, 25% of the employment, 33% of the nonoil exports and about 90% of the raw material for industry. More than 40% of the population is directly engaged in agriculture. Therefore any improvement in agricultural productivity will directly affect their livelihood.

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Climate

Iranian climate is characterized by several different microclimates. Iran is a land of extreme temperatures, with differences between the lowest and the highest temperatures of around 35°C across seasons and in different regions.

One of the basic features of the climate in Iran is its extreme dryness in summers. Even in cooler seasons (fall, winter and the beginning of spring) there is limited rainfall, particularly in the plateau section of the country. The annual precipitation ranges from above 1,400 mm in the coasts of the Caspian Sea to 25 mm in the southeast of Dasht-e-Lut desert. The average precipitation of the country is about 240 mm yr^{-1}.

Agroclimatic zones of Iran

On the basis of the three criteria of moisture regime, winter type and summer type, 28 agroclimatic zones have been differentiated, of which only 6 (A-C-W, A-C-VW, A-M-VW, SA-K-W, SA-C-W, and SA-K-M) occupy nearly 90% of Iran (Fig 1 and Table 1).

Water

Water has always been a critical problem in Iran. Of the 400 billion m^3 of rainfall, 75% falls on only 27% of the land, and evaporation is also very high (70%). Of the total rainfall, 120 billion m^3 per year is surface runoff or percolates as groundwater, and the agriculture sector uses 82 billion m^3 of

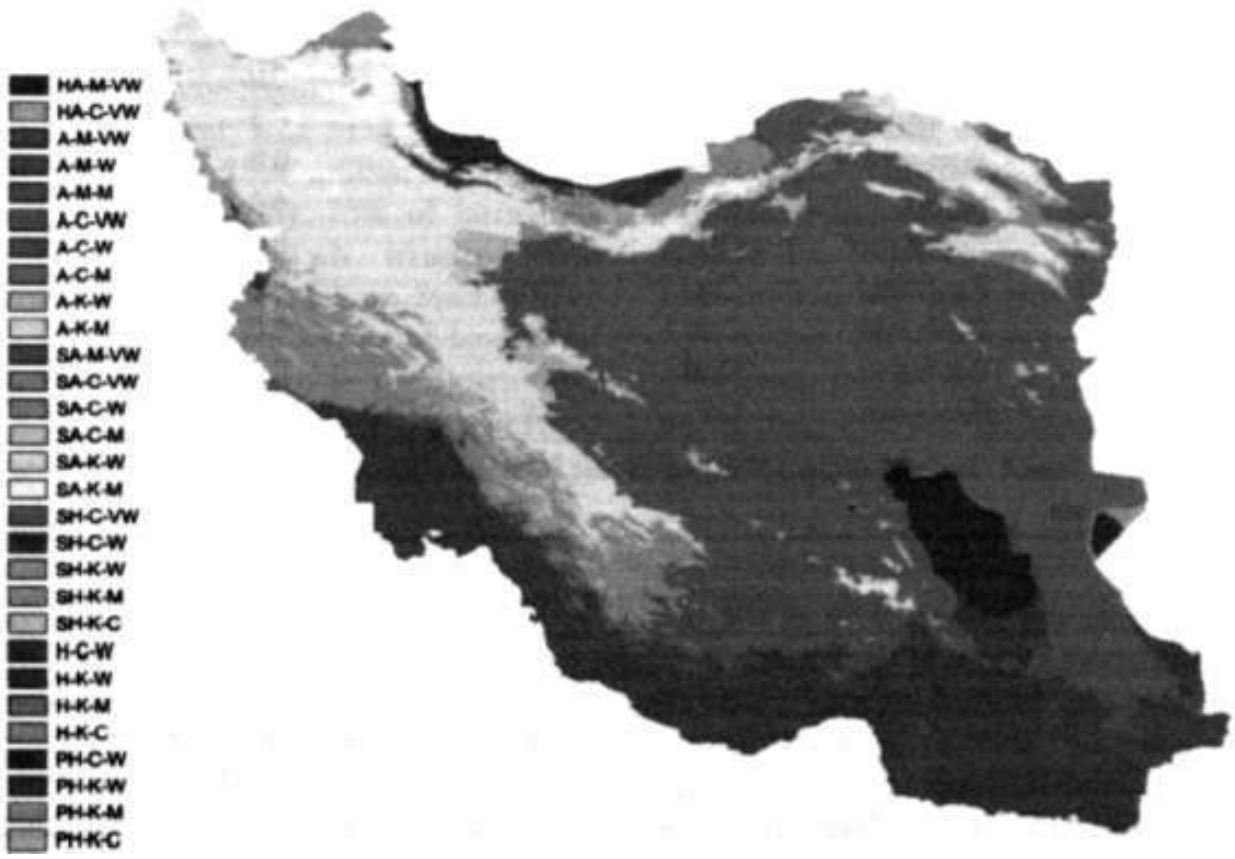

Figure 1. Agroclimatic zones of Iran

Table 1. Agroclimatic zones of Iran and their extent.

Symbol	Moisture regime	Temperature regime winter	Temperature regime summer	%of country	Approx. area (km^2)
HA-M-VW	Hyper-arid	Mild	Very warm	2.5	41,647
HA-C-VW	Hyper-arid	Cool	Very warm	0.2	3,687
A-M-VW	Arid	Mild	Very warm	16.7	286,822
A-M-W	Arid	Mild	Warm	0.6	9,705
A-C-VW	Arid	Cool	Very warm	18.7	305,814
A-C-W	Arid	Cool	Warm	26.2	429,257
A-C-M	Arid	Cool	Mild	0.0	11
A-K-W	Arid	Cold	Warm	2.3	36,485
A-K-M	Arid	Cold	Mild	0.2	2,758
SA-M-VW	Semi-arid	Mild	Very warm	0.3	5,380
SA-C-VW	Semi-arid	Cool	Very warm	1.6	26,454
SA-C-W	Semi-arid	Cool	Warm	7.3	117,526
SA-C-M	Semi-arid	Cool	Mild	0.0	8
SA-K-W	Semi-arid	Cold	Warm	17.2	271,593
SA-K-M	Semi-arid	Cold	Mild	3.0	47,039
SH-C-VW	Subhumid	Cool	Very warm	0.0	344
SH-C-W	Subhumid	Cool	Warm	0.5	8,380
SH-K-W	Subhumid	Cold	Warm	0.8	12,248
SH-K-M	Subhumid	Cold	Mild	1.0	15,529
SH-K-C	Subhumid	Cold	Cool	0.0	33
H-C-W	Humid	Cool	Warm	0.3	4,682
H-K-W	Humid	Cold	Warm	0.0	395
H-K-M	Humid	Cold	Mild	0.0	419
H-K-C	Humid	Cold	Cool	0.0	53
PH-C-W	Per-humid	Cool	Warm	0.5	8,502
PH-K-W	Per-humid	Cold	Warm	0.0	48
PH-K-M	Per-humid	Cold	Mild	0.0	8
PH-K-C	Per-humid	Cold	Cool	0.0	19

Source: E. De Pauw, A. Ghaffari, V. Ghasemi (2004). Agroclimatic Zones Map of Iran. Agricultural Research and Education Organization, Iran

the remainder (about 94% of the total water consumption of the country).

Despite limited water resources, which are the main constraint to agricultural development, the climatic diversity, soil, and trained manpower give Iran a considerable potential for agricultural development.

The water used for irrigation has increased from 49 billion m^3 in 1970 to 82 billion m^3 in 2000. Review of the water balance sheet of the country reveals that even if all the country's exploitable surface water is controlled, the agricultural sector will face a severe shortage of water in the near future,

due to population growth, expansion of urban areas, and development of the industry and services sectors. However, the efficiency of irrigation is very low - it has been calculated to be about 34%. It is planned to increase this rate to 47% by the end of the Fourth Development Plan (March 2010).

Land

About 90 million ha (54%) of the 164.8 million ha that constitute the total area of Iran are covered by pastures. Nomads, semi-nomads, and villagers use the pastures to graze their livestock. Nearly 12.3 million ha (7.5%) is covered by forests, of which 3.4 million ha is under natural forests of direct economic importance. According to some estimates, during the last three decades the forest area has decreased by more than 6 million ha due to overexploitation, overgrazing and conversion to arable lands.

The current area under agricultural production is 18.8 million ha (11.4%) (Table 2). Annually, 75% of farmlands are cultivated (both irrigated and rainfed) and 25% is fallow. Studies have shown that 32 million ha of land areas are fertile and suitable for agriculture, of which 10 million ha are classified as suitable for irrigation. During 1980-95, arable land and land under permanent crops have increased due to the pressure of population and growth in demand. However, due to expansion of urban areas and a spectacular increase in price of urban lands, the best agricultural lands surrounding the cities have been put to nonagricultural uses.

Crop production

The most important part of the agriculture sector (55% of the total value) is comprised of crop and horticulture production, excluding forage production. During the last 25 years, the volume of agricultural production (crops and orchards) has grown by about 5.7% annually.

Food grains (wheat, barley, and rice) are the most important crops that are cultivated in about nine million ha of land each year. The area under individual crops fluctuates from year to year, depending on rainfall and other conditions. However, wheat alone occupies between 6.5 million ha and 7 million ha, followed by barley (about two million ha), and rice (0.6 million ha). Other crops grown are legumes (chickpea, lentil and fababean) and oil seeds (brassicon and safflower).

Table 2. Area under cultivation and production, 1977-2002.

Year	Area (million ha)	Production (million ton)	Yield (kg/ha)	Per capita production (kg)
1977	9.3	18.7	2,010	530
1992	14.4	51.4	3,569	900
2002	14.5	71.3	4,920	1,080

Source: Ministry of Jihad-e-Agnculture. Agricultural Yearbooks

Livestock production

Livestock contributes about 43% to the total value of the agriculture sector. In addition to supplying meat, milk, milk products and manure, the livestock sector provides wool for the carpet industry, which is an important source of foreign exchange earnings.

The biggest role in livestock production is played by about two million transhumant pastoral migratory tribal people who move their herds and flocks to the mountains in summer and to the plains in winter. Between one-third and three-fourths of the sheep and goats fall in this category. Some of these pastorals have settled in the plains, where they grow cash crops. The government is helping nomads to settle on farms and is encouraging them to grow more feed and other agricultural products with the objective of slowing down the degradation of rangelands.

By and large, the pastures in Iran are overgrazed and have been depleted extensively. According to studies, 9.3% of rangelands are classified as grade 1 (good), 37.3% as grade 2 (medium) and 43.3% as grade 3 (weak). Not only are the rangelands being overgrazed, but the area under ranges is also gradually decreasing. Large areas of ranges have been plowed, either to prove or to gain ownership rights. If this trend continues, the end result will probably be barren lands, which will lead to critical soil erosion problems. High meat prices and weaker controls on grazing have led the nomads to increase the numbers of their sheep and goats. It is estimated that grazing is three times the carrying capacities of pastures.

Farm holdings

Iran has a high proportion of small farmers. Although there is no official classification of farmers in Iran, the widely accepted criterion is the farm size. With regard to fallow and rainfed lands, a large number of farms (78% of the total of 3 million) with an area of less than 10 ha fall under the category of small farms, of which 11% are below 1 ha. Farms under 10 ha occupy about 37% of the cropland and produce almost the same proportion of the agricultural output. However, they produce less than 10% of the marketed agricultural products. Small farmers are operating purely at subsistence levels, with no surplus for sale. Farms over 10 ha provide about three-quarters of the marketed supplies. Large farms (over 100 ha) are very few and make only a small contribution to the agricultural output of the country. The national farm size distribution for agricultural land is shown in Table 3.

The farms of the majority of farmers are dispersed in 5-6 plots. In small farms, the owner and his/her family supply most of the labor force. Therefore, women play an important role in food and agricultural production. Women's role differs in different social and cultural settings, cropping patterns and farm sizes. In the northern part of the country, women play a major role not only in farm management but also in meeting the labor requirements. The women's participation in other parts of the country is not as high as in the north. It is estimated that women's participation in planting is 27% and in other activities as high as 37%. In livestock production, women's share is 20% in grazing, 45% in feeding, 87% in milking, and 47% in other

Table 3. Size distribution of irrigated and rainfed farms.

Average size (ha)	Total area (ha)	Percent of total area	Percent area		Average size (ha)
			irrigated	rainfed	
Under 1	196	1.6	3.1	0.3	0.4
1-2	423	3.4	5.7	1.4	1.1
2-5	1630	13.5	17.4	9.3	2.4
5-10	2371	18.5	20.4	17.6	4.8
10-25	4467	35.5	29.1	40.7	9.8
25-50	1585	12.6	10	14.7	21.2
50-100	961	7.5	6.2	8.8	41.8
Over 100	947	7.5	8.0	7.1	118.5
Total	2580	100	100	100	4.9

Source: Statistical Center of Iran, Crop Sample Survey 1992, Tehran, 1993.

activities. In dairy production, women's share is as high as 86%. Also, women produce handicrafts and weave carpets in their free time. These percentages have not changed much during the past 20 years.

3 Agricultural research for development

Agricultural research in Iran dates back to more than 50 years. At that time, some pioneer research institutes were established: Razi Vaccine and Serum Research Institute (1924), Animal Science Research Institute (1933), Plant Pests and Diseases Research Institute (1943), and Seed and Plant Improvement Institute (1959). These institutes aimed to enhance the agricultural production by combating animal and plant pests and diseases, to mitigate the cyclical droughts, and to improve the productivity of agriculture. Later on, other institutes such as the Soil and Water Research Institute were established. In addition to these Institutes, the agricultural colleges conducted research projects on agriculture. However, the largest apex body for agricultural research in Iran is the Agricultural Research and Education Organization (AREO), which has a well-distributed network of 23 research institutes, 60 provincial research centers and 300 research stations that cover all AEZs of the country.

AREO has contributed greatly to the sustainable development of agriculture sector of the country by releasing large numbers of improved crop varieties; decreasing the application of pesticides; and introducing new soil management, crop, and animal nutrition methods to farmers and herders. Sixty new cultivars of various crops were released during the period 1996-2000 (before the merger of the Ministry of Agriculture and the Ministry of Rural Development). About 790,000 tons of breeder seeds and certified seeds of basic crops (such as

wheat and rice) were produced and made available to the farmers. AREO staff also inspected about 740,000 ha of private seed producing units in this period.

The agricultural research policies in Iran during the last four decades went through 3 major stages.

The 1st Stage: 1961-1978

The first stage began in the mid-1960s with a significant land reform that abolished the old feudal system. This involved the creation of 70 large agricultural production units with land holdings of more than 500 ha each, and 250 semi-large units with farms between 300 and 500 ha each. These units included agribusinesses, farm corporations, production cooperatives and large commercial farms that used the most modern methods of farming to enhance productivity. These were the pioneers of the green revolution in Iran. There were also 645,000 farmers with medium-sized land holdings of 10 to 300 ha. These farms were semi-mechanized and used tractors and harvesters for wheat and barley. The third group included the 2.2 million farmers with small farms ranging in size from 0.5 to 10 ha; these were not easily mechanized because of their small size and the shortage of financial resources. At this stage the research institutes focused almost all their activities on the needs of the large farms.

The 2nd Stage: 1979-1989

The second stage was the post-revolution and post Iran-Iraq war period. Due to these two important events and fluctuating policies, the agricultural productivity remained stagnant. The infrastructure investments for the agriculture sector were neglected. But the research on the production of high-yielding varieties, weed/pest control, and optimum fertilizer application continued using classical methods of research. During this stage, the concepts of better environment and sustainability of agriculture were almost forgotten, and all efforts were concentrated on increasing the production of staple food crops. The main concern was to provide subsidized food for the increasing urban population.

The 3rd Stage: 1989 to date

By the commencement of the First Five-Year Development Plan in 1989, the renaissance of the agriculture began. More funds were allocated to research, training, and extension. New HYVs for field crops, and in particular for wheat and rice, were released from research institutes; new vaccines and serums for animals were produced on a massive scale. Research projects were conducted for plant and animal improvement, better farming practices, pests and disease diagnosis and control, and soil and water improvement. During the Second Five-Year Development Plan that ended on March 2000, much attention was paid to restructuring of the organization, capacity building, and renovation of the agricultural research and extension body, there were many scientific achievements which helped to increase agricultural production. The result was a growth in productivity of field crops and orchards during this period. But

the dry farming (wheat, barley, pulses) did not show any significant increase in productivity, because research efforts were concentrated on irrigated farming till 1992 and the available technology could not address the need in increasing the productivity of dryland farming.

4 Emerging challenges in agricultural research

Despite the improvements in the last two decades, Iran's agriculture system has not yet achieved full efficiency and stabilization. The reasons for this are many:

- Poverty is widespread in rural areas, especially in dry farming areas. The research findings and the new technologies are rarely adopted by farmers, because of their unawareness of these technologies, lack of financial resources, and the unsuitability of the technologies for the small farmers.
- The huge migration of rural youth to urban areas and the aging of rural population have caused the villages in dry areas to become ghost villages.
- The transfer of capital from agriculture sector to other sectors is still under way.
- Natural resources have become vulnerable to shocks and stresses, affecting the livelihood of poor farmers in dry areas. Desertification and deforestation are still the main issues of concern.
- Ecological integrity and biological diversity has reduced; especially in the dry areas, leading to the downward spiral relationship between poverty and natural resources.
- Despite shortage of water, the water productivity is too low. The water use efficiency is less than 35%.
- Due to overexploitation of ground-water and improper irrigation the salinity problem has become more and more critical.
- The foodstuff storage, processing, and distribution systems are still elementary, resulting in high prices for consumers, low income for farmers, and high rate of wastage of produce.

5 Research needs

The *National Document of Agricultural Research and Training* (henceforth referred to as the Document) prepared by AREO is considered the base document of the Fourth Five-Year Development Plan for Agricultural Research (March 2005-March 2010). It has been compiled and presented to the Ministry of Jihad Agriculture. The Document will then be presented to the Management and Planning Organization and then to the Parliament for final approval. This is a very important document as it covers more than 90% of the agricultural research in Iran. Therefore it is worthwhile to mention the main sections of the Document here.

Objectives

The objectives set by the Document are: the achievement of food security, environmental sustainability, relative self-sufficiency in main foodstuffs, higher level of income for farmers, and a balanced development between agriculture and other sectors of the Iranian economy.

Increased mechanization and extensive use of modern technology will be promoted to support and drive the desired changes in farm and agricultural production systems.

6 Agricultural research strategies

The long-term growth and development objectives for the creation of a modern and competitive agriculture sector will be achieved through the implementation of the following strategies:

- Increasing the food security indices, by giving priority to livestock and fisheries.
- Increasing the production of agricultural products especially the strategic products (wheat, barley, rice, oil seeds, sugar-beet).
- Dry farming. The importance of nonirrigated production and rainfed farming, which cover more than 40% of the cultivated area of the country, have opened new horizons for research in dry farming and arid areas. Since most of the research efforts in the past have concentrated on the areas with prime lands having irrigation facilities, the nonirrigated areas have benefited little from research in optimizing their production potential. Fortunately, research in this direction has already begun in research/ extension farms in collaboration with international research centers. New varieties have been released and are being adopted by farmers. In the Document, enhancement of dry farming and development of crop varieties compatible with unfavorable conditions of marginal lands are emphasized.
- Developing new technologies (biotechnology, nanotechnology and genetic engineering) in production and processing of agricultural, horticultural, livestock, and aquatic products as well as medicinal plants.
- Improving the nutritional quality of food, including biofortified crops.
- Increasing water productivity. The agriculture sector *is* facing the increasing limitations of available water resources due to an increase in competing demands for water (urban and industrial).
- Development, utilization, and conservation of plant genetic resources and genetic diversity.
- Strengthening the role of the private sector. Considering the fact that 90% of the agricultural production results from private sector activity, promoting the investment of this sector is essential for the development of agriculture. Therefore, improving the rate ofcapital return and enhancing the competitiveness of the private sector through the application of knowledge is essential and is regarded as one of the most important incentives for increasing productivity. Promoting the development of private extension and training services as well as due attention to women's educational needs are among the priorities of the Document.
- Developing new methods for increasing the productivity of agricultural inputs and production factors in a sustainable way, without degrading soil and water resources. Working on soil plant relationship with the objective to achieve balanced plant nutrition

and to maintain soil productivity, decrease pesticide use, and conserve genetic resources of the country continue to receive high priority.
- Developing intensive cropping (greenhouse production).
- Enhancing the productivity and decreasing the losses of agricultural produce. A sustained growth of agriculture in coordination with other economic sectors will ensure food sufficiency including proper storage, value-addition, and food processing. Efficient waste management including recycling the wastes to produce useful products such as enzymes and feed has become a priority in the future R&D.
- Improving the exportable products.
- Increasing resistance of horticultural crops to abiotic and climatic stress with priority to cold stress.
- Developing technologies for control of major plant and livestock diseases, pests, pathogens, weeds, and harmful animals.
- Enhancement of applied and development research activities in forests, rangelands, and watershed management.

It is planned to reach the above-mentioned objectives by implementation of 41,000 research activities through 10 Master Plans.

Main research activities

- Horticultural research
- Poultry and livestock research
- Aquatics and fisheries research
- Forests, rangelands, and watershed management research
- Biotechnology, nanotechnology, and genetic engineering research
- Research on productivity and agricultural waste management of basic products
- Research on quality of agricultural products
- Combating livestock and aquatic diseases, and diseases common between animals and human beings
- Protection, collection, assessment, revival, and development of agricultural, horticultural, rangeland, livestock, poultry, and aquatic genetic resources
- Information and communication technology
- Development of agricultural and natural resources research parks

Water challenge: Karkheh River basin challenge program project

A new approach to agricultural research is being applied in the western part of Iran to address the water challenge and rural poverty in the area. These projects are among the 16 projects that have been approved by the CGIAR in the Water for Food Challenge Program. The projects are to be implemented by the International Center for Agricultural Research in the Dry Areas (ICARDA) in Karkheh River Basin in collaboration with AREO (as main partner) and other international and national agricultural institutions. One of these projects is designed for improving onfarm agricultural water productivity, while the other is for strengthening the livelihood resilience in upper catchments of dry areas.

7 Gap analysis

Despite the attempts made by the concerned authorities of the agricultural research sector to compile a wide-ranging program for the development of agricultural research in the Document, there are still a multitude of issues that are either not mentioned or emphasized in the Document:

- Setting priorities for agricultural research and rural development issues
- Research on socioeconomic issues
- Research on gender issues and women's participation in agricultural practices
- Integrated farming system approach
- Marketing and postharvest technology
- Integrated soil and water management
- Integrated crop-livestock farming system
- Agroforestry, especially in the dry areas
- Optimization of resource utilization and exploitation
- Integrated natural resources management (INRM)

Bridging the gap

The following activities should be performed in order to bridge the mentioned gaps:

- Strengthening research systems
  - Restructuring the agricultural research system
  - Higher research investment
  - Human resources development: enhancing the capacities of planners and researchers by training
  - Applying logical methods for research priority setting based on a bottom-up approach
  - Multidisciplinary research and adoption of holistic approach in agricultural research planning
  - Strengthening the link between research, extension, and end users (farmers and consumers)
  - Participation of stakeholders in planning, implementation, and monitoring of research activities
  - Strengthening the monitoring and evaluation mechanisms by establishing a data collecting system to be used in M&E activities
  - Establishing a follow up and impact assessment system
  - Changing the mode of system from research oriented to demand oriented
- Upscaling and outscaling of research findings
- Enhancement of research on socio-economic and gender issues
- Setting theme priorities for each of the identified agroecosystems.

8 Implication on agricultural research priorities

Systematic prioritization of the activities to bridge the gaps is of prime importance and should be done as soon as the identification of gaps has been completed. Some of the gaps may need a multidisciplinary approach to be bridged and some of them are out of the domain of agricultural research. All the related institutions should take the responsibility of their related issues and

at the same time keep their activities in concordance with other stakeholders. In all the phases, an independent group should apply an efficient system of monitoring and assessment.

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Synthesis

Cynthia S Bantilan[1] and Mruthyunjaya[2]

The last four decades have witnessed impressive gains in food production, food security and reduction in rural poverty in developing countries thanks largely to the use of modern technology, development of high-yielding varieties, and intensive use of irrigation and fertilizers. However, there has been a skewed distribution of such gains. Low productivity, water scarcity, degradation of natural resources, widespread poverty, globalization, and WTO issues are threatening to further marginalize agriculture and livelihoods of poor people. Since agriculture is the dominant economic activity in these countries, enhancing productivity, profitability, and employment in agriculture is vital for improving the well-being of the poor. In this context, enhancing public investments in agricultural research and technology development assumes critical significance.

Given the limited resources available for public research investments; competing demands including research investment demand; and the need for greater, wider and quicker impacts; research prioritization is essential for optimal development of agriculture. The Asia-Pacific Association of Agricultural Research Institutions, after developing broader research priorities for member countries in the Asia-Pacific region, felt the need for a critical gap analysis for a clear and comprehensive assessment of research needs that require priority attention. In earlier studies, APAARI had listed certain broad research themes that should be prioritized in all the developing countries (See Mruthyunjaya et al., this volume) However, since the need was felt to further identify local priorities within the framework of these broad priorities, APAARI, in collaboration with ICRISAT and NCAP of ICAR organized an international workshop on "Research need assessment and prioritization of agricultural research for development in South and West Asia", on 7-8 October 2004 at ICRISAT, Patancheru. The primary objective of the workshop was to identify research priorities at the micro-level based on gap analysis by national programs in South and West Asia. The specific objectives of the workshop were (a) to develop a set of recommendations on research priorities based on gap analysis for South and West Asia and influence the global research agenda; and (b) undertake a synthesis of the regional research needs and priorities for South and West Asia. The workshop was structured into five sessions: an inaugural session, three technical sessions and a concluding session (see Annexure-IV). There were 40 participants including country representatives of South and West Asian NARS (India, Sri Lanka, Bangladesh, Nepal, and Iran), CGIAR institutes, donors, NGOs, farmer associations,

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agricultural universities, and the private sector. The list of participants is given in Annexure-V

In the inaugural session, the Director General of ICRISAT, Dr William Dar, extended a warm welcome to the participants and featured this workshop as part of APAARI, ICRISAT, and ICAR's ongoing collaborative effort to establish a demand-driven research agenda based on a participatory approach. Dr RS Paroda presented a detailed background of the research priorities initiative, highlighting the objectives, functions, strategies and action plan of APAARI, and featured the major issues for consideration that include gap analysis, implications of the existing network, development of new proposals and partnerships, and funding strategy. Dr Cynthia Bantilan, leader of Global theme on SAT Futures and Development Pathways of ICRISAT, highlighted the objectives of the workshop. Representatives of five South and West Asian countries presented country papers on research needs and priorities.

Socioeconomic profiles

The South and West Asian countries have similar sociopolitical institutions and economic, agricultural, and governance systems although they differ considerably in terms of size of population, geographical area, and economy (see Table 1). All these countries are classified as low-income countries. Though these countries have improved their economic performance in the 1990s, they suffer from other problems such as unchecked growth in population; a large percentage of the population below the poverty line, particularly in rural areas; and malnourishment (particularly among women and children) (Mruthyunjaya et. al. 2003). Despite all these odds, these countries have made tremendous

Table 1. Basic socioeconomic indicators for South and West Asian countries, 2003.

Indicator	Bangladesh	India	Iran	Nepal	Sri Lanka
GDP, current (billion US$)	51.90	599	137	5.80	18.50
GDP growth (annual %)	5.33	8	5.90	2.98	5.50
Agriculture, value added (% of GDP)	21.73	22.68	10.80	40.14	19.72
Export of goods and services (% of GDP)	14.22	14.86	25.06	14.38	34.96
Trade in goods (% of GDP)	29.45	20.78	43.08	35.81	65.21
Population, total (millions)	138	1060	66.40	24.70	19.20
Population growth (annual %)	1.74	1.49	1.29	2.19	1.18
Literacy rate, adult female (% of females ages >= 15)	31.40	..	70.40	26.38	89.62
Literacy rate, adult total (% of people ages >=15)	41.09	..	..	44.01	92.08

Source: World Bank 2003

progress in terms of achieving self-sufficiency in food grain production and, increased milk production. Crop yields and productivity of agricultural workers are still low in the region, irrigated area is limited, and per capita availability of land is steadily declining. Furthermore, declining farm size, creation of limited or no additional employment opportunities in agriculture, natural resource degradation, and management of new challenges from the global developments in trade are all taking their toll in these countries. Health issues are also affecting the often uneducated and poor agricultural labor segment. Institutional and policy responses to address these issues have also been either inadequate or not effective enough. Research intensity is very low in these countries (except India) with a spending of less than 0.3% of AgGDP on agricultural research and education (Mruthyunjaya et al. 2003).

High population growth, degradation of natural resources, shortage of water, hunger and poverty are among the most complex issues that challenge these countries. Agriculture, being the main source of income in all these countries, must address such critical concerns as food and nutritional security, employment and income generation, and alleviation of poverty. The allied sectors of horticulture, animal husbandry, dairy and fisheries must also be promoted and tapped in order to improve the overall economic conditions and health and nutrition of the rural masses. In most of these countries, the most efficient way to solve these problems is to strengthen the agriculture sector and ensure its sustainable growth and thus improve the well-being of the poor, both in rural and urban areas.

In this scenario, stepping up public investments in agricultural research and technology development is of critical significance. In India, use of modern technology, HYVs, and intensive use of irrigation and fertilizers led to impressive gains in food production, food security and reduction in rural poverty. In Nepal, despite continuous efforts in agricultural research and development, poverty alleviation and food security have been the two major challenges facing the country. Agriculture is blamed for not meeting the challenges in the name of less available technology and ineffective technology delivery system. But the overall impact of agricultural research and development in the country has been greatly affected by rugged topography, poor infrastructure (road, communication, electricity, market etc.) smaller land holding size, limited arable land, low income and high prices in hills and mountains compared with terai and urban areas.

In Bangladesh, the growth potentials of major crops and agricultural commodities are two to three times more than the present levels of production. Therefore, developed and sustained agriculture would go a long way toward providing increased production, helping to reduce food deficit and shortage of industrial raw materials, and providing employment opportunity with reasonable income. The consequent increase in productivity and income, along with self-reliance in food, could result in a more desirable socioeconomic and institutional frame-work as part of the development process.

In Sri Lanka, agricultural production has been declining over the years and the food imports are going up. The traditional crops of rice and rubber are losing areas while an upward trend is noted in case of coconut, floriculture, tea, and spices.

Country papers

The country paper of India, entitled "Research need assessment and prioritization of agricultural research for development: India", provided a comprehensive model framework for the other country papers. The presentation mentioned that India achieved an impressive agricultural growth in the postindependence period but there were increasing concerns about the skewed regional and economic class distribution of benefits and the long-term sustainability of agriculture. To improve the relevance of research, research priorities have to be set both at the macro level as well as at the micro level, with a mechanism to bring out convergence between the two.

The disturbing trends on the agricultural front such as decelerating public investments and declines in growth rates of production and productivity, along with the increasing problems of growing water scarcity, land degradation, lack of service and support systems were stressed. Amidst all these challenges, the research system has to cater to location-specific problems and needs. The Innovations in Technology Dissemination (ITD) component of the NATP followed the bottom-up approach to prepare the SREP for 28 districts drawn from seven states of the country. These districts covered four major production systems in the country with the exception only of the arid agroecosystem. In each district, separate prioritization of research and extension problems was attempted for each of the AES (2 to 6 per district). When the research needs were identified and compared with the research portfolio of about 850 projects funded under NATP, considerable gaps were noticed between them. Major research gaps existed in the theme areas of genetic improvement and NRM (including IPM and IPNM). The identified gaps, if classified alternatively, mostly fall under the themes of sustainable seeds and technology systems, livestock, and commercialization and diversification of production systems in that order. As regards different ecologies, research gaps are highest in hill and mountain and irrigated agroecology followed by coastal and rainfed agroecologies. Under each of these categories, the specific research gaps that have been identified need to be prioritized and assigned to research and extension institutions located in the regions to be appropriately addressed.

The country paper of Sri Lanka highlighted the drastic changes going on in Sri Lankan agriculture. Agricultural production is declining, food imports are going up, the traditional crops of rice and rubber are losing areas, and an upward trend is noted in coconut, floriculture, tea and spices. Uncertainty of funding, lack of priority-setting mechanisms and inefficient management of available resources plague the research system in Sri Lanka. There are problems of coordination as six ministries deal with agricultural research. Priorities of research are set based on five criteria with 30% weight given to income and employment generation. The formal priority setting methodology was complemented by discussions with the

agricultural department to arrive at the National Agricultural Research Priorities for the period 2004 to 2006. A process has been initiated to develop a strategic research plan and a human resource development plan to consolidate the NARS on a long-term basis. The priorities identified have been listed in the paper, and are as varied as plant breeding/ genetic improvement of commercially important crops and underutilized crops, hybrid seed development, biotechnology, conservation and utilization of genetic resources.

The country paper of Bangladesh highlighted the good progress made in agriculture by Bangladesh after independence, but also brought out the fact that there is a supply gap of 6 million t with respect to food grains and that 87% of the export earnings come from agriculture. The research system, which is functioning under the umbrella of BARC, is working on the regional and local problems. The government has targeted a 21% increase in food production between 2000 and 2025, for which the growth rate of agricultural production has to be stepped up from the present level of 2.6% per year to 3.6% per year. About 30% of the net sown area is saline and hence soil health issues need to be addressed on a priority basis. The food security of the 50 million poor is also a matter of concern. The government is planning to increase the irrigation coverage to 80% from the present level of 40%. The research and extension linkages need to be strengthened to achieve the short-term and long-term objectives of the agricultural sector. The returns to investment on agricultural research and extension need to be assessed. The major research priorities include (i) development of modern, hybrid and super varieties, (ii) crop management practices (iii) farm tools and machinery, (iv) poverty alleviation, (v) agro-based processing, (vi) breeding and hatchery and nursery management of carps, (vii) technologies for the preservation and storage of seeds, (viii) identification of constraints to marketing of crops and suggestions for improvement, (ix) development of drought-resistant, salinity-tolerant, flood-tolerant, and short-duration varieties, (x) tissue culture propagation, (xi) soil improvement, (xii) cattle breeding and cattle feeding, (xiii) plantation technique for forest, and (xiv) development of MIS and GIS system.

The country paper of Nepal highlighted the progressive increase in rice and wheat yields and the fact that food production at national level is in excess due to surplus in the terai region that covers the hill/mountain deficit. Since Nepal has joined WTO, trade has become a challenge. The research priorities of the APP (1997-2016) include food crops, high value crops, dairy production, soil and water, human resources, outreach and developing scientific research information system. In the vision of NARC, the research priorities include crops, natural resources, marketing human resources, and gender. The research needs that were enumerated include food crops, fruit crops, vegetables, livestock, fisheries, socioeconomic and policy research, biodiversity and NRM. The research gaps prioritized were in yields, knowledge and research, disciplinary focus and linkages between science-extension and research-farmer. The

steps needed to bridge the gaps were investment in R&D, knowledge and information, livelihoods analysis, biotech tools, IPM, stakeholder consultation, up scaling and delivery of research tools. Despite several constraints, Nepal has achieved distinction in decentralization, participatory forestry, and marketing. Yet less favorable production environments (mountain and hill regions) and leveling of production disparities across regions vis-a-vis subsidies for agriculture and inputs need to be given priority.

The country paper of Iran mentioned that climate and water scarcity are significant limiting factors for agricultural production in Iran. Horticulture, especially dry fruits, is important in Iran but postharvest and marketing problems exist. Gender distribution of labor in various agricultural activities is discussed in detail. Emerging challenges in agricultural research were noted as poverty, agricultural wastes, rural-urban migration, capital flight from agriculture, natural resource degradation, low water productivity salinity, desertification, food safety, storage, climate change and drought. The main agricultural research needs were emphasis on food security, increase in agricultural production through dry farming and increase in water productivity. Agricultural research gaps were identified as were the activities required to bridge these gaps.

During discussions on the country papers, it was suggested that research on small areas be considered the basis for maximum impact, matching research needs of farmers (particularly small and marginal) with research agenda of research institutions, more objective research prioritization, effective and functional feedback system for on-course correction of research, balanced allocation of research resources, and considering futuristic needs while prioritizing research.

Research priorities of IARCs, NGOs, and the private sector

There were nine presentations by IARCs and six presentations by different NGOs, Farmer Organizations, and Private Sector and Research Institutions.

The presentation on IFPRI highlighted the Institute's vision and focus on technology, institutions, infrastructure, and policy. IFPRI's South Asia strategy process is yet to be launched. The Institute's priorities are in line with the priority areas identified by Global Forum on Agricultural Research (GFAR) and CGIAR. The GFAR priorities are:

- Genetic resources management and biotechnology
- NRM and agroecology
- Commodity chains (production and consumption) and underutilized species
- Policy management and institutional development
- Sustainable financing mechanisms

The CGIAR priorities for Asia are

- Enhancing germplasm through conventional approaches and biotechnology
- Sustainable production systems
  - Integrated crop and livestock systems
  - Systems for drought-prone areas
- Strengthening of NARS and other rural institutions

- ❖ Building the organization and management capacity of NARI
- Improving policies
  - ❖ Postharvest value addition and processing
- Germplasm collection and conservation; saving biodiversity
- Crosscutting activities
  - ❖ Better and stronger impact work in and on systems
  - ❖ Development of new research tools (biotechnology and genomics)
  - ❖ Development of new information tools
  - ❖ Identifying poverty: mapping location

The International Potato Center (CIP) highlighted priority needs for potato improvement in South Asia. The mandate crops and activities of CIP include potato and sweet potato, and NRM. CIP's activities in Asia mainly focus on Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. CIP's research areas in the different regions of the world are:

- Germplasm supply to participating NARS
- Assistance in evaluation of germplasm
- Dissemination of improved technology
- Crop diversification issues involving potato
- Mountain agriculture
- Peri-urban agriculture
- Socioeconomic analysis of the transfer process and impact of new technologies

The International Plant Genetic Resources Institute (IPGRI) highlighted research need assessment and prioritization of PGR activities in South Asia. IPGRI essentially works on crops that other CG centers are not addressing on, including coconut, banana, plantain, tropical fruits, and forestry species. The research priorities are germplasm collection, characterization, exchange and conservation, HRD and capacity building. The future thrust of the Institute is on

- Diversity for livelihoods
- Understanding and managing biodiversity
- Improving livelihoods in commodity-based systems
- Global partnership
- Public awareness
- Policy and law
- Capacity development
- Knowledge management

The International Livestock Research Institute (ILRI) highlighted the assessment and prioritization of international livestock research-for-development. ILRI positions its research at the dynamic interface of poverty alleviation and livestock to sustainably enhance the livelihoods of the poor. ILRI's research addresses three pathways out of poverty:

- Securing the assets of the poor,
- Improving the productivity of their livestock systems, and
- Improving their market opportunities.

ILRI and its partners address five priority interdisciplinary themes:

- Targeting research and development opportunities
- Enabling innovation
- Improving market opportunities

- Biotechnology
- People, livestock, and the environment

The International Water Management Research Institute (IWMI) highlighted South Asia regional strategy for 2004-2008. The overarching research question for IWMI is "How can we grow more food and sustain rural livelihoods with less water in a manner that is socially acceptable and environmentally sustainable?" The centerpieces of IWMI's strategy in South Asia are:

- Develop and strengthen strategic partnerships within the region and internationally to exchange cutting-edge approaches to research and policy,
- Undertake applied and policy-oriented research while effectively building on regional research capacity (conventionally defined NARES, universities, knowledge-based NGOs, and civil society organizations), and
- Disseminate IWMI's and partners' outputs in order to achieve policy impact at a range of levels.

The three central priorities for agricultural water and land management in the region are:

- Water resources and land use implications of water scarcity, particularly focusing on institutional responses to river basin closure.
- Minimizing the tradeoffs between water use by agriculture and the environment, assessing upstream-downstream tradeoffs in watersheds, smallholder management options, compensation for environmental services, ecological amenities, and water security.
- Urbanization and the impacts of mega-cities on water for agriculture and the environment in a river basin context.

The following are first-cut priority focal areas for theme/ cross-theme programming by IWMI in South Asia:

- Krishna, Rechna Doab, Ruhuna Benchmark Basins: focusing on improving water productivity
- Smallholder land and water management ("watershed management") potential in the light of historical canal irrigation investments and future river linking in India. Nepal-North India linkages are evident in watershed-irrigation co-management.
- Smallholder "watershed management" across regional South Asia-Africa South-South partnership particularly focusing on institutionalizing community-based approaches
- Northern and eastern region development in Sri Lanka
- Multiple uses of water, focusing primarily on productive (irrigation) + domestic (drinking)
- Wastewater use and growing urbanization: Faisalabad, Musi, and other locations
- Irrigation sector reforms, particularly 2nd generation IMT/PIM issues: A.P., Gujarat, Maharashtra
- Surface irrigation - groundwater conjunctive use and management, salinity and sustainability trends, particularly relevant for NW India and Pakistan, and further development of groundwater in Eastern India and Bangladesh.

- Irrigation impacts and assessment of the Indian experience
- Fluoride and arsenic in groundwater, health impacts, sustainability: Central-western India, Indo-Gangetic Plains, and Bangladesh

The Asian Vegetable Research and Development Center (AVRDC) highlighted opportunities for smallholders in fruits and vegetables. The priority thrust areas of AVRDC are:

- Postharvest losses/technology
- Integrated pest and disease management
- Safe vegetables
- Small farmers and supermarkets
- Organic vegetables

These priority areas are focusing on developing high nutritional content, high value vegetables.

ICRISAT highlighted on research need assessment and prioritization of agricultural research for development in SAT Asia. ICRISATs goal is to harness the power of technology for development, food security, poverty alleviation, and environmental protection targeted at poor rural families in general, and women in particular. This is *Science with a Human Face:* research not for its own sake, but targeted at specific goals and implemented through genuine partnerships. In line with APAARI Vision 2025, the goal of ICRISAT for SAT Asia is to contribute to sustainable improvements in productivity of agricultural systems and to the quality of natural resources in SAT Asia. A multi-pronged approach for sustainable livelihood in SAT Asia identified water as an entry point with strategies for diversification, marketing and commercialization, institutional innovations, strengthening of basic infrastructure, better targeting of the poor, and building partnerships, focusing on salient problems of SAT. Based on a comprehensive needs assessment in SAT, the priority research outputs are:

- Improved germplasm, parental lines and HYVs for SAT crops developed and available

  More sustainable soil, water, crop and nutrient management and innovative watershed management options developed and available
- Strategies to improve product market linkages developed and disseminated in SAT Asia
- Institutional and policy recommendations to support livelihoods developed in SAT Asia
- Best-bet technologies for diversified and sustainable crop-livestock production systems developed and disseminated in SAT Asia
- Strategies for efficient seed delivery systems for mandate crops developed for SAT Asia
- Validated research methods for rainfed agriculture relevant to capacity development of partners in SAT Asia promoted

The International Rice Research Institute (IRRI) presented "Rice research need assessment and prioritization", covering the following:

- Challenges and opportunities for rice research
- Rice research need assessment and prioritization
- Program highlights

- Assessment of IRRI's research priorities and the mode of conducting research.

Integrated Mountain Development (ICIMOD), spoke about the research areas and priorities. ICIMOD's functional mandate is to provide secure and sustainable livelihoods for mountain people. The mountain areas are characterized by fragility, marginality (resource-wise, politically, etc.), and diversity. ICIMOD collaborates with client countries in the Himalaya-Hindu Kush region, and impacts of ICIMOD's work are evident in India, Nepal, and Tibet.

Bharatiya Agro-industries Foundation (BAIF), an NGO, highlighted the transfer of technologies for improving agricultural production in developing countries. It further emphasized that agricultural research should focus on the problems of the poor farmers and go beyond crop productivity. The following areas were noted to be important:

- Agri-horti-forestry models for different regions;
- Economics of mixed farming with different species of livestock;
- Farming systems for arid and desert regions;
- Varietal selection of fruit and vegetable crops for processing;
- Economics of aromatics, and medicinal and cash crops for waste lands and arid lands;
- Economics of low external input sustainable agriculture;
- Organic farming: Economics and impacts;
- Biopesticides and biofertilizers; and
- New varieties of food crops for stress conditions.

India Natural Resource Economics and Management (INREM) Foundation, another NGO, highlighted agricultural research needs in India as perceived by them. The main problems that should be urgently addressed in Indian agriculture are

- Rural poverty and unemployment
- Water scarcity and recurrent droughts
- Land degradation
- High risk and uncertainty and vulnerability
- Low level of agricultural productivity
- Small size of land holdings and lack of financial viability
- Low public investment in agriculture
- Inappropriate property rights in land and water
- Irrational pricing of water and electricity used for pumping water
- Lack of access to markets and marketing facilities
- Weak problem-solving action-oriented applied research, extension and training systems in agriculture
- Lack of professionalism in administration and management of agricultural research

MS Swaminathan Research Foundation (MSSRF), another NGO, stressed the fact that extension and adoption are critical factors and in this context the debate on relationship between farm size and financial viability assumes significance. The uncertain structural changes in the future, particularly on institutional arrangements and their adaptability, need to be addressed.

A farmer organization based in the Philippines (Federation of Free Farmers Coops. Inc.) highlighted that the major policy issues that can influence prioritization of research needs are

- the need for demand-driven technology,
- access to technology,
- globalization,
- sustainability, and
- partnerships

The Federation of Farmers Associations highlighted the pressing research needs of dryland agriculture. A farmer organization representative from Indonesia highlighted a case study of action research in Mesir Dwi Jaya, Indonesia.

BIOSTADT MH Seeds Ltd., a private sector firm, highlighted that there should be organizational, structural, and procedural changes in the mandate of IARCs, ICAR, and NARS. The major focus should be on

- New parental lines
- Germplasm augmentation
- Identifying new sources of resistance
- New gene constructs
- Biotic stresses
- Integrated crop production technologies.

Finally it was pointed out that the private sector has an important role in producing, distributing, and marketing end products.

To arrive at a clear picture of research priorities at the zonal level, four working groups were formed, namely, Coastal agroecosystem, Hill and mountain agroecosystem, Irrigated agroecosystem, and Rainfed agroecosystem (including SAT and arid ecosystem). The reports of groups under enterprises improvement, NRM, and institutions and policies are as follows:

Coastal agroecosystem

The group report highlighted the salient features of the agroecosystem followed by discussion on the following themes: enterprises improvement, NRM, and institutions and policies. Under enterprise improvement, coconut-based cropping system, fisheries enterprise and mangroves, and agroforestry systems were mentioned as priorities. Under NRM, the priorities to be addressed are rainwater harvesting and management of groundwater, maintaining soil health and avoiding seawater ingress, water pollution, and coral reef destruction. Under institutions and policy, priorities included processing, cold chain, anchorage and landing facilities in the coast, credit support to fishermen extension system and the research-extension interface. During the discussion, it was suggested that the model should consider homestead production models for communities; and processing units have to be integrated with production catchments.

Hill and mountain agroecosystem

Under enterprise improvement, it was suggested that the emphasis should be on high-value, low-volume and low-weight products like horticulture, livestock, medicinal plants, and vegetables locally produced and used as food crops. Tourism and mountain handicrafts were highlighted as additional priorities. Both traditional and modern methods and

practices, along with need assessment of infrastructure should be given importance. Success stories should be used for replication of good ideas and best practices. Under NRM, treating watershed as the functional unit for assessment, linking NRM with enterprise improvement activities, and involving local people should be explored. Under policy and institutions, review and shift policy paradigm, identification of institutions and programs, and validation and spread of policy changes are important. It was suggested that policies should match with features, involve local leaders, and intercountry networking, equitable high and lowland linkages and suitable compensation mechanisms to the people to be in place.

Irrigated agroecosystem

Irrigated agroecology occurs in all agroecosystems. However, it is basically land and water management ecology. Under enterprise improvement, diversification (on farm and off farm), food quality, and safety issues were stressed upon. Under NRM, water scarcity, soil degradation and water quality issues were emphasized. Under institutions and policies, food quality and global markets, participatory irrigation management and food procurement/ pricing were highlighted.

Rainfed / arid agroecosystem

Under enterprise improvement, breeding for tolerance to abiotic and biotic stresses, evolving diversified cropping systems and integration of livestock with crops and agri-horti-silvi-pastoral systems were stressed upon. Under NRM, harvesting of surface runoff on a watershed basis, improvement of soil health, selective mechanization, and conservation of biodiversity were emphasized. Under institutions and policies, input price distortions, collective action, alternative livelihood opportunities, suitable public-private partnerships and safety net mechanisms were mentioned.

In each of these group reports strategies for implementation with emphasis on networking, multi-disciplinary approach, planning and monitoring, participatory approach, capacity building, and improved delivery of services were stressed upon.

A representative from the donor community, after endorsing the group reports, said that factoring future challenges into the present and the priorities have to be matched with the millennium goals. We have to make rapid progress with the prioritized agenda to address the issues of widespread malnutrition, stagnating agriculture, risk and vulnerability, globalization, threats of HIV/AIDS on agriculture, and socially excluded groups like SC/ ST population.

The workshop, as expected, was able to flag broad macro-priorities, zonal priorities and also micro-priorities of some member countries under the broad themes of genetic improvement, NRM, and socioeconomic research. There were wide variations in the methods used to identify priorities, from congruence approach to PRA/RRA and collective wisdom of groups of experts and research managers. The country papers, after recognizing the progress made in agriculture in their countries, highlighted the persistent problems and emerging

challenges. The problems included food and nutrition security at household level, risk and vulnerability, dwindling and degrading natural resources, plateauing of yields, inadequate resource and support system, poor governance, marketing problems, quality human resource, and problems of socially excluded groups. The new challenges mainly related to WTO regime, IPR, quality and safety, global market, etc. By and large, the identified priorities are common across member countries. Some of them include genetic improvement; hybrid seed development; biotechnology; IPM; IPNS; irrigation water management; food technology; postharvest processing and value addition; livestock improvement; aquaculture; labor-saving machinery and equipments; organic farming; diversification; precision farming; agricultural information and communication technology; capacity development; socioeconomic, gender, and policy issues; public-private sector partnership; and O&M reforms. The multidisciplinary, multi-institutional, and farming system approach in agroecosystem mode is emphasized.

The CGIAR institutions are generally alive to these needs and gearing up to meet the emerging challenges of the sector and the region. Perhaps they need to focus more on facilitating exchange of genetic resources, capacity building, sharing cross-country experiences and success stories, and enhancing the capacity of the member countries for policy dialogue with policy makers and planners.

During the concluding session, the need for a short but focused list of priorities for effective implementation and systemwide impact, south-south collaboration, matching the priorities with millennium development goals, climate change, integrated genetic and NRM management, regional information management, and quality and cost competitiveness were highlighted.

Thus, the workshop has been able to spell out specific priorities at macro-, meso- and even micro-level in some cases under the broad themes of genetic improvement, NRM, and socioeconomic and policy research. In genetic improvement, system approach with agri-horti-silvi-pastoral system, diversification with emphasis on legumes, and genetic resource management including postharvest technology, value addition, and agri-business-marketing aspects are important. In NRM, integrated watershed management, soil fertility/ health management, and salinity/quality of water are important. In policy, higher investment on infrastructure, marketing, credit, and pricing are important. The private sector has to be brought in for capital investment. Extension mechanisms have to be strengthened for effective R-E-F linkages at the grass root level. Partnership of key players at all levels is very important. However, separate brainstorming sessions for each one of the four agroecologies and lower level ecologies wherever possible have to be undertaken to fine-tune the priorities for maximum uptake and implementation. Finally, we have to

Annexure-I

Table 3. Research needs and gaps in different agroclimatic zones of India.

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
Himachal Pradesh	Submountain & low hills sub-tropical, mid-hill subhumid, high hill wet subtemperate	Kangra	Aonla	Development of suitable elite and drought-tolerant germplasm (GI)	1		1
			Aonla	Nursery technology and standardiza-tion of grafting methods (NRM)	5		2
			Citrus	Standardization of maturity indices in citrus and litchi (NRM)	5		2
			Citrus	Development of elite and drought-tolerant germplasm (GI)	1		1
			Diversification of horticulture	Development of Silvi-Agri-Horti for low hills (IPNM)	5	4	
			Fisheries	Fish farming in static water (FM)	5		9
			Fisheries	Feeding and management of fish fingerlings in ponds (FM)	5		9
			Guava	Standardization of IPM for control of fruit fly (IPM)	1		3
			Maize	Evaluation and recommendation of weedicide for weed control (NRM)	1		2

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Mango/litchi	Nursery technique for reducing mortality in mango & litchi plants (NRM)	5		2
			Mango/litchi	Standardization of frost protection technology (NRM)	5		2
			Mango/litchi	Standardization of maturity indices (NRM)	5		2
			Mango/litchi	Standardization of Ethysorb and waxing technology, $CaCl_2$ & ripening with ethephone (PHT)	5		5
			Mango/litchi	Selection of elite and drought-tolerant germplasm (GI)	1		1
			Paddy	Development of suitable HYVs (GI)	1		1
			Papaya	Selection of frost and collar rot-resistant varieties (GI)	1		1
			Pasture development	Introduction of improved and weed suppressing grasses in the pasture (NRM)	5	1	
			Potato	Development of a prototype for making low cost potato chips (PHT)	5		5
			Sericulture	Development of fast growing high-yielding mulberry varieties (GI)	1		1
			Strawberry	Standardization of mulching treatment and plantation time (NRM)	5		2
			Vegetables	Standardization of sowing time for off-season vegetables (NRM)	5		2

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Vegetables	Nursery raising in polyhouse (NRM)	5		2
			Vegetables	Standardization of CFB cartons for packaging of vegetables (PHT)	5		5
Himachal Pradesh	Submountain low hill	Hamirpur	Buffalo	Balanced feed-proper feeding schedule for milch animal (AM)	3		8
			Buffalo	Breed upgradation through semen of high pedigree buffalo bull (GI)	3	1	
			Buffalo	Calf management (AM)	3		8
			Citrus	Breeding for pest resistance (GI)	3		1
			Citrus	Grading and packaging (PHT)	4		5
			Citrus	Research to organize growers into societies (SEPR)	4		7
			Citrus	Research on drought-tolerant root stock (GI)	1		1
			Cow	Proper feeding schedule for animals (AM)	3	8	
			Cow	Balanced feed (AM)	3	8	
			Maize	Development of HYVs (GI)	1		1
			Maize	Cultivation as cash crop (SEPR)	5		7
			Maize	Weed management (NRM)	1		2
			Maize	Control of stalk rot (IPM)	1		3
			Maize	Control of cutworm (IPM)	1		3
			Mango	Grading and packaging (PHT)	5		5

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Mango	Research to organize growers into societies (SEPR)	4		7
			Mango	Management of malformation (IPM)	1		3
			Mango	Management of insect pest & diseases (IPM)	1	3	
			Pulse	Cultivation of mash during *kharif* (NRM)	5		2
			Toria	Maintaining proper plant population (NRM)	5		2
			Toria	Balanced fertilizer application (NRM)	5		2
			Wheat	Loose smut and Karnal Bunt disease management (IPM)	1		3
			Wheat	Improved varieties and crop management practices (NRM)	1		2
			Wheat	Weed management (NRM)	1		2
Himachal Pradesh	Subhumid hill to temperate	Shimla	Apple	Development of high-yielding early maturing apple varieties (GI)	1		1
			Apple	Control measure of premature leaf fall (NRM)	5		2
			Apple	Research to check irregular bearing (NRM)	5		2
			Apple	Control of apple mites (IPM)	1		3
			Apple	Long juvenile/ late bearing in apple (NRM)	1		2
			Apple	Frost free injury resistant varieties (GI)	1		1

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Buffalo	Research on late maturity, infertility and repeat breeding problems (GI)	3		1
			Buffalo	Research on acclimatization of buffaloes for conception/calving in cool areas (AM)	3		8
			Buffalo	Research on chronic hematuria (AM)	3		8
			Buffalo	Control measure against placenta retention (NRM)	3		8
			Cattle	Control measure for chronic bovine hematuria (AM)	3		8
			Cattle	Control measure against placenta retention (AM)	3		8
			Cattle	Research on late maturity, infertility and repeat breeding problems (GI)	3		1
			Maize, wheat, potato	Increasing productivity of poor structured and textured soils (NRM)	6	2	
			Paddy	Breeding short-duration varieties (GI)	1		1
			Paddy	Varieties and technologies against frost, hailstorms, long snow and dry spells (NRM)	5		2
			Potato	Control measure for white grub, cutworms and aphids (IPM)	1	3	
			Potato	Development of varieties resistant to white grub, cutworms and aphids (GI)	1	1	

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Sheep & goat	Control measures for PPR and CCPP diseases (AM)	3		2
			Tomato, cabbage, cauliflower, capsicum	Research on IPM and INM in vegetables and fruits (IPNM)	1	4	
Himachal Pradesh	Submountain low hill-subtropical	Bilaspur	Crossbred cows	Repeat breeding, infertility, and prolapse problem in crossbred cows (NRM)	3		2
			Crossbred cows	Exact etiology for metoestrus bleeding problem in crossbred cows (AM)	3		8
			Fisheries	Unexploited potential of fish farming in rivulets/rivers/kuhals (FM)	5		9
			Gram & rajmash	Development of varieties for pure and intercropping of rajmash and gram (GI)	1		1
			Gram & rajmash	Control measures for wilt and pod borer (IPM)	1		3
			Gram & rajmash	Development of varieties resistant to insect pest and diseases (GI)	1		1
			Gram & rajmash	Development of technology to control wilt and pod borer in gram (IPM)	1		3
			Maize	High-yielding composite and hybrid maize varieties (GI)	1		1
			Maize	Varieties resistant to bacterial stalk rot (GI)	1		1
			Paddy	Development of nonlodging variety of paddy (GI)	1		1

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Paddy	Development and testing of fine varieties of paddy, preferably basmati (GI)	1		1
			Wheat	Development of suitable HYV of wheat (GI)	1		1
Punjab	Hilly-semi hilly-undulating-central plain	Gurdaspur	ITK	Research to validation of ITK in crop management (NRM)	5		2
			Mango	Research to address alternate bearing in mango (NRM)	5		2
			Paddy	Development of suitable variety for rainfed lands (GI)	1		1
			Paddy	Development of basmati rice resistant to pests and diseases (GI)	1		1
			Paddy	Development of rice varieties resistant to bacterial leaf blight (GI)	1		1
			Pulses	Development of short-duration varieties (GI)	1		1
			Sugarcane	Evolving suitable short-duration varieties (GI)	1		1
			Sugarcane	Development of disease & pest resistant good ratooning varieties (GI)	1		1
			Vegetables	Development of early season varieties (GI)	1		1

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Wheat	Research on development of high-yielding, disease-resistant, & export quality durum (GI)	1		1
			Wheat	Research on control of weed resistance (GI)	1		1
Punjab	Southwestern region	Faridkot	Cotton	Development of high-yielding and high quality American varieties (GI)	1	1	
			Cotton	Development of varieties resistant against insect pests and diseases (GI)	1	1	
			Fisheries	Fish culture in waterlogged area in saline water (FM)	5		2
			Honeybee	Introduction of round-the-year flora (NRM)	5		2
			Livestock	Improvement in genetic potential of cows and buffaloes through embryo transfer and progeny testing (GI)	3	1	
			Livestock	Improvement in yield through feed, fodder and housing system (AM)	3	8	
			Livestock	Improvement in quality of milk and milk products with permissible levels of microorganisms and micronutrients (AM)	3		8
			Paddy/wheat	Selection and hybridization of quality and scented basmati rice (GI)	1		1
			Paddy/wheat	Control of resistant weeds in rice and wheat with new herbicides (NRM)	5		2

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Paddy/wheat	Standardization of IPM in paddy, cotton, sugarcane (IPM)	1		3
			Pulses	Development of short-duration varieties of mung (GI)	1		1
			Pulses	Development of high-yielding and disease-resistant varieties of chickpea (GI)	1		1
			Pulses	Research on processing and packaging (PHT)	4		5
			Sugarcane	Early maturing disease-resistant varieties (GI)	1		1
			Vegetables	Studies on postharvest management and export (PHT)	5	5	
Punjab	Central-western plain	Sangrur	Buffalo	Development of remedy for high incidence of worms in buffaloes (AM)	3		8
			Buffalo	Evolving technology for detection of silent and seasonal heat period (AM)	3		8
			Buffalo	Development of remedy for hemorrhagic septicemia (NRM)	3		8
			Cattle (Crossbred & local)	Development of short-duration fodder varieties (GI)	3	1	
			Cattle & buffalo	Long intercalving period due to leaving 3 or more heats after parturition (AM)	3		8

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Cattle & buffalo	Improving genetic potential of buffalo and cow through embryo/ improved breeding techniques (GI)	3		1
			Cotton	Development of suitable hybrid cotton variety (GI)	1	1	
			Cotton	Suitable seed drill for sowing of hybrid cotton (NRM)	5		2
			Cotton	Suitable IPM technology (Bollworm, white fly) (IPM)	1	3	
			Maize, tomato, brinjal, chilly, okra, potato, desi and American cotton, gram, turmeric, basmati rice, peanut, rapeseed, mustard and pulses.	Development of suitable IPM technologies (IPM)	1		3
			Rice	Development of resistant variety against BHP (IPM)	1		3
			Rice-wheat	Research on INM in continuous rice-wheat system (IPNM)	1	4	
			Sheep & goat	Control of kid mortality in goats (AM)	3		8
			Sugarcane	Development of varieties resistant to wilt (IPM)	1		3

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Sugarcane	Research for high sugar recovery (PHT)	5	5	
			Wheat	Weed management, particularly of Phaleris minor (NRM)	1		2
			Wheat	Research on resistance of weeds to herbicides (NRM)	1		2
Punjab	Central-undulating plain	Jalan-dhar	Bee	Identification of round-the-year flora in Agri-Bee system (NRM)	5		2
			Bee	Development of new methods of bee keeping (NRM)	5		2
			Bee	Improvement in Bee-Mushroom-Vegetables System (NRM)	5	2	
			Fisheries	Study of fish varieties as per AES (FM)	5		9
			Groundnut	Development of root rot complex resistant varieties (GI)	1		1
			Livestock	Conducting research trial for foot and mouth disease (AM)	3		8
			Pulses	Development of short-duration varieties of pulses (GI)	1		1
			Rice	Development of disease & waterlog-ging resistant varieties (GI)	1		1
			Rice	Development of IPM package (IPM)	1		3
			Rice	Research on control of resistant weeds (NRM)	1		2

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Rice	Research on judicious and safe use of insecticides (IPM)	1		3
			Rice	Development of hybrid rice (GI)	1		1
			Rice	Study of marketing aspects of basmati rice (SEPR)	4		7
			Sugarcane	Development of high sugar recovery varieties (GI)	1	1	
			Sugarcane	Control of sugarcane wilt (IPM)	1		3
			Sugarcane	Refinement of IPM package in sugar-cane (IPM)	1		3
			Vegetable	Development of short-duration varieties of vegetables (GI)	1		1
			Vegetable	Control of insects (IPM)	1		3
			Wheat	Development of disease and pest resistant varieties (GI)	1		1
			Wheat	Research on control of weeds (NRM)	1		2
			Wheat	Study of marketing aspects of durum wheat (SEPR)	4		7
Bihar	South Bihar alluvial plain	Munger	Cattle & buffalo	Research on control measures for diseases like surrah, hemorrhagic septicemia (HS), Black Quarter (BQ), Liver fluke and reproductive diseases (prolapse, mastitis) (AM)	3		8

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Poultry	Control and management of Ranikhet disease (AM)	3		8
			Rice	Breeding varieties tolerant to insect pest and diseases to reduce yield gap (GI)	1	1	
			Tomato	Development of improved variety of tomato (GI)	1		1
			Vegetables & fruit	Nonavailability of improved variety seeds of fruits and vegetables (GI)	1		1
			Vegetables & fruit	Development of IPM and INM (IPNM)	1		4
			Vegetables & fruit	Research on in situ conservation of soil moisture (NRM)	6		2
Bihar	South Bihar alluvial plain	Patna	Horticulture	Studying the causes of widespread drying of sisam tree (NRM)	1		2
			Horticulture	Research on intercropping system in orchards (NRM)	5		2
			Horticulture	Improved cultivation practices for medicinal and aromatic plants (NRM)	5		2
			Horticulture	Improved cultivation practices for mushrooms and vegetables (NRM)	5		2
			Livestock	Research on low cost cattle feed from locally available microorganisms and micronutrients (AM)	3		8
			Livestock	Development of technology for sustainable riverine fish production (AM)	3		8

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Chickpea	Preservation technique development for green chickpea (PHT)	5		5
			Paddy/Wheat	Standardizing INMS/ IPM in rice and wheat (IPNM)	1	4	
			Paddy/Wheat	Participatory plant breeding and varietal selection (GI)	1		1
			Paddy/Wheat	Cropping intensity based micronutri-ents scheduling (NRM)	1		2
			Paddy/Wheat	Improving soil health through soil organics (NRM)	1		2
Bihar	Northwest alluvial plain	Muzaf-farpur	Fruit & vegetables	Research to promote fig and litchi marketing (SEPR)	4		7
			Fruit & vegetables	Research on value addition, marketing, packaging and processing (PHT)	5		5
			Fruit & vegetables	Cultivation of off-season, nontraditional vegetables (NRM)	5		2
			Forage	Forage cultivation for dairy enterprises (NRM)	3		2
			Livestock	Backyard poultry (AM)	3		8
			Livestock	Feeding of livestock and dairy management (AM)	3		8
			Maize	Development of sweet corn and quality protein maize (GI)	1		1

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Fisheries	Research on improving leasing policy of fisheries tanks (SREP)	5		7
			Wheat	Zero tillage /surface seeding of wheat (NRM)	1	2	
			Wheat	IPM/ INM & integrated weed management (Phaleris minor) (IPNM)	1		4
Bihar	Northwest alluvial plain	Madhubani	Arhar and rajmash	Research on arhar and rajmash in rabi (NRM)	1		2
			Cattle & buffalo	Research for improving local breeds (GI)	3		1
			Cattle & buffalo	Research for improving milk productivity (AM)	3		2
			Fisheries	Research on utilization of water bodies for aquaculture (WM)	5		6
			Fruit & vegetables	Development of moisture-tolerant, flood-tolerant fruit and vegetable varieties (GI)	1		1
			Fruit & vegetables	Performance of turmeric, ginger and amorphophalus (*oal*) under orchard land (NRM)	1		2
			Fruit & vegetables	Research on identification of summer varieties of sunflower, sesame, and groundnut (GI)	1		1

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Litchi	Measures against litchi mites and borer (IPM)	1		3
			Litchi	Research on PHT and preservation technology (PHT)	1		5
			Mango	Development of variety/ technology to address alternate bearing in mango (GI)	1		1
			Mung	Mung varieties having good compatibility with DWR and high yield potential (GI)	1		1
			Quality seed	Testing performance of turmeric, ginger and amorphophalus (*oal*) under orchard land (NRM)	1		2
			Rice	Development of variety and control measures for BPH in rice (GI)	1	1	
			Rice	Technology for increasing the productivity of flashflood affected areas (NRM)	6		2
			Rice	Lack of cold-tolerant boro rice varieties (GI)	1		1
			Rice	Submergence tolerant varieties and varieties having elongation with HYP in deep water ecosystem (GI)	6		1
			Sesame	Sesame varieties having good compatibility with DWR and high yield potential (GI)	1		1

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Sunflower, sesame & groundnut	Summer varieties of sunflower, sesame & groundnut (GI)	1		1
			Wheat	Short-duration HYV wheat for surface seeding and zero tillage (NRM)	1		2
Orissa	Eastern Ghat highland-South-eastern Ghat	Koraput	Backyard poultry	Disease management (AM)	3		8
			Backyard poultry	Feed management (AM)	3		8
			Buffaloes	Research on low and stagnant productivity in buffalo and breed upgradation (AM)	3		8
			Cabbage	Disease management (Root rot disease) (IPM)	1		3
			Cabbage	IPM (Cabbage moth, thrips and leaf webber) (IPM)	1		3
			Cotton	Research on water management (WM)	6	6	
			Cotton	IPM (bollworm, aphid, etc) (IPM)	1		3
			Crossbred cows	Technological gaps in management practices (SEPR)	3		7
			Fisheries	Disease management (FM)	5		9
			Fruit & vegetables	Research on postharvest handling, value addition & agro-processing (PHT)	5		5

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Fruit & vegetables	Testing feasibility of off-season vegetables (SEPR)	5		7
			Goat, sheep & rabbit	High mortality rates in goat (AM)	3		8
			Goat, sheep, rabbit	Opportunity for expansion of goat rearing and rabbit farming, and sheep rearing (AM)	3		8
			Maize	Research on IPM (IPM)	1		3
			Maize	Research on INM (IPNM)	1	4	
			Mushroom	Testing economic potential for mushroom cultivation (SEPR)	5		7
			Paddy	Research on integrated plant nutrient supply in rice-based cropping system (IPNM)	1	4	
			Paddy	Research on identification and characterization of aromatic rice variety (GI)	1		1
			Paddy	Research on rice variety suitable for jholla lands (kharif and rabi) and soils with iron toxicity (GI)	6		1
			Paddy	Development of suitable hybrid rice variety (GI)	1		1
			Paddy, maize, ragi, cotton	Lack of varieties tolerant to adverse weather and key pests (GI)	1	1	

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Paddy, maize, ragi, cotton	Technology for increased cropping in submarginal lands (NRM)	6		2
			Ragi	Research on IPM (IPM)	1		3
			Ragi	Research on INM (IPNM)	1		4
Orissa	Northwestern plateau & west central tableland	Sambalpur	Cattle & buffalo	Research to increase productivity in dairy animals due to inadequate green fodder (AM)	3		8
			Cattle & buffalo	Evolving technology for reducing nutritional imbalance in livestock (AM)	3		8
			Cattle & buffalo	Technology for serious disease problems (FMD, BQ, HS, Mastitis etc.) (AM)	3		8
			Fisheries	Development of technology for increasing fish productivity per unit area of water body (FM)	5		9
			Fisheries	Standardization of fish feed using locally available materials (FM)	5		9
			Fruit & vegetables	Research to minimize excess postharvest loss (PHT)	5		5
			Fruit & vegetables	Research to reform research recommendations based on farming situation (NRM)	5	2	
			Fruit & vegetables	Biological control of fruit and shoot borer (IPM)	1		3

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Groundnut	Research on elimination of aflatoxin (IPM)	1		3
			Groundnut	Development of high-yielding pest-resistant varieties (GI)	1		1
			Pulses (mung, biri, arhar)	Measures for improving the productivity of pulse (NRM)	1		2
			Pulses (mung, biri, arhar)	Breeding high-yielding and pest tolerant varieties (GI)	1		1
			Rice	Variety/ technology to address yield plateauing in paddy (GI)	1		1
			Rice	Evolving low cost technology for checking runoff (NRM)	6	2	
			Rice	Breeding biotic and abiotic tolerant varieties (GI)	1	1	
			Rice	Research on identification of constraints (SEPR)	5		7
			Rice	Research on in situ conservation of soil moisture (NRM)	6	2	
Orissa	Southeastern coastal plain	Khurda	Arhar	Technological package to control blister beetle and pod borer (IPM)	1		3
			Arhar	Identification of varieties resistant to sterility mosaic and pod borer (GI)	1		1
			Brinjal & tomato	Improvement of local varieties resistant to fruit & shoot borer (GI)	1	1	

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Brinjal & tomato	Identification of varieties resistant to wilt complex (GI)	1		1
			Buffalo	Cytological study on breeding programs (AM)	3		8
			Cattle	Study on reasons for decrease in cattle population (SEPR)	3		7
			Cattle	Development of low-cost cattle feed by using locally available ingredients (AM)	3		8
			Coconut	Study on fruit drop of coconut (IPM)	1		3
			Coconut	Integrated management of coconut black headed caterpillar (IPM)	1		3
			Fisheries	Study on biological control of pond weeds (FM)	5		9
			Fisheries	Artificial feeding using locally available materials (FM)	5		9
			Floriculture	Market study on commercial floriculture (SEPR)	5		7
			Floriculture	High value flower cultivation (SEPR)	5		7
			Groundnut	Preservation of groundnut seeds through rainy season (PHT)	1		5
			Groundnut	Development of runner varieties with shorter duration for kharif (GI)	1		1
			Groundnut	Suitable groundnut planter for labor saving (NRM)	5		2

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Groundnut	Development of varieties resistant to collar rot diseases (GI)	1		1
			Horticulture	Package of practices for dryland horticulture (NRM)	1		2
			Mango	Study on intercropping system in cashew orchard (NRM)	5		2
			Mango	Identification of appropriate hybrids for regular bearing (GI)	1		1
			Mung	Study of postharvest losses in mung and arhar (PHT)	5		5
			Mung	Development of varieties resistant to powdery mildew (GI)	1		1
			Mung	Postharvest management using Begonia leaves (PHT)	5		5
			Mushroom	Cultivation practices to be standardized (NRM)	1		2
			Rice	Study of micronutrient requirement (NRM)	1		2
			Rice	Rice-fish integrated farming system (NRM)	5	2	
			Rice	Study on appropriate measures to avoid sprouting in panicle due to heavy rain during harvesting (NRM)	1		2
			Rice	Management of drought-tolerant varieties (GI)	1	1	

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Rice	Increasing fertilizer use efficiency in lowland rice (IPNM)	1	4	
			Rice	Development of flood and waterlogging resistant varieties (GI)	6	1	
			Rice	Refinement of INM/IPM package of practices (IPNM)	1	4	
			Rice	Validation of ITK on control of pest by using Karda leaves, etc. (IPM)	5		3
			Rice	Management of stem borer and salinity-resistant varieties (GI)	1		1
			Rice	Management of early maturing and saline-tolerant varieties (GI)	6		1
			Rice	Cultivation of hybrid rice (GI)	1		1
			Rice	Identification of suitable transplanter, seed drill and reaper (NRM)	5		2
			Sericulture	Rearing of silkworm (NRM)	5		2
			Vegetables	Vegetable cultivation in ayacut of dug-wells/LIPs (NRM)	6	2	
Andhra Pradesh	Scarce rainfall zone	Kurnool	Cotton	Research on intercropping of soybean with cotton (NRM)	5	2	
			Fruit & vegetables	Research on intercropping in young mango orchards (NRM)	5		2
			Groundnut	Research on development of sprinkler irrigation in groundnut (NRM)	6		2

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
Andhra Pradesh	North Telangana	Adilabad	Horticulture	Balanced use of fertilizers including micronutrients (IPNM)	1	4	
			Paddy	Research on water and nutrient management in paddy (WM)	6	6	
			Soybean	Research on leaf miner management (IPM)	1		3
			Soybean	Development of improved varieties of soybean (GI)	1		1
			Soybean	Integrated pest/ nutrient management in soybean and jowar (IPNM)	1		4
			Soybean	Weed management in soybean and jowar (NRM)	1		2
Andhra Pradesh	Southern zone	Chittoor	Cattle & buffalo	Increasing genetic potential and milk productivity (GI)	3		1
			Cattle & buffalo	Research on minimizing mortality of calves (AM)	3		8
			Cattle & buffalo	Research on management of worms (AM)			8
			Chillies, gourds, beans, melons, Cassandra and jasmine	Development of IPM against pest and diseases (IPM)	3		3
			Groundnut	Research on seedborne diseases (IPM)	1	3	

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Groundnut	Development of HYV varieties (GI)	1		1
			Mango	Research on management of irregular bearing (NRM)	1		2
			Mango	Development of regular bearing varieties (GI)	1		1
			Mango	Development of variety suited to export quality and high density planting (GI)	5		1
			Mango	Research to determine irrigation schedule for mango (WM)	6	6	
			Paddy	Breeding blast-resistant variety (GI)	1	1	
			Paddy	Intensification of research on biofertilizers for INM (IPNM)	1	4	
			Paddy	Development of cold-tolerant varieties (GI)	1		1
			Sugarcane	Availability of sugarcane ratoon variety tolerant to shoot borer and red rot (GI)	1		1
			Sugarcane	Technology for improving color and keeping quality of jaggery (PHT)	5		5
Maha-rashtra	Assured to high rainfall zone	Amravati	Cotton	Research to overcome declining productivity due to irregular rainfall (NRM)	6	2	
			Cotton	Technology for using cotton straw as cattle feed (NRM) (NRM)	3		2
			Cotton	Low-cost production technology (NRM)	5	2	
			Cotton	Studies on micronutrient management and growth regulators (IPNM)	1	4	

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Cotton	Production technology for organic farming of cotton (NRM)	5	2	
			Cotton	Evolution of pest (bollworm, white fly) tolerant cultivars (GI)	1	1	
			Orange	Soil and water management research to address salinity and poor drainage (NRM)	6	2	
			Orange	Technology for regular bearing in orange (NRM)	1		2
			Orange	Technology for prolonging the economic life of orange trees on adverse soils (NRM)	6	2	
			Rice	Development of improved/HYV of paddy to replace local/traditional varieties (GI)	1		1
			Soybean	Research to overcome monoculture of soybean (NRM)	1		2
			Soybean	Pests and disease management research (IPM)	1		3
Maharashtra	Ghat hilly, Plain, transition & scarcity	Ahmadnagar	Bajra	Measures to improve declining yield (NRM)	1	2	
			Bajra	Testing of short-duration hybrid bajra for rainfed conditions (GI)	1	1	
			Bajra	Evolving integrated nutrient management technology (IPNM)	1	4	

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Buffalo	Measures to minimize long intercalving period/ reduced reproductive ability (AM)	3		8
			Buffalo	Development of heat detection techniques, including improvement of conception rate (AM)	3		8
			Buffalo	Development of balanced ration for livestock (AM)	3		8
			Buffalo	Research on preventing deterioration of genetic status due to use of nonde-script he buffalo for service (GI)	3		1
			Buffalo	Studies to reduce/control mortality in buffalo calves (AM)	3		8
			Cattle	Research on FMD, reproductive differ-entiation and low milk yield due to lack of mineral and vitamins (NRM)	3		2
			Cotton	Development of resistance against bollworm (GI)	1	1	
			Cotton	Measure for control of anthracnose of cotton (IPM)	1	3	
			Crossbred cattle	Repeat breeding (GI)	3		1
			Crossbred cattle	Research on breed upgradation in livestock (GI)	3	1	

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Crossbred cattle	Management of tick borne diseases (AM)	3		8
			Gram	Development of varieties resistant to *Heliothis* (GI)	1	1	
			Gram	Research on *Heliothis* control and biofertilizers (NPV) of gram (IPNM)	1	4	
			Grapes	Research on improving quality bunches (NRM)	1		2
			Grapes	Development of downy mildew and powdery mildew resistant varieties/ technologies (GI)	1	1	
			Grapes	Management of soil fungus-reducing plant population (IPM)	1		3
			Grapes	Measures to check cracking of fruits (NRM)	1		2
			Grapes	Research on micronutrient deficiency and physiological disorders (IPNM)	1		4
			Grapes	Research on application of IDM (IPM)	1	3	
			Grapes	Studies on storage, processing and transportation technologies for minimizing PH losses (PHT)	5		5
			Groundnut	Breeding improved varieties of summer groundnut (GI)	1		1

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Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Groundnut	Technology to minimize losses by hairy caterpillar (IPM)	1		3
			Groundnut	Saline water technology of different crops to be refined (NRM)	6		2
			Groundnut	Refinement of IPM package based on indigenous knowledge (IPM)	5		3
			Groundnut	Development of HYV for improving yield potentials of groundnut varieties (GI)	1		1
			Orange	Research on heavy losses in orange due to gummosis (IPM)	1		3
			Orange	Losses due to fruit sucking moth (IPM)	1		3
			Orange	Technology for bahar treatment in major fruit crops (IPM)	1		3
			Paddy	Technology for late paddy cultivation (NRM)	1		2
			Sheep & goat	Slow weight gain and low productivity (AM)	3		8
			Sheep & goat	Breeding stall-fed goats (GI)	3		1
			Sheep & goat	Studies on prevention and control of FMD (AM)	3		8
			Wheat	Development of varieties suitable for temperature fluctuations during crop season (GI)	1		1

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Wheat	Development of wheat variety for late sowing (GI)	1		1
Maha-rashtra	Assured & scarce rainfall zone	Aurang-abad	Bajra	Development of HYV bajra (GI)	1	1	
			Bajra	Moisture stress and diseases (NRM)	6		2
			Buffalo	FMD, malnutrition, infertility, infection (AM)	3		8
			Buffalo	Prevention for mastitis (AM)	3	8	
			Buffalo	Research to control long intercalving in buffaloes and deterioration of genetic status due to silent heat (AM)	3	8	
			Onion	Infestation of thrips and onion blight (IPM)	1		3
			Cattle	Development of suitable drugs for control of mastitis (AM)	3	8	
			Cotton	Studying causes of drying of square and flowers in cotton, (NRM)	1		2
			Gram	IPM for *Heliothis* in gram (IPM)	1	3	
			Groundnut	Development of short-duration and drought-resistant varieties of groundnut (GI)	1		1
			Maize	Develop short duration, high-yielding drought-resistant variety of maize (GI)	1		1

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Pasture & forestry	Identification of nutritious grasses for cultivation under degraded forest and wastelands (NRM)	5		2
			Sheep & goat	Studies on crossbreeding of local and Osmanabadi goat using African bush-buck and selection of triplet in local and Osmanabadi goats for breeding purposes (AM)	3		8
			Sorghum	Research on salinity and drainage problems due to excessive irrigation in sorghum (NRM)	6		2
			Arhar	Control measures against infestation of pod borer complex (IPM)	1	3	
			Arhar	Low-cost plant protection technology (IPM)	1	3	
			Vegetables	Control measures against viral diseases (IPM)	1		3
			Vegetables	Cost-saving technologies for cabbage, tomato, chilly and other vegetables (NRM)	5		2
Jharkhand	Southeastern plateau	W. Singh-bhum	Fisheries	Studies on composite pisciculture in water bodies (FM)	5		9
			Fisheries	Studies on ploy culture in village tank (FM)	5		9

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Fisheries	Studies on decentralized production of fingerlings (FM)	5		9
			Fruit & vegetables	Research on off-season cultivation of vegetables (NRM)	5		2
			Fruit & vegetables	Research on dryland horticulture (NRM)	5	2	
			Fruit & vegetables	Commercial cultivation of organic spices, floriculture and mushroom (NRM)	5	2	
			Fruit & vegetables	Research on postharvest management & value addition (PHT)	5		5
			Fruit & vegetables	Research on commercial production of honeybee (NRM)	5		2
			Livestock	Breed upgradation in dairy animals through high pedigree bulls (GI)	3	1	
			Livestock	Studies on better management of piggery and backyard poultry (AM)	3		8
			Paddy	Substitution of upland rice crop for millets and pulses (NRM)	5		2
			Plantation crops	Studies on alternative land use with agroforestry & farm forestry (NRM)	5		2
			Plantation crops	Cultivation of mulberry, sericulture and medicinal plants (NRM)	5		2

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
Jharkhand	Central & north-eastern plateau	Dumka	Cattle, buffalo, sheep & goat	Improvement of local breeds (GI)	3		1
			Cattle, buffalo, sheep & goat	Balanced feeding (AM)	3		8
			Cauliflower, knoll khol, cabbage	Development and testing of improved varieties (GI)	5		1
			Cauliflower, knoll khol, cabbage	Development of IPM and INM (IPNM)	1		4
			Cauliflower, knoll khol, cabbage	Micronutrient research (IPNM)	1		4
			Maize	Evolving HYV to replace low-yielding traditional varieties (GI)	5	1	
			Maize	Birsa maize-I and ecology management of stem and cob borer (IPM)	1		3
			Maize	Evolving second rabi crop technology and variety (NRM)	1	2	
			Maize	Control measures for high infestation of stem borer and cob caterpillar (IPM)	1		3
			Maize	Development of tolerant varieties and measures against stem rot (GI)	1		1
			Maize	Research on stress and drought susceptibility (NRM)	6		2
			Mustard	Screening of suitable varieties (GI)	1		1
			Mustard	Research on management of infestation of aphids (IPM)	1		3

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Paddy	Development of short-duration varieties (GI)	1		1
			Paddy	Evolving disease pest resistant varieties (GI)	1		1
			Paddy	Evolution of drought/stress-resistant varieties /technologies (GI)	6		1
			Paddy	Breeding drought-resistant varieties (GI)	6		1
			Pigeonpea	Screening of short-duration HYV (GI)	1		1
			Pigeonpea	Adaptive trail on ecological and management of pod borer (IPM)	1		3
			Pigeonpea	Development of pod borer resistant varieties (GI)	1		1
			Pigeonpea	Control measure for arhar mosaic (IPM)	1		3
			Potato	Development and testing of improved varieties (GI)	1		1
			Potato	Research on management of bacterial and fungal blights (IPM)	1		3
Jharkhand	Eastern plateau & hills	Jamtara	Buffalo	Balanced feeding (AM)	3		8
			Fish	Standardization of fish feed using locally available materials (FM)	5		9
			Fruit & vegetables	Standardization of packaging technology (PHT)	5		5

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Fruit & vegetables	Adaptive trials for new hybrids (NRM)	5		2
			Goats	Reduce kid mortality (AM)	3		8
			Lac	Good quality lac seed (GI)	5		1
			Medicinal plants	Identification of locally available medicinal plants (NRM)	5		2
			Medicinal plants	Characterization of germplasm of selected medicinal plants (NRM)	5		2
			Mulberry	Good quality leaf producing species (GI)	5		1
			Poultry	Control of RD and fowl pox (AM)	3		8
			Poultry	Management of Red Divyan poultry breed (AM)	3		8
			Rice	Drought and disease-resistant varieties of paddy, maize, arhar, urd & mung (GI)	1		1
			Rice	Standardization of INM/IPM in rice, fruits and vegetables (IPNM)	1	4	
Jharkhand	Western plateau	Palamau	Lac	Scientific Lac cultivation on palash tree (NRM)	5		2
Andhra Pradesh	High-moderate-scanty rainfall		Buffalo	Simple methods to diagnose the subclinical mastitis and subclinical tryphasomiasis (AM)	3		8
			Fruit & vegetables	Increasing shelf life and reducing transit losses in fruits and vegetables. (PHT)	5		5

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Fruit & vegetables	Development of high-yielding, drought and saline-resistant varieties of fruit & vegetables (GI)	1		1
			Fruit & vegetables	Development of mechanical mango harvesters (NRM)	5		2
			Mulberry	Introducing biofertilizers in mulberry cultivation (IPNM)	5		4
			Mulberry	Research on IPM for root-rot disease management in mulberry (IPM)	1		3
			Paddy	Studies on feasibility of growing crops like green gram and black gram before paddy (SEPR)	4		7
			Paddy	Reclamation of salt affected soils (NRM)	6		2
			Paddy	Standardization of INM/ IPM practices in paddy and fruits and vegetables (IPNM)	1	4	
			Pearl culture	Fresh water pearl culture (NRM)	5		2
Maha-rashtra	Very high rainfall zone	Ratnagiri	Cattle and buffalo	Improving conception rate in CB cows and nondescript (AM)	3		8
			Cattle and buffalo	Research to check outbreak of entero-toxemia and FMD in cattle (AM)	3		8
			Cattle and buffalo	Improving genetic make up of ND cows (GI)	3	1	

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Cattle & buffalo	Research on INM and integrated fodder management (IFM) (AM)	3		8
			Fisheries	Development of diagnostic techniques for marine fish diseases (FM)	5		9
			Fisheries	Refinement of pearl production technology (FM)	5		9
			Fisheries	Use of biotechnology and genetic engineering for increased aquaculture production (GI)	5		1
			Fruit, tubers, spices, nutmeg, vegetables and flowers and forest trees and medicinal plants	Development of suitable propagation techniques (NRM)	1	2	
			Gram, cowpea, lablab bean, mathi, chickpea	Development of short-duration HYVs (GI)	1		1
			Gram, cowpea, lablab bean, mathi, chickpea	Development of drought-tolerant varieties (GI)	6		1
			Niger, sesamum, mustard, groundnut	Development of drought-tolerant, short-duration HYVs (GI)	1		1
			Rice	Development of hybrid rice variety and technology (GI)	1		1

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Rice	Development of scented variety of rice (GI)	1		1
Orissa	East & south eastern coastal plain & north-eastern ghat	Ganjam	Cotton	Standardization of IPM in cotton (IPM)	1	3	
			Cotton	Studies on intercropping in cotton and maize (NRM)	1		2
			Fisheries	Standardizing fish feed using locally available materials (FM)	5	9	
			Fisheries	Disease management in freshwater fish (FM)	5		9
			Plantation crop	Mixed plantation using different proportion of fuel wood and fodder species (NRM)	5		2
			Fruit & vegetables	Selection of suitable brinjal varieties (GI)	1	1	
			Livestock	Reducing kid mortality in goats (AM)	3		8
			Livestock	Feeding and disease management of cows, buffalo and goats (AM)	3		8
			Maize	Studies on production of hybrid seeds (GI)	5		1
			Paddy	Studies on IPNS in paddy (IPNM)	1		4
			Paddy	Use of farm implements to reduce production cost (NRM)	1		2

Continued

Table 3. *Continued.*

State	Agroclimatic zones	District	Commodity/ Enterprise/ Sector	Research needs	Themes identified for macro priorities*	Research attempted under NATP*	Research gaps
			Paddy	Participatory variety selection against weather aberration (GI)	1		1
			Paddy	Rainwater management in rainfed upland against drought (WM)	6	6	
			Paddy	Identification and characterization of aromatic rice (GI)	1		1
			Paddy	Selection of salt-tolerant variety with maturity duration of 150 days (NRM)	6	2	
			Paddy	Identification and validation of ITKs for control of pests (IPM)	1		3
			Plantation	Rejuvenation of old cashew orchards (NRM)	5		2
			Plantation	IPNS and IPM in beetle vine crop (IPNM)	1		4
			Plantation	Standardization of IPM package for coconut (IPM)	1		3
			Poultry	Control of RD and fowl fox in poultry (AM)	3		8
			Pulses	HYVs of mung, biri and pigeonpea (GI)	1		1
			Sugarcane	Selection of varieties resistant against early shoot borer and red rot diseases (GI)	1		1

* 1. GI: genetic improvement; 2. NRM: Natural resource management; 3. IPM: Integrated pest management; 4. IPNM: Integrated plant nutrient management; 5. PHT: Postharvest management; 6. WM: water management; 7. SEPR: Socioeconomics and policy research; 8. AM: Animal management; 9. FM: Fisheries management.

Annexure-II: Acronyms and Abbreviations

AES	Agroecosystem
APAARI	Asia-Pacific Association of Agricultural Research Institutions
ATMA	Agricultural Technology Management Agency
CGIAR	Consultative Group on International Agricultural Research
CLAN	Cereals and Legumes Asia Network
FAO	Food and Agriculture Organization
GDP	Gross domestic product
GIS	Geographical information system
GNP	Gross national product
HA	Hot-arid agroecosystem
HRD	Human resources development
HRH	High rainfall humid (agroecosystem)
HYV	High-yielding variety
IARCs	International agricultural research centers
ICAR	Indian Council of Agricultural Research
INM	Integrated nutrient management
IPM	Integrated pest management
IPNM	Integrated pest and nutrient management
IPR	Intellectual property rights
ISH	Irrigated subhumid (agroecosystem)
ITD	Innovations in technology dissemination
IWM	Integrated water management
KVK	Krishi Vigyan Kendra
MANAGE	National Institute of Agricultural Extension Management
NAP	National Agricultural Policy
NARS	National Agricultural Research Systems
NATP	National Agricultural Technology Project
NGO	Nongovernmental organizations
PRA	Participatory rural appraisal
SAMETI	State Agricultural Extension Management and Training Institute
SAU	State agricultural universities
SPS	Sanitary and phytosanitary measures
SREP	Strategic Research and Extension Plan
VO	Voluntary organization
WTO	World Trade Organization

Annexure-III: Partners

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Agricultural Research & Education Organisation (AREO), Tehran, Iran
Asian Vegetable Research and Development Center (AVRDC), Taiwan, Republic of China
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Biostadt M.S. Seeds Ltd.
Council for Agricultural Research Policy (CARP), Sri Lanka
Centro Internacional de Mejoramiento de Maiz y de Trigo (CIMMYT), Mexico City, Mexico
Centro Internacional de Agriculture Tropical (CIAT), Cali, Colombia
Center for International Forestry Research (CIFOR), Bogor, Indonesia
Federation of Farmers Association, Hyderabad, Andhra Pradesh
Federation of Free Farmers Coops. Inc., The Philippines
International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria
International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India
International Food Policy Research Institute (IFPRI), Washington D.C., USA
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World Agroforestry Centre, Nairobi, Kenya
World Fish Center, Penang, Malaysia

Annexure-IV: Program

Thursday, 7 October

08:30	Registration	
09:00	Welcome remarks	- William D Dar
09:20	Objectives of the Workshop	- Cynthia S Bantilan
10:00	Research Prioritization Initiatives by APAARI	
	- Genesis for the present exercise	- RS Paroda
	EMCEE(MC):	- CLL Gowda
10:30	*Group Photograph and Coffee break*	

Technical Session 1: Research Needs and Priorities

Chair: Dyno Keatinge, ICRISAT
Rapporteur: KPC Rao, ICRISAT

11:15	Presentation of country paper - India	- Mruthyunjaya
11:35	Discussion	
12:30	Presentation of country paper - Sri Lanka	- H Samaratunga
12:45	Discussion	
13:00	*Lunch*	

Technical Session 2: Research Needs and Priorities

Chair: Shanmugasundaram, AVRDC
Rapporteur: Chris Scott, IWMI

14:00	Presentation of country paper - Bangladesh	- Md. Ismail Hossain
14:15	Discussion	
14:30	Presentation of country paper - Nepal	- Surya Laxmi Maskey
14:45	Discussion	
15:00	Presentation of country paper - Iran	- Mohsen Mohsenin
15:15	Discussion	
15:30	*Coffee break*	

Technical Session 3: Comments and Contributions from IARCs and NGOs in South Asia Region

Chair: Cynthia S Bantilan, ICRISAT
Rapporteur: Mruthyunjaya, NCAP

15:45	IFPRI, CIP, IPGRI, ILRI, IWMI, AVRDC, ICRISAT, IRRI, ICIMOD (10 mins each.)	
17:15	NGOs	- N G Hegde - K Singh - M Velayutham
17:45	Closure	
18:00	*Cocktails and Dinner*	

Friday, 8 October

Technical Session 3 (continued): Comments and Contributions from Stakeholders in South Asia Region

Chair: JS Kanwar
Rapporteur: CLL Gowda, ICRISAT

08:30	Farmer Organizations	- Raul Montemayor, - D Ramakrishna Reddy
09:00	Private Sector	- KR Chopra
09:15	Research Institutions	- EA Siddiq
09:30	Formation of discussion groups and guidelines for discussions - Need assessment and priorities by agroregions/ commodities.	
10:00	*Coffee break*	
10:15	Group discussions	
12:30	*Lunch*	
14:00	Concluding Session	

Chair: RS Paroda, APAARI
Rapporteur: S Pande, ICRISAT

• Presentation by groups	
• Chairperson's synthesis and main conclusions	
• Concluding remarks	- Kevin Crockford, DFID - Dyno Keatinge, ICRISAT
Vote of thanks	- Cynthia S Bantilan

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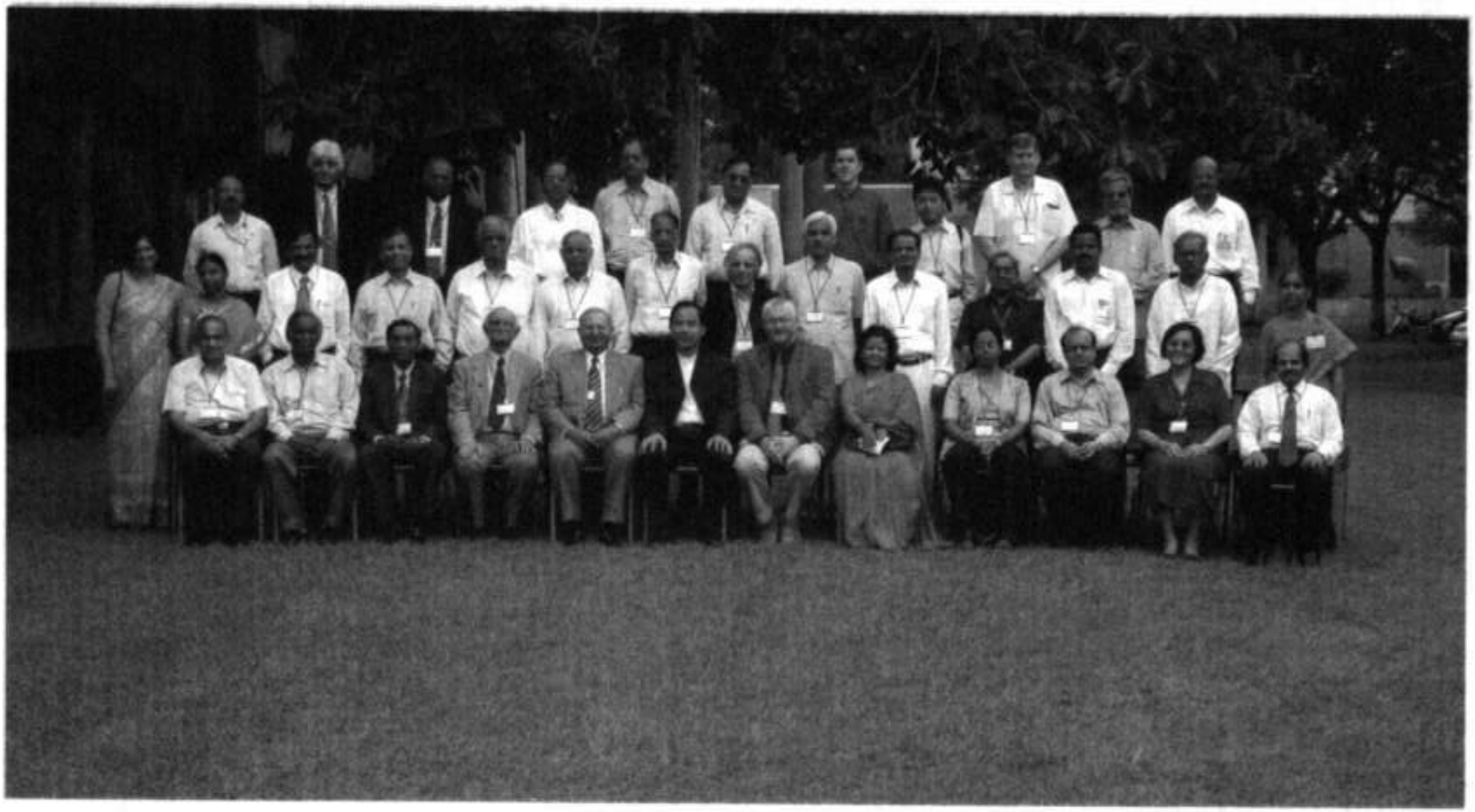
Global Theme on SAT Futures and
Development Pathways



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About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization belonging to the Future Harvest Alliance of Centers supported by the Consultative Group on International Agricultural Research (CGIAR). Established in 1972, ICRISAT generates and shares cutting-edge technologies that support the livelihoods of more than 300 million people – the poorest of the poor in semi-arid areas of the developing world.

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