NARC's Strategic Vision for Agricultural Research (2011-2030)

Meeting Nepal's Food and Nutrition Security Goals through Agricultural Science & Technology

Nepal Agricultural Research Council

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Abbreviations and Acronyms

AGDP	Agricultural Gross Domestic Product
AnGR	Animal Genetic Resources
APARI	Asia Pacific Association of Agricultural research
APP	Agricultural Perspective Plan
ARS	Agricultural Research Station
AVRDC	World Vegetable Center
CBO	Community Based Organization
CEAPRED	Centre of Environment and Agriculture Policy, Research, Extension and Development
CGIAR	Consultative Group for International Agricultural Research
CGRS	Competitive Research Grant System
CIMMYT	International Maize and Wheat Improvement Center
CLIMA	Center for Legumes in Mediterranean Agriculture
DADO	District Agriculture Development Office
DATWG	District Agricultural Technical Working Group
DHM	Department of Hydrology and Meteorology
DLS	Department of Livestock Services
DLSO	District Livestock Services Office
DOA	Department of Agriculture
DOF	Department of Forestry
DOFD	Directorate of Fisheries Development
FAO	Food and Agriculture Organization of United Nation
FTQC	Food Technology and Quality Control
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMO	Genetically Modified Organism
GON	Government of Nepal
HICAST	Himalayan College of Agriculture, Science and Technology
IAAS	Institute of Agriculture and Animal Sciences
ICARDA	International Center for Agricultural Research in Dry Areas
ICRISAT	International Crop Research Institute for Semi-arid Tropics
IFDC	International Fertilizer Development Corporation
IIPR	Indian Institute of Pulses research
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
INGO	International Non-governmental Organization
INGOs	International Non-governmental Organization
IPGRI	International Plant Genetic Resource Institute
IPR	Intellectual Property Rights
IRRI	International Rice Research Institute
KU	Kathmandu Univrsity
MOAC	Ministry of Agriculture and Cooperatives
MOE	Ministry of Environment
MOST	Ministry of Science and Technology
NABRC	National Agricultural Biotechnology Research Centre
NARC	Nepal Agricultural Research Council
NARDF	National Agriculture Research and Development Fund
NARI	National Agricultural Research Institute
NARS	National Agricultural Research System
NARSC	National Agricultural Research and Service Center
NASRI	National Animal Science Research Institute
NAST	Nepal Academy of Science and Technology
NATWG	National Agricultural Technical Working Group
NDRI	National Dairy Research Institute (India)
NEC	Nepal electricity Corporation
NGO	Non-governmental Organization
NLSS	Nepal Living Standards Survey
NMRP	National Maize Research Programme
NORP	National Oilseed Research Programme
NPC	National Planning Commission
NPRP	National Potato Research Programme
NRRP	National Rice Research Programme
NWRP	National Wheat Research Programme
PU	Purwanchal University
R&D	Research and Development
RARS	Regional Agricultural Research station
RATWG	Regional Agricultural Technical Working Group
SAARC	South Asian Association for Regional Cooperation
TC Lab	Tissue Culture Laboratory
TYIP	Three Year Interim Plan
USAID	United States Association for International Development
WFC	World Fish Center
WTO	World Trade Organization

Executive Summary

Nepal's economic future is inextricably linked to the health of its agriculture sector. Eighty percent of the country's population lives in rural areas, and agriculture is their primary livelihood. While the share of agriculture in total gross domestic product (GDP) has been declining over the years, it still accounts for one-third of GDP. However, stagnation in the agriculture sector is one reason behind a rural poverty rate that is over three times that of urban areas, 35 percent compared to 10 percent.

Beyond economic productivity and poverty reduction, agricultural stagnation undermines the Government's goal of achieving food security for all citizens of Nepal. An estimated 60 percent of households cannot meet their own food needs, especially in mountainous areas, and agricultural production only meets food requirements for three-to-eight months per year.[1]

Investments in social safety nets for the impoverished and malnourished offer relief in the short- to medium-term; however, they are not a long-term solution, and they cannot contribute to economic development while addressing the other critical social needs. Investment in an agricultural renewal—one that increases agricultural diversity, boost productivity, and develops value-added post harvest technology that bring about transformative change in food security, poverty, and competitiveness—is what Nepal needs now.

Challenges to Nepal's Agriculture Sector

The Government of Nepal recognizes the importance of agriculture in the Agriculture Perspective Plan, the Nepal Agriculture Policy, and the Three-Year Interim Plan. However, uneven institutional development over several decades, especially for agricultural research, has resulted in a confused system suffering from instability and uncertainty. Achieving the goals set forth in the plans will require reform and reinforcement of the agricultural research system to overcome the four-part challenge of low productivity, low competitiveness, poverty, and food and nutrition insecurity.

Nepal's already struggling agriculture sector is further challenged by several emerging trends, the most prominent of which, perhaps, is climate change. Farmers, especially those working in rainfed conditions are subject to the vagaries of the weather and other natural forces. Nepal has always been vulnerable to several types of natural disasters—including, landslides, hailstorms, floods, drought and fire—and according to projections the quantity and intensity of these events will increase with climate change.

Global economic liberalization and the country's admission to the World Trade Organization raises new challenges but also opportunities. The subsidies and other support provided to Nepal's farmers and agro-entrepreneurs on either side of the open border with its southern neighbor determine their competitiveness in the cross-border markets. This has created pressure on national agricultural research system to develop cost effective technologies.

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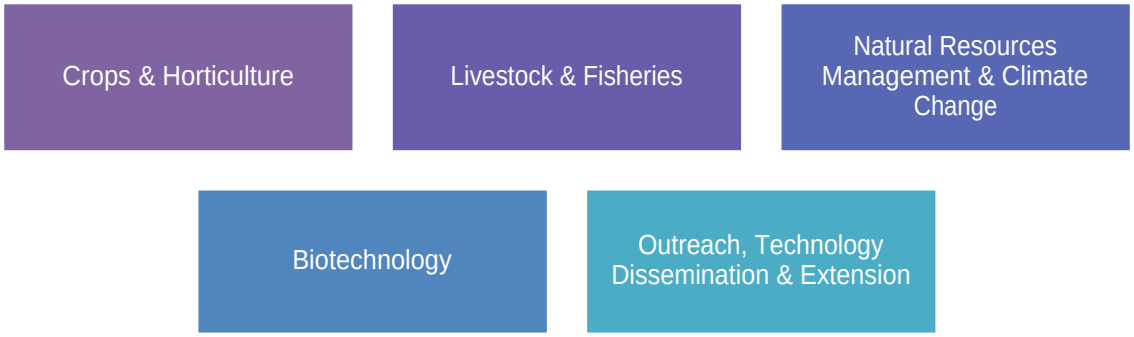
[1] Action Against Hunger. 2006. Alarming Malnutrition Rates In Northwestern Nepal. http://www.actionagainsthunger.org/pressroom/releases/2006/05/12

Finally, agricultural research has suffered from budget constraints in terms of the envelope and delivery of resources, which has limited funding for core research and much less critical research programs.

Creating a New Vision for Agricultural Research

The vision of the Nepal Agricultural Research Council (NARC) is to tap institutional, human, and financial resources from the government and a wider spectrum of stakeholders—civil society, research centers, donors, and ultimately the private sector—to move the system from agricultural research *and* development to agricultural research *for* development.

Future research priorities will be based on creating and scaling up technologies that contribute to food security, poverty reduction, value addition, export promotion, environmental sustainability and cost effectiveness. In order to deliver those desired results NARC research areas are rationalized into five broad based thematic areas of intervention:



Each theme will include several research programs—such as, commodity improvement, resource management, marketing and value chain development.

The vision focuses on reducing poverty through the effective and efficient use of scientific knowledge to increase sustainable agriculture productivity and related natural resources. The major agricultural research areas include field crops, horticulture, livestock, fisheries, on-farm water management, agro-forestry, related natural resources issues, socio-economic aspects of the farming systems, post-harvest operations, gender issues, and, above all, policy research.

Considering the agro-ecological diversity, socio-economic situation and R&D actors, NARC will emphasize the development of region-specific agricultural research programs. It will prioritize a participatory systems-based research approach that incorporates multiple disciplines and address multiple commodities. Environmental sustainability, inclusiveness, growth promotion, and income generation will be the distinguishing features of all research undertakings, besides their explicit positive contribution to poverty alleviation and food security.

Indigenous knowledge, traditional practices and local resources—including soil, water, genetic material, and skills—will be used in research and technology development in sustainable way. Due consideration will be made in creating and adjusting the technologies to exploit benefits arising and counter any negative effect brought out by climate change.

NARC will also promote commercial agriculture by generating post-harvest technologies that create value added products from cereal crops, cash crops, vegetables and fruits, livestock, poultry and fisheries; and their downstream processing opportunities. By the same token, it will also give attention

to the problems and needs of clients in the input industries and service providers—such as, farm machinery, irrigation equipment, agro-chemicals and animal feed.

NARC will shift to the role of promoter, facilitator, regulator, and implementer of efficient modern agricultural technology in partnership with stakeholders. It will draw on research results from neighboring countries, the Consultative Group for International Agricultural Research, and relevant international institutions to the extent possible, but it must enhance Nepal's own capacity to adapt and modify technologies to best meet its farmers' requirements.

In addition to its role of technology generation and policy analysis, NARC will contribute to establishing a national agricultural research system that provides a favorable environment for a broad and pluralistic participation and resource co-ordination amongst all potential service providers and beneficiaries.

Change is Required by all Stakeholders

Achieving a reinvigorated agriculture sector that addresses the multiple challenges to farmers in Nepal will require efforts by the government, NARC, and the donor community. On the part of the government, increased funding delivered on a reliable schedule will help stabilize the agricultural research system by securing the core funding needed to attract, retain, and develop the strong human resources necessary for such a system. Additionally, the Government needs to revisit the position of NARC within the government, especially the relative seniority of the Executive Director of NARC, to increase the linkages with government planning processes and government agencies responsible for the dissemination of technology.

NARC needs structural and functional re-orientation to make it more effective and efficient. Some of the existing Commodity Research Program and Agricultural Research Stations will be merged to reduce administrative costs and avoid duplication of efforts. A strong incentive system will be put in place to retain the qualified staff and get best out of them for the benefit of the country. NARC will carry out a thorough review of its role, responsibilities and achievements every five years and make appropriate changes and modifications in its strategy and operational procedures as required.

Donors need to align their support to the priorities and reforms outlined in this vision document to avoid duplication of effort or conflicting priorities, which waste limited investment resources.

Nepal's agriculture sector can be transformed into the engine of growth for poverty reduction, and food security that the country needs for its long-term economic development with the appropriate investment, reform, and innovative collaboration.

1. Nepal's Agriculture Sector

Nepal's economic growth is determined largely by the growth of its agricultural sector. Although the share of agriculture in total Gross Domestic Product (GDP) has been declining over the years, it is still the single largest sector in the economy, accounting for one-third of GDP at present. Out of the total population of 26.4 million, almost 80 percent reside in rural areas and are predominantly employed in agriculture. However, agriculture suffers from low labor productivity, as evidenced by two-thirds of nation's labor force employed in agriculture contributing nearly one-third of GDP.

Furthermore, farms are getting smaller and subsistence family farms are on the rise. Average farm size in Nepal declined by 28 percent between 1961 and 2001. Today, small and marginal farms dominate with the average holding size being only 0.8 ha. Nearly half of all farms have less than 0.5 ha of land and those with less than 1 ha of land constitute nearly three-fourths of all holdings. The landless (laborers or tenant farmers) are gradually leaving agriculture to look for better opportunities in urban centres within the country and abroad.

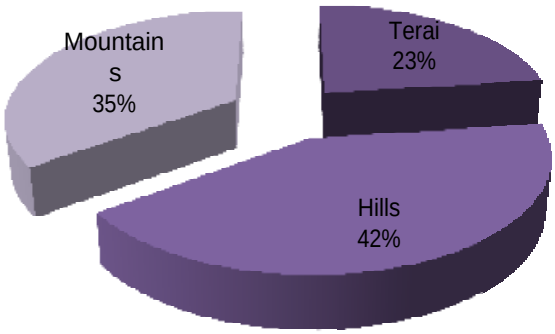
The scope of agricultural mechanization is limited because of difficult terrain in the mountains and hills and even in the *terai* due to small size of farms. Technological breakthrough is, therefore, required to pull Nepal's agriculture out of vicious circle of poverty.

Agro-ecological Landscape

Nepal has three major ecological belts running parallel from east to west: the *terai* in the south, hills in the middle and mountains in the north. These ecological belts have distinct geological, soil, climatic, and hydrological characteristics, which results in distinct land use patterns.

The Terai. Often referred to as the "granary" of Nepal, the *terai* consists of flat and fertile alluvial land that extends from the Indo-Gangetic plains at an altitude of 60 to 800 meters of the Mahabharat foot-hills. Forty-one percent of the total land area is cultivated. Technically, most of the *terai* can be irrigated and crops can be cultivated throughout the year, so it has greater potential for productivity growth than the other ecological regions. Better access to irrigation water, fertile soils, and flat terrain permit the cultivation of a variety of crops—such as, rice, wheat, maize, sugarcane, jute, and vegetables, and also commercial livestock and fish farming.

Figure 1Agro-ecological zones as a proportion of total land area



The Hills. Located at an altitude between 800 and 1,800 meters the hills comprise sloped lands with many small valleys. Only 20 percent of this area is cultivated, and maize is the single most important crop. Livestock keeping has been an integral part of farming. The region includes several attractive valleys and

basins—such as, Kathmandu, Pokhara, and Surkhet. These valleys support a relatively high percentage of the hills' population.

The Mountains. Above 1,800 meters is the mountainous area, where only 5 percent of the land is suitable for cultivation. This region is mostly steep, rugged, and cold. The mountains are sparsely populated. People's main occupation is raising livestock, and cultivation is limited to only one crop per year or three crops in two years. Livestock, especially yak and sheep are important part of farming. Vegetables are cultivated as cash crops in a few areas with access to markets. However, the vast majority of the mountains are remote and access to markets and roads is limited.

These varied agro-ecological settings—and the micro-climatic zones within them—have tremendous potential to produce plant and animal products suitable for tropical to alpine climates. Part of this potential is being utilized, for example, vegetables produced in the hills are fetching off-season prices in the *terai* and nearby markets in India and Bangladesh. Medicinal and aromatic plants found in the wild or cultivated in different micro-climates are also fetching high prices in national and international markets. Nepal has had limited success in harnessing the potential of these markets in the past. This calls for future research strategy and plans to be designed such a way that farmers in each micro-climate can exploit their comparative and competitive advantage through the appropriate mix of enterprises.

Agricultural Policies

The 20 year Agriculture Perspective Plan 1995—2015 (APP), outlines the broad policy context for agriculture development in Nepal and has five interrelated objectives:

- To increase factor productivity for an accelerated agricultural growth rate;
- To alleviate poverty and significantly improve living standards through accelerated growth and expanded employment opportunities;
- To transform subsistence agriculture into commercial agriculture through diversification and exploiting comparative advantage;
- To expand opportunities for overall economic transformation by fulfilling the precondition of agricultural development; and
- To identify immediate, short-term, and long-term strategies for implementation and to provide clear guidelines for preparing periodic plans and programs in future.

The APP emphasizes a few priority inputs, outputs, and outcomes. The 'green revolution' package for the *terai* and high value commodities for the hills and mountains are strategies to achieve "catch-up" growth, reach markets, reduce poverty, and safeguard the environment. Regional interaction among the mountain, hills and the *terai* based on their specific comparative advantages are central to APP priorities and are premised on the concept of rural growth linkages.

Subsequent periodic plans—the Tenth Five-Year Plan (2002-2007), Three-Year Interim Plan (TYIP 2007-2010), and the National Agriculture Policy (2004)—draw on the fundamentals set by the APP and share the common thread of agricultural commercialization and diversification for broad-based, inclusive growth and poverty reduction. The policies envision agriculture growth creating opportunities for farms and other enterprises while safeguarding the environment and achieving food security. They also recognize that the public sector alone cannot achieve this vision. The private sector and NGOs will be active participants with the state increasingly adopting the role of facilitator rather than implementer, unlike in the past.

As stipulated in the TYIP, all sector development interventions are geared toward contributing to the overriding national objective of poverty reduction. This objective is to be achieved by ensuring food security, enhancing economic growth, effective and efficient utilization of scientific information, and sustainable exploitation of agriculture and related natural resources. Agriculture and livestock development are to be treated as the lead sector in this respect.

Emerging Challenges

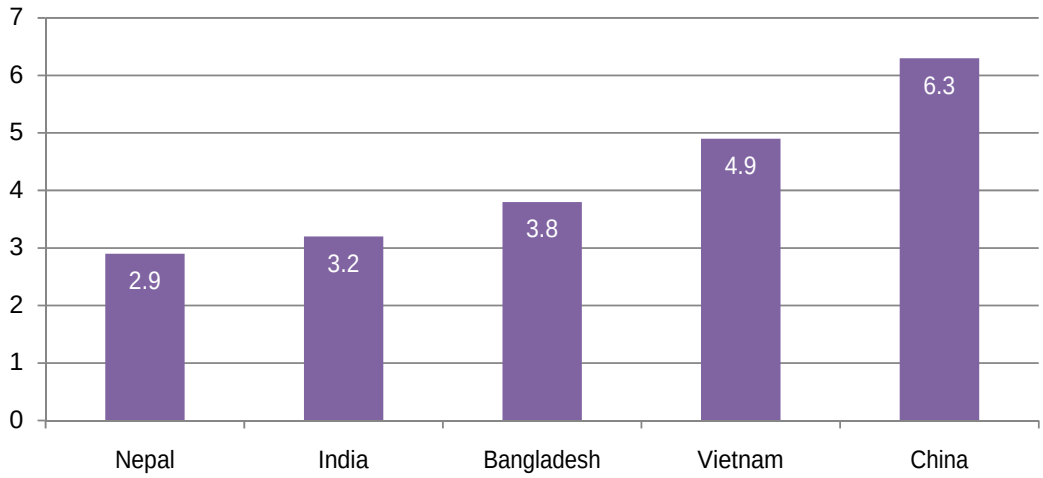
The agriculture sector grew by just over 3 percent per year between 1997 and 2006 and by less than 2 percent more recently. Production is oriented mainly towards subsistence, with rice, wheat, and maize accounting for about 35 percent of Agricultural Gross Domestic Product (AGDP). Other crops contribute 15 percent, livestock 26 percent, horticulture (including fruits and vegetables) 17 percent and fisheries 2 percent in the AGDP. Major reasons behind waning performance in agriculture over the years are discussed below.

The international and national context directly related to agricultural research has drastically changed in recent years and this needs to be assessed carefully while developing strategies. Some of the emerging contextual issues directly related to Nepal are described below.

Reviving agricultural productivity

Rural poverty and agricultural productivity are closely linked in Nepal given the dominant role of agriculture in the economy. Current crop yields in the country are insufficient to raise the rural poor out of poverty. A comparison of crop yields across South Asian countries suggests that Nepal is lagging behind. In 2008 the country's cereal yields were about 89 percent of India's, 88 percent Pakistan's, 65 percent of Sri Lanka's, and 60 percent Bangladesh's (FAOSTAT). Rice, which accounts for 20 percent of Nepal's agricultural gross domestic product (AGDP) and 49.4 percent of total food grains lags far behind comparable producing countries (see figure 2). The virtual stagnation in agriculture has generated food security problems. In fact, 43 of 75 districts are food deficit and 10 more are considered vulnerable.

Figure 1 Comparative Rice Yields in Nepal and Select Countries (tons/ha)



There appears to be a relationship between low crop productivity and low fertilizer use. It is estimated that in 2006/07 the average fertilizer use per ha of cropped area in Nepal was less than 20 kg, which is far below the South Asian average of 115Kg/ha and East Asian average of 278

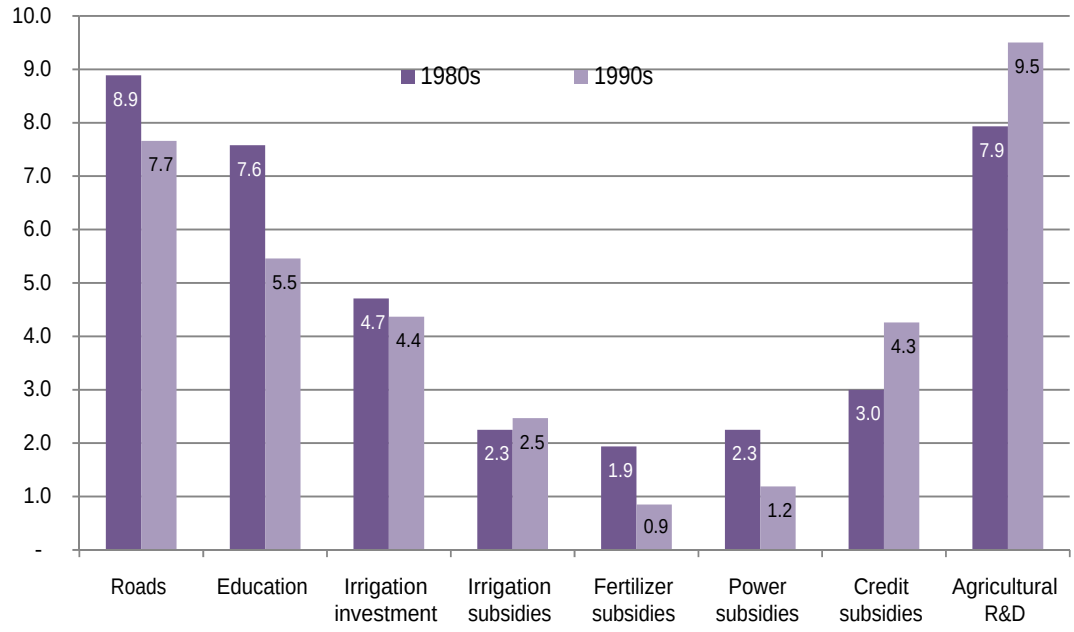
kg/ha (IDFC). In addition to low fertilizer consumption, Nepal's agriculture is constrained by limited irrigation potential, uninsured weather shocks, poor access to infrastructure and markets, and low priority to agricultural research and development.

Nepal has a mixed crop-livestock-forest farming system. Livestock plays an important role as a food source, a source of power (pack and draft) and manure for crop cultivation, and as a hedge against shocks. An estimation by NARC shows that Nepal is about 10 percent deficit in milk, and 38 percent deficit in meat production. Poor access to animal feed, lack of minimum quality standards for livestock products, and poor access to better quality breeds are the main constraints in livestock sector. The availability of green fodder has also declined drastically as a result of dwindling grazing area and access to forests. According to a study (ANZDEC, 2002), Nepal's livestock sector suffers from a 34 percent deficit of total digestible nutrients.

Working with resource constraints for agricultural research

The GON places a high priority on agriculture, given its role in the overall economy; however, resource constraints over the years have led to declining budget allocations to the Ministry of Agriculture and Cooperatives (MOAC) from 3.7 percent of total national budget in 1997/98 to 2.4 percent in 2008/09. Within the budget for agriculture, the proportion of NARC has similarly declined from 14.4 percent in 1997/98 to 8.9 percent in 2008/09 and to 7.1 percent in 2009/10. A study by Fan, Gulati and Thorat (2008) shows that returns on investment to agricultural research relative to other traditional investments have been strong from the 1960s through the 1990s. Moreover, returns have held steady over the decades compared to other investments—e.g., roads, credit subsidies, etc. Declining resource allocation for agricultural research and development will have direct implication on attaining the objective of poverty reduction and food security. The challenge for NARC is to produce as many relevant research outputs to meet the changing needs of Nepalese farmers under increasing resource constraints.

Figure 2 Returns on investment in traditional areas for growth and poverty



Mitigating the risks of and adapting to climate change

Nepal's share in the global emission of greenhouse gases (GHGs) is negligible, but she faces consequences of global warming nonetheless. The country has always been vulnerable to several types of natural disasters. The middle hills are prone to landslides and hailstorms while the *terai* is prone to floods, drought and fire. Projections show that these events will increase in quantity and intensity with changes in the climate.

Future climate projections indicate increased temperatures. The Second National Communication Report, 2008 shows an already increasing trend in the annual average temperature by 0.06^0C per year in Nepal as a result of global warming, and this warming is more pronounced in the northern high altitude regions. It is projected that the average temperature will increase by 4°C during winter and 2.5 to 3°C during summer by the end of this century. The predicted increase in the amount and intensity of summer rainfall – in the range of 15 to 20 percent - is expected to increase floods. On the other hand, the predicted slight decrease in winter rainfall is expected to cause droughts.

With limited irrigation sources, rainfall is critical to agriculture in Nepal, so any change in climatic variables is likely to have serious consequences for agriculture. Climate change due to global warming is expected to modify agricultural activities in the following ways:

- The altitude boundaries for agro-ecological zones may shift and lead to movement of certain crops, livestock and fish species to higher altitudes;
- Changes to and losses of agro-biodiversity due to limited adaptability;
- Impact on shrinking habitats and fewer shelters in livestock and fisheries sub-sector;
- Less irrigation water due to uncertain rainfall patterns;
- Increased land degradation and soil erosion;
- A shift in the cycle of existing weeds, diseases and pests and possible invasions of new weeds, diseases and pests; and
- Lower quantity and quality of some crops and animal products.

Nepal is already seeing visible effects of climate change—such as increased melting of glaciers in the Himalaya Region, the changing pattern of monsoon rains, and thick cloud cover during the winter in the *terai*—which are impacting agriculture, biodiversity, and the natural resource base.

Nepal's current adaptive capacity to climate change is limited. Productivity is already low and poverty is high, especially amongst the rural population, which limits household ability to withstand climate shocks. In the face of these expected impacts on agriculture, climate change represents a serious issue to be taken into consideration and incorporated into future thematic research programs developed within NARC.

Boosting productivity when irrigation facilities are limited

Agricultural productivity in Nepal is severely affected by uneven nature of rainfall, frequent drought, and lack of sufficient irrigation systems. Data published by MOAC (2006) shows that 934,989 ha—or only about 33 percent of cultivated land—is irrigated. Difficult topography has limited irrigation development to only about 10 percent of cultivated land in the mountain and hill districts. In the *terai*, 56 percent of cultivated land is irrigated. Of the total irrigated land, only about 40 percent is irrigated throughout the year. This has limited the number of crops grown per annum and the crop productivity.

Overcoming poor accessibility for market access and food security

Access to roads infrastructure has major implications for food security, because while most of the surplus production takes place in *terai,* the majority of households in the rest of Nepal are net buyers of cereals (NLSS II 2004/05). Although the road network has expanded significantly mainly through the efforts of local authorities, many roads are of poor quality and are impassable during the rainy season. Despite the impressive increase in road construction, only 69 of 75 districts headquarters are connected by road. Even where districts have road access at some point, they have still larger areas several miles away from the road. One-fourth of the country's area is still more than a four-hour walk from a road head.

Rebuilding in the wake of conflict

The conflicts of the last decade disrupted flows of agricultural credit and input supplies (e.g., seeds, fertilizers, irrigation, pesticides, machinery and other technology, and research and extension services).

NARC suffered heavy loss of its physical facilities during insurgency. A total of 11 NARC facilities, including one at Guthichaur in Jumla, one of the most remote areas, and Khumaltar in Kathmandu suffered damages. Total physical losses to NARC are estimated at 62 million rupees, and these assets have yet to be repaired.

Promoting food and nutrition security

Maintaining food security is a major problem for Nepal especially since population growth outstrips agricultural growth. Major food policy goals of Nepal include increased food production, equity in regional distribution of food, improvement in nutritional status of the poor, and food security through reduction in the variability in food production. Maintaining food security, however, is a major problem for Nepal, especially since population growth outstriped agricultural growth in the recent past.

The interim constitution of Nepal (2006) recognizes food security as a fundamental human right. Consequently, GON has approved a food security plan as part of TYIP (2007-2010) that seeks to safeguard the right to sustainable food security for all. The challenge is to do this while maintaining proper conservation and management of natural resources together with sustainable agricultural production, equitable distribution, increased employment opportunities, increased quality of food products, and reduced vulnerability of disadvantaged population (children, old, occupational caste, women, marginalized tribes, and people living in inaccessible areas). The five main objectives of Nepal’s food and nutrition security plan are:

- to increase the country's self-reliance for basic food stuffs;
- to improve the nutrition situation;
- to enhance standards and safety of food stuffs that are available in markets;
- to enhance capacity for managing food insecurity that arise from emergency conditions; and
- to improve the access to food by groups prone to food and nutritional insecurity.

The major strategy is to attain food self-sufficiency by increasing production/productivity by providing research and extension support. Agricultural production is expected to grow by 4.5 percent per annum by the end of the TYIP. Production of high value commodities based on comparative and competitive advantage and provision of additional transport and market infrastructure will help to improve the well being of farmers, especially those living in the hills.

Similarly, the National Agricultural Policy (2004) has targeted modernizing the central food laboratory to make it capable of providing a variety of food and agriculture-related testing and to get it accredited internationally. Early warning and disaster preparedness are the other major strategies to be taken as part of ensured food security.

Adjusting to changing political economy

The socio-political setting of Nepal has changed. With the monarchy gone, the country is in the process of becoming a federal republic. The people's ambitions of economic development and improved livelihoods have increased substantially, but resource productivity has not kept pace. At the same time, people and government have recognized that centralized decision is not sufficient in a dynamic environment, so decentralization, even in agricultural research and development, is being encouraged.

Making globalization work for Nepal's farmers

The world's capital and financial markets are increasingly integrated, and the stability of Nepal's monetary and financial sectors is steadily more dependent on global markets. On the positive end, this means new opportunities for external investment into Nepal. On the negative side, it means that problems arising in other countries can impact Nepal's economy. The link with India is particularly important, and economic changes in India are felt almost immediately in Nepal. Given the open border situation, the levels of subsidy and other support provided to the farmers and agro-entrepreneurs on either side of the border determine their competitiveness in the cross-border markets. While Nepal's relatively small economy surrounded by large ones makes it particularly vulnerable to cross-border variations in public sector support, technological choices, and market access, it also offers opportunities that could benefit Nepal's agrarian communities.

Nepal is a signatory to various international agreements related to globalization specific to the agriculture sector, including the World Trade Organization (WTO). WTO-related issues are prominent in many areas of economic development and the agricultural policies of Nepal. One positive factor is that the indigenous knowledge and technologies and intellectual property rights (IPR) of farmers, communities, and intellectuals will be secured. WTO rules to grant transit rights to international markets is also beneficial for a land-locked country like Nepal.

Harnessing information technology for research and extension

Information technology has been expanding very quickly over the past decade. Scientists in Nepal now have better access than ever before to the latest information, and better communication is possible between partners within and between institutions through electronic transmission. This has improved opportunities for collaboration.

Attracting the private sector to agriculture in Nepal

Global companies that develop and market plant and animal protection chemicals and improved seeds are consolidating. Private companies in Nepal are now beginning to enter the agriculture sector, which in the past was dominated by public institutions. Improved seeds, eggs, semen, embryo, and other improved technologies produced by research institutes are now being channeled through the private sector. This is forcing public institutions to find new roles in a changing system. As this happens, IPR will become an increasingly important issue, particularly with regard to seeds, eggs, embryos and others.

Managing the opportunities and risks of biotechnology

Biotechnology offers an incredible potential for those involved in agriculture. The potential of genetically modified organism (GMO) are already being exploited by international agricultural and livestock research centers. The scope for developing new biotechnology products that involve licensing, and hence royalties, should be explored. This is a highly sensitive area and future use of GMO in Nepal needs to be guided by a clear policy environment.

Creating a New Vision for Science and Technology in Agriculture

Nepal's agriculture must move from an extensive system dependent on unavailable inputs and information with little linkage to the market to an intensive system of innovation that depends on new knowledge, technology, and practices that will get more and diverse crops for farmers who can feed the country and compete in national, regional, and global markets.

Agricultural science and technology holds promising solutions for Nepal's three-fold challenge of low agricultural productivity, rural poverty, and food in-security. Investing in research and development is an investment in not just more food, but a more stable supply of food that is more nutritious. It is also an investment that can yield higher farmer incomes, which allow rural households to have a more varied and nutritious diet:

- Understanding the biodiversity of indigenous species can improve the management, protection, and use of appropriate crop varieties.
- New varieties/hybrids of crops and improved breeds of animals and fish have the potential to increase yields, withstand drought conditions, and provide more nutrients to Nepal's people.
- New farming practices can get *more crop per drop* of water, protecting a resource whose supply is shrinking while demand is growing.
- Introducing more high-value crops can open new market opportunities for farmers, especially in the hill areas.
- Research on pests and diseases can lead to effective and environmentally sound deterrents that will save crop yields.

Strategically planned and dedicated research is one feasible path to achieving GON's goals of poverty reduction, food security, and commercialized agriculture. Research should be on the same priority level as agricultural extension to providing more flexibility in the working environment, and research programs should be designed to meets those national goals while also safeguarding natural resources.

This new vision of NARC outlined in this paper replaces the previous vision prepared in 2002, which was not sufficient to streamline the agricultural research system of Nepal and holistically address nationally identified needs and priorities.

2. An Overview of Agricultural Research in Nepal

The Policy Foundation

The APP and the Nepal Agriculture Policy of 2004 form the foundation for GON's agricultural policies, and they are reflected in shorter-term planning documents such as the TYIP (2007-

2010). The goal of GON in agriculture is to achieve broad-based, gender-inclusive and sustainable agricultural growth. In achieving the overall goal, the agriculture sector has to achieve the following specific objectives:

- increasing agricultural production and productivity;
- achieving food and nutrition security;
- stimulating structural transformation of the agriculture sector from subsistence to commercial to exploit comparative advantages and market opportunities,;
- increasing employment opportunities for rural youth, women, and deprived groups; and
- conserving, promoting, and harnessing agricultural biodiversity through the development and dissemination of environment friendly techniques.

The TYIP recognizes the central role of agricultural research in increasing the resource productivity and efficiency, and the government has specified the following strategies for technology development and dissemination:

- The agricultural research system will be made practical, accountable, and results-oriented by giving it a high priority in public sector investment.
- Priority will be accorded to reconstruct and repair physical structures damaged during the conflict and to manage biological assets.
- Agriculture research, extension, and education will be implemented in a coordinated and integrated manner.
- The agricultural production system will be made more competitive and commercial through the extension of appropriate agricultural technology.
- Regular and reliable agriculture market information will be provided to farmers.
- The Nepal Agriculture Extension Strategy 2006 will be effectively implemented.

NARC's Mandate and its Alignment with National Policies

As an apex level agricultural research organization NARC currently conducts, promotes, supports, coordinates, and evaluates research activities related to agriculture, including crop husbandry, livestock husbandry, aquaculture, natural resources, and rural development. Major areas of responsibility include:

- Ensuring that the national research agenda and resource allocation reflect the priorities of rural communities and agro-entrepreneurs, and that agricultural, livestock, and natural resource research is undertaken with the full participation and collaboration of relevant stakeholders, including farmers and agro-entrepreneurs, with particular emphasis on resource poor farmers, small entrepreneurs, and remote areas of the country;
- Promoting the active participation of all potential service partners within and outside the public sector, including government departments, university systems, non-governmental organizations, private sector companies, and qualified individuals;
- Mobilizing national and international resources for the promotion of agricultural research;
- Implementing, co-coordinating, and facilitating a streamlined national research agenda, setting priorities and allocating resources for core and competitive research programs;
- Encouraging the growth of pluralistic regional research and development (R&D) capabilities for agricultural, livestock, and natural resources; and

- Developing a suitable mechanism to transfer appropriate agricultural technologies to farmers and other users and ensuring proper coordination among various technology delivering agencies in the public and private sectors and in civil society.

NARC has a coherent working relationship with MOAC and the National Planning Commission (NPC). It provided inputs in designing policies related to the agriculture and natural resource sectors starting with the APP. Since then, the government has mandated that NARC be involved in formulating agricultural related policies—including, Animal Health and Livestock Services Act, Animal Slaughterhouse and Meat Inspection Act, Nepal Veterinary Council Act (1999), Nepal Biodiversity Strategy (2002), National Agriculture Policy (2004), the Agriculture Biodiversity Policy (2006), and the recently-completed Animal Breeding Policy and Poultry Policy. As a responsible partner in policy making, NARC has also aligned its research agenda to achieve the objectives set out in national policies and programs as illustrated in table 1.

Table 1 NARC's Alignment to TYIP (2007-2010)

NARC Research Agenda Item	Objectives of TYIP[a]				
	I	ii	iii	iv	V
• Increasing productivity and generating on-farm and off-farm employment for food security	v	v			
• Commercialization of agriculture for employment generation, poverty alleviation and export promotion			v		
• Utilization of available farm resources for rainfed and relatively low fertile land				v	v
• Sustainable use of natural resources and utilization of degraded land (conservation agriculture)	v				v
• Cost effective technology, especially for small and marginal farmers	v	v			
• Eco-friendly management practices					v
• Farming system-oriented outreach research	v	v	v	v	v
• Coping with negative effect of climate change and global warming	v	v			v

Notes: a. The TYIP objectives are listed in earlier section.
Source: (1) NARC 2000, NARC guideline and Directives for the preparation of Agricultural Research Projects, NARC, Kathmandu, and (2) NPC 2007, Three Year interim Plan (2007/08-2009/10), NPC, Kathmandu.

Institutional Development for Research

Agricultural research in Nepal began in 1937 during the Rana regime when the Agriculture Council and several agriculture research stations were created. The Council was dissolved in 1951 and agriculture research was entrusted to the departments under MOAC.

In 1987, a separate organization called the National Agriculture Research and Service Centre (NARSC) was created under the Ministry of Agriculture to undertake all agricultural research works, and all central divisions located at Khumaltar, research centres, and government farms came under its management.

In 1991, NARSC was dissolved and Nepal Agricultural Research Council (NARC) was formed as an autonomous organization to conduct all agricultural research needed for the country.[2] Since then, NARC has been the apex body of Nepal's national agricultural research system (NARS). However, not all of the research assets—such as, central laboratories, research farms, and human resources—that were enjoyed by NARSC were handed over to NARC. Comparatively better equipped horticulture, livestock and fisheries sector research facilities were kept under the Department of Agriculture and the Department of Livestock Services, whose mandate is extension. This set back some horticulture, livestock, and fisheries research.

In 2001, a separate institution—National Agricultural Research and Development Fund (NARDF)—was established under the Ministry of Agriculture and Cooperatives to implement a competitive grant system for agricultural research and development. This institution does not implement research projects, but it provides grants to government and non-government organizations on a competitive basis. There is no formal coordination mechanism between NARC and NARDF. This has resulted to a continuing risk of duplication of work.

The Institute of Agriculture and Animal Science (IAAS)[3] also conducts research on agriculture. While most IAAS research work fulfills the academic requirement of post-graduate students, they also do research to solve farmers' problem with research grants from national and international donors.

Agricultural research in Nepal has been and remains a public sector activity; however, the government institutions involved have been subject to frequent organizational changes leading to instability and uncertainty. This has contributed to the Nepal's lagging agriculture sector compared to neighboring countries. The nature and reasons of the institutional changes—driven less by demands of the system or its end users, the farmers—have also contributed to a disjointed system that is not working optimally. Despite difficulties in the operating environment, NARC has made a tremendous contribution to agricultural research and development and is moving to build an efficient NARS as envisaged by APP.

Funding for Agricultural Research

The Government of Nepal (GON) allocated 5,759 million rupees for MOAC in the fiscal year 2008/09, which represented 2.44 percent of the total national budget. Though the budget for agriculture development has increased over the last decade in absolute terms, its share of the national budget has declined from 3.66 percent in 1997/98 to 2.44 in 2008/09.

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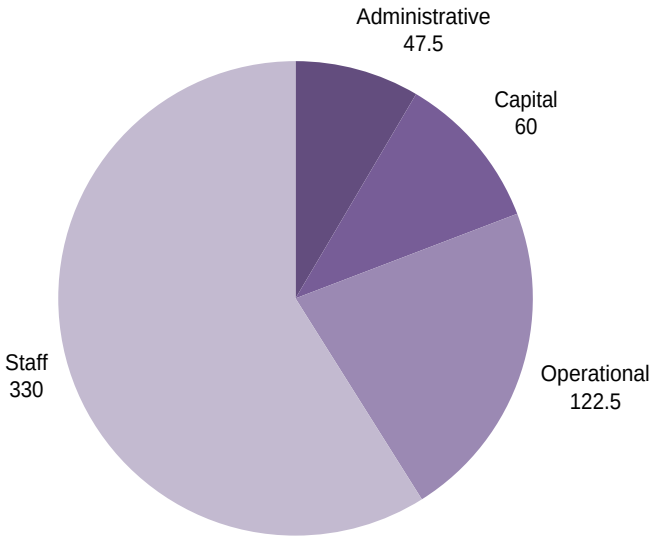
[2] Under the Nepal Agricultural Research Council Act 1991.

[3] College affiliated to Tribhuwan University.

Although the number of donor projects increased over the years, overall support for the agricultural research has waned. NARC is highly dependent on funds from the government. The government budget for NARC was 326 million rupees in 1997/98 and 510 million in 2008/09, an increase of 56 percent, in absolute terms. However, in relative terms it declined as core inflation between those periods was about 100 percent. The share of NARC in national budget also decreased substantially. In 1997/98 NARC's share of the national and MOAC budget was 0.53 percent and 14.40 percent, respectively. However, it had declined to only 0.22 percent and 8.85 percent, respectively, in 2008/09.

Because of declining budgets staff and administrative costs are consuming an ever-increasing proportion of the NARC budget (see figure 4). Allocation for operational costs remained between 22 to 34 percent of total budget and this ratio is declining over the years. Largest year to year fluctuation is observed in capital budget ranging from 2 to 30 percent. Within the operational budget, about 28 percent is allocated for crop, 14 percent for horticulture, 20 percent for livestock 7 percent for fisheries, and 30 percent to multi-sector activities. Similarly, 5 percent of operational budget is allocated for the high-hills, 65 percent for mid-hills and 30 percent for the *terai*.[4]

Figure 3 Breakdown of 2009/10 Fiscal Year Budget for NARC (in million Rs)



3. Practices and Challenges in NARC's Current Operations

NARC is mandated to manage agricultural research, technology generation, and dissemination that meet the needs of Nepal's different production environments. It works through different disciplinary divisions, commodity research programs, RARSs, and ARSs that conduct research at stations to generate basic information and validate research results in farmers' fields to improve the adoption of new technologies.

[4] Based on budget allocation to its offices located in those ecological regions.

Research Management, Priority Setting and Resource Allocation

NARC follows bottom-up and top-down convergent approach in research planning process. The bottom-up approach is made through the participation of farmers, extension personnel, NGOs, and other research clients in district level planning workshops and regional technical working group (RTWG) meetings. NARC has developed guidelines for preparing research proposals where it clearly mentions that the proposals should primarily focus on contributing to meeting the objectives of TYIP and follow the guidelines of the National Agriculture Policy, APP, and the NARC vision. The disciplinary and cross-cutting divisions, commodity programs, RARS and ARS are required to prepare the research proposals for the next fiscal year and submit to the headquarters by April.[5]

Research projects are grouped into five areas (see box 1). The priorities of NARC research projects are guided by the overall goal of poverty alleviation through broad based, inclusive and sustainable agricultural growth. Following are the priority issues:

- Major food crops such as rice, maize, wheat and potato;
- Minor food crops such as barley, buckwheat, millets, and amaranthus;
- Potential commercial crops such as apple, citrus, mango, banana and vegetables;
- Cash crops such as large cardamom, ginger, turmeric and other spices;
- Industrial crops such as tea, coffee, jute, sugarcane, cotton, sunflower and Jatropha (bio-fuel);
- Specialized commodities such as sericulture, bee keeping, flower, mushroom and wool animals;
- High value low volume commodities such as saffron, *yarshagumba*, herbs and non-timber forest products;
- Fish, including cold water fish and warm water fish;
- Dairy animals such as buffalo, cattle and yak;
- Animals for meat production such as poultry, goats, sheep, buffalo and pigs; and
- Power use in agriculture and agro-industries—draft animals, solar, bio-diesel and farm waste utilization.

Technology Generation and Improvement

In the last 19 years, NARC has developed and released 126 improved varieties and one hybrid variety of crops with their package of practices suitable for different agro-ecological zones of the country. These varieties are developed for their resistance to pests and diseases, the higher yields they produce, and/or their tolerance to extreme conditions, such as drought. These releases have improved production—off-season vegetables, for instance—taking advantage of different micro-climatic conditions. At the same time, NARC has also promoted cost-effective zero or minimum tillage technology and other resource conserving cultivation practices.

[5] Fiscal year starts by middle of July.

In the livestock and fisheries sector, NARC introduced participatory livestock improvement and efficient feed preparation techniques and feeding practices. It also successfully demonstrated trout breeding technology has been in farmers' fields, and introduced community based rice-fish farming, which resulted in a nearly 12 percent additional rice yield while producing 300-514 kg/hectare of fish within one rice cropping cycle. In poultry, NARC development breeding techniques for Giriraja poultry, which have become very popular among rural farmers in the Eastern and Central regions due to its high meat and egg production. See Annex 4 for a more thorough list of technologies that NARC has developed, up-scaled, and promoted.

Box 1. Research Areas of NARC

- core research
- technology development
- policy and socio-economic
- environmental science
- new frontier/ exploratory research
- Climate change

Technology Dissemination

While NARC is responsible for generating technologies, the Departments of Agriculture and Department of Livestock Services and their district offices (including service centers) are responsible for technology dissemination. Several other organizations such as Poverty Alleviation Fund, Women Development Program, Irrigation Program, Watershed Management Program, and NGOs also do agriculture technology dissemination and development activities.

Agriculture Technical Working Group (ATWG) at the district and regional levels are tasked with identifying field level problems and distributing technologies that address them. The National Agriculture Technical Working Group (NATWG) coordinates the overall performance of this process. People from research, extension, NGOs, and private sector take part in ATWG meetings, but there is no mandatory system of working together in the field.

Several other organizations—including NARDF, NGOs and INGOs and development projects, disseminate agriculture technology as do agro-vets and seed traders, but coordination among these institutions is lacking.

The majority of NARC's research stations, especially R/ARS, have outreach research sites on farmers' fields. Potential technologies are tested at these sites and farmers' preferences are considered in their development. The action and adaptive researches conducted at these outreach sites also help disseminate technologies in short period of time.

NARC communicates about its research and development activities through many channels—including, technical reports, workshops (and proceedings), NARC research highlights, annual reports, and newsletters. In addition, NARC scientists publish their findings in the form of brochures, booklets, workshop proceedings and journal articles. It also uses mass communication—website, radio, television, and daily newspapers for disseminating its latest innovations and knowledge. NARC operates the National Agriculture Library where a significant amount of print and electronic documents are placed for the use of scientists, academics, students, development workers, and others.

Reforms to Meet NARC's Mandate

While NARC has had several successes in its current form, it can play a better leading role in creating a favorable environment for generating the technologies and increasing the flow of those technologies to potential end-users. However, it will need to enhance its own capacity and that of

partner organizations to critically evaluate the relevance, acceptability, and competitiveness of technologies for the diverse socio-economic, agro-climatic, and resource endowment situations of the majority of Nepal's farmers and agro-entrepreneurs. The following are some of the major issues that NARC needs to consider in the process of generating and disseminating the technologies.

Incorporating poverty, equity, and gender concerns

In the context of the overriding national concern for poverty alleviation and the state's obligation to address the specific needs of the deprived and marginalized sections of the population, research providers must increasingly reorient their focus to include these issues in their core programs. These areas have not been sufficiently addressed in the past, which partly explains why some NARC outputs have not been effective in benefiting small, marginal and resource poor farmers and agro-entrepreneurs that constitute the majority of the rural community.

Technological development and dissemination need to be sensitive to the conditions of rural women, whose contribution is often greater than that of men in the production, storage, processing and marketing of crops, livestock and fishery products, and in the collection, use, and management of natural resources. Under the new strategy, agricultural research needs to ensure that gender concerns are properly accounted.

Safeguarding the environment while increasing agricultural production

In the past, agriculture research in Nepal has had a fragmentary approach concentrating on specific sub-sectors, commodities and disciplines, while neglecting the constraints and opportunities of the wider natural resources systems. The result has been declining soil fertility and degradation of agricultural and other natural resources, which pose a major challenge to sustainable agricultural growth and environmental balance. NARC will have to initiate measures to directly deal with these issues. The scope of agricultural research should expand to include these *and* agro-forestry, water management, and other related natural resource systems.

Adding commercial crops to the agriculture agenda

Agricultural research in the past focused mainly on production of food crops with less attention to high value commodities—such as, vegetables, spices, herbs, and dairy sectors. Research has not been able to provide the specific technological requirements of a large number of agro-processors, traders, distributors, and other agro-entrepreneurs. NARC needs to include those areas in its future research agenda to make Nepal's agriculture more competitive. Key areas of focus for the overall national agricultural research system in future should also constitute improved access to markets, proper methods of post-harvest handling, market and price information, and quicker access to knowledge and information. Increased commercialization will be made compatible with biodiversity conservation and environmental sustainability.

4. Renewed Research Agenda for Nepal's Agriculture

In order to deliver the strategic orientation outlined in the previous sections, NARC has organized its research program into five broad thematic areas of intervention:

- crops and horticulture;

- livestock and fisheries;
- natural resource management and climate change;
- biotechnology; and
- technology dissemination, extension, and outreach.

These themes are dynamic pillars for organizing research outputs to serve Nepal's agriculture in an environment that is increasingly changing and challenging. The themes are integrated rather than isolated. Therefore, research programs developed from these thematic areas will also be dynamic and integrated. For example, natural resource management and climate change priorities will directly feed into the research program for crops and livestock.

Crops and Horticulture Thematic Area

Crop and horticulture research—particularly for the most important crop commodities: rice, maize, wheat, finger millet, legumes, fruit and vegetables, and potato—plays a major role in food security. Research priorities include developing new varieties based on yield, disease and pest resistance, nutrient value, etc.; agronomic practices, plant protection; plant nutrient management; and post harvest processing and marketing. Experience has shown that conventional food crops alone will not resolve increasing food insecurity looming large in many districts, especially in the hills and mountains. In these areas, indigenous food crops could improve food security if given due priority for research and development. Therefore, crop research will seek to maintain a balance between major cereals and indigenous food crops.

The crops and horticulture research program will broadly focus on improvement of crop varieties, on-farm crop management, marketing and value chain development, and policy issues. The following is a summary of key components of thematic focus (see Annex 7 for detailed list):

Theme 1: Improving crop varieties

- Germplasm collection, maintenance, and utilization of food, fibre, legume, fruits 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

- Develop integrated crop management, including IP/WM, and IPNM practices.
- Develop cost effective integrated crop management package of practices.
- Develop package of practices for organic farming.
- Strengthen farm mechanization operations including conservation tillage.
- Disseminate technology for quality seed and sapling production and management.

Theme 3: Marketing and value chain development

- Development and up scaling of post harvest technologies including drying, processing and value addition techniques
- Generation of technology for value addition on non-timber forest products (NTFP) including medicinal and aromatic plants (MAP)
- Study national and international markets for exportable agricultural products, including quality demanded by the markets.
- Review the governments export policies and suggest appropriate actions to increase value of export.

Livestock and Fisheries Thematic Area

Livestock and fisheries play a strategic role of insuring rural farming communities from shocks to farming and other livelihoods. The challenge is to increase livestock productivity, improve the quality of livestock products, and increase market access. The strategy for livestock and fisheries development is to improve the living standard of the rural communities by: (i) increasing nutrition, incomes, and employment through improved livestock productivity in a sustainable and equitable manner; and (ii) enhancing the capacity of people to manage the process of livestock development. NARC is already engaged in various research efforts towards this end, which will continue to be strengthened. In addition, NARC will promote the following activities (see Annex 8 for detailed list).

Theme 1: breed improvement and management

- Germplasm collection, conservation, maintenance and utilization of dairy, meat, eggs and wool and fiber animal, fish commodity, forage and range land species.
- Sustainable conservation and utilization of domestic AnGR of Nepal.
- Enhancing productivity of dairy animals through selection and cross breeding
- Developing meat type buffalo.
- Enhancing productivity of sheep and goat through selection and cross breeding for meat, fibre and milk (goat cheese) production
- Development of suitable cross breed pig and poultry for value addition.
- Enhancing fish productivity through increasing fish species diversity and integrated fish farming in ponds, lakes, running water and rice fields.
- Development of suitable meat and wool type rabbits for different agro-ecological zones of Nepal.

Theme 2: Fodder and feed management

- Development of round the year 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 non-conventional feed resources.
- Improving productivity of fish through developing appropriate feeds and feeding management.
- Nutrients fortification in mechanically compressed feed block.
- Promotion of integrated crop, forest, livestock and fisheries development.

Theme 3: Animal health

- Enhancing 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 plant and ethno veterinary 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 & skin processing techniques for product diversification.

Natural Resource Management and Climate Change Thematic Area

The relationship between agriculture, the environment, and natural resources is complex because of a meager resource base, fragile geographical ecosystems, sub-optimal technological capabilities, and limited knowledge of their inter-relationships. Problems such as deforestation, nutrient mining, soil erosion and land degradation, eutrophication of surface water, increased encroachment of marginal lands for cropping, degradation of range and pasture lands and reduced level of agro-biodiversity are directly related to increased pressure on land and water. There is need to maintain long-term balance between sustainable agriculture, natural resources, and ecological security which is possible through continuous research and development in those sectors (see Annex 9 for a full list). NARC also needs to further refine its policy on conservation of agro-biodiversity and agricultural genetic resources through *in-situ* and *ex-situ* conservation strategies.

NARC can play a major role in climate change forum by developing resilience agricultural technologies to adapt and mitigate the climate change effects in agricultural sector as it has varied types of climatic zones from tropical to alpine range. The technologies will be developed for all of the sub-sectors, prioritized and integrated among crops, livestock and fisheries. Decision support tools will be used to integrate different sub-sectors/ commodities/ system with climate change scenario to assist planning and decision making for different stakeholders and policy makers. Following are some of the actions that NARC will be undertaking for natural resource management and mitigate climate change effects:

Theme 1: Natural resource management

- Develop land capability classification and crop suitability mapping for various crops
- Develop conservation tillage practices to maintain soil health and improve water retention.
- Identification and promotion of biological nitrogen fixing (BNF) species to maintain soil fertility in agro-forestry systems.
- Development of Sloping Agricultural Land Technology (SALT) approaches 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: Mitigate climate change effects

- Estimation and development of mitigation measures of GHGs emission from agriculture and livestock.
- Estimation of carbon sequestration under various agricultural practices and development of appropriate mitigation measures of GHG emission.
- Identification, development and promotion of climate friendly agricultural technologies to adapt climate change and contribute to sustainable agriculture development while maintaining agro-ecosystems and agro-bio-diversity.
- Develop methodology for the different agricultural crops area and yield estimation before harvest to improve preparedness to any extreme situations.
- Increasing capacity within NARC and other partners through collaborative research and jointly explore the adaptation and mitigation options.

Biotechnology Thematic Area

Biotechnology has the potential to address problems not solved by conventional agricultural research. In addition, it may speed up research processes and increase research precision. Owing to the development of biotechnology in global scenario and richness of diversity in plant and animal genetic resources in Nepal, there is great potential to use biotechnology for increased food production and promoting sustainable agriculture.

Molecular markers are particularly useful for accelerating the breeding works with desirable traits. Diversity assessing, construction of linkage maps, gene tagging, and quantitative trait locus (QTL) mapping using DNA markers are the very important preliminary works for marker assisted selection and gene pyramiding in crops - rice, maize, wheat pigeon-pea, potato, buckwheat and livestock and fish.

The major areas of contribution of bio-technology research in obtaining the objectives of productivity increase, food security and poverty reduction include, but not limited to, the following two themes (see list of proposed interventions in Annex 10).

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.
- Characterize crop species/varieties at a molecular level for better utilization in breeding program.
- Increasing efforts in marker-assisted selection and developing diagnostic kits for breeders.
- Transforming technology, such as golden rice, to feed the poor while also supplementing vitamin A needs.
- Assessing the diversity of indigenous crops.

Theme 2: Improvement of livestock and fisheries

- Assessing the diversity of indigenous livestock and fisheries to generate information for breeders, gene banks, and policy makers.
- Developing and refining semen production technologies in livestock and fish.

- Characterizing and conservation of livestock and fish species at a molecular level.
- Applying molecular marker (DNA) in genome mapping for marker assisted selection in livestock and fish species.
- Inducing polyploidy and cloning in exotic and native aqua-culture fish species.
- Developing techniques for ova and embryo as well as other genetic materials production.

Outreach, Technology Dissemination and Extension Thematic Area

Outreach research is an interface between research and extension. Research institutions should generate refined research messages and test them at outreach research sites in farmers' fields. On-farm testing of technologies should be done by a strong multidisciplinary team of experts in the R/ARS and OR site with functional coordination maintained between NARC and service providers (DOA, DLS, and CBOs). Outreach activities should also be modified so that they are suited not only to crop and horticulture research but also to livestock and fisheries (see Annex 11 for a full list).

While NARC should concentrate on technology generation and verification; DOA, DLS, NGO/INGOs and CBOs should focus their priorities on technology promotion and dissemination with a new zeal to meet the present challenge of client demand. The following activities will be built in to strengthen the relationship between research and extension agencies and make technology dissemination effective:

Theme 1: Outreach research

- Programs development and implementation for outreach research sites with tripartite involvement of research (NARC), extension (DOA, and DLS) and end users at OR site.
- The researchable problems identified and reported by DOA and DLS and other partners in DATWG and RATWG workshops will be verified at OR site involving all concerned partners.
- A mandatory mechanism designed so that concerned higher authorities from research and extension monitor and evaluate on-going field activities in OR sites.

Theme 2: Technology dissemination

- Supply of source seed including livestock and fish and technical backstopping to private seed producers to ensure quality seed to end users.
- Built-in program to provide regular training to SMS and other extension personnel.
- Capacity enhancement of the DATWG and RATWG members and increase 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 maintenance of NARC website with regular updates.
- Develop mechanism to get feedbacks from concerned stakeholders.

5. Repositioning NARC to Address the Challenges

The context in which NARC and its partners work has changed dramatically since it set forth its vision in 2002. NARC 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.

Strategic Direction

The new vision, mission and strategy are guided by the need for NARC to play a central role in the national campaign on poverty alleviation through the development and utilization of scientific knowledge, technology and skills in agriculture and natural resources. NARCs responsibility is to develop a research system for agriculture and natural resources not only for safeguarding national food security, but also for the promotion of agriculture based industrialization, export promotion and sustainable livelihood improvement. Schematic presentation of NARC's strategic focus is given in Annex 5.

NARC's renewed strategic vision

NARC will provide leadership to the National Agricultural Research System in promoting commercial and competitive agriculture and natural resource sectors through innovative science, technology, and services.

NARC's renewed mission

NARC's mission is to contribute to a national campaign of increasing productivity, reducing poverty, and promoting commercialization and competitiveness of the agriculture and natural resource sectors through the generation and promotion of technology, knowledge, and information that respond to client demands and climate change.

Seven Guiding Principles for Agricultural Research

The new guiding principle for agricultural research is built on the currently existing status of knowledge and opportunities available nationally and globally. NARC will pursue the following key activity areas:

Providing leadership in agricultural research

Following its redefined role, NARC will provide effective leadership to agricultural research activities from policy creation through dissemination, and enhance the capacity of Nepal's research system to deliver results. NARC will accredit qualified research providers and coordinate agriculture research and development activities in both public sector institutions and private sector players—such as NGOs, agro-vets and traders (see figure 5).

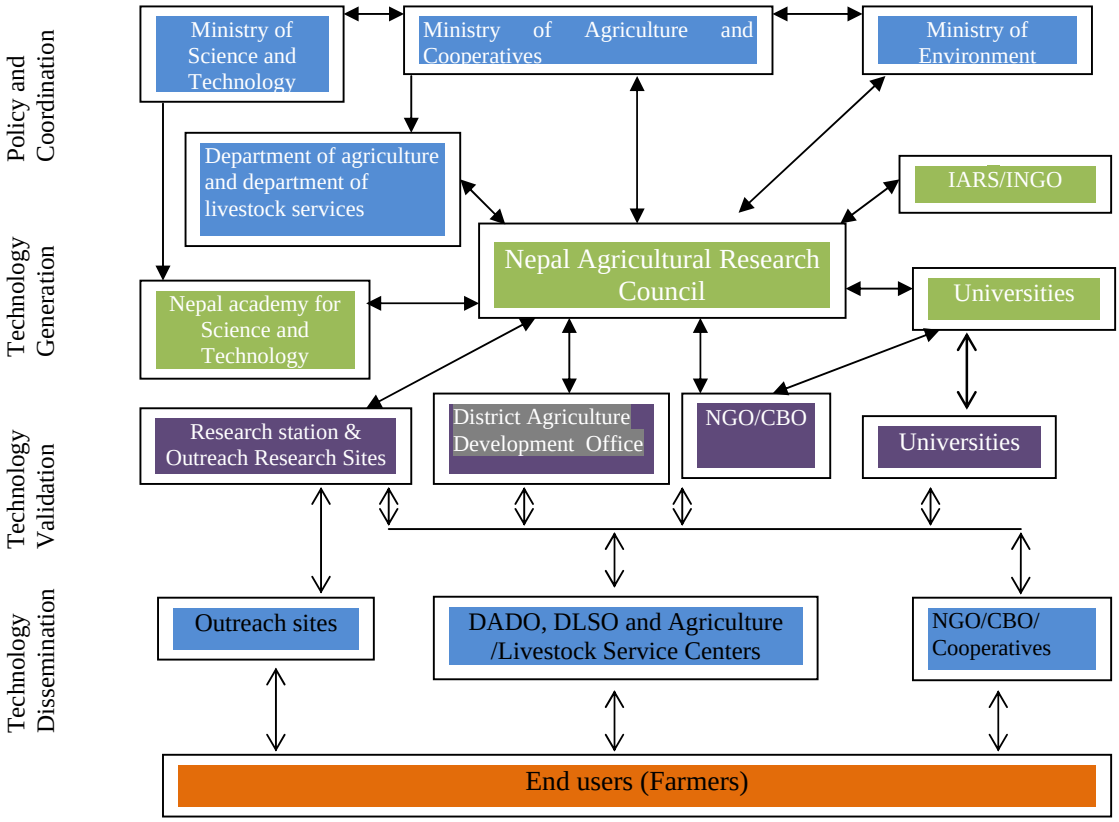
Building effective partnerships with national and international agencies

NARC will encourage scientific co-operation nationally and internationally, capitalizing on achievements made in neighboring countries and those available from regional organizations such as South Asian Association for Regional Cooperation Agriculture Center. NARC already works in

collaboration with many international research centers—such as, CIMMYT, IRRI, ICRISAT, IPGRI, ILRI, World Fish Center, etc.—and National Agriculture Research Systems in the region to develop relevant technologies for ensuring food security and reducing poverty.

At the national level, NARC has different research and development stakeholders—e.g., MOAC, Ministry of Environment (MOE) and Ministry of Science and Technology (MOST), academic institutions, universities, and the private sector (both national and international). In the process of technology generation, NARC works in coordination with the MOE to make sure that there are no regulatory violations or negative environmental impacts. New technologies are then validated in NARC outreach sites and NGO and university testing sites. They are further refined based on the feedback from farmers, and proven technologies are disseminated through the DOA, DLS, NGO/CBOs and partly through NARC outreach sites. Linkages have been established with IAAS, Rampur, NARDF and NGOs working in agricultural research and development.

Figure 4 Partnerships for agricultural research and technology



Achieving equitable distribution of research resources across agro-ecological regions

NARC will seek to balance research among the *terai*, hills, and mountain agro-ecological regions. *Terai* farmers are relatively better endowed with farm resources and access to markets, and therefore it is expected that relatively faster impacts can be achieved with new technologies there. However, most farmers are actually located in the mountains and hills, so NARC will increase its emphasis on developing technologies suitable for those regions in order to improve their livelihoods. Improved food security, higher incomes, and better employment opportunities in the hills and mountain communities may, in turn, stabilize migration into the *terai* region and urban areas.

Re-orienting staff to respond to client demand

NARC will ensure that the research and technology development system is responsive to the diverse needs of the Nepali farmers, who work in diverse agro-ecological, resource endowment, and farming systems. Client demand will be the cornerstone of future technologies—a major departure from past practice where new technologies were poorly adapted to local conditions. NARC will capitalize on the ever-changing indigenous technology and knowledge that comes from farmers, agro-veterinarians, and others in agriculture-related economic activities.

Promoting competitive agriculture

To take advantage of globalization and WTO membership, Nepal needs to be competitive both in national and international markets. The country continues to face challenges on the technical standard of exportable agricultural products. While resource productivity constrains production, fertilizer and pesticide residues constraint access to export markets. NARC will work with the Government of Nepal to develop policies, strategies, and plans by providing periodic analysis of WTO related issues. NARC will strive to overcome these constraints and develop good agricultural practices to enhance Nepal's competitiveness in international markets..

Promoting adaptability to climate change

Nepal is already witnessing significant climate-induced variations in production conditions, and GON is keen to address this issue head-on in order to ensure food security, reduce the vulnerability of its agriculture sector, and protect and sustain its natural resource base. GON expects NARC to spearhead this process, and NARC's renewed vision reflects this role.

Towards this end, NARC has identified a number of short-term adaptation measures needed to reduce vulnerability:

- identifying and developing crop varieties, livestock and fish species that are tolerant to stress conditions and locally-emerging pests and diseases;
- supplying farmers with the new crop varieties, livestock and fish species; and
- demonstrating appropriate farming practices to reduce vulnerability and maximize returns from new agricultural technologies.

Providing accountability and delivery of results

NARC will promote transparency by developing appropriate formats and guidelines for priority setting, program development and budgeting, and program monitoring. NARC will also monitor participating institutes to assess their effectiveness and overall impact.

NARC will have overall authority and responsibility to streamline research in crops, horticulture, livestock, fisheries, socio-economic development of agrarian society, and natural resource management. To do so, it will form an internal team of professionals accountable for delivering results, regardless of whether the research is conducted with core, donor-assisted, or private sector funds. A strong reward and sanction system will be developed and implemented in this respect.

6. Critical Path to Achieve Nepal's Agriculture, Food, and Nutritional Goals

This section outlines a new vision for agricultural research for development to address the pressing problems of food security, production, and competitiveness. Achieving this vision will take commitment and action on the part of all stakeholders to Nepal's agriculture. The actions outlined in this section detail critical steps that must be taken by the Government, NARC, and by donors to move closer to the vision of a food secure and prosperous country.

Reforms Needed for NARC to Fulfill its Mandate

Match government funding to priorities, at least for core costs

Most research outputs, especially those not geared to major cash crops, are essentially public goods that rely on public funds. As public funds diminish, NARC has limited scope to cover even its overhead expenses. Government funding of NARC equals 0.16% of the AGDP, which is very low compared to other Asian countries. The TYIP and other government documents place agricultural research in the priority one (P-I) category, and the funding should match this prioritization. Funding should be increased to at least one percent (1%) of AGDP to cover core costs and allow for adequate program planning and sustainability.

Government funding should be transferred on a predictable schedule

NARC will be addressing the coordination issues that have led to poor performance of past R&D efforts, but another reason for poor performance is the uncertainty in the annual and quarterly budgets release. NARC needs to help NPC and MOF create a clear vision of research needs and priorities, and the Government needs to respond to this effort by releasing sufficient budget on time, at least three months in advance, so that planning for research programs can be done with confidence. The provision of a revolving fund[6] will help NARC to continue its research activities in case the release of regular budget is delayed due to unforeseen circumstances.

Reposition NARC within the government structure

NARC was made autonomous to accelerate research activities by removing many of the bureaucratic processes that take time. However, over the years NARC autonomy has resulted in isolation from mainstream government, which has limited the dissemination of NARC technology because it is detached from key institutions, such as DOA, DLS, and CBOs. The proposed restructuring will establish that necessary link public policymakers and with the technology dissemination system.

In the proposed restructuring, the Executive Director (ED) of NARC will become *ex-officio* Secretary (Research) in the Ministry of Agriculture and Cooperatives, as is done in India (based on the August 2007 recommendations of a high level panel). This arrangement will make NARC part and parcel of a government entity that can address the emerging issues of technology generation and address the grey area between technology generation and dissemination. Counter to previously held assumptions, it will actually speed decision-making on implementation of government policies and programs, and will enhance collaboration with government and donors. Annex 2 diagrams the proposed structure of NARC.

Reorganization of NARC to adapt to a changing environment

NARC's facilities, structures, and processes have remained essentially the same since it was founded in 1991, and its leadership fully recognizes the need to modernize and rationalize the research system it oversees. Given the changing circumstances of the country, NARC plans to re-organize its administrative structure, priority-setting processes, and research management. It will

[6] A fix amount of fund to be kept aside to be used in case regular fund is not received in time. This will be reimbursed as soon as regular fund is available.

also modernize its facilities and create the proper working environment and human resource policies to make the institution, and the system, both effective and sustainable.

Clarify the governance structure of NARC

The present structure of NARI, NASRI, the commodity program, and research stations and outreach sites will be retained; however, a clear line of command among them will be redrawn to help each of them perform their duties more efficiently. The administrative line of command between RARS and ARS will also be clearly drawn to avoid administrative confusion and delay while simultaneously reducing the administrative burden of the central office, which currently administers each individually. An internal task force will be created to complete detailed framework plan of operation within one year.

A clear line of command will be defined among the stations and centers and their staff, and any interference from outside of the line of command will not be tolerated. A strong monitoring division headed by a senior director will be established at NARC headquarters to follow up the activities/progress. The staffing of the NARC secretariat and institutions will be relatively small and efficient, with an adequate balance of policy analysis, research management, impact evaluation, and information technology.

Improve the prioritization and coordination of research programs and funds

Food security, employment generation, and poverty reduction will continue to be important guiding principles in the agricultural research agenda. Contrary to the past practice of thinly spreading scarce resources across different research activities, the future research agenda will be based strictly on selected priority commodities.

The area and level of research conducted by different NARC bodies (disciplinary divisions, commodity programs, RARS, and ARS) will be improved and maintained. Disciplinary research will be forward-looking to guide others in the system. There must be good coordination between commodity research programs and disciplinary divisions while developing project proposals. Inter-disciplinary research proposals will be encouraged in order to avoid duplication and to improve effective use of resources to attain a common objective. Arrangements will be made to integrate and manage existing ongoing projects, new NARC projects, externally-funded collaborative projects, and research and development activities with NGOs and other agencies.

The present Agricultural Technical Working Groups (ATWGs) at the district, regional, and national levels will be strengthened to ensure that the collaboration currently mandated actually happens. The MOAC will make sure that ATWGs meet regularly as outlined in the "Implementation Guidelines for Agricultural Technical Working Groups" (2008). Provisions will be made for NARC scientists to visit problem areas and provide technical guidance to subject matter specialists and other extension workers on a demand-driven basis. This will also help the scientists to gather feedback to further improve technologies.

While developing research proposals on sustainable livelihoods, especially of the rural poor, will be considered, research projects aimed at specific problems faced by poor and disadvantaged communities that aim to improve livelihoods with relative speed will be given special consideration. Arrangements will be made for local/regional needs based proposals to originate from local/regional stations through a participatory needs assessment and planning process. Priority will be accorded to the technologies that ensure:

- Quality food security;

- Employment/income generation;
- Poverty reduction and social inclusion;
- Value addition;
- Scale of production;
- Import substitution and export promotion;
- Natural resource and bio-diversity conservation;
- Cost effectiveness; and
- Consistency with national policies.

To make best use of limited skilled manpower, collaborative projects with DOA, DLS, IAAS, and universities will be encouraged. Funds are often available from international, and even from national agencies, to perform specific results-oriented research. To capture these funds NARC will develop a culture of excellence among its scientists and support staff. It should also leverage research funding—for instance, using its available land resources for seed multiplication. As agriculture commercialization gains momentum in Nepal, NARC expects the private sector to begin investing in research, so a partnership plan for private sector led research initiatives must be developed.

To better the strategic allocation of funds, NARC will adopt a competitive grant research scheme (CGRS) in keeping with the provisions made in the CGIAR system. The fund will constitute grants from the government, contributions from donor agencies and international collaborating organizations, grants and donations from individuals and trusts, internally generated levies and taxes, contributions from commodity boards and associations, and funds provided by industries and agro-entrepreneurs for technology generation in specific research areas of their interest. Necessary funds will be provided to partner research providers from CGRS for the implementation of identified basic and core researches.

Consolidate research centers, stations, and programs

More than 50 research stations scattered across Nepal are directly involved in agricultural technology generation and promotion, and they have duplicated efforts in the absence of proper coordination, which raises administrative costs and needlessly uses valuable operations funds. A detailed review may find that some of these stations and commodity programs that are physically near one another and performing similar technical work can be combined without reducing their efficiency. This will not limit the scope of establishing new research stations to exploit yet untapped natural resources and develop appropriate technology demanded by concerned stakeholders.

This reform is important to the country's decentralization agenda. The role of concerned research stations will explicitly be linked with the technological needs of the areas where the R/ARS are situated. Strong coordination between the national commodity programs and those of R/ARS will be maintained to streamline the research activities, develop understanding and avoid any duplication.

Modernize research facilities

Most of the office space and laboratory facilities that NARC has inherited are old and in need of massive renovation or repair. It is a basic premise that modern research cannot be done using out-dated equipment. Equipment must be updated and irrigation facilities developed before some priority research can get underway. Similarly, facilities at research stations must be updated

before valid research can be done. For instance, several location lack proper fencing making them subject to encroachment (by local people and wild and domestic animals) which renders technology tests invalid.

All commodity programs and research stations working on crops and horticulture should have at least soil testing, seed testing, pathology, and entomology laboratories. Similarly, programs and stations working on livestock development should have at least nutrition and veterinary labs, while those working on fish will have at least limnological (study of inland waters) and fish nutrition labs. Provisions will be made to provide sufficient supplies to run and maintain the laboratories to produce expected results.

Human resource development

NARC has no facilities for continuing education and training of its staff. International research and development organizations and donors have helped fill the gap by providing opportunities for some staff to pursue higher studies and access outside trainings, but these opportunities are limited. NARC's responsibilities are expanding and its staff is growing, and it would be more efficient to partner with a qualified university to manage the development and training of staff in the country.

NARC will conduct extensive training programs especially for professionals involved in agriculture development in the different departments of MOAC, other concerned ministries, non-governmental organizations, and private sector to instill in them the knowledge and skills on promoting and disseminating new ideas, innovations, and modifications to modern agricultural technology. NARC envisions having one Deemed University to be located at one of its sites to provide higher education and trainings, regularly.

Align staff to meet priority outputs

All NARC activities will be output-oriented and staffing of each station/program will be decided accordingly. NARC will create a task force to recommend a strict ratio of scientists, technical staff, and administrative staff that should be maintained. Scientists and technical staff will be fielded to specific stations/programs according to their expertise. NARC will also develop proper monitoring and evaluation system to measure staff performance in different locations and conditions. Performance will be judged at team level rather than the individual level, and a reward and sanction system will be put in place as performance incentive.

Improve cost efficiency and research effectiveness

NARC will make 4 or 5 of its stations "centers of excellence" that will produce the most appropriate and best quality technologies. These stations will mentor and provide technical know-how to other stations/centers. Considering the wide agro-ecological diversity across the regions of Nepal, a strong regional emphasis will be given to all research programs. NARC will design and publish criteria and guidelines to encourage research in priority areas and ensure efficiency and "good practices" in the R&D process.

Management decision-making with rigorous monitoring and evaluation

NARC will have a strong monitoring mechanism at the central and regional level to track the generation, adoption, and performance of the specific technologies. Indicators to track the

efficient use of resources; quantity, quality, and timeliness of inputs; service standards for processes; and appropriateness of outputs will be closely monitored and any weaknesses corrected at that appropriate level. The monitoring system will also ensure a reasonable balance between increased production, environmental management, regional balance, and social inclusion. NARC will design a detailed M&E plan that will clearly define the responsibility of M&E officers stationed in each of institute, station, and program.

A continuous, participatory and rigorous self-monitoring and evaluation system will be encouraged among the research providers. NARC and other research providers and collaborating institutions will undertake internal and external program review, the results of which will be circulated to relevant ministries, development partners, and key stakeholders.

An in-depth evaluation of outputs, outcomes, and impact will be carried out by an independent body every five years to assess the achievements of the research system. This will inform a review of the roles, responsibilities, scope, and organization of NARC. The findings will guide any modifications in structure, strategy and operational procedures of NARC to make agricultural research more effective and efficient to cater the technology needs of the day.

Coordination with the Government and Donors

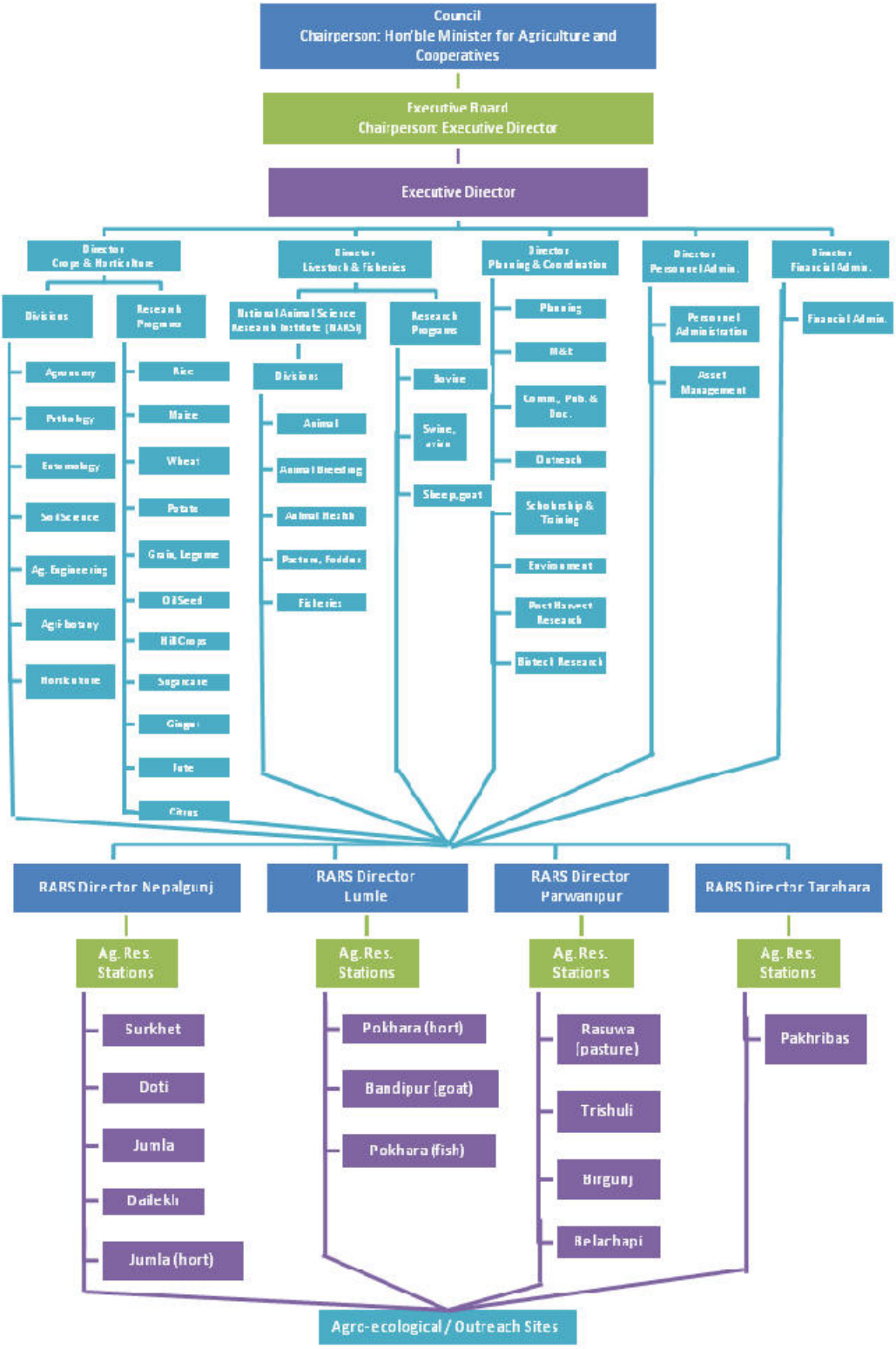
Donors should use the vision and follow-up action plans of NARC to define their assistance agenda for agricultural research and technology in Nepal. The reform plans of NARC and the government could be used as indicative milestones for donor engagement—i.e., if milestone X is achieved, donor A will fund improved laboratory facilities for crop research.

It will be important for donors to talk with GON, NARC, to coordinate their assistance and avoid duplication of efforts or needless competition, much along the lines of NARC's internal reforms. Given the great need for investment throughout the economy, it is critical to make the most efficient use of donor funds for agricultural research for development as possible.

Annex 1. Current Organizational Structure of NARC

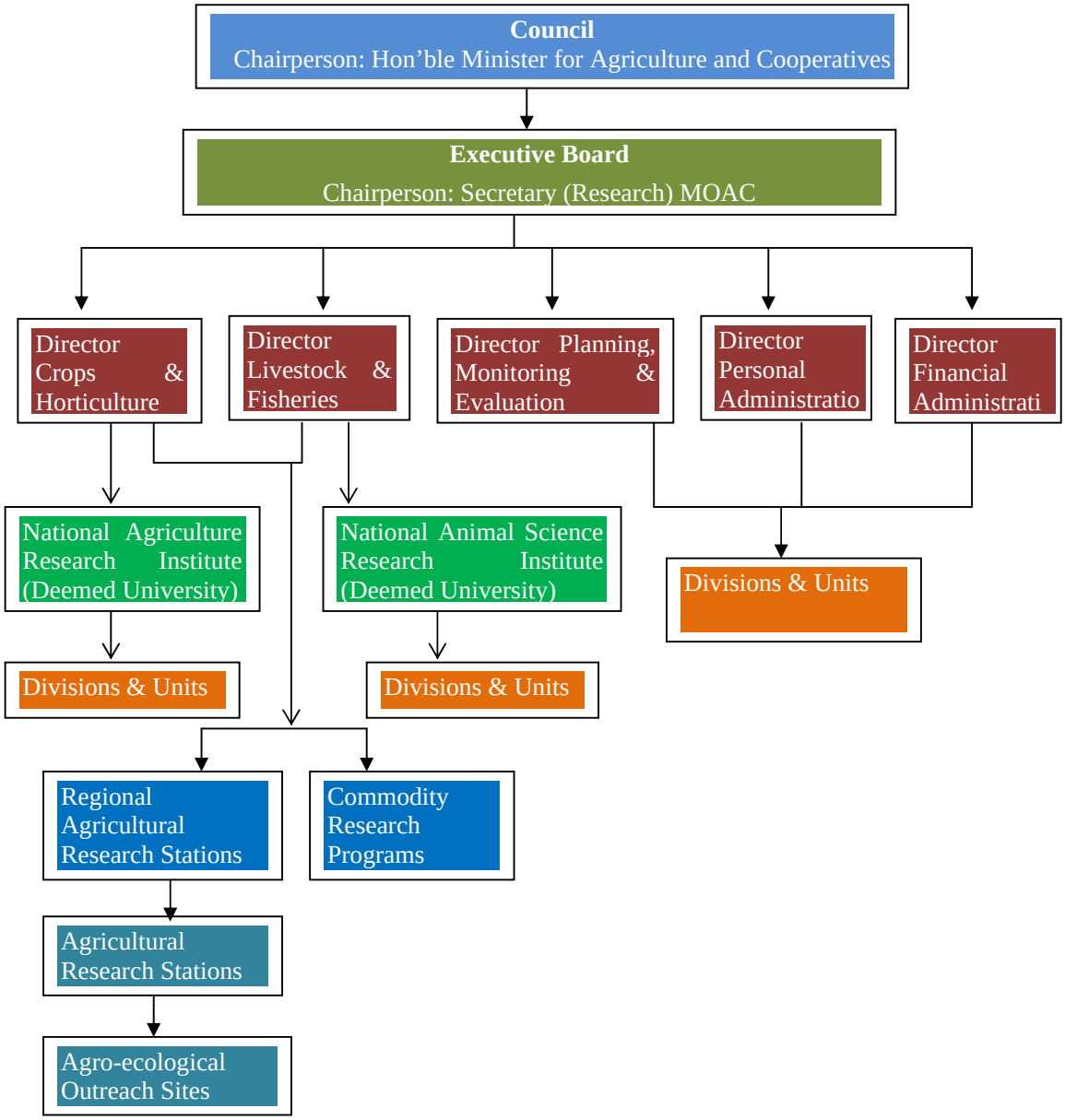
NARC has a two-tiered governing body: the Council and the Executive Board. The council is the apex body for policy level work on agricultural research. The sixteen member council is chaired by the Minister for Agriculture and Cooperatives. The Executive Director (ED) acts as the member secretary of the Council. The Council formulates policy with due consideration of the National Agricultural Policy and provides necessary directions to the Executive Board. An eight-member Executive Board, chaired by the Executive Director of NARC, implements and executes a research program approved by the Council. One of the program directors acts as member secretary of the Executive Board.

National Agricultural Research Institute (NARI), National Animal Science Research Institute (NASRI), commodity programs and Regional Agricultural Research Stations (RARS) work under supervision/control of NARC headquarters. NARI, NASRI, other disciplinary divisions, and cross-cutting divisions/units provide technical support to commodity programs, RARS, and Agricultural Research Stations (ARSs). Outreach sites are governed by concerned RARS or ARS.



Source: NARC 2008, Annual Report 2007/08, NARC, Kathmandu.

Annex 2. Proposed Organizational Structure of NARC



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

Annex 3. NARC's Existing Facilities and Human Resources

NARC headquarter is located at Singhdurbar Plaza adjacent to central secretariat of the government. NARI, NASRI, 12 disciplinary divisions, 6 cross cutting divisions/units and central level research facilities are located at Khumaltar and Fishery Research Division at Godavari in Lalipur district. There are 14 commodity programs, 4 RARS and 13 ARS located in the different part of the country representing different agro-ecological conditions. In addition each RARS and ARS has outreach research sites for technology testing in farmers' fields. NARC has been operating 12 central laboratories at NARI and NASRI complex at Khumaltar, Kathmandu. Similarly, soil, pathology, engineering, entomology, tissue culture, limnology, nutrition, seed testing, wet-lab and veterinary related laboratories are located in 15 of the NARC research sites (table 2).

Table 2 Types of Laboratories Under Different Research Stations of NARC

S.No.	Name of office	Lab Types
1	National Rice Research Program, Hardinath	Soil & Pathology
2	National Wheat Research Program, Bhairahawa	Soil & Pathology
3	Regional Agricultural Research Station, Nepalgunj	Soil
4	Regional Agricultural Research Station, Parwanipur	Soil
5	Agriculture Research Station (Agri-implement), Ranighat	Engineering
6	Agriculture Research Station, Belachapi, Dhanusa	
7	Regional Agricultural Research Station, Tarahara	Soil, Pathology, Entomology
8	National Citrus Research Program, Paripatle, Dhankuta	Tissue Column
9	Fishery Research Division, Godawari	Limnological (water quality), Fish Nutrition
10	Regional Agricultural Research Station, Lumle	Biotechnology, Soil, Pathology, Entomology, Seed Testing, Nutrition, & Veterinary
11	Agriculture Research Station (Fish), Begnas, Pokhara	Limnological (water quality), Fish Nutrition
12	Agriculture Research Station (Goat), Bandipur	Animal Nutrition & Vetrinary
13	Agriculture Research Station (Fish), Trishuli	Limnological (water quality), Fish Nutrition
14	ARS (Fish), Kaligandaki	Limnological (water quality), Fish Nutrition Lab, Wet Lab for Hatchery
15	Agriculture Research Station, Pakhribas	Soil, Pathology, Entomology, Seed Testing, Nutrition, & Veterinary
16		Animal Breeding & Genetics

S.No.	Name of office	Lab Types
	Central Lab, Khumaltar (There are a total of eleven central laboratories at NARI and NASRI Complex at Khumaltar)	Plant Pathology (Mushroom)
		Entomology
		Biotechnology
		Food Research
		Tissue Culture (Potato)
		Animal Nutrition
		Seed Testing
		Animal Health
		Dairy
		Soil
		Engineering

Source: From NARC records (unpublished)

NARC owns 1286.16 ha of land including office space and research farms out of which 318.81 ha is in the high-hills, 429.74 ha in mid-hills and 537.61 ha in the *terai* ecological regions (table 3). NARC has a total of 1280 staff out of which 177 are scientists, 292 technical officers, and 811 other staff, but these numbers represent only 70 percent of approved positions. Largest difference in approved and filled up position is in scientist staff (56% positions vacant). Twenty seven percent of approved position of technical officers and 20 percent of approved positions of other staff are vacant as shown in table 4.

Table 3 Total Land Area Under Different Research Stations of NARC

S. No.	Name of office	Area (ha.)	Ecological Region
1	National Rice Research Program, Hardinath	42.00	Terai
2	National Maize Research Program, Rampur	100.17	Terai
3	National Wheat Research Program, Bhairahawa	35.00	Terai
4	National Grain Legume Research Program, Rampur	14.10	Terai
5	National Oilseed Research Program, Nawalpur	36.00	Terai
6	Sugarcane Research Program, Jitpur, Bara	34.00	Terai
7	Jute Research Program, Itahari	22.00	Terai
8	Regional Agricultural Research Station, Nepalgunj	75.50	Terai
9	Regional Agricultural Research Station, Parwanipur	60.00	Terai
10	Agriculture Research Station (Agri-implement), Ranighat	2.14	Terai
11	Agriculture Research Station, Belachapi, Dhanusa	12.70	Terai
12	Regional Agricultural Research Station, Tarahara	104.00	Terai
	Total	537.61	
13	Hill Crops Research Program, Kavre	15.80	Mid-Hill
14	National Citrus Research Program, Paripatle, Dhankuta	20.00	Mid-Hill
15	Ginger Research Program, Salyan, Kapurkot	4.85	Mid-Hill
16	National Agriculture Research Institute, Khumaltar	24.80	Mid-Hill
17	National Animal Science Research Institute, Khumaltar	22.40	Mid-Hill

S. No.	Name of office	Area (ha.)	Ecological Region
18	Fishery Research Division, Godawari	6.50	Mid-Hill
19	Agriculture Research Station, Surkhet	38.50	Mid-Hill
20	Agriculture Research Station, Dailekh	11.92	Mid-Hill
21	Regional Agricultural Research Station, Lumle	66.00	Mid-Hill
22	Agriculture Research Station (Fish), Begnas, Pokhara	19.80	Mid-Hill
23	Agriculture Research Station (Horticulture), Malepatan, Pokhara	9.00	Mid-Hill
24	Agriculture Research Station (Goat), Bandipur	79.00	Mid-Hill
25	Agriculture Research Station (Fish), Trishuli	8.80	Mid-Hill
26	Agriculture Research Station, Pakhribas	92.37	Mid-Hill
27	Agriculture Research Station, Doti	10.00	Mid-Hill
	Total	429.74	
28	National Sheep & Goat Research Program, Guthichaur, Jumla	300.00	High-Hill
29	Agriculture Research Station, Bijayanagar, Jumla	2.16	High-Hill
30	Agriculture Research Station (Horticulture), Rajikot, Jumla	10.00	High-Hill
31	Agriculture Research Station (Pasture), Rasuwa	6.65	High-Hill
	Total	318.81	
	Grand Total	1286.16	

Source: From NARC records (unpublished)

Table 4 NARC's Human Resources

Division	HR Positions	Approved	Filled	Balance
Crop and horticulture	Scientists	262	121	141
	Technical officers	239	179	60
Livestock and fisheries	Scientists	84	35	49
	Technical officers	103	71	32
Cross-cutting divisions/ units	Scientists	60	21	39
	Technical officers	58	42	16
Total	Scientists	406	177	229
	Technical officers	400	292	108
	Other staff	1017	811	206

Source: NARC 2008, Annual Report 2007/08, NARC, Kathmandu.

Annex 4. Prominent Technologies Developed by NARC

<table>
<tr><td colspan="2">A: Crops and Horticulture</td></tr>
<tr><td>Crops</td><td>
Breeding and varietal development

Developed and released 126 improved varieties of different crops as part of a complete package of cultivation practices.
Genotypes of other crops identified as superior types and 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 chickpea and rajma bean.
Developed IP/WM and IPNM technologies

Farm equipment and resource conserving technology (RCT)

Developed technologies/practices like zero-till, minimum or reduced-tilling, surface seeding, bed-planting, and direct seeding.
Developed drum seeder technology for direct rice sowing.

Post harvest technologies

Developed techniques to control storage pests using botanicals.
Developed a hand and paddle operated corn sheller 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 agri-silvo pastoral system model—i.e. terrace riser based agro-forestry 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 (herb).

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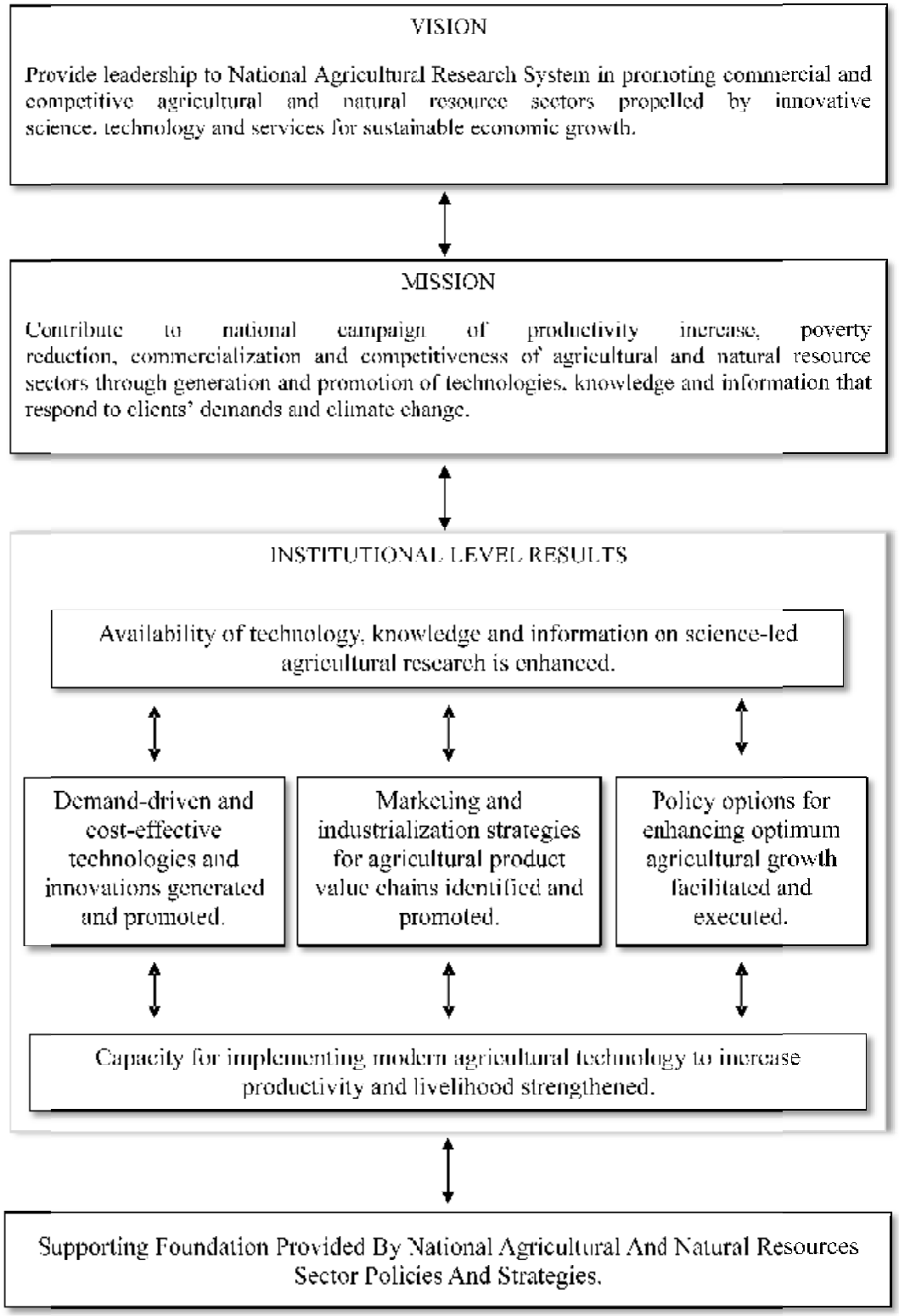
Horticulture	Breeding and varietal development • Developed a hybrid tomato variety. • Developed true potato seed (TPS) techniques and viral disease-free seed potato production using tissue culture techniques. • Identified blight tolerant potato genotypes and commenced testing in farmers' field. • Identified a late variety of sweet orange and early variety of mandarin orange. Crop management technique • Developed plastic house technologies for the production of off-season vegetables. • Developed an off-season onion production technology. • Identified a bio-control technique for diamond back moth in cabbage. • Developing an integrated technique to manage club root disease in vegetables. • Developed a culturing technique for *gynoderma* (red mushroom). Others • Standardized a grafting technology for tomato 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 to 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 of pig and poultry • Developed technology for buffalo fattening. • Documented nutritive value of few indigenous pasture and fodder species. Others • Studied and documented the diversity of native cattle, buffalo, sheep, goat and poultry. • Developed control techniques for Khari disease of buffalo.

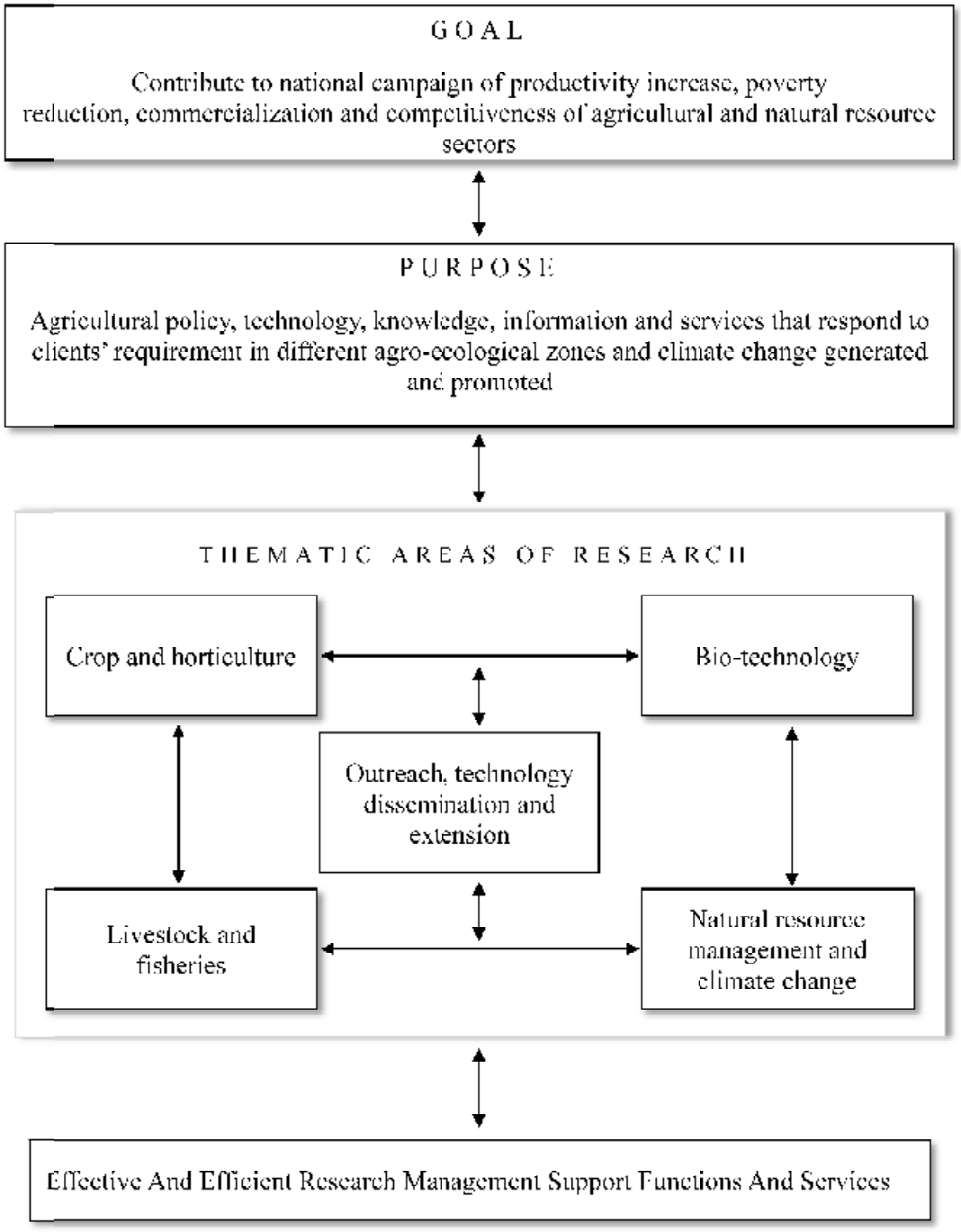
Fisheries	Breeding and improvement • Standardized breeding technology for rainbow trout. • Substantial achievements gained in breeding and rearing *Sahar* fish. • Developed breeding techniques for aquarium fish. • Developed farming technology for Tilapia and African cat-fish and its hybrid. Feed and 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. • Substantial achievements gained in feed formulation techniques for *Sahar* fish. • Developed a technological package for fancy carp.

Source: NARC records

Annex 5. Schematic Representation of NARC's Vision



Annex 6. Schematic Arrangement of Thematic Areas of Research



Annex 7. Interventions Proposed for Crops and Horticulture

Commodities	Intervention areas	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 need of each domain.	
	Developing the technologies in early and full season OPV maize genotypes for enhancing maize productivity in hills and terai	CIMMYT, DOA, NGOs
	Strengthen the screening QPM maize genotypes against major disease, insect and abiotic stresses.	
	Development of hybrid maize technology to enhance maize productivity in subtropical region of Nepal	
	Development of high yielding wheat varieties for improving wheat productivity and sustainability in terai, inner terai and foot hills of Nepal	CIMMYT, DOA, NGOs
	Development of high yielding wheat varieties for improving wheat productivity and sustainability in hills of Nepal	
	Development of high yielding fingermillet, 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
Agronomic interventions /crop management	Develop proper nutrient and water management technologies for boro, spring and main season aerobic and transplanted rice	IRRI, CIMMYT, DOA, NGOs, Universities
	Develop proper moisture conservation technologies both for upland and lowland rainfed cropping systems.	
	Develop integrated crop management, including IP/WM practices for major diseases and insect pests for rice, wheat and maize.	
	Develop integrated nutrient, moisture and pest management technologies for fingermillet, barley, buckwheat, legumes, oilseeds and hill crops.	
	Develop profitable and sustainable integrated crop management and cropping system for different agro-eco systems to mitigate negative effect of climate change.	
Marketing, value	Increasing the livelihood of maize farming communities of	CIMMYT, DOA,

Commodities	Intervention areas	Potential Collaborators
chain and policy	Nepal through promotion of quality protein maize	NGOs
	Determine pesticide residue level of fruits, fresh vegetable and exportable agricultural commodities to avail quality agricultural product for domestic consumers and International trade	
Others	Strengthen 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
	Develop suitable technology for quality seed production and management.	
B: Horticultural and commercial crops		
Breeding and improvement	Develop new varieties of fruits (citrus, apple, mango) and vegetables (tomato, cauliflower, cabbage, beans, cucumber, chilli) through conventional and modern breeding technique to address climate change and food crisis.	AVRDC, FAO, IDE
	Promotion of sustainable eco-friendly technology in horticulture crops	
	Improving and strengthening tea sector by development of Nepalese tea varieties suitable to different production environments	
	Development and dissemination of improved cardamom cultivation technology in the hills of Nepal.	
Agronomic interventions /crop management	Develop new cultivation package of practice with judicious use or non-use of chemicals	
	Develop proper technology for low cost, water saving and resistant to draught and pests.	
	Identify appropriate harvesting time, develop proper drying technology and storage practices for large cardamom	
	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 post harvest loss of horticultural commodities	
	Study national and international markets for tea and cardamom including quality demanded by the markets.	
	Review the governments export policies and suggest appropriate actions.	
	Commercialization of floriculture for income generation	
Others	Conservation of local horticulture biodiversity through improvement and utilization in WTO context	
	Development of cost effective methods of plucking, manuring, weeding and irrigation method in tea cultivation.	
	Develop 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,

Commodities	Intervention areas	Potential Collaborators
Agronomic intervention/crop management	Develop cost effective crop management package of practices based on organic cultivation principles.	HELVETAS and GTZ
	Develop appropriate technologies for soil, water and pest management practices.	
Marketing, value chain & policy	Development and up scaling of drying, processing and value addition techniques for improved income level of stakeholders.	
Others	Develop suitable technology for quality seed production and management.	

Annex 8. Interventions Proposed for Livestock and Fisheries

Commodities	Intervention areas	Potential Collaborators
A. Bovine		
Breeding and improvement	Dairy Animal Genetic Improvement	DLS, ILRI, ICAR
	Enhancing productivity of yak and Chauries through improving breeding, feeding, health and management	DLS, ICAR ICIMOD, YRS (Tibet, Arunchal)
	Integrated bovine infertility management	DLS, IAAS, HICAST
Feed and feeding management	Development of round the year 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, HICAST
Health and nutrition	Nutritional intervention for enhancing dairy animal productivity and reduction of green house gasses	DLS, ILRI, ICAR
	Herd health program for enhancing dairy animal productivity	DLS, DMPCU, IAAS, NGOs, CBOs
Others	Value addition on milk and meat products	DFQT
B: Sheep and Goats		
Breeding and improvement	Carpet wool sheep breed development	NZ, FAO, ILRI, DLS
	Enhancing the productivity of goats by developing technologies through selection and cross breeding for meat, fiber and milk (goat cheese) production in different agro ecological zones	DLS, ABD
	Development of technology for AI in goat and sheep	HEIFER International
Feed and feeding management	Development of nutritional packages for stall feeding of goats	DLS
	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 Programme for enhancing sheep and goat productivity in different ecological zone	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	Development and Scaling up of Productive Black Pigs	HEIFER

Commodities	Intervention areas	Potential Collaborators
improvement	Development of technology for AI in pigs	International, DLS
	Development of wild X domestic cross pig for value addition	DOF
Health and nutrition	Enhancing 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 farmer's pig herd through scaling up of generated technologies	DLS, NGO's and INGO's
D. Poultry		
Breeding and improvement	Development of suitable backyard poultry breeds	DLS
Feed and feeding Management	Improvement of non conventional feedstuff available in farmer's field	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 agro-ecological zones of Nepal	ILRI
Others	Development of suitable rabbit fiber, meat & skin processing techniques for product diversification	ILRI
F. Cross-cutting		
Breeding and improvement	Sustainable utilization and conservation of domestic AnGR of Nepal	DAP, ILRI, CAAS
	Establishment of gene bank for germplasms and microorganisms	DLS, TU, IAAS, HICAST
Feed and feeding management	Nutrients fortification in mechanically compressed feed block	NDRI, ILRI, DLS, IAAS
	Evaluation of forage crops for varietal selection, improvement and development	DLSO, PFR-Newzealand, IGFRI, India
	Strengthening source seeds production of different forage and pasture crops and supply through community-based approach.	DLS, CBOs
	Photographic catalogue documentation and production performance of promising native forages in terai, mid hill and high hill regions of Nepal	DLS, DOAs, Godawari BotanicalGarden
	Exploration and identification of native and exotic cereal and tuber fodder crops for both grain and fodder production for high hill regions.	DLS, DOAs, Godawari BotanicalGarden
Health and nutrition	Study on quality aspects of dairy, meat, eggs, and fiber production and product diversification.	ILRI, ICAR, Universities, DLS, IAAS, HICAST
	Poisonous plant and ethno veterinary medicine	
G. Aquaculture and fisheries		
Breeding and improvement	Enhancing fish productivity through increasing fish species diversity in warm water aquaculture of Terai	DoA, IAAS, WFC, NGOs, WB, ADB,

Commodities	Intervention areas	Potential Collaborators
		NTNU
	Enhancing productivity of carps and trout through breed improvement	DoA, IAAS, Private hatcheries FAO, JICA
	Productivity improvement of integrated fish farming in ponds and rice fields	DoA, IAAS, NGOs
	Improving production of ornamental fish through developing technological package for import substitution	DIFD, DoFD, NGOs, CBOs, Traders
Feed and feeding management	Improving productivity of carp and trout through developing appropriate feeds and feeding management	FTQC, Fish producers' association, CBOs, FAO, JICA, USAID, DFID
Others	Enhancing productivity and scaling up of cage fish farming in lakes and reservoir 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
	Scaling-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
	Enhancing natural fish yield by integrating program with hydro power facilities	NEC

Annex 9. Interventions Proposed for Natural Resource Management and Climate Change

	Intervention areas	Potential Collaborators
A. Natural Resource Management		
Sustainable Soil Management at Midhills underneath Change Climatic Circumstances	Develop land capability classification and crop suitability mapping for various crops	ICIMOD, IBSRAM and other relevant International Research Institutes
	Conservation tillage to maintain a cover on the soil surface of residues (mulching) or vegetation that helps retain soil and water.	
	Nitrogen-fixing herb, shrub and tree species used to maintain soil fertility in agro-forestry systems.	
	Development of Sloping Agricultural Land Technology (SALT) approaches to create a living barrier to sediments and gradually transform the sloping lands to terraced land.	
	Green Manure/Cover Crops/Mulching to improve or restore fertility and soil texture.	
	Effective Microorganisms (EM) Technology and EM Composting to improve the soil quality and health.	
	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 NGO and ICIMOD
	Study of hydrological process, their control and linkages on the watershed and downstream resources.	
	Development of the hydrological, land use, cropping system, soil loss, and water management models	
	Integrated Land and Water Management practices in participatory approach at the Terai-Siwalik Interface	
B: Mitigate Climate Change Effect		
Monitoring of GHGs emission and carbon sequestration	Estimation of GHGs emission from agriculture and livestock sector.	IRRI, CIMMYT, DOHM, ICIMOD, IAAS, NAST, ICRISAT, ICARDA, APARI
	Development of mitigation measures of GHGs emission 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 agro-meteorological data, and soil and crop cultivation/production data	IRRI, CIMMYT, ICIMOD, IAAS, NAST, ICRISAT, ICARDA, APARI
	Simulation of climate variability scenario for agricultural crop production	
	Development of Climate friendly agricultural technologies to adapt climate change	
	Production of teaching materials and conduct trainings different stakeholders on climate change impact on	

	Intervention areas	Potential Collaborators
	agriculture.	
Crop inventory and yield estimation through remote sensing and GIS	Prepare maps of spatial area distribution of different agricultural crops	ICIMOD, ICAR, World Bank
	Develop methodology for the different agricultural crops area and yield estimation before harvest to improve preparedness to any extreme situations.	

Annex 10: Interventions proposed for Biotechnology Research

Intervention areas	Potential Collaborators
Marker Assisted Selection (MAS) in crop improvement for resistance to biotic and abiotic stresses including the followings: • Screening of cereals' lines at phenotypic and molecular level • Identification of beneficial QTL resistance to rice blast disease • Genotyping of susceptible and resistance rice varieties using SSR primers linked to blast resistant gene • Developing near isogenic lines of rice, wheat and tomato • Crossing and use of molecular markers detecting the desired resistant trait	IRRI, CIMMYT, IPGRI, ICAR, ICGEB, USDA, Bioversity International, USAID, European Commission, GEF, NAST, IAAS, CEAPRED, and NGOs
Application of molecular markers towards the improvement of maize varieties for hybrid vigor	CIMMYT, IAAS, HICAST, IPGRI, SAARC, ICAR, NAST
Molecular Markers in the study of genetic diversity of important crop and livestock and fisheries of Nepal	IRRI, CIMMYT, ICRISAT, IPGRI, WHO, ICAR, ICGEB, USDA, Korea, Bioversity International, USAID, European Commission, GEF, NAST, CEAPRED, and NGOs
Characterization and DNA finger printing of under-utilized but value added and native species of crop and livestock	ICRISAT, ICARDA, CIMMYT, IPGRI, FAO, ICAR, ICGEB, USDA, Bioversity International, USAID, European Commission, GEF, NAST, CEAPRED, and NGOs
Haploid breeding for inducing homozygous lines in different crops in short period of time	IRRI, CIMMYT, ICRISAT, IPGRI, WHO, ICAR, ICGEB, USDA, Bioversity International, USAID, European Commission, GEF, NAST, CEAPRED, and NGOs
Distant hybridization programme 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 equipments.	IRRI, CIMMYT, ICRISAT, ICARDA, ICAR, FAO, WHO, ICGEB, USDA, Bioversity International, USAID, European Commission, GEF

Annex 11. Interventions Proposed for Outreach, Technology Dissemination, and Extension

	Intervention areas	**Potential Collaborators**
Outreach research	Multidisciplinary team of experts to address pertinent on-farm research issues	CGIAR, ICAR, IAAS, DOA, DLS, DADO, DLSO, CBO.
	Functional coordination between research (NARC) and service providers (DoA, DLS and CBOs)	
	Participatory research for micro-climate specific technologies generation and verification	
Technology Dissemination	Mandatory inbuilt program to take technologies from NARC and disseminate them by service providers	DOA, DLS, DADO, DLSO, CBO.
	Two way feedbacks between researchers and service providers on technology availability, utilization and effectiveness to end users and vice versa	
	Effective liaison among researchers, extensionists and end users	
	Effective use of modern electronic media for the dissemination of the technologies.	
Others	Natural resources, environment, agri-business and trade related policy research	CGIAR, ICAR, IAAS, DOA, DLS, CBO.
	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	