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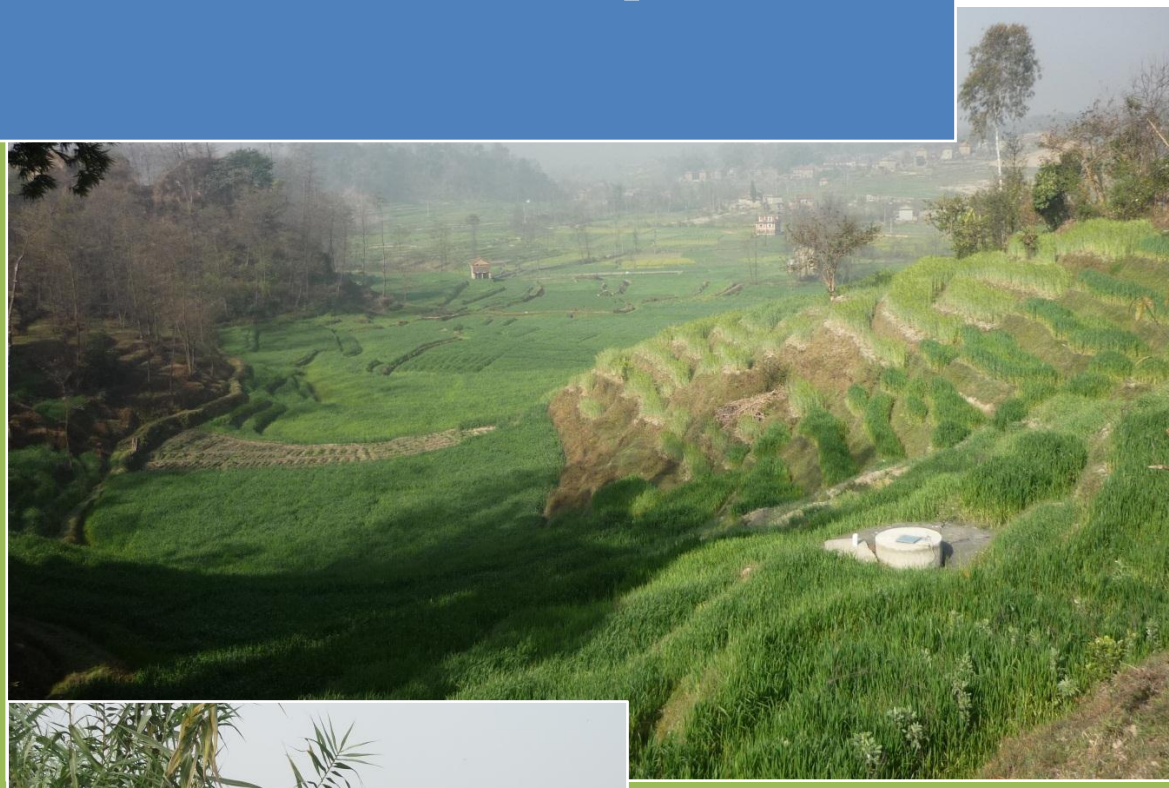
Report on Prioritizing Demand-Driven Agricultural Research for Development in Nepal



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Preface and Acknowledgements

Reducing food and nutrition insecurity in Asia requires new solutions to the constraints of: (1) stagnating food productivity and production, (2) unconnected or fragmented food supply chains, and (3) underinvestment in agricultural research and development. Pragmatic short-term solutions are needed that target small-scale farmers who comprise the bulk of food producers in Asia. Simultaneously, the foundations must be established for long-term structural measures that promote the availability, accessibility, and utility of nutritious and safe food, especially for vulnerable groups in Asia.

In an effort to develop both short- and long-term solutions, the Asian Development Bank (ADB) enlisted the International Food Policy Research Institute (IFPRI) under the auspices of a "Regional—Research and Development Technical Assistance (R-RDTA)" agreement in 2011 to provide technical assistance for strategic research on sustainable food and nutrition security in Asia. This ADB R-RDTA addresses important challenges to reducing food and nutrition insecurity in Asia.

One component of this program—characterizing agricultural research for development (AR4D) in South Asia—is addressed in the present document. AR4D is a topic of urgent importance in South Asia. The diversification and intensification of agricultural production throughout the region are among the many issues raised in discussions around South Asia's AR4D agenda at the seminal Global Conference for Agriculture and Rural Development (GCARD) convened in Montpellier in March 2010. Efforts to make further progress on defining and executing a pro-poor and pro-growth AR4D strategy in South Asia requires more evidence on what has worked in the past, where investments are being made at present, and what priorities should be established for future research.

In an effort to support this objective, IFPRI partnered with the Asia-Pacific Association of Agricultural Research Institutions (APAARI) in 2011 to conduct a series of policy dialogues on the prioritization of demand-driven agricultural research for development in South Asia. Dialogues were conducted with a wide range of stakeholders in Bangladesh, India, and Nepal in mid-2012 and this report captures feedback from those dialogues.

This report has benefited greatly from the contributions of Raj Paroda and Bhag Mal of APAARI who were engaged in the entire process. The report has also benefited from insights provided by P. K. Joshi, Mark Rosegrant, and David J. Spielman of IFPRI, as well as technical support from Vartika Singh and Vaishali Dassani of IFPRI and Ram Niwas Yadav of APAARI.

Finally, the report has been made possible by the enthusiastic involvement of the Nepal Agricultural Research Council (NARC), the Bangladesh Agricultural Research Council (BARC), and organizations under the umbrella of the Indian Council for Agricultural Research (ICAR).

In the end, we hope that this exercise will initiate further research and inquiry on these issues and the charge for future agricultural research for development in South Asia will be taken up by researchers from both national and international systems, as well as other key stakeholders.

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Acronyms

ABD	Animal Breeding Division
ADB	Asian Development Bank
ADB/N	Agricultural Development Bank Nepal
ADO	Agriculture Development Office
AEC	Agro Enterprise Centre
AGDP	agricultural gross domestic product
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APP	Agricultural Perspective Plan
AR4D	agricultural research for development
AREP	Agricultural Research and Extension Project
AVRDC	Asian Vegetable Research and Development Centre
CAAS	Chinese Academy of Agricultural Sciences
CBO	community-based organization
CBS	Central Bureau of Statistics
CEAPRED	Centre for Environmental and Agricultural Policy Research and Development
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Centre
CMS	Consolidated Management Services
DADO	District Agriculture Development Office
DAP	Directorate of Animal Production
DFID	Department for International Development (United Kingdom)
DFQT	Division of Food Quality Testing
DFRS	Department of Forest Research and Survey
DHM	Department of Hydrology and Metrology
DIFD	Directorate of Inland Fisheries Development
DLS	Department of Livestock Services
DLSO	Department of Livestock Services Office
DMPCU	District Milk Producers Cooperative Union
DOA	Department of Agriculture
DOF	Department of Forestry
DOFD	Directorate of Fishery Development
DOHM	Directorate of Hydrology and Metrology
DOI	Department of Irrigation
DSC	Department of Soil Conservation
DSCWM	Department of Soil Conservation and Watershed Management
FAO	Food and Agriculture Organization of the United Nations
FDC	Fisheries Development Centre
FMIS	farmer-managed irrigation schemes
FNCCI	Federation of Nepalese Chambers of Commerce and Industry
FORWARD	Forum for Rural Welfare and Agricultural Reform for Development
FTE	full-time employee
FTQC	Food Technology and Quality Control
GCARD	Global Conference on Agricultural Research for Development
GDP	gross domestic product
GEF	Global Environment Fund

GTZ	Gesellschaft für Technische Zusammenasbeit, Gmbh
HELVETAS	Swiss INGO
IAAS	Institute of Agriculture and Animal Science
IBSRAM	International Board for Soil Research and Management
ICAR	Indian Council or Agricultural Research
ICARDA	International Centre for Ariad Agriculture
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICIMOD	International Centre for Integrated Mountain Development
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
ICT	information and communication technology
IDE	International Development Enterprises
IFPRI	International Food Policy Research Institute
IGFRI	Indian Grass and Forage Research Institute
IIPR	Indian Institute of Pulses Research
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
INGO	International Non Government Organization
IOF	Institute of Forestry
IPGRI	International Plant Genetic Research Institute
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
JICA	Japan International Cooperation Agency
LI-BIRD	Local Initiative for Biodiversity Research and Development
MFSC	Ministry of Forests and Soil Conservation
MOAC	Ministry of Agriculture and Cooperatives
MOE	Ministry of Environment
MOST	Ministry of Science and Technology
MOWR	Ministry of Water Resources
MPFS	Master Plan for Forestry Sector
NACA	Network of Aquaculture Centre Asia Pacific
NAP	National Agriculture Policy
NARC	Nepal Agricultural Research Council
NARDF	Nepal Agricultural Research and Development Fund
NARI	National Agricultural Research Institute
NASDP	National Agriculture Sector Development Priority
NASRI	National Animal Science Research Institute
NAST	Nepal Academy of Science and Technology
NDC	National Development Council
NDRI	National Dairy Research Institute
NEC	Nepal Electricity Corporation
NGO	Non-Government Organization
NPC	National Planning Commission
NTNU	Norwegian University of Science and Technology
NWP	National Water Plan
NZ	New Zealand
PAR	Participatory Action Research
PFRD	Pasture and Forage Research Division
PFR–New Zealand	Pasture Forage Research, New Zealand

PPP	Purchasing Power Parity
PPRS	Pedigree and Performance Recording Scheme
PTD	Participatory Technology Development
PVD	Participatory Varietal Development
R&D	Research and Development
RARC	Regional Agricultural Research Center
RONAST	Royal Nepal Academy of Science and Technology
R-RDTA	Regional Research and Development Technical Assistance
SAARC	South Asian Association for Regional Cooperation
SARP	Swine and Avian Research Programme
SDC	Swiss Agency for Development and Cooperation
SEDA	Sustainable Energy Development Authority Malaysia
TU	Tribhuvan University
TYIP	three-year interim plan
TYP	three-year plan
USDA	United States Department of Agriculture
USAID	United States Agency for International Development
WB	World Bank
WFC	World Fish Centre
WHO	World Health Organization
YRS	Yak Research Station

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Executive Summary

Historically Nepal has never been a major food-deficit country. But since the 1980s it has become increasingly dependent on cereal imports. The number of malnourished people is on the rise and per capita foodgrain availability has been falling. Cereal production grew only at an average rate of 1.84 percent over the period 1995–2010, against an estimated population growth of 2 percent. The overall growth rate in agriculture remained centered around 2.77 percent in the last decade (2001–10). This low growth rate is largely responsible for the continued food insecurity and poverty incidence. One of the main factors (besides the insurgency problem) for less-than-satisfactory performance of the agriculture sector is the low level of investment. This in turn has been caused partly by a lack of effort to prioritize development interventions. The main objective of this report is to objectively review the performance of the agriculture sector and prepare a framework for prioritization of demand-driven agricultural research for development to guide investment programs for potential donors in this sector.

The report takes a broad view of the agriculture sector, covering several subsectors: food security and nutrition, crops, horticulture, livestock, fisheries, irrigation and water management, and soil conservation and watershed management. It examines the reasons for less-than-satisfactory performance and suggests interventions for agricultural research based on thematic areas in order to address the food security problem for a growing population. These are essentially research priority portfolios at the policy level, which need to be developed into individual research projects based on local conditions, capability of institutions, and donor interests.

Not only, as mentioned earlier, has the agriculture sector's performance in the last decade remained far from satisfactory, but it also remained primarily subsistence oriented, with use of modern inputs very limited. This situation has affected the overall growth of agricultural productivity, as reflected in the increase in the number of districts with food deficits, which has reached 47 in recent years. During the period 2001–10 the average agricultural gross domestic product (AGDP) growth in real terms hardly surpassed population growth, and the year-to-year growth of AGDP remained highly variable. Although the country's plans and policies are well conceived and formulated, they are yet to show a positive impact on the performance of the agriculture sector, largely because of lack of commitment and a large gap between plans/policies and implementation. On the whole, available information suggests that the country's situation of food and nutrition insecurity and poverty, if not increasing, is among the worst in the region.

Nepal's economy is dominated by agriculture, which contributes one-third of the total national gross domestic product and employs two-thirds of the nation's work force. The shares of crops and horticulture in the AGDP are 42 and 31 percent, respectively. The shares of area covered by improved varieties of the staple crops rice, maize, and wheat are 74, 69, and 91 percent, respectively. Despite the increasing trend of using improved varieties of crops, the average yields under farmers' field conditions are around 50 percent of the attainable yields shown by research farms. An ineffective technology transfer system; limited access to agricultural inputs; infrequent replacement of improved seeds; insufficient availability of irrigation; limited access to credit; and weak linkages between production, processing, and markets are the principal factors contributing to the less-than-satisfactory performance of the crop subsector, including horticulture. On the other hand, investment in research is still worthwhile when we consider the

investment made in wheat research in the country in the past (1960–90), which has generated an internal rate of return of 75–84 percent.

One of principal reasons for mediocre performance of the livestock subsector is poor animal productivity, associated mainly with a poor genetic base and a declining feed resource base. Other factors that are responsible for poor performance in livestock are the high cost of ruminant animal production, weak extension support services, limited access to credit, and limited access to the raw milk market. In the case of the fishery subsector, lack of reliable data, unavailability of fish fingerlings in required quantities, a weak research system to generate appropriate technologies, and inadequate extension and training support to fish farmers are the major contributing factors for its poor performance.

The major problems affecting soil and watershed performance are lack of clarity of roles, responsibilities, and functions of the leading agency, the Department of Soil Conservation and Watershed Management, and of other related stakeholders in the field; lack of clear-cut guiding principles on aspects of technological packages; and unclear scope of soil conservation and watershed management programs.

Overemphasis on hardware development and complacency in software development, coupled with lack of stakeholder participation, were major contributors to problems in irrigation development projects in the past. Greater participation of user groups in water management in general and on-farm irrigation in particular are now popular. Sustaining this system to a larger extent, however, is constrained by the poor capability of implementing agencies.

Institutional support to the agriculture sector dates back to the 1960s and 1970s, when a number of public-sector institutions were established. These institutional arrangements were made to ensure timely supply of modern inputs, facilitate marketing of agricultural products, and safeguard the interests of producers and consumers. While creation of these institutions shifted the responsibility of providing institutional support and services at least partially from private to public sector, these arrangements, after implementation for almost two decades, have been found to be unsustainable, mainly because of the requisite subsidies, which have become an unbearable burden to the government. As a result, efforts are being made to waive subsidies and to either return these institutions to the private sector or allow them to function alongside the private sector on a competitive basis. Such a move limits the role of the public sector to policy and regulatory functions. While the private sector has shown greater enthusiasm in taking over the business of input supply, financing, and marketing of agricultural products, it has yet to participate in a significant way in providing agricultural research and extension support to farmers, and thus these latter responsibilities still lie heavily with the government.

The growth rate projected under the Agricultural Perspective Plan (1995–2015) and subsequent plans, ever-increasing agricultural imports, ample opportunities to enhance agricultural exports, and the gap between actual and attainable yields exhibit the existence of substantial potential in the agriculture sector. Tapping these potentials, however, lies in creating an appropriate policy and institutional environment, and directing investment to the prioritized areas through design and implementation of appropriate programs that are demand-driven.

Agricultural research is, depending upon the nature of the problem, basically a long-, medium-, or short-term activity that needs an assured source of funding. More than 60 percent of the investment in agricultural research is carried through the Nepal Agricultural Research Council (NARC). Despite the priority given to this sector, agricultural research in the past heavily depended on donor funding, which created a sense of false security for as long as it continued.

NARC has gone through this situation, and once the donor funding terminated, it had to overstretch its operational budget to support staff expenses, keeping scientists idle in the research centers and laboratories. Lack of adequate funding, lack of required facilities at research establishments, and poor staff morale due to lack of incentives are factors contributing to the poor performance of agricultural research.

Most past efforts have provided the lesson that unless programs are demand-driven with greater beneficiary participation, they remain unsustainable. As a result, a shift in the design and implementation process is emerging in NARC. NARC is developing its research programs by setting priorities based on thematic areas. The research problems are discussed at meetings of regional and district technical working groups, where the stakeholders—farmers, extension personnel, nongovernmental organizations—participate in the discussion. For preparing research proposals, NARC has organized its research program into five broad thematic areas:

- Crops and horticulture
- Livestock and fishery
- Natural resource management and climate change
- Biotechnology
- Outreach and technology dissemination

Under the above thematic areas this report has identified specific programs for intervention through investment. These identified programs could be developed into projects as and when needed, depending upon the availability of resources. All the proposed programs for intervention are related to enhancement of agricultural productivity and promotion of commercial agriculture to solve the twin scourges of nutrition/food insecurity and poverty by developing technologies without disturbing ecological balance. The programs for intervention identified in this report not only conform to government policies and priority but are also the priority concerns of donors operating in the country.

Implementing the proposed programs requires huge resources, well beyond the means of the government, and thus would require assistance from donors. The proposed programs for intervention range from immediate to short-, medium-, and long-term duration. Donors willing to assist Nepal in addressing its looming problems of food insecurity and poverty require not just money but patient perseverance over a long period of time. Agricultural research is not a one-time business; therefore, for continued support, it is vital that the government seriously commit to the prospect of changing Nepal's traditional agriculture to a vibrant commercial one through agricultural research and education.

1. INTRODUCTION

1.1. Background

Nepal, a small country of South Asia, lies between India and China, bordering India on the east, south, and west, and China on the north. Its area spans slightly more than 147,000 km^2. Despite its geographically small size, it is topographically disparate, with three distinct, parallel, east-to-west physiographic regions, known as the mountains in the north, the hills in the middle, and the alluvial flatland of the Terai in the south. The mountains and the hills account for 35 and 42 percent each of the country's area, while the share of the Terai is a mere 23 percent. The mountains have about 10 percent of the country's productive agricultural land, the hills about 56 percent, and the Terai about 33 percent, in contrast to their respective shares of the population, 7 percent, 44 percent, and 49 percent.

Traditionally a monarchial nation, Nepal has recently changed its polity to that of a democratic republic after the people stood against the kingship. Members have been elected to the Constituent Assembly and since then—more than four years—the assembly is struggling to draft the constitution of this fledgling republic. How the country will federate, it is too early to anticipate.

Despite its strategic position between two large and rapidly growing economies (those of India and China), Nepal has not been able to take advantage of the location to transform its poor economy commensurate to its neighbors' due to its sluggish growth rate. Its per capita income was estimated at US$645[*] in 2010/11. In terms of other socioeconomic indicators, it is behind its neighbors on several fronts. Adult literacy is the lowest in the region, especially female literacy. Mortality among children under 5 years of age was estimated at 54 per 1,000 live births in 2011. On an average 39 percent of children are born underweight, while 57 percent of those under 5 years old have stunted growth (Nepal, CBS 2011). About 51 percent of women suffer from anemia in the Far-Western Region and 31 percent in the Eastern Region. The overall human development is the lowest in South Asia, with an index value of 0.534 in 2007. Though poverty has seen a decline over the years, it still cuts across all castes and ethnicities. The proportion of the population below the poverty line was 42 percent in 1995/96 and 31 percent in 2003/04; recently it has been estimated at 25.16 percent. On the other hand, the gap between rich and poor has increased during the same period. The Gini coefficient, a measure of income disparity, is reported to be decreasing more in urban areas than in rural areas and was 0.328 in 2010/11.

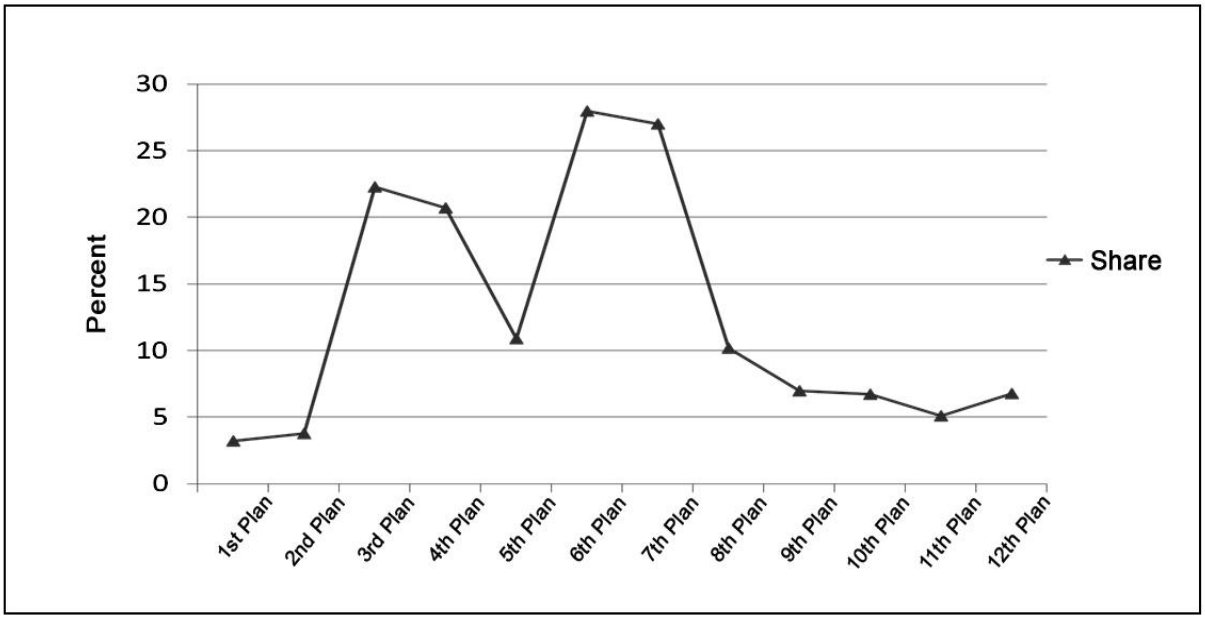
The country's economy is dominated by agriculture—it contributes one-third of the nation's gross domestic product and provides employment to two-thirds of the country's work force. Though registering a growth rate of 3.3 percent per year during the period 2000–07, cereal production has not kept pace with the growth in population since 1960. Consequently, a food-exporting country has turned into a net importer of cereals for most of the years since the 1980s.

This sluggish performance of the agriculture sector, among other factors, is associated mainly with lack of appropriate priority setting, rudimentary infrastructure, and a slow pace of implementation of sector strategies. Scattering of scarce resources to all the regions and subsectors without looking at the potential, according to a principle of equity; improper pricing policies; skewed distribution systems for agricultural inputs and credit; lack of farmer-responsive

[*] All dollar amounts are in U.S. dollars.

technology and ineffectiveness of the technology dissemination system; and low availability of irrigation facilities are the major factors considered responsible for the poor performance of the agriculture sector. Inadequate resource allocation is another important factor in the sagging performance of the agriculture sector. The government's rhetoric is not commensurate to its commitments. In fact, the government's investment in agriculture has consistently been declining over successive five-year plans (Figure 1).

Figure 1 Declining share of investment in agriculture from first plan period to date



Source: Gauchan and Shrestha 2012.

Recognizing these facts and underlying factors, the government formulated the Agricultural Perspective Plan (APP) in 1995 (Nepal, MOAC, 2007) and provided for its subsequent implementation through incorporating its objectives, strategies, and priorities in the ninth five-year plan (1997–2002). The APP adopted poverty reduction as its main goal. Through 5 percent annual growth in the agriculture sector, it aimed to enhance food security by increasing annual per capita food availability from 270 kg in 1996 to 420 kg in 2002 and reducing poverty from 42 percent to 32 percent within the same period.

The ninth plan adopted the basic strategy of the APP, which was to accelerate agriculture and rural growth through concentrated investment in a small number of priority inputs: shallow tube-well irrigation, agricultural roads, fertilizer use, and technology development and delivery through research and extension. The strategies were developed as a priority productivity package for each of the three ecological belts (mountains, hills, and Terai). The Terai strategy was technology-driven and was basically aimed at achieving a Green Revolution in cereal production. The strategy for the hills and the mountains was demand-driven, focusing on raising incomes in the Terai in order to increase demand for the types of high-value agriculture and livestock products in which the other two belts have comparative advantage, particularly in the off-season. Agricultural commercialization based on the complementarities of comparative advantage and exchange of surpluses through the market mechanism was thus the core of the APP.

The tenth plan (2002–06) also had poverty reduction as its central focus, to be achieved through attaining high growth rates in broad-based sectors. Agriculture, which is the most broad-based sector with potentials to have immediate impacts on poverty, was thus accorded top priority. The tenth plan was expected to streamline public-sector investment along the priorities of the APP and create an appropriate policy environment to attract maximum private-sector investment in agriculture. In contrast to the overall performance of the economy, average performance of the agriculture sector during the period of the tenth plan remained highly variable (agricultural gross domestic product varied from 1 to 4.8 percent) and averaged slightly higher (2.8 percent) than population growth (2.3 percent). This outcome implies only a slight growth in the per capita income of people in rural areas, since agriculture is mostly a rural function. During this period the country was struggling with the Maoist insurgency, when most of its physical infrastructures, imperative for development, were destroyed.

Although the APP has been endorsed and used by successive governments as a basic policy guideline for agricultural development efforts, it was not free from criticism, and its implementation was also not a smooth sail. The policy initiatives of the government, despite implementation lapses, are reported to have made positive impacts on agricultural growth and also on poverty reduction. However, these positive gains have remained much smaller than what the APP envisaged. According to reports (Anzdec and CMS 2002), agricultural growth in the post-APP period (2.94 percent) surpassed the same in the pre-APP period (1.75 percent) and poverty incidence shrank from 42 percent in 1996 to 38 percent in 2002.

The APP has remained the main long-term perspective plan for agricultural development in Nepal, and it is further articulated by the National Agriculture Policy (NAP) (Nepal, MOAC 2004). The NAP is seen as a means to achieve the APP goals rather than a new strategic document. Although not explicitly stated, there is a strong emphasis on creating an enabling environment through improving government capacity for service delivery. The strategic framework drawn by the APP and the NAP remains the official guideline to date for all interventions to be made for agricultural development in Nepal. This framework is supplemented by a range of specific sector policies during implementation.

The Tenth plan ran from 2002 to 2006. Following the political sea change in 2006, a three-year interim plan for 2007–09 (Nepal, NPC, 2007) was launched, followed by a second three-year plan (TYP) for 2010–13, the latter currently under implementation. The overall thrust of the TYP (2010–13) is to continue the process of transforming subsistence agriculture into a competitive, commercial, and employment-generating sector with a focus on poverty reduction and increased food security. The objectives for the agriculture sector stated in the TYP (2010–13) are as described in the National Agriculture Sector Development Priority (NASDP), covering 2010–15 (Nepal, MOAC 2010, summarized in Appendix 1).

The objective of the NASDP is to facilitate planning and implementation of priority activities in coordination with development partners through a framework that identifies priority areas. Using the NASDP framework, development partners can assist in meeting Nepal's commitment vis-à-vis Millennium Development Goals 1 and 7, "Eradicate extreme poverty and hunger" and "Ensure environmental sustainability," respectively. The NASDP also contributes to the achievement of Nepal's commitment to the World Food Summit Plan of Action and the Paris Declaration on Aid Effectiveness. As a strategic planning and resource mobilization tool, the document focuses on seven priority outcomes:

1. Enhanced food and nutrition security
2. Improved agricultural technology
3. Improved enabling environment
4. Improved market orientation and competitiveness
5. Sustainable natural resource conservation and use
6. Improved infrastructure support facilities
7. Adaptation to the effects of outmigration and feminization of agriculture

Despite various challenges, Nepal's development potential remains rich. It is imperative that the country modernize its agriculture in order to transform it from a subsistence level to a commercial and competitive system. For this to happen, the country needs to reform policies and strategies—apart from easy access to inputs and credit, year-round water availability, and improved market and infrastructural facilities—to effectively address the issue of agricultural research to generate modern technology for development.

1.2. Objectives

Since the trickle-down and "market magic" approaches failed to feed the majority of the hungry, undernourished, and poor, most agriculture-based economies and donor agencies have realized there is no other engine for driving the growth that will reduce hunger and poverty than investing in agricultural research (Singh, 2009). On this premise, the Asian Development Bank has identified the International Food Policy Research Institute (IFPRI) and the Asia-Pacific Association of Agricultural Research Institutions (APAARI) as its main partners to undertake technical assistance for its Strategic Research for Sustainable Food and Nutrition Security in Asia project under its regional research and development technical assistance (R-RDTA) agreement. In order to develop both short- and long-term solutions for addressing the challenges to reducing food and nutrition insecurity in Asia, IFPRI is leading three components of the R-RDTA agreement: addressing water-saving irrigation and investment priorities for food security and water sustainability, delivering agri-food value chains, and prioritizing demand-driven agricultural research for development (AR4D) in South Asia.

This report is prepared for Nepal under the last component of this agreement, AR4D in South Asia. The broader aim of the proposed mission is to support IFPRI and its partner APAARI to refine the agricultural research agenda suggested by the Global Conference on Agricultural Research for Development (GCARD) for South Asia by undertaking a study of various aspects of the agricultural research situation in Nepal, with the following specific objectives:

- Review the key policies and institutions that influence AR4D priority setting and execution
- Review the structures, processes, and issues related to AR4D priority setting, financing, and execution
- Include views from the demand side (farmer groups, civil societies, and the private sector) through a series of policy dialogues
- Prepare a strategic plan for enhancing AR4D in Nepal, including research prioritization, expanded investment sources, and innovative AR4D delivery

- Assess the potentials of selected technology on yield improvement, production cost reduction, sustainable natural resource use, and trade

The report outcomes will feed into the GCARD meeting due to take place in Uruguay in October 2012, helping to shape the agenda of global agricultural research that addresses the needs of poor and small farmers for effective adoption of innovation with a focus on food and nutrition security and poverty reduction.

1.3. Methodology

The report recognizes AR4D in a broad perspective. Accordingly, its review analyses of the agriculture sector in Nepal cover sectors where agricultural research has an important role in solving food and nutrition insecurity and poverty; this scope covers both subsectors directly related to agriculture and those indirectly related yet influencing the development priorities and activities of the sector. More specifically, the following subsectors have been taken into account for review:

A. Subsectors directly related to AR4D

- Food security and nutrition
- Field crops
- Horticulture
- Livestock
- Fisheries

B. Supporting subsectors influencing AR4D

- Irrigation and water management
- Soil conservation and watershed management
- Inputs and credit
- Agricultural extension
- Agricultural marketing and processing

This report is based on a review of secondary information and study reports prepared by the government and concerned agencies, as well as discussions and meetings held with various organizations, stakeholders, and individuals related to agricultural research and its implementation for enhancing agricultural production and poverty alleviation. The reviews, analyses of issues and opportunities, and implementation experience of the APP and periodic plans assisted in building an understanding of the emerging needs and priorities for AR4D to consider. The analysis relied heavily on the research plans and programs of the Nepal Agricultural Research Council (NARC), the sole agricultural research organization in the public sector, to understand the present status of agricultural research in the country. In this respect, NARC's earlier vision document, "Vision 2020: Agricultural Research for Sustainable Livelihood Improvement" (NARC 2001)—a strategic vision for agricultural and natural resources research to address national needs and priorities—and its recent *Strategic Vision for Agricultural Research (2011–2030)* (NARC 2010) provided a basic framework for identifying the research priorities and interventions needed under different thematic areas.

The analysis looked at programs and priorities cautiously, recognizing that too many priorities may often mean no priorities. Therefore an attempt was made to keep the list of priorities reasonably short and manageable, avoiding overlaps. Accordingly, instead of drawing up new priority areas, the analysis used the interventions already on NARC's drawing board as the agenda for agricultural research, weighing whether each is timely and demand-driven, from stakeholders' point of view. Stakeholders' comments and suggestions on the NARC interventions, obtained during widely held discussion sessions, augment the draft report.

2. AGRICULTURE SITUATION ANALYSIS

2.1. Introduction

Alleviation of the twin scourges of hunger and poverty has remained the foremost development priority in government programs in Nepal since the eighth plan. Nevertheless, the number of undernourished people is not decreasing, making the targets of reducing food insecurity and poverty elusive. Soaring food prices have exacerbated the situation. Almost half of the population (40–60 percent) is unable to meet the minimum daily per capita intake of 2,220 kcal.

Cereal production grew at an average annual rate of 1.8 percent over the period 1995–2010 against estimated population growth of 2 percent (ADB 2011). From the point of view of food security, this declining trend must be reversed by further increasing the yield levels, for which there is no better engine than investing in agricultural research.

Agriculture is basically a rural function, and so is poverty in Nepal. The rural population remains large and is increasing, despite growing urbanization, from about 18 million (89 percent of the total population) in 1996 to 24 million (84 percent) in 2010 (Table 1). Agriculture employed about 5.9 million persons in 2001, 66 percent of the total 8.9 million work force in the country with an additional unidentified number in subsistence and unskilled agricultural livelihoods.

Table 1. Population and poverty, 1981–2011

Census year	Total population (in thousands)	Rural population (in thousands)	Population below poverty line (%)
1981	15,023	14,062	40.0
1991	18,491	16,790	42.0
2001	23,151	19,933	31.0
2011	28,043	24,432	25.4

Sources: National Living Standards Survey 1995 and 2005; Nepal, CBS 2009.

Agriculture is the dominant sector of the Nepalese economy. It constitutes the highest proportion of gross domestic product (GDP) and is the main source of livelihood for the majority of people, particularly in rural areas, where 60–65 percent of people are engaged in this sector. Despite the fact that the share of agriculture in GDP has been declining over the years, its contribution is still 35 percent. Crops, horticulture, livestock, and fisheries constitute 42 percent, 31 percent, 26 percent, and 2 percent of agricultural gross domestic product (AGDP), respectively. Area coverage by improved varieties of rice, maize, and wheat is 74 percent, 69 percent, and 91 percent, respectively.

The growth rate in the agriculture sector during 2000–10 has been unstable despite its annual growth by 3.3 percent in the first half of the period and by 3.04 percent in the second half (Table 2).

Table 2. Performance of agriculture in the national economy, 2000–11

Period	GDP	AGDP	Share of agriculture in GDP (%)	Growth rate of AGDP (%)
	Nepalese rupees (in millions)			
2000/01	413,428	209,049	36.1	-
2001/02	430,396	220,614	36.9	3.1
2002/03	460,325	230,291	36.0	3.3
2003/04	500,699	245,944	35.4	4.8
2004/05	548,485	262,277	34.7	3.5
2005/06	611,118	278,056	33.1	1.8
2006/07	675,859	299,385	32.1	1.0
2007/08	755,257	329,401	31.1	1.8
2008/09	909,309	409,987	32.5	3.0
2009/10	1,060,681	500,837	34.6	1.3
2010/11	1,219,116	584,963	35.3	4.1

Source: Nepal Ministry of Finance, Economic Survey (2011).
Notes: GDP = Gross domestic product. AGDP = Agricultural gross domestic product.

The productivity of most crops is far below the yield potential that research has obtained in experiments as well as in farmers' fields. Despite the increasing trend of rice, wheat, maize, and potato yields (Table 6), the average yields under farmers' field conditions are around or, in most cases, below 50 percent of the attainable yields (Table 3).

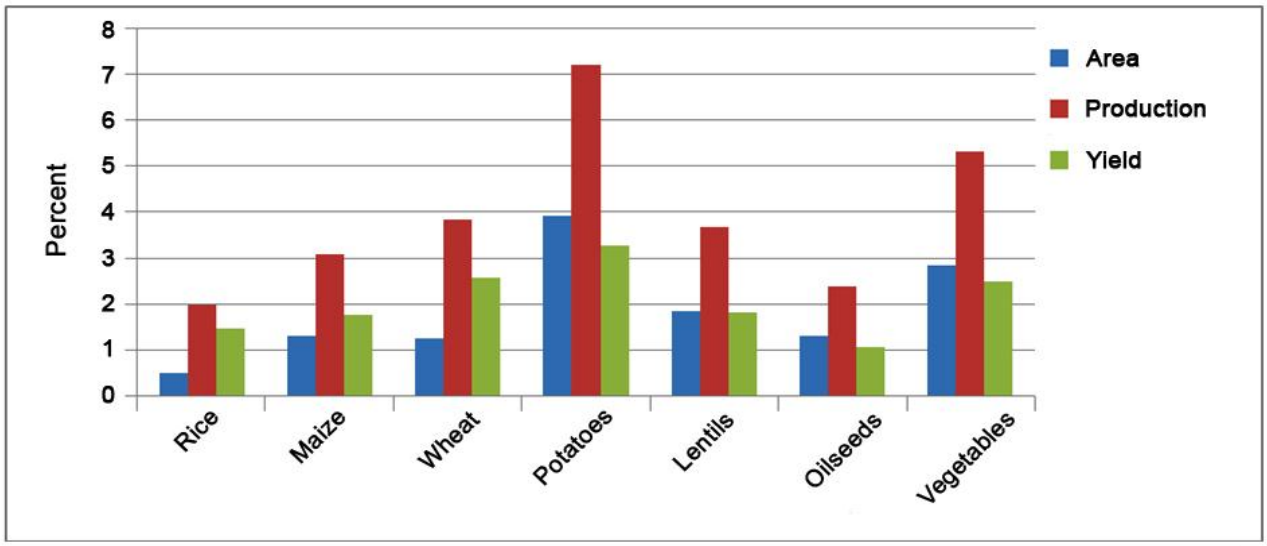
Table 3. Yield at research farm versus yield under farmers' field conditions

Crop	Ecological region	Yield at research farm (metric tons/ha)		Yield in farmers' fields (metric tons/ha)		Farmers' yield compared with research yield (%)	
		Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Rice	Terai	4.00	3.50	2.50	2.00	63	57
	Hill	4.25	3.25	3.20	2.40	75	74
Maize	Terai	4.50	3.75	1.70	1.60	38	43
	Hill	4.75	4.25	-	1.70	-	40
Wheat	Terai	4.25	2.75	1.60	1.40	38	51
	Hill	3.75	2.75	1.50	1.40	40	51
Potatoes		30.00	-	9.60	-	32	-
Cow milk (kg)		1,700.00		385.50		22	

Source: Adapted from various sources

In spite of the lower productivity in farmers' fields, total food production in the last 25 years has doubled, from 4 million tons[†] in 1984/85 to almost 9 million tons in 2009/10, with an average growth rate of almost 32 kg/year during the period. Among food crops, production and yield of wheat grew at the fastest rates, 3.8 percent and 2.6 percent, respectively. This result is very much in line with the investment made in wheat research in the past (1960–90), which has generated an internal rate of return ranging from 75 percent to 84 percent (Morris, Dubin, and Pokharel 1994). In the last 50 years (1961/62–2010/11), wheat production has increased by 11 times, whereas rice production has doubled, despite the relatively low yields of both crops. Among all crops, the highest production growth rate per year was for potatoes (7 percent), followed by vegetables (5 percent), as shown in Figure 2.

Figure 2. Annual growth rate for key crops, 1984/85–2009/10



Source: Gauchan and Shrestha 2012.

2.2. Situation of Production Subsectors

2.2.1. Food and Nutrition Security

Food security, in broader terms including nutrition security, refers to the condition of all people's having access to sufficient and sufficiently nutritious food for an active and healthy life. Total production of commodities thus serves as a good indicator of the country's overall food security situation. In this respect, Table 4 estimates the food production situation at the national level vis-à-vis estimated requirements during 2008/09 and 2009/10. The table shows that the country does not produce enough food to feed its population. Although fluctuating, the balance of food production is toward negative, and the negative balance is growing over the years. During the same period, a look at food production and requirements by ecological region (Table 5) shows the mountains and the hills in a food-balance deficit but the Terai in a surplus, indicating the reason for the severe food and nutrition insecurity that exists in the remote hills and mountains of Nepal.

[†] Metric tons are used throughout the text.

Table 4. Food production and requirements in Nepal, 2008/09 and 2009/10

Particulars	2008/09	2009/10
Production (metric tons)	5,160,406	4,967,469
Requirements (metric tons)	5,213,316	5,297,444
Balance (-/+)	(-) 52,910	(-) 329,975

Source: Statistical Information on Nepalese Agriculture, MOAC (2009).

Table 5. Food production and requirements by ecological region, 2009/10

Particulars	Mountain	Hill	Terai
Production (metric tons)	279,765	2,040,441	2,647,263
Requirements (metric tons)	376,982	2,451,345	2,469,117
Balance (-/+)	(-) 97,217	(-) 410,904	(+) 178,146

Source: Statistical Information on Nepalese Agriculture, MOAC (2009).

The food production and requirements situation suggests that from the food production point of view, not only is the country food insecure but the problem seems to be growing over time.

In terms of nutritional security, the scenario is still not encouraging, whether one looks at per capita food availability or total dietary energy supply. The Agricultural Perspective Plan (APP) target of per capita food availability of 420 kg per year by 2002 is yet to be achieved. Although no official statistics are available, experts suggest that the per capita availability of food is around 300 kg per year or a little higher.

The dietary energy supply was 2,124 kcals/day in 1996, and with meager increases it had reached 2,144 kcals/day by 2003/04. By 2010/11 it had reached 2,220 kcals/day (Nepal, CBS 2011). Although there has been a substantial change in food consumption patterns, particularly among the poor, still more than 90 percent of the daily dietary energy consumption of people in the country comes from plant sources and not quite 10 percent from animal sources (Nepal, CBS 2011). Within the plant sources, the majority of energy is supplied by cereals, with minimal contribution from fruits and vegetables, an imbalance that leads to nutritional disorders. The problem of nutritional insecurity in the country is also reflected in a high percentage of children with malnutrition, low birth weight, and stunted growth, as well as a high prevalence of protein energy malnutrition.

The critical review of the food and nutrition security subsector identified a number of factors considered responsible for the high and growing level of food and nutritional insecurity, including low agricultural productivity, lack of crop diversification, lack of effective nutrition education, lack of research and development on locally available food, and lack of transportation and marketing infrastructures. Further, the low level of income and skewed distribution system due to rugged topography are equally important factors.

2.2.2. Field Crops

Among various subsectors of agriculture, the crop subsector is the major component, contributing 60 percent of AGDP. Rice is the most dominant crop, on average making up 35 percent of the cropped area. Rice is followed by maize (20 percent), wheat (16 percent), cash crops (10 percent), legumes (7 percent), and minor crops (7 percent). Performance of major crops during the years 2001–10 is presented in Table 6.

Table 6. Performance of major crops, 2001–10

Year	Rice		Maize		Wheat		Potatoes	
	Area ('000 ha)	Yield (metric tons/ha)	Area ('000 ha)	Yield (metric tons/ha)	Area ('000 ha)	Yield (metric tons/ha)	Area ('000 ha)	Yield (metric tons/ha)
2001	1,560	2.70	825	1.80	641	1.81	129	10.18
2002	1,517	2.73	826	1.83	667	1.89	135	10.90
2003	1,545	2.67	836	1.88	669	2.01	140	10.92
2004	1,559	2.86	834	1.91	665	2.09	143	11.49
2005	1,542	2.78	850	2.02	675	2.13	147	11.85
2006	1,549	2.72	851	2.04	672	2.07	151	13.09
2007	1,440	2.56	870	2.09	703	2.16	154	12.66
2008	1,549	2.77	870	2.16	706	2.22	157	13.11
2009	1,556	2.90	875	2.20	695	1.93	182	13.30
2010	1,481	2.72	876	2.12	731	2.13	183	13.43

Source: Nepal Ministry of Finance, Economic Survey (2011).

The performance of cereals, as shown, remained far from satisfactory during the decade, remaining lower than what was planned in the tenth five-year plan. Data suggest that rice yield depended to a great extent on the rainfall pattern during monsoon. Moreover, the observed performance of the these crops suggests that yield growth was tied to growth of area rather than use of inputs, which is very low, and technology.

These observations are substantiated by the *Agriculture Sector Performance Review* (Anzdec and CMS 2002), which indicated several factors for the less-than-satisfactory performance of the crop subsector, including an ineffective research and extension system; limited access to and infrequent replacement of improved seed; limited availability and inefficient use of irrigation; limited access to credit; and weak linkages between production and markets, due mainly to poor marketing and transportation infrastructures.

2.2.3. Horticulture

The horticulture subsector comprises three main components: fruits, vegetables (including roots and tuber crops), and floriculture. Although all three components of the subsector are important, most of the research and development initiatives so far have been centered on the first two components, with floriculture getting a minimal focus. The situation and performance of fruits and vegetables are presented in Tables 7 and 8.

Table 7. Area, production, and yield of major fruits in Nepal, 2009/10

Crop	Area (ha)	Productive area (ha)	Production (metric tons)	Productivity (metric tons/ha)
Citrus fruits	33,898.00	22,903.00	259,191.00	11.30
Apples	9,891.00	45,102.00	41,754.90	9.25
Mangoes	25,673.50	16,667.50	127,315.10	7.63
Bananas	7,266.90	5,813.50	91,042.30	15.66

Source: Statistical Information on Nepalese Agriculture, MOAC (2009).

Table 8. Growth of area, production, and yield of vegetables in Nepal, 2008/09–2009/10

Measure	2008/09	2009/10
Area (ha)	225,154	235,098
Production (metric tons)	2,754,406	3,003,821
Productivity (metric tons/ha)	12.23	12.77

Source: Statistical Information on Nepalese Agriculture, MOAC (2009).

In the case of vegetables, production of seasonal vegetables and vegetable seeds for commercial purposes are priority programs of the APP and the tenth plan. In spite of an increasing number of districts participating in commercial vegetable production and off-season vegetable production, the less-than-expected performance of the horticulture subsector is generally linked to a number of constraints related to production, processing, and marketing.

On the production front, unavailability of appropriate planting materials; lack of irrigation facilities for fruits, vegetables, and other high-value horticultural crops; high interest rates on loans to fruit farmers; ineffective extension and training activities; and weak research are the major constraints that require immediate attention in policy and development initiatives.

On the processing front, lack of suitable varieties for processing, uncertainties in production and hence lack of assured supply to processors, low productivity and consequent high cost on the domestic market, lack of proper knowledge of packaging materials and postharvest technologies, inadequate cold storage facilities, and poor linkages between producers and processors are the major challenges that need policy interventions and development activity.

Similarly, on the marketing front, lack of competitive markets (dominance of high marketing margins retained by traders); scattered production and lack of transportation facilities; inadequate market information; lack of adequate technical skill on harvesting, grading, and packaging; and lack of market research are the areas where interventions are necessary for progress and development of this subsector.

2.2.4. Livestock

Next to the crop subsector, livestock is the second most dominant subsector of the agriculture sector, accounting for 29 percent of AGDP. Almost two-thirds of agricultural households in the country rear cattle; around half keep buffalo, sheep, goats, and poultry; about 10 percent keep pigs; and around 4 percent rear ducks. Nepal is known for having among the highest livestock density in the world, with a population of 7.2 million head of cattle, 5 million buffalo, 9.2 million goats, 0.8 million sheep, 1.1 million pigs, 39.5 million chickens, and 0.37 million ducks in 2010/11 (Nepal, MOAC 2011). Despite high density, the livestock population is on the increase. Table 9 presents growth in livestock numbers by species group.

Table 9. Growth of livestock population in Nepal, 2000/01–2009/10

Species	2000/01	2004/05	2009/10	Growth (%)
Cattle	6,982,660	6,994,463	7,199,260	3.10
Buffalo	3,624,020	4,081,463	4,836,984	33.47
Sheep	850,170	816,727	80,1371	(-) 5.73
Goats	6,478,380	7,153,527	8,844,172	36.51
Pigs	912,530	947,711	1,064,858	16.69
Chickens	19,790,060	22,790,224	25,760,373	30.16
Ducks	411,410	391,855	379,753	(-) 7.69
Milk cows	852,583	902,286	954,680	11.97
Milk buffalo	936,811	1,050,977	1,252,770	33.72
Laying hens	5,998,367	6,643,350	7,290,875	21.54
Laying ducks	215,376	183,208	175,300	(-) 18.60

Source: Statistical Information on Nepalese Agriculture, MOAC (2009).

From 2000/01 to 2009/10, the higher annual growth rates of small ruminants over large ones and of productive animals over total animals within categories indicate changing a livestock-rearing strategy on the part of farmers. On the one hand, a high growth rate of the livestock population indicates gradual commercialization of the subsector; on the other, it calls for immediate attention toward possible depletion of the feed resource base.

Milk, meat, eggs, and wool are the principal products of the livestock subsector. The production situation of these products from 2000/01 to 2009/10, together with their growth rates, is presented in Table 10. During the period, milk, meat, and egg production has increased but wool production has declined by 5.57 percent owing to the decreasing sheep population.

Table 10. Production of livestock products, 2000/01–2009/10

Product	Unit	2000/01 Production	%	2009/10 Production	Increment %
Milk	**Metric tons**	**1,124,132**	100	**1,495,897**	**13.20**
Cow milk		342,738	100	429,030	25.17
Buffalo milk		781,394	100	1066,867	36.53
Meat (net)	**Metric tons**	**194,258**	100	**248,573**	**27.96**
Buffalo		124,848	100	162,213	29.92
Mutton (sheep)		2,856	100	2,691	(-) 5.77
Goat		37,769	100	49,851	31.98
Pork (pig)		15,239	100	17,066	11.98
Chicken		13,259	100	16,527	24.64
Duck		287	100	225	(-) 21.60
Eggs	**Thousands**	**507,323**	100	**643,203**	**26.78**
Hen		491,566	100	629,793	28.11
Duck		15,757	100	13,410	(-)14.89
Wool	**Kg**	**613,824**	100	**579,631**	**(-) 5.57**

Source: Statistical Information on Nepalese Agriculture (2009).

In general, the productivity of the livestock subsector is low. For example, milk productivity is less than half the average productivity in Asia and just under 67 percent of the average for developing countries. Although some improvements in livestock productivity have been noticed in recent years, these increases are small.

One of the principal reasons for less-than-satisfactory performance of the livestock subsector is poor animal productivity, which is in turn associated mainly with a poor genetic base of animals[‡] and a declining feed resource base, which meets only 67 percent of the population's requirement. Other challenges that have a bearing on the performance of this subsector are the high cost of ruminant animal production, weak extension and veterinary services, and limited access to bank credit and market facilities. In the case of nonruminants, the high cost of production is the result of poor-quality feed and use of expensive feed ingredients.

2.2.5. Fisheries

Nepal is endowed with plenty of water resources. Total water surface area in the country is estimated at about 819,000 ha, made up of rivers (48 percent), irrigated paddy fields (49 percent), lakes (8.6 percent), reservoirs (0.2 percent), ponds (0.8 percent), and swamps (1.4 percent). Since these surface-water bodies provide opportunities for natural fishery as well as for aquaculture, fishery has been a traditional business for certain groups of people, and it has made a significant contribution to the agriculture sector. In the tenth plan, fish production was 46,750 tons, against the target of 49,000 tons, registering only a 6 percent annual increase during the plan period (Nepal, NPC 2007, Chapter 9, "Agriculture").

[‡] Improved animal breeds in Nepal as recorded by Sherchand (2001) are 12 percent, 36 percent, and 5 percent for cattle, buffalo, and goats, respectively.

Table 11. Summary of fish production in Nepal, 2009/10

Particulars	Ponds (number)	Total area (ha)	Production (metric tons)	Yield (kg/ha)
A. Production from aquaculture practices			**28,230**	
Pond fish culture	24,418	6,900	24,837	3,600
Other areas (ghol)	-	2,000	2,600	1,300
Paddy cum fish culture	-	100	45	450
Cage fish culture (m^3)	-	80,000	480	6
Enclosure fish culture	-	100	140	1,400
Trout fish in raceway (m^2)	-	5,000	100	20
Fish production in public sector	-	-	28	-
B. Production from capture fisheries			**21,500**	
Rivers	-	395,000	7,110	18
Lakes	-	5,000	850	170
Reservoirs	-	1,500	385	257
Marginal/swamps/ghol	-	11,100	5,990	540
Irrigated paddy fields	-	398,000	7,165	18
Total fish production			**49,730**	

Source: Statistical Information on Nepalese Agriculture, MOAC (2009)

The situation and performance of the fisheries subsector is presented in Table 11. Total fish production in the country was 49,730 tons during 2009/10, which has increased to 52,970 tons in 2010/11 (Nepal, MOAC 2011). In the early 1980s, an aquaculture production program was initiated with financial support from the Asian Development Bank (ADB) and technical assistance from the Food and Agriculture Organization of the United Nations (FAO). This assistance continued for more than 10 years, helping to promote extension of the fisheries subsector all over the Terai districts. Increasing pond fish productivity (Table 12) led to a sharp increase in fish production from aquaculture, which was 28,230 tons in 2009/10 from about 6,900 ha of water surface area. In contrast with aquaculture, capture fishery contributed only 43 percent of total fish production during that period. The second-rate showing of capture fishery is mainly due to lack of reliable data on the production and productivity of open-water fishery.

Although performance of the fisheries subsector is in an increasing trend, it is far from satisfactory from the viewpoint of the targets set in the successive plans—12 percent annual growth rate in the eighth plan, 8.8 percent in the ninth plan, and 8 percent in the tenth plan—as well as market demand.

Table 12. Area, production, and productivity of pond fish culture in Nepal, 2000/01–2009/10

Year	Water surface area (ha)	Fish production (metric tons)	Productivity (kg/ha)
2000/01	5,945	15,320	2,577
2001/02	5,954	15,516	2,606
2002/03	5,987	16,000	2,672
2003/04	6,093	18,060	2,964
2004/05	6,220	20,213	3,250
2005/06	6,337	22,545	3,558
2006/07	6,500	23,750	3,654
2007/08	6,735	24,295	3,607
2008/09	6,700	23,780	3,549
2009/10	6,900	24,869	3,604

Source: Statistical Information on Nepalese Agriculture, MOAC (2009)

The review of the fishery subsector revealed various factors responsible for its poor performance: data gaps, unavailability of fish fingerlings of required species, a weak research system to generate appropriate technology, inadequate extension and training support, and inadequate coordination between supporting line agencies within and outside the Ministry of Agriculture and Cooperatives (MOAC). Further, complacency on the part of development agencies regarding the harmful effects of constructions like reservoirs, roads, and industry along natural water bodies is taking its toll in terms of the progress of this subsector.

2.3. Situation of Supporting Subsectors

2.3.1. Irrigation and Water Management

Recognizing irrigation water as a vital input of agriculture, the government has given priority to development of irrigation since the beginning of the planned development effort (1956). The continued priority accorded to irrigation development in the past led to construction of irrigation infrastructures to irrigate about 1 million ha by 1994/95. An additional 30,000 ha were developed during a period with no plan (1995/96–1996/97) after the eighth plan. During the ninth plan an additional 249,000 ha were targeted in line with the APP strategy, but only 44 percent of this target was achieved. Failure to attain the target was mainly due to very low progress in the development of groundwater irrigation (below 20 percent achievement) because of the withdrawal of the subsidy program for shallow tube wells. Table 13 shows the total area under irrigation in the country.

Table 13. Total area under irrigation, 2010/11

Irrigation type	Area (ha)	Total by class (ha)
Surface-water irrigation		
Agency-managed	325,919	
Agency-supported	352,658	
Traditional FMIS	274,203	
Surface irrigation total		**952,780**
Groundwater irrigation		
Shallow tube wells	318,280	
Deep tube wells	45,135	
Groundwater total		**363,415**
Grand total		**1,316,195**

Sources: Adapted from data by Department of Irrigation and Ground Water Resource Development Board.
Note: FMIS = Farmer-managed irrigation schemes.

Development of irrigation in the country until 2001 was relatively rapid. However, the pace of development has slowed over recent years. From 1991/92 to 2000/01 irrigated area expanded by an average of 54,000 ha every year, but since then the rate of growth has declined to 17,000 ha/year. The key reasons for slowed growth are the Maoist insurgency starting in 1996, budget limitations, withdrawal of subsidy, and reduced involvement of ADB in the agriculture sector. Irrigation development appears to be picking up now, however, with the Ground Water Resource Development Board reporting 7,000 shallow tube wells installed in 2010/2011, 9,000 planned for 2011/12, and a targeted increase of 20,000 per year for five years to meet current demand.

Of the total irrigation systems developed in the country, only 70 percent are reported to be in the actual catchment area. Of the total catchment area irrigated, only 54 percent is covered by year-round irrigation. Thus the developed irrigation systems are not irrigating the total catchment area they were designed to serve, even in the summer. This underperformance is caused by overambitious design and water limitation, the latter in turn due to a combination of low supply into the land, conveyance out of the catchment area, and loss due to poor management. In the surface irrigation plan, less land is irrigated during winter, when irrigation is needed most. This deficient system design, lack of year-round water supply for the catchment area, lack of beneficiaries' participation in project development, and poor system management are some of the major reasons for poor performance of the irrigation subsector.

2.3.2. Soil Conservation and Watershed Management

Agriculture is a land-based activity, and land conditions are determined by soil characteristics, water availability, and topographical features. Suitability of land for agriculture thus depends upon the combined effects of all these natural factors. Of the total land area of Nepal (147,181 km^2), about 2,359,000 ha, or 16 percent, was under cultivation in 1980. With the growing pressure of ever-increasing human and livestock populations, the cultivated area increased to 2,968,000 ha, or almost 20 percent of total land area, by 1985. This is probably the upper frontier for the expansion of cultivation because this area remained constant until 1999/2000. The increase in cultivated land came at the expense of forest, wetland, and grazing land, and

also involved use of steep land in the hills and mountains. Land use intensity, which was 120 percent in 1985, went up to 140 percent in 1999/2000. The meager use of plant nutrient supplements, combined with increased land use intensity, has led to further depletion of the soil nutrient reserve, aggravating soil degradation.

With the continued degradation of watershed areas, 0.4 percent, 1.5 percent, and 11.7 percent of the total watershed area of the country, respectively, is in very poor, poor, and fair condition. The watershed areas in good and excellent condition, 33.8 and 52 percent, respectively, are also facing fast deterioration due to overexploitation of watershed resources by their inhabitants. The watershed conditions of the Siwalik region are very geographically fragile and highly erosion prone, with a dwindling water table.

Although the Department of Soil Conservation and Watershed Management (DSCWM) has implemented a number of soil conservation and watershed programs in the field with success, the review of this subsector reveals various constraints in the smooth implementation of watershed management programs. These constraints include lack of clarity of roles, responsibility, and functions of the DSCWM, which is the lead agency, and of other related stakeholders in the field; lack of clear-cut guiding principles on aspects of technological packages; and unclear scope of soil conservation and watershed management programs.

2.3.3. Inputs and Credit

Institutional support to agriculture-sector development in Nepal dates back to the 1960s and 1970s, when a number of public-sector institutions were established, such as Agricultural Inputs Corporation, Nepal Food Corporation, Agricultural Tools Factory, Dairy Development Corporation, Nepal Tea Development Corporation, Agriculture Development Bank Nepal (ADB/N), and a number of sugar mills. These institutional arrangements were made to ensure timely supply of modern inputs, furnish credit, ensure marketing of agricultural products, and safeguard the interests of producers and consumers. While creation of these institutions shifted the responsibility of providing institutional support and services at least partially from the private sector to the public sector, these initiatives, after implementation for two decades or more, are being found unsustainable mainly because of the subsidies tied with these institutional arrangements that have turned out to be a heavy burden to the government. As a result, efforts are being made to gradually remove subsidies, either by turning these institutions over to the private sector or by allowing them to function alongside the private sector on a competitive basis through limiting the role of the public sector to policy and regulatory functions. With this policy shift, private-sector institutions are also given the responsibility of import and distribution of agricultural inputs, and their participation is solicited in development activities.

In the financial sector, apart from ADB/N, a large number of commercial banks, microfinance institutions, and cooperatives are involved in rural financing, including financing in the agriculture sector. Despite the fact that a number of institutions are providing rural financing services, ADB/N still contributes about 80–90 percent of agricultural lending; moreover, farmers' access to institutional borrowing is still low, estimated at only 20 percent.

2.3.4. Agricultural Extension

While the private sector has shown great enthusiasm in taking on the business of input supply, financing, and marketing of agricultural products, it is not yet ready to be involved in a significant manner in providing agricultural research and extension support to farmers. Thus these functions lie heavily with the government.

Although a number of institutions and nongovernmental organizations are also involved in a limited way in providing agricultural extension support to farmers, the major responsibility of supporting farmers with information on new technology remains with the Department of Agriculture and the Department of Livestock Services, both under MOAC. Both the departments provide their services to farmers through a chain of organizational structures comprising 5 regional directorates; 75 district offices; and a number of service centers, subcenters, and farms.

From time to time, new institutions are created and old ones reorganized in order to match the zeitgeist so that these institutions remain relevant to the times. With such reorganization, not only has the responsibility of providing agricultural extension and training services to farmers shifted from one organization to another, but there have also been changes in approaches to extension and training. The earlier approach in extension and training services was the block approach. Since then different approaches have been tried through the support of various donors and projects, especially after creation of a unified Department of Agriculture in 1972. The latest approach to agricultural extension being adopted is the group approach.

Irrespective of the approach adopted, the performance of agriculture in the past has often raised questions as to the effectiveness of agricultural extension and training in the country. The major problems related to ineffective agricultural extension services are the thin spread of junior technicians and junior technical assistants; inability of front-line extension workers to provide need-based, practical advice; lack of mobility of the front-line extension workers; insufficiently equipped offices and service centers; poor coordination among related institutions; limited access to markets; and poor input supply.

2.3.5. Agricultural Marketing and Processing

As in any other developing country in South Asia, agriculture in Nepal is predominantly a subsistence activity carried out by smallholder farmers. The average farm size is less than half a hectare and is likely to decline further, given the limited scope for expansion of cultivable land as the population continues to grow by almost 2.3 percent annually. The consequence is that farmers not only produce less but have very little surplus to bring to the market for sale. This characteristic of production and marketing has, by and large, shaped the development and present state of agricultural production and processing in the country.

Until the 1950s, marketing and processing of agricultural products were entirely in the hands of the private sector. Organized public-sector interventions in agricultural marketing and processing began in the 1960s with the establishment of a number of public corporations such as Nepal Food Corporation, Tea Development Corporation, Jute Development and Trade Corporation, and Agricultural Input Corporation, as well as creation of the Agricultural Marketing

Services Department.[§] Further, during the same period, cooperative societies, known as Sajha cooperatives, were established to undertake marketing of both agricultural inputs and outputs.

With the initiation of economic reform measures in the mid-1980s, the limited role of the public sector in marketing and processing was further reduced. Fertilizer marketing has now been liberalized and the private sector is also involved in the import and distribution of fertilizers. Similarly, manufacturing, import, and distribution of improved farm tools, equipment and machinery, and plant protection chemicals are now completely with the private sector. This sector is increasingly involved in the production and distribution of improved seeds and animal feed as well.

With due recognition of the characteristic production and postproduction features of agriculture in the country, the government's support programs for the improvement of marketing and processing facilities have so far been focused in the following areas: development of marketplaces, such as periodic markets or rural primary markets, by providing minimum facilities; development of wholesale markets; training small producers on different aspects of marketing; organizing small farmers to take up group and cooperative marketing; construction of rural roads to connect production pockets with primary or secondary markets; encouraging the private sector in the construction of storage and cold storage facilities; and streamlining policies in order to attain the commercialization of agriculture as envisaged by the APP. The effort to commercialize agriculture has been further articulated in the three-year interim plan (2007–09) and the three-year plan (2010–13).

[§] Tea Development Corporation has been handed over to the private sector, and Agricultural Input Corporation has been split up into two companies, one dealing with seed and other with fertilizer. Jute Development and Trade Corporation has been dissolved. The Agricultural Marketing Services Department was dissolved and its function is now carried out by the Agricultural Marketing Directorate in the Department of Agriculture.

3. OVERRIDING DEVELOPMENT PLANS AND POLICIES

Despite agriculture's having been identified as a priority sector in all plans, the government's continuity and investment in this sector are not commensurate with its order of priority. Though the budget allocated to agriculture and related sectors has apparently increased over the years, the investment figures still do not match stated priorities. For example, until the eighth five-year plan (1992/93–1996/97), the allocation for agriculture and related sectors remained above 25 percent of all government expenditures. From the ninth plan (1997/98–2001/02) onward, the government's position on the need for development in this sector remains the same, but the relative share of allocations has declined (see Appendix 2), reaching 12.9 percent in the 2007/08–2009/10 three-year interim plan (TYIP).

3.1. Agricultural Perspective Plan (1995–2015)

In 1995 a 20-year Agricultural Perspective Plan (APP) came into existence. It emphasizes a focus on four priority input areas—irrigation, fertilizer, technology, and rural agricultural roads and energy—for livestock, high-value crop, agribusiness, and forestry-sector growth. Poverty reduction and food security are its priorities.

The APP emphasizes demand-led commercialization with Green Revolution–type agriculture in the Terai and high-value commodities in the hills and mountains, with coordinated production and marketing relationships. The APP set objectives as follows:

- To accelerate growth in agriculture through increased productivity
- To alleviate poverty through expansion of employment opportunities
- To transform subsistence agriculture into commercial agriculture through diversification of crops by identifying areas of comparative advantage
- To expand economic transformation opportunities by fulfilling preconditions for agricultural development
- To identify short- and long-term strategies for implementation
- To establish guidelines for preparing periodic plans and programs

The plan aims to achieve 3 percent growth of agricultural gross domestic product per year and reduce the incidence of poverty to 14 percent by 2015. It envisages multiplier effects of agricultural interventions on the nonagriculture sector through these strategies:

- Accelerated economic growth through technology-driven agricultural development
- Agricultural growth creating production demand with multiplier effects on all sectors of the economy
- Higher employment growth
- Investment in human capital, physical infrastructure, and service delivery institutions
- A package approach to development with coordination of activities launched in the hills, mountains, and Terai
- Broader participation of key stakeholders, including women

Since its adoption, the APP has remained a major policy document for agriculture and rural development. All successive governments formed after its creation have directly or indirectly endorsed it as a policy document. To date, the APP remains in a way a policy framework for the government in agriculture and rural development, as it continues to reiterate consistent aims and approaches for poverty reduction.

3.2. Three-Year Interim Plan (2007/08–2009/10)

The 2007/08–2009/10 TYIP encompassed the mandates provided by the People's Movement II. It aimed to ensure prosperity, peace, and social justice in the country. It was developed with a vision for modernizing and commercializing agriculture in line with the APP and the National Agriculture Policy (NAP) (Nepal, MOAC 2004). It underlined the importance of broad-based, gender-inclusive, and sustainable agricultural growth through the following means:

- Increase agricultural production and productivity
- Maintain food sovereignty
- Transform subsistence agriculture to commercial agriculture
- Increase employment opportunities
- Ensure sustainable use of agricultural biodiversity

The TYIP adopted the Poverty Reduction Strategy Papers approach and the priorities of the United Nations' Millennium Development Goals by undertaking the reforms that were envisaged but had remained pending during the tenth five-year plan period. It targeted annual economic growth of 5.5 percent, with 3.6 percent and 6.5 percent growth in the agriculture and nonagriculture sectors, respectively.

Along with the sustainable use of productive resources (land and water), the TYIP emphasized the use of quality seeds and rearing of improved breeds of animals. Other aspects underlined by the plan were provisions for access to modern technologies, institutional credit, and marketing capacity development. Similarly, infrastructure development support for production-pocket areas, promotion of agricultural value chains, human resources development, promotion of agricultural biodiversity, and maintenance of genetic resources were also stressed.

With the close of the TYIP in June 2010, another three-year plan (TYP) followed, for 2010/11–2012/13. This plan, currently in force, aims to transform subsistence agriculture into a competitive and employment-generating sector for poverty reduction and food security.

Keeping in view the emerging needs of the country, the TYP has adopted the following objectives for the agriculture sector:

- To ensure food and nutritional security
- To make the agriculture sector competitive and business-oriented through increased production and productivity
- To reduce poverty by increasing employment and income-generating opportunities
- To minimize the adverse effects of environment and climate change in the agriculture sector
- To develop cooperatives for agricultural development
- To develop human resources for a sustainable agricultural development process

3.3. Master Plan for Forestry Sector (1989)

Nepal developed its Master Plan for Forestry Sector (MPFS) in 1989 (Nepal, MFSC 1989), which provides a 25-year policy and planning framework for the forestry sector. The long-term objectives specified by the MPFS are these:

- To meet people's basic needs for forest products on a sustainable basis
- To conserve ecosystems and genetic resources
- To protect land against degradation and the effects of ecological imbalance
- To contribute to local and national economic growth

The MPFS has laid out six primary programs for forestry, putting greater emphasis on community and private forestry development through collective conservation and use practices. Focus is on programs in these areas:

- Community and private forestry development
- National and leasehold forestry development
- Medicinal and aromatic plants development
- Soil conservation and watershed management
- Conservation of ecosystem and genetic resources
- Policy, legal, and institutional reforms

3.4. National Water Plan (2005)

Nepal is in a monsoon zone, where the rainfall varies in both spatial and temporal terms. The river systems flood during monsoon season and there are dry spells in the winter and summer.

The country has untapped potentials for gravity flow and groundwater. The National Water Plan (NWP) (Nepal, MOWR 2005) emphasizes their conservation and sustainable management for overall development and maintenance of the livelihood of people, while promoting economic growth. The plan focuses on these major priority areas: mitigation of hazards, environmental protection, and resolving water use conflicts. It specifies three output areas: security, utilization, and institutional systems for effective service delivery.

The plan recognizes the necessity of strong institutional mechanisms for efficient as well as integrated water management systems development. It also places priority on the promotion of regional and bilateral cooperation for mutual benefits.

The overall objective of the NWP is to contribute to economic development, poverty reduction, food security, public health and safety, and protection of the natural environment. The plan follows the policy of integration, coordination, decentralization, participatory approach, and implementation of water-related programs within the framework of sustainable development.

3.5. National Agriculture Policy (2004)

Nepal aims to transform its subsistence agriculture into a competitive agribusiness sector. The NAP (Nepal, MOAC 2004) holds a long-term vision of developing sustainable agriculture for food security and poverty reduction. The specific objectives of the NAP are these:

- To increase agricultural production and productivity
- To make agriculture competitive with regional and world markets by developing a commercial agricultural system
- To protect, promote, and utilize natural resources, the environment, and biological diversity

The NAP aims to assist farmers who have access to means and resources as well as those who have comparatively low access to means, resources, and opportunities. It emphasizes enhancing agriculture production and productivity, developing a commercial and competitive agriculture system, and protecting as well as promoting the use of natural resources without adverse effect on the environment.

In addition, several policies related to the agriculture sector have been framed in order to guide the performance of its subsectors. The major ones include these:

- National Seed Policy (2000)
- National Tea Policy (2000)
- National Fertilizer Policy (2002)
- National Coffee Policy (2003)
- Irrigation Policy (2003)
- Agribusiness Promotion Policy (2006)
- Agriculture Biodiversity Policy (2007)
- Commercial Agriculture Policy (2007)
- Dairy Development Policy (2007)
- Pesticide Policy (under preparation)

While going through these plan and policy documents, one finds that Nepal already has a rich body of plans/policies that are often well envisioned and formulated. While these plans/policies can be improved and new ones may be needed as the times change, one main issue is the large gap between plans/policies and implementation. A number of factors are responsible for this gap: weaknesses in planning and institutional capacity, irregular and inadequate funding, limited skilled human resources, a weak accountability system, and a weak monitoring and evaluation mechanism.

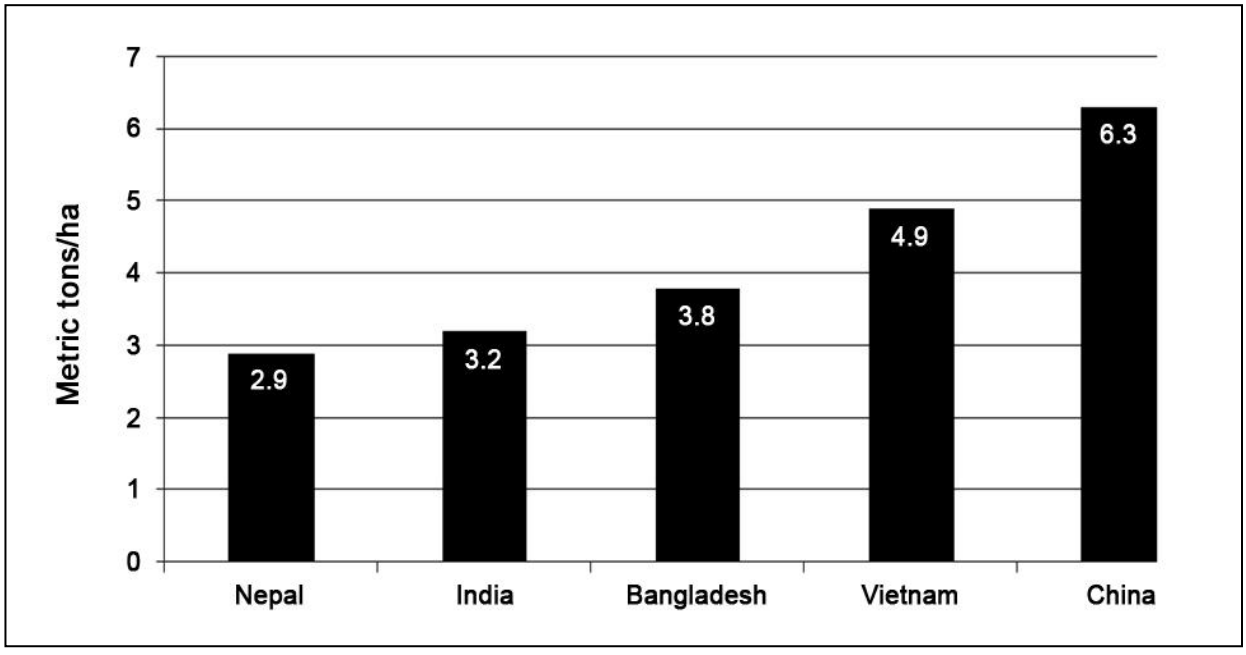
4. AGRICULTURAL RESEARCH FOR DEVELOPMENT

4.1. Introduction

Nepal has an 80-year history of agricultural research and development. In 1924, the Department of Agriculture was opened; that same year, a trial demonstration farm in Singh Darbar, Kathmandu, and a fruit nursery farm at Godawari, Lalitpur, were established. Since then, the agricultural research system and its management and technology dissemination have undergone several institutional changes. The latest change on the front of agricultural research was the creation by statute of the Nepal Agricultural Research Council (NARC) in 1991 as an autonomous institution. It is an apex body mandated to conduct, promote, support, coordinate, and evaluate research activities related to the agriculture sector.

Rural poverty and agricultural productivity are interlinked in Nepal due to the dominant role of agriculture in the economy. Current crop yields in the country are not sufficient to eradicate poverty from rural areas. A comparison of Nepal's crop yields with those of other South Asian countries indicates that Nepal lags far behind its neighbors. The cereal yields in Nepal in 2008 were 89 percent those of India, 88 percent those of Pakistan, 65 percent those of Sri Lanka, and 60 percent those of Bangladesh. Rice yield in Nepal, which accounts for 20 percent of the country's agricultural gross domestic product (AGDP) and 49.4 percent of total foodgrain production, lags far behind when compared with the production of other rice-growing countries in Asia in terms of yield per hectare (Figure 3). The stagnation in agriculture due to low productivity has intensified the food security problems in the country. In fact, 43 out of 73 districts are at a food deficit and 10 more districts are considered vulnerable (NARC 2010).

Figure 3. Comparative rice yields in Nepal and selected countries, 2008



Source: NARC'S Strategic Vision for Agricultural Research (2011-2030)

To date, several crop-, horticulture-, livestock-, and fisheries-related technologies have been developed and disseminated to farmers. However, the impact of these technologies in the agriculture sector, judging by the poor subsector performance, has remained nominal. Despite the fact that agricultural research in the country is lopsided toward crops, productivity growth in the principal crops has been quite low, and when compared with that of neighboring countries, it is far behind (Table 14). Crop yields in Nepal were the highest among the countries of South Asia during the early 1960s—198 percent of those in India, 111 percent of those in Bangladesh, 212 percent of those in Pakistan and 108 percent of those in Sri Lanka. But the situation in the late 1990s was reversed, with Nepal having the lowest crop yields in South Asia—46.7 percent of India's, 87 percent of Bangladesh's, 46.3 percent of Pakistan's, and 64.9 percent of Sri Lanka's. During the periods compared, average yield of all crops in Nepal grew by only about 1.25 percent per year while that in India, Bangladesh, Pakistan, and Sri Lanka grew, respectively, by 5.28 percent, 1.92 percent, 5.5 percent, and 2.7 percent.

Low crop productivity is attributed to very low use of inputs, particularly mineral fertilizers. It is estimated that in 2006 the average fertilizer use per hectare of cropped area was less than 20 kg, which is far below the South Asian average of 115 kg/ha. In addition to low fertilizer consumption, Nepal's agriculture sector is constrained by limited irrigation water availability, the vagaries of monsoons, poor infrastructure and market access, and the low priority given to agricultural research.

Table 14. Per-hectare yield and growth rates of major crops in Nepal and other South Asian countries, 1961–63 versus 1997–99

Yield	1961–63				1997–99			
Country	**Rice**	**Wheat**	**Sugar**	**All**	**Rice**	**Wheat**	**Sugar**	**All**
Nepal yield (kg/ha)	1,940	1,230	1,979	1,854	2,410	1,630	3,579	2,940
Nepal yield as % of								
India	129	146	46	198	83.05	63.17	53.68	46.71
Bangladesh	116	198	53	111	85.81	74.43	84.92	87.05
Pakistan	140	150	61	212	84.38	75.78	74.68	46.32
Sri Lanka	101	NA	119	108	74.29	NA	66.02	64.91
Growth rate (%)	NA				1961–63 to 1997–99			
Nepal					0.59	0.76	1.63	1.25
India					1.79	3.07	1.20	5.28
Bangladesh					1.41	3.46	0.34	1.92
Pakistan					1.97	2.64	1.07	5.50
Sri Lanka					1.43	NA	3.26	2.66

Source: FAO-RAP (2003).
Note: NA = Not applicable.

Traditionally, lack of adequate funding, fewer facilities than required at research establishments, and poor staff morale due to lack of incentives have been regarded as the main factors contributing to poor agricultural research performance. These constraints, to a large extent, remain valid. However, new dimensions have increasingly been pointed out as the causes of ineffective research system management. Among others, these include predominance of a top-down approach to research planning, which implies a lack of stakeholder participation, and low priority on policy research owing to a lack of separation of the policy body and the research implementation body within NARC. Like many other public-sector agencies, NARC is also blamed for its frequent leadership changes due to political interference. This situation has overwhelmingly affected the autonomous functioning of NARC.

In the past 19 years NARC has developed and released 126 improved varieties and 1 hybrid variety of crops, with a package of practices suitable for the different agroecological zones of the country. These varieties were developed for their higher yields, resistance to pests and diseases, and tolerance to extreme conditions such as draught. These released varieties have improved the production of field and horticultural crops, taking advantage of different microclimatic conditions of the country. At the same time, NARC has also developed and promoted cost-effective zero- or minimum-tillage technology to conserve resources.

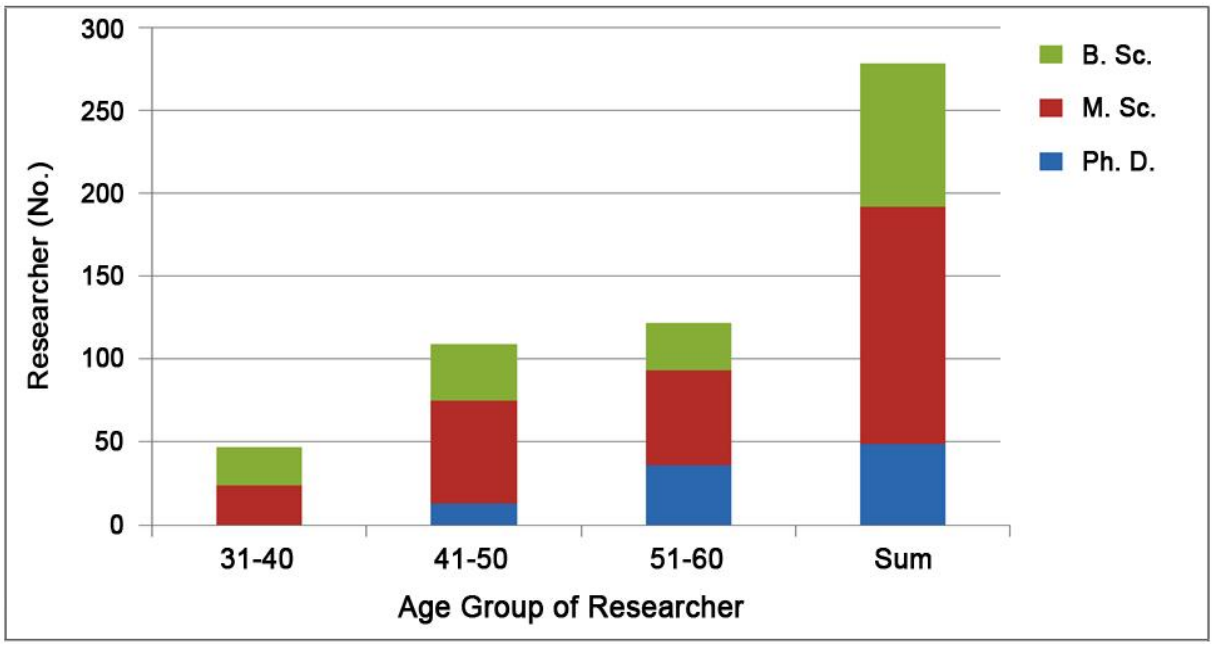
In the livestock and fisheries subsector, NARC has introduced livestock improvement and efficient feed preparation techniques and feeding practices. It has also successfully demonstrated trout breeding technology in farmers' fields and introduced community-based combination rice–fish farming, resulting about 12 percent additional rice yield and 300–515 kg/ha of fish produced within a single rice cropping cycle.

A detailed list of technologies that NARC has developed, scaled up, and promoted is given in Appendix 3.

In 2009, Nepal's agricultural research intensity, that is, research and development (R&D) spending as a ratio of AGDP, which is a useful indicator of comparative investment in agricultural research across countries, was $0.26 for every $100 of AGDP. During the Agricultural Research and Extension Project (AREP), a World Bank–funded project that ran from 1998 to 2002, this ratio slightly increased to $0.43 (in 2001), but with the completion of this project the ratio came back down to the level of the late 1990s (Stads and Shrestha 2006). The number of full-time researchers per farmer, another comparative indicator of R&D intensity, followed a declining trend. In the late 1990s the number of agricultural researchers employed in the country was 50 for every million farmers. This number significantly decreased, to only 33, by 2009.

The number of researchers employed in NARC by age group and academic qualification is shown in Figure 4. More researchers with postgraduate qualifications are within the highest age group (51–60 years); when they retire in the near future, if they are not replaced, NARC is going to face a problem. If this staffing issue is not properly addressed in time, in light of the almost 400 scientific and technical positions vacant, NARC is soon going to face a dearth of researchers to conduct its research programs.

Figure 4. Age of NARC researchers by academic degree, 2010



Source: Gauchan and Shrestha (2012)

4.2. Evolution of the Research System in Chronology

As mentioned earlier, the agricultural research system in Nepal, like those in many other countries, has taken its time to evolve to its present form, and its development has been commensurate with the development of the country as a whole. The chronological development of Nepal's agricultural research can be traced out as follows:

1950s–1970s: Traditional and Preliminary Form of Agricultural Research System

- Establishment of agricultural research farms and stations with local extension mandate
- Establishment of disciplinary divisions with laboratory and other infrastructural facilities
- Development and recruitment of scientific manpower

1970–1990s: Conventional Public-Dominated National Agricultural Research System

- Setting up of coordinated national commodity programs (1972)
- Initiation of on-farm cropping and farming system research
- Establishment of National Agriculture Research and Service Centre (1986) as a first step in the creation of an independent research organization to conduct and coordinate agricultural research in Nepal

1990–1999: Restructuring of Agricultural Research System with Clearly Defined Research Mandate

- Establishment of NARC to consolidate and coordinate agricultural research in the country.
- Integration of British-funded Pakhribas Agricultural Centre and Lumle Agricultural Centre into NARC.
- New perspectives with pluralistic structure of the national agricultural research system to encourage participation of nongovernmental organizations (NGOs) and the private sector in agricultural research.

2000–present: Emerging trend in the involvement of multiple actors and source of funding for agricultural research for development (AR4D)

- Initiation of a competitive grant system by the Hill Agricultural Research Project from 1998 to 2000.
- Establishment of Nepal Agricultural Research and Development Fund (NARDF) in 2001/02 for funding adaptive R&D projects.
- Emerging trend in the participation of multiple actors (international NGOs, community-based organizations, the private sector) and donor-funded projects in location-specific participatory R&D (PVS, PTD, PAR) through multiple sources of funding and partnership

4.3. Other Agencies Engaged in AR4D

There are two other agencies in the public sector—the Nepal Academy of Science and Technology (NAST), formerly known as the Royal Nepal Academy of Science and Technology (RONAST), and the Department of Forest Research and Survey (DFRS)—that undertake agricultural R&D in Nepal to a very limited extent. Their combined share in agricultural R&D capacity in terms of staffing was recorded at only 4 percent in 2009.

NAST

NAST is under the purview of the Ministry of Science and Technology and was established in 1982 as an independent body to promote science and technology. Its broad mandate includes advancing science and technology for national development, preserving and modernizing indigenous technologies, promoting science and technology research, and identifying and facilitating appropriate technology transfer (RONAST 2005). NAST's involvement in agricultural research is largely in the areas of biofertilizers, biopesticides, and molecular studies. It has a very limited number of scientists, with 13 agricultural researchers in 2009. It has maintained a linkage with NARC, and the agencies share some facilities.

DFRS

DFRS is under the Ministry of Forests and Soil Conservation and comprises two divisions. The Forest Research Division is heavily engaged in forestry research and management, agroforestry, soil analysis, and socioeconomics. The Forest Survey Division generates statistics and data inputs for planning of forestry development (Nepal, DFRS 2011). It had only two agricultural researchers working in 2009.

NARDF

In 2001 the government introduced a competitive grant system for agricultural research. A separate institution called NARDF was established under the Ministry of Agriculture and Cooperatives (MOAC). This agency does not carry out research but awards research grants to government organizations and NGOs on a competitive basis. At the end of the research project, the researchers have no accountability to implement their research findings as a recommendation for farmers' practices. Similarly, NARDF has neither the authority nor a mechanism to recommend the technology developed through grant-assisted research projects. Therefore, once the grant-assisted project terminates, there is no one to own the responsibility if anything untoward happens when farmers use the research results. The agricultural extension system also does not seem to use findings generated through NARDF grants. Further, there is no formal mechanism between NARC and NARDF to interact and consult. This disconnect has increased the risk of duplication of research work. Not only is there a waste of resources, then, but NARDF is nothing more than an appendage without any functional responsibility for implementing the results of the research projects executed with its grant assistance.

In order to address criticisms of NARDF, the government in recent years has adopted a working policy of allowing NGOs and the private sector to do regular monitoring of research studies carried out through its grant assistance. But still there is no mechanism for farmers to use the results of NARDF projects, since the extension agencies are reluctant to recommend them as part of their package of practices.

Tribhuvan University

Tribhuvan University is the only higher education agency involved in agricultural R&D in Nepal; it works through the Institute of Agriculture and Animal Science (IAAS) and the Institute of Forestry (IOF). Including both institutes, its share of agricultural R&D capacity in terms of staffing was about 16 percent in 2009. Most of the research works in these institutes are carried out to fulfill students' degree requirements. However, to a limited extent the institutes do research to solve farmers' problems with research grants from donors. Recently, the government announced the formation of the University of Agriculture and Forestry, but it is yet to come into functioning.

NGOs

Compared with their role in many other South Asian countries, the role of NGOs in agricultural R&D in Nepal is relatively important. In 2009 NGOs accounted for 9 percent of agricultural research capacity in terms of staffing. There are three NGOs involved in agricultural R&D in Nepal:

1. The Local Initiative for Biodiversity Research and Development (LI-BIRD), which employed 32 agricultural researchers in 2009, works to reduce poverty and improve

social justice through participatory approaches to R&D. It works in natural resource management, biodiversity, and ecosystem service.

2. The Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), which employed two agricultural researchers in 2009, is committed to helping the poor and addressing social inequity. Its agricultural R&D component utilizes a participatory approach and works in the areas of crops and technology dissemination.

3. The Centre for Environmental and Agricultural Policy Research and Development (CEAPRED) conducts research on climate change, sustainable livelihoods, and environmental policy. Its policy research generates input data that are helpful to the government for its decisionmaking processes.

4.4. Emerging Challenges

Along with increasing food production by narrowing yield gaps, a challenge also lies in conserving valuable natural resources while sustaining agricultural production. The conventional approach to agricultural research as a public good has been changing, and involvement of the private sector as a partner in developing and promoting technologies has become the order of the day.

Agricultural research in Nepal has drastically changed over the past two decades. New national and international contexts have rendered it more complex and challenging.

New National Context

New dimensions in the national context include (1) better connectivity (roads, Internet, mobile devices, and so on); (2) outmigration and remittance; and (3) a new political context that is moving toward devolution of power and participation of stakeholders at different levels, from planning to execution.

These new dimensions have several implications for agricultural research, necessitating a new approach in the context of the overall agricultural development strategy. Better connectivity implies not only easier access to markets but also faster access to information and knowledge. The success of information and communication technology penetration in South Asia has demonstrated innovative options for linking smallholder farmers to markets and technology. One example is e-Choupal in India.

Outmigration, particularly from rural areas, has reached a substantial level: about 200,000 people in 2010 in search of productive employment not available at home. This has created a labor problem in the agriculture sector, posing a challenge to agricultural research to find a replacement for manual labor in cheaper tools and machines. On the other hand, outmigration has some positive aspects in terms of remittances and bringing back new skills and capacities.

The participation of stakeholders at various levels from planning to execution is a step forward toward decentralization and will help bring people and communities that have long been marginalized into the mainstream of the country. Such participation will be a key issue that needs to be addressed in the agricultural research strategy.

New International Context

New dimensions in the international context include (1) unstable and increasing world food prices, (2) rapidly growing regional markets, and (3) climate change.

After recovery from a global economic meltdown, the prices of commodities, including most food commodities, have started to rise and become unstable again. In recent years, most food prices seem to have reached a plateau at a higher level. This situation is a challenge as well as an opportunity for a country like Nepal. If the country's agricultural trade remains weak and the country continues to import food, high international prices will have a negative impact on food security. On the other hand, as a potential large exporter of agricultural commodities (including high-value products), Nepal could take advantage of high international prices of commodities, provided its productivity and competitiveness increase through the use of modern technologies.

The issue of climate change is at the forefront of all development work in the country. The sensitivity to this issue in policies and programs both within and outside the government is encouragingly noticeable. Its impact on agriculture is being assessed as follows and the issue will become more pressing over the following decades:

Climate Change and Agriculture

Nepal is largely an agrarian economy and therefore highly sensitive to changes in climate and natural resources availability. Climate change threatens to reduce effectiveness of development initiatives across Nepal. For example, drying—added to a trend of warming—will impair food security and affect the availability of water resources. This will increase the vulnerability of marginalized and poor people in both rural and urban areas of western Nepal. Further increase in the intensity of rains in other parts of Nepal—particularly those where the topography is broken and soils eroded—will experience increased flooding and landslide risks threatening human security, water supplies, and urban infrastructure. Hence effective climate change adaptation is

There is no doubt that agricultural research needs to play a vital role in the future due to increasing population and scarcity of agricultural land and water, and to be competitive under open-market policies and trade liberalization. Agricultural research will have to respond to the new challenges by generating technologies to enhance productivity of the agriculture sector. This will be achieved only through various institutional innovations, for which farsighted research policies are required.

4.5. Policy Foundation

The Agricultural Perspective Plan (1995–2015) and the National Agriculture Policy (Nepal, MOAC 2004) form the core foundation of the government's agriculture policy, a foundation reflected in the planning document of the three-year interim plan (TYIP) for 2007/08–2009/10. The TYIP recognizes the central role of agricultural research in enhancing the productivity of the agriculture sector, and thus the government has specified in it strategies for technology development and dissemination.

NARC has developed a 20-year strategic vision plan (NARC 2010) that outlines broad strategies for addressing the agricultural research needs of the country. The vision provides broad policy guidelines and direction for implementation of research programs of various subsectors of agriculture over a period of 20 years. It is a rolling plan and so will require refinement and modification to address the changing needs of the agricultural research system in the context of national policies and priorities.

NARC'S vision (NARC 2001) focuses on poverty reduction through effective and efficient utilization of scientific information in agriculture and natural resources. The major research priorities envisaged in NARC's strategic vision plan (NARC 2010) include field crops, horticulture, livestock, fisheries, natural resource issues, socioeconomic aspects of the farming system, price analysis and marketing, on-farm water management, gender, and policy research (Maskey, Manandhar, and Gauchan 2004). For the implementation of its vision plan, NARC has recently drafted a strategic plan that includes the following:

- 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
- NARC's ability to achieve its objectives improved
- Direct services mandated appropriately

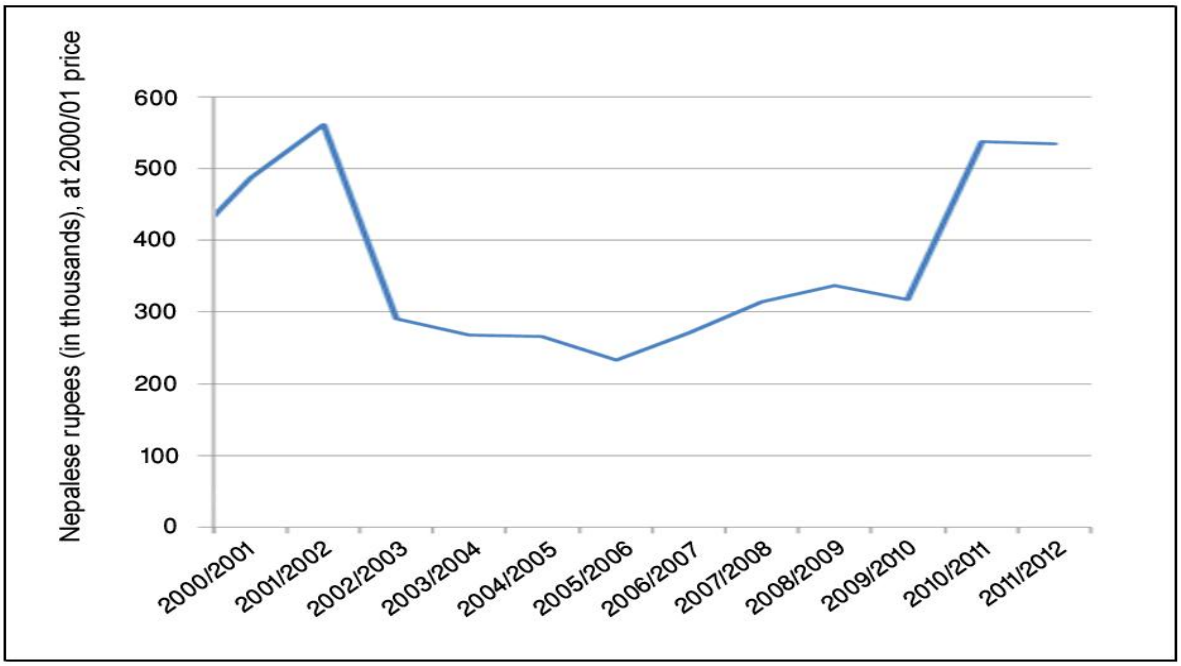
NARC's research programs are usually adaptive, applied, need-based, and demand-driven. Priority research topics are those generated from village-level workshops, where researchers, extension workers, development agencies, and farmers' groups participate, supported by regional technical working groups.

4.6. Funding for Agricultural Research

Despite the fact that the funding needs of agricultural research are extremely modest in comparison with those of most other development agencies, there is an inexplicable reluctance in the government to adequately fund this vital activity. For example, investment intensity has never gone above 0.2–0.3 percent of AGDP, which is far below globally acceptable investment norms and even lower than the average for all developing countries. While the policy pronouncements accord high priority to this investment, it is not reflected in the financial allocation.

Evidence of faltering productivity and production potential has always prompted a critical stance on the part of managers of public funds, but there has been no official attempt to systematically compile, analyze, and document the necessity for research resources. Rather, public fund managers invent an arbitrary ceiling for the routine financial exercise of public expenditure every year. This has been a major concern of agricultural research managers in the public research system. And because of this ad hoc approach, not only is the resource allocation in agricultural research erratic (Figure 5), but the research arena is starved of funds, forcing scientists to sit idle in the laboratories.

Figure 5. Trend of NARC research budget in constant price, 2000/2001–2011/12



Source: Adapted from Gauchan and Shrestha (2012)

In 2009, Nepal invested 520 million Nepalese rupees (Rs.), or US$23 million purchasing power parity (PPP) (both adjusted to 2005 constant prices) in agricultural R&D (Table 15). The investment is carried out mainly through NARC, which accounted for more than 60 percent of the country's total agricultural research expenditures.

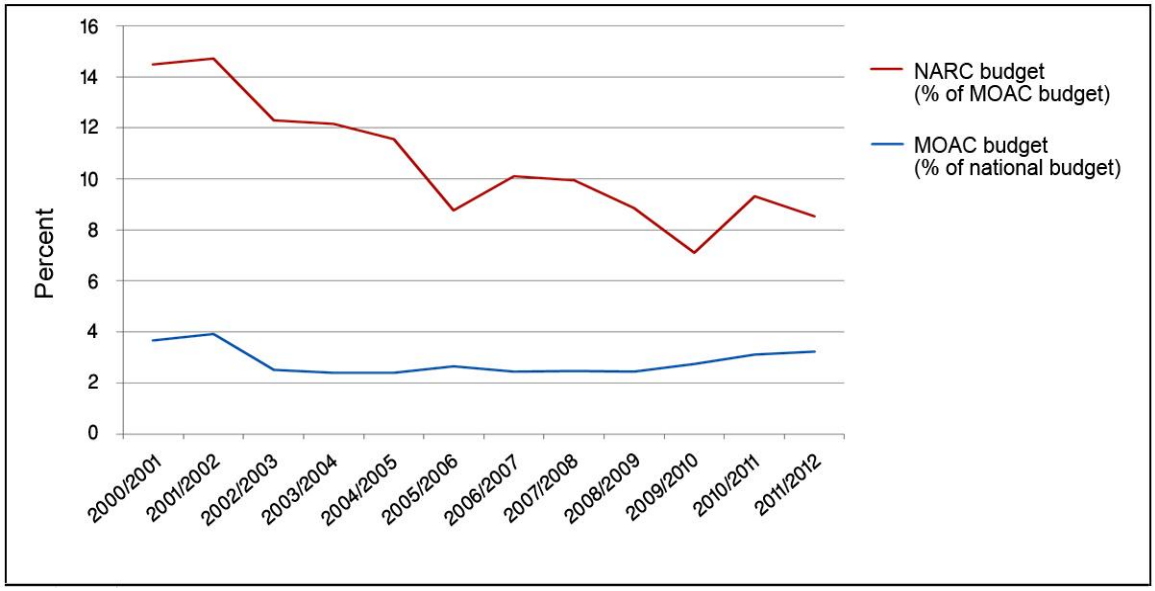
Table 15. Overview of spending on agricultural research and development, 2009

Agency	Total spending			Total staffing	
	Nepalese rupees (in millions)	PPP (US$)	Share (%)	FTEs	Share (%)
NARC	321.8	14.2	61.9	278.0	71.5
Other government (2)	37.4	1.7	7.2	14.5	3.7
Nongovernmental orgs. (3)	86.2	3.8	16.6	35.3	9.1
Tribhuvan University	74.6	3.3	14.4	60.8	15.6
Total	**520.0**	**23.0**	**100.0**	**338.6**	**100.0**

Source: Rahija, Shrestha, and Stads 2011.
Notes: Spending is adjusted to 2005 constant prices. PPP = Purchasing power parity. FTEs = Full-time employees. Figures in parentheses indicate the number of agencies.

Despite the priority given to the sector, the budget allotted to research has declined over the years when compared not only with the national budget but also with the MOAC budget (Figure 6).

Figure 6. Declining share of NARC budget in MOAC budget, 2000/01–2011/12



Source: Gauchan and Shrestha 2012.

Although donor contributions, in terms of the number of projects, have increased over the years, overall support for agricultural research has waned since the termination of the World Bank–funded Agricultural Research and Extension Project (AREP) in 2002. Moreover, NARC is totally dependent on the government for its budget requirement. The government allocated Rs. 326 million in the year 1997/1998 and Rs. 510 million in the year 2008/09, an increase of 56 percent in absolute terms but a decline in relative terms due to the increase in core inflation by about 100 percent during that period. The share of NARC in the national and MOAC budgets also decreased substantially during that period. In 1997/98, its share in the national budget was 0.53 percent and in the MOAC budget it was 14 percent. These proportions had declined by 2008/09 to 0.22 percent and 8.85 percent, respectively. The government's budget allocation for NARC from 2002 to 2007 was almost constant, and only since 2010 has it increased significantly (Table 16).

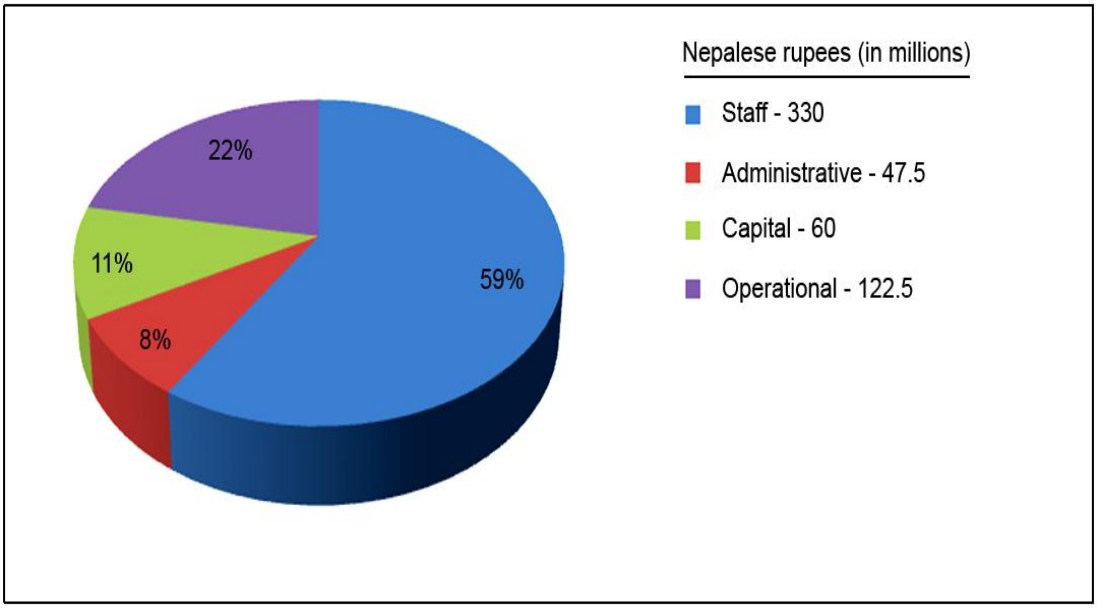
Table 16. Government funding of agricultural research through NARC, 2000/01–2011/12

Fiscal year	Budget allocated, Nepalese rupees (in millions)
2000/01	486.586
2001/02	577.780
2002/03	313.239
2003/04	300.575
2004/05	311.249
2005/06	295.055
2006/07	362.660
2007/08	449.100
2008/09	541.600
2009/10	560.000
2010/11	980.000
2011/12	1,060.000

Source: Adapted from data provided by NARC'S Finance Division.

Because of the declining trend of the budget for agricultural research, staff costs (at 59 percent) have overwhelmed all other expenditures, based on the budget allocation for 2009/10 (Figure 7). Operational costs, at 34 percent in the past, have declined to 22 percent of NARC's budget, implying that it is very difficult, if not impossible, to carry out any new research projects, thus pushing NARC into a status quo situation. Administrative and capital costs are 8 percent and 11 percent, respectively. Within the operational budget, about 28 percent is allocated for field crop research, 14 percent for horticultural research, 20 percent for livestock research, 7 percent for fisheries research, and 30 percent for multisector activities.

Figure 7. Breakdown of NARC budget, 2009/10



Source: NARC (2010).

4.7. Funding Concerns of the Research System

There is a misconception among the managers of public funds that funding for agricultural research is a subsidy or grant, not an investment, and it often appears as if the government is doling out charity to such research. As long as this attitude remains unchallenged, the full potential of agricultural research as an *engine of growth* in the war on poverty cannot be achieved. The victims of this situation will not be scientists but the country's poor. Investment in agricultural research therefore is not a matter of charity but of wisdom and prudence on the part of managers of public funds. Under the prevailing situation, the budget allocated by the government for agricultural research forces researchers to produce new technologies (outputs) to meet the changing needs of farmers under conditions of increasing resource constraint.

The other government agencies engaged in research, NAST and DFRS, together accounted for 7 percent of agricultural R&D spending in 2009. The three larger NGOs (LI-BIRD, FORWARD, and CEAPRED) that are also involved in agricultural R&D accounted for about 17 percent of agricultural R&D expenditure in 2009, up from 12 percent in 1990. The two agricultural research institutes of Tribhuvan University, IAAS and IOF, had a combined share accounting for about 15 percent of total agricultural R&D spending in the country in 2009.

The most tangible evidence for government support to agricultural research is the financial backing it gives to the national agricultural research system. The Food and Agriculture Organization of the United Nations (FAO), the World Bank, and others have suggested various normative targets as desirable goals for financial support to agricultural research. The most widely used indicator is the ratio of research expenditure to value of AGDP (IFPRI and ISNAR 1991). The UN World Food Conference in 1974 suggested a target of 0.5 percent of AGDP by 1985. This was later increased by FAO to 1 percent for 1990 and 2 percent by World Bank. Working Group 1 (under the stakeholders' perspective) of the Expert Consultation on Agricultural Research for Development in Asia and the Pacific Region (APAARI 2009) also suggested funding for agricultural research at a minimum of 2 percent of AGDP and recommended that 50 percent of it should be for operational expenses.

NARC's budget was only 0.17 percent of AGDP in 2010/11, and this ratio has always been less than 0.5 percent. Furthermore, the government has heavily depended on donors' contributions for agricultural research funding. This situation created a false sense of security in NARC, which was debunked when the 2002 termination of the World Bank–funded AREP resulted in a budget crisis. Thus, for NARC to be truly sustainable requires a deep commitment from its own government for agricultural research in Nepal, a commitment that is not yet forthcoming.

Above all, the existing process of budget allocation through MOAC, NARC's contact ministry, needs to be revisited if one wants to see NARC proactive and vibrant. In the existing process, NARC submits its program and budget to MOAC to discuss at the National Planning Commission (NPC). During the discussion, MOAC is unconcerned whether agricultural research gets more money or less, because the general mind-set in the ministry is that it is not MOAC's headache since NARC is an autonomous body. Therefore, for NARC to be more effective and responsive, it needs to submit its program and budget to the NPC directly, and once it is discussed and finalized, let the disbursement be channeled through MOAC.

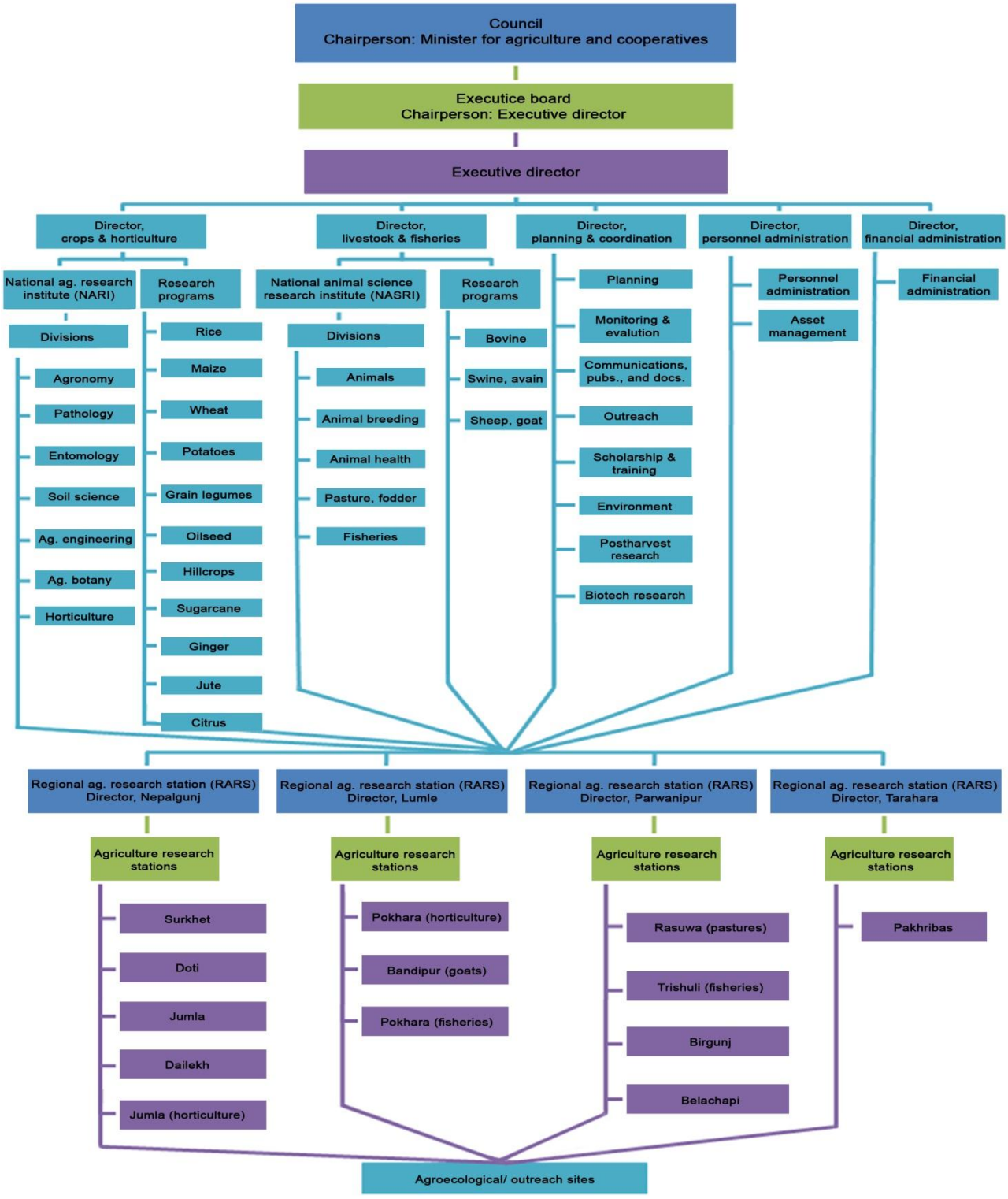
4.8. Current Structure of NARC and Argument for Its Repositioning

As an apex-level agricultural research organization mandated by statute, NARC has been entrusted with the formulation of agricultural research policies and engaged in conducting, promoting, coordinating, and evaluating research activities for agriculture and related sectors. In order to ensure smooth execution of its responsibilities, NARC has its organizational structure as shown in Figure 8. It has a two-tired governing body: the council and the executive board. The 16-member council is chaired by the minister for agriculture and cooperatives. The executive director acts as member–secretary of the council. The council formulates policy with due consideration of the National Agricultural Policy and provides necessary directions to the executive board. An 8-member executive board, chaired by the executive director of NARC, implements and executes the research program approved by the council. One of the program directors acts as member–secretary of the executive board.

The National Agricultural Research Institute (NARI), National Animal Science Research Institute (NASRI), commodity programs, and regional agricultural research centers (RARCs) work under supervision and control of NARC headquarters. NARI, NASRI, other disciplinary divisions, and crosscutting divisions and units provide technical support to commodity programs, RARCs, and agricultural research stations. Outreach sites are governed by concerned RARCs or agricultural research stations.

Since it set forth its vision in 2002, the context in which NARC is working has changed dramatically. It is being redefined as a promoter, facilitator, regulator, and implementer. Its agenda is expanding to address the emerging issues of commercialization, globalization, climate change, and food security. It is time for NARC to promote research *for* development instead of research *and* development.

Figure 8. NARC's current organizational structure



Source: NARC (2010).

There is one school of thought in NARC that its current structure and mandate are not sufficient to provide effective leadership to the national agricultural research system, which has various R&D stakeholders. NARC's autonomy over the years has resulted in a sense of isolation from the mainstream—that is, government bureaucracy—and this has affected NARC as it receives complacent behavior from MOAC and others. Although no one would like to talk about it openly, in private and off the record they agree that it is due to the autonomy that NARC enjoys. This group is in favor of repositioning NARC in the government ministry by restructuring it to establish necessary linkages with public policymakers and the technology dissemination system. The proponents of this idea argue that it will endow NARC with assured funding and consistent support from the government.

In this group's proposed restructuring, the executive director of NARC would become ex officio secretary (research) in MOAC, as has been done in India. This arrangement would make NARC part and parcel of a government entity that can address the emerging issues of technology generation as well as the gray area between technology generation and dissemination. Counter to previously held assumptions, this group believes that it would actually speed decisionmaking on the implementation of government policies and programs, and would enhance collaboration with both government and donors. Appendix 4 shows this proposed restructuring of NARC.

There is a second school of thought in NARC that argues that despite its autonomous status, NARC has never been allowed to work in an autonomous environment due to constant political interference at various levels. Under a bureaucratic mind-set, the creativity of scientists is likely to be stifled due to lack of research ambience, which demands freedom in working style, time, and hours, and science-friendly rules and regulations. Such an environment is not possible in the government bureaucracy. Therefore, this group is of the opinion that with some reforms and adequate time, the present NARC should be allowed to function in a truly autonomous environment before any makeover of its status is attempted.

However, there is a third school of thought, which is of the opinion that in light of the importance of agricultural research as an engine of economic growth, NARC needs to be strengthening and upgrading its status so that it is not bogged down by bureaucracy, as the situation at present is. Proponents of this view say that NARC needs to be elevated to the status of a national agricultural science academy and chaired by the prime minister. NAST, which is much smaller in organization and functioning—indeed in every respect—than NARC, is itself chaired by the prime minister; therefore if NARC were to be elevated to national academy status, it would be very appropriate for it to be chaired by the prime minister. The government needs to look at this proposal from the point of view of its commitment to poverty alleviation, food security, and natural resource management.

4.9. Structural Concerns of the Research System

Through the years, NARC has been seriously plagued by the bureaucratic mind-set that has overwhelmed its research administration, turning it into a business-as-usual bureaucracy. The situation is further aggravated by the push and pull of political interference. The result is that good performance is never rewarded and poor performance is rarely punished. This state of affairs has had a serious demotivating impact on young scientists, with an obvious consequence of brain drain, a threat to both the success and the sustainability of NARC's research programs. The problem has been compounded by lack of decisiveness on the part of NARC leaders, who always look for a security blanket, even while exercising the autonomy bestowed by statute. This trait is the most damaging weakness of NARC leaders (Joshy 1999), which has given

strength to those who advocate changing the autonomous structure of NARC and bringing it under MOAC. The structural concerns have been expressed as follows:

- Research is lacking in science-friendly management.
- Is NARC really functioning as an autonomous organization?
- Appointment of NARC's council members is more like a selection of political faithfuls than appointment of professionals with credibility in their fields.
- Is NARDF relevant in the present research system?
- Due to the lack of rewards and punishments and the lack of the right person in the right place, NARC does not seem to be different from any other government bureaucracy.
- Can NARC's structure and process attract the private sector to participate or invest as a research partner?

5. POLICIES AND PROGRAMS INFLUENCING AGRICULTURAL RESEARCH FOR DEVELOPMENT

Prioritizing the lead sector, agriculture, has been one of the main policies of the government since the beginning of planned development. There is huge body of strategies, plans, rules and regulations is formulated and implemented in order to develop this sector (Nepal, MOAC 2009). In the 1990s, after formulation of the Agricultural Perspective Plan (APP), agriculture-sector policy was shaped by the strategies and priorities of the APP. Both the ninth plan and the tenth plan adopted the strategy and priorities of the APP as their focus.

To attain high growth in the agriculture sector and thereby help to enhance food security and reduce poverty, the APP recognized the need to reorient agricultural research and extension strategy toward critical problem-specific priority areas. For this, the APP stressed the need to focus effort in those areas that lead to fast technological change in order to increase the productivity of high-value commodities and thereby promote agricultural trade in the country. To this end, the plan recommended a shift in the research and extension policy from one of scattering resources to many areas to one of concentrating them in a few priority areas.

Policy shifts recommended under the APP include reorientation of research and extension efforts toward addressing resource management, food security, and the commercialization concerns of the agriculture sector. Research priorities to address resource management concerns included soil fertility management, focusing on high-intensity farming systems in areas served by shallow tube wells, and integrated pest management. Likewise, research priorities to address food security concerns included increasing the production and productivity of major food crops. Emphasis on research efforts aimed at high-value commodities like citrus fruits, apples, vegetables (including off-season), apiculture, sericulture, and livestock are the priority commercialization concerns.

During the no-plan period after the tenth plan, the government's agricultural policies were still based on the APP and the Nepal Agriculture Policy (NAP) (Nepal, MOAC 2004). They were reflected in the three-year interim plan (TYIP) for 2007–10, which had these specific objectives:

- Increasing agricultural production and productivity
- Achieving food and nutrition security
- Stimulating structural transformation of the agriculture sector from subsistence to commercial agriculture to exploit comparative advantages and market opportunities
- Increasing employment opportunities for rural youth, women, and deprived groups
- Conserving, promoting, and harnessing agricultural biodiversity through the development and dissemination of environment-friendly technologies

On the technology dissemination front, the statement of the plan was to direct agricultural extension and dissemination toward comparatively beneficial production, agribusiness promotion, and market integration. In an effort to better integrate research and extension toward solving farmers' problems, the policy advocated developing and mobilizing agricultural farms and research stations as resource centers and also mobilizing nongovernmental organizations (NGOs) in this respect.

5.1. Food and Nutrition Security

Food and nutrition security are affected by policies and programs implemented under different sectors; however, it was only in the eighth plan that food and nutrition policies and programs were conceptualized and formulated in an integrated manner for the first time. Development plans thereafter launched several programs on nutrition, together with income-generating activities in various sectors like agriculture, health education, and local development.

The TYIP (2007/09–2009/10), which adopted policies and priorities of the APP and the NAP (Nepal, MOAC 2004) to attain a high growth rate in agriculture and thereby improve food security and reduce poverty, emphasized increased production of nutritious food, distribution of micronutrients in highly problematic areas, incorporation of nutrition education in primary schools, and mobilizing the private sector and NGOs in the implementation of nutrition programs. In conformity with the World Food Conference (1996), the TYIP outlined policies and programs to reform the four main aspects of food security: food availability, accessibility, proper use, and stability.

5.2. Field Crops

In line with the strategies and priorities of the APP, the TYIP adopted a policy of launching intensive crop production and productivity improvement programs for cereal and traditional cash crops in areas served by irrigation projects. The 2010–13 three-year-plan (TYP), which is currently under implementation, has also followed this policy with additional implementation vigor.

5.3. Horticultural Crops

Endorsing the APP, the TYIP adopted a policy of transforming the subsistence agriculture system toward a productivity-oriented, comparatively advantageous, and commercialized agriculture system that integrates high-value horticultural crops on a priority basis for sustainable development. The TYIP clearly stated implementation policies for the promotion of crops like vegetables, fruits, and silk with due priority in areas served by roads and small irrigation. Prioritized programs included those for development of citrus, apple, and vegetable seed production; off-season vegetables; sericulture; and apiculture. The TYP has continued this policy.

5.4. Livestock

In the livestock subsector, the APP strategy and priorities have been shaped by the long-term plans prepared earlier. These include the Livestock Master Plan, a 15-year plan with 1993 as base year; the 10-year Dairy Development Plan (1990–2000); and the Master Plan for Forestry Sector (1988–2010). As envisaged under the APP, the TYIP emphasized the private sector as taking the lead role in livestock development, with a complementary and enabling role played by the public sector. Major programs emphasized by the plan in the livestock subsector included livestock breed improvement; livestock health improvement; management improvement for livestock farms; development of livestock markets; and provision of livestock credit to farmers, including women and those from marginalized communities.

5.5. Fisheries

Although there is no specific mention of this subsector in the APP, looking at its importance as an income-generation activity, a job opportunity in rural communities, and a supply of supplementary high-value animal protein, the subsequent plans have included some policy-related programs for fisheries development. These include emphasizing commercial fish farming utilizing river and stream resources, and enabling private-sector fish farms and hatcheries through supplying required fingerlings. Thus limiting the role of public-sector farms to that of support, the fishers are encouraged to form groups and engage in fish farming along the rivers, swamps, and communal ponds and reservoirs after getting training in aquaculture. Further, genetic improvement of aquaculture species for sustaining productivity, development and standardization of low-cost feed, and fish health are also identified as the priority areas of this subsector.

6. NEPAL AGRICULTURAL RESEARCH COUNCIL'S PRIORITIES

Research cannot be effective and successful unless it is carefully planned and prioritized to produce results of maximum value through minimum investment. At present no scientific mechanism exists for priority setting and resource allocations for agricultural research for development (AR4D) in the Nepal Agricultural Research Council (NARC). While preparing its research programs, NARC is presently allocating its research resources according to priority themes and commodities as identified in the Agricultural Perspective Plan (APP) (APROSC and JMA 1995) and the NARC "Vision 2020" document (NARC 2001). The priorities identified under the APP are these:

- Major food crops: rice, maize, wheat, and potatoes
- High-value crops and commodities: citrus fruits, apples, off-season vegetables, sericulture, and apiculture
- Dairy production: animal nutrition, high-value fodder crops
- Development of soil fertility and shallow tube well systems
- Development of human resources
- Development of a scientific research information system

6.1. Overarching Priorities

NARC has identified major overarching priorities that cut across the various commodities and disciplines as its major research areas:

- Natural resource management
- Mountain agriculture
- Socioeconomic and policy research
- Germplasm conservation and improvement
- Strengthening basic and strategic research

6.2. Priorities by Theme

The priorities of NARC are guided by the overall goals of food and nutrition security, and poverty reduction. To achieve these goals, NARC organizes its research programs into these thematic areas:

Priorities by Theme—Field Crops

Varietal improvement

- Improving yields (rice, wheat, maize, and pulses)
- Developing climate-resilient varieties
- Adding value and nutritional quality to products
- Dual-purpose (food and feed) crops

Mountain and rainfed areas

- Postharvest handling of rice, wheat, and niche crops
- Diversifying the production system
- Integrated pest management, natural resource management, and integration of livestock and forage
- Sustainable seed production technology transfer

Small-scale mechanization for women- and youth-friendly implementation

Priorities by Theme—Horticulture

- Postharvest handling, value addition, and supply chain management of potatoes and vegetables
- Apple, citrus, mango, and other high-value horticulture, orchards, and floriculture
- Promotion of eco-friendly technology and varietal improvement for off-season vegetables to address climate change and nutritional security
- Tropical, subtropical, and temperate horticultural crops
- New varieties of vegetable crops (tomatoes, cauliflower, cabbage, beans, cucumbers, chilies, and so on)
- Improving the commercialization of tea, coffee, cardamom, and ginger in the hills

Priorities by Theme—Livestock Including Poultry

- Productivity enhancement of cows and buffalo; yaks and *chauri*; poultry and swine (improving breeding, feeding, health management)
- Improvement of technologies for efficient crop–livestock integration
- Transboundary zoonotic diseases (Japanese encephalitis, swine flu, bird flu, blue tongue, and others)
- Balanced animal feeds (fodder, pasture, field crop residues, supplements)
- Productivity of goats and sheep by selection, artificial insemination, embryo transfer, and crossbreeding for meat, milk (cheese—goats), and fiber
- Value chain and food safety (quality aspects of dairy, meat, and eggs, and product diversification)
- Rangeland management (poisonous plants and so on)

Priorities by Theme—Fisheries

Capture Fishery

- Capture fisheries–friendly management (of hydropower and irrigation infrastructures) and socioeconomic management

Warm-water aquaculture

- Genetic improvement and fish health management (carp, catfish, Tilapia, trout, and native fishes)
- Intensive fish culture management (aquaculture)
- Postharvest technology

Cold-water aquaculture

- Commercialization of trout cultivation

Promotion of indigenous fish (such as *jalkapoor)*

- Climate change and its impact on fisheries

Priorities by Theme—Natural Resources Management

- Conservation of genetic (crops, livestock, fish, agroforestry), water, and land resources
- Improving efficiency in distribution and use of irrigation water (policy, technology, and institutional issues)
- Rainwater harvesting vis-à-vis watershed management (lowering water table in the Terai and Chure-Bhabar region)
- Sustainable land use, soil fertility management, and organic recycling

Priorities by Theme—Genetic Resources Enhancement

- Establishment of gene bank for germplasm and microorganisms
- Plant genetic resources conservation and improvement
- Livestock selection and improvement (including fisheries)
- Seed quality and marketing system improvement
- Conservation of indigenous livestock breeds

Priorities by Theme—Socioeconomic and Policy

- Poverty mapping and investment priority setting
- Study of the impact of subsidies and safety net programs versus investment in agricultural research
- Market intelligence, market integration, and trade liberalization
- Risk management (price, yield, climate)
- Youth- and woman-friendly agriculture
- Policy and institutional aspects of AR4D (instead of research *and* development) with particular reference to smallholders

6.3. Priorities Identified during the Policy Dialogue Meeting

During the policy dialogue meeting, participants were divided into four groups: (1) priorities for AR4D, (2) structure and institutions, (3) funding and financing mechanism, and (4) innovative technology delivery system. After a brainstorming exercise, each group came up with its top 10 priorities (Appendix 5), which were later put to the whole group for voting. The number in parentheses indicates the number of votes each priority received from the participants during voting. The top 10 priorities across the groups that received the greatest number of votes are presented below in diminishing order:

1. Promote woman-, youth-, and small farmer–friendly agriculture (27)
2. Promote and strengthen the role of the private sector, cooperatives, nongovernmental organizations, and agroveterinary scientists in the dissemination of technologies (21)
3. Transform subsistence agriculture to competitive and commercial agriculture (17)
4. a) Recruit through an independent commission to select appropriate person(s) in NARC and the national agricultural research system (15)
   b) Set a need-based research agenda (domain, ecology, gender, and environment) in site-specific perspective (15)
   c) Narrow the knowledge and information gap between researchers and end users (15)
5. Establish/strengthen agricultural research system to receive funds and mobilize it through one window for AR4D (14)
6. a) Perform more research in rainfed agriculture (11)
   b) Enhance role of researchers through increasing their participation in technology diffusion (11)
7. Document promising indigenous knowledge and promote for use (10)
8. a) Eliminate the executive board in order to give the executive director more independence in executing authority (9)
   b) Increase resource allocation for AR4D from the present level of 0.3 percent to 2 percent of AGDP (9)
9. a) Study the effect of climate change on agriculture (8)
   b) Perform priority productivity package research on high-value commodities (8)
   c) Strengthen human resources by exchange program between NARC and academic institutions (8)
10. a) Emphasize hill farming mechanization and postharvest processing (6)
    b) Ensure functional autonomy in NARC through wider representation (6)
    c) Evolve NARC into a national agricultural research system (6)

7. INSTITUTIONS INFLUENCING AGRICULTURAL RESEARCH FOR DEVELOPMENT

7.1. Advisory Bodies

At the national level, three types of institutional arrangements are in operation. The first one is advisory bodies, such as various policy- and planning-related commissions. The second one is line ministries, responsible for policy planning and implementation. The third type of institution theoretically combines both advisory and implementation functions.

The National Development Council (NDC) is the apex body with the responsibility of approving plans prepared by the National Planning Commission (NPC), which is entrusted with the responsibility of preparing periodic plans and setting national goals, objectives, strategies, and policies for the overall development of the nation. The NPC serves as the secretariat of the NDC. Planning cells of various line ministries contribute to the planning process by preparing plans and programs for their respective sectors. Both the NDC and the NPC are headed by the prime minister. Because of their political nature, they serve as a venue to reflect political commitments.

7.2. Policy-Implementing Institutions

The responsibility for sectoral policy design, program development, and implementation lies with the various line ministries. The cabinet and the parliament, as appropriate, approve these policies. Although the subsectors covered under this review may have direct or indirect relationship with agricultural research for development, the subsectors fall under different ministries. The Ministry of Agriculture and Cooperatives has full responsibility for development of crops, horticulture, livestock, and fishery. The Ministry of Water Resources has responsibility for irrigation development. The Ministry of Forest and Soil Conservation has responsibility for looking after soil conservation and watershed management. While rural development is the purview of the Ministry of Local Development, the Ministry of Health and Population has responsibility for the nutrition subsector. The Ministry of Finance, above all, is responsible for the allocation of budget to all these ministries.

7.3. Implementation-Level Institutions

Four types of institutions are created in the public sector at the national level to implement national policies, including those related to food security and poverty alleviation. Generally these institutions are also expected to translate government policies into sets of operational rules, plans, programs, and projects, and to implement them. These institutions are the line departments, autonomous boards, affiliated corporations, and companies. In essence they are the implementation arms of the ministries.

To fulfill the designated responsibilities, these departments, boards, and corporations have created district-level offices, which vary depending upon their functions.

7.4. Private-Sector Organizations

The private sector in agriculture in Nepal comprises households engaged in subsistence or semicommercial production (small and large), food processors and manufacturers, and traders.

Over the years, increasing efforts are being made to form private-sector organizations to best serve the interests of these private-sector operators, either formal or informal. These include user groups centered around protection and utilization of national resources (forestry, irrigation, and so on), as well as farmers' groups centered around production and even marketing of agricultural commodities. Similarly, on the inputs supply side, there are a number of traders involved in the import and distribution of agricultural inputs. While such groups are formed or operate at the local level, the tendency now is to form larger organizations at the district and national levels (district cooperative unions, the National Federation of Milk Producers, and the like).

With a view to projecting and promoting the interests of the private sector, which is engaged in commercial and industrial ventures, traders have an organization called the Federation of Nepalese Chambers of Commerce and Industry (FNCCI) at the national level, with offices at the district level as well. Under FNCCI, an organization called the Agro Enterprise Center has been formed by 10 commodity-based organizations to support development of a number of agricultural commodities, such as tea, coffee, sericulture, floriculture, apiculture, and others.

Although the major policy documents of the government have stressed greater private-sector participation across all sectors of the economy, no specific measure has yet been pronounced to promote and support the private sector. As far as involvement of the private sector in agricultural research is concerned, it is not yet encouraging due to the subsistence nature of agriculture in the country.

8. POTENTIALS FOR INTERVENTION

8.1. Overview

During the preparation of the Agricultural Perspective Plan (APP), potentials of the agriculture sector to grow were sufficiently assessed. Based on that assessment, the APP projected growth of the agriculture sector to be in the range of 4–5 percent annually between the years 1995–2015, on condition that the APP strategies and priorities identified be seriously implemented. During the same period, the APP projected that 50–64 percent of the attainable growth rates would be contributed through harnessing potential in the crop subsector, 34–44 percent in the livestock subsector, and 2.5–3.0 percent in the fishery subsector. The potentials to increase per-hectare fertilizer use, cultivable land under improved varieties, and irrigation facilities were reckoned as major contributing factors in realizing the growth potential in the crop subsector; in the livestock subsector, potential to increase milk, meat, and poultry were assessed as the major contributors. Although not specified in the growth accounting framework analysis carried out under the APP, the potential of aquaculture is the important component of growth in the fisheries subsector.

8.2. Potentials as Shown by Agriculture-Sector Trade Deficit

Nepal has always been a net importing country. In 2006/07, the deficit in trade balance was on the order of Rs. 135.31 billion, and it grew to Rs. 317.67 billion in 2009/10. The deficit in trade balance thus grew almost two and a half times in a period of 4–5 years (Table 17).

Table 17. Exports, imports, and balance of trade, 2006/07–2009/10

Particulars	Value, Nepalese rupees (in millions)			
	2006/07	2007/08	2008/09	2009/10*
Imports	194,694.6	221,937.8	284,469.6	378,795.6
Exports	59,383.2	59,266.5	67,697.5	61,126.8
Trade balance	(-) 135,311.4	(-) 162,671.3	(-) 216,772.1	(-) 317,668.8

Source: Nepal, CBS 2010.
Note: * Provisional.

Trade in agricultural imports and exports makes up about 16 percent of total trade. Agricultural exports were dominated by high-value crops like lentils, tea, cardamom, fruits, ginger, and medicinal and aromatic plants, while imports were mostly of cereal crops, fruits, vegetables, dairy and animal products, and raw materials for processing (oilseeds) and manufacturing (wool for carpets and textiles for garments). The balance of trade indicates that the agriculture sector, compared with other sectors, has not been able to keep pace with increased demand. There is a good potential for import replacement in cereal crops, vegetables, fruits, and dairy and animal products when we look at the value of imports (Rs.13,629 million), which is almost two times the total export value of agricultural commodities (Table 18). This suggests that there is an ample scope for substituting imports through improved performance of the agriculture sector, which is and indication of the sector's potential.

Table 18. Value of imports and exports of agricultural commodities, 2009/10

Commodity	Exports, Nepalese rupees (in millions)	Imports, Nepalese rupees (in millions)	Trade balance, Nepalese rupees (in millions)
Cereal crops	**112**	**4,195**	(-) **4,082**
High-value crops	**7,116**	**8,573**	(-) **1,457**
Lentils	3,745	230	3,515
Tea	1,195	35	1,160
Cardamom	1,172	57	1,114
Fruits	486	4,715	(-) 4,228
Ginger	456	46	410
Vegetables	26	2,097	(-) 2,071
Coffee	24	14	11
Beans	11	1,379	(-) 1,368
Medicinal and aromatic plants	**440**	**Not significant**	**440**
Dairy products	**Not significant**	**861**	(-) **861**
Total	**7,668**	**13,629**	(-) **6,400**

Source: Nepal, CBS 2010.

8.3. Yield Gaps in the Agriculture Sector

As mentioned earlier in this report, the productivity of the agriculture sector has been far from satisfactory in terms of both growth over time and comparison with that of neighboring countries. Poor or unsatisfactory productivity does not, however, indicate lack of or low potential in the agriculture sector. Even without considering the new potentials that research might generate in the future, farmers have been able to get only about 50 percent of the yield potential of the crops they grow. Similarly, in the case of milk production, only about 22 percent of the yield potential has been obtained (Nepal, DLS 2010).

Given its wealth of agroecological environments, Nepal is unique among small countries for the variety of agricultural products that it could produce. However, the commercial production of these products has been constrained due to their lower observed yields as compared with their potential yields. This low productivity is related to access to and adoption of technology, availability of inputs (seeds, breeds, fertilizer, irrigation, electricity, credit, and so on), and limited investment in the sector. The yield gap for a number of selected products is shown in Table 19, which indicates that the potential for yield increase is huge in several products.

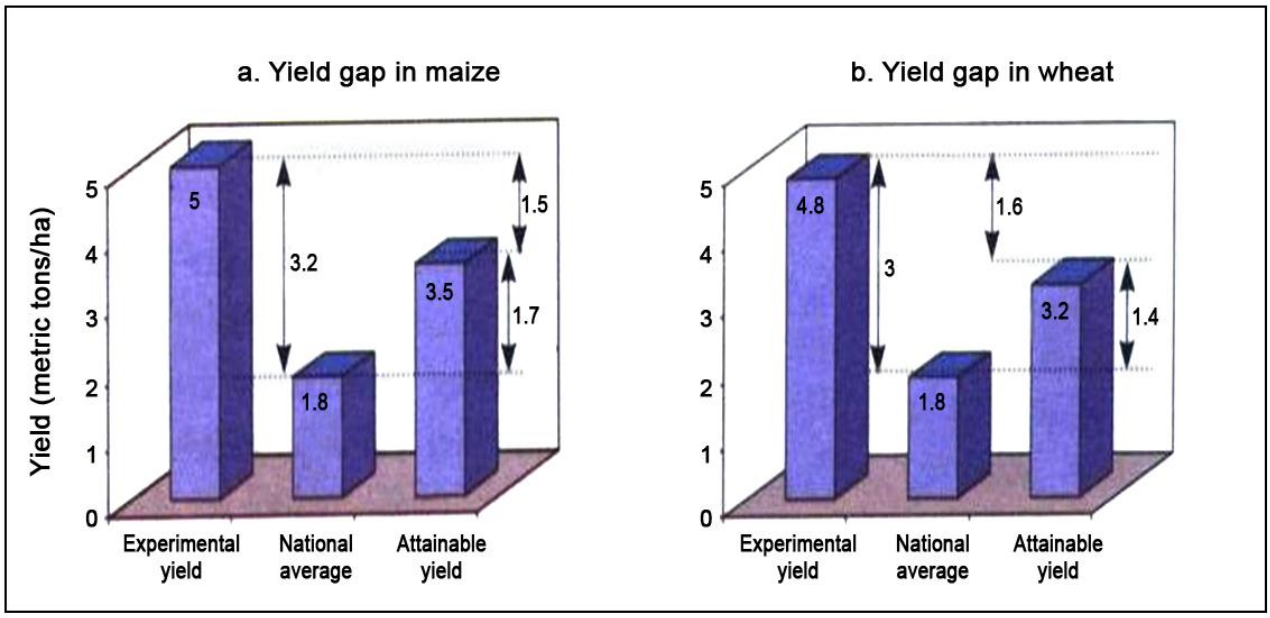
Table 19. Yield gap of selected agricultural commodities

Product	Unit	Current yield	Potential yield
Fish	metric tons/ha/year	3.6	10.0
Vegetables	metric tons/ha/year	12.8	17.0
Buffalo milk	liters/lactation	900.0	2,000.0
Timber	m^3/year	0.4	13.4

Source: For fish, Nepal, DOFD (2010). For vegetables, MOAC (2012). For buffalo milk, Nepal, DLS (2010). For timber, Nepal, MFSC (1989).

Productivity (farm-level yield) of most food crops is low and generally falls at 50 percent or less of attainable potential (Maskey, Manandhar, and Gauchan 2004). The case is the same for priority crops like rice, wheat, maize, potatoes, and the like. Figure 9 shows that the yields of maize (panel a) and wheat (panel b) in experimental stations are 5 and 4.8 tons/ha, respectively, and the national average is 1.8 tons/ha for both crops, while the attainable yields are 3.5 and 3.2 tons/ha respectively. If only 70–80 percent of research station crop yields are assumed attainable, potential still exists to increase yield by about 1.7 tons/ha in the case of maize and 1.4 tons/ha in the case of wheat. Such a potential is still higher in the case of potatoes (more than 14 tons/ha).

Figure 9. Gap between experimental, national average, and attainable yields



Source: Maskey, Manandhar, and Gauchan (2004).

8.4. Knowledge, Information, and Linkage Gaps

Knowledge and information gaps exist at various levels between scientific communities of different disciplines, between scientists and extension/development agencies, and between scientists and farming communities or agroentrepreneurs. These gaps are evident in the limited focus of research themes on the livelihoods of the rural poor and in the lack of effective program-level linkages and participatory research with both farming communities and the private sector.

8.5. Research Gap

At present, the research program of the National Agricultural Research Council (NARC) has given very little attention to broad natural-resource issues, technology adoption and its impact assessment, gender issues, market price analysis, policy research, postharvest operations, and value-addition research. There is a need to shift the present lopsided focus of the research

program from only the commodity and farming system to the development of technologies that fit into the livelihood strategies of farming households. This paradigm shift is imperative to meet the country's poverty alleviation goal as envisaged by the tenth plan and the subsequent three-year interim plan.

Several other research providers exist in the country and could contribute to achieving the goal of agricultural research for development (AR4D). However, there is neither vertical nor horizontal linkage between NARC and these other actors in agricultural research. Among these research actors and NARC a large gap exists in terms of coordination, facilitation, and monitoring, which has obviously created duplication of effort, wasting scarce resources. The key gaps hindering effective AR4D are these:

- Absence of functional monitoring and review of research projects carried out by different research providers and stakeholders in order to avoid duplication
- Weak formal program-level linkage, horizontal and vertical, with extension and educational institutions
- Virtual nonexistence of dissemination of technologies through information and communication technology; very limited on-farm participatory research
- Limited access of NARC to higher decisionmaking bodies, funding sources, donor agencies, and formulators of agricultural development programs and policies

9. SOME NEW TECHNOLOGIES RELEVANT TO AGRICULTURAL RESEARCH FOR DEVELOPMENT

Several cutting-edge technologies in use in various countries are at different stages of development, depending on the countries' research capability and resource availability. Such new technologies have a potential of wider application and could be scaled up to any desired level. They include hybridization, biotechnologies, conservation technologies, nanotechnologies, postharvest technologies, biorisk management, mechanical technologies, and information and communication technology (ICT). In Nepal some of these technologies are in use but on a very modest scale. These technologies could accelerate agricultural growth by increasing food production manyfold, thereby reducing food scarcity at the national level. However, development of these technologies is expensive and time-consuming, and requires a high level of expertise. To deploy them would call for upgrading and strengthening the present research system and building capacity to access the potential of these frontier technologies to enhance the productivity of Nepal's agriculture sector. Appropriate research structures and processes, and necessary funding must be planned to effectively use these technologies in the research system, which is not geared at present to handle these dimensions.

Nanotechnologies: This technology is new to the country, in spite of its multifaceted application in agriculture and several other areas. Under present conditions, nanotechnologies could be used to make the agriculture system "smart." High cost and low availability of inputs, particularly fertilizers, is overburdening the majority of farmers. Similarly, the availability of surface water and groundwater is becoming limited. Due to this situation, farmers are complaining that cultivation of major food crops—particularly rice, wheat, and maize—is not profitable. The production system of these crops will be at greater risk if the government withdraws the subsidies provided for inputs. Under such a situation, application of nanotechnologies to make plants use water, fertilizer, and pesticide more efficiently, and to reduce pollution and make agriculture more environmentally friendly, could be of great benefit. Apart from this application, their use in the agricultural value chain has great potential.

Biotechnologies: Biotechnologies have generated considerable optimism for expanding and sustaining crop production and productivity, particularly in countries that are largely dependent on agriculture. The expectations of generating "designer plants" and superior cultivars with novel traits of commercial value through genetic engineering have already become a reality in several countries. However, various concerns are being raised about the biosafety of transgenic crops; people are distinctly polarized in support of or against the use of genetically engineered plant materials. But in a country like Nepal, where the majority of farmers are resource-poor with small farm holdings, it needs to be highlighted that appropriate biotechnologies are capable of reaching and bringing benefits to resource-poor farmers. Intervention using biotechnologies has helped to lower production costs by improving the productivity of targeted crops. Biotech research is equally important, in the light of dwindling indigenous plants, to prepare a fingerprint of local landraces that will help to protect intellectual property rights. Under diminishing natural resources and increasing biotic and abiotic pressure, where traditional agriculture is failing to produce enough, biotechnologies are tools in the hands of scientists for meeting the challenge of feeding an ever-increasing population. Yet they are neither a magic wand that resolves all problems in crop improvement nor a solution devoid of constraints.

The recent row that has flared up in the media about multinational seed company Monsanto's introducing its hybrid seeds in the country shows that Nepal's preparedness to quickly undertake prescribed environmental and biosafety tests is grossly inadequate. As a result, not only are scientists demoralized but society also misses the benefits of scientific breakthroughs.

The situation is not conducive to the application of frontier technologies in agriculture, which is an urgent need for agricultural growth.

Postharvest technologies: In the context of the World Trade Organization and the push toward a global open economy, research and development of a bulk handling system of crop produce and livestock products for safe long-distance transport is of increasing importance. New products are developed through value addition by various techniques, and this trend has tremendous opportunities in the fast-food and spices industries, which are growing rapidly. Such value-added products are juices, essential oils, wines, dried powders and pastes from various fruits, dry fruits and vegetables, condiments, and so on. Research on various indigenous materials for packing different fresh or finished products is another area to be considered.

Resource conservation technologies: Conservation-based agriculture has great potential in minimizing the degradation of land and water resources while preserving the environment and helping to produce more at lower costs. Popular technologies that have potential for scale-up are no-till (zero tillage) rice–wheat farming, and diversification and adoption of microirrigation technology. In the context of diminishing water resources in the country, it is equally important to promote the concept of agricultural productivity not only per unit of area but also per unit of water and time. The concept of integrated farming systems needs greater consideration in view of controlling pests and diseases, including new ones, and efficient soil nutrient management, particularly in sloping lands.

ICT and remote sensing: Rapid growth of computer science has led to a number of ICT applications using integrated model-based systems with data-based system concepts. These systems are equally important in the agriculture sector for applications such as water management, soil management, plant protection, market and weather forecasting, and so on. ICT tools can be highly useful in agricultural extension. The reach of the extension workers to farmers, at presented limited by their number and the topography of the country, can be increased and the message delivery system sped up. Remote sensing technology could also be used in several areas related to agriculture. In the past, remote sensing and satellite imagery were extensively used in land resource mapping.

Biorisk management: This area is exclusively used for the management of insects, other pests, and diseases at the local level. An innovative technology is being focused and adapted in integrated pest/weed management and integrated plant nutrient management systems, wherein resources are inadequate and unavailable. Transboundary movement of plant pests and diseases and animal diseases needs to be restricted through effective implementation of laws and rules. This area demands detailed study of innovative and effective technologies, along with capacity development in terms of human and financial resources and infrastructure facilities.

Mechanical technologies: Mechanization of agricultural operations has become of utmost importance for timely and proper farm operation in the context of a shortage of farm labor and the feminization of Nepalese agriculture. Research should be undertaken for designing appropriate and specific farm machinery to cater to the needs of mostly smallholding farming communities and women farmers. Also greater attention is needed to develop suitable and economically viable mechanical technologies that will help to attract and retain youth in agriculture; this is a challenge for agricultural scientists as well as for policymakers.

10. PROPOSED THEMATIC AREAS FOR AGRICULTURAL RESEARCH FOR DEVELOPMENT

Although implicit in the development plans implemented in the past, improved food security and poverty alleviation have come out as explicit objectives only from the ninth plan onward. The tenth plan, the three-year interim plan, and the three-year-plan have categorically identified, for the agriculture sector, increasing productivity and promoting commercialization as major goals to solve the twin problems of poverty and food insecurity, which are looming large in the country.

Before the creation of the Nepal Agricultural Research Council (NARC), the sole organization responsible for conducting agricultural research and implementing it, agricultural research was directed largely by government policy toward increasing basic foodgrain production, with the result that research in the other subsectors—such as horticulture, livestock, and fisheries—and noncommodity areas—such as socioeconomic and policy research, marketing issues, gender, and natural resource management—were given second priority. The creation of NARC resulted in a paradigm shift in agricultural research, moving the system from agricultural research *and* development to agricultural research *for* development. Thus the priority has changed from conventional areas to meeting the changing needs of the time by generating and scaling up technologies that contribute to food security improvement, poverty reduction, commercialization, and sustainability. In order to deliver these results, NARC identified five broad-based thematic areas of intervention as its priority areas:

- Crops and horticulture
- Livestock and fisheries
- Natural resource management and climate change
- Biotechnology
- Outreach and technology dissemination

Based on these themes, specific areas for intervention are proposed to address the objectives set in the development plan through research programs.

10.1. Crops and Horticulture

Crop and horticulture research—particularly involving crops like rice, maize, wheat, finger millet, legumes, fruits and vegetables, and potatoes—plays a major role in improving food security. Experience has shown that conventional food crops alone will not resolve the increasing food and nutrition insecurity looming large in the hills and mountains. In these areas, indigenous food crops could contribute to improving food security if given due priority for research and development.

The crop and horticulture research program will broadly focus on crop improvement, on-farm crop management, market and value chain development, and policy issues. The important components of thematic focus are as follows:

Theme 1: Improving crop varieties

- Germplasm collection, maintenance, and utilization for food, fiber, legume, fruit, and vegetable crops
- Development of suitable high-yielding varieties of major food crops such as rice, wheat, and maize, and minor crops such as millets, barley, and buckwheat through selection and hybridization to ensure food security
- Enhancement of productivity of oilseeds, and winter and summer legumes with emphasis on tolerance to drought and other stresses
- Variety improvement of cash crops such as tea, coffee, cardamom, sugarcane, ginger, and jute through selection and hybridization for enhancing quality production and productivity
- Generation and promotion of off-season vegetable- and floriculture-related technologies

Theme 2: On-farm crop management and improvement of agronomic practices

- Development of integrated crop management, including integrated pest/weed management and integrated plant nutrient management practices
- Development of cost-effective integrated crop management package of practices
- Development of package of practices for organic farming
- Strengthening of farm mechanization operations, including conservation tillage
- Dissemination of technology for quality seed and sapling production and management

Theme 3: Marketing and value chain development

- Development and scale-up of postharvest technologies, including drying, processing, and value-addition techniques
- Generation of technology for value addition on nontimber forest products, including medicinal and aromatic plants
- Study of national and international markets for exportable agricultural products, including quality demanded by the markets
- Review of the government's export policies, suggesting appropriate actions to increase value of exports

10.2. Livestock and Fisheries

Considering the importance of livestock and fisheries and their likely contribution in enhancing nutrition, income, and employment through improved productivity, the following key components are identified in this thematic area:

Theme 1: Breed improvement and management

- Germplasm collection, conservation, maintenance, and utilization for dairy, meat, egg, wool, and fiber animals; fish commodities; foraging and rangeland species
- Sustainable conservation and utilization of domestic-animal genetic resources of Nepal
- Enhancing productivity of dairy animals through selection and crossbreeding
- Developing meat-type buffalo
- Enhancing productivity of sheep and goats through selection and crossbreeding for meat, fiber, and milk (goat cheese) production
- Development of suitable crossbred pigs and poultry for value addition
- Enhancing fish productivity through increasing fish species diversity and through integrated fish farming in ponds, lakes, running water, and rice fields
- Development of suitable meat- and wool-type rabbits for different agroecological zones of Nepal

Theme 2: Fodder and feed management

- Development of year-round fodder production system for reducing the production cost of dairy animals
- Rangeland resource management through exploration of indigenous and scientific knowledge
- Improvement of locally available nonconventional feed resources
- Improved productivity of fish through developing appropriate feeds and feeding management
- Nutrient fortification in mechanically compressed feed blocks
- Promotion of integrated crop, forest, livestock, and fisheries development

Theme 3: Animal health

- Enhanced animal productivity through prevention and control of economically important diseases
- Surveillance and control of zoonotic diseases in strategically important locations
- Identification and exploitation of adaptive and disease-resisting traits of indigenous animals
- Proper utilization of poisonous plants and ethnoveterinary medicines

Theme 4: Marketing and value addition

- Development and promotion of value-adding technologies for import substitution and export promotion of dairy, meat, eggs, fish, and wool
- Development of suitable fiber, meat, and skin processing techniques for product diversification

10.3. Natural Resource Management and Climate Change

Because of limited knowledge, the relationship between agriculture, the environment, and natural resources is not only complex but challenging as well. Deforestation, nutrient mining, soil erosion, land degradation, eutrophication, and agrobiodiversity degradation are the results of increased pressure on land and water. A balance needs to be maintained in relation to natural resource management in order to offset the harmful effects to farming in particular and nature in general. The key components have been identified as follows:

Theme 1: Natural resource management

- Development of land capability classification and crop suitability mapping for various crops
- Development of conservation tillage practices to maintain soil health and improve water retention
- Identification and promotion of nitrogen-fixing species to maintain soil fertility in agroforestry systems
- Development of technology approaches for sloping agricultural land to create a living barrier to sediments and gradually transform the sloping lands to terraced land
- Utilization of the hydrological, land use, cropping system, soil loss, and water management models
- Development and promotion of technologies for rehabilitation of degraded land

Theme 2: Mitigation of climate change effects

- Estimation and development of mitigation measures for greenhouse gas emissions from agriculture and livestock
- Estimation of carbon sequestration under various agricultural practices and development of appropriate mitigation measures for greenhouse gas emissions
- Identification, development, and promotion of climate-friendly agricultural technologies to adapt to climate change and contribute to sustainable agricultural development while maintaining agroecosystems and agrobiodiversity
- Development of a methodology for estimating agricultural crop area and yield before harvest to improve preparedness for any extreme situations
- Enhanced capacity within NARC and other partners through collaborative research and joint exploration of adaptation and mitigation options

10.4. Biotechnology

While speeding the research process and enhancing research precision, biotechnology also has great potential for increasing food production and thereby promoting sustainable agriculture to conserve biodiversity in plant and animal resources. Applications of biotechnology research in increasing productivity, food security, and poverty reduction include, but are not limited to, the following program components in this thematic area:

Theme 1: Improvement of crops and horticulture

- Development of crop varieties/hybrids to address biotic and abiotic stress as well as quality
- Development of technologies through tissue and embryo culture to improve crop productivity
- Characterization of crop species/varieties at a molecular level for better utilization in breeding programs
- Increased efforts in marker-assisted selection and development of diagnostic kits for breeders
- Transformative technology, such as golden rice, to feed the poor while also supplementing vitamin A requirements
- Assessment of the diversity of indigenous crops

Theme 2: Improvement of livestock and fisheries

- Assessment of the diversity of indigenous livestock and fisheries to generate information for breeders, gene banks, and policymakers
- Development and refining of semen production technologies in livestock and fish
- Characterization and conservation of livestock and fish species at a molecular level
- Application of molecular markers (DNA) in genome mapping for marker-assisted selection in livestock and fish species
- Induction of polyploidy and cloning in exotic and native aquaculture fish species
- Development of techniques for production of ova and embryos as well as other genetic materials

10.5. Outreach and Technology Dissemination

Outreach research is an interface between research and extension. In the technology-generation process, technologies generated by researchers, before being delivered to farmers, need to be refined at outreach sites in farmers' fields in order to suit farmers' requirements. The following program components are necessary to make technology dissemination effective and relevant:

Theme 1: Outreach research

- Program development and implementation for outreach research sites with tripartite involvement of research (NARC), extension (Department of Agriculture [DOA] and Department of Livestock Services [DLS]), and end users at outreach site

- Verification at outreach sites of the researchable problems identified and reported by DOA, DLS, and other partners in district and regional technical working groups and workshops, involving all concerned partners
- Design of a mandatory mechanism so that concerned higher authorities from research and extension can monitor and evaluate ongoing field activities at outreach sites

Theme 2: Technology dissemination

- Provision of source seed, including livestock and fish breeding stock, and technical backstopping to private seed producers to ensure quality seed to end users
- Design of a built-in program to provide regular training to subject-matter specialists and other extension personnel
- Capacity enhancement of the district and regional technical working group members to promote their ownership of process and results
- Utilization of mass media such as FM radio, television, mobile phones, and Internet to disseminate modern technologies
- Further development and regular updating of the NARC website
- Development of a mechanism to get feedback from concerned stakeholders

11. PROPOSED PROGRAM FOR INTERVENTION

To keep pace with emerging needs, research priorities have been changing over the past decade. However, the foremost problems of food and nutrition security, poverty reduction, and employment have continued. In order to address these important issues, the Nepal Agricultural Research Council (NARC) has identified priorities for different thematic areas of agricultural research—from production to market and policy analysis. Under these priority areas, programs have been identified as areas of intervention for agricultural research for development. Concerned experts will expand them as research projects during program and planning exercises as and when needed. Donors also may choose from this portfolio the program of their interest and develop it as a research proposal to fund agricultural research in Nepal. Under different thematic areas the programs for intervention are identified with their possible collaborators as follows:

Interventions Proposed for Crops and Horticulture Research

Commodity	Intervention area	Potential collaborators**
A. Cereal, oilseeds, and pulses		
Breeding and crop improvement	Development of suitable high-yielding varieties to raise the productivity of irrigated rice in the subtropical region	IRRI, DOA, NGOs
	Development of suitable high-yielding varieties to raise the productivity of rainfed rice	
	Development of high-yielding rice varieties for warm and cool temperate zones with major emphasis on tolerance to drought and cold, based on the needs of each domain	
	Developing technologies in early and full-season open-pollinated variety genotypes for enhancing maize productivity in hills and Terai	CIMMYT, DOA, NGOs
	Strengthening the screening of quality-protein maize genotypes against major disease, insect, and abiotic stresses	
	Development of hybrid maize technology to enhance maize productivity in the subtropical region of Nepal	
	Development of high-yielding wheat varieties for improving wheat productivity and sustainability in the Terai, inner Terai, and foothills of Nepal	CIMMYT, DOA, NGOs
	Development of high-yielding wheat varieties for improving wheat productivity and sustainability in the hills of Nepal	
	Development of high-yielding finger millet, barley, and buckwheat varieties with early maturity and other desirable traits for different production environments in the mid- and high hills	CIMMYT, DOA, NGOs
	Enhancement of productivity of oilseed crops in Nepal	ICRISAT, DOA, NGOs
	Development of high-yielding, desirable winter and summer legumes for different production environments with emphasis on tolerance to drought and other stresses	ICARDA, ICRISAT, AVRDC, IIPR, IITA, DOA, NGOs

** Please see the list of abbreviations on pages iii–v.

Agronomic interventions / crop management	Development of proper nutrient and water management technologies for boro, spring, and main-season aerobic and transplanted rice	IRRI, CIMMYT, DOA, NGOs, universities
	Development of proper moisture conservation technologies for upland and lowland rainfed cropping systems	
	Development of integrated crop management, including integrated pest/weed management practices for major diseases and insect pests for rice, wheat, and maize	
	Development of integrated nutrient, moisture, and pest management technologies for finger millet, barley, buckwheat, legumes, oilseeds, and hill crops	
	Development of profitable and sustainable integrated crop management and cropping system for different agroecosystems to mitigate negative effects of climate change	
Marketing, value chain, and policy	Increasing the livelihood of maize-farming communities of Nepal through promotion of quality-protein maize	CIMMYT, DOA, NGOs
	Determining pesticide residue level of fruits, fresh vegetables, and exportable agricultural commodities to produce quality agricultural product for domestic consumers and international trade	
Others	Strengthening farm mechanization operations in rice–wheat system, including minimum tillage	IRRI, CIMMYT
	Promoting conservation and sustainable use of plant genetic resources for food and agriculture	IRRI, NGOs, universities
	Development of suitable technology for quality seed production and management	
B. Horticultural and commercial crops		
Breeding and improvement	Development of new varieties of fruits (citrus, apples, mangoes) and vegetables (tomatoes, cauliflower, cabbage, beans, cucumbers, capsicum) through conventional and modern breeding techniques to address climate change and food crisis	AVRDC, FAO, IDE
	Promotion of sustainable eco-friendly technology in horticulture crops	ICAR
	Improvement and strengthening of tea sector by development of Nepalese tea varieties suitable for different production environments	
	Development and dissemination of improved cardamom cultivation technology in the hills of Nepal	
Agronomic interventions / crop management	Development of new cultivation package of practices with judicious use or nonuse of chemicals	
	Development of proper technology for low cost, water saving, and draught and pest resistance	ICARDA
	Identifying appropriate harvesting time, development of proper drying technology and storage practices for large cardamom pods	
	Increasing productivity and sustainability of potato crop through development /dissemination of improved cultivation practices suitable for different production environments	

Marketing, value chain, and policy	Contributing to food security through decreasing postharvest loss of horticultural commodities	ICAR
	Studying national and international markets for tea and cardamom, including quality demanded by the markets	
	Review of the government's export policies, suggesting appropriate actions	FNCCI
	Commercialization of floriculture for income generation	
Others	Conservation of local horticulture biodiversity through improvement and utilization in World Trade Organization context	
	Development of cost-effective methods of plucking, manuring, weeding, and irrigation methods in tea cultivation	
	Development of suitable technology for quality seed and sapling production and management	
C. Sugarcane, coffee, ginger, and jute		
Breeding and improvement	Variety improvement of sugarcane, coffee, ginger, and jute crops through selection and hybridization for enhancing quality production and productivity	DOA, Tea and Coffee Board, HELVETAS, GIZ
Agronomic intervention / crop management	Development of cost-effective crop management package of practices based on organic cultivation principles	
	Development of appropriate technologies for soil, water, and pest management practices	
Marketing, value chain, and policy	Development and scale-up of drying, processing, and value-addition techniques for improved income level of stakeholders	
Others	Development of suitable technology for quality seed production and management	

Interventions Proposed for Livestock and Fisheries Research

Commodity	Intervention area	Potential collaborators
A. Bovines		
Breeding and improvement	Dairy animal genetic improvement	DLS, ILRI, ICAR
	Enhanced productivity of yak and *chauri* through improved breeding, feeding, health, and management	DLS, ICAR ICIMOD, YRS (Tibet, Arunachal)
	Integrated bovine infertility management	DLS, IAAS
Feed and feeding management	Development of year-round fodder production system for reducing the production cost of dairy animals	DLS, NGOs, CBOs
	Development of low-cost feeding package for buffalo meat production	ILRI, FAO
	Development of low-cost feeding package for dairy animals	DLS, PFRD, IAAS
Health and nutrition	Nutritional intervention for enhancing dairy animal productivity and reduction of greenhouse gases	DLS, ILRI, ICAR
	Herd health program for enhancing dairy animal productivity	DLS, DMPCU, IAAS, NGOs, CBOs
Others	Value addition for milk and meat products	DFQT

B. Sheep and goats		
Breeding and improvement	Development of a carpet-wool sheep breed	NZ, FAO, ILRI, DLS
	Enhancing the productivity of goats by developing technologies through selection and crossbreeding for meat, fiber, and milk (goat cheese) production in different agroecological zones	DLS, ABD
	Development of technology for artificial insemination in goats and sheep	Heifer International, DLS
Feed and feeding management	Development of nutritional packages for stall feeding of goats	DLS, ICARDA
	Rangeland resource management through exploration of indigenous and scientific knowledge in the high hills and mountainous regions of Nepal	DLS, NGOs, CBOs
	Development of fodder-based feeding strategies for improving goat farming in rural and peri-urban areas for commercialization	
Health and nutrition	Flock health program for enhancing sheep and goat productivity in different ecological zones	DLS, NGOs, INGOs
Others	Commercialization of Chyangra Pashmina (Cashmere) fiber in mountains and trans-Himalayan region of Nepal	DLS, HIMALI project
C. Swine		
Breeding and improvement	Development and scale-up of productive black pigs	Heifer International, DLS
	Development of technology for artificial insemination in pigs	
	Development of wild x domestic cross pig for value addition	DOF
Health and nutrition	Enhanced pig productivity through prevention and control of economically important diseases	DLS, pig research centers
	Development of low-cost feeding technology for commercial and subsistence farming systems	
Others	Improving farmers' pig herds through scale-up of generated technologies	DLS, NGOs, INGOs
D. Poultry		
Breeding and improvement	Development of suitable backyard poultry breeds	DLS
Feed and feeding management	Improvement of nonconventional feedstuffs available in farmers' fields	ILRI, DLS, ADOs, IAAS, NGOs, INGOs
Health and nutrition	Development of suitable vaccination technologies in commercial poultry	SARP
	Surveillance and characterization of influenzas (avian and swine) in strategically important locations	
E. Rabbits		
Breeding and improvement	Development of suitable meat- and wool-type rabbits for different agroecological zones of Nepal	ILRI
Others	Development of suitable rabbit fiber, meat, and skin processing techniques for product diversification	ILRI

F. Crosscutting		
Breeding and improvement	Sustainable utilization and conservation of domestic animal genetic resources of Nepal	DAP, ILRI, CAAS
	Establishment of gene bank for germplasms and microorganisms	DLS, TU, IAAS
Feed and feeding management	Nutrient fortification of mechanically compressed feed blocks	NDRI, ILRI, DLS, IAAS
	Evaluation of forage crops for varietal selection, improvement, and development	DLSO, PFR–New Zealand, IGFRI, India
	Strengthening of source seed production of different forage and pasture crops and supply through community-based approach	DLS, CBOs
	Photographic cataloging and documentation of production performance of promising native forages in the Terai, mid-hill, and high hill regions of Nepal	DLS, DOA, Godawari Botanical Garden
	Exploration and identification of native and exotic cereal and tuber fodder crops for both grain and fodder production for high hill regions	DLS, DOA, Godawari Botanical Garden
Health and nutrition	Study of quality aspects of dairy, meat, eggs, and fiber production and product diversification	ILRI, ICAR, universities, DLS, IAAS
	Study of poisonous plants and ethnoveterinary medicine	
G. Aquaculture and fisheries		
Breeding and improvement	Enhancement of fish productivity through increasing fish species diversity in warm-water aquaculture of the Terai	DOA, IAAS, WFC, NGOs, WB, ADB, NTNU
	Enhancement of productivity of carp and trout through breed improvement	DOA, IAAS, private hatcheries, FAO, JICA, NACA
	Productivity improvement of integrated fish farming in ponds and rice fields	DOA, IAAS, NGOs
	Improved production of ornamental fish through developing technological package for import substitution	DIFD, DOFD, NGOs, CBOs, traders
Feed and feeding management	Improved productivity of carp and trout through developing appropriate feeds and feeding management	FTQC, fish producers' association, CBOs, FAO, JICA, USAID, DFID
Others	Enhanced productivity and scale-up of cage fish farming in lakes and reservoirs of Nepal	DOA, NGOs, CBOs
	Impact assessment of climate change in fisheries and aquaculture of Nepal and improvement of adaptation measures	DOA, IAAS, NGOs, CBOs
	Improvement of market for minor fish through value addition	DOA, IAAS, NGOs, CBOs
	Scale-up of warm-water hatchery-based aquaculture system for commercial fish production	DOFD, FDCs, IAAS, NGOs, CBOs, World Fish Centre
	Commercialization of rainbow trout production for food security in mountain region of Nepal	DOA, NGOs, CBOs
	Enhancement of natural fish yield by integrating program with hydropower facilities	NEC

Interventions Proposed for Natural Resource Management and Climate Change Research

Intervention area		Potential collaborators
A. Natural resource management		
Sustainable soil management at mid-hills under changed climatic circumstances	Development of land capability classification and crop suitability mapping for various crops	ICIMOD, IBSRAM, other relevant international research institutes
	Study of conservation tillage to maintain a cover on the soil surface of residues (mulching) or vegetation that helps retain soil and water	
	Study of use of nitrogen-fixing herb, shrub, and tree species to maintain soil fertility in agroforestry systems	
	Development of sloping agricultural land technology approaches to create a living barrier to sediments and gradually transform the sloping lands to terraced land	
	Study of green manure / cover crops / mulching to improve or restore fertility and soil texture	
	Study of integrated plant nutrient system	
Land and water management at the Terai–Siwalik interface	Establishment of runoff and water-quality gauging stations and metrological stations	NARC, DSC, DOA, DOI, DHM, local NGOs, ICIMOD
	Study of hydrological processes, their control, and linkages to the watershed and downstream resources	
	Development of hydrological, land use, cropping system, soil loss, and water management models	
	Development of integrated land and water management practices in participatory approach at the Terai–Siwalik interface	
B. Mitigation of climate change effects		
Monitoring of greenhouse gas emissions and carbon sequestration	Estimation of greenhouse gas emissions from agriculture and livestock sector	IRRI, CIMMYT, DOHM, ICIMOD, IAAS, NAST, ICRISAT, ICARDA, APAARI
	Development of mitigation measures of greenhouse gas emissions from agriculture and livestock	
	Estimation of carbon sequestration under various agricultural practices and development of appropriate mitigation measures	
Climate-friendly agricultural technologies	Review of time-series agrometeorological data, and soil and crop cultivation/production data	IRRI, CIMMYT, ICIMOD, IAAS, NAST, ICRISAT, ICARDA, APAARI, MOST
	Simulation of climate-variability scenario for agricultural crop production	
	Development of climate-friendly agricultural technologies to adapt to climate change	
	Production of teaching materials and conducting of trainings for different stakeholders on impact of climate change on agriculture	
Crop inventory and yield estimation through remote sensing and geographic information systems	Preparation of maps of spatial-area distribution of different agricultural crops	ICIMOD, ICAR, World Bank
	Development of methodology for estimating different agricultural crop areas and yields before harvest to improve preparedness for any extreme situations	

Interventions Proposed for Biotechnology Research

Intervention area	Potential collaborators
Marker-assisted selection in crop improvement for resistance to biotic and abiotic stresses, including the following: • Screening of cereal lines at phenotypic and molecular level • Identification of beneficial quantitative trait loci resistance to rice blast disease • Genotyping of susceptible and resistant rice varieties using simple sequence repeat primers linked to blast-resistant gene • Development of near-isogenic lines of rice, wheat, and tomatoes • Crossing and use of molecular markers to detect the desired resistant trait	IRRI, CIMMYT, IPGRI, ICAR, ICGEB, USDA, Bioversity International, USAID, European Commission, GEF, NAST, IAAS, CEAPRED, NGOs
Application of molecular markers toward the improvement of maize varieties for hybrid vigor	CIMMYT, IAAS, IPGRI, SAARC, ICAR, NAST
Analysis of molecular markers in the study of genetic diversity of important crops, livestock, and fish of Nepal	IRRI, CIMMYT, ICRISAT, IPGRI, WHO, ICAR, ICGEB, USDA, Korea, Bioversity International, USAID, European Commission, GEF, NAST, CEAPRED, NGOs
Characterization and DNA fingerprinting of underutilized but value-added and native species of crops and livestock	ICRISAT, ICARDA, CIMMYT, IPGRI, FAO, ICAR, ICGEB, USDA, Bioversity International, USAID, European Commission, GEF, NAST, CEAPRED, NGOs
Haploid breeding for inducing homozygous lines in different crops in a short period of time	IRRI, CIMMYT, ICRISAT, IPGRI, WHO, ICAR, ICGEB, USDA, Bioversity International, USAID, European Commission, GEF, NAST, CEAPRED, NGOs
Development of distant hybridization program for inducing disease-resistant lines in different crops	
Production of disease-free planting materials for mass production in different crops	CIP, ICRISAT, IPGRI, SDC, SEDA, ICAR, NGOs
Construction and facilitation of biotechnology laboratories with installation of modern biotechnological equipment	IRRI, CIMMYT, ICRISAT, ICARDA, ICAR, FAO, WHO, ICGEB, USDA, Bioversity International, USAID, European Commission, GEF

Interventions Proposed for Outreach and Technology Dissemination Research

Intervention area		Potential collaborators
Outreach research	Multidisciplinary team of experts to address pertinent on-farm research issues	CGIAR, ICAR, IAAS, DOA, DLS, DADO, DLSO, CBOs, NGOs, FNCCI/AEC
	Functional coordination between research (NARC) and service providers (Department of Agriculture, Department of Livestock Services, and community-based organizations)	
	Participatory research for microclimate-specific technologies generation and verification	
Technology dissemination	Mandatory, built-in program to take technologies from NARC and disseminate them to service providers	DOA, DLS, DADO, DLSO, CBOs, NGOs, FNCCI
	Two-way feedback between researchers and service providers on technology availability, utilization, and effectiveness to end users, and vice versa	
	Effective liaison among researchers, extension agents, and end users	
	Effective use of modern electronic media for the dissemination of technologies	
Others	Policy research related to natural resources, the environment, agribusiness, and trade	CGIAR, ICAR, IAAS, DOA, DLS, CBOs
	Prioritization of research areas and allocation of reasonable resources for increased efficiency and equity	
	Ex ante and ex post agricultural research evaluations	
	Gender and social inclusion studies	

12. CONCLUSION

The growth rate of Nepal's agriculture sector hovered around 3 percent over the past decade, marginally exceeding the country's annual population growth of 2.3 percent. The trailing growth rate of the agriculture sector has exacerbated the incidence of poverty as well as food and nutrition insecurity in the country, also taking its toll in terms of degradation of the natural resource base, including soil erosion and forest mining.

Food security involves highly complex political decisions affecting many aspects of agricultural development strategy. The slow growth rate of the agriculture sector has not only affected the earning capacity of the rural population but has limited investment opportunities in rural areas, as well as widening the gap between poor and rich. Agricultural research in Nepal has been struggling to help solve the twin scourge of food insecurity and poverty by generating technologies capable of increasing agricultural production and productivity without disturbing ecological balance. This effort has called for a national policy that prioritizes agricultural development programs vis-à-vis the research agenda. At present, the research programs of the Nepal Agricultural Research Council (NARC) are lopsided toward production-oriented programs and tend to be repetitive in certain areas. On the other hand, very little attention has been paid to natural resource management issues or to marketing and policy analysis. In order to address changing needs, a paradigm shift in the conventional program of NARC is beginning. This report offers a critical review of current agricultural research for development and proposes substantive adjustments by introducing thematic concepts in developing the research agenda based on priority.

Fortunately, the technical know-how to increase food production and sustain it at a higher level is no secret; its major elements are availability of irrigation water at farmers' fields when they need it, availability of information on production technology that farmers can use, and availability of inputs when farmers need them. Most important of all, farmers must get an assured return on their investment.

Some years have seen exceptionally good harvests (the Ministry of Agriculture and Cooperatives estimated a record yield of summer crops for 2011/12), with embarrassing short-term glut, suggesting that gradual technical change is occurring, even if it is not always perceptible. This offers ground for hope, especially if trade within and outside the country is created for surplus production. At present, the national average yield of food crops is only half of the yield estimated to be attainable in farmers' fields. This suggests that there is no technological barrier, as such, to doubling the productivity in farmers' fields and meeting the target of foodgrain production set by the Agricultural Perspective Plan and the current three-year plan.

Thus, agricultural research must be demand-led, taking into account the constraints that farmers face in practicing recommended technologies. The available technologies are largely limited to irrigated and high-input conditions, which do not represent the majority of Nepal's farming community. Thus the conventional approach to prioritizing the agenda must be changed to a thematic approach, which is more focused on addressing the pressing problem of food and nutrition security and on increasing productivity, competitiveness, and commercialization of the agriculture sector.

Recognizing the pivotal role of agricultural research in solving the aforesaid problems, donors have been assisting to strengthen agricultural research in the country by supporting NARC through various institution-building and human resource development projects. Yet much remains to be done to invigorate the national agricultural research system in the country. Obviously, an increase in research investment is imperative so that the present research capability and facilities can be improved to effectively address the problems of food and nutrition insecurity and poverty by increasing agricultural productivity in a sustainable manner.

The programs thus identified under thematic areas for investment on a priority basis not only offer the potential for sustainable yield increases but have the possibility of strong international collaboration as well. Once funding agencies show their areas of interest, these proposed programs will be developed into detailed projects by experts in each respective field.

Appendix 1. Priorities for the Agriculture Sector in the Three-Year Plan (2010/11–2012/13)

Major objectives of the agriculture sector in the three-year plan (TYP) for 2010/11–2012/13 will remain as follows:

1. To ensure food and nutrition security
2. To make the agriculture sector competitive and business-oriented, with increased production and productivity
3. To reduce poverty by increasing employment and income-generating opportunities in the agriculture sector
4. To minimize adverse effects of environmental and climate variability and climate change in the agriculture sector
5. To develop cooperatives for agricultural development
6. To develop human resources for the management of sustainable agricultural development processes

Strategies related to the accomplishment of these objectives will be as follows:

Related to Objective 1: "Ensure food and nutrition security"

- Increase production and productivity of agriculture (including crops, livestock, and fish)
- Increase access to quality technical services
- Emphasize research on farmers' problems, including quick-yielding technology
- Arrange for quality testing, monitoring, and regulation of edible products
- Control and prevent communicable livestock diseases and epidemics

Related to Objective 2: "Make the agriculture sector competitive and business-oriented, with increased production and productivity"

- Develop agro-industries
- Make production and processing of agricultural products more competitive
- Substitute imports and promote exports
- Increase access to domestic, regional, and world markets for agribusiness

Related to Objective 3: "Reduce poverty by increasing employment and income-generating opportunities in the agriculture sector"

- Adopt inclusive agricultural development processes to increase equitable employment opportunities
- Promote value chains encompassing production to postproduction stages
- Encourage production of low-volume, high-value commodities by small and marginalized farmers

Related to Objective 4: "Minimize adverse effects of environmental and climate variability and climate change in the agriculture sector"

- Carry out climate impact assessment, adaptation, and awareness activities and related research
- Develop and disseminate environment- and climate-friendly technology
- Conserve, promote, and utilize agricultural biodiversity

Related to Objective 5: "Develop cooperatives for agricultural development"

- Develop rural cooperatives as an integral part of agricultural development
- Develop agricultural extension, infrastructure development, marketing, and local resource mobilization through cooperatives
- Develop regulations to promote and strengthen the cooperative sector
- Promote a "working together" approach among government, cooperative, nongovernment, and private-sector agencies

Related to Objective 6: "Develop human resources for the management of sustainable agricultural development processes"

- Train farmers, entrepreneurs, and specialists to utilize technologies developed for agriculture commercialization, monitoring, and quality testing and control; also train on regulations to be followed
- Promote a "working together" approach through joint activities with the agricultural education sector—for example, with the Institute of Agriculture and Animal Science

In relation to the above-mentioned objectives and strategies, the following *working policies* will be adopted:

- Support the supply of fertilizers, seeds, breeds, and infrastructure (for example, irrigation and agriculture roads) to enhance production
- Strengthen sources of seed, including establishment and effective operation of certified seed production farms/centers
- Emphasize production of secondary crops in addition to the major crops
- Expand services coverage for the benefit of farm stakeholders
- Increase production of raw materials for agriculture-based industries
- Orient programs toward facilitating import substitution
- Develop market networks (collection and wholesale centers) closer to commercial production pocket areas
- Intensively mobilize resources in priority areas
- Promote programs directly contributing to reducing poverty and ensuring food security
- Develop income-generating programs based on community resources
- Empower women, Dalits, and Janajatis for effective agricultural development programs
- Conduct climate impact assessment and support to prioritize and implement adaptation strategies and relevant research to manage adverse effects of climate change on agriculture
- Organize awareness-raising programs on appropriate use of pesticides and controlling their negative effects
- Promote organic farming
- Promote and strengthen the roles of agriculture cooperatives and farmers' groups
- Coordinate agriculture education, research, and extension activities
- Make farmers' participation mandatory in monitoring and evaluation of implemented programs

Based on the various agricultural development issues assessed, the TYP (2010/11–2012/13) emphasizes attention toward areas including, but not limited to, the following:

- Ensuring food security and nutrition
- Making the agriculture sector competitive and business-oriented
- Developing market networks in inaccessible and remote areas
- Launching agro-industry-friendly programs
- Developing vegetable and fish markets
- Constructing animal slaughterhouses in urban areas
- Adapting agriculture to changing climate and natural disasters
- Maintaining public health conditions by controlling and preventing communicable diseases related to livestock

- Ensuring availability of improved seeds/breeds for enhancing production and productivity
- Promoting and strengthening seed sources as well as certified seed-producing farms/centers
- Increasing access of farmers and agro-based entrepreneurs to the delivery of services
- Making agribusiness competitive for import substitution and export promotion
- Promoting coordination with local government bodies, cooperatives, nongovernmental organizations, and the private sector
- Providing a subsidy on organic and chemical fertilizers
- Monitoring and regulating the quality of food and production inputs
- Emphasizing commercial production with market management in the areas with already developed road infrastructure
- Organizing agricultural research programs for the prevention of diseases, and testing soils based on the problems encountered by farmers

Appendix 2. Sectoral Allocations under Various Periodic Plans

Sectors/subsectors	Total outlay, Nepalese rupees (in millions)	Sectoral allocation as percentage of total outlay	
		Agriculture-related	Other than agriculture
First five-year plan (1956/57–1960/61)	**330**		
Agriculture and forestry		9.7	
Irrigation and drinking water		6.1	
Village development		12.9	
Public works, transportation, and communications			37.6
Electricity			9.1
Industry, mining, and tourism			7.6
Health			7.6
Education			5.8
Miscellaneous			3.8
Second three-year plan (1962/63–1964/65)	**600**		
Agriculture, irrigation, and forestry		13.6	
Land reform, surveying and statistics, and training		13.2	
Transportation, communications, and power			39.1
Social services			17.1
Industry and tourism			17.0
Third five-year plan (1965/66–1969/70)	**2,500**		
Agriculture and irrigation		25.9	
Transportation, communications, and power			37.2
Industry			17.5
Social services			16.6
Miscellaneous			2.8
Fourth five-year plan (1970/71–1974/75)	**3,540**		
Agriculture, land reform, irrigation, forestry, and botany		33.1	
Transportation and communications			35.4
Industry, commerce, power, and mining			20.3
Panchayat, education, health, and social services			10.8
Statistics			0.4
Fifth five-year plan (1975/76–1979/80)	**11,404**		
Agriculture, land reform, irrigation, and forestry		34.8	
Transportation and communications			29.7
Industry, commerce, electricity, and mining			17.9
Education, health, drinking water, *panchayat*, and social services			17.6
Sixth five-year plan (1980/81–1984/85)	**33,940**		
Agriculture, irrigation, and forestry		31.1	
Industry, mining, and power			26.0
Social services			25.6
Transportation and communications			17.3
Seventh five-year plan (1985/86–1989/90)	**50,410**		
Agriculture, irrigation, and forestry		34.3	
Social services			29.8
Industry, mining, and power			21.5
Transportation and communications			14.4

Eighth five-year plan (1992/93–1996/97)	**113,479**		
Agriculture, irrigation, and forestry		25.7	
Social services			31.6
Electricity			20.9
Transportation and communications			17.7
Industry and mining			2.0
Trade and tourism			1.3
Miscellaneous			0.9
Ninth five-year plan (1997/98–2001/02)	**372,711**		
Agriculture, irrigation, and forestry		16.8	
Electricity, gas, and water			19.1
Social services			17.1
Finance and land (real estate)			16.4
Transportation and communications			13.0
Industry (including quarrying and mining)			9.5
Trade, hotels, and restaurants			6.2
Construction			1.9
Tenth five-year plan (2002/03–2006/07)	**609,823**		
Agriculture, irrigation, and forestry		13.8	
Social services			21.5
Transportation and communications			20.1
Finance and land (real estate)			15.0
Electricity, gas, and water			14.1
Trade, hotels, and restaurants			7.3
Industry and mining			6.0
Construction			2.2
Three-year interim plan (2007/08–2009/10)	**280,281**		
Agriculture, irrigation, and forestry		12.9	
Social services			41.5
Electricity, gas, and water			19.5
Transportation, communications, and storage			17.9
General administration and defense			3.1
Miscellaneous			2.7
Trade (wholesale and retail)			1.2
Hotels and restaurants			0.7
Industry, geology, and mining			0.6
Three-year plan (2010/11–2012/13)	**1,018,831**		
Agriculture and forestry		12.8	
Fishery		0.3	
Industry			15.0
Services			71.9

Source: Nepal, NPC 1986, and the respective plan documents.
Note: Classification of sectors/subsectors is presented as per the segments categorized under the respective periodic plans.

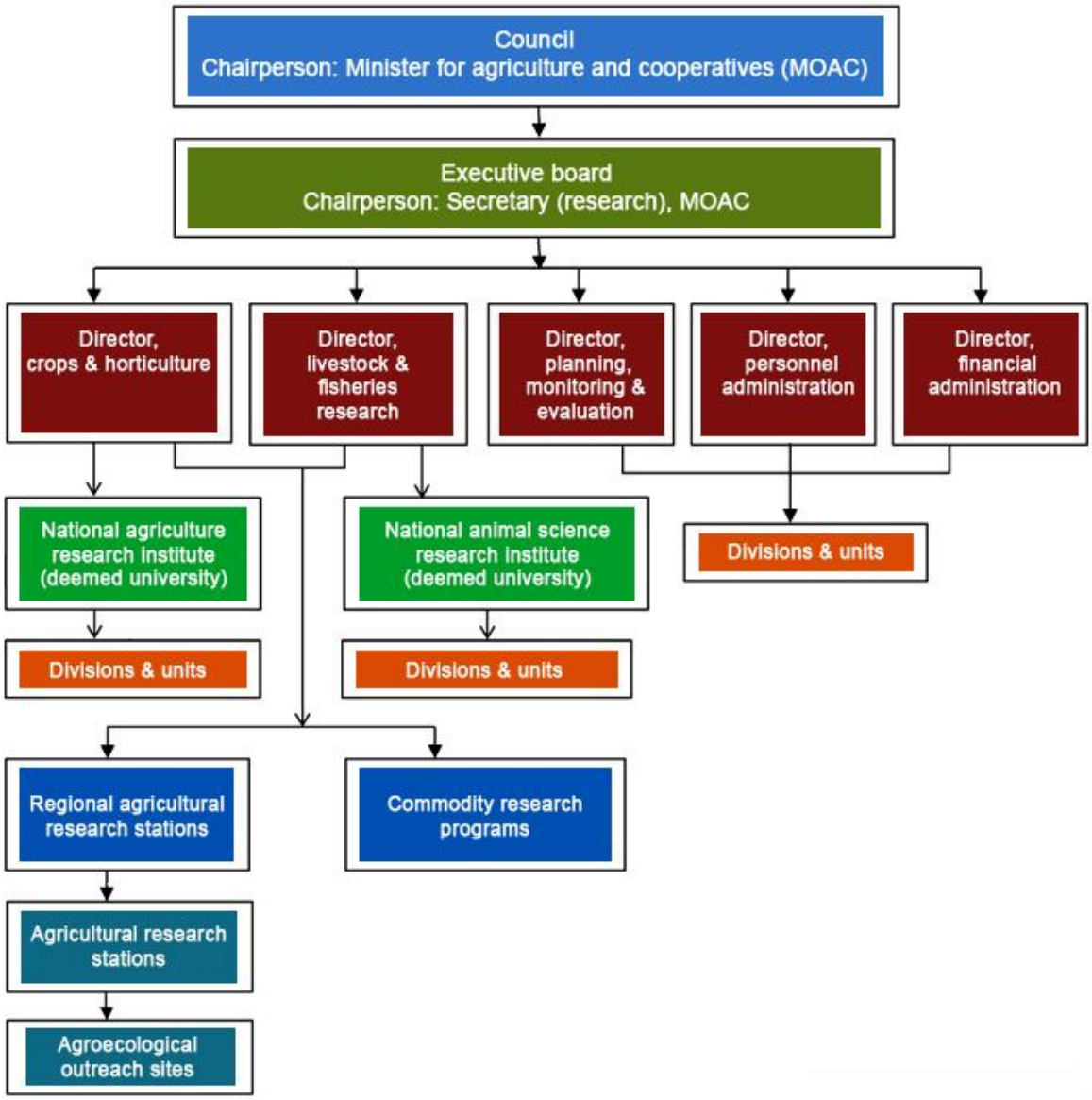
Appendix 3. Some of the Prominent Technologies Developed by the Nepal Agricultural Research Council

A. Crops and horticulture	
Crops	**Breeding and varietal development** • Developed and released 126 improved varieties of different crops as part of a complete package of cultivation practices • Identified genotypes of other crops as superior types; these are in the process of release • Developed suitable varieties and a package of practices for winter (boro) rice production • Initiated work to develop hybrid varieties of maize and rice • Identified a high-malt barley for industrial use • Identified high-yielding genotypes of buckwheat • Identified causes of wheat sterility and developed a technique to manage it **Crop management techniques** • Developed technologies for high-density maize planting and identified suitable intercrops to boost farmer incomes • Developed a technique to control white grubs using disease-causing fungi • Developed a package of cultivation techniques for chickpeas and *rajma* (red kidney) beans • Developed integrated pest/weed management and integrated plant nutrient management technologies **Farm equipment and resource-conserving technology** • Developed technologies/practices such as zero-till, minimum or reduced tilling, surface seeding, bed planting, and direct seeding • Developed drum seeder technology for direct rice sowing **Postharvest technologies** • Developed techniques to control storage pests using botanicals • Developed a hand- and paddle-operated corn shelling machine • Developed a millet thresher and pearling machine • Developed a cost-effective technique of jute retting for high-quality production • Added value to millet and buckwheat production by developing a technique to prepare cookies, bread, and noodles **Others** • Developed an innovative agro-silvo-pastoral system model—that is, terrace riser–based agroforestry for the mid- and high hills • Developed a propagation method for *allo* (nettle) through seed and stem cutting • Developed a propagation and cultivation technique for *chiraito* (an herb)

Horticulture	**Breeding and varietal development** • Developed a hybrid tomato variety • Developed true potato seed techniques and viral disease–free seed potato production using tissue culture techniques • Identified blight-tolerant potato genotypes and commenced testing in farmers' fields • Identified a late variety of sweet orange and early variety of mandarin orange **Crop management techniques** • Developed plastic-house technologies for the production of off-season vegetables • Developed an off-season onion production technology • Identified a biocontrol technique for diamondback moth in cabbage • Developed an integrated technique to manage clubroot disease in vegetables • Developed a culturing technique for *Ganoderma* (red mushrooms) **Others** • Standardized a grafting technology for tomatoes to control root nematodes • Initiated variety selection in coffee and developed a commercial coffee-pulping machine
B. Livestock, fisheries, and poultry	
Livestock	**Breeding and improvement** • Successfully implemented farmers' participatory buffalo improvement program • Implemented PPRS program for dairy animals • Achieved significant productivity gains by improving the breed of local Khari goat • Developed and commercialized a breed of Pakhribas black pig • Initiated an embryo transfer technique in cattle • Developed production techniques (breeding) for Giriraja poultry **Feed and management practices** • Developed production of plastic-bag silage for dairy animals • Developed production techniques for urea molasses mineral block to feed cattle during the dry season • Developed low-cost feeding package for pigs and poultry • Developed technology for buffalo fattening • Documented nutritive value of some indigenous pasture and fodder species **Others** • Studied and documented the diversity of native cattle, buffalo, sheep, goats, and poultry • Developed control techniques for Khari disease of buffalo
Fisheries	**Breeding and improvement** • Standardized breeding technology for rainbow trout • Gained substantial achievements in breeding and rearing *sahar* fish • Developed breeding techniques for aquarium fish • Developed farming technology for Tilapia, African catfish, and a hybrid **Feed and management practices** • Standardized rainbow trout fish farming and feed formulation • Developed a technique for community-based rice–fish farming • Developed cage-fish culture of grass carp in lakes • Gained substantial achievements in feed formulation techniques for *sahar* fish • Developed a technology package for fancy carp

Source: Nepal Agricultural Research Council (NARC) records.

Appendix 4. Proposed Organizational Structure of the Nepal Agricultural Research Council



Source: NARC (2010)
Note: A committee of management experts and scientists will work out details on number of divisions, programs, and research stations required in the new structure.

Appendix 5. Priorities Recommended by Four Groups in the Policy Dialogue Meeting

Group A: PRIORITIES FOR AGRICULTURAL RESEARCH FOR DEVELOPMENT

1. Sustainable natural resource management and utilization (5)
2. Rainfed agriculture (11)
3. Effects of climate change on agriculture (8)
4. Women-, youth-, and small farm–friendly agriculture technology (27)
5. Competitive and commercial agriculture (17)
6. Priority productivity package research on high-value commodities (8)
7. Biological and food safety (3)
8. Hill farming mechanization and processing (6)
9. Domestication of nontimber forest products
10. Postharvest technologies and value addition (3)

Group B: STRUCTURE AND INSTITUTIONS

1. Design council to be led by professionals (0)
2. Ensure functional autonomy by wider representation of institutions (6)
3. Dissolve executive board—not required (9)
4. Evolve Nepal Agricultural Research Council (NARC) into a national agricultural research system (6)
5. Establish technical advisory committees (0)
6. Recruit for national agricultural research system through independent commission (15)
7. Recruit executive director of national agricultural research system “openly” through defined criteria (1)
8. Establish mandatory linkage with technology delivery institutions through competitive grants, collaborative projects, and institutionalization of training (2)
9. Establish mandatory linkage for building partnerships in technology generation with private sector, nongovernmental organizations, academic institutions, and other stakeholders (0)
10. Deem as universities the transformed/strengthened national research institutes under NARC and the national agricultural research system (4)

Group C: FUNDING AND FINANCING MECHANISM

1. Strengthen human resources by involvement of scientists in academic institutions to create interest of young people and professors in research (8)
2. Set need-based research agenda (domain, ecology, gender, environment) in site-specific perspective (15)
3. Create pressure groups for demanding budget, and mobilizing people and stakeholders to reach the policy level (2)
4. Allocate emergency budget to grow another crop in the event of failure in productivity to balance annual productivity (1)
5. Encourage investment by donor agencies in megaprojects in Nepal for integrating research and development (including technical backstopping) (2)
6. Increase proposed agriculture funding from 0.3 percent to 2 percent of agricultural gross domestic product. Sources could be national budget, international funding agencies, private and public sectors. (9)
7. Establish/strengthen agricultural research systems to receive funding and to be mobilized as one window for facilitating research and development (14)
8. Build corporate funding for development of creditability (3)
9. Focus on involving youth and educated personnel in agricultural research and development (3)
10. Develop research as an attractive profession (2)

Group D: INNOVATIVE TECHNOLOGY DELIVERY SYSTEM

1. Use national agricultural research system communication for technology dissemination (2)
2. Increase the role of scientists in the diffusion of technology (11)
3. Build into projects components for communication and dissemination (4)
4. Promote and strengthen the role of the private sector, cooperatives, nongovernmental organizations, and agroveterinarians in dissemination of technology (21)
5. Develop policy for accessing technology from the world (1)
6. Develop and strengthen technology marketing system (4)
7. Narrow the knowledge and information gap between researchers and end users (15)
8. Use information and communication technology for promotion and market accessibility (for both inputs and outputs) (4)
9. Document and use promising indigenous knowledge (10)
10. Increase accessibility and assurance of agricultural inputs and credit (develop a policy with modality) (1)

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