# Implementing the International Treaty on Plant Genetic Resources for Food and Agriculture in Nepal: Achievements and Challenges

2016

**Editors:** Bal Krishna Joshi, Pashupati Chaudhary, Deepak Upadhya and Ronnie Vernooy

LI-BIRD NARC MoAD Bioversity International

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LI-BIRD

NARC

MoAD

Bioversity International

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**LI-BIRD (Pokhara, Nepal; http://www.libird.org)**
Local Initiatives for Biodiversity, Research and Development (LI-BIRD) is a non-profit, non-governmental organization established in 1995 to reduce poverty and promote social justice by empowering rural poor and marginalized smallholder farmers, especially women, who depend primarily on agriculture, biodiversity, and natural resources for their livelihoods. To achieve these goals, LI-BIRD is committed to capitalizing on local initiatives, synergy, and partnerships for sustainable management of renewable natural resources. Through development-oriented research in agriculture and natural resource management, LI-BIRD contributes to several innovative methods and approaches, aiming to achieve a positive impact on the livelihoods of rural poor and marginalized farmers through appropriate technological, social, and policy changes. LI-BIRD plays an instrumental role in institutionalizing these approaches in national systems.

**NARC (Singhadarbar Plaza, Kathmandu, Nepal; http://narc.gov.np)**
The Nepal Agricultural Research Council (NARC), established in 1991 as an autonomous organization,is an apex body for agricultural research in Nepal. It includes many commodity programs, research stations located across the country, and disciplinary divisions as well as a national gene bank in Khumaltar. NARC carries out research on various aspects of agriculture, identifies solutions to existing problems in agriculture,and assists the government in formulating agricultural policies and strategies.

**MoAD (Singhadarbar, Kathmandu, Nepal; http://www.moad.gov.np)**
The Ministry of Agricultural Development (MoAD) is the central body of the Government of Nepal responsible for agriculture and allied fields. The ministry consists of five divisions, two centres, one research and development fund, two departments, five projects, and autonomous bodies, consisting of a research council, a corporation, two development boards, two companies, and several development committees. The Honorable Minister for Agricultural Development is in charge of the ministry; the secretary is the administrative head and chief advisor to the minister on policy, planning, and administration.

**Bioversity International (Rome, Italy; https://www.bioversityinternational.org)**
Bioversity International is a member of the CGIAR consortium. Its vision is that agricultural biodiversity nourishes people and sustains the planet. Bioversity International produces scientific evidence and develops management practices and policy options to safeguard agricultural and tree biodiversity and attain sustainable global food and nutrition security.

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# Contents

# Foreword

Food insecurity, hunger, and malnutrition are an everyday reality in many parts of the world, particularly in underdeveloped and developing countries. Countries with poor biological diversity and those relying heavily on other countries for food are highly vulnerable to these challenges. Although some farmers maintain rich agricultural diversity, others are losing diversity at a rapid rate, often irreversibly. Climate change is further contributing to biodiversity loss, exacerbating food insecurity and climate vulnerability, and ultimately increasing the interdependence of farmers.

Nepal is rich in agr obiodiversity owing to its diverse geography, climatic zones, ecosystems, and agro-ecology. The country has preserved 2275 accessions of 10 ITPGRFA Annex I crops in its national gene bank and deposited more than 23600 accessions in international and national gene banks, allowing others to use these genetic materials. However, diversity is becoming eroded, thus limiting the choices of food, nutrition, and breeding materials. Although Nepal already depends heavily on other countries for the genetic materials it needs to develop new varieties, continuous genetic erosion will further increase the dependence of farmers on resources from other farmers, both within and outside the country.

An effort is needed to analyze the interdependence of Nepal with other countries, identify sources of plant genetic resources both on-farm and in the public domain, and develop policies and laws to increase farmers' access to those materials. It is timely that Nepal has signed the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), which facilitates the exchange of crop genetic resources under a multilateral system (MLS) of access and benefit-sharing. As a signatory, the country must fulfill a number of obligations.

The Ministry of Agricultural Development (MoAD), the Nepal Agricultural Research Council (NARC), Local Initiatives for Biodiversity, Research and Development (LI-BIRD) jointly implemented the project Genetic Resources Policy Initiative (GRPI) between 2003 and 2007 with the support of Bioversity International. A second phase of this project was carried out between 2012 and 2016, and the GRPI 2 project team has done painstaking work to accomplish the planned activities and document results. This book is a testimony to their toil.

We thank all the members of the project team for their hard work and the strong team spirit they demonstrated. This is a shining example of how government and non-government institutions can work together to produce high-quality outputs. We are also grateful to the steering committee members for their cooperation, timely decision-making, and guidance throughout the project period.

NARC, in particular the National Agriculture Genetic Resources Centre (also known as the national gene bank), and LI-BIRD management team members and support staff also deserve special mention for providing management and logistic support. Last, but not the least, we would like to express our gratitude to the farmers who collaborated and who provided invaluable information to the project team; without their support the project would not have achieved its goals.

We are happy to be a part of this initiative and believe it is a great contribution to the nation, mainly in the field of agrobiodiversity conservation and policy reform aimed at improving food security, reducing hunger, and enhancing community resilience to climate change. We believe this book will be read widely and used as a valuable reference in the field of agrobiodiversity conservation, use, management, and exchange, both within the country and outside.

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# Preface

Humanity is facing the interconnected challenges of food security, climate change and the loss of agricultural biodiversity of global and economic significance. Over one billion people are suffering from chronic hunger and undernourished. At the same time, the world population continues to grow and climate change is causing new pressures and challenges on food production. The availability of a broad genetic base of agricultural crop varieties - a diversity of which 75 per cent has already been lost forever, is most crucial to breeding new crop varieties that achieve higher yields with nutrition quality and are adaptable to new climate pressures.

The International Treaty on Plant Genetic Resources for Food and Agriculture, which entered into force in 2004, in harmony with the Convention on Biological Diversity, provides a legally binding international framework for the conservation and sustainable use of plant genetic resources for food and agriculture. It gives guidance on measures at the national level, on Farmers' Rights, on a Multilateral System facilitating access to crop genetic resources and on a benefit-sharing mechanisms supporting initiatives for the conservation and sustainable use of crop diversity in developing countries.

Nepal's ratification of the International Treaty and as a Contracting Party since 2009 demonstrates to the world the Government's commitment to management and governance of plant genetic resources for food and agriculture. It represents the Government's commitment to contribute to improving human livelihoods, food security and nutrition, preventing hunger and conserving the country's richness of plant genetic diversity.

This book "Implementing ITPGRFA in Nepal: Achievements and Challenges" is one of the most relevant, informative and timely publications. It is a stocktaking of the work on biodiversity and genetic resources carried out in cooperation with farming communities, community seed banks, and all other stakeholders at local and national levels including international experts. I believe this publication will be an important reference for the country's development of policies and tools for the conservation and sustainable use of biodiversity and plant genetic resources for food and agriculture.

Shakeel T. Bhatti, PhD
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# Acknowledgements

The Genetic Resources Policy Initiative (GRPI), which inspired this book, was funded by the Dutch government through the Directorate-General for International Cooperation, Ministry of Foreign Affairs. The CGIAR Research Programme on Climate Change, Agriculture and Food Security provided technical support during implementation of project activities in Nepal. Phase 2 of the GRPI project was implemented and managed through a multi-stakeholder governance structure in which key stakeholders and leaders in development and research into plant genetic resources (PGRs) for food and agriculture were represented.

Led by experts from the Nepal Agricultural Research Council (NARC), the Ministry of Agricultural Development (MoAD), and Local Initiatives for Biodiversity, Research and Development (LI-BIRD), the project was implemented by developing a two-tier structure consisting of a National Steering Committee chaired by the ITPGRFA focal point (MoAD) and a Project Management Committee, coordinated by the chief of the National Agriculture Genetic Resources Centre. The ITPGRFA focal point also acted as national project director and chaired the National Steering Committee, which included decision-makers from NARC, MoAD, the Department of Agriculture, LI-BIRD, the Convention on Biological Diversity focal point from the Ministry of Forest and Soil Conservation, a representative of civil society organizations, and farmer organizations from the hills (Kaski) and plains (Bara) regions. Many relevant stakeholders were included and/or invited to meetings, workshops, and field visits and were interviewed for various purposes during the project implementation process.

We are very thankful to all farming communities, community seed banks, all other stakeholders, and national and international experts for their contributions to making the project a success. This book could not have been realized without the insightful contributions of all the chapter authors. All the exciting findings would not exist without the incredibly dedicated team that always kept things on track: Michael Halewood and other colleagues of the Policy Unit at Bioversity International; Hari Dahal, Udaya Chandra Thakur, Ramita Manandhar, Deepak M. Pokhrel, Prabhakar Pathak, Jay Mukunda Khanal, and Uttam Kumar Bhattarai from MoAD; and Prem Mathur and Sarika Mittra from the office of Bioversity International in India. We thank Sandra Garland for her exceptional editing work.

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# Acronyms and Abbreviations

| | |
|---|---|
| ABD | Agriculture Botany Division |
| ABS | access and benefit-sharing |
| ACIAR | Australian Centre for International Agricultural Research |
| AD | Agronomy Division |
| ADCS | Agriculture Development and Conservation Society |
| AFU | Agriculture and Forestry University |
| AIC | Agriculture Inputs Company |
| ANSWER | Asia Network on Sweet Potato Genetic Resources |
| APGR | agricultural plant genetic resources |
| APP | Agriculture Perspective Plan |
| AVRDC | Asian Vegetable Research and Development Center |
| BC | Before Christ |
| BCDC | Biodiversity Conservation and Development Centres |
| BS | Bikram Sambat (Nepali date) |
| BTD | Bio-Technology Division |
| CAT | Climate Analogues tool |
| CBD | Convention on Biological Diversity |
| CBM | Community-based Biodiversity Management |
| CBS | Central Bureau of Statistics |
| CBSP | community-based seed producer |
| CDD | Crop Development Directorate |
| CEAPRED | Center for Environmental and Agricultural Policy Research, Extension and Development |
| CG | Consultative Group |
| CGIAR | Consultative Group on International Agricultural Research |
| CGRFA | Commission on Genetic Resources for Food and Agriculture |
| CIMMYT | International Maize and Wheat Improvement Center |
| CIP | International Potato Centre |
| CLS | Centre for Legal Services |
| COP | Conference of Parties |
| CPRI | International Plant Genetic Resources Institute |
| CSB | community seed banks |
| CTEVT | Council for Technical Education and Vocational Training |
| DADO | District Agriculture Development Office |
| DAO | District Administration Office |
| DoA | Department of Agriculture |
| DUS | distinct, uniform and stable |
| EGPs | Eastern Gangetic Plains |
| EPA | Environment Protection Act |
| EURISCO | European Plant Genetic Resources Search Catalogue |

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|---|---|
| FAO | Food and Agriculture Organization |
| FDI | foreign direct investment |
| GDP | Gross Domestic Product |
| GIS | Geographic Information System |
| GLRP | Grain Legume Research Program |
| GoN | Government of Nepal |
| GPS | Global Positioning System |
| GRFA | Genetic Resources for Food and Agriculture |
| GRIN-USDA | Germplasm Resource Information System of the United States Department of Agriculture |
| GRPI | Genetic Resource and Policy Initiative |
| HICAST | Himalayan Collage of Agricultural Science and Technology |
| HYV | high-yielding variety |
| I/NGO | international non-governmental organization |
| IAAS | Institute of Agriculture and Animal Sciences |
| IAT | International Aqua-Tech |
| ICARDA | International Center for Agriculture Research in Dry Areas |
| ICIMOD | International Centre for Integrated Mountain Development |
| ICIS | International Crop Information Systems |
| ICRAF | World Agroforestry Centre |
| IDRC | International Development Research Centre |
| IFAD | International Fund for Agricultural Development |
| IFDC | International Fertilizer Development Center |
| INGER | International Network for Genetic Material Evaluation and Research |
| IPCC | Intergovernmental Panel on Climate Change |
| IPR | Intellectual Property Rights |
| IRHON | International Rice Hybrid Observation Nursery |
| IRR | internal rate of return |
| IRRI | International Rice Research Institute |
| ITPGRFA | International Treaty on Plant Genetic Resources for Food and Agriculture |
| IUPGR | International Undertaking of Plant Genetic Resource |
| IWIS | International Wheat Information System |
| LDC | least developed countries |
| LI-BIRD | Local Initiatives for Biodiversity, Research and Development |
| LIEN | Lentil International Elite Nurseries |
| MAS | marker assisted selection |
| MLS | multilateral system |
| MoAD | Ministry of Agricultural Development |
| MoFSC | Ministry of Forest and Soil Conservation |
| MoU | Memorandum of Understanding |
| MV | Modern Variety |
| MWRP | National Wheat Research Program |

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| NAF | Nepal Agro-Forestry Foundation |
| NABCC | National Agricultural Biodiversity Conservation Committee |
| NABIC | Network for Agro Biodiversity Conservation |
| NACC | National Assessment on Climate Change |
| NAGRC | National Agriculture Genetic Resources Centre |
| NALIP | National Grain Legume Improvement Program |
| NARC | Nepal Agricultural Research Council |
| NARS | National Agricultural Research System |
| NAST | National Academy of Science and Technology |
| NBS | National Biodiversity Strategy |
| NBSAP | Nepal Biodiversity Strategy and Action Plan |
| NEAT | Nepal Economic, Agriculture and Trade |
| NFN | NGO Federation of Nepal |
| NGLIP | National Grain Legumes Improvement Program |
| NGLRP | National Grain Legumes Research Program |
| NIAS | National Institute of Agro-biological Sciences |
| NPDP | National Potato Development Program |
| NPQP | National Plant Quarantine Program |
| NPRP | National Potato Research Program |
| NPV | net present value |
| NRRP | National Rice Research Program |
| NSB | National Seed Board |
| NSC | National Seed Company |
| NWRP | National Wheat Research Program |
| OFID | OPEC-funded international development |
| OPEC | Organization of the Petroleum Exporting Countries |
| PBS | pre-basic seed |
| PGR | plant genetic resources |
| PGRFA | plant genetic resources for food and agriculture |
| PIC | prior informed consent |
| PPB | participatory plant breeding |
| RAPD | random amplified polymorphic DNA |
| RAFI | Rural Advancement Foundation International |
| RARS | Regional Agricultural Research Station |
| RRN | Rural Reconstruction Nepal |
| RSTL | Regional Seed Testing Laboratory |
| SANPGR | South Asia Network on Plant Genetic Resources |
| SARPoD | Socioeconomics and Agricultural Research Policy Division |
| SARO | South Asian Regional Office |
| SARRC | South Asian Association for Regional Cooperation |
| SDC | Swiss Agency for Development and Cooperation |

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| SEAN | Seed Entrepreneurs' Association of Nepal |
| SMTA | Standard Material Transfer Agreement |
| SNP | Single-nucleotide polymorphism |
| SQCC | Seed Quality Control Centre |
| SRES | Special Report on Emission Scenario |
| SSR | simple-sequence repeat |
| SSTD | Seed Science Technology Division |
| STRASA | Stress-Tolerant Rice for Africa and South Asia |
| TANSAO | Taro Network for Southeast Asia and Oceania |
| TPS | true potato seed |
| TRIPS | Trade-Related Aspects of Intellectual Property Rights |
| TRIVSA | Tracking Rice Variety for South Asia |
| TV | Traditional Varieties |
| USAID | United States Agency for International Development |
| USDA | United States Department of Agriculture |
| VDC | Village Development Committee |
| WTO | World Trade Organization |

# Glossary

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| Access to genetic resources | The arrangement made to collect, acquire, or receive genetic materials, resources, or traditional knowledge from the owner for the use of others. |
| Act | A constitutional plan passed by congress or any legislature that is referred to as a bill until it is ratified and becomes a law. |
| Agricultural genetic resources | Any genetic material of actual or potential value for food and agriculture. Does not include human genetic resources. |
| Agricultural plant genetic resources | All cultivated plant landraces and varieties, wild edible plants, and wild relatives of crops. |
| Benefit-sharing | Sharing monetary or non-monetary benefit acquired by accessing and using genetic material, resources, or traditional knowledge as per an agreement between provider and receiver. |
| Bill | A proposal to make a new law. Ordinarily, it is in the form of a document that outlines what the proposed law is to be and the policy behind it. The bill is presented to the legislature where it is debated, altered (if necessary), and voted on. If the majority of the members of the legislature vote in favour of the bill, it is said to have been "passed in the house."Once a bill becomes law, it is called an act. |
| Black box | A system for depositing samples that does not constitute a legal transfer of genetic resources; the repository genebank does not claim ownership over the deposited samples and that ownership remains with the depositor, who has sole right of access to the materials. The repository genebank is not entitled to the use or distribute the germplasm. It is the depositor's responsibility to ensure that the deposited material is of high quality, to monitor seed viability over time, and to use their own base collection to regenerate the collection when it begins to lose viability. |
| Community genebank | A community storage facility for seeds of orthodox types and a one or more fields where farmer communities grow recalcitrant types of crops and maintain them over time. |
| Cultivar | Any distinct genotype under cultivation, including both landraces and varieties. |
| Distribution | Fair and equitable distribution of acquired benefit from the access to genetic material, resources, or traditional knowledge between farmers and stakeholders. |
| Ex-situ conservation | The conservation of genetic resources maintained outside their natural habitat. |
| Farmer | The people and communities, who identify, conserve, preserve, develop, or use genetic material, resources, and traditional knowledge. |
| Genetic material | All or part of the functional units of heredity consisting of the genetic characteristics of domestic or wild animals, plants, microbial organisms, viruses, or other origin. |
| Global Annex I crops | Also called IT Annex I crops. Crop species that are included under the multilateral system, listed in Annex I of the ITPGRFA, and accessible to all contracting parties through a Standard Material Transfer Agreement. |
| Global crop gene pool | Agricultural plant genetic resources that are necessary to secure food and nutrition for the global community. |
| In-situ conservation | The conservation of genetic resources in their original ecosystem and natural habitat. In the context of agricultural genetic resources, conservation in the surroundings where they have developed their distinctive properties (with at least one allele originating there). Both active (growing) and dormancy (after seed matures) periods occur in the same place. |
| Landrace | Genotype not altered by breeders but grown continuously by farmers over years. It may be local or introduced. |

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| Law | Any system of regulations that govern or rule the conduct of people, society, or a community usually for protection. It may be in the form of an act, ordinance, order, bylaw, rule, or regulation. |
| Legal person | A non-human entity that is treated as a person for limited legal purposes. |
| Legislation | The act of making or en acting laws. |
| Multilateral access | An arrangement made under the provisions of the ITPGRFA to access and use plant genetic resources for food and agriculture by national governments and international organizations working in the area of agriculture and food security for the welfare of human kind. |
| Multilateral system | Under the ITPGRFA, the multilateral system (MLS) comprises a pool of 64 selected crops that are made accessible. On ratifying the treaty, countries agree to make their genetic diversity and related information about the crops stored in their gene banks available to all through the MLS. |
| National crop gene pool | Agricultural plant genetic resources in the country that are necessary to secure food and nutrition for human kind. |
| Natural person | A human being, naturally born, versus a legally created juridical person. |
| Nepal Annex I crops | List of accessions of crops from Nepal included in the MLS. |
| On-farm conservation | The conservation of agrobiodiversity in farmers' fields and/or in community gene banks (seed bank and field gene bank), where new traits or alleles have not originated, but have been cultivated over a period of time. Active life (growing period) remains in the field and dormancy period (after harvest) remains in the man made structure nearby field. |
| Ordinance | Under the constitution,the president has the power and authority to enforce any bill in the form of law even if it is not passed by the legislature; such bills are called ordinances. An ordinance is promulgated on the recommendation of Cabinet. Ordinances are issued when there is some urgent need or requirement by the people at large. |
| Origin of landrace | Area where farming communities have been growing a landrace for more than 60 years or the location where a landrace was collected. |
| Origin of variety | Location where a distinct form of genotype is developed either by crossing or selection. |
| Policy | The principles that guide the actions of a government, business, or other collective entity. |
| Public domain | Space containing genetic materials that are not protected by intellectual property rights. |
| Safety backup | Safety duplication of accessions at one or more sites and/or using an alternative conservation method or strategy, such as in-vitro or cryo preservation or field gene bank. Both depositor and repository gene banks can use and distribute the germplasm. |
| Safety duplication | The duplication of genetically identical sub samples of an accession to mitigate the risk of its partial or total loss caused by natural or man-made catastrophes. Safety duplicates are genetically identical to the accessions in the base collection and are referred to as the second-most original samples. Safety duplicates include both the duplicated material and its related information and are deposited in a base collection at a different location from the originals, usuallyin anothercountry. Safety duplication is generally organized under a black-box agreement. |
| Traditional knowledge | Knowledge, skills, technology, or practices used by farmers from generation to generation to identify, manage, conserve, develop, or use genetic material or resources. |
| Variety | Genotype developed by breeders. It may be under cultivation or in the process of development. |

# Background

Pashupati Chaudhary, Bal Krishna Joshi, Deepak Upadhya and Ronnie Vernooy

Agro biodiversity plays a pivotal role in improving food and nutrition security, reducing hunger, and building resilience to climate change. However, despite scientific endeavors and continued investment, we continually fail to use agro biodiversity aptly to combat food insecurity, hunger, and malnutrition problems. In the meantime, persistent loss of biodiversity and genetic erosion are reducing our ability to find and develop crops that can survive biotic and abiotic stresses. Climate change has emerged as a new challenge, as increasing temperatures in many agricultural regions combined with erratic, unpredictable and extreme weather events accelerate the loss of biodiversity. These events are leading to greater food insecurity in particular in regions of the developing world.

No country is self-sufficient in plant genetic resources (PGRs). Research results clearly show that Nepal has a very high level of interdependence on other countries in terms of access to genetic materials for research and development. To stop — or even reverse — loss of biodiversity, countries' already deeply rooted interdependence will likely become even stronger. Through scientific efforts, PGRs have been collected, preserved in the public domain and in global gene pools, and exchanged for breeding purpose. Over 4.6 million crop accessions are currently held in such collections around the world. Developing countries and countries with economies in transition a re the main beneficiaries of these resources, and public research organizations, universities, regional organizations, germplasm networks, and gene banks play a major role in their distribution.

Nepal uses PGRs from other countries extensively in its breeding programs. Many of the newly developed varieties that contribute to national food security have benefited from foreign genetic materials. The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) makes international exchange of such much-needed new germplasm possible, particularly through its multilateral system (MLS) of access and benefit-sharing. The ITPGRFA was seen by many countries as a mechanism to overcome some of the limitations of the Convention on Biological Diversity (CBD) to make access and benefit-sharing work for smallholder farmers and other stakeholders in the developing world.

The ITPGRFA was approved by the United Nations Food and Agriculture Organization Conference in November 2001 and came into effect on 29 June 2004. Nepal ratified it in January 2007 and became a "party" on 19 October 2009. Signatory countries are obliged to create the proper policy and legal conditions to implement the treaty effectively. In Nepal, the Genetic Resources Policy Initiative (GRPI) project, which was implemented in two phases with technical and financial support from Bioversity International (thanks to a grant from the government of the Netherlands), contributed significantly to this goal.

The first phase was carried out by the Nepal Agricultural Research Council (NARC), Local Initiatives for Biodiversity, Research and Development (LI-BIRD), and the Ministry of Agricultural Development (MoAD) between 2003 and 2007. During phase 1, the team was able to sensitize key stakeholders to the value of PGRs for food and agriculture, conduct demand analysis using action research, introduce the "3M approach" (multi-stakeholder, multi-disciplinary, and multi-sectoral), build the capacity of community-based organizations, and publish key policy documents in local languages. The project also played a facilitating role in the country's ratification of the ITPGRFA as well as in the drafting the Plant Variety Protection and Farmers' Rights Bill, the Access and Benefit-Sharing Bill, and the Agro biodiversity Policy 2007.

Building on these results, the second phase of the project (2012–2015) accomplished a number of important tasks. The main goal during this phase was to strengthen national capacity to implement the ITPGRFA through research and capacity-building in five areas:

- Developing national-level, multilateral system policy: Common core activities (and products) with 10 components including policy review.
- Developing capacity to implement the ITPGRFA effectively: Research on policy network structure, actor characteristics, and coalitions.
- Mapping and measuring PGR flows and interdependence: The dynamics of the global crop commons under four components: Overview of food and forage crops and PGRs; germplasm flows, uses, and determining factors; benefits from international PGR exchange; and future levels of interdependence as a result of climate change.
- Linking farmers to the ITPGRFA/MLS: Potential and challenges of strengthening access to PGRs through community-based gene and seed banks.
- Transferring technology: Generating non-monetary benefit-sharing in support of conservation and sustainable use of PGRs under three components: Organizational case studies, technology transfer case studies, and a national stakeholders' survey.

This book presents the results of the work done in these five areas. It consists of nine chapters, coherently interlinked, each with direct relevance to the implementation of the ITPGRFA and the MLS. Summaries of these chapters are presented below.

Chapter 1 provides empirical evidence of how strongly Nepal relies on foreign-sourced PGRs for its agricultural research and development of food security. It reviews patterns and progress in domestication, introduction, and adoption of important food and forage crops and the roles of relevant institutions in developing new varieties. One of the major highlights: more than 12 countries conserve Nepalese agricultural PGRs, in the form of 23600 accessions; 3624 accessions of 32 food and 8 forage crops are in the MLS.

Chapter 2 describes and illustrates the patterns of germplasm flow and their contribution to the development of modern crop varieties,traces the pedigree of modern varieties of selected crops, and documents key stakeholders' perceptions of the pros and cons of exchange of PGRs through the MLS. It reveals that about 73% of the varieties released in Nepal have foreign ancestors and, for wheat, potatoes, and lentils, the contribution is close to 80%. It also makes clear that climate change is going to increase dependence on exchange by compounding the loss of biodiversity and genetic erosion. A highlight is that the 35 wheat varieties developed so far in Nepal have benefited from 89 ancestors originating in 22 countries.

Chapter 3 assesses the economic benefits of improved varieties of selected major food crops developed using foreign PGRs accessed through the MLS. The chapter also documents sources of genetic materials used in breeding programs, adoption patterns of the varieties developed using those materials, and benefits arising from the new varieties. Using the example of Khumal-4 rice, a released variety popular in the mid-hills, the authors assess monetary and non-monetary benefits of new varieties developed using materials obtained through the MLS.

Chapter 4 analyzes temperature and rainfall trends, assesses their impact on crop yield using rice as an example at two reference sites, and as certains the correlation between these trends and crop yield. The chapter also identifies past and future analogous climate sites using the Climate Analogues tool and assesses the potential for PGR exchange between those sites now and in the future. The authors suggest field-testing of novel genetic materials exchanged between analogous sites to validate the utility of the Climate Analogues tool in identifying similar locations and aiding decision-making.

Chapter 5 presents policy network structures and decision-making processes, identifies key actors in the ITPGRFA policy network, examines the nature of the connections between actors, and summarizes perceptions of key stakeholders of the benefits of the ITPGRFA and the MLS. The authors discuss the changes required in policy network structures and relations and link them to policy implementation outcomes. The chapter reveals that about 70% and 60% of key stakeholders believe that the ITPGRFA and MLS, respectively, are beneficial for Nepal. The future outlook, as suggested in the chapter, includes policy awareness, strengthening the policy network, building capacity for policy action research, and strengthening agro-biodiversity policy.

Chapter 6 examines possible modes of collaboration and agreement between community seed banks (CSBs) and the national gene bank with respect to the MLS and identifies options concerning in-situ materials under Article 12.3.h of the ITPGRFA. The chapter outlines the problems faced by CSBs and argues that they cannot survive without the support of strong, well-governed local institutions. Moreover, it suggests establishing a "one-window" system for exchanging PGRs through the MLS, increasing awareness among farmers of the benefits of the MLS, establishing CSBs in strategic locations, ensuring coordination between CSBs and the national gene bank with clearly defined roles, and developing a robust mechanism for benefit-sharing and prior informed consent.

Chapter 7 deals with potential and promising technologies that can generate monetary and non-monetary benefits to relevant stakeholders, key organizations, and actors involved in developing and transferring these technologies, as well as the mode and pathways of transfer and use of technologies for conservation, characterization, and evaluation of PGRs. The chapter presents germplasm-based and non-germplasm-based benefits and offers the following conclusions: PGR-based technologies facilitate and accelerate the flow, exchange, and use of germplasm; technologies are often transferred on an ad hoc basis; South–South and horizontal transfer techniques are lower in cost, more rapid in diffusion, and better adapted to local contexts compared with North–South and vertical transfers; and germplasm-based technologies are easier and faster to transfer than non-germplasm-based technologies.

Chapter 8 highlights the current incentives and disincentives of PGR conservation and use, identifies key policy options to create incentives and encourage voluntary inclusion of PGRs in the MLS, and provides useful insights into mechanisms and strategies for their voluntary inclusion. Securing ownership rights and recognition are the main incentives for sharing PGRs. Most breeders, researchers, farmers, and policy makers are relatively unaware of the incentives and disincentives for material exchange through the MLS.

Chapter 9 reviews and summarizes national policy documents relevant to the ITPGRFA and identifies the challenges and opportunities presented by those policies for implementing the treaty. The chapter suggests that the policy environment in Nepal could be improved, although some progress has been made in recent years, such as consideration of implementation of the ITPGRFA in harmony with the Convention on Biological Diversity in the National Biodiversity Strategy and Action Plan 2014–2020. A positive development is the drafting of new policy and legal instruments, such as the agro-biodiversity conservation and utilization act and regulations. This bodes well for effective implementation of the ITPGFRA and the MLS in the near future.

# Chapter I : Food and forage crop genetic resources

Bal Krishna Joshi, Madan Raj Bhatta, Krishna Hari Ghimire and Pashupati Chaudhary


### Key messages

- Of the 145 plant species that ensure food security in Nepal, 35 food and 29 forage species can be found in Annex I of the International Treaty on Plant Genetic Resources for Food and Agriculture, a list of major crops needed for global food security.
- In addition to the 145 food and forage crops, Nepal's crop gene pool contains 551 released and registered varieties.
- 3624 accessions of 32 food and 8 forage crops have been listed in the multilateral system: 226 are released varieties, 1987 are safely duplicated in CGIAR genebanks, 1403 are accessions held in other foreign genebanks, and 8 are forage crops.
- More than 12 countries conserve Nepalese agricultural plant genetic resources, in about 23600 accessions.
- Nepalese accessions are held in GeneSys (12489), CGIAR banks (11702), the World Vegetable Center (850), the National Institute of Agrobiological Sciences (4136), the European Plant Genetic Resources Search Catalogue (3510), and the Germplasm Resource Information System of the United States Department of Agriculture. As of December 2015, about 0.37% of accessions in the global crop gene pool are Nepalese.
- 31 varieties of 18 crops have been developed from local landraces in Nepal.
- Strong research and development along with close collaboration with various organizations are major factors in Nepal's ability to develop farmer-friendly varieties.

Nepal enjoys an extraordinarily rich diversity of natural flora and fauna, as well as cultivated crops, because of the great variation in climate, ecology, farming systems, and sociocultural settings. Comprising less than 0.1% of the earth's land area, the country is home to about 600 species of food plants, 400 species of agro-horticultural crops, 60 species of wild edible fruits, 200 species of commercially important medicinal and aromatic plants, 300 species of orchids, 5000 species of insects, 185 species of fishes, and a variety of other economically and ecologically important species (MFSC 2002, Upadhyay and Joshi 2006, Gautam 2008). Agricultural plant genetic resources (PGRs) play a vital role in the national economy and food security, as more than three-quarters of the country's population depends on agriculture for their livelihoods. In the recent times, the country has been losing significant crop diversity because of a liberal economic policy, promotion of modern varieties, and lack of an overall policy on the conservation and sustainable use of these resources (Chaudhary et al. 2004, Gauchan et al. 2005).

An overview of Nepal's food and forage crops can contribute to better understanding of the importance of PGRs in food and nutrition security. As Nepal is a party to the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), identification of crops listed in the treaty's Annex I — the crops most important for global food security — is a prerequisite for implementation of the treaty. Moreover, a systematic assessment of the dependence of particular countries on PGRs from beyond their borders, and the gains that have accrued to those countries as a result of international exchange of PGRs can provide policymakers with the information they need to make informed decision about how to implement and participate in the treaty's multilateral system (MLS) for sharing genetic material. At the same time, it may raise awareness of the interdependence of stakeholders and encourage more active involvement in the MLS.

Unfortunately, few studies have documented the actual or potential benefits to be gained by particular countries from implementation of the ITPGRFA and the MLS. Little is known about how domestication, exchange, and adoption of PGRs take place and what role these resources play in biodiversity conservation and food security. Information about the availability of PGRs collected from Nepal by various agencies around the world and how such resources are used for agricultural research and development (e.g., breeding and crop improvement) is also not readily available, nor is documentation of the institutional roles involved in using PGRs for crop improvement, livelihood enhancement, and food security.

In this chapter, we provide empirical evidence of the extent to which Nepal is dependent on foreign-sourced PGRs for its agricultural research and development (including breeding) and, ultimately, for its food security. We focus on the history of the domestication, introduction, and adoption of important food and forage crops in the country and examine the role and current uses of key crop genetic resources in breeding and crop improvement. Finally, the roles of institutions involved in the use of PGRs to develop high-yielding, insect and disease resistant, and climate resilient varieties are discussed.

## Methods

Many rounds of discussion and several consultation meetings were organized to identify the major crops and the organizations working on PGRs. A literature review was carried out to compile data on the domestication, introduction, adoption/contribution to national diet, food security, national agricultural production, exports, and gross domestic product (GDP) of four major crops selected for this study: rice, wheat, lentils, and potatoes. Various crop breeding centres were also visited and experts were consulted. Criteria for the listing of Nepalese PGRs in the MLS were developed and discussed with various stakeholders. National and international PGR databases were searched and analyzed for additional information.

## Global and national crop gene pools

A total of 145 species contribute to food security in Nepal (see Appendix I). This high number is largely due to the climatic variation and diverse cultural values. Many crop species that are important in Nepal are not listed in the ITPGRFA's Annex I (see Appendix II), as they are not significant globally.

The crops listed under the MLS form the Global Crop Gene Pool. They are available through GeneSys, the National Institute of Agrobiological Sciences (NIAS) in Japan, the World Vegetable Center (AVRDC), the European Plant Genetic Resources Search Catalogue (EURISCO), and the Germplasm Resource Information System of the United States Department of Agriculture (GRIN-USDA). They include 52 genera of 35 food crops and 81 species of 29 forage crops. Nepal's national crop gene pool consists of major food and forage crops, released and registered varieties, IT Annex I crops, and other local crops (**Figure** 1.1).

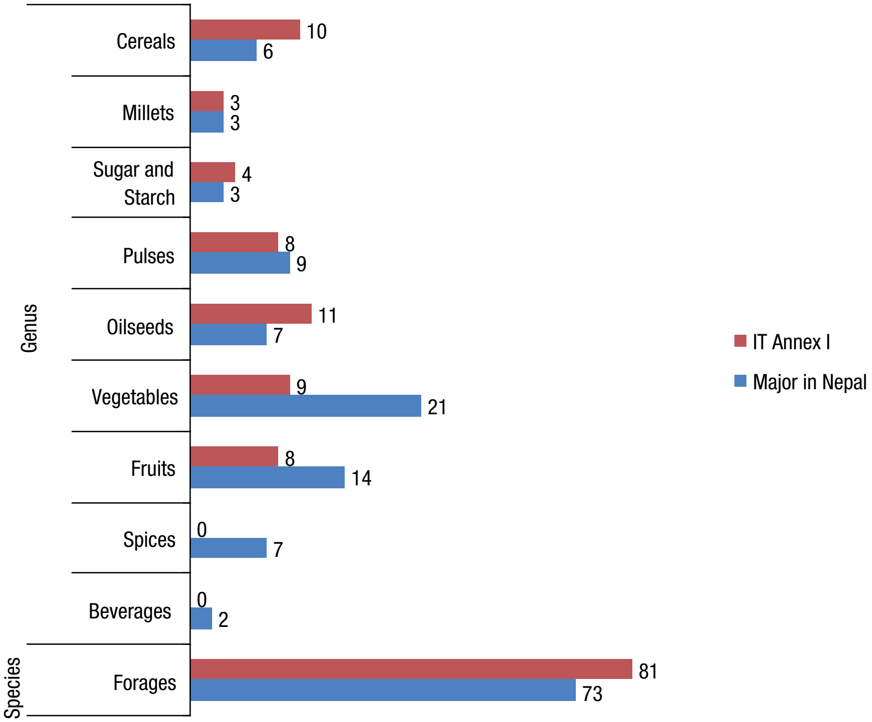


**Figure 1.1.** Number of genuses of food crops and forage species listed in the ITPGRFA's Annex I (IT Annex I, $n = 134$) and those considered important in Nepal (Major in Nepal, $n = 145$).

At the species level, 134 food and forage crop species are listed in the ITPGRFA's Annex I and 145 in Nepal's national crop gene pool. Both lists are grouped into cereals, millets, sugar and starch, pulses, oilseeds, vegetables, fruits, spices, beverages, and forage crops. Among the 10 cereals listed in Annex I, only six are considered important for food security in Nepal. In contrast, for fruits, vegetables, spices, beverages, and pulses, Nepal's list contains more important species than Annex I. Currently, Nepal's genebank (National Agriculture Genetic Resources Centre) has a total of 2275 accessions of 10 crops that are listed in Annex I (**Figure**

1.2). In Nepal, 551 varieties have been released and registered under the National Seed Board; among them, 215 varieties are from the crops listed in Annex I (**Figure** 1.3).

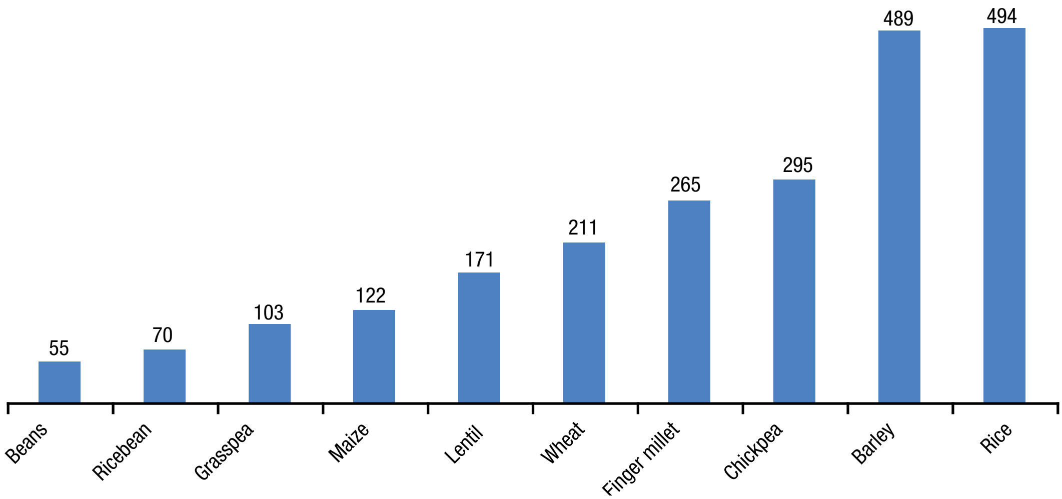


**Figure 1.2.** Accessions of Annex I crops conserved in Nepal's genebank and in the public domain as defined by the ITPGRFA.

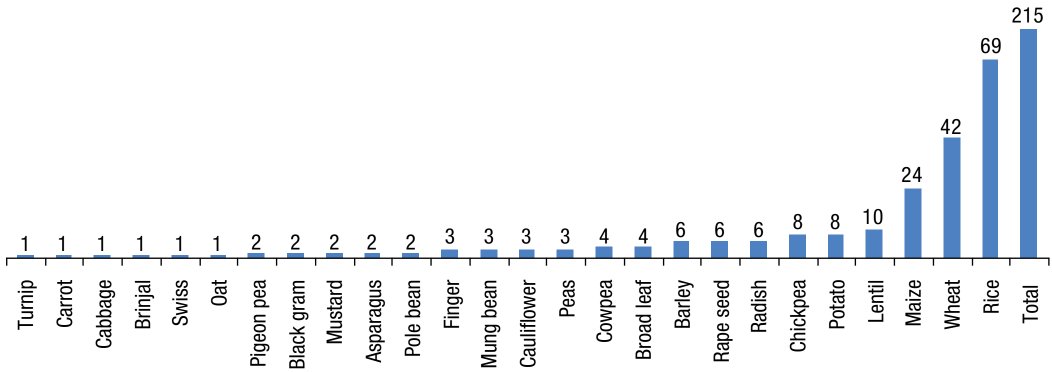


**Figure 1.3.** Varieties of crops released in Nepal that are also listed in the ITPGRFA's Annex I.

## Nepal's Annex I crops

As a member country of ITPGRA, Nepal must share its crop accessions with the global community though the MLS. To do this, the national Genetic Resources Policy Initiative 2 team developed criteria for inclusion of accessions in the national crop gene pool. These criteria were discussed with various stakeholders and a list of accessions that meet the criteria has been prepared. This list (consisting mainly of orthodox seeds) is called Nepal's Annex I crops and is the first list of crop accessions to be included in the MLS. Criteria for inclusion of crop accessions in the MLS are:

- Should be in the public domain (selected based on collection site, i.e., geographic location, less researched, less common, rare and endangered accessions, underutilized, and localized)Should be released, registered, and de-notified (removed from the national list of poor performers).
- Should be safely duplicated in various genebanks of the Consultative Group for International Agricultural Research (CGIAR).
- Should be able to contribute to global food security.

A total of 3624 accessions of 32 food and 8 forage crops have been listed for inclusion in the MLS at this stage (**Table** 1.1). Among these, 226 are released varieties, 1987 are safely duplicated in CGIAR banks, 1403 are similar to those in foreign genebanks, and 8 are forage crops.

### Table 1.1. Nepalese crops considered for inclusion in the ITPGRFA's multilateral system (Nepal's Annex I crops)

### Food crops

| Common name | Scientific name |
|---|---|
| Asparagus | *Asparagus officinalis* L var. *altilis* L |
| Asparagus Bean | *Vignaunguiculata*subsp.*sesqui-pedalis* (L) Verdc |
| Barley | *Hordeum vulgare* L |
| Beans | *Phaseolus* spp |
| Black Gram | *Vigna mungo* L Hepper |
| Brinjal | *Solanum melongena* L |
| Broad Leaf Mustard | *Brassica juncea* L var. *rugosa* |
| Cabbage | *Brassica oleracea* L var. *capitata* L |
| Carrot | *Daucus carota* L |
| Cauliflower | *Brassica oleracea* L var. *botrytis* L |
| Chickpea | *Cicer arietinum* L |
| Cowpea | *Vigna unguiculata* L |
| Finger Millet | *Eleusine coracana* Gaertn |
| Grasspea | *Lathyrus sativus* L |
| Indian Mustard | *Brassica juncea* Cass |
| Knol-Khol | *Brassica caulorapa* L |
| Lentil | *Lens culinaris* Medic |
| Maize | *Zea mays* L |
| Mung Bean | *Vigna radiata* (L) R Wilczek |
| Naked Barley | *Hordeum vulgare* L var. *nudum* Hook f |
| Oat | *Avena sativa* L |
| Pak Choi | *Brassica rapa* var. *chinensis* |
| Pea | *Pisum sativum* L |
| Pigeon Pea | *Cajanus cajan* Millsp |
| Pole Bean | *Phaseolus vulgaris* L |
| Potato | *Solanum tuberosum* L |
| Radish | *Raphanus sativus* L |
| Rapeseed | *Brassica campestris* var. *toria* Dutch |
| Rice | *Oryza sativa* L |
| Sugar Beet | *Beta vulgaris* L |
| Turnip | *Brassica oleracea* var. *rapa* L |
| Wheat | *Triticum aestivum* L |

### Forage crops

| Common name | Scientific name |
|---|---|
| Grass Pea | *Lathyrus sativus* |
| Yellow Lucerne, Yellow Clover | *Medicago falcate* |
| Lucerne (Alfalfa) | *Medicago sativa* |
| Berseem | *Trifolium alexandrium* |

| Common name | Scientific name |
|---|---|
| Red Clover | *Trifolium pretense* |
| White Clover, Ladino | *Trifolium repens* |
| Shaftal Clover | *Trifolium resupinatum* |
| Rye Grass | *Lolium perenne* |

## Agricultural PGR holders in Nepal

In Nepal, PGRs are managed and conserved by various organizations and individuals using ex-situ, on-farm, and in-situ strategies. The main holders using an ex-situ system are the National Agriculture Genetic Resources Centre (NAGRC), the National Academy of Science and Technology, the Institute of Agriculture and Animal Sciences, and various research programs and stations of the Nepal Agricultural Research Council, the Department of Agriculture, the National Seed Board, the Agriculture and Forestry University, and the Department of Plant Resources. Community seed banks, household genebanks (seed banks and field genebanks at the household level), and community field genebanks are conserving PGRs on-farm. Those using an in-situ system include national parks, conservation areas, wildlife and hunting reserves, world heritage sites, and Ramsar sites.

These PGR holders can be grouped into three categories:

- Public domain
  - National level: NAGRC, Institute of Agriculture and Animal Sciences, Tribhuvan University, National Academy of Science and Technology
  - International level: CGIAR banks, world heritage sites, Ramsar sites
- Under the management and control of the government
  - Protected areas (10 national parks, 6 conservation areas, 3 wildlife reserves, and 1 hunting reserve)
  - Horticulture and vegetable farms across the country
  - Nepal Agricultural Research Council stations across the country
- Private
  - Households
  - Seed companies
  - Community-based and nongovernmental organizations

## Nepalese agricultural PGRs around the world

Many national and international biologists, naturalists, adventuress, travelers, and plant hunters have explored and collected germplasm from various parts of Nepal over many years. Collections have mainly targeted food crops; similar collections may have been made of horticultural plants, fodder, grasses, edible wild plants, and medicinal plants, but these lack documentation.

Nepalese specimens were first collected in 1802 by Francis Buchanan-Hamilton (1762–1829), and this practice was continued by Nathaniel Wallich (1786–1854) in 1820–21. Since then, many parts of Nepal have been well explored. Specimens can be found in major herbaria, such as the National Herbarium and Plant Laboratories, Kathmandu; the British Museum, London; the Royal Botanic Garden, Kew; the University of Tokyo, Japan; the Smithsonian Institution, Washington, DC; the University of Grenoble, France; and the Royal Botanical Garden, Edinburgh. It is estimated that the British Museum has over 40000 specimens, the University of Tokyo about 100000, and the National Herbarium and Plant laboratories of Kathmandu, 150000. In addition, approximately 10000 specimens are housed in various institutions of Tribhuvan University (MFSC 2002). More than 12 countries (USA, Mexico, Sweden, Germany, Italy, Syria, China, India, Japan, Philippines, Australia, and several African countries) have conserved Nepalese agricultural PGRs totaling more than 23600 accessions.

With the establishment of the NAGRC in 2010, agricultural PGRs are now systematically managed, conserved, and used in Nepal. The bank conserves more than 11000 accessions of different crop species using medium- and long-term conservation strategies. The NAGRC has also stored 1987 duplicate accessions of maize, rice, wheat, chickpea, finger millet, barley, grasspea, and lentil species in various CGIAR banks, e.g., the International Maize and Wheat Improvement Center, the International Rice Research Institute (IRRI), the International Crops Research Institute for the Semi-Arid Tropics, and the International Center for Agricultural Research in the Dry Areas (ICARDA). Recently, 69 accessions of barley have been placed in the World Seed Vault, Korea, under a "black box" system, i.e., they remain under the management and control of Nepal. Global databases indicate that there are more than 46 million accessions in the Global Crop Gene Pool (GeneSys, NIAS, AVRDC, EURISCO, and GRIN-USDA) that are freely accessible for research and development (**Figure** 1.4). Nepalese accessions in the Global Crop Gene Pool include 12489 in GeneSys, 11702 in CGIAR genebanks, 850 in AVRDC, 4136 in NIAS, 3510 in EURISCO, and many in GRIN-USDA for a total of 4644604 or about 0.37% of all accessions in the Global Crop Gene Pool.

In terms of rice accessions, 3980, collected from all cultivated areas of Nepal, have been deposited in national and foreign genebanks (**Figure** 1.5). Both cultivated and wild species are being conserved in these banks.

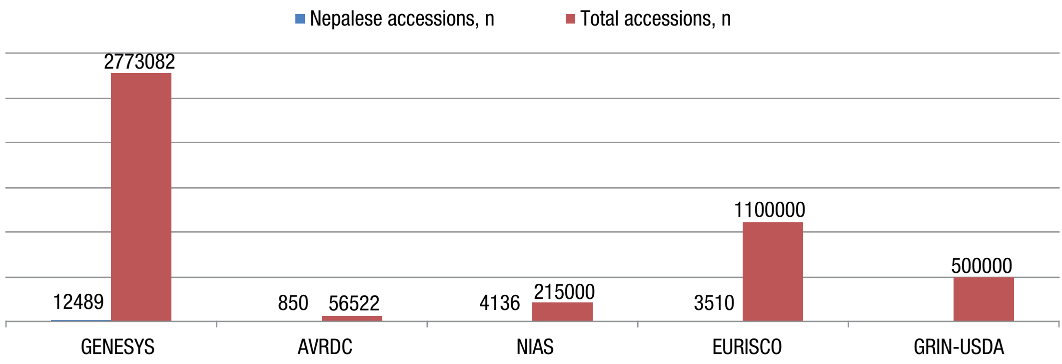


**Figure 1.4.** Nepalese accessions in the Global Crop Gene Pool.
Note: Genesys includes CGIAR, EURISCO, and USDA banks.

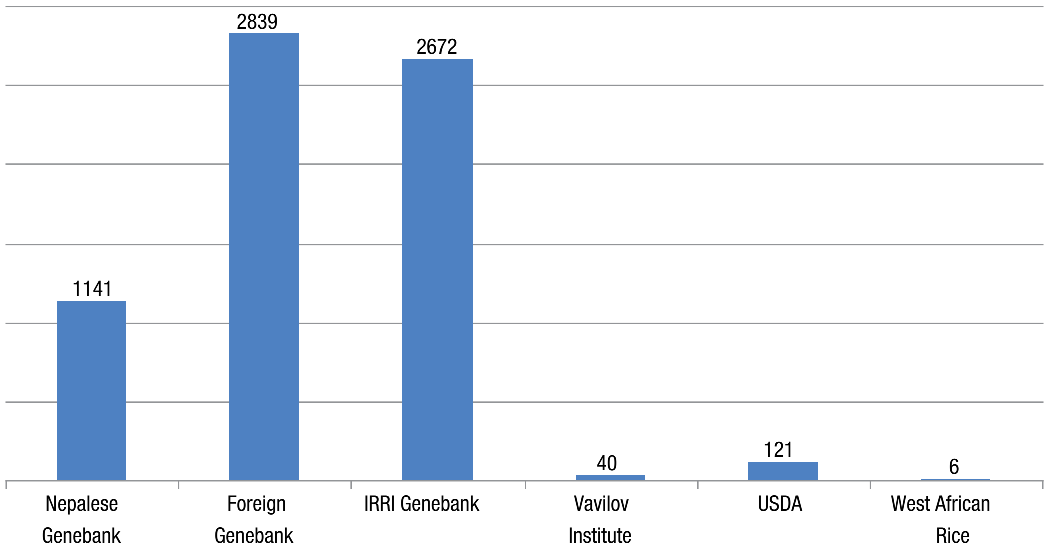


**Figure 1.5.** Nepalese rice accessions in various genebanks.

## Use of Nepalese PGRs in breeding

All crop-breeding programs in the country are based on the genetic materials developed by international crop-breeding stations. Major activities in the country involve evaluating and testing. Hybridization is carried out only in major crops, such as rice, maize, and wheat, and foreign germplasm is commonly used as the parent varieties.

To date, 31 varieties of 18 crops have been developed based on local landraces (**Table** 1.2). The trend toward using local landraces in breeding programs is increasing, and it is assumed that the diverse landraces that are being cultivated in diverse climates can meet the expected diversity between parents during crossing. How Nepalese PGRs are used in foreign countries is not known. Pedigree analysis of rice, wheat, and potato varieties indicates that no landraces from Nepal were used as parental lines in national breeding programs.

**Table 1.2. Improved crop varieties developed from local landraces in Nepal**

| Crop | No. varieties developed | | Variety | Parent | Release date |
|---|---|---|---|---|---|
| | Local selection | Landrace/ exotic cross | | | |
| Asparagus | 2 | — | Khumal Tane | | 1994 |
| | | | Sarlahi Tane | | 1994 |
| Barley | 2 | — | Solu Uwa | NB 1054 | 1990 |
| Blackgram | 1 | — | | | |
| Broad Leaf Mustard | 3 | — | Khumal Broad Leaf | | 1989 |
| | | | Marpha Broad Leaf | | 1994 |
| | | | Khumal Rato Pat | | 1994 |
| Cauliflower | 1 | — | Kathmandu Local | | 1994 |

| Crop | No. varieties developed | | Variety | Parent | Release date |
|---|---|---|---|---|---|
| | Local selection | Landrace/ exotic cross | | | |
| Chickpea | 2 | — | Trishul | Local cultivars from Nepal | 1979 |
| | | | Dhanush | Local cultivars from Nepal | 1979 |
| Cowpea | 2 | — | | | |
| Cucumber | 1 | — | Kusle | Local selection | 1994 |
| Eggplant | 1 | — | Sarlahi Green | | 1994 |
| Finger Millet | 2 | — | Okhale-1 | Local cultivar from Okhaldhunga | 1980 |
| | | | Kabre Kodo-1 | Local cultivar from Surkhet | 1990 |
| Lentil | 3 | — | Sindur | Local selection (Lo-111-25) | 1979 |
| Maize | — | 6 | Hetauda composite | Exotic/ local | 1973 |
| | | | Ganesh-2 | Exotic/ local | 1989 |
| | | | Manakamna-1 | Exotic/ local | 1987 |
| | | | Rampur-2 | Exotic/ local | 1989 |
| Pigeonpea | 2 | — | Bageswori | | 1991 |
| | | | Rampur Rahar | | 1991 |
| Radish | 2 | — | Pyuthane Rato | | 1994 |
| Rice | 2 | 5 | Khumal-2 | Jarneli/KN-1B-361-BLK-2-8 | 1987 |
| | | | Khumal-4 | IR 28/Pokhreli Masino | 1987 |
| | | | Palung-2 | BG94-2/Pokhreli Masino | 1987 |
| | | | Chhommrong | Local selection | 1991 |
| | | | Khumal-5 | Pokhreli Masino/ KN-1B-361-BLK-2-6 | 1990 |
| Sesame | 2 | — | | | |
| Soybean | 1 | — | Lumle 1 | | 1996 |
| Sponge Gourd | 2 | — | Kantipure | | 1994 |

Source: Upadhyay and Joshi (2006).

## Role of key food crops in ensuring national food security and biodiversity

Because of the climatic diversity of Nepal, many key food crops are site specific: for example, rice in terai regions, maize in hill districts, and barley or wheat in mountainous areas. Key food crops are rice, maize, wheat, potato, lentil, broad leaf mustard, beans, banana, mango, cauliflower, finger millet, barley, amaranths, buckwheat, cowpea, pumpkin, and pear (**Table** 1.3). Diverse genotypes of the various crop species are adapted to different localities and Nepalese culture. Increases in cultivated area and production of some major crops are depicted in **Figure** 1.6.

### Table 1.3. Distribution of food crops in Nepal

| Zone (elevation) | Crops |
|---|---|
| Terai (60–1000 m) | Paddy, maize, wheat, chickpea, pigeon pea, lentil, jute, niger, sesame, perilla, wild relatives of rice, sugarcane, tobacco, finger millet, mustard, banana, mango, cauliflower |
| Hills (1000–3000 m) | Paddy, maize, wheat, barley, buckwheat, covered barley, field peas, niger, perilla, wild relatives of buckwheat, finger millet, rice bean, jute, sesame, bean, cowpea, rape, mustard, proso millet, fox-tail millet, black gram, pigeon pea, sugarcane, soybean, pumpkin |
| Mountains (3000–8848 m) | Cold-tolerant rice, wheat, maize, amaranths, chenopods, rice bean, black gram, soybean, field peas, niger, sesame, Brassica spp., perilla buckwheat, mithe buckwheat, proso millet, naked barley, pear, etc. |

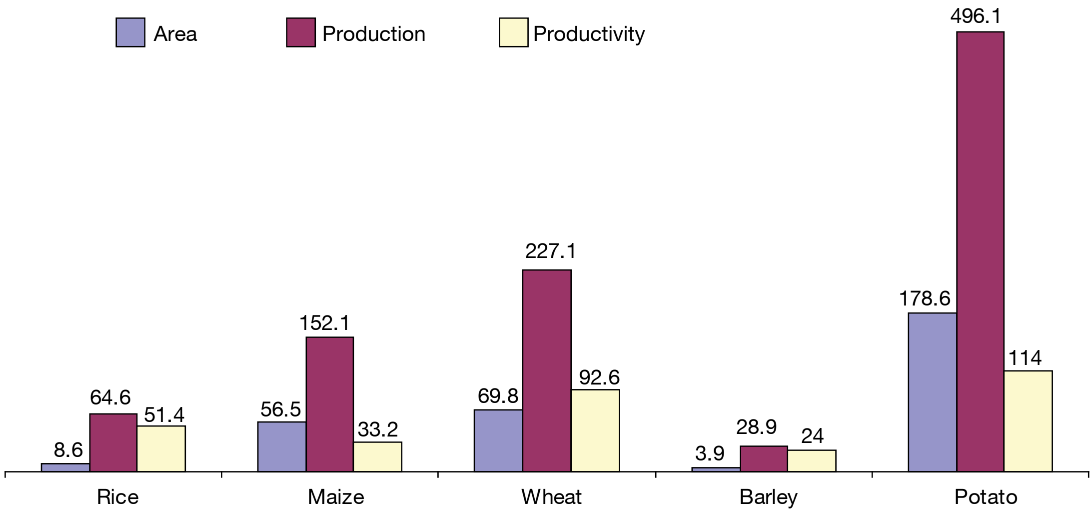


**Figure 1.6.** Increase in productivity (%) of major food crops in Nepal over 25 years, 1984–2010.

## Rice

Rice (*Oryza sativa* L., $2n = 2x = 24$) feeds half the world population. It is the most important staple food crop in Nepal and has been grown since 1500 BC. Rice is considered to be a livelihood crop and most important to Nepal's economy. It contributes significantly to food security at the national and household level and is considered important in all agro-ecosystems of the country.

Rice supplies 38.5% of the dietary protein and 7.2% of the dietary fat of Nepalese people. Preliminary estimates indicate that rice is grown on 1.5 million ha, which produce 4.5 million t of rough rice at a rate of 2.98 t/ha in 2011. About half of cultivated rice fields are irrigated, fully or partly, and the rest are rainfed. Nearly 87% of the rice crop by area consists of improved varieties. The country's long-term agriculture projections envisage that rice production must increase to 6 million t in 2015 to feed the growing population (APP 1995). The increase is to be achieved by increasing productivity to 4.0 t/ha. A total of 69 improved rice varieties have been developed for terai, mid-hills, and high-hill agrozones. All have been conventionally bred.

Rice can be grown in two seasons a year in the terai, inner terai, and foothills of Nepal: February/March to June/July and June/July to October/November. During the last 20 years, the productivity of rice has remained nearly constant despite the fact that top priority has been placed on developing the agricultural sector during that period (NRRP 1997). Until 1988, Nepal was a rice-exporting country, but low productivity (< 3.5 t/ha) and a high rate of population growth have made it a rice-importing country (NRRP 1997).

## Wheat

Wheat (*Triticum aestivum* L., $2n = 6x = 42$) is the third most important crop in terms of food security in Nepal after rice and maize. Until the mid-1960s, it was a minor cereal, but, as a result of the introduction of high-yielding, disease-resistant, and widely adapted Mexican semi-dwarf varieties introduced at that time, there has been a remarkable increase in area cultivated, production, and productivity. Currently, wheat is grown on about 765000 ha with total production reaching 1.846 million t. Overall wheat productivity is 2.4 t/ha (MoAD 2012). During last 27 years (1985 to 2012), the area under wheat cultivation has increased by 37.90%, total production by 172.88%, national productivity by 97.87%, and area coverage by modern varieties exceeds 97%. The average rate of increase in yield has been 51.1 kg/ha a year during this period. At present, Nepal produces wheat worth 50 billion Nepalese rupees (NPR; about 470 million United States dollars) and this crop plays a vital role in the country's food security. Current per capita wheat consumption is about 62 kg/year compared with 17 kg/year in 1972. The internal rate of return on wheat research in Nepal has been reported to be 75–84% (Morres et al. 1992).

The first generation high-yielding wheat variety Sonalika (RR21), selected in India and later introduced in Nepal, began the wheat revolution in Nepal. Sonalika could be planted any time in December up to the first week of January in the terai, and it was far superior to existing local varieties in terms of grain yield. The release of additional short-growing season, post-anthesis heat-tolerant, high-yielding, disease-resistant varieties further revolutionized wheat production in Nepal during the 1980s and 1990s.

Wheat is used mainly as a human food. It is nutritious, easily transported, and can be processed into various types of food products. Unlike any other plant-derived food, wheat contains gluten protein, which enables leavened dough to rise by forming minute gas cells that hold carbon dioxide during fermentation. This process produces light-textured bread. Wheat supplies about 20% of the food calories for the world's people and is a national staple in many countries besides Nepal. Wheat protein, when complemented with other foods that supply certain amino acids, such as lysine, is an efficient source of protein. In Nepal, wheat is generally consumed in the form of chapatti, leavened bread, noodles, cookies, and biscuits. Wheat straw is fed to domestic animals.

## Lentils

Lentil (*Lens esculenta* Moench, synonym: *Lens culinaris* Medikus, $2n = 2x = 14$) is one of the oldest and most nutritious pulse crops. It is an annual plant in the Leguminosae family. It is strictly self-pollinating as the anthers release pollen before the flower opens. Based on seed size, lentils are broadly divided into two subclasses: macrosperma (large seeds) and microsperma, (small seeds). Whole or split seeds are used to prepare *dal* and delicious *namkin*, as well as soup and porridge; the green pods are consumed as vegetables; and the leaves and stalks are used as feed for cattle and small ruminants. Lentil is a hardy crop. It is grown in cool, dry areas and requires few inputs. It has a great potential for climate resilience in dry areas.

Lentils are an excellent supplement to cereal grain diets and are used mainly in soups, casseroles, and salads in Nepal. *Dal* (lentil soup) is enjoyed by many people as it takes only a short time to cook compared with other legume dishes. About a third of the calories in lentils come from protein, the third-highest level of protein by weight of any legume or nut. The seeds contain about 20–25% protein and are a rich source of iron (64–127 mg/100 g), zinc (35–88 mg/100 g), and selenium (NGLRP 2013). The crop contains no cholesterol, virtually no fat, and very low levels of anti-nutrients. Lentils are nitrogen sequestrating and, thus, improve soil fertility and increase the sustainability of agricultural production systems.

The popularity of lentils is increasing, and world production has been rising steadily for the last 25 years: global production has more than tripled since 1980. In Nepal, the crop has emerged as an important export commodity. Within the last 2 years, the price of lentils has doubled. Of total lentil exports from Nepal during 2012, more than 80% went to Bangladesh at $1200/t.

Lentils are the most important pulse crop in Nepal in terms of area, production, and productivity. They represent 62% by area (206522 ha) and 64% by production (226931 t/year) of all grain legumes; productivity is 1.1 t/ha (MoAD 2012). In 2012, Nepal accounted for 4.57% of the world's lentil production (FAO 2012). Lentils are grown in all districts of Nepal except Manang and Dolpa, at a range of elevations from 60 to 2000 m above sea level. However, 95% of the area under lentil production is in the terai.

Although lentils are an exportable crop, they are largely neglected by many farmers, who, thus, ignore such management practices as land preparation, fertilization, irrigation, weeding, plant protection measures, etc. Nepalese lentils, known globally as "Small Pinky," are highly rated by international consumers because of their cooking qualities, tasty red cotyledons, and micronutrient content. Their share of the global export market is about 3.2%. In 2010/11, 33.2ton of lentils were exported from the country to Bangladesh (80%), India, Singapore, United Arab Emirates, Bahrain, and Hong Kong earning NPR 2678 million (MoAD 2012). Increases in area, production, and yield are due to conversion of rice fallow areas into lentil cultivation, improved technologies, technical support, and an increasing export market.

Lentils that fail to meet food-grade standards can be used as livestock feed because of their high protein content and lack of digestive inhibitors. They are also a key commodity in crop diversification and intensification programs in the country.

## Potatoes

Potatoes are the fifth most important major crop in Nepal — after rice, maize, wheat, and lentils — in terms of area covered and second in production. They are widely grown throughout Nepal, from the southern terai at altitudes below 100 m, to the northern mountains at elevations as high as 4000 m.The potato crop becomes relatively more important in the high hills (roughly 1800–3000 m above sea level), as it is more productive there relative to other staple crops such as rice, maize, and finger millet. This altitude range is also well suited to the production of potatoes to be used as seed tubers at lower altitudes, as virus infection occurs more slowly at higher altitudes and storage is much less challenging (Dhital 2000).

Potatoes are an important crop for food security in Nepal as they produce the greatest amount of dry matter per unit time and area. Several studies have shown that potato production is more profitable than that of food-grain crops (DoAD 1992). Although potatoes are more expensive to grow than cereals, the crop is also more profitable. The average net return from potatoes has been reported to be five times that from cereals (DoAD 1992).

Because of the small landholdings per household and the fact that most agricultural land lies in temperate and sub-temperate areas of the mid and high hills, potatoes are an important crop in Nepal. In higher altitudes (above 2000 m), low temperatures decrease the productivity of cereal crops, so potatoes are the only option for farmers. At 3000–4800 m, potatoes are widely cultivated and, because of the occurrence of micro-climatic areas across the country, potatoes can be grown throughout the year and can be adapted to different cropping patterns (Joshi and Khatri-Chhetri 2000–2001).

From 1975 to 2004, potato productivity increased by 102% (5.88 t/ha to 11.85 t/ha). When Nepal's population was slightly more than 25 million, people consumed an estimated 1.65 Mt of potatoes a year or about 65 kg per capita. This is very high by world standards, about the same as in Peru (the centre of origin of the potato), and over twice the average consumption rate in India. Brown and Scheidegger (1995) estimated that, in 1991/92, per capita consumption was approximately 24 kg in the terai and over twice that, 51 kg, in the hills and mountains.

## Domestication and diversity of the major crops

### Rice

There are 23 species of rice, 21 wild and 2 cultivated in the world. Current species originated in the southeast Himalayan region; many types, varieties, and forms of various qualities are found in Southeast Asia, India, China, Indochina, and Nepal. Yoshida (1978) found that the highest variation in rice species occurs in Nepal, Bhutan, Laos, Vietnam, India, and Yunnan province of China. Rice samples from 500 years ago can be found at Simaraungarh in the Bara district. Different forms of Nepalese rice include early and late maturing varieties; upland, deep water, and floating rice; and Indica (terai regions), Japonica (high hills), and Javanica (mid-hill areas) types.

Various landraces and species of wild rice have been reported by Mallick (1981/82), Adhikari et al. (1995), Sherchand et al. (1998), Shrestha and Upadhyay (1999), Gupta et al. (2000), Rana et al. (2000), Joshi (2004, 2005), and Chaudhary et al. (2004). About 2000 landraces are still under cultivation, some at elevations as high as at 3050 m, the highest rice growing area in the world. Five major rice-growing environments exist based on the source of irrigation: early rice with assured irrigation, main rice with partial or full irrigation, high altitude rice with rainfed or partial irrigation, upland rainfed rice, and submerged deep-water rice. High altitude and upland rice are genotypes genetically adapted to tolerate low water availability and the chilling temperatures in the mountains.

The co-existence of four wild rice species (*Oryza nivara*, *O. rufipogan*, *O. granulata*, and *O. officinalis*) and wild relatives (*Hygrorhiza aristata* Nees and *Leersia hexandra* L.) and cultivation of many traditional varieties on-farm in the form of landraces indicate a high degree of genetic diversity and an important gene pool for rice research (Shrestha and Vaughan 1989, Upadhyay 1995, Joshi 2004, 2005). Rice is grown in all 73 districts of Nepal, except Manag and Mustang.

Weedy rice, *O. sativa* f. *spontanea* is found in rice fields across the country. *O. rufipogon*, one of the wild parents of present-day cultivated rice, is reported to have been found in Nepal at the northernmost limit and the highest altitude in the world (Shrestha and Vaughan 1989). Nepal is considered to be an area of potentially new and useful genes for rice breeders. Some of them are conserved at IRRI in the Philippines and in the NAGRC, Khumaltar.

The diverse cultural values of rice in Nepal also indicate that the country is a centre of diversity of this crop. Wild rice grain has religious significance and is sold at six times the price of cultivated rice. It is used at the *Tij* festival and is considered the purest offering to the gods in Nepal. Local people also use wild species as special food during religious ceremonies and as fodder for livestock.

## Wheat

Wheat is believed to have originated in southwestern Asia in the Fertile Crescent of the Middle East. Some of the earliest signs of the crop have been found in Syria, Jordan, and Turkey. Primitive relatives of present-day wheat have been discovered in some of the oldest excavations of the world in eastern Iraq, which date back 9000 years. Other archeological findings show that bread wheat was grown in the Nile Valley in about 5000 BC as well as in India, China, and even England at about the same time. Man has been dependent on wheat for food and to feed livestock for thousands of years (Gibson and Benson 2002).

The natural evolution of hexaploid wheat began 10000–12000 years ago. The modern semi-dwarf wheat plant was made possible by the introduction of Noren10 (Rht 1 and Rht 2) dwarfing genes from Japan, derived from a Japanese dwarf wheat called Daruma. The highest diversity of hexaploid wheat and its ancestors can be found in Turkey, Tunisia, and eastern Iraq. However, China, India, Russia, the United States, Canada, Australia, Argentina, and the European Union are the major centres of domestication.

Before 1900, the cultivation of bread wheat in Nepal was confined to the far and mid-western hills, although the exact date of the entry of these tall wheat varieties in that area is not known. Wheat is believed to have been introduced in the 16$^{th}$ or 17$^{th}$ century in far-western Nepal from India, and many landraces are still grown by farmers in this area. The wheat landraces (pure spring bread wheat) are widely adapted to withstand abiotic and biotic stresses. Some winter wheat landraces have been reported in the northern high mountain area bordering Tibet. These are generally grown on marginal lands where soil fertility is low and under rainfed conditions. Currently, about 5% of Nepal's total wheat area is devoted to these local landraces.

Many landraces of wheat are also cultivated in western Nepal (Joshi et al. 2006). Cultivated landraces of spring and winter type wild relatives and diploid species of wheat are also found in Nepal.

In 1965, the Department of Agriculture launched a "grow more wheat" campaign, with the introduction of Mexican semi-dwarf varieties, such as Kalyan Sona S227, Lerma Rojo 64, Sonora 64, and Pitic 62. As a result, there was a rapid expansion in wheat area and production in the country. In 1967, Lerma Rojo 64, Sonora 64, and Pitic 62 were recommended for general cultivation. Lerma Rojo 64 become very popular and replaced other varieties because of its high yield and non-lodging trait. In 1968, Kalyan Sona S227 was recommended for plains areas and gained much popularity within for several years before succumbing to leaf rust in 1972/73 (NWDP 1975).

## Lentils

The putative progenitor of the cultivated lentil is *Lens culinaris* subsp. *orientalis* (Boiss), which is found from Greece to Uzbekistan and from the Crimean Peninsula to Jordan (Ladizinsky 1979, Cubero 1981). The oldest carbonized remains of lentils are from the Franchthi cave in Greece dated 11000 BC and from Tell Mureybit in Syria, dated 8500–7500 BC (Zohary 1972, Hansen and Renfrew 1978). As it is not possible to differentiate wild from cultivated small-seeded lentil, the state of domestication of these and other carbonized remains is unknown. However, the finding of a large hoard of lentils (about 1.4 million seeds) at Yiftahel, dated 6800 BC, is suggestive of domestication (Zohary 1992). The oldest lentil seeds that are larger than wild seeds were found at Tepe Sabz, Iran and are dated 5500–5000 BC (Helbaek 1969). The overlap in the distribution of wild lentil and the early archeological records indicates that lentils originated or were domesticated at about the same time as wheat and barley in the Fertile Crescent about 13000 years ago.

From the Near East, the crop spread to the Nile and central Europe via the Danube. Lentils are often found in the early agricultural settlements of the 5$^{th}$ millennium BC in Europe, beyond the original distribution of *L. culinaris* subsp. *orientalis*, indicating its early domestication. Lentils were definitely associated with the start of the "agricultural revolution" in the Old World, which began with the domestication of einkorn and emmer wheat, barley, peas, flax, and lentils (Zohary 1976). The crop was part of the assemblage of Near Eastern grain crops introduced to Ethiopia by the Hamite invaders. From the Bronze Age onward, lentils remained an important companion crop of wheat and barley throughout the expanding realm of Mediterranean agriculture. The eastward dissemination of the Near Eastern grain crops, including lentils, reached Georgia in the 5$^{th}$ and early 4$^{th}$ millennia BC.

The crop appears in the archeological record in India around 2500 BC as part of the Harappan crop assemblage. Alphonse de Candolle (1882) wrote that, on linguistic grounds, it may be supposed that the lentil was not in India before the invasion of the Sanskrit-speaking race (before 2000 BC). The crop probably reached its current Old World range about 3000 years ago. It was carried to the New World after Columbus. The domestication of lentils serves as a good example of how crops have evolved in the hands of humans. Since 7000 BC, lentils have developed into a range of varieties according to local conditions and the preferences of the growers. Unique landraces with high variation in both nutritional composition and appearance exist today.

A collection of 171 lentil landrace accessions from 24 lentil-growing districts of Nepal are conserved at the NAGRC in medium- and long-term storage. However, the use of Nepalese landraces in the breeding program is minimal. About 95% of lentil breeding materials in the National Grain Legume Research Program (NGLRP) are genetic resources received from external sources, especially ICARDA. Aside from ICARDA, major lentil collections are conserved in Australia, Iran, the United States, the Russian Federation, India, Chile, Canada, Turkey, Syria, and Hungary.

## Potatoes

The centre of origin of the potato is the Andean Mountains of South America in the vicinity of Lake Titicaca, near the current border between Peru and Bolivia. Based on archeological evidence, its domestic use began some 8000 years ago. It is believed that once cultivation was started, the crop spread throughout the Andes. In the early 16th century, farmers were cultivating potatoes throughout the high lands of Bolivia, Chile, Columbia, Ecuador, and Peru.

The potato was originally believed to have been domesticated independently in multiple locations, but later genetic testing of the wide variety of cultivars and wild species proved they had originated from a single area in what is now southern Peru and extreme northwestern Bolivia. Potatoes are derived from a species in the *Solanum brevicaule* complex, and were domesticated 7000–10000 years ago. Over 99% of currently cultivated potatoes worldwide descended from varieties that originated in the lowlands of south-central Chile, which displaced formerly popular varieties from the Andean highlands.

There are about 5000 potato varieties worldwide, with about 200 wild species and subspecies. Repeated cross-breeding has transferred resistance to certain pests and diseases from wild to cultivated varieties. The most common species grown worldwide is *Solanum tuberosum* (a tetraploid with 48 chromosomes), and modern varieties of this species are the most widely cultivated. Among cultivated species, there are also four diploids (24 chromosomes), *S.stenotomum*, *S.phureja*, *S.goniocalyx*, and *S.ajanhuiri*; two triploids (36 chromosomes), *S.chaucha* and *S.juzepczukii*; and one pentaploid (60 chromosomes), *S.curtilobum*. *Solanum tubersosum* has two major subspecies: *andigena* (Andean) and *tuberosum* (Chilean).

British Colonel James Kirkpatrick provides evidence of potato cultivation in the 1790s in India (Khairagoli 1979). In 1793, potatoes were introduced into Nepal, initially in the Kathmandu Valley, and there are reports of seed potatoes being brought from Patna to Kathmandu for cultivation. Potatoes are a winter crop in the terai and low hills, a spring and autumn crop in the mid-hills, and a summer crop in the high hills and mountains.The number of days to maturity depends on variety, but is greater at higher altitudes.

In 1957, a trial of 20 varieties of local and exotic potatoes was carried out on experimental farms in Singha Durbar, Parwanipur, and Rapti. However, potatoes remained a relatively minor and unrecognized crop in Nepal until the first official attempt to improve potato production in 1962 under a program sponsored jointly by Nepal and India. In 1966, various agriculture extension offices distributed 276 t of seed potato in 10 mountain districts. The following year, three new potato development programs were established in Kirtipur, Daman, and Jaubari. In 1972, the National Potato Development Program was established to focus on the production of higher-quality tubers.In 1977, under a collaborative program with the Centro Internacional de la Papa (CIP) in Lima, Peru, Nepal received financial and technical support to accelerate its potato research program. This was followed by the establishment of greenhouses for seed production and a tissue culture laboratory in 1978 with financial and technical support from the government of Switzerland.

## Research on major crops

### Rice research in Nepal

Research on local rice varieties began before 1951 (Mallick 1981/82). Promising local varieties included Tauli, Marshi, and Thapachiniya, and several Japanese varieties were introduced in 1951. In the late 1950s, a number of rice varieties were also introduced from the Philippines, India, and the United States and tested in Kathmandu Valley. China-13, CH45, and N136 were introduced from India in 1958. CH45 was tested in Kathmandu and Parwanipur and then released for general cultivation in 1959. BR34 and BR8 varieties were introduced from India in 1961 and later released for cultivation in the terai. In 1965, Taichung Native-1, the first dwarf indica variety was introduced from India. However, the revolution in rice improvement in Kathmandu started in 1964 when nine varieties were introduced from Taiwan, followed by 16 varieties from IRRI in the Philippines, and 14 from India in 1966.

During the mid-1960s the yield potential of semi-dwarf, high-yielding varieties showed promise for increasing rice production in the country. Several exotic varieties were obtained through IRRI and from Taiwan (NRRP 1997). In 1972, the National Rice Improvement Program was established at Parwanipur to organize the research and development of rice as a commodity crop.

Rice breeding for heterosis began in 1999 (Joshi 2000). Beginning in 2002, the National Rice Research Program, Hardinath, conducted systematic research on hybrid rice through the International Network for Genetic Evaluation of Rice. This was discontinued in 2005 because of a policy change at IRRI. During this period, some farmers started to cultivate hybrid rice, especially in the terai, inner terai, and foothills. The seed source was mainly India and, to a lesser extent, China. The rice research program also evaluated some rice hybrids originating in India and China, and, after a year of evaluation, the best ones — three from China and 14 from India — were registered with the government for general cultivation. After the country became a formal member of the hybrid rice consortium in 2011, it again began to receive hybrid germplasm from IRRI in 2012.

### Wheat breeding research in Nepal

Historically, breeding and research on bread wheat in Nepal can be divided into three periods: the introduction and selection of tall wheat during the late 1950s and early 1960s; the introduction of Mexican high-yielding, input-responsive, and widely adaptive semi-dwarf wheat during the mid and late 1960s; and the establishment of the National Wheat Research Program in 1972.

Wheat breeding in the form of selection from exotic material started in 1953, but was intensified during the late 1960s (Bhattarai 1976). Before 1960 and in the early 1960s, several varieties in the New Pusa (NP) series from India and others from elsewhere were introduced into Nepal for experimental purposes (Basnet 1967, Bhattarai 1976).

During the early 1960s, wheat breeding research concentrated on selection of non-lodging, high-yielding, disease-resistant genotypes introduced from India and other wheat-growing countries (Basnet 1967). The outcome of early work (1958–1960) was identification of a tall but relatively high-yielding wheat variety, Lerma-52, which yielded 2177 kg/ha and was released in 1960 for use in the hilly region (Basnet 1967). Lerma-52 is the first improved cereal variety released in the history of cereals research in Nepal, and, within a few years, it became very popular in hill areas (Bhattarai 1976). It is well adapted under rainfed, low fertility conditions, throughout the mid and high hills regions. Although it succumbed to leaf rust during the early 1970s, its popularity among western hill farmers continued until the early 1980s.

In 1962, NP809 was recommended for the hill regions, but did not become popular because it was awnless (thus, damaged by birds) and late maturing (Basnet 1967). Kenya 291, also recommended for hill farmers, failed to gain popularity (Basnet 1967). During the same period, several varieties, such as NP835, NP852, and NP884, were recommended for the plains, which encouraged terai farmers to grow wheat (Basnet 1967, Bhattarai 1976).

In 1965/66, Mexican semi-dwarf wheat with its adaptability to wider areas and increased production was introduced through the Grow More Wheat campaign. This encouraged policymakers and agriculturists to establish an autonomous coordinated National Wheat Research Program (NWRP) in 1972.

NWRP was flooded with wheat genetic materials from CIMMYT ($F_2$ segregating populations, international nurseries, elite wheat yield trials, etc.), from India (uniform regional yield trials, now called advanced trials), and from ICARDA (nurseries and yield trials). During the 1970s, breeding concentrated mainly on introduced germplasm in the form of finished materials and $F_2$ segregating populations from CIMMYT and other national programs. A more specific crossing and selection program using genetically diverse germplasm from CIMMYT was initiated only after the mid-1980s.

Since the establishment of CIMMYT's South Asia Regional Office in Nepal, a strong germplasm exchange network has developed among CIMMYT and neighbouring countries adding new genetic variability for increased grain yield, disease resistance, and adaptation to environmental stresses. CIMMYT also provided the necessary support for wheat breeding research activities at NWRP and the Agriculture Botany Division at Khumaltar.

NWRP breeders used CIMMYT parent material extensively in crossing programs to develop such cultivars as Pavon-76, Nacozari-76, Parula, Alondra, Garuda, Junco, Trap-1, Mango, Chilero, Crow, Banks, Papago, Veery, and Super Kauz, to incorporate resistance to leaf and stripe rusts. Also several gene pools for Helminthosporium leaf blight (HLB) resistance from Brazil, Zambia, China, and CIMMYT were introduced into the NWRP wheat breeding program and several hundred elite germplasm materials resistant to HLB were developed at NWRP as a result of successful CIMMYT/NWRP joint breeding efforts. Later, during the mid- and late-1990s, several HLB-resistant lines were distributed regionally and internationally through CIMMYT's South Asia Regional Office.

From 1997 to 2009, CIMMYT and the NWRP jointly coordinated the Eastern Gangetic Plains (EGP) research partnership, a regional wheat germplasm and research information network. The purpose of the EGP network was to assemble elite wheat lines provided by National Agricultural Research System (NARS) breeders working in eastern and far-eastern India, Bangladesh, and the terai of Nepal and to distribute and test them in the EGP. The main goal was to identify, select, and share improved wheat germplasm with combined resistance/tolerance to HLB, leaf rust, and heat stress as well as appropriate adaptation and high-yield potential. The germplasm was distributed in the form of screening nurseries and yield trials each season. Many wheat breeders in the region benefited from this network, and Bangladesh alone released two wheat varieties as a result of this work: Bejoy (NlL297*2/LR25) and Pradip (G162/BL1316//NL297).

## Lentil research in Nepal

Research on grain legumes started in 1972 on farms in Parwanipur and Khumaltar. Later in 1977, the Grain Legumes Research Project was initiated at Khumaltar to strengthen grain legume research and development in the country. Lentil research received strong emphasis after the establishment of the National Grain Legumes Improvement Program at Rampur in 1986, later renamed National Grain Legume Research Program (NGLRP) after the establishment of the Nepal Agricultural Research Council (NARC).

Ten varieties have been released so far for cultivation in various agro-ecological zones — all are in the microsperma subclass. These released varieties were developed using various breeding strategies. For instance, Sindhur was selected from a Nepalese landrace; Simrik, Sisir, Simal, Shital, Khajura Masuro-1, Sikhar, and Khajura Masuro-2 were locally selected from genotypes of South Asian origin, which were introduced from India and Syria. Sagun and Maheswor Bharati are from crosses of South Asian and West Asian materials, specifically to suit conditions in Nepal; they produce 40–60% higher yield and 20–30% larger seeds, compared with the released varieties, Shital and Simal, and are resistant to moderately resistant to *Stemphylium* blight and wilt disease. Simal, released in 1990, is the most popular and widely adopted variety in Nepal because of its medium bold seed and suitability for relay-cropping with rice. NGLRP receives genetic materials each year in the name of Lentil International Elite Nurseries for screening against biotic and abiotic stresses.

## Potato research in Nepal

In the early days, the focus was mainly on the introduction of imported potato varieties and the selection multiplication of promising clones at various horticulture farms and in the Plant Pathology Division of NARC. The earliest cultivar, Kufri Jyoti, was introduced from India in the 1960s and selected at Jaubari Potato Farm, Ilam, during early 1970s (Dhital 2000).

Over the last 25 years, germplasm has been received regularly, mainly from CIP, in the form of tuberlets, true potato seed (TPS) varieties, or in vitro plantlets. Since 1980, the National Potato Research Program (NPRP) has been working on variety development, focusing on higher tuber yield, pest and disease resistance, consumer preference, and processing. Variety testing and selection are the fundamental activities. NPRP has released 10 potato varieties for different agro-ecological regions and registered two TPS progenies.

NPRP has a research agreement with CIP to obtain germplasm, and almost all varieties of potato have been developed from exotic germplasm. Among the released varieties, Janak Dev is popular in the mid-hills and occupies the largest area (15% of potato-growing area), followed by Khumal Seto-1 (7%), which is drought tolerant and suitable for rainfed conditions. Currently, NPRP receives germplasm from 60 varieties of potato annually from CIP in two forms: true seed families (crossed seeds or lines) and in vitro material (diploid and tetraploid varieties). The in vitro material is obtained as two plantlets of each genotype, based on the import permit. Crossed seeds are used for evaluation, whereas the diploid and tetraploid material is mostly used for developing biofortified varieties by crossing.

## Factors related to making modern varieties popular

Strong research and development, along with good collaboration among organizations, are needed to develop more farmer-friendly varieties of rice, wheat, lentils and potatoes in Nepal. Various commodity programs have developed strong coordinated research networks at national and international levels to produce high-yielding, disease-resistant, and heat-tolerant varieties for different agro-ecological regions. Strong links between research and extension systems along with government support and such strategies as mini-kits, farmers' fields trials, participatory varietal selection, diversity kits, and informal research and development incentives, have also played a significant role in making modern varieties popular.

The continuous flow of germplasm from CGIAR centres as well as from India and China has enabled Nepalese breeders to develop new varieties and provide a choice of varieties to farmers. Nepal releases an average of six new varieties annually, along with accompanying management practices. At present, improved varieties cover about 97% of the area devoted to major crops.

Efficient breeding practices have also helped develop a large number of varieties. For example since 1996, a resource efficient system of bulk selection is being used. Shuttling of generation lines (growing a crop in two successive season a year) during the off season has become an integral part of breeding to speed up the varietal release process. This has become possible because of the varied agro-ecological diversity in the country.

Area, production, and productivity of lentils have increased by 111%, 257%, and 69%, respectively, between 1985 and 2011. The large increases in production and area show that farmers are shifting toward pulses, particularly lentils, because of their high value and export potential. NGLRP has been highly instrumental in popularizing lentils. It has not only released 10 varieties suitable for cropping systems, but it also developed cost-effective production technologies, such as zero tillage, and distributed improved seed kits along with technology demonstration packages to farmers and increased awareness among farmers about the economic, nutritional, and soil health benefits of lentils.

ICARDA has strong ties with national program partners, such as NGLRP, to harness specific comparative research advantages. Crosses are made as agreed with cooperators and segregating generations are grown at ICARDA. The selection of bulk segregating populations is then undertaken in the target environment by national programs. This functional collaboration between NGLRP and ICARDA is another influencing factor compelling Nepal's government to emphasize research on this crop.

Special periodic projects and programs, such as the Secondary Crop Program of the Department of Agriculture; the government's Lentil Mission; the Ministry of Agricultural Development; the Australian Centre for International Agricultural Research; the Centre for Legumes in Mediterranean Agriculture; the International Fund for Agriculture Development (IFAD-954); OPEC-Funded International Development; USAID-funded Nepal Economic, Agriculture and Trade (NEAT) Project; and CGIAR's Bio-fortification Harvest Plus Challenge Program, have played significant roles in promoting and popularizing lentils in Nepal.

## References

Adhikari NP, MM Plaikhe and RN Devkota. 1995. Status of rice, maize and wheat genetic resources in Nepal. **In** *Plant Genetic Resources: Nepalese Perspective*. Proceedings of national workshop, 28 Nov–1 Dec 1994. MP Upadhyay, HK Saiju, BK Baniya and MS Bista (eds). International Plant Genetic Resources Institute, Rome, Italy. pp.74–77.

APP. 1995. Nepal agriculture perspective plan (APP). National Planning Commission, Government of Nepal, Kathmandu, Nepal; Agricultural Project Services Centre and John Mellor Inc., Washington, DC, USA.

Basnet NB. 1967. Review of wheat varietal trials conducted in Nepal since 1961–1966. *Nepalese Journal of Agriculture* 4:5–16.

Bhattarai AN. 1976. Wheat varietal research in Nepal. *Nepalese Journal of Agriculture* 6:3–15.

Brown K and U Scheidegger. 1995. Seed study for six countries. Swiss Development Corporation, Bern, Switzerland; International Potato Centre, Lima, Peru.

Chaudhary P, D Gauchan, RB Rana, BR Sthapit and DI Jarvis. 2004. Potential loss of rice landraces from a terai community of Nepal: A case study from Kachorwa, Bara. *Plant Genetic Resources Newsletter* 137:14–21.

Cubero JI. 1981. Origin, taxonomy and domestication. **In** *Lentils*. C Webb and G Hawtin (eds). Commonwealth Agricultural Bureau, Farnham, UK. pp.15–38.

de Candolle AP. 1959. *Origin of Cultivated Plants* (reprint). Hafner, London, UK.

Dhital BK. 2000. Diffused light storage of seed potatoes in the hills of Nepal in relation to seed tuber physiology, production environment and socio-economics. *PhD Thesis*. University of Newcastle upon Tyne, Tyne and Wear, UK.

DoAD. 1992. Cost of production and returns of major crops in Nepal. Economic Analysis Division, Department of Agricultural Development (DoAD), Harihar Bhawan, Lalitpur, Nepal.

FAO. 2012. Production of lentils by countries. Food and Agriculture Organization (FAO), United Nations, Rome, Italy. Last accessed on 21 February, 2014 available at http://faostat.fao.org/site/339/default.aspx.

Gautam P. 2008. Magnetic fabric of Siwalik sediments (Nepal): Implications to time-space evolution of stress field. *Journal Nepal Geology Sociology* 38:39–48.

Gauchan D, M Smale, N Maxted, M Cole, BR Sthapit, D Jarvis and MP Upadhyay. 2005. Socioeconomic and agroecological determinants of conserving diversity on-farm: the case of rice genetic resources in Nepal. *Nepal Agriculture Research Journal* 6:89–98.

Gibson L and G Benson. 2002. History and origin of wheat. Department of Agronomy, Iowa State University, Ames, Iowa, USA.

Gupta SR, MP Upadhyay and DM Dongol (eds). 2000. Nepalese germplasm catalogue – 2000. Agriculture Botany Division, Nepal Agricultural Research Council, Khumaltar, Nepal.

Hansen J and JM Renfrew. 1978. Paleolithic-neolithic seed remains at Franchthi cave, Greece. *Nature* 71:349–352.

Helbaek H. 1969. Plant collecting, dry-farming and irrigation agriculture in prehistoric Deh Luran. **In** *Prehistory and Human Ecology of the Deh Luran Plain: An Early Village Sequence from Khuzistan*. F Hole, KV Flannery and JA Neely (eds). University of Michigan Press, Ann Arbor, Michigan, USA. pp.383–426.

Joshi BK and RB Khatri-Chhetri. 2000–2001. Production trend in rice and potato based cropping patterns. *Journal of the Institute of Agriculture and Animal Science* 21–22:9–18.

Joshi BK, A Mudwari and MR Bhatta. 2006. Wheat genetic resources in Nepal. *Nepal Agriculture Research Journal* 7:1–10.

Joshi BK. 2000. Heterosis for yield and yield components in rice. *Nepal Agriculture Research Journal* 4:6–13.

Joshi BK. 2004. Rice gene pool for mid and high hills and its conservation in Nepal. **In** *Agricultural Research for Enhancing Livelihood of Nepalese People*. BK Joshi, SL Joshi and KP Paudyal (eds). Proceedings of second SAS-N Convention, 30 July - 1 Aug. 2003, Kathmandu, Nepal. pp.252–264.

Joshi BK. 2005. Rice gene pool for tarai and inner tarai areas of Nepal. *Nepal Agriculture Research Journal* 6:10–23.

Khairagoli LP. 1979. *Potato Production*. Sarita Khairagoli, Sahayogi Printing Press, Kathmandu, Nepal

Ladizinsky G. 1979. The origin of lentil and its wild gene pool. *Euphytica* 28:179–187.

Mallick RN. 1981/82. *Rice in Nepal*. Kala Prakanshan, Kathmandu, Nepal.

MFSC. 2002. Nepal biodiversity strategy. Ministry of Forest and Soil Conservation (MFSC), Singh Durbar, Kathmandu, Nepal.

MoAD. 2012. Statistical information on Nepalese agriculture (2012). Ministry of Agricultural Development (MoAD), Agribusiness Promotion and Statistics Division, Government of Nepal, Singha Durbar, Kathmandu, Nepal.

Morres ML, HJ Dubin and T Pokhrel. 1992. Economic returns to wheat research in Nepal. *Journal of Economics*.

NGLRP. 2013. *Annual Report 2069/70 (2012/13).* National Grain Legume Research Program (NGLRP), Nepal Agricultural Research Council, Chitwan, Nepal.

NRRP. 1997. *25 Years of Rice Research in Nepal (1972–1997).* National Rice Research Program (NRRP), Nepal Agricultural Research Council, Kathmandu, Nepal.

NWDP. 1975. *Annual Report*. National Wheat Development Program (NWDP), Nepal Agricultural Research Council, Kathmandu, Nepal.

Rana RB, P Chaudhary, D Gauchan, SP Khatiwada, BR Sthapit, A Subedi, MP Upadhyay and DI Jarvis. 2000. In situ crop conservation: Findings of agro-ecological, crop-diversity and socio-economic baseline survey of Kachorwa ecosite, Bara, Nepal. Working paper 1/2000. Nepal Agricultural Research Centre; Local Initiatives for Biodiversity, Research and Development, Kathmandu, Nepal; International Plant Genetic Resources Institute, Rome, Italy.

Sherchand KK, NP Adhakari, SP Khatiwada, AC Shrivastav, J Bajracharya, KD Joshi, KB Kadayat, M Chaudhary, P Vhaudhary, SS Vishwakarma and S Yadav. 1998. Strengthening the scientific basis for in-situ conservation of agrobiodiversity: Findings of site selection in Bara, Nepal. Working paper 2/98. Nepal Agricultural Research Council, Kathmandu; Local Initiatives for Biodiversity, Research, and Development, Pokhara, Nepal; International Plant Genetic Resources Institute, Rome, Italy.

Shrestha GL and MP Upadhyay. 1999. Wild relatives of cultivated rice crops in Nepal. **In** *Wild Relatives of Cultivated Plants in Nepal.* Proceedings of national conference, 2–4 June 1999, Kathmandu. R Shrestha and B Shrestha (eds). Green Energy Mission, Kathmandu, Nepal. pp.72–82.

Shrestha GL and DA Vaughan. 1989. The wild relatives of rice in Nepal. **In** *Proceedings of the 6th International Congress of SABRAO.* S Lyama and G Takedo (eds). Society for the Advancement of Breeding Research in Asia and Oceania, Tsukuba-machi, Japan.

Upadhyay MP. 1995. Food crop genetic resources. **In** *Plant Genetic Resources: Nepalese Perspectives*. Proceedings of the national workshop on plant genetic resources conservation, use and management, 28 Nov– 1 Dec 1994. Nepal Agriculture Research Council, Khumaltar, Nepal.

Upadhyay MP and BK Joshi. 2006. Nepal. **In** *Plant Genetic Resources in SAARC Countries: Their Conservation and Management*. South Asian Association for Regional Cooperation, Kathmandu, Nepal. pp.297–422.

Yoshida T. 1978. Japan's agricultural technology. Its characteristics and outlook. *Farming Japan* 12:10–20.

Zohary D. 1972. The wild progenitor and place of origin of the cultivated lentil: *Lens culinaris*. *Economic Botany* 26(4):326–332.

Zohary D. 1976. Lentil. **In** *Evolution of Crop Plants.* NW Simmonds (ed). Longman, London, UK. pp.163–164.

Zohary D. 1992. Domestication of the neolithic near eastern crop assemblage. **In** Préhistoire *de l'agriculture: nouvelles approches expérimentales et ethnographiques* (monograph 6). PC Anderson (ed). Centre national de la recherche scientifique, Paris, France. pp.81–86.

# Chapter II : Mapping and measuring the flow and interdependence of plant genetic resources

Bal Krishna Joshi, Madan Raj Bhatta, Krishna Hari Ghimire, Pashupati Chaudhary and Deepa Singh

## Key messages

- Over 100 organizations in Nepal work with plant genetic resources. The national gene bank is playing vital role in germplasm flow within the country.
- There is no restriction on the exchange of germplasm within Nepal, but when it comes to commercialization, the National Seed Board should assume a leadership role in the registration and release of varieties.
- Breeding programs and seed suppliers are independently collecting PGRs from within Nepal as well from CGIAR centres and from India and China, mainly using the Standard Material Transfer Agreement (SMTA), and registering and commercializing those varieties.
- The National Wheat Research Program receives more than 1000 genotypes annually; 14 International Network for Genetic Material Evaluation and Research nurseries are received from the International Rice Research Institute each year, each consisting of 30–100 genotypes; and more than 50 genotypes of potatoes are received annually from Centro Internacional de la Papa.
- About 73% of the released varieties in the country (about 80% for wheat, potatoes, and lentils alone) have ancestors that come from outside Nepal and 27% have ancestors originated in Nepal.
- 47 landraces originating in 12 countries were used to develop 20 mid- and high-hills rice cultivars and 35 landraces originating in 11 countries were used to develop 28 terai rice cultivars. 13 landraces originating in eight countries were used to develop the Khumal-4 rice variety.
- Only exotic parents were used to develop all 35 modern wheat varieties: 89 ancestors originated in 22 countries, most from the United States (13%), India (13%), France (12%), Argentina (6%), and Italy (6%).
- Only exotic parents were used to develop eight modern varieties of potato in Nepal; most were from Germany. 11 varieties of lentils have been released so far, only one was bred in Nepal.
- Nepal is 95–100% dependent on foreign germplasm for varietal development, and this dependency is expected to increase with climate change as pest and disease outbreaks in major crops resulting from increased heat, drought, and erratic rainfall.

The strong interdependence of countries on plant genetic resources (PGRs) for food and agriculture is a key rationale for the creation of the multilateral system (MLS) of access and benefit sharing under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). Because of improved infrastructure, increased mobility, globalization, and bilateral and multilateral agreements, the flow of genetic materials is increasing. Interdependence is also likely to increase as a result of the impact of climate change on agriculture and the need to find germplasm with adaptive traits. However, most people are unaware of the current and future importance of interdependence and how the flow of genetic materials between countries contributes to national food security. Nepal is no exception in this regard.

To effectively implement the MLS and facilitate exchange of genetic materials, it is important to generate empirical evidence of the extent to which Nepal is dependent on foreign-sourced PGR for its agricultural research and development (including breeding) and, ultimately, food security. It is also important to examine the flow of PGRs: how these resources are used for agricultural research and development and what the pedigree of varieties important for food security looks like. It is also important to understand the gap in understanding of stakeholders on constraints and opportunities for the exchange of PGRs through the MLS.

In this chapter, we describe and illustrate the patterns of germplasm flow and their contribution to the development of modern crop varieties. We analyze the pedigree of modern varieties of selected crops that are important for national food security, identify the origin of ancestors of these modern varieties, and document key stakeholders' perceptions of the pros and cons of exchange of PGRs through the MLS. This will improve understanding of these subjects and provide information needed for policymaking.

## Methods

### Identification of major institutions involved in PGRs

Based on an inter-agency meeting, a review of the literature, and an Internet search, the following major institutions were identified as key actors in terms of PGR flows and related information.

- International gene banks (CGIAR centres)
- Foreign national gene banks
- National gene banks
- Department of Agriculture under the Ministry of Agricultural Development, other government departments, and university units
- Regional PGR and crop improvement networks
- Community seed banks
- Plant breeding programs in the public and private sectors
- Participatory breeding programs or initiatives
- NGOs and other organizations involved in seed delivery

## PGR flows and related uses

We gathered information related to Nepal's reliance on PGRs originating in other countries. Information and data were compiled on germplasm flows and uses and variety pedigrees from the following sources: CGIAR centres, the National Agriculture Genetic Resources Centre (national gene bank), breeders and researchers in Nepal, NGOs, farmers, and detailed pedigree analysis of modern varieties released in Nepal.

Four crops were identified for detailed study: rice, wheat, lentils, and potatoes. Three key issues were researched: PGR flows into, within, and out of the country and related uses; factors influencing flows of PGRs into, within, and out of the country; and stakeholders' perceptions of constraints and opportunities related to PGR exchange in the future.

Information was collected by visiting four commodity research programs: the National Rice Research Program (NRRP) at Haridnath; the National Wheat Research Program (NWRP) at Bhairawa; the National Potato Research Program (NPRP) at Khumaltar; and the National Grain Legumes Research Program (NGLRP) at Rampur. During visits, we interviewed breeders and reviewed their data and relevant literature. We also visited two community seed banks (Dalchoki and Kachorwa). Views on germplasm flows were gathered through email discussions with Nepal Agricultural Research Council (NARC) personnel. The organizations are also listed below.

- Rice: NRRP, NARC's Agriculture Botany Division (ABD), farmers (Community Seed Bank in Kachorwa), Seed Entrepreneurs' Association of Nepal (SEAN), and the International Rice Research Institute (IRRI)
- Wheat: NWRP, the International Maize and Wheat Improvement Centre (CIMMYT), ABD, farmers, and seed companies (Kalika Seed Company, Bhairahawa, and Lumbini Seed Company)
- Lentils: NGLRP, the International Center for Agricultural Research in the Dry Areas (ICARDA), and the Agronomy Division of NARC
- Potatoes: the Centro Internacional de la Papa (CIP), NPRP, and farmers (at Panchakhal, Hemja, and Dolakha)

Information on determinant factors was collected through focus group discussions, and interviews with breeders and community seed bank managers were organized to obtain information on factors influencing flows of PGRs and stakeholders' perceptions of constraints and opportunities relating to PGR exchange in the future

## Pedigree of modern varieties released in the country

For the four key crops, we reviewed crop improvement and crop-specific pedigree literature, including plant breeders' data books, and interviewed breeders. Pedigree information on released varieties was obtained from national and international literature and the International Crop Information System maintained by CGIAR centres.

We gathered information on the total number of released varieties, the origins of modern varieties, the proportion of genetic material from ancestors in modern varieties, and the origin of the ancestors and their role in developing modern varieties. The number of native and exotic parents used in developing a variety was traced as far back as possible. This information was used to create a pedigree tree for each modern variety (**Figure** 2.1).

Detailed pedigrees of 48 rice varieties were traced back to their ancestors, and the origins of those ancestors were documented. Rice varieties were categorized according to their suitability for mid-hill, high-hill, and terai regions.

The genetics of a rice variety were estimated using the following formula:

$$A_i = \sum_{i=n}^{A} \frac{1}{2N}$$

where, $A_i$ is the proportion of genetic material derived from an ancestor, $N$ is the total number of crosses made after the appearance of the ancestor's DNA in the pedigree tree, and $n$ is the number of times the ancestor appeared in the pedigree tree.

The genetic proportion of all ancestors in the modern cultivar was computed for all pair-wise combinations. The assumptions for estimating genetic portion (contribution of ancestors) were those described by Delannax et al. (1983) and Joshi (2006).

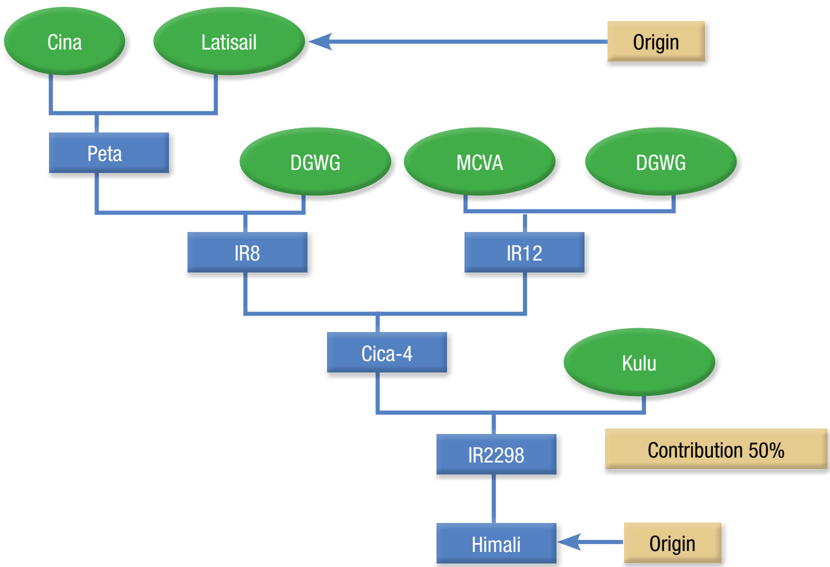

Figure 2.1. Pedigree tree for Himali rice.

Pedigree trees for 35 wheat cultivars released between 1960 and 2001 were also developed and analyzed. Sources of information were mainly Jain (1994), NARC (1997), Bland (2001), Skovmand et al. (1997), Joshi and Mudwari (2003), and Skovmand et al. (2000). Pedigree information and analysis were based on the International Wheat Information System (IWIS$^{TM}$, version 4).

The total number of released varieties of lentils and potatoes along with their origins were documented. Information on the ancestors, origins, and pedigree of these modern varieties is limited.

## Institutions providing information on PGR flows

More than 100 organizations are working on PGRs (**Table** 2.1).

**Table 2.1. Institutions identified for collection of information on PGR flows into, within, and out of Nepal**

| Category | Institutions |
|---|---|
| International gene banks (CGIAR centres) (5) | IRRI, Philippines; CIMMYT, Mexico; CIP, Peru; International Crops Research Institute for the Semi-Arid Tropics, India; ICARDA, Syria |
| Foreign national gene banks (9) | National Institute of Agrobiological Sciences, Japan; United States Department of Agriculture, United States; National Bureau of Plant Genetic Resources, Indian Grassland and Fodder Research Institute, India; United Kingdom; Germany; Canada; Switzerland; Korea; New Zealand |
| National gene banks (3) | National Agriculture Genetic Resources Centre; Nepal Academy of Science and Technology Gene Bank; Himalayan Seed Bank |
| Department of Agriculture under the Ministry of Agricultural Development, other departments, and universities (34) | Horticulture farms at Solukhumbu, Sindhuli, Panchkhal, Godawari, Trishuli, Daman, Boch (Dolakha), Marpha (Mustang), Palpa, Jumla, Dadeldhura, Dailekh, Baitadi, Humla, Yagyapuri (Chitawan); Extensive Horticulture Farm, Sarlahi; Horticulture Centre, Kirtipur; Root/ tubers Crop Development Centre, Sindhuli; Vegetable Development Farm, Khumaltar; Nucleus Potato Centre, Nigale (Dolakha); Vegetable Development Farm, Rukum; Pasture and Grasses Seed Production Farms, Janakpur; Ranjitpur, Sarlahi; Gaughat (Banke); Tissue Culture Laboratory, National Herbarium and Plant Laboratory, Godavari, Department of Plant Resources; Central Department of Botany, Tribuvan University, Kirtipur, Kathmandu; HICAST, Purbanchal University, Ghattaghar, Bhaktapur; Agriculture and Forestry University, Rampur (Chitwan); Institute of Agrculture and Animal Science, Lamjung, Paklihawa, Tribhuvan University; Kathmandu University, Dhulikhel, Kavre; Nepal Academy of Science and Technology, Khumaltar, Lalitpur; Seed Quality Control Centre, Hariharbhawan (Lalitpur); National Spices Development Program, Khumaltar; Agriculture Inputs Company Ltd, Teku, Kathmandu; National Seed Company Ltd, Kathmandu; Council for Technical Education and Vocational Training, Thimi (Bhaktapur) |
| Regional PGR and crop improvement networks (7) | South Asia Network on Plant Genetic Resources; Asian Vegetable Research and Development Centre, Taiwan, China; South Asian Association for Regional Cooperation, Dhaka, Bangladesh; Asian Network for Small Scale Agricultural Biotechnolgies, Lajimpat; Asian Grain Legume Network; Asia Network on Sweet Potato Genetic Resources; Taro Network for Southeast Asia and Oceania |
| Community gene banks (4)* | Dalchowki Community Seed Bank, Lalitpur; Kachorwa Community Seed Bank, Bara; Simariya Community Seed Bank, Sunsari; Gadhariya Community Seed Bank, Kailali |
| Plant breeding programs in the public (NARC) and private sector (28) | National Rice Research Program, Baniniya, Hardinath; National Maize Research Program, Rampur, Chitwan; National Wheat Research Program, Bhairahawa, Rupandehi; National Potato Research Program, Khumaltar, Lalitpur; National Grain Legumes Research Program, Rampur, Chitwan; National Oilseeds Research Program, Nawalpur, Sarlahi; Hill Crops Research Program, Kavre, Dolakha; Sugarcane Research Program, Jitpur, Bara; Ginger Research Program, Salyan; Citrus Research Program, Paripatle, Dhankuta; Jute Research Program, Itahari, Sunsari; Agriculture Botany Division, Khumaltar, Lalitpur; Horticulture Research Division, Khumaltar, Kathmandu; Commercial Crops Division, Khumaltar, Kathmandu; Pasture and Grasses Research Division, Khumaltar, Kathmandu; Regional Agricultural Research Center, Khajura, Nepalganj; Agricultural Research Station, Surkhet; Agricultural Research Station, Doti; Agricultural Research Station, Jumla; Agricultural Research Station, Dailekh; Agricultural Research Station, Rajikot, Jumla; Regional Agricultural Research Center, Lumle; Agricultural Research Station, Malepatan, Pokhara; Regional Agricultural Research Center, Parwanipur; Agricultural Research Station, Rasuwa; Agricultural Research Station, Belachapi, Dhanusa; Regional Agricultural Research Center, Tarahara; Agricultural Research Station, Pakhribas, Dhankuta |

| Category | Institutions |
|---|---|
| International/National Non-Governmental Organizations (I/NGOs) and other organizations involved in seed delivery (30) | Forum for Rural Welfare and Agricultural Reform for Development; Center for Environmental and Agricultural Policy Research, Extension and Development; Seed Entrepreneurs' Association of Nepal; Action Aid Nepal; Local Initiatives for Biodiversity, Research and Development; Oxfam; Group of Helping Hands (SAHAS); Tissue Culture Factory, Godavari; Nepal Biotech Nursery; Research Laboratory for Agricultural Biotechnology and Biochemistry; Rural Reconstruction Nepal (RRN); Helvetas; International Centre for Integrated Mountain Development; Nepal Permaculture Group; International Corn Foundation; Lutheran World Federation; Plan International; Care Nepal; Natural Resources and Agriculture Management Center; Nepal Agricultural Technical Association; Agriculture Enterprise Center; Coffee Promotion Project-Helvetas (COPP); Lumbini Seed Company; Universal Seed Company; Anmolbiu Seed Company; Kalika Seed Company; Sidhartha Seed Company; Everest Seed Company; Global Agro Tech; Nepal Agro-Forestry Foundation (NAF) |

* Only community seed banks working directly with the National Agricultural Genetic Resources Center are listed.

At the local level, more than 100 community seed banks have been established for managing PGRs, making access easy for local communities across the country (Joshi 2013). They are generally dealing with landraces and improved varieties.

## Flow and use of PGRs

The import and export of germplasm in Nepal has not been systematized, and rules and regulations are not strictly followed. Import and export of germplasm is currently under the authority of the Seed Quality Control Centre and the National Plant Quarantine Office. However, a considerable amount of germplasm enters and leaves the country "informally."

Varieties and landraces are registered, listed, and released through the Seed Quality Control Centre. Both the public and private sectors can request registration of a variety or landrace. Once listed, a variety or landrace can be commercialized. NARC is the main public organization responsible for developing varieties using both national and international gene pools. Most released varieties are based on material developed at CGIAR centres.

The National Agriculture Genetic Resources Centre (NAGRC) plays a vital role in germplasm flow within the country. It currently holds approximately 11000 accessions collected from farming communities. Duplicates of some of these accessions are being made available internationally through CGIAR centres, which have acquired material from Nepal at various times. For example, IRRI holds 3000 accessions of rice originally collected from Nepal. Recently, Nepal sent duplicate samples of approximately 2000 accessions of rice, barley, finger millet, and wheat to IRRI, ICARDA, and CIMMYT (www.genesys.pgr.org).

Four community seed banks recently deposited genetic material in the NAGRC. These holdings may be redistributed within Nepal and farmers have direct access to all germplasm conserved in the gene bank. Other community seed banks and individual farmers are willing to conserve material in the NAGRC. Within the country, germplasm exchange is easy and without restriction.

Registration and commercialization of varieties developed in India and China is increasing in Nepal, and registration of landraces has also started.

A large number of improved materials are being transferred from CGIAR centres' breeding programs to Nepal. Breeding programs and seed suppliers are independently collecting PGRs in Nepal as well from CGIAR centres and from India and China. Increasingly, research stations are also requesting germplasm from the NAGRC, while also sending local collections to the gene bank. Generally, material from CGIAR centres is subjected to the Standard Material Transfer Agreement adopted by the ITPGRFA's governing body.

Major crops introduced regularly from outside the country are rice, wheat, maize, potatoes, lentils, some vegetables, and some forage crops. Rice, wheat, and some vegetables are regularly sent to other countries, mainly Bhutan, India, and Kenya, for research and production. Some vegetables are regularly exchanged within countries of the South Asian Association for Regional Cooperation.

## Germplasm from CGIAR centres

Established in 1972, the Co-ordinated Rice Research Program (later called NRRP) has developed links with IRRI for the exchange of germplasm. The NRRP has been acquiring International Network for Genetic Evaluation of Rice (INGER) nurseries of rice from IRRI for testing under different agro-ecological conditions; 14 nurseries are received annually, each consisting of 30–100 genotypes. In 2010, NRRP sent three rice varieties for INGER evaluation through IRRI. Similarly, Nepal receives more than 50 potato genotypes yearly from the CIP.

Since 1970, Nepal's NWRP has been receiving wheat breeding nurseries and trials from CIMMYT. It receives more than 1000 genotypes annually (**Figure** 2.2); however, the number of genotypes varies. New trials and nurseries are added to address various biotic and abiotic stresses and find high-yielding lines.

In turn, NWRP has been sending 100–125 advanced lines that it has developed to Kenya every year since 2005, as well as some selected $F_3$ and $F_4$ crosses (40–60) of segregating populations every year for screening against Ug99 (wheat stem rust). In addition, NWRP and wheat research programs in Bangladesh share advanced lines of wheat.

Beginning in 1997 and ending in 2005, advanced lines from Nepal (100) and Bangladesh (50) and a few varieties from India were included annually in the Eastern Gangetic Plains Wheat Breeding Program, a collaboration among the three countries. In addition, in the 1990s, Nepal shared wheat genetic materials, particularly Helminthosporium Leaf Blight resistant germplasm, regionally and globally through CIMMYT. Indian wheat breeders, especially those in the eastern plains have used Nepalese lines extensively in their breeding programs, and Bhutan has used Nepalese cold-tolerant rice and wheat varieties.

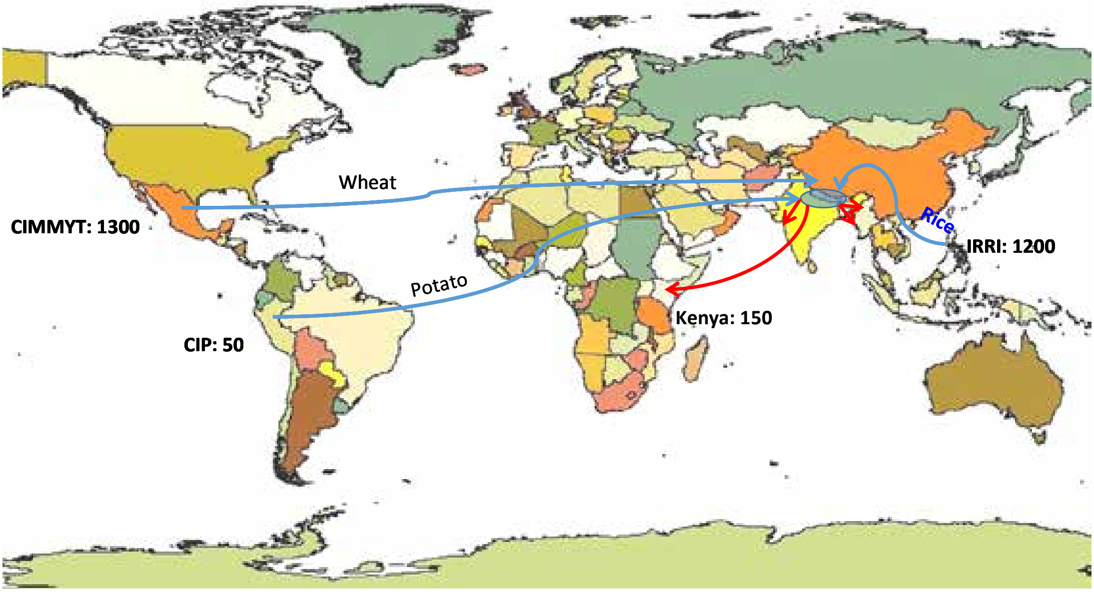


**Figure 2.2.** Recent flows of rice, wheat, and potato germplasm to and from Nepal.

## Use of PGRs

Foreign genetic materials are used for research, as parental lines in crossing programs, for testing across locations, and partly for production. Such materials are also used extensively for academic purposes, e.g., thesis research, despite the availability of many local genotypes. Some seed suppliers import foreign materials and sell them directly to farmers.

National commodity research programs, such as NRRP, NWRP, etc., are the major users of external materials and rely mainly on external PGRs for variety development. Wheat genetic material received in the form of nurseries, yield trials, and some $F_3/F_4$ material from CIMMYT are used strictly for breeding purposes and any new varieties resulting from such materials are shared freely with CIMMYT and Nepalese farmers. Bangladesh has released three advanced lines developed in Nepal that are very popular because of their tolerance to heat stress. Genetic rice material is being used in crossing experiments and elite lines are being identified through rigorous testing. These materials are being used by government organizations, NGOs and farmers.

## Factors influencing the flow of PGRs into, within, and out of Nepal

Free and easy access to advanced lines is the major factor influencing germplasm flow. This is associated with levels of skill and investment of time and money. Other factors are the state of research facilities in the country, the degree of collaboration among the various breeding stations, the presence of private breeding companies, the level of priority given to food security in national policies, market and farmers' demand, and the perceived and felt impact of climate change.

Since the 1970s, the NWRP has been active in research and development. It has created a strong nationally coordinated wheat research network to develop high-yielding, disease-resistant, and heat-tolerant wheat varieties for various agro-ecological regions of the country.

The government's goal to achieve food security also stimulates the introduction of new varieties. A continuous flow of wheat germplasm from CIMMYT and from India's wheat research program reflect good collaboration among these organizations.

The increase in production of lentils and the area under cultivation shows that farmers are shifting toward pulses, particularly lentils, because of their high value and export potential. The establishment of the NGLRP was important in popularizing lentils in Nepal. NGLRP has not only released 10 varieties suitable for various cropping systems, but it has also developed cost-effective production technologies, such as zero tillage, distributed improved seed kits to farmers along with demonstration packages, and created awareness among farmers about the economic, nutritional, and soil health benefits of growing lentils. Strong collaboration of ICARDA with national programs provides research advantages; since 1985, ICARDA has made specific crosses for these programs, including NGLRP. NGLRP's collaboration with ICARDA since its establishment is another factor influencing Nepal's government to emphasize research on this crop.

Special periodic projects and programs, such as the Secondary Crop Program of the Department of Agriculture, the government's Lentil Mission, the Australian Centre for International Agricultural Research's CLIMA program, the International Fund for Agriculture Development, OPEC-Funded International Development, the USAID-funded Nepal Economic, Agriculture, and Trade Project, and CGIAR's Bio-fortification Harvest Plus Challenge Program, are playing a significant role in promoting and popularizing lentil farming in Nepal, which has influenced the flow of lentil germplasm.

## Stakeholders' perceptions of constraints and opportunities relating to future PGR exchange

Ownership of genetic materials and the sharing of benefits arising from their use are major concerns of stakeholders in terms of the future exchange of PGRs. International agreements and monopolization of the technology (patenting), including genetic engineering, may constrain PGR flow in the future. Other constraints mentioned by stakeholders are national policy, the long process involved in moving germplasm within and outside the country (e.g., the need for quarantine, phytosanitary regulations, import and export permits), the need to use the Standard Material Transfer Agreement and the difficulty of monitoring compliance with agreements after receiving materials.

There are likely to be many opportunities for PGR exchange in the future. The availability of diverse materials at a low cost is a major factor promoting such exchanges. Climate change and changes in the demands of both growers and consumers increase the value of diverse materials. Advanced material with detailed information is inexpensive in terms of generating and developing new varieties. Other opportunities include the growth in research, the backup duplications on the agenda, benefits of "high-tech" harvesting, the ability to test material in multiple locations, and the implementation of novel access and benefit-sharing agreements.

## The origin of released crop varieties in Nepal

A look at the origin of Nepal's crop varieties reveals the country's dependence on foreign genetic materials. Of the 254 crop varieties released for general cultivation, 185 (73%)

originated outside the country and 52 were from CGIAR centres (**Figure** 2.3). Although Nepal is rich in rice diversity, 68% of rice varieties originated outside the country; for wheat, potato, and lentil varieties that number increases to 80% (**Figure** 2.4).

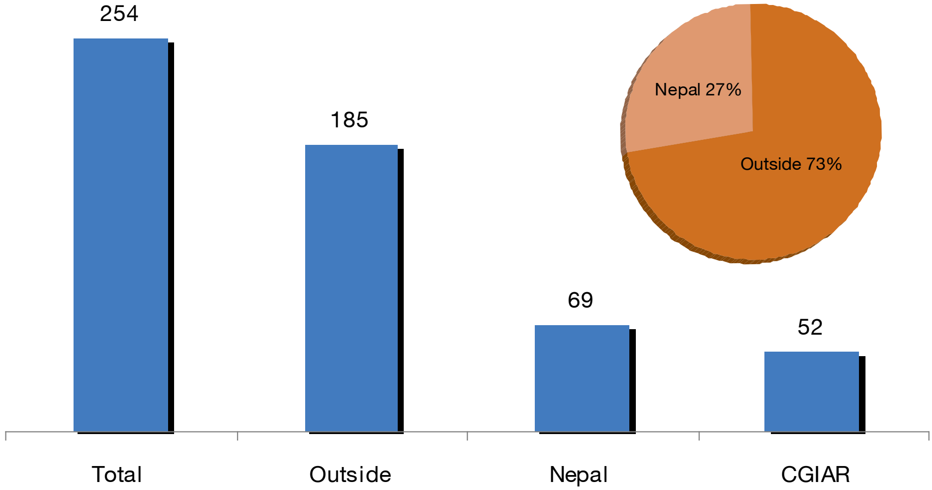


**Figure 2.3.** Origin of crop varieties released in Nepal.

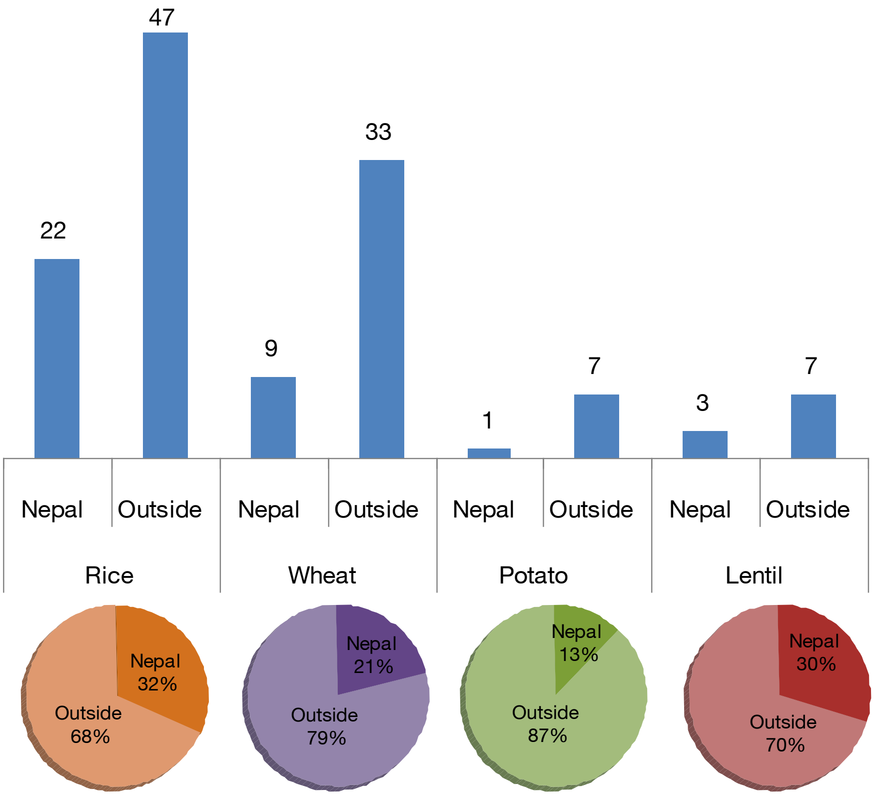


**Figure 2.4.** Origin of released varieties of four major crops: rice, wheat, potatoes, and lentils.

## Pedigree analysis of modern varieties released in the country

### Rice

Twenty improved rice varieties adapted to the mid- and high hills of Nepal and released between 1967 and 2002 were analyzed regarding their ancestors and origin (**Table** 2.2). The large number of crosses involving many parental lines in such cultivars as Kanchan, Khumal-4, Khumal-6, and Manjushri-2 indicates the effort of scientists to collect valuable genes in a single genotype.

**Table 2.2. The 20 improved rice varieties recommended for mid- and high-hill areas of Nepal**

| Variety | Origin | Year of release | Location |
|---|---|---|---|
| Chhommrong | Nepal | 1991 | Warm temperate |
| Khumal-4 | Nepal | 1987 | Warm temperate |
| Khumal-5 | Nepal | 1990 | Warm temperate |
| Khumal-11 | Nepal | 2002 | Kathmandu |
| Khumal-2 | Nepal | 1987 | Warm temperate |
| Machhapuchhre-3 | Nepal | 1990 | Warm temperate |
| Manjushri-2 | Nepal | 2002 | Jumla, warm temperate |
| Palung-2 | Nepal | 1987 | Warm temperate |
| Chandhanath-1 | IRRI | 2002 | Jumla, warm temperate |
| Chandhanath-3 | IRRI | 2002 | Jumla, warm temperate |
| Himali | IRRI | 1982 | Warm temperate |
| Kanchan | IRRI | 1982 | Warm temperate |
| Khumal-7 | IRRI | 1990 | Warm temperate |
| Khumal-6 | IRRI | 1999 | Kathmandu |
| Khumal-9 | IRRI | 1990 | Warm temperate |
| Chianan-2 | Taiwan | 1967 | Warm temperate |
| Chianung-242 | Taiwan | 1967 | Warm temperate |
| Taichung-176 | Taiwan | 1967 | Warm temperate |
| Tainan-1 | Taiwan | 1967 | Warm temperate |
| Khumal-3 | India | 1983 | Warm temperate, Chaite, and Barkhe |

Source: NRRP (1997) and updated by the authors.

A total of 47 ancestors (landraces) originating in 12 countries, mainly in Asia, were used to develop these rice cultivars (**Table** 2.3). Most ancestors were from India and Taiwan followed by China and Nepal. Only four landraces, Jarneli, Jumli Marshi, Pokhreli Masino, and Ghankdruk Local from Nepal were used in developing these cultivars, although 2000 landraces have been reported to exist (Mallick 1981/82). The involvement of ancestors from 12 countries indicates the introduction of genes adapted to different geographic locations. Among the ancestors, 48.94% were of the long-grained indica ecotype and 23.40% short-grained japonica; 97.87% were *Oryza sativa* species and 2.13% were *O. nivara*.

**Table 2.3. Ancestors of the 20 improved rice cultivars developed for mid- and high-hill regions of Nepal**

| Ancestor | Origin | Group | Species |
|---|---|---|---|
| China 1039 | India | Indica | Sativa |
| CO 18 | India | Indica | Sativa |

| Ancestor | Origin | Group | Species |
|---|---|---|---|
| GEB 24 | India | indica | Sativa |
| HR 21 | India | Indica | Sativa |
| K-28-76-B-1 | India | Japonica | Sativa |
| Mudgo | India | Indica | Sativa |
| PTB-18 | India | Indica | Sativa |
| PTB-21 | India | Indica | Sativa |
| SLO | India | Indica | Sativa |
| Dee Geo Woo Gen | Taiwan | Indica | Sativa |
| Hsinchu-4 | Taiwan | Japonica | Sativa |
| Tadukan | Taiwan | Indica | Sativa |
| Taichung Native-1 | Taiwan | Indica | Sativa |
| Taichung-150 | Taiwan | Japonica | Sativa |
| Taichung-45 | Taiwan | Japonica | Sativa |
| Taichung-65 | Taiwan | Japonica | Sativa |
| Taipei-7 | Taiwan | ? | Sativa |
| Tsai Yuan Chung | Taiwan | Indica | Sativa |
| China 971 | China | ? | Sativa |
| China-1039-DWF-MUT | China | Indica | Sativa |
| Cina | China | ? | Sativa |
| Jinlilng-78-102 | China | Japonica | Sativa |
| Yunlen-1 | China | Japonica | Sativa |
| Ghandruk Local | Nepal | Japonica | Sativa |
| Jarneli | Nepal | Indica | Sativa |
| Jumli Marshi | Nepal | Japonica | Sativa |
| Pokhreli Masino | Nepal | Indica | Sativa |
| KN-1B-214-1-4-3 | Indonesia | Indica | Sativa |
| Remadja | Indonesia | Indica | Sativa |
| Sigadis | Indonesia | Indica | Sativa |
| FUJI-102 | Japan | Japonica | Sativa |
| Shinei | Japan | ? | Sativa |
| Akiyudaka | Korea | Japonica | Sativa |
| BPI 76 | Philippines | Indica | Sativa |
| Century Patna | United States | Indica | Sativa |
| Kulu | Australia | Indica | Sativa |
| Latisail | Pakistan | Indica | Sativa |
| Tetep | Vietnam | ? | Sativa |
| Dunghan Shalil | ? | Indica | Sativa |
| GP-15 | ? | ? | Sativa |
| Jerak | ? | ? | Sativa |
| LD-66 | ? | ? | Sativa |
| MCVA | ? | ? | Sativa |
| *O. nivara* | ? | ? | Nivara |
| O-Luamchu | ? | ? | Sativa |
| R. Heenati | ? | ? | Sativa |
| Shiniri Aikoku | ? | ? | Sativa |

Note: ? = unknown.
Source: Joshi 2004.

Cultivar performance may be affected by the origin of its ancestors, the number of ancestors used, and number of crosses required to develop them (**Figure** 2.5). For example, 13 parents and 42 crosses were needed to develop Khumal-4, which is a popular cultivar among farmers. Even though the role of Nepalese rice landraces is not known, Nepal is recognized for its contribution to world rice development. A single landrace from each of six countries (**Table** 2.3) has been used in developing rice cultivars, likely because of the valuable genes it contains.

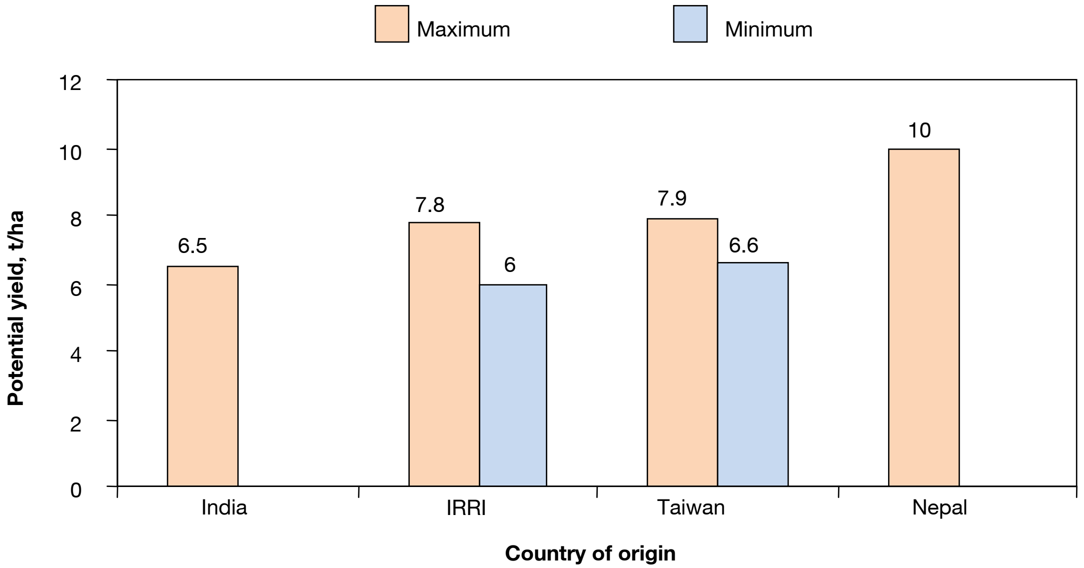


**Figure 2.5.** Potential yield of rice cultivars based on their origin.

Source: Joshi 2006.

In a second round of rice pedigree analysis, we considered 28 improved varieties suitable to the terai, inner terai, and foothills of Nepal and released between 1959 and 2002 (**Table** 2.4). Most originated from IRRI. A large number of crosses including many parental lines was used to develop the cultivars Sabitri, Laxmi, and Chaite-4.

**Table 2.4. The 28 improved rice varieties recommended for terai, inner terai, and foothills regions of Nepal**

| Variety | Parentage | Origin | Year released | Location |
|---|---|---|---|---|
| Chaite-2 | BG34-8/IR2061-522-6-9 | IRRI | 1987 | Terai and inner terai |
| Chaite-4 | BG34-8/IR28//IR2071-625-1-252 | IRRI | 1987 | Terai and inner terai |
| Chandina | Peta* 3/TN1//TKM6 | IRRI | 1978 | Terai and inner terai |
| IR8 | Peta/DGWG | IRRI | 1968 | Irrigated |
| IR20 | IR 262-24-3/TKM6 | IRRI | 1972 | Irrigated |
| IR22 | IR 8/Tadukan | IRRI | 1972 | Irrigated |
| IR24 | IR8/// Century Patna/SLO//Sigadis | IRRI | 1975 | Terai and inner terai |
| Laxmi | IR833-6-2-1-1//IR1561-149-1/IR1737 | IRRI | 1979 | Terai and inner terai |
| Parwanipur-1 | Peta* 4/TN1 | IRRI | 1973 | Terai and inner terai |
| Radha-4 | BG 34-8/IR 2071-625-1 | IRRI | 1995 | RL, MW, FW terai |
| Sabitri | IR 1561-228-1/IR 1737//CR 94-13 | IRRI | 1979 | Irrigated |
| Durga | Jaya//IR8/Latisail | India | 1979 | Irrigated |
| Ghaiya-2 | MTU15/Waikakku | India | 1987 | Upland + RL shallow |

| Variety | Parentage | Origin | Year released | Location |
|---|---|---|---|---|
| Jaya | TN1/T141 | India | 1973 | Irrigated |
| Kajura-2 | RP72/Mutant65 | India | 1987 | Irrigated MW |
| Radha-11 | Local selection | India | 1995 | RL, Central |
| Radha-12 | TNI/T141//Annapurna | India | 1995 | Partly irrigated + RL, E |
| Bindeswari | TN 1/Co29 | India | 1981 | Terai and inner terai |
| Chaite-6 | NR6-5-46-50/IR28 | Nepal | 1991 | Terai and inner terai |
| Radha Krishna-9 | IR 42/Masuli | Nepal | 1991 | Partly irrigated + RL |
| Radha-7 | Janaki/Masuli | Nepal | 1991 | Partly irrigated + RL |
| Rampur Masuli | Lal Nakanda/IR30 | Nepal | 1999 | Irrigated + CW |
| Janaki | Peta*3/TN1//Remadja | Sri Lanka | 1979 | Irrigated |
| Makwanpur | Ob678/IR20//H4 | Sri Lanka | 1987 | Partly irrigated + RL |
| Malika | CP/SLO*2//Sigadis | Bangladesh | 1982 | Terai and inner terai |
| China-45 | Selection at CRRI | China | 1959 | Terai and inner terai |
| Barkhe-2 | C4-63GB/B531b -TK39 | Indonesia | 1987 | Irrigated |
| Masuli | Mayang Ebos 80*2/Taichung 65 | Malaysia | 1973 | Irrigated and rainfed lowlands medium deep |

Note: RL = rainfall lowland, MW = mid-western, FW = far western, E = eastern, CW = central and western.
Source: NRRP 1997, Mallick 1981/82, and updated by the authors.

These cultivars were developed from 35 ancestors originating in 10 countries, mainly Asian (**Table** 2.5). Most were from India, followed by Indonesia, Sri Lanka, and Taiwan. This diversity indicates the introduction of genes adapted to different geographic locations. Nepal contributed four cultivars. Most commonly used ancestors were Latisail, Cina, DGWG, Sigadis, SLO, and Century Patina (**Figure** 2.6).

A complete pedigree tree for one common rice variety, Khumal-4, is depicted in **Figure** 2.7. The portion of genetic material contributed by each ancestor is shown along with its origin. A total of 13 landraces originating in eight countries were used to develop Khumal-4, indicating the dependency on foreign genetic materials. The highest proportion of genetic material comes from a landrace originating in Nepal. Two landraces originating in Malaysia and Taiwan were used in breeding Masuli, which has been the most popular variety in the last few years.

**Table 2.5. Ancestors of the 28 rice cultivars developed for terai, inner terai, and foothills regions of Nepal**

| Ancestor | Origin | Group | Species |
|---|---|---|---|
| CO-18 | India | Indica | Sativa |
| CO-29 | India | Indica | Sativa |
| GEB-24 | India | Indica | Sativa |
| Lalnakanda | India | Indica | ? |
| MTU15 | India | Indica | Sativa |
| PTB 18 | India | Indica | ? |
| PTB 21 | India | Indica | ? |
| RP72 | India | Indica | Sativa |
| SLO | India | Indica | Sativa |
| T141 | India | Indica | Sativa |
| TCA-80-4 | India | Indica | Sativa |
| MAS | Indonesia | Indica | ? |

| Ancestor | Origin | Group | Species |
|---|---|---|---|
| Remadja | Indonesia | Indica | Sativa |
| Sigadis | Indonesia | Indica | Sativa |
| H4 | Sri Lanka | Indica | Sativa |
| H501 | Sri Lanka | Indica | ? |
| OB678 | Sri Lanka | ? | ? |
| Dee-Geo-Woo-Gen | Taiwan | Indica | Sativa |
| Taichung Native1 | Taiwan | Indica | Sativa |
| Taichung-65 | Taiwan | Japonica | Sativa |
| China-45 | China | ? | Sativa |
| Cina | China | ? | Sativa |
| Mayang EBOS-80 | Malaysia | Indica | Sativa |
| Shankara | Nepal | Indica | Sativa |
| Latisail | Pakistan | Indica | Sativa |
| Tadukan | Philippines | Indica | Sativa |
| Century Patna | United States | Indica | Sativa |
| Annapurna | ? | ? | ? |
| B531B-TK39 | ? | ? | ? |
| C4-63-GB | ? | ? | ? |
| GP-15 | ? | ? | ? |
| Mutant-65 | ? | ? | ? |
| *O. nivara* | ? | ? | Nivara |
| PP | ? | ? | ? |
| Waikakku | ? | ? | ? |

Note: ? = unknown.

Sources: Joshi et al. 2003, IRRI 1970, IRR GEU, Shahi and Heu 1979, Joshi 2005.

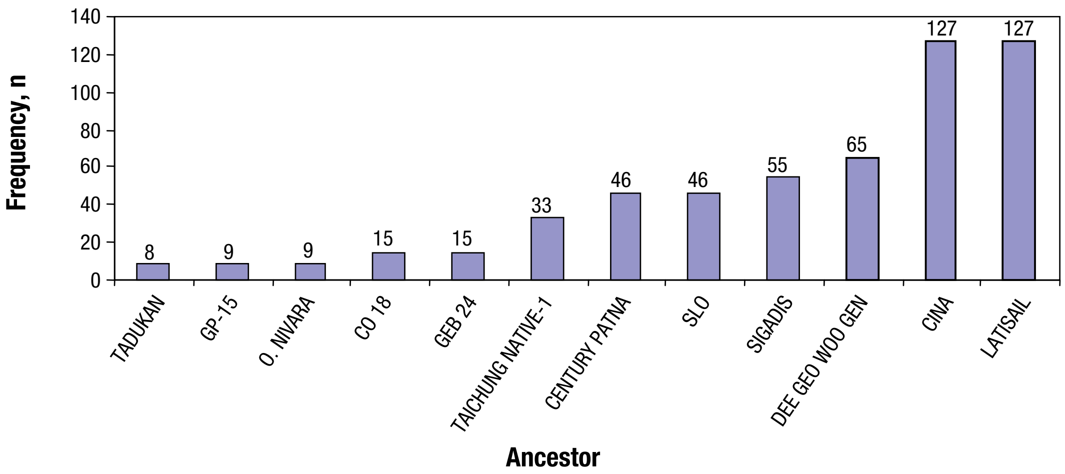


**Figure 2.6.** Ancestors used most frequently in the development of Nepalese rice cultivars.

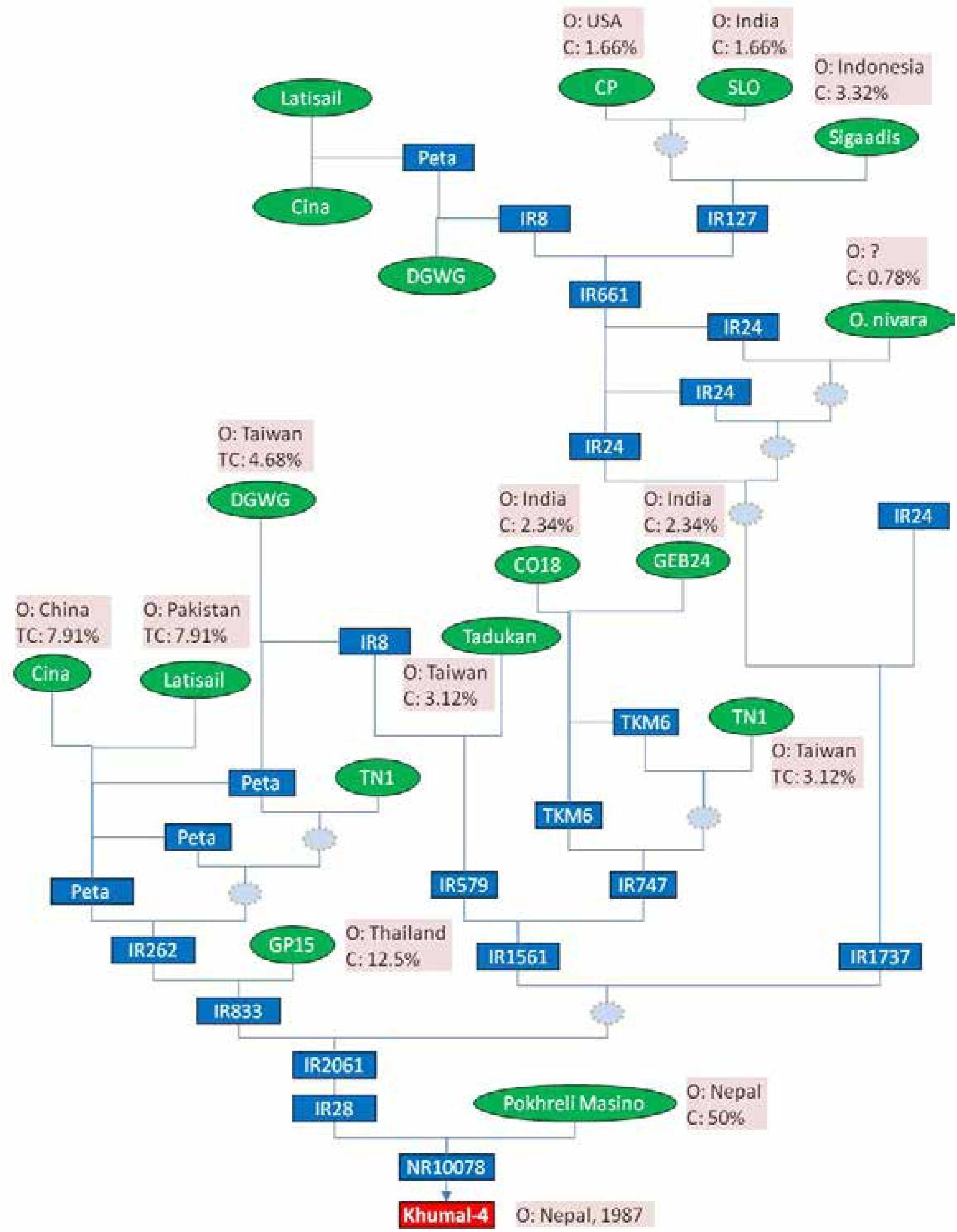


**Figure 2.7.** Pedigree tree for the rice cultivar Khumal-4 showing ancestors in green ovals along with their country of origin (O) and contribution to Khumal-4 (C) or total contribution (TC) for varieties used more than once.

Source: Joshi 2008.

## Wheat

The 35 varieties of wheat released in Nepal originated in India (16 varieties), Mexico (14), Nepal, and Kenya (**Table** 2.6). In Nepal four cultivars were bred and developed using foreign landraces.

### Table 2.6. Improved bread wheat varieties released between 1960 and 2013 in Nepal and their pedigree

| Variety | Pedigree | Origin | Year released | Location |
|---|---|---|---|---|
| Achyut | CPAN168/HD2204 | India | 1997 | Plain |
| Annapurna2 | NAPO/TOB//8156/3/KAL/BB | India | 1988 | Hills |
| Hybrid Delhi1982 | E5557/HD845 | India | 1975 | Western plains |
| Lumbini | E4871/PJ | India | 1981 | Plains |
| Nepal Line251 | WH147/HD2160//2*WH147 | India | 1988 | Plains |
| Nepal Line297 | HD2137/HD2186//HD2160 | India | 1985 | Plains |
| Nepal Line30 | HD832/BB | India | 1975 | Western plains |
| New Pusa799 | NP 792 | India | 1962 | Hills |
| New Pusa809 | DO/C518//SPP/NP114/3/WIS245 | India | 1962 | Hills |
| New Pusa835 | NP760/RN | India | 1962 | Plains |
| New Pusa852 | KF/2*NP761 | India | 1962 | Plains |
| New Pusa884 | KC6042/GUL//PLT/3/K58/N/4/NP755 | India | NA† | Plains |
| Siddhartha | HD2092/HD1962//E4870/3/K65 | India | 1983 | Plains |
| Triveni | HD1963/HD1931 | India | 1982 | Plains |
| Uttar Pradesh262 | S 308/BAJIO 66 | India | 1978 | Plains |
| Vinayak | LC55 | India | 1983 | Plains |
| Annapurna1 | KVZ/BUHO//KAL/BB | Mexico | 1988 | Hills |
| Annapurna3 | KVZ/BUHO//KAL/BB | Mexico | 1991 | Hills |
| Annapurna4 | KVZ/3/CC/INIA//CNO/ELGAU/4/SN64 | Mexico | 1994 | Hills |
| Bhrikuti | CMT/COC75/3/PLO//FURY/ANA | Mexico | 1994 | Plains |
| Kalyansona | PJ/GB55 | Mexico | 1968 | Plains |
| Kanti | LIRA/FFN//VEE | Mexico | 1997 | Hills |
| Lerma52 | MTA/K324 | Mexico | 1960 | Hills |
| Lerma Rojo64 | Y50/N10B//L52/3/2*LR | Mexico | 1967 | Hills |
| Pasang Lhamu | PGO/SERI | Mexico | 1997 | Hills |
| Pitic62 | YT54/N10B 26.1C | Mexico | 1967 | Hills |
| Rust Resistant21 | II53.388/AN/3/YT54/N10B/3/LR/4/B4946.A/ Y53//3*Y50 | Mexico | 1971 | Hills and plains |
| S331 | LR64/HUAR | Mexico | 1971 | Hills and plains |
| Sonora64 | YT54/N10B//2*Y54 | Mexico | 1967 | Hills |
| Vaskar | TZPP/PL//7C | Mexico | 1983 | Mid-western plains |
| Bhairwa Line1022 | PVN/ALD | Nepal | 1991 | Western terai |
| Bhairwa Line1135 | QTZ/TAN | Nepal | 1994 | Plains |
| Bhairwa Line1473 | NL297/NL352 | Nepal | 1999 | Plains and hills |
| Rohini | PRL/TONI//CHIL | Nepal | 1997 | Plains |
| Kenya291 | NA† | Kenya | 1962 | Hills |

† NA, Not available.

Sources: NARC 1997, Bland 2001, Shrestha 1976, Joshi et al. 2004.

The pedigree tree for Pitic-62 (**Figure** 2.8) shows that three ancestors originating from three countries (Japan, United States, and Mexico) were used to develop it. The genetic contribution of landraces from these countries was 25%, 25%, and 50%, respectively. A total of 89 ancestors from 22 countries were used to develop these cultivars (**Table** 2.7). Most were from India followed by the United States and Kenya. Pedigree analysis of modern wheat varieties in Nepal shows that all ancestors and landraces were from other countries and international organizations, empirical evidence of Nepal's dependency on foreign PGRs for wheat research and development.

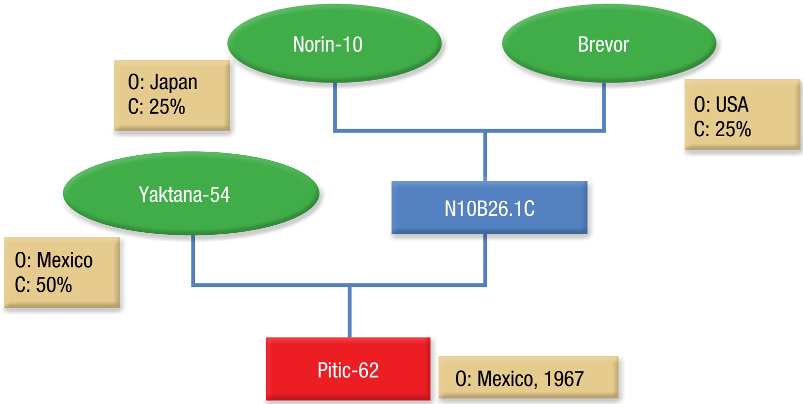


**Figure 2.8.** Pedigree tree for the Pitic-62 wheat cultivar showing its ancestors (ovals), along with their country of origin (O) and contribution (C) to Pitic-62.

### Table 2.7. Ancestors of 35 Nepalese wheat cultivars and their country of origin

| Name | Origin | Growth habit | Species |
|---|---|---|---|
| 8A | India | ? | *T. aestivum* |
| 8B | India | ? | ? |
| 9D | India | ? | *T. aestivum* |
| C13 | India | Spring | *T. aestivum* |
| C209 | India | Spring | *T. aestivum* |
| Cpan1687 | India | Spring | *T. aestivum* |
| Hard red Calcutta | India | Spring | *T. aestivum* |
| Hybrid Delhi845 | India | Spring | *T. aestivum* |
| Khapli | India | Spring | *T. durum* |
| LC55 | India | ? | ? |
| Mundia | India | ? | ? |
| New Pusa773 | India | Spring | *T. aestivum* |
| NP114 | India | ? | *T. aestivum* |
| S339 | India | Spring | *T. aestivum* |
| Fury | Kenya | Spring | *T. aestivum* |
| Kenya C6042 | Kenya | ? | ? |
| Kenya Governer | Kenya | Spring | *T. aestivum* |
| Kenya Standard | Kenya | Spring | ? |
| Kenya117a | Kenya | Spring | *T. aestivum* |
| Kenya256 | Kenya | Spring | ? |
| Kenya291 | Kenya | Spring | *T. aestivum* |
| Kenya324 | Kenya | Spring | ? |

| Name | Origin | Growth habit | Species |
|---|---|---|---|
| Kenya350-A-D9-C-2 | Kenya | Spring | *?* |
| Kenya58 | Kenya | Spring | *T. aestivum* |
| Brevor | United States | Winter | *T. aestivum* |
| Chris | United States | Spring | *T. aestivum* |
| Davis6301 | United States | ? | *T. aestivum* |
| Democrate | United States | ? | *T. aestivum* |
| Hope | United States | ? | *T. aestivum* |
| Iumillo | United States | Spring | *Durum* |
| Kanred | United States | Winter | *T. aestivum* |
| Mida-U | United States | Spring | *T. aestivum* |
| Santa Elena | United States | Spring | *T. aestivum* |
| Willet Erono | United States | Spring | *T. aestivum* |
| 36896 | Argentina | ? | *T. aestivum* |
| El Gaucho | Argentina | Spring | *T. aestivum* |
| General Urquiza | Argentina | Spring | *T. aestivum* |
| Klein Atlas | Argentina | Spring | *T. aestivum* |
| Klein Rendidor | Argentina | Spring | *T. aestivum* |
| Sinvalocho Ma | Argentina | Spring | *T. aestivum* |
| Tezanos Pintos Precoz | Argentina | Spring | *T. aestivum* |
| Federation | Australia | Spring | *T. aestivum* |
| Gabo-Aus | Australia | Spring | *T. aestivum* |
| Hard Federation | Australia | Spring | *T. aestivum* |
| Marsall's No 3 | Australia | ? | *T. aestivum* |
| Steinwedel | Australia | Spring | *T. aestivum* |
| Thew | Australia | Winter | *T. aestivum* |
| Timestein | Australia | Spring | *T. aestivum* |
| Kentana48 | Mexico | Spring | *T. aestivum* |
| Lerma Rojo | Mexico | Spring | *T. aestivum* |
| Nainari60 | Mexico | ? | *T. aestivum* |
| P4160E | Mexico | Spring | *T. aestivum* |
| Yaktana54 | Mexico | Spring | *T. aestivum* |
| Alfredo chaves 6.21 | Brazil | Spring | *T. aestivum* |
| Centenario | Brazil | Spring | *T. aestivum* |
| Frocor | Brazil | Spring | *T. aestivum* |
| Polyssu | Brazil | Spring | *T. aestivum* |
| Bonza | Colombia | Spring | *T. aestivum* |
| Napo | Colombia | Spring | *T. aestivum* |
| Narino59 | Colombia | Spring | *T. aestivum* |
| McMurachy | Canada | Spring | *T. aestivum* |
| Red Fife | Canada | Spring | *T. aestivum* |
| Red Mace | Great Britain | Winter | *T. aestivum* |
| Spalding Prolifique | Great Britain | ? | *T. aestivum* |
| Akagomughi | Japan | Winter | *T. aestivum* |
| Norin10 | Japan | Winter | *T. aestivum* |
| Clement | Netherlands | Winter | *T. aestivum* |
| Wilhelmine | Netherlands | Winter | *T. aestivum* |
| Type1 | Pakistan | ? | *T. durum* |

| Name | Origin | Growth habit | Species |
|---|---|---|---|
| Type9 | Pakistan | ? | *T. aestivum* |
| Kavkaz | Russia | Winter | *T. aestivum* |
| Vernal Emmer | Russia | Spring | *T. durum* |
| Carianca422 | Chile | Winter | *T. aestivum* |
| Fufan17 | China | Spring | *T. aestivum* |
| Gaza | Egypt | Spring | *T. durum* |
| Marne Desprez | France | Winter | *T. aestivum* |
| 21931 | Israel | ? | *T. aestivum* |
| Weique | Germany | Winter | *T. aestivum* |
| Marroqui | Morocco | Spring | *T. aestivum* |
| Olesen's Dwarf | Zimbabwe | Spring | *T. aestivum* |
| B4946.a.4.18.2.iy | ? | ? | ? |
| Bunge no. 2 | ? | ? | ? |
| Button | ? | ? | *T. aestivum* |
| Florence | ? | ? | ? |
| La Estanzuela2787c | ? | ? | ? |
| Quintzel | ? | ? | ? |
| Reiti | ? | ? | ? |
| Wagga13 | ? | ? | ? |
| Wis 245 | ? | ? | ? |

Note: ? = unknown.

Source: Joshi and Mudwari 2003.

The contributions of these ancestor varieties to Nepal's genetic base for wheat were unequal, ranging from 0.0001% to 7.5% (**Table** 2.8). Although a large number of ancestors appear in the pedigrees of Nepalese wheat cultivars, more than half of the genetic base of these cultivars comes from only 14 ancestors (**Table** 2.8). Local landraces were not traced in the breeding history of wheat cultivars.

**Table 2.8. Ancestors, their origin, and number of wheat varieties contributed**

| Landrace | Origin | Contribution, % | Number of cultivars with contribution |
|---|---|---|---|
| Fultz | United States | 2.2 | 23 |
| Improved Fife | United States | 1.5 | 23 |
| Kanred | United States | 2.8 | 23 |
| Mediterranean | United States | 1.1 | 23 |
| Oro | United States | 3.0 | 23 |
| Squarehead | United States | 1.9 | 24 |
| Turkey | United States | 1.3 | 23 |
| Turkey Red | United States | 4.0 | 23 |
| Total contribution | | 17.8 | 185 |
| Barleta | Argentina | 1.1 | 18 |
| Chino | Argentina | 1.1 | 18 |
| Egypt Na101 | Argentina | 2.3 | 19 |
| Maria Escobar | Argentina | 1.5 | ? |
| Total contribution | | 6.0 | 55 |
| Purple Straw | Australia | 1.0 | 23 |
| Steinwedel | Australia | 3.7 | 20 |

| Landrace | Origin | Contribution, % | Number of cultivars with contribution |
|---|---|---|---|
| White Naples | Australia | 1.5 | 23 |
| Total contribution | | 6.2 | 66 |
| Alfredo Chaves 6.21 | Brazil | 2.1 | 18 |
| Polyssu | Brazil | 2.6 | ? |
| Total contribution | | 4.7 | |
| HD 845 | India | 3.1 | 2 |
| Hard Red Calcutta | India | 3.0 | 23 |
| Total contribution | | 6.1 | 25 |
| Akagomughi | Japan | 7.5 | 24 |
| Daruma | Japan | 2.0 | 23 |
| Total contribution | | 9.5 | 47 |
| Kenya 324 | Kenya | 4.5 | 24 |
| Kenya Bf4-3b.10.V.1 | Kenya | 2.3 | 18 |
| Total contribution | | 6.8 | 42 |
| Red Fife | Canada | 4.6 | ? |
| Gaza | Egypt | 2.5 | 20 |
| Rieti | Italy | 3.8 | 24 |
| Fife | Poland | 1.5 | 23 |
| Red Egyptian | South Africa | 2.6 | 17 |
| Iumillo | Spain | 2.5 | 23 |
| Americano 25e | Uruguay | 1.2 | 18 |
| Ladoga | USSR | 1.5 | 23 |
| Jacinth | - | 1.3 | 22 |

Note: ? = unknown.

Source: Rosyara and Joshi 2005.

Pedigree analysis of modern wheat varieties in Nepal showed that all ancestors and landraces were from other countries and international organizations. Only exotic ancestors were used for developing 35 modern wheat varieties.

## Lentils

Eleven lentil varieties have been released in Nepal (**Table** 2.9). Only one was bred in Nepal; Shikhar, Shital, Sagun, and Maheswor Bharati were bred at ICARDA specifically for conditions in South Asia and selected for high yield, improved seed size, and tolerance to *Stemphylium* blight and wilt diseases. Every year, NGLRP receives genetic materials as "Lentil International Elite Nurseries" for screening against various biotic and abiotic stresses. Genetic material from the Middle East and Argentina has been used to improve South Asian lines, and many new varieties have been released to farmers in Bangladesh, Nepal, India, and Pakistan.

All varieties released so far are in the microsperma subclass. These are selections from a Nepalese landrace (Sindur) and local selections from genotypes of South Asian origin from India (Simrik, Sisir, Simal, Shital, and Khajura Masuro-1) or Syria (Sikhar, Khajura Masuro-2). Sagun and Maheswor Bharati are from crosses of South Asian and West Asian materials, specifically developed for Nepal; they produce a 40–60% higher yield and 20–30% larger seeds than Shital and Simal and are moderately resistant to *Stemphylium* blight and wilt disease. Simal, which was released in 1990, is the most popular and widely adapted variety in Nepal because of its medium bold seed and suitability for use in a relay cropping system with rice. About 95% of lentil breeding materials at NGLRP are from external sources, especially ICARDA.

**Table 2.9. Released varieties of lentils in Nepal**

| Variety | Accession | Pedigree | Origin | Year released | Location |
|---|---|---|---|---|---|
| Sisir | P43 | | India | 1979 | Terai, mid-hills |
| Simrik | T36 | | India | 1979 | Terai, mid-hills |
| Simal | LG 7 | Landrace from India | India | 1989 | Terai, mid-hills |
| Khajura Masuro-1 | LG 198 | | India | 1999 | Western terai |
| Khajura Masuro-2 | PL 639 | T 9-12 (India) × T 8 (India) | India | 1999 | Western terai |
| Shital | ILL 2580 | | ICARDA | 2004 | Terai, mid-hills |
| Sagun | ILL 6829 | ILL 4407 (Pakistan) × ILL 4605 (Argentina) | ICARDA | 2009 | Mid-hills, valleys |
| Maheswor Bharati | ILL 7982 | 91S 88526 | ICARDA | 2009 | Mid-hills, valleys |
| Khajura Masuro-3 | ILL 7723 | | ICARDA | Proposed | Mid-western terai |
| Sindur | LO-111-25 | | Nepal | 1979 | Terai, mid-hills |
| Sikhar | ILL 4404 | | Pakistan | 1989 | Terai, mid-hills |

## Potatoes

Only exotic parents have been used to develop the eight modern varieties of potato in Nepal (**Table** 2.10). One variety was developed in Nepal using foreign landraces, but most varieties are from CIP and India. Most of the ancestors used in developing these potato varieties were from Germany (**Figure** 2.9). For example, 14 landraces originating in Germany were used to produce Janak Dev. Although there are many unique landraces of potato in Nepal, not a single one has been found in the pedigree of released varieties.

**Table 2.10. Pedigree and country of origin of released varieties of potatoes in Nepal**

| Variety | Pedigree | Year released | Origin | Location |
|---|---|---|---|---|
| Khumal Laxmi | BWH-87.316 × BK (LB) | 2008 | CIP | Terai, hills |
| IPY8 | BWH-87.316 × BK (LB) | 2008 | CIP | Terai, hills |
| Khumal Seto-1 | MP161375.23 × B-5.65 = Atlantic × Huinkul | 1999 | CIP | Terai, foothills, mid- and high hills |
| Khumal Rato-2 | US136.6 ×[3345 D (1) × 2288 (2)] | 1999 | India | Terai and inner terai |
| Janak Dev | Atizimba × Desiree = (Urgenta × Depeache) | 1999 | Nepal | Terai, foothills, mid- and high hills |
| Disiree | Urgenta Depeache | 1992 | Netherlands | High and mid-hills, terai |
| Kufri Sinduri | Kufri Red × Kufri Kundan = C-140 | 1992 | India | Mid-hills and terai |
| Kufri Jyoti | 3069 d (4) × 2814 a (1) = SLB/Z-389 (b) | 1992 | India | High and mid-hills |

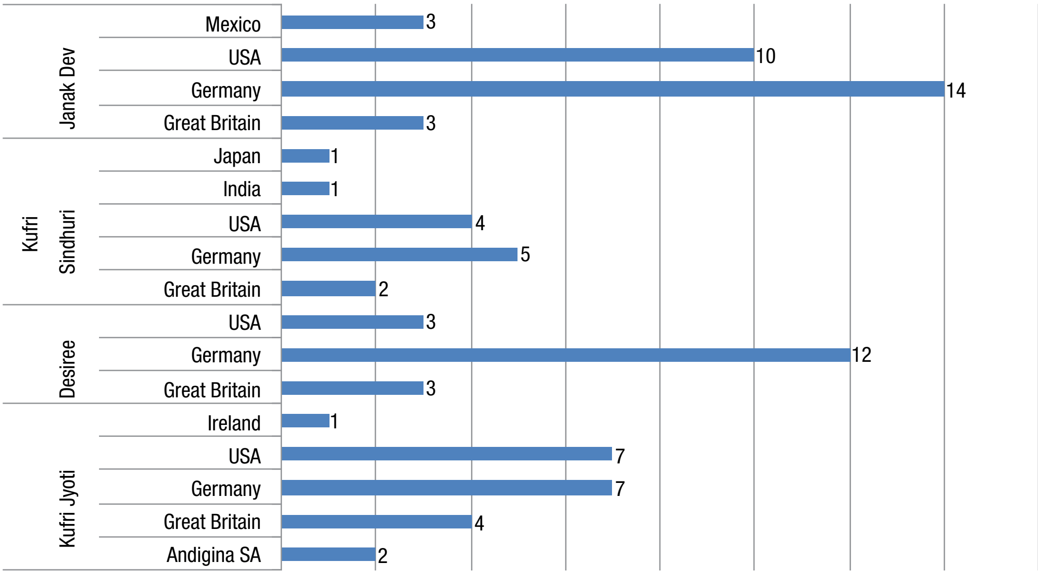


**Figure 2.9.** Origin and number of ancestors used in developing four modern potato varieties.

## Climate change and interdependence

Global grain production and food supply are being greatly affected by climate change. More grain must be produced on limited arable land, and agricultural production is becoming unstable and unpredictable. We expect that Nepal will increasingly have to search for better adapted PGRs to sustain crop production. As in the past, Nepal will likely remain dependent on foreign germplasm; thus, we expect that global interdependence on PGRs will increase further in the near future.

National commodity programs are already receiving PGRs aimed at making crops tolerant of drought, heat, water logging, and other abiotic stresses. The use of indigenous PGRs has not been made a priority, mainly because of inadequate facilities and lack of people trained to explore the traits related to biotic and abiotic stresses and high yield. Our survey indicates that Nepal is very dependent on outsourced PGRs because of climate change and diseases of major economic importance. For example, the stress-tolerant rice varieties Swarna Sub-1, Sambha Sub-1, Sukkha Dhan and wheat varieties Bhrikuti, Gautam, Nepal-297, Vijay, Adityain, WK-1204, Gaura and Dhaulagiri are all based on external PGRs. The NRRP is receiving drought, heat, cold, and submergence tolerant nurseries from IRRI through INGER for testing in the context of climate change in Nepal. Compared with 10–15 years ago, many more wheat PGRs are being imported to address biotic stresses, such as Ug99 and Yellow rust resistance, and abiotic stresses, such as heat and drought.

More than 100 institutions are participating in PGR conservation, improvement, and utilization. The main institutions involved in germplasm flow are NARC, the Seed Quality Control Centre, the Department of Agriculture, and the National Quarantine Office. Because of the lack of regulation of germplasm flows in the country, both private and public sectors are directly involved in germplasm exchange. Most modern varieties have been developed outside the country using exotic ancestors, and CGIAR centres are the main source of PGRs for adaptation, crop improvement, and production trials.

Nepal is 95–100% dependent on foreign germplasm for varietal development (**Table** 2.11). The contribution of native landraces to crop improvement at the international level has not been documented, but very few local landraces are used in crop breeding. Nepal's dependency will further increase as a result of changes in climate and the demands of growers and consumers.

**Table 2.11. Frequency of native and exotic parents used in developing Nepal's major crop varieties and area coverage by improved varieties**

| Crop | No. varieties | Native parents | Exotic parents | Area coverage, % |
|---|---|---|---|---|
| Rice | | | | 92 |
| Hill set | 20 | 4 | 43 | |
| Terai set | 28 | 1 | 34 | |
| Wheat | 35 | 0 | 87 | 97 |
| Potatoes | 8 | 0 | All | 85 |
| Lentils | 11 | 1 | All | ? |

## References


Basnet NB. 1967. Review of wheat varietal trials conducted in Nepal since 1961–1966. *Nepalese Journal of Agriculture* 4:5–16.

Bhattarai AN. 1976. Wheat varietal research in Nepal. *Nepalese Journal of Agriculture* 6:3–15.

Bland B. 2001. Nepalese wheat pool. In *The World Wheat Book: A History of Wheat Breeding*. AP Bonjean and WJ Angus (eds). Intercept, TEC and DOC, Lavoisier, New York, NY, USA. pp.817–830.

Delannax X, DM Todgers and RG Palmer. 1983. Relatives genetic contribution among ancestral lines to North American soybean cultivars. *Crop Science* 23:944-949.

Gauchan D and MP Upadhyay. 2006. International Treaty on Plant Genetic Resource for Food and Agriculture (ITPGRFA): prospects and challenges for Nepal. A summary report of the study carried out under the Regional Program on Securing Farmers' Rights to Livelihood in the Hindu-Kush Himalayan Region. Propublic/SAWTEE, Kathmandu, Nepal.

IRRI. 1970. Catalog of rice cultivars and breeding lines (*Oryza sativa* L.) in the world collection of the International Rice Research Institute. International Rice Research Institute (IRRI), Philippines.

Jain KBL. 1994. Wheat cultivars in India: names, pedigrees, origins, and adaptations. Research bulletin 2. Directorate of Wheat Research, Karnal, India.

Joshi BK, LP Subedi, SB Gurung and RC Sharma. 2003. Evaluation of cultivars and landraces of Oryza sativa for restoring and maintaining wild aborted cytoplasm. *Himalayan Journal of Science* 1:87-91.

Joshi BK. 2004. Rice gene pool for mid and high hills and its conservation in Nepal. **In** Agricultural Research for Enhancing Livelihood of Nepalese People. BK Joshi, SL Joshi and KP Paudyal (eds). Proc. 2nd SAS-N Convention, 30 July - 1 Aug 2003, Kathmandu, pp.252-264. http://sites.google.com/site/jafgaubase/publication/book-editorial-1

Joshi BK. 2005. Rice gene pool for Taria and Inner Tarai areas of Nepal. *Nepal Agriculture Research Journal* 6:10-23.

Joshi BK. 2006. Crossing frequency and ancestors used in developing Nepalese mid and high hill rice cultivars: Possible criteria for yield improvement and rice genes conservation. **In** Proceedings of 4th National Conference on Science and Technology, 23-26 March 2004, Kathmandu, National Academy of Science and Technology. Vol I, pp. 502-513. http://sites.google.com/site/jafgaubase/publication/proceedings-1

Joshi BK. 2008. Diversity based on coefficient of parentage among rice cultivars recommended for mid and high hills of Nepal. *SAARC Journal of Agriculture* 6(1):1–12. http://www.saarcagri.net/documents/download_SJA/sja_v_6_i_1/DIVERSITY.pdf.

Joshi BK. 2013. A brief overview of community seed bank initiatives in Nepal. **In** *Community Seed Banks in Nepal: Past, Present, Future*. P Shrestha, R Vernooy and P Chaudhary (eds). Proceedings of a national workshop, LI-BIRD/USC Canada Asia/Oxfam/The Development Fund/IFAD/Bioversity International, 14–15 June 2012, Pokhara, Nepal, pp.41–46.

Joshi BK and A Mudwari. 2003. Wheat gene pool and its conservation in Nepal. Paper presented in the International Conference on Himalayan Biodiversity, 26–28 January 2003, Kathmandu, Nepal.

Joshi BK, A Mudwari and MR Bhatta. 2006. Wheat genetic resources in Nepal. *Nepal Agriculture Research Journal* 7:1-10.

Joshi BK, A Mudwari, MR Bhatta and GO Ferrara. 2004. Genetic diversity in Nepalese wheat cultivars based on agro-morphological traits and coefficients of parentage. *Nepal Agriculture Research Journal* 5:7-18.

Joshi BK, LP Subedi, SB Gurung and RC Sharma. 2003. Evaluation of cultivars and landraces of *Oryza sativa* for restoring and maintaining wild aborted cytoplasm. *Himalayan Journal of Science* 1:87–91.

Mallick RN. 1981/82. *Rice in Nepal*. Kala Prakanshan, Kathmandu.

NRRP. 1997. *25 Years of Rice Research in Nepal (1972–1997)*. National Rice Research Program (NRRP), Nepal Agricultural Research Council, Kathmandu, Nepal.

NWRP. 1997. *25 Years of Wheat Research in Nepal (1972–1997)*. National Wheat Research Program (NWRP), Nepal Agricultural Research Council, Kathmandu, Nepal.

Rosyara UR and BK Joshi. 2005. Genetic base of wheat cultivars recommended in Nepal. *Nepal Agriculture Research Journal* 6:1–9.

Shrestha RB. 1976. Wheat production technology in Nepal. *Nepalese Journal of Agriculture* 6:18-24.

Skovmand B, MC Mackary, C Lopez and A McNab (eds). 2000. Tools for the millennium (CD). CIMMYT, Mexico, Mexico.

Skovmand B, R Vilereal, M Van Ginkel, S Rajaram and GO Ferrera. 1997. *Semidwarf Bread Wheats: Names, Parentages, Pedigrees and Origins*. CIMMYT, Mexico, Mexico.

# Chapter III : Benefits from the international exchange of plant genetic resources

Devendra Gauchan, Krishna Prasad Pant, Bal Krishna Joshi and Rachana Devkota

## Key messages

- Foreign sources of genetic resources have contributed more to improvements in major staples, such as rice, wheat, and maize, than to non-staple crops. The benefits to Nepal from future international flows of rice germplasm are estimated to be high.
- Nepal's rate of adoption of rice varieties derived through the multilateral system (MLS) and from other sources, including India and local areas, is high.
- The incremental benefit derived from externally sourced germplasm (50% national, 50% foreign genes) of the Khumal-4 variety is high: about NPR 1.05 billion annually at the current price and the 2010–2012 level of adoption.
- Non-monetary benefits from Khumal-4 are increased production stability as a result of its relatively better disease resistance and non-lodging nature, as well as the ability to grow subsequent crops because of Khumal-4's short growing season.
- Greater investment in plant breeding is needed to incorporate foreign-sourced germplasm into indigenous germplasm to improve productivity and profitability of crops as well as adaptability to changing climate conditions.

Humanity has benefited greatly from the international exchange of genetic resources. In the past, exchanges of plants and animals among farmers, communities, countries, and continents were mainly based on traditional values and customs. Nowadays, the exchange of germplasm is occurring much more frequently. Plant breeders use genetic materials that have been improved by other professional breeders and landraces that are selected and maintained by farmers. They use germplasm developed for environments similar to their own or for new target environments (Maredia and Byerlee 1999, Evenson et al. 1979). In the crop improvement chain, spillover effects occur at several nodes, which complicates precise calculation of the economic benefits of germplasm exchange.

Modern varieties, developed using germplasm acquired through the multilateral system (MLS), can produce good yields and the benefits can be estimated by comparison with local varieties of the same crop. However, differences between modern and "control" varieties are partly confounded by crop management effects, as the performance of modern varieties is often influenced by new crop management practices, farmers' experiments, different use of inputs, irrigation technology, and the incidence of diseases and pests. Changes in climatic conditions can further compound performance differences.

Investment in crop breeding generates appealing rates of return (Echeverria 1990, Alston et al. 2000, Evenson 2001). The major benefits come from increased yield, higher-quality grain, decreased cost of crop management, increased fodder production, and shortened growing season. Such benefits stem from better responses to fertilizers, irrigation, and management; increased resistance to diseases and pests; and increased tolerance of stresses, such as unfavourable temperature, drought, and water logging. Thus, the exchange and use of plant genetic resources (PGRs) are important for food security and adaptation to climate change. The role of PGRs from around the world in developing high-yielding varieties and combating food insecurity is detailed in chapters 1 and 2.

Increasing resistance to heat and drought (Mortimore and Adams 2001, Howden et al. 2007, Phiri and Saka 2008, Asfaw and Lipper 2012), as well as the development and adoption of new cultivars, is necessary to adapt crops to climate change and increase food production (Rosegrant and Cline 2003). Breeding resistant varieties requires access to a large pool of parent materials, which is possible only through international exchange of genetic materials, as no country is self-sufficient in PGRs (FAO 2004).

Article 13 of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) clearly recognizes the benefits of facilitated access to PGRs for food and agriculture, which are included in the MLS. According to the ITPGRFA, the benefits accruing from such PGRs shall be shared fairly and equitably. To verify whether sharing takes place, quantification of the benefits and measurement of contributions are warranted. Literature relating to the empirical estimation of economic benefits of the international exchange of PGRs for a given country or region is very limited. In Nepal, no such studies have been carried out to date. Thus, in this context, we aim to assess the economic benefits of improved varieties of selected major food crops developed using foreign PGRs made available through international exchange under the MLS.

We identify popular new varieties that have been most facilitated by international exchange, analyze adoption patterns, and assess the benefits accruing to Nepal. The research questions we address are: What new varieties of key food crops have resulted from international PGR exchange? What have been the dissemination and adoption patterns of these new varieties? What benefits would be foregone in the absence of these new varieties?

## Concepts and context of benefits

Benefits of the international exchange of PGRs under the MLS can be grouped into three types: non-monetary benefits, indirect monetary benefits, and direct monetary benefits (**Figure** 3.1). Non-monetary benefits include facilitated access and exchange of PGRs and related information. They also include support of technology transfer, capacity building, production stability brought about by genetic resources, and protecting the rights of farming communities to genetic resources. Indirect monetary benefits include a reduced transaction cost for the exchange and use of PGRs using a Standard Material Transfer Agreement (SMTA) rather than the cumbersome process of accessing material through bilateral systems. They also include real value-added benefits arising from facilitated access, use, and exchange of PGRs in plant breeding in the country and around the globe. Direct monetary benefits are those generated from the access to and exchange and use of PGRs; these include license fees, payment of royalties, up-front payments, and milestone payments through access to PGRs under the SMTA with the payment to the ITPGRFA's benefit-sharing fund.

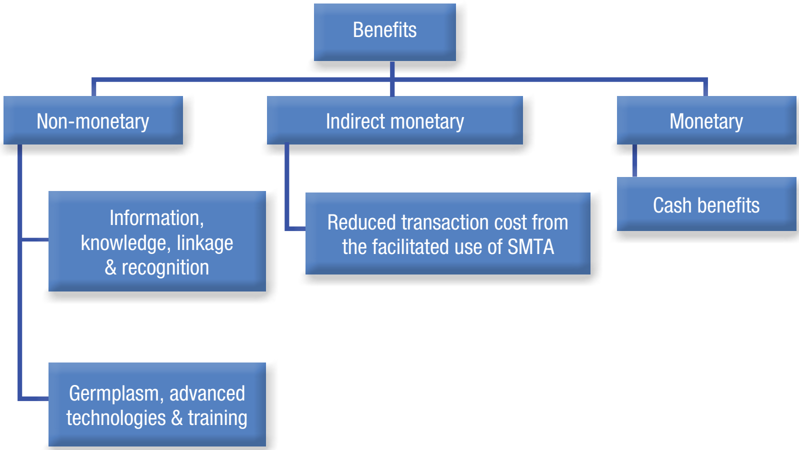


**Figure 3.1.** Potential benefits to Nepal of sharing plant genetic resources voluntarily under the multilateral system.

Under the provisions of the ITPGRFA, monetary benefits can include either mandatory payment of 1.1% of the gross sales (minus 30% of the cost to cover marketing) if the product is not available without restriction or, alternatively, a payment to discounted rate of 0.5% of the gross sale value regardless of whether the material is available freely or not. However, direct monetary benefits are yet to be realized globally. Evidence shows that the real value-added benefits arising from facilitated access, use, and exchange of PGRs in plant breeding in the country and around the globe can be high. Evenson and Gollin (2003) report the potential for high economic benefits from plant breeding research, particularly through incorporation of genes from international sources into national programs. Hossain et al. (2003) estimate annual gains from adoption of improved rice varieties in Asia at about US$10.8 billion — nearly 150 times the annual investment in rice research made by the International Rice Research Institute (IRRI) and the Nepalese Agricultural Research System together. The rate of return from wheat breeding research, particularly from the flow of international germplasm into Nepal, is also estimated to be high. Morris et al. (1992) estimate an internal rate of return of 85% from wheat breeding research in Nepal that used improved wheat germplasm from international sources between 1960 and 1995. Pant et al. (2011) report that rice consumers in Nepal value the aromatic traits of international rice varieties much higher than the taste-related traits of locally available landraces (US$153 million versus US$28 million per annum).

A recent study by the Australian Centre for International Agricultural Research on improvements in rice yields (1985–2009) from using germplasm supplied by IRRI to three East Asian countries (Philippines, Indonesia, and Vietnam) indicate a high economic rate of return and average increases in yield of 11.2% a year. These gains were mainly the result of the development of high-yielding varieties from externally sourced germplasm (Brennan and Malabyabus 2011). The economic value of this yield increase was estimated US$1.46 billion a year across the three countries.

## Methods

We assessed the economic benefits of the international exchange and flow of germplasm of key improved varieties of rice. We carried out a literature review, held consultation meetings with plant breeders and other researchers from national commodity research programs, and conducted field surveys and case studies. The literature review and initial expert consultations helped to identify popular rice varieties that have benefited from the international exchange of germplasm. These include the most popular rice varieties, Radha-4 and Sabitri grown in the terai and Khumal-4 in hills and mountains. Khumal-4 was selected as a case study for assessing economic impact, as it was developed from both external (e.g., IR-28) and indigenous PGRs (e.g., Pokhreli Masino).

Pedigree analysis of the Khumal-4 variety was carried out to identify and track the source of major genes and identify the extent of external PGRs incorporated into this widely adopted variety.

To obtain information about area planted, adoption, and yield, we reviewed and analyzed household adoption data from the Socioeconomics and Agricultural Research Policy Division (SARPoD) of the Nepal Agricultural Research Council (NARC). This information was collected mainly through the IRRI-supported projects Tracking Improved Varieties in South Asia (TRIVSA), Stress-tolerant Rice for Africa and South Asia (STRASA), and Seed-net. Some supplementary information was also collected through a field survey. Comparative data on the yields of both improved varieties derived from foreign-sourced germplasm and an existing local variety without foreign-sourced germplasm were collected and analyzed. We estimated the incremental economic benefits to Nepal from the flow of improved varieties containing genes from external/international sources. We compared adoption area, yields, and price data for varieties derived from foreign-sourced versus locally sourced germplasm.

### Selection of rice for the case study

We selected rice for the case study because it is the principal crop in Nepal. It is grown on about 1.5 million ha of land, or about half the net cultivated area of the country and accounts for a fifth of the agricultural GDP. Rice is the most important cereal crop in terms of cultivated area, production, and livelihood as it supports over two-thirds of farm households. Rice also supplies about 40% of the food calorie intake of the people of Nepal with average per capita consumption at 122 kg per annum (MoAD 2013).

## Economic framework for estimating benefits

Economic surplus can be used to measure an area affected by incorporation of genes from foreign sources through a plant breeding program either indirectly (in the form of a shift in the supply curve, which implicitly reflects changes in area planted) or directly (by estimating the rate of adoption of modern varieties derived from external sourced germplasm and applying this rate of adoption to the area planted to the crop). The main advantage of using this method is that it requires less information than other models (Alston et al. 1998, 2000) and permits the estimation of economic benefits from the adoption of an innovation (new variety), compared with the situation before adoption (only traditional varieties available) (Morris et al. 1992).

Benefits over the base area were estimated using the conventional method of multiplying genetic gains attributable to modern varieties (in this case, the yield losses foregone) by the area planted with varieties derived from foreign-sourced germplasm. The benefits that would be foregone in the absence of the innovation provide a measure of the opportunity cost of not engaging in international PGR exchange.

## Parameters needed to calculate the value of additional production

Once the area planted with Khumal-4 was estimated, the productivity gains of Khumal-4 over its original parent Pokhreli Masino were assessed. Three key parameters were needed: the area planted with modern varieties, the productivity gains attributable to adoption of the modern varieties, and the price of rice. Using a simple economic surplus model, these three parameters were combined to calculate the value of additional production in a given period (*t*):

$$B_t = A_t \, (Y_t - C_t) \, P_t$$

Where, *B* is the value of additional production attributable to rice breeding using foreign-sourced germplasm; *A* is the area planted with the rice variety developed using foreign-sourced germplasm; *Y* is the yield gain attributable to the new variety; *C* is the additional cost of production of the new over the traditional variety expressed in rice equivalents; and *P* is the farm gate price of rice of the designated variety, all over time *t*.

The average yield of Pokhreli Masino obtained during the field survey was compared with that of Khumal-4 to estimate the productivity gain attributable to adoption of Khumal-4. Using the farm gate price of both varieties obtained during the field survey, the net additional value (in NPRs) was estimated for rice-breeding research using international genes.

## Pedigree analysis

In 2013, the country had 69 released rice varieties (MoAD 2013). Most were obtained from the International Rice Research Institute (IRRI) through the International Network of Genetic Evaluation of Rice (INGER) and were released directly or used as parents for developing new varieties. A few were selected from popular local landraces in Nepal. Pedigree analysis of popular rice varieties revealed that 68% of the varieties released in Nepal since the beginning of the variety development process came from foreign sources (**Table** 3.1).

The pedigree analysis of Khumal-4 is presented in chapter 2 (**Figure** 2.7). Khumal-4 was developed by crossing the popular exotic rice variety IR-28 with the popular indigenous Pokhreli Masino, which has unique grain qualities (good taste, fine grains, taller plant height, and local adaptation). Khumal-4, which was released in 1987, is intermediate in plant height and combines the high yield and disease tolerance of IR-28 with the grain quality and straw yield of Pokhreli Masino. IR-28 was originally developed in IRRI from many crosses using germplasm from Taiwan, India, Indonesia, Thailand, and the United States. It has a dwarf gene from the DGWG variety (Taiwan) and the high-yield trait of IR-8 (IRRI). It is most popular among farmers in the mid-hills (800–1500 m above sea level) of Nepal and among consumers in Kathmandu Valley.

**Table 3.1. Contribution of foreign-sourced germplasm to popular rice varieties in Nepal**

| Category | No. and name | Source of germplasm | | CGIAR (MLS) and bilateral flow |
|---|---|---|---|---|
| | | Nepal (%) | Foreign (%) | |
| All improved varieties released | 68 (released) +1 (registered) | 32 | 68 | Mostly IRRI |
| Improved varieties with all genes acquired through MLS | Sabitri, Radha-4 | 0 | 100 | IRRI (MLS) |
| Improved variety with 50% genes through MLS | Khumal-4 | 50 | 50 | IRRI (MLS) + Nepal |
| Improved varieties with foreign-sourced genes but non-MLS | Sona mashuli, Sarju-52 | 0 | 100 | Cross-border informal flow from India |
| Improved varieties with all domestic genes | Lalka basmati, Jethobudho | 100% | 0 | 0 |

## Farm-level adoption of improved varieties

Household survey data collected under IRRI's TRIVSA project were analyzed to identify the extent of adoption of improved varieties derived from the MLS. The study was carried out from 2010 to 2012 in various ecological zones and development regions of Nepal by the Socioeconomics and Agricultural Research Policy Division of NARC (Velasco et al. 2014, Gautam et al. 2013). Analysis showed that 87% of the total area under rice in 2010–2012 was planted with improved varieties (Gautam et al. 2013, Gautam and Gauchan 2013) developed with parent germplasm obtained from formal international sources (IRRI) and informal cross-border flows from India. This finding is consistent with those of earlier household surveys, the STRASA project (Gauchan et al. 2012), and government statistics (MoAD 2011).

The findings of the TRIVSA survey of 1160 farmers in 29 districts of Nepal indicate that great variation exists in the extent and pattern of adoption of varieties in different agro-ecological zones and development regions of the country. The degree of adoption of modern varieties is very high in the terai (97%), moderate in the hills (65%), and very low in mountain regions (12%).

According to our data, 57% of the rice area in Nepal is under improved varieties derived from genetic resources received through the MLS, mainly from IRRI (**Figure** 3.2). These include popular varieties, such as Radha-4, Sabitri, Hardinath-1, and Masuli. Improved varieties derived from India through informal cross-border flows occupy 38% of the rice area. The dominant varieties here include Sona mashuli, Kanchhi masuli, Samba masuli, Sarjoo-52, and Ranjeet.

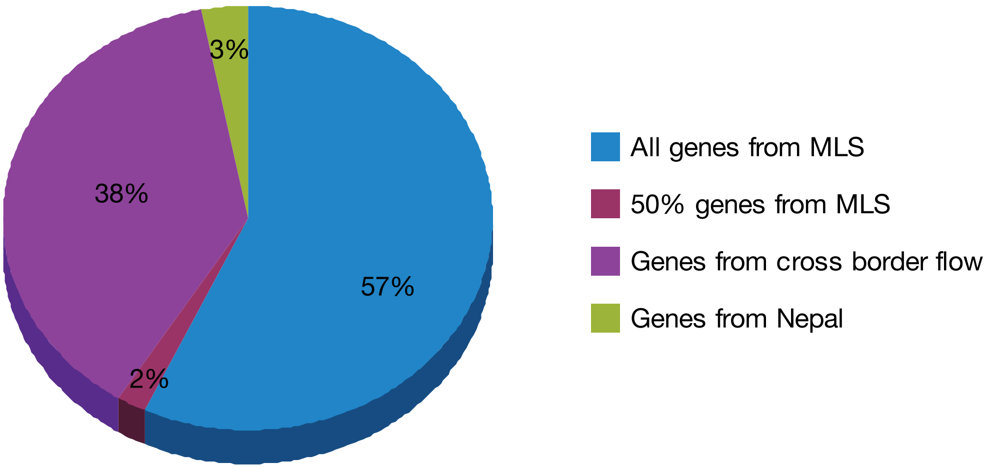


**Figure 3.2.** Farm-level adoption of germplasm derived through the MLS and other sources in Nepal.

About a dozen rice varieties are dominant in Nepal, but their popularity varies by region. Sona mashuli is the number one variety, accounting for 13% of the area planted with modern varieties mainly in the central terai, followed by Radha-4 (12%) mainly in western and mid-western regions. Kanchhi masuli is dominant in 9% of the total modern varieties area, but confined to the eastern terai region. Sabitri covers 6% of the total modern variety area and is popular in both terai and lower hills (below 700 m elevation). Khumal-4 is commonly grown in at 900–1500 m in the upper mid-hills and mountain regions (2% of the total modern varieties area), but over 9% in the mid-hills region and 7% in the high hills. The findings also indicate that about 20 varieties were being adopted in more than 1% of total modern varieties rice area in Nepal during 2010–2012.

## Extent and pattern of adoption of Khumal-4

Incidence and intensity are two widely used indicators of adoption. Incidence of adoption is the percentage of farmers growing modern varieties at a specific time, whereas intensity of adoption is the percentage of area planted to modern varieties (Gauchan et al. 2012). We used intensity, i.e., percentage area of Khumal-4 at the farm level, as an indicator of adoption for this study.

Adoption reflects farmers' decision to incorporate modern varieties into their production system by replacing traditional varieties or replacing improved varieties of older vintage. Available survey data revealed that the extent and pattern of adoption of Khumal-4 varied across districts in Nepal (Gautam et al. 2013).

Khumal-4 was developed and recommended for altitudes of 800–1500 m. Hence, it was mainly adopted by farmers in the mid-hills and lower parts of mountainous districts. Of 29 districts surveyed in 2010–2012, Khumal-4 was found in 9 of the 16 hill districts (Kavre, Bhaktapur, Dailekh, Lamjung, Parbat, Myagdi, Kaski, Gorkha, and Baglung) and one of the two mountain districts (Sankhuwasabha) (**Figure** 3.3). The highest rate of adoption was found in Bhaktapur, Kavre, and Dailekh districts. Khumal-4 was not reported from Jumla, a high-mountain district nor in some of the hill districts (e.g., Udayapur) where the rice-growing area is at lower altitudes (< 800 m), in river basins and lowland valleys. No farmers in terai districts have cultivated Khumal-4.

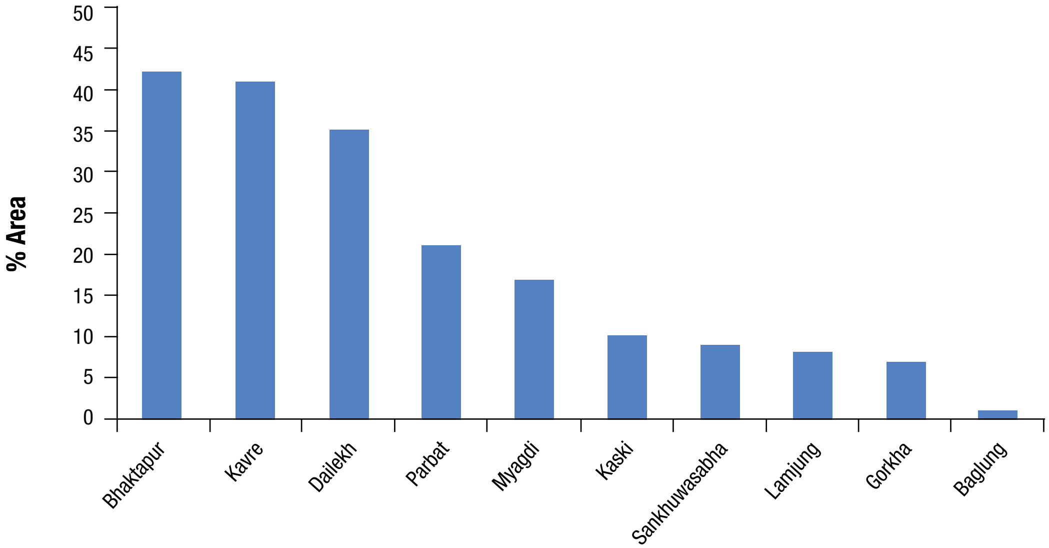


**Figure 3.3.** Percentage of rice-growing area planted with Kumal-4 in nine hill and one mountain (Sankhuwasabha) districts.

Source: Field survey; Tracking Improved Varieties in South Asia data (2010–2012).

## Estimating the economic benefit from Khumal-4 rice

### Area planted with Khumal-4 rice

To estimate the economic benefits of a given variety, we must have farm-level data on coverage of that specific variety. Official data on average rice area for the three years of the survey period (**Table** 3.2) indicate that Khumal-4 was planted on 35856 ha in the hills region and 4659 ha in the mountains. This accounts for about 9% and 7% of the total rice area in those regions for a total of more than 40 thousand ha covered by Khumal-4 during the study period.

**Table 3.2. Average area devoted to rice crops (2009–2011) and estimated Khumal-4 coverage**

| Region | Rice area, ha | | | 3-year average, ha (% of total) | Khumal-4 coverage, ha (% of rice area) |
|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | | |
| Mountain | 64915 | 66713 | 68051 | 66560 (4) | 4659 (7) |
| Hill | 392664 | 407037 | 395492 | 398398 (26) | 35856 (9) |
| Terai | 1098361 | 1022726 | 1067950 | 1063012 (70) | 0 |
| All | 1555940 | 1496476 | 1531493 | 1527970 (100) | 40515 |

Sources: MoAD (2011) and NARC TRIVSA field survey (2010–2012).

## Value of increased rice production

**Table** 3.3 shows comparative yields of Khumal-4 and Pokhreli Masino and an estimate of the benefits of growing Khumal-4 in Nepal. There is a clear yield gain when farmers switch from the traditional Pokhreli Masino variety to Khumal-4, as the latter yields about 1.5 t/ha more than the traditional variety. However, the cost of production of Khumal-4 is relatively higher (rice yield equivalent of 1.25 t/ha) as compared to Pokhareli Masion (rice yield equivalent of 1.0 t/ha). Estimating yield in terms of cost in rice yield equivalents for both varieties by adjusting with production costs, the net yield gain from adoption of Kumal-4 remains at 1.25 t/ha.

Although all costs associated with PGR transfer and breeding, mostly within public-sector institutions, are not included in our analysis, part of those costs are included in the price of seeds sold by breeding institutions. The costs of seed multiplication and marketing, mostly within the private sector, are automatically included in seed prices and reflected in cost of production.

In terms of net revenue, the additional revenue from growing Khumal-4 was NPR 26250 (US$275) per hectare. Based on analysis of total area planted with Khumal-4 in 2010–2011, the gain was NPR 1.05 billion (US$11 million). Although this estimate is somewhat crude, we conclude that there are economic benefits from incorporation of Khumal-4, despite its relatively low adoption rate in the hill and mountain regions of Nepal.

**Table 3.3. Increased yield and revenue gained from growing the modern Khumal-4 variety compared with the traditional Pokhreli Masino variety in Nepal**

| Variety | Average yield (t/ha) | Yield in terms of rice cost equivalents* (t/ha) | Net yield gain from adoption (t/ha) | Farm gate price (NPRs/t) | Revenue (NPRs /ha) |
|---|---|---|---|---|---|
| Khumal-4 | 3.50 | 1.25 | 2.25 | 25000 | 56250 |
| Pokhreli-Masino | 2.00 | 1.00 | 1.00 | 30000 | 30000 |
| Difference | 1.50 | 0.25 | 1.25 | -5000 | 26250 |

* Estimated equivalent rice yield from actual cost of production data.

Note: During this study, 95.5 Nepalese rupees = 1 United States dollar.

Khumal-4 also provides other benefits that we have not included in the above estimate. These include production stability as a result of disease tolerance and less lodging compared with Pokhreli Masino. Its shorter growing season also enables farmers to increase cropping intensity by cultivating vegetables and cash crops.

Considering that 68% of rice varieties released in Nepal contain genes of foreign sources (chapter 2), the benefits from the transfer of rice genetic resources from foreign sources are great. Many other crops grown in Nepal also carry genes from foreign sources, in particular wheat, maize, pulses, and vegetables. Even such crops as soybean and sugarcane grown in Nepal, although not included in Annex I of the ITPGRFA, have benefited from genetic resources of foreign origin.

## Conclusions and implications

This study estimates the economic benefits of the adoption of improved germplasm at one point in time. Estimates over longer periods would have allowed more accurate measures, such as net present value and internal rate of return. Accounting for the benefits of innovations in crop varieties requires detailed disaggregated data for adoption rates, yields, prices, and farm-level information as well as complex analytical methods, econometric techniques, and statistical tools. Considering resource and time constraints, this study used available data and simple calculations to estimate the benefits of easy access and use of PGRs from international exchanges.

Major staples, such as rice, wheat, and maize, have benefited more from foreign sources of genetic resources than non-staple crops. Our case study of rice demonstrates that adoption of varieties that include parents obtained through the MLS and other sources (cross-border flows from India and local origins) in Nepal is high. This suggests that future benefits from the international flow of germplasm in rice could also be high.

The use of foreign-sourced germplasm to develop Khumal-4 provides annual benefits of about NPR 1.05 billion at the current price and the 2010–2012 adoption level. Non-monetary benefits include production stability and the ability to grow additional crops on the same land. If Khumal-4 had not been developed and promoted, the country would have lost these substantial monetary and non-monetary benefits, implying a high opportunity cost of not engaging in international PGR exchange.

Considering the great benefits accruing from easy access to foreign-sourced germplasm, facilitated access under the MLS is important to promote and sustain variety innovations in developing countries like Nepal, where agriculture is critical to food security and the livelihood of the people. Moreover, there is a need for more investment in plant breeding by incorporating foreign sourced germplasm in the existing indigenous germplasm to improve productivity and profitability of the crop as well as to improve adaptability of farming systems to changing climate conditions.

## References


Alston JM, GW Norton and PG Pardey. 1998. *Science under Scarcity: Principles and Practices for Agriculture Research Evaluation and Priority Setting*. Cornell University Press, Ithaca, New York, USA.

Alston JMC, MC Chan-Kang, PJP Marra and TJ Wyatt, 2000. *A Meta-Analysis of Rates of Return to Agricultural Research and Development: Ex Pede Herculem*. International Food Policy Research Institute, Research Report 113, Washington, DC, USA.

Asfaw S and L Lipper. 2012. Economics of plant genetic resource management for adaptation to climate change: A review of selected literature. ESA working paper 12-02. Food and Agriculture Organization, Rome, Italy. Last accessed on September 2014 available at http://www.fao.org/3/a-an649e.pdf.

Brennan JP and A Malabayabas. 2011. International Rice Research Institute's contribution to rice varietal yield improvement in South-East Asia. Impact assessment series report 74. Australian Centre for International Agricultural Research, Canberra, Australia. p.111.

Echeverria RG. 1990. Assessing the impacts of agricultural research. In *Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research*. RG Echeverria (ed). International Service for National Agricultural Research, The Hague, Netherlands.

Evenson RE. 2001. Economic impacts of agricultural research and extension. **In** *Handbook of Agricultural Economics*. B Gardner and G Rausser (eds). Elsevier Science, Philadelphia, Pennsylvania, USA.

Evenson RE and D Gollin. 2003. Assessing the impact of the Green Revolution, 1960 to 2000. *Science* 300(5620):758–762.

Evenson RE, JC O'Toole, RW Herdt, WR Coffman and HE Kauffman. 1979. Risk and uncertainty factors in crop improvement research. **In** *Risk, Uncertainty and Agricultural Development*. JA Roumasset, JM Boussard and I Singh (eds). Southeast Asian Regional Center for Graduate Study and Research in Agriculture, College Laguna, Philippines.

FAO. 2004. *International Treaty on Plant Genetic Resources for Food and Agriculture.* Food and Agriculture Organization (FAO), United Nations, Rome, Italy. Available at http://www.planttreaty.org/content/texts-treaty-official-versions.

Gauchan D. 2014. Seed system structure and actors in rice seed production and supply: Options for effective seed-net development in Nepal. Seed Net development report EC-IFAD. International Rice Research Institute, Los Baños, Philippines.

Gauchan D, HK Panta, S Gautam and MB Nepali. 2012. Synthesis of key results and implications. **In** *Patterns of Adoption of Improved Rice Varieties and Farm-Level Impacts in Stress-Prone Rainfed Areas in South Asia.* S Pandey, D Gauchan, M Malabayabas, M Bool-Emerick, B Hardy (eds). International Rice Research Institute, Los Baños, Philippines. pp.35–103.

Gautam S and D Gauchan. 2013. *Tracking, Adoption of Improved Rice Variety in Different Agro-ecological Regions of Nepal*. Summer crop workshop. National Maize Research Program, Rampur, Nepal.

Gautam S, HK Panta, ML Velasco, YN Ghimire, D Gauchan and S Pandey. 2013. *Tracking of Improved Rice Varieties in Nepal*. Country report. International Rice Research Institute, Los Baños, Philippines.

Hossain M, D Gollin, V Cabanilla, E Cabrena, N Johnson, G Khush and G McLaren. 2003. International research and genetic improvement in rice: evidence from Asia and Latin America. **In** *Crop Variety Improvement and its Effect on Productivity: the Impact of International Agricultural Research*. RE Evenson and D Gollin (eds). CABI Publishing, Wallingford, UK.

Howden SM, JJ Soussana, FN Tubiello, N Chhetri, M Dunlop and H Meinke. 2007. Adapting agriculture to climate change. *Proceedings of the National Academy of Sciences of the United States of America* (PNAS) 104:19691–19696.

Maredia M, and D Byerlee (eds). 1999. The global wheat improvement system: prospects for enhancing efficiency in the presence of research spillovers. Research report 5. CIMMYT, Mexico, Mexico.

MoAD. 2011. Statistical information on Nepalese agriculture. Ministry of Agriculture Development (MoAD), Kathmandu, Nepal.

MoAD. 2013. Statistical information on Nepalese agriculture. Ministry of Agriculture Development (MoAD), Kathmandu, Nepal.

Morris ML, HJ Dubin and T Pokhrel. 1992. Returns to wheat research in Nepal. Economics working paper 92-04. CIMMYT, Mexico, Mexico.

Mortimore MJ and WM Adams. 2001. Farmer adaptation, change and crisis in the Sahel. *Global Environmental Change* 11:49–57.

Pant KP, JC Gautam and E Wale. 2011. Valuation of rice diversity in Nepal: a trait-based approach. **In** *The Economics of Managing Crop Diversity: On-farm Case Studies from the Genetic Resources Policy Initiative*. E Wale, AG Drucker and KK Zander (eds), Earthscan, London, UK. pp.45–64.

Phiri IMG and AR Saka. 2008. The impact of changing environmental conditions on vulnerable communities in the Shire valley, Southern Malawi. **In** *The Future of Drylands*. C Lee and T Schaaf (eds). Springer and United Nations Educational, Scientific and Cultural Organization (UNESCO) publishing, Paris, France. pp.545–559.

Rosegrant MW and SA Cline. 2003. Global food security: challenges and policies. *Science* 302:1917–1919.

Velasco L, TW Tsusaka and T Yamano. 2014. TRIVSA synthesis report on rice. Tracking Improved Varieties in South Asia (TRIVSA), International Rice Research Institute, Los Baños, Philippines.

# Chapter IV : Interdependence on plant genetic resources in light of climate change

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## Key messages

- Farmers' interdependence on plant genetic resources, both within Nepal and beyond, has played a pivotal role in the development of agriculture. No country in the world is self-sufficient in genetic resources.
- Climate change is further increasing this interdependence because of the need for countries to adapt by accessing new sources of biodiversity. Little is known, yet, about what shape or course interdependence will take in light of climate change adaptation in the future.
- Effects of climate change on crop yield are evident in Nepal and have stimulated efforts to identify"novel" germplasm with better adaptive capacities.
- The Climate Analogues tool can identify geographic areas with similar climate conditions (i.e., analogous sites) in current, past, and future years, leading to the possibility of finding and exchanging suitably adapted germplasm.
- Using the Climate Analogues tool, we identified current and future analogous sites within and outside Nepal, suggesting that genetic material could be exchanged with these sites. This could be done by using the ITPGRFA's multilateral system.
- Rigorous field-testing of genetic material from analogous sites will help validate the utility of the Climate Analogues tool.

For generations, farmers have been relying on each other to conserve, use, and improve plant genetic resources (PGRs) and associated knowledge and skills to ensure on-farm diversity as a strategy to secure livelihoods (FAO 2011). In addition to the unconscious actions of farmers, scientists have been making deliberate efforts to create diversity and develop biotic and abiotic stress-resistant, high-yielding varieties by manipulating genetic materials from around the world (Zeven and De Wet 1982, Ramirez-Villegas et al. 2013). No country in the world is self-sufficient in PGRs in terms of meeting domestic needs and international market demand (IPGRI 1996, Boring 2000).

Interdependence on PGRs at all levels, from local to global scales, is increasing and becoming more complex as a result of globalization and easier means of transportation. For example, some south and central African countries rely on external sources for over 80% of the germplasm they use (Palacios 1998, Ramirez-Villegas et al. 2013). Similarly, forage grasses originating in sub-Saharan Africa cover about 90% of all land under forage grasses worldwide (Boonman 1993); alfalfa (*Medicago sativa*), a forage legume species, alone covers 79 million ha of land (Putnam et al. 2007). A mega biodiversity centre in northwest India holds more than 14% of the world's cultivated plants (Brush 2013). A wheat variety, Attila, developed by breeding diverse ancestors, is cultivated on 20 million ha worldwide. In India alone, it covers 8 million ha and produces 28 million t of wheat worth over US$66.5 billion annually (Rajaram and Braun 2008, Yadav 2010).

Over 4.6 million crop accessions are available in the public domain, and the CGIAR centres alone preserve more than 700 thousand accessions of crops and forage species collected from over 100 countries (Halewood et al. 2013). These materials have been distributed mainly (more than 90%) through public research organizations, universities, regional organizations, germplasm networks, and genebanks; about 80% of distributed material goes to developing countries and countries with economies in transition  (SGRP 2011).

Climate change is one of the most pressing challenges facing the world; it has already had a profound impact on PGRs and the livelihoods of people, mainly smallholders living in marginal environments (FAO 2011). Climate change may render locally available PGRs inadequate, thus underscoring the importance of access to other PGR sources (Esquinas-Alcazar 2005, FAO 2011, Fujisaka et al. 2011). Novel strategies to conserve and use PGRs are likely required to strengthen farmers' capacities to adapt to climate change. The multilateral system (MLS) of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) could be of great help in putting these strategies into practice.

The use of "climate analogues" is one such strategy. Climate Analogues is an open-access tool developed by the program on Climate Change, Agriculture and Food Security in conjunction with the International Center for Tropical Agriculture and the Walker Institute (Ramírez-Villegas et al. 2011). Used to support adaptation to climate change in the agricultural section, its main applications are in policy and planning. The tool can be used to identify future climate conditions at a particular location, sites that currently resemble these conditions, and locations that have or will have similar climate conditions. Based on careful analyses using the tool and data from actual conditions in farmers' fields, scientists can formulate possible intervention strategies, including identification of appropriate PGRs or development of new varieties for specific locations of interest (Vernooy et al. 2015). However, efforts to address climate change remain a major challenge in developing and underdeveloped countries with large numbers of smallholder farmers.

In this chapter, we analyzed temperature and rainfall trends at two reference sites and assess the impact on crop yield using rice as an example. We also identify analogous sites, identify rice collections and material in the public domain, and assess the potential for PGR exchange between analogous sites in Nepal. Data were analyzed with the help of the Climate Analogues Tool, and maps were prepared and further refined using DIVA-Geographic Information System (DIVA-GIS). Analogous sites were identified using various climate change scenarios outlined in the *Special Report on Emission Scenarios* (Nakicenovic et al. 2000). GIS has already been used to manage wild rice in Nepal and to identify analogue sites for varietal trials (Joshi et al. 2008a, 2008b).

## Methods

### Site and crop selection

We selected two districts as reference sites: Begnas village in Kaski district, representing the mid-hills region and Kachorwa village in Bara district, representing the lowland terai. These sites are rich in agrobiodiversity at the species, variety, and gene levels (Sherchan et al. 1998, Rana et al. 2000). Several species are rare and localized or on the verge of extinction (Chaudhary et al. 2004, Joshi et al 2005). In 1998, an in-situ conservation project was initiated at both the villages and, since then, continuous efforts have been made to promote in-situ conservation of agrobiodiversity on farm. Some important features of the project sites are presented in **Table** 4.1.

We selected rice for this study as it is the most important staple crop grown by a large number of farmers in many parts of Nepal. Farmers of both Kachorwa and Begnas grow aromatic fine rice varieties, namely Basmati and Jethobudho. There is potential for expansion of these varieties in analogue sites across the world, in particular given their economic value.

**Table 4.1. Features of the two study sites**

| Characteristic | Begnas, Kaski | Kachorwa, Bara |
|---|---|---|
| Altitude (m above sea level) | 668–1206 | 80–90 |
| Coordinates | 28°11’N, 84°09’E | 26°54’N, 85°10’E |
| Total area (ha)* | 2450 | 840 |
| No. households† | 596 | 1614 |
| Dominant ethnic group† | Brahman, Chhetri, and Gurung | Yadav, Kanu, and Muslim |
| Ecological conditions | Sub-tropical to sub-temperate | Sub-tropical |
| Major crops, 2014 | Rice, finger millet, maize | Rice, wheat, lentils, mustard |
| Number of rice varieties, 2014 | 48 | 99 |
| Overall development index† | 6 | 55 |

Sources: * Google Earth; † Central Bureau of Statistics (2012).

### Weather and crop data

Weather data for Kachorwa and Begnas were obtained from the closest meteorological stations at Simara and Pokhara airports for the period 1971–2011. Crop yield and area data at the district level were obtained from the Ministry of Agricultural Development for the period 1991–2011. A trend analysis of maximum and minimum temperature and annual total rainfall, as well as coverage and productivity of rice was carried out to observe changes over that period. Correlation analysis between crop yield and selected climate parameters was also done for 1991–2011 to understand the impact of climate change.

## Scenario analysis

We used the online Climate Analogues Tool (http://www.ccafs-analogues.org/tool/) to assess current and future climate conditions and identify sites analogous to the reference sites (**Table** 4.1). We used DIVA-GIS software (http://www.diva-gis.org) to refine the maps produced using Climate Analogues. We identified seven possible scenarios relating analogue and reference sites (**Table** 4.2).

### Table 4.2. Possible scenarios for the relation between analogue and reference sites

| Possible relationship | Rationale |
|---|---|
| Current situation in location X = current situation in location Y | Potential exchange of PGRs between the two locations at present time |
| Current situation in location X = past situation in location Y (e.g., 30 years ago) | Crops and varieties grown in location Y 30 years ago could now be introduced at location X |
| Current situation in location X = future situation in location Y (e.g., 30 years from now) | Crops and varieties grown in location X now could become suitable for location Y in 30 years |
| Future situation (e.g., in 30 years) in location X = current situation in location Y | Crops and varieties grown in location Y now could become suitable for location X in 30 years |
| Past situation (e.g., 30 years ago) in location X = current situation in location Y | Crops and varieties grown in location X 30 years ago could now be introduced at location Y |
| Past situation in location X = past situation in location Y | Crops grown in location X were likely similar to crops grown in location Y in the past |
| Future situation in location X = future situation in location Y | In the future, crops grown in locations X and Y could be exchanged |

Of these, we analyzed three types of relationship: current situation at location X = current situation at location Y, current X = past Y, and current X = future Y. The current/current scenario allowed us to examine the relation between the baseline situation at the reference and analogue sites. Current/past and current/future comparisons allowed us to look at three scenarios based on emissions scenarios described in the IPCC's *Special Report on Emissions Scenarios* (Nakicenovic et al. 2000) and embedded in the Climate Analogues tool. The tool allows users to choose the most appropriate scenario based on specific research questions. The pertinent emissions scenarios are briefly described in **Table** 4.3.

### Table 4.3. Description of emissions scenarios used for the analysis

| Scenario | Description |
|---|---|
| A1B | The A1 scenario is based on the lowest population. It assumes low fertility and low mortality with a global population that peaks in mid-century (at 8.7 billion) and declines thereafter (toward 7 billion by 2100). It describes a future world of rapid economic growth and introduction of new and more efficient technologies. The A1 scenario has three sub-scenarios: fossil fuel intensive (A1FI), non-fossil energy sources (A1T), and a balance across all sources (A1B). |
| A2 | The A2 scenario is based on the largest population (15 billion by 2100). It assumes a slow decline in fertility for most regions and stabilization at replacement levels. It falls below the long-term United Nations 1998 projection of 18 billion and describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. |
| B1 | The B1 scenario describes a convergent world with the same global population growth as in A1, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives. |

Source: Adapted from Nakicenovic et al. 2000.

The matching sites were grouped into four categories based on the likelihood of matching: 0.75–1 probability (highly matching), 0.5–0.75 (moderately matching), 0.25–0.5 (less likely to match), and 0–0.25 (unlikely to match).

### Selection of criteria in Climate Analogues

Using Climate Analogues, we chose monthly mean temperature and monthly precipitation under "Climatic and bioclimatic variables," as these are key factors affecting rice yield during the growing period. Temperature and precipitation were given the weights 0.4 and 0.6, respectively, as precipitation is slightly more important than temperature, as the selected site is predominantly rain fed. We used the model "Ensemble" to decrease uncertainty. For the rice-growing period, June to November was considered. For "rotation," we chose "both" as there is a high variation in both temperature and precipitation during the rice-growing season. **Table** 4.4 summarizes the selection criteria used.

**Table 4.4. Options chosen for use in the Climate Analogues tool**

| Time frame | Direction (comparison between) | Model | Scenario |
|---|---|---|---|
| Current–current | None (1960–1990) | Current | Baseline |
| Current–future | Forward (1960–1990 vs 2020–2049) | Current–ensemble | A1B, A2 |
| Future–current | Backward (2020–2049 vs 1960–1990) | Ensemble–current | A1B, A2 |

## Climate variability over time

A trend analysis of temperature and rainfall shows variation over time, especially in total annual rainfall, at both the study sites. Both maximum and minimum temperatures have increased over time at both the sites, more so at Begnas (Kaski district; minimum temperature has increased 0.05°C/year and maximum 0.04°C/year) as its altitude is higher than Kachorwa's (Bara district; minimum temperature increase 0.03°C/year; maximum 0.009°C/year) (**Figure** 4.1). This is consistent with previous findings showing that higher latitude and altitude regions are facing a more rapid temperature rise than lower ones (Shrestha et al. 1999, Shrestha and Devkota 2010). In both regions, the range between minimum and maximum temperatures is shrinking over time, as minimum temperature is increasing faster than maximum temperature. This is also consistent with previous findings (Houghton et al. 2001, Upadhya and Grover 2012, Mandala 2012, Krishna 2014).

Annual rainfall has fluctuated greatly over time at both Begnas and Kachorwa, making it harder to predict, unlike in the past when people were able to plan their agricultural activities based on more stable patterns. In Begnas, the least amount of rain fell in 1981 (2469 mm); Kachorwa received the least rain (893 mm) in 1972. In contrast, the years of greatest rainfall in Begnas and Kachorwa were 1995 (5102 mm) and 2007 (2380 mm), respectively (**Figure** 4.1).

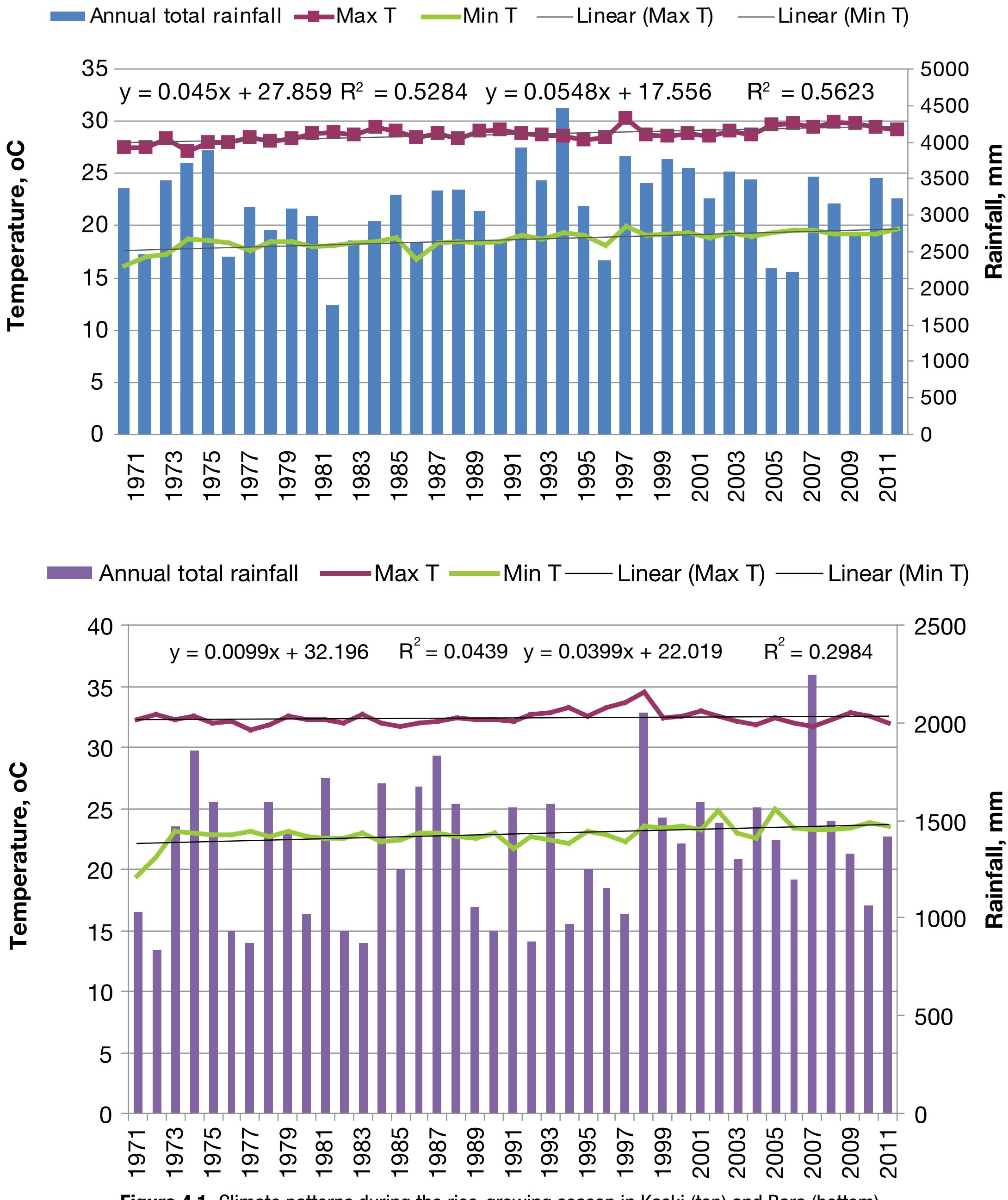


**Figure 4.1.** Climate patterns during the rice-growing season in Kaski (top) and Bara (bottom) districts based on data obtained from meteorological stations.

## Trends in rice area, production, and productivity

At both sites, the area under rice has remained more or less constant, yet production and productivity have increased, mainly after 1996 (**Figure** 4.2). In 2007, production and productivity at both the sites decreased, which coincides with excessive rainfall in Kachorwa that year.

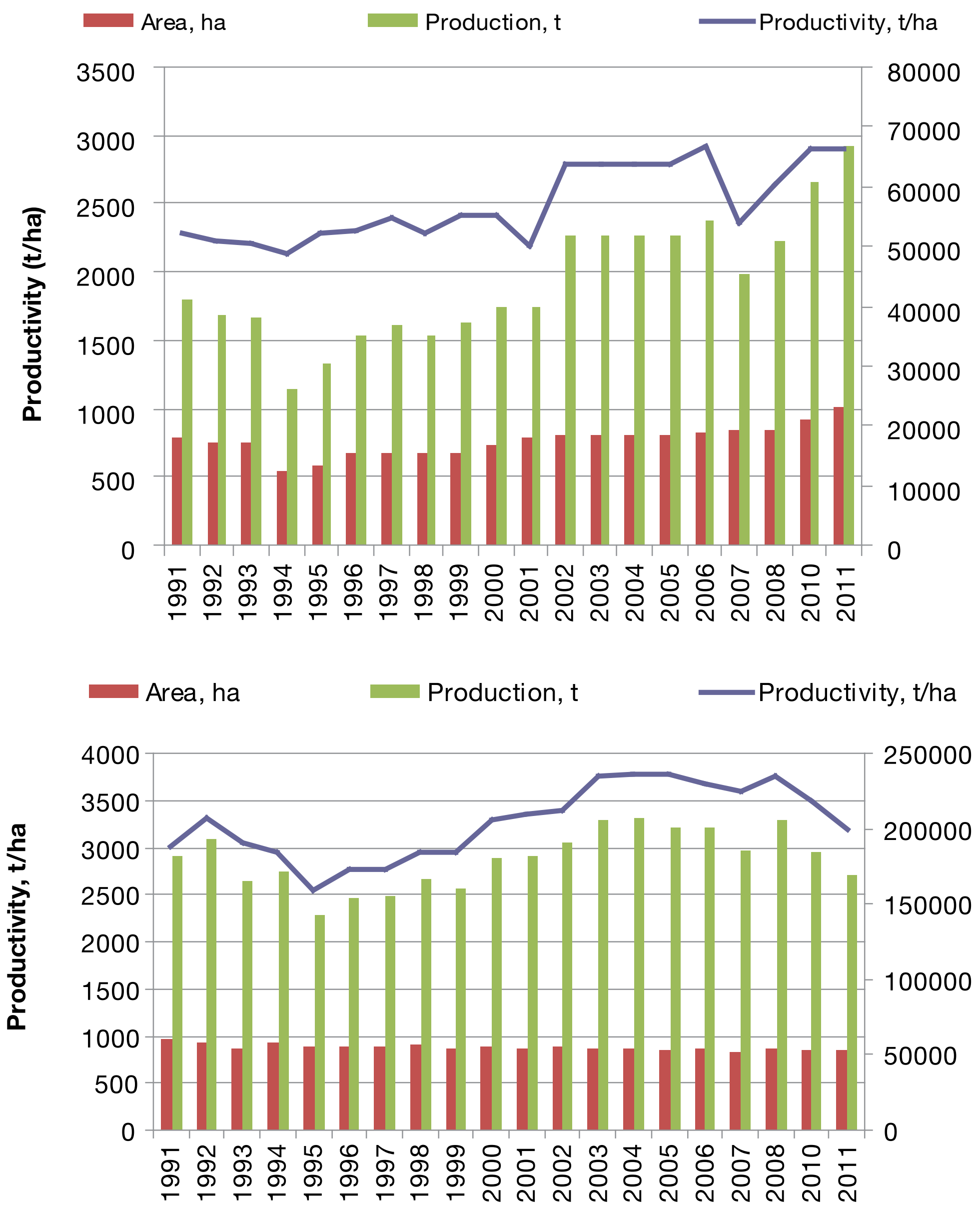


**Figure 4.2.** Rice production trends over years in Kaski (top) and Bara (bottom) districts.

## Correlation between climate and crop yield

The data show a highly positive correlation between production and productivity; however, for other parameters, results are mixed (**Table** 4.5). For instance, in Kaski district the area planted with rice is positively correlated with productivity, whereas in Bara district the correlation is negative. Production is also positively correlated with area to a significant degree in Kaski, but negatively correlated, although not at a significant level, in Bara.

**Table 4.5. Correlation between rice production and climatic parameters for Begnas (Kaski) and Kachorwa (Bara), 1991–2011**

| | Area | Production | Productivity | Max. temp. | Min. temp. |
|---|---|---|---|---|---|
| **Begnas, Kaski** | | | | | |
| Production | 0.934** | | | | |
| Productivity | 0.703** | 0.907** | | | |
| Max. temp. | 0.383 | 0.363 | 0.286 | | |
| Min. temp. | 0.3252 | 0.348 | 0.306 | 0.536** | |
| Seasonal rainfall | -0.241 | -0.297 | -0.342 | -0.216 | 0.330 |
| **Kachorwa, Bara** | | | | | |
| Production | -0.159 | | | | |
| Productivity | -0.456* | 0.951** | | | |
| Max. temp. | 0.362 | -0.531** | -0.593** | | |
| Min. temp. | -0.546** | 0.249 | 0.393* | -0.093 | |
| Seasonal rainfall | -0.315 | 0.087 | 0.181 | -0.071 | 0.176 |

* and ** Significant at 5% and 1%, respectively.

## Past, present, and future analogous sites

Our analysis clearly showed a number of sites that are analogous to Begnas and Kachorwa (**Tables** 4.6 and 4.7 and **Figures** 4.3 and 4.4). The analysis revealed that some of the districts are in common, but locations differ slightly for current, future, and past scenarios and some districts in each category do not match each other. It was also obvious that most of the future analogous sites are north of the reference sites, which indicates that rising temperatures are making sites more similar to previously warmer locations in lower altitudes in the southern region. The northern regions are generally colder and at higher elevations than the southern regions.

**Table 4.6. Districts of Nepal that may be analogues of Begnas (reference site) currently, in the future, and in the past**

| Probability of matching | Current analogue sites | Future analogue sites (forward selection) | Past analogue sites (backward selection) |
|---|---|---|---|
| Highly likely (0.75–1) | Dhading, Gorkha, Kaski, Kavrepalchok, Nuwakot, Sankhuwasawa, Sindhuli, Sindhupalchok, Southern, Tanahun, Taplejung **(11)** | Dhading, Dolkha, Gorkha, Kaski, Kavrepalchowk, Khotang, Lamjung, Makwanpur, Myagdi, Nuwakot, Ramechhap, Sankhuwasabha, Sindhupalchowk, Solukhambu, Syangja, Tanahun **(16)** | Bhojpur, Dhading, Dhankutta, Gorkha, Ilam, Khotang, Morang, Nuwakot, Solukhumbu, Tanahun, Terathum **(11)** |
| Moderately likely (0.5–0.75) | Syangja, Ilam, Dhankuta, Bhojpur, Sankhuwasabha, northern part of Morang, Bara, Parsa, Rautahat, Sarlahi, Mahotari, Dhanusa, Siraha, north and east Chitwan, mid-western Dang<br>Some Parts of Baitadi, Dadeldhura, Kailali, Doti, Achham, Surkhet, Dailekh, and Salyan<br>Central Kaski, eastern Parbat **(25)** | Parbat, Syangja, Palpa, Dhading, Gulmi, Terathum, Panchthar, Dhankuta, Bhojpur, and Khotang<br>Central and southern Kaski, Lamjung, Gorkha, SIndhupalchowk, Dolkha, Sankhuwasabha, and Taplejung<br>Northern Makwanpur, Ilam, Sindhuli, and Udapur<br>Parts of Baitadi, Dadeldhura, Kailali, Doti, Achham, Surkhet, Dailekh, and Salyan **(29)** | Bardiya, Banke, Kapilvastu, Rupandeshi, Nawalparasi, Tanahun, Chitwan, Parsa, Bara, Rautahat, Sarlahi, Mahotari, Dhanusa, Siraha, Sunsari, Morang, Jhapa, Ilam, Dhading, Dolkha, Sindhupalchowk, and Nuwakot<br>Some Southern parts of Kaski, Lamjung, Gorkha, and Terathum<br>Parts of Baitadi, Darchula, Dadeldhura, Kanchanpur, Kailali, Doti, and others **(32)** |

| Probability of matching | Current analogue sites | Future analogue sites (forward selection) | Past analogue sites (backward selection) |
|---|---|---|---|
| Less likely (0.25–0.5) | Almost all districts of Nepal | Almost all districts of Nepal **(75)** | Almost all districts of Nepal except Bara, Parsa, Rautahat, Sarlahi, Mohattari, Dhanusa, Siraha, Saptari, Sunsari, Jhapa **(65)** |
| Unlikely (0–0.25) | No districts | No districts | No districts |

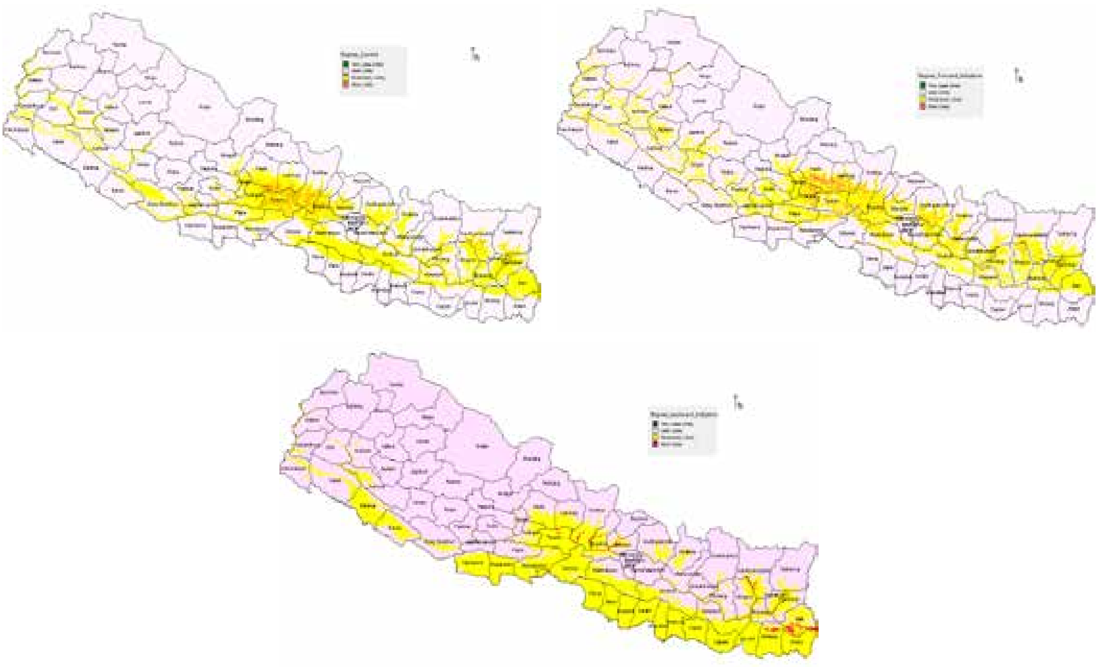

**Figure 4.3.** Sites in Nepal that may be analogous to Begnas currently (top left), in the future (top right), and in the past (bottom).

## Table 4.7. Districts of Nepal that may be analogues of Kachorwa (reference site) currently, in the future, and in the past

| Probability of matching | Current analogue sites | Future analogue sites (forward selection) | Past analogue sites (backward selection) |
|---|---|---|---|
| Highly likely (0.75–1) | Kapilvastu, Rupandeshi, Nawalparasi, Chitwan, Parsa, Bara, Rautahat, Sarlahi, Mahottari, Dhanusa, Siraha, Saptari, Sunsari, southeastern Udaypur, southwestern Morang, northwestern Banke **(16)** | North and south Palpa, northern Parsa, Bara, Mahotari, and Sarlahi Southern Chitwan, Makwanpur, Sindhuli, Udaypur, Pyuthan, Dang, Arghakachi, Syangja, Dadeldhura, and Gulmi Parts of Baitadi, Achham, Doti, Salyan, Saptari, Banke, and Kanchanpur **(22)** | No districts |

| Probability of matching | Current analogue sites | Future analogue sites (forward selection) | Past analogue sites (backward selection) |
|---|---|---|---|
| Moderately likely (0.5–0.75) | Kanchanpur, Kailali, Bardiya, Banke, Dang, Kapilvastu, Rupendehi, Morang, Jhapa, Sindhuli, Dhankutta, Tanahun, southern Makwanpur, Ilam and Khotang, eastern Bhojpur, western Surkhey, and Dadeldhura Parts of Dhading, Nuwakot, Kavrepalanchowk, Ramechap, and Okhaldhunga **(23)** | | Morang, Jhapa, Sunsari, Saptari, Siraha, Dhanusa, Mahotari, Sarlahi, Rautahat, Bara, Parsa, Rupendehi, Kapilvastu, Bardiya, Banke, Kanchanpur, and Chitwan Southern parts of Kailali, Makwanpur, Sindhuli, Udaypur, and Ilam Parts of Surkhet, Dadeldhura, Salyan, Pyuthan, Palpa, Tanahun, Dhading, Kavrepalanchowk, Okhaldhunga, and Khotang **(33)** |
| Less likely (0.25–0.5) | Almost all districts of Nepal except Bara, Parsa, Rautahat, Sarlahi, Mohattari, Dhanusa, Siraha, Saptari, Sunsari, and Jhapa **(66)** | | All except Bara, Parsa, Rautahat, Sarlahi, Mohattari, Dhanusa, Siraha, Saptari, Sunsari, Morang, Rupendehi, and Jhapa **(62)** |
| Unlikely (0–0.25) | No districts | No districts | Some parts of Mugu **(1)** |

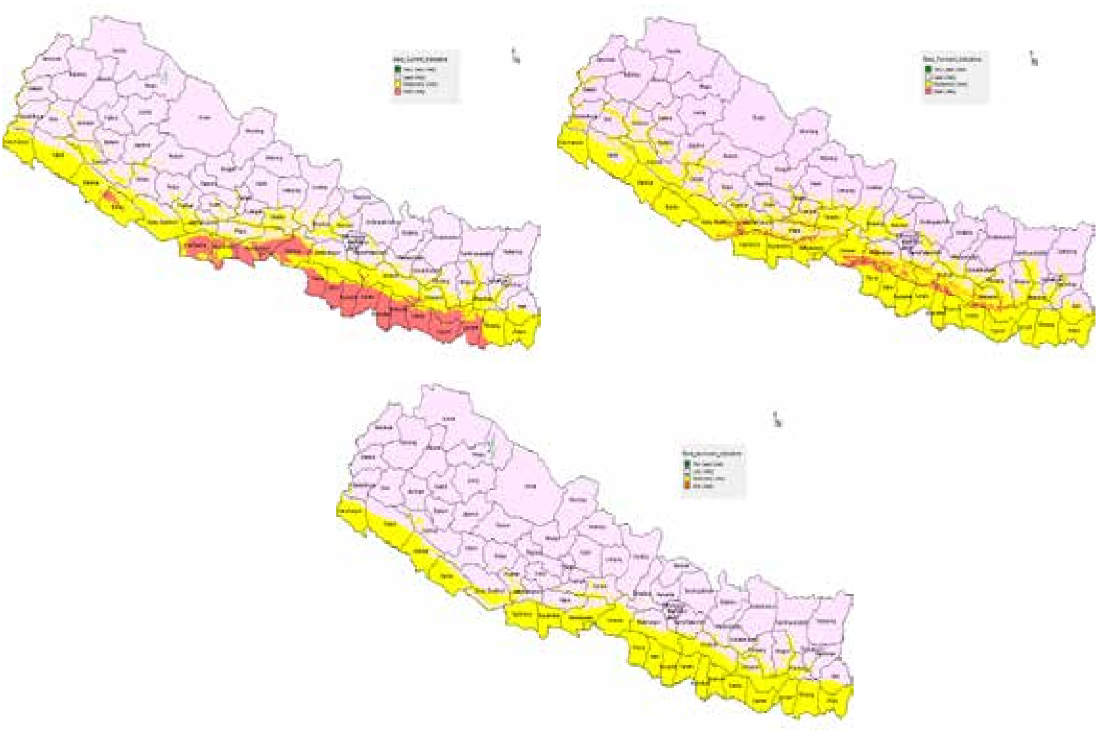

**Figure 4.4.** Sites in Nepal that may be analogous to Kachorwa currently (top left), in the future (top right), and in the past (bottom).

## Analogue sites outside Nepal

We found a number of locations around the world that match at present, will match in future, and matched in the past the current conditions at the reference sites. Highly matching analogous sites for Begnas are found in some parts of China, and for Kachorwa such sites are found in Bihar, Jharkhand, Madhya Pradesh, and Uttar Pradesh, India (data not presented here). Current analogous sites for Begnas and Kachorwa in Asia are listed in **Table** 4.8. Current analogous sites for both locations are depicted in **Figure** 4.5.

**Table 4.8. Locations in Asia that might be analogous to sites in Begnas and Kachorwa**

| Probability of matching | Analogue sites of Begnas | Analogue sites of Kachorwa |
|---|---|---|
| Highly likely (0.75–1) | Wucunxiang, China | Bariarpur Kuntari, Bihar, India; Tati, Jharkhand, India; Dindori, Madhya Pradesh, India and Sisotar, Uttar Pradesh, India |
| Moderately likely (0.5–0.75) | Gowaryo, Pakistan; Kerman and Horozygon, Iran; Hainana Sheng, China; Salavan, Laos | Shandong Sheng, China; Indus river side Pakistan; Henan Sheng, China; Vietnam; Pichaguntrahalli, Karnataka, India; Gorja, Pakistan; Kerman, Iran; Baldwyn, Saudi Arabia |
| Less likely (0.25–0.5) | Most of the Asian region | Most parts of Asia |
| Unlikely (0–0.25) | Zhejiang, China; Ayni, Tajikistan; Victoria, Sri-Lanka; Shirmine, Japan | Gifu-shi, Gifu-ken, Japan; Meghalaya Kynshi, India; Changsha Shi, Changsha Xian, China; Hasalaka Road side, Ulpathagama, Sri Lanka; Chatkal, Kyrgyzstan; and many others |

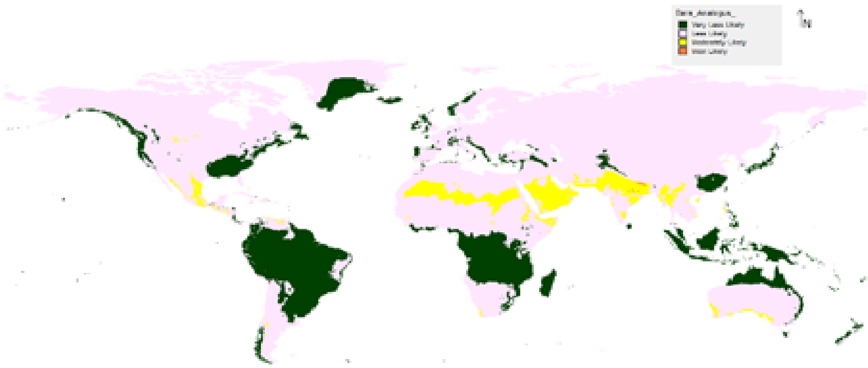

**Figure 4.5.** Locations throughout the world that may be analogous to Begnas (top) and Kachorwa (bottom).

## Wild rice collection sites and their analogues in Nepal

Wild rice collection sites are shown in **Figure** 4.6 and current analogous sites for the species *Oryza rufipogan* are shown in **Figure** 4.7 (a, b). The wild rice habitats are mostly found in the terai and inner terai region with few exceptions for the mid-hill regions of the country. For *O. rufipogan*, the current analogous sites are near the southern borders, while the future analogue sites are likely to move northward.

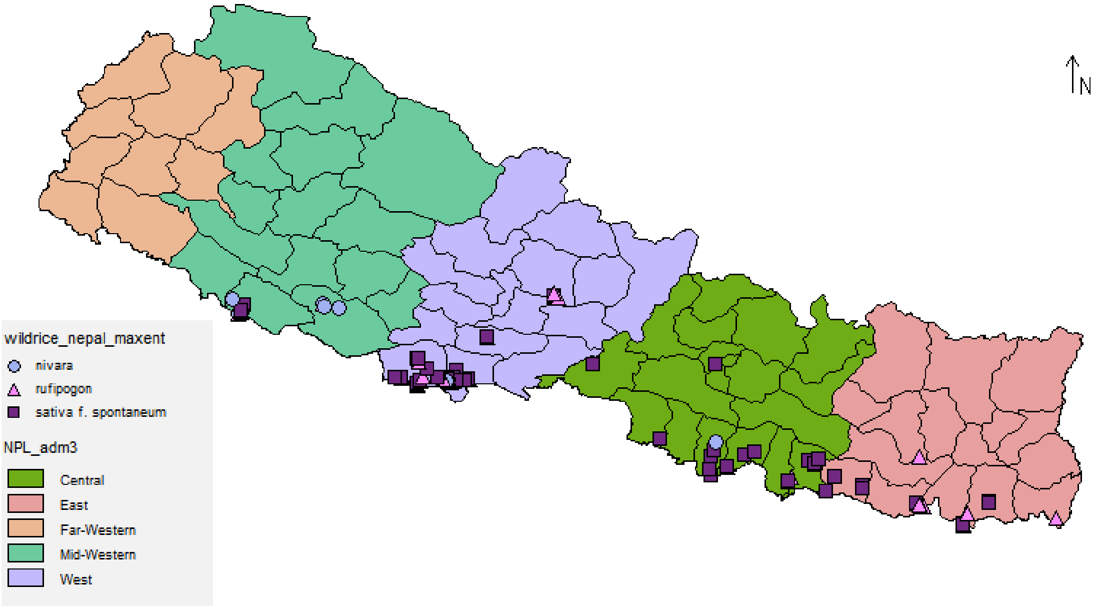


**Figure 4.6.** Nepal map showing wild rice collection sites.

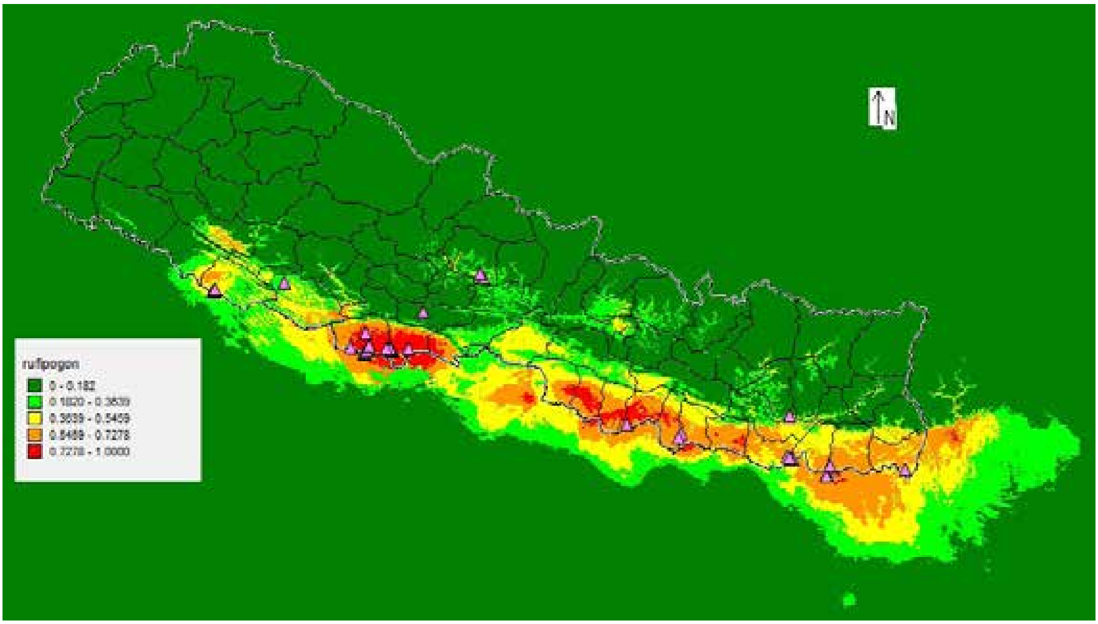


**Figure 4.7(a).** Climate analogue sites for *Oryza rufipogan* at present in Nepal.

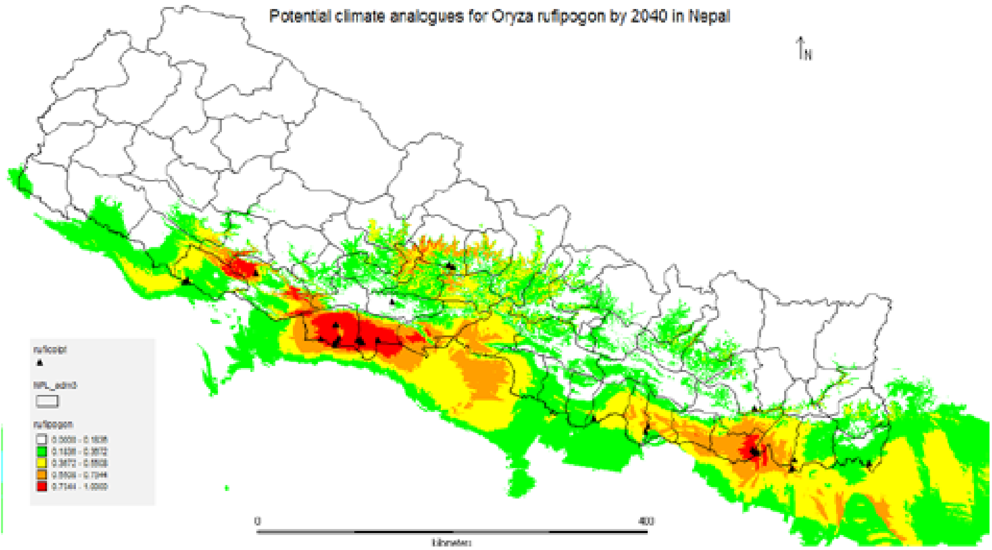


**Figure 4.7 (b)**. Climate analogue sites for *Oryza rufipogan* at future 2040 in Nepal.

## Collection sites and analogues for PGRs available in the public domain

The national genebank (the National Agriculture Genetic Resources Centre), an agency in the public domain, preserves more than 11000 accessions of various crop species (1141 species of rice alone) that were once grown or are currently grown in the country. Similarly, 2839 accessions from various parts of the country have already been added to the global gene pool, mainly via the International Rice Research Institute, other CGIAR centres, and the United States Agency for International Development (for details, see chapter 1). Some of the accessions found in these public domain collections serve as backup duplicates of material preserved in community seed banks managed by farmers and are grown by farmers on farm.

A total of 100 rice accessions from the Kachorwa site can be found in Genesys and 15 in the National Agriculture Genetic Resources Centre.

## Key findings and the way forward

Our findings vividly reveal that climate change is an inevitable problem facing Nepal and will have both positive and negative implications for crop production and productivity — at varied scales in different locations and over different timespans. When existing crop diversity is inadequate to survive changing conditions, new varieties will be required to adapt to those changes. This will increase interdependence on PGRs among regions and countries.

Going forward, the first step is to identify possible matching sites between which genetic material could be exchanged for potential adaptation to new environments. It is also important to assess crop diversity at the matching sites, and then examine what crops and varieties could be exchanged and tested between the sites.

The analysis using the Climate Analogues tool suggests that current, future, and past analogue sites exist, both within the country and beyond, that could exchange genetic material. Many regions are similar at present, while many others will become similar in future. Although we can promote material exchange among current analogous sites now, the future will also open up the possibility of exchange between different locations. Several of the matching districts were recently affected by earthquakes, suggesting that materials could be transferred from less- to more-affected regions to supply farmers who lost seeds during that crisis. Among countries, genetic materials could be exchanged between similar regions, using the Standard Material Transfer Agreement through the ITPGRFA's MLS, if analogue regions are in signatory countries.

Accessions preserved in genebanks will be useful now and in the future as climate alters, as they can be transferred to various locations depending on need. To be useful in the future, genebank material must be carefully preserved. However, in this process, policies on farmers' rights and access and benefit sharing mechanisms must be developed and put into practice to avoid conflicts over the roles of custodian farmers.

Our study shows that wild rice sites exist and that there are suitable habitats for wild rice at various locations; new sites may also become suitable for regeneration in the future. Some analogue sites may still have wild rice, but they remain unexplored. Analogue sites for material in the public domain, including holdings of the national genebank, could be used to regenerate ex-situ material periodically, so that this material can co-evolve under local climatic conditions to some extent and adapt to changing biophysical conditions.

In the future, we intend to identify more precisely which analogue sites could be used to develop location-specific strategies to adapt to climate change and build the resilience of farmers. Field-testing of novel genetic material will be the ultimate test of the utility of the Climate Analogues tool. Before any new form of exchange of genetic materials can be established, it is important to examine agricultural diversity (crops and crop varieties grown on-farm) and other basic characteristics of the reference and analogous sites and assess the potential for material exchange among them.

## References


Boonman JG. 1993. *East Africa's grasses and fodders: their ecology and husbandry.* Tasks for vegetation science series 29. Springer, Dordrecht, Netherlands.

Boring J. 2000. The international undertaking on plant genetic resources for food and agriculture: Is it now or never? *IPGRI Newsletter for Asia, the Pacific and Oceania* 31:1–2.

Brush SB. 2013. Agro-biodiversity and the law: regulating genetic resources, food security and cultural diversity (book review). *Journal of Peasant Studies* 40 (2):447–467.

CBS. 2012. National population and housing census 2011. Central Bureau of Statistics (CBS), National Planning Commission Secretariat, Government of Nepal, Kathmandu, Nepal.

Chaudhary P, D Gauchan, RB Rana, BR Sthapit and DI Jarvis. 2004. Potential loss of rice landraces from a Terai community of Nepal: A case study from Kachorwa, Bara. *Plant Genetic Resources Newsletter* 137:14–21.

Esquinas-Alcázar J. 2005. Protecting crop genetic diversity for food security: political, ethical and technical challenges. *Nature Reviews Genetics* 6: 946–953.

FAO. 2011. Draft updated global plan of action for the conservation and sustainable utilization of plant genetic resources for food and agriculture. Food and Agriculture Organization of the United Nations (FAO), United Nations, Rome, Italy. Document CGRFA/WG-PGR-5/11/2 Rev 1. Available at http://www.fao.org/fileadmin/templates/agphome/documents/PGR/ITWG/ITWG5/CGRFA_WG_PGR5112__REV1finalnumbX.pdf

Fujisaka S, D Williams, and M Halewood. 2011. The impact of climate changes on countries' interdependence on genetic resources for food and agriculture. Background study paper 48. Food and Agriculture Organization, Rome, Italy. Last accessed on February, 2014 available at ftp://ftp.fao.org/docrep/fao/meeting/017/ak532e.pdf.

Halewood M, I Lopez Noriega, and S Louafi (eds). 2013. *Crop Genetic Resources as a Global Commons: Challenges in International Governance and Law.* Earthscan, Routledge, London, UK.

Houghton JT, Y Ding, DJ Griggs, M Noguer, PJ van der Linden, X Dai, K Maskell, and CA Johnson (eds). 2001. *Climate Change 2001: The Scientific Basis.* Contribution of Working Group I to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. Available at https://www.ipcc.ch/ipccreports/tar/wg1/pdf/WG1_TAR-FRONT.PDF.

IPGRI. 1996. Access to plant genetic resources and the equitable sharing of benefits: a contribution to the debate on systems for the exchange of germplasm. Issues in genetic resources 4. International Plant Genetic Resources Institute (IPGRI), Rome, Italy. Available at http://pdf.usaid.gov/pdf_docs/Pnacl682.pdf.

Joshi BK, A Mudwari, DB Thapa, MP Upadhyay, and MR Bhatta. 2008a. Selecting environmentally analogous areas for wheat variety recommendation using GIS. *Journal of Plant Breeding* 3:31–36.

Joshi BK, HB KC, MP Uadhyay, SR Gupta, BR Lu, PN Mathur, and BR Sthapit. 2008b. Ex-situ and in-situ management of wild and weedy rice in Nepal using a geographical information system. *Plant Genetic Resources Newsletter* 155:69–74.

Joshi BK, HB KC, RK Tiwari, P Shrestha, R Amagain, and MP Upadhyay. 2005. Varietal richness of agricultural crop species and farmers' preferred traits over space and time in Nepal. *Botanica Oreintalis* (*Journal of Plant Science*) 5:69–74.

Mandala UK. 2012. Climate variability and soil moisture status in the KhadoKhola watershed in eastern terai region of Nepal. *Economic Journal of Nepal* 35(3):35–42.

Nakicenovic N, J Alcamo, G Davis, B de Vries, J Fenhann, S Gaffin, K Gregory, A Grübler, TY Jung, T Kram, E Lebre La Rovere, L Michaelis, S Mori, T Morita, W Pepper, H Pitcher, L Price, K Riahi, A Roehrl, HH Rogner, A Sankovski, M Schlesinger, P Shukla, S Smith, R Swart, S van Rooijen, N Victor, Z Dadi. 2000. Special report on emissions scenarios. Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK. Available at http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=0.

Palacios XF. 1998. Contribution to the estimation of countries' interdependence in the area of plant genetic resources. Background study paper 7, rev. 1. Commission on Genetic Resources for Food and Agriculture, Rome, Italy. Available at ftp://ftp.fao.org/docrep/fao/meeting/015/j0747e.pdf.

Putnam DH, and CG Summers. 2007. Alfalfa production systems in California. **In** *Irrigated Alfalfa Management for Mediterranean and Desert Zones*. CG Summer and DH Putman (eds). University of California, Berkeley, Oakland, California, USA. pp.1–19.

Rajaram S and JH Braun. 2008. Wheat yield potential. **In** *International Symposium on Wheat Yield Potential: Challenges to International Wheat Breeding*. MP Reynolds, J Pietragalla, and HJ Braun (eds). CIMMYT (International Maize and Wheat Improvement Center), Mexico, Mexico. pp.103–107.

Ramírez-Villegas J, C Lau, AK Köhler, J Signer, A Jarvis, N Arnell, T Osborne, and J Hooker. 2011. Climate Analogues: Finding tomorrow's agriculture today. Working paper 12. CGIAR Research Program on Climate Change, Agriculture and Food Security, Cali, Colombia. Available at http://ccafs.cgiar.org/sites/default/files/assets/docs/ccafs-wp-12-climate-analogues-web.pdf

Ramirez-Villegas J, A Jarvis, S Fujisaka, J Hanson, and C Leibing. 2013. Crop and forage genetic resources: international interdependence in the face of climate change. **In** *Crop Genetic Resources as a Global Commons: Challenges in International Law and Governance*. M Halewood, I Lopez Noriega, and S Louafi (eds). Earthscan, Routledge, Oxon, UK. pp.78–98.

Rana RB, P Chaudhary, D Gauchan, SP Khatiwada, BR Sthapit, A Subedi, MP Upadhyay and DI Jarvis. 2000. In-situ crop conservation: Findings of agro-ecological, crop-diversity and socio-economic baseline survey of Kachorwa ecosite, Bara, Nepal, NP working Paper No 1/2000. NARC/LI-BIRD, Nepal/IPGRI, Rome, Italy.

SGRP. 2011. CGIAR centers' experience with the implementation of their agreements with the treaty's governing body, with particular reference to the use of the SMTA for Annex I and non Annex I materials. System-wide Genetic Resources Programme (SGRP), CGIAR.

Sherchand KK, RB Rana, BR Sthapit, YR Pandey, and N Adhikari. 1998. Strengthening the scientific basis for in-situ conservation of agrobiodiversity: findings of site selection in Bara, Nepal. Working paper 2/98. National Agricultural Research Council, Local Initiatives for Biodiversity, Research, and Development, Kathmandu, Nepal, and International Plant Genetic Resources Institute, Rome, Italy.

Shrestha AB, CP Wake, PA Mayewski, and JE Dibb. 1999. Maximum temperature trends in the Himalaya and its vicinity: an analysis based on temperature records from Nepal for the period 1971–94. *Journal of Climate* 12:2775–2786.

ShresthaAB and LP Devkota. 2010.Climate change in the eastern Himalayas: observed trends and model projections: climate change impact and vulnerability in the Eastern Himalayas.Technical report 1. International Centre for Integrated Mountain Development, Kathmandu, Nepal.

Upadhya D, and DK Grover. 2012. Behaviour and magnitude of changing climate pattern in central Punjab: case study of Ludhiana district. *Indian Journal of Economics and Development* 8(1):36–50.

Vernooy, R., G Otieno, G Bessette, C Fadda, J van de Gevel, M Halewood, P Mathur, S Mittra, P Rudebjer, J Steinke, B Sthapit, J van Etten, and M van Zonneveld. 2015. A novel strategy to discover and use climate-adapted germplasm. Bioversity International, Rome, Italy. Available at http://www.bioversityinternational.org/e-library/publications/detail/a-novel-strategy-to-discover-and-use-climate-adapted-germplasm/

Yadav R, SS Singh, N Jain, GP Singh, and KV Prabhu. 2010. Wheat production in India: technologies to face future challenges. *Journal of Agricultural Science* 2(2):164–73.

Zeven AC, and JMJ De Wet. 1982. *Dictionary of Cultivated Plants and their Regions of Diversity Excluding Most Ornamentals, Forest Trees and Lower Plants* (2nd edition). Pudoc, Wageningen, Netherlands.

# Chapter V : Policy network for the conservation and use of germplasm

Bidya Pandey, Krishna Hari Ghimire, Devendra Gauchan, Rachana Devkota, Deepak Upadhya and Aseffa Wedajoo

## Key messages

- About 70% of surveyed key stakeholders believe that the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is beneficial for Nepal, and about 60% feel the same about the multilateral system (MLS).
- Effective implementation of the MLS could facilitate access to core germplasm and enable integration of that germplasm into national crop improvement programs, thereby increasing the capacity of the country to address food security and adaptation to climate change.
- Perceived advantages of effective implementation of the MLS include both monetary and non-monetary benefits, such as capacity building and access to information.
- The benefit-sharing scheme of the MLS could help build national capacity at institutional and local levels for farmers, scientists, and other stakeholders and strengthen global networking and information sharing.
- Survey respondents contend that lower-capacity developing countries like Nepal will generate fewer benefits relative to their genetic resource contribution, compared with higher-capacity countries.
- Key players in the national policy structure related to the ITPGRFA and its MLS are Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Bioversity International, the Nepal Agricultural Research Council (NARC), the Ministry of Agricultural Development (MoAD), the South Asian Watch on Trade, Economics, and Environment, and the Food and Agriculture Organization. LI-BIRD, NARC, and MoAD are the top three organizations that provide scientific expertise to multiple organizations.
- Effective implementation of the ITPGRFA and the MLS in Nepal will require increasing policy awareness, strengthening the policy network through the flow of information, building capacity for policy action research, and developing human resources in the area of agro-biodiversity policy.

Mapping and understanding the policy infrastructure in countries that have ratified and are implementing the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) can help identify the key actors at different levels, their positions in the network, and the ways they are connected. Ascertaining the perspectives of policymakers towards the ITPGRFA and the multilateral system (MLS) can provide important additional insights into how international agreements are implemented at the national level. Such analysis also includes identifying existing policies, the importance of policy coalitions, and areas of actual and expected cooperation and conflict. In addition, the roles and rights of farmers, who are formally or informally a part of policy coalitions, should be understood if we are to implement the MLS effectively and in the spirit of the ITPGRFA.

Despite the potential role of the conservation, exchange, and sustainable use of plant genetic resources (PGRs) for food and agriculture in improving Nepal's economy, we lack a clear understanding of the policy issues and methods that lead to identification of future research priorities, strategies, and action plans for the implementation of the ITPGRFA and the MLS (Gauchan and Upadhyaya 2006). Decision-makers are generally positive about conserving PGRs, but lack appropriate information and knowledge to formulate policy in accordance with the needs and goals of the Nepalese agro-economy (Gauchan et al. 2003). In this context, an investigation of policy networks — their structure, participants' characteristics, and features — can provide important insight.

In this chapter, we map policy network structures and decision-making processes in Nepal related to the country's position as a signatory of the ITPGRFA. We identify key actors in the ITPGRFA policy network, determine how they are positioned and connected with each other, and ascertain their views on the ITPGRFA. We also discuss levels of actual or expected cooperation and interaction. We identify those who are believed to be actively involved in policy, but who are not currently engaged. We paint a transparent picture of the structure and policy actors who are important for the effective implementation of the ITPGRFA and MLS; document stakeholders' perceptions of the benefits of the ITPGRFA and MLS and opportunities or the need for interaction with or inclusion of new actors; and discuss the changes required in policy network structures and relations and link them to policy implementation outcomes.

## Approach and methods

Policy networks comprise a set of formal and informal links among government and non-governmental actors (Parag 2006) who share mutual interests and beliefs regarding policymaking and implementation (Borzel 1998, Rhodes 2006). Links between network members represent channels for the exchange of information, expertise, trust, and policy resources needed to achieve a particular policy outcome (Rhodes 2006). Network analysis examines how the structures, relations, and flow of resources affect policy outcomes.

Policy networks range from strongly integrated communities to loosely formed issue-based networks (Thatcher 1998, Smith 2000). Core actors in a policy community are typically focused on a particular problem, such as the integration of elements of the ITPGRFA with existing national policies or the delegation of authority for implementation. However, the policy issue network is broader and includes both core actors and a larger number of people who have various degrees of commitment and involvement (Sabatoer 1988, Borzel 1998, Thatcher 1998). Policy network analysis has been applied previously in agriculture and environment contexts (Smith 2000, Hirschi et al. 2013, Vignola et al. 2013). This study employs a policy network framework to investigate the structure and relations among those who are potentially responsible for implementing the ITPGRFA. The results are expected to provide information to policymakers to facilitate policy implementation.

## Sampling design and data collection

People engaged, directly or indirectly, in implementation of the ITPGRFA were defined as the target population for this study. They were identified through a snowball sampling approach. The first round of interviews was carried out with key ITPGRFA policy actors, who then named other individuals with whom they work. A second round of interviews was then conducted with those who were referred. This process was continued until the team was satisfied that all key policy actors were interviewed, i.e., when interviewees could not offer any new names. This snowball method has been used in other studies to identify a sample population for network analysis (Sudman and Kalton 1986, Subedi et al. 2003, Elgin and Weible 2013).

People in the following organizations were interviewed.

- Ministry of Agricultural Development (MoAD)
- ITPGRFA focal point
- Gender Equity and Environment Division
- Market Research and Statistics Management Program (MRSMP), Department of Agriculture
- Nepal Agricultural Research Council (NARC)
- National Agriculture Genetic Resources Centre
- Socioeconomic and Agricultural Policy Research Division
- Seed Science and Technology Division
- National Rice Research Program (NRRP)
- Tribhuvan University
- Department of Botany
- Institute of Agriculture and Animal Sciences
- Karnali Development Commission
- National Assessment on Climate Change (NACC)
- Local Initiatives for Biodiversity, Research and Development (LI-BIRD)
- International Development Research Center (IDRC)
- USC-Canada Asia, Nepal
- South Asia Watch on Trade, Economics and Environment (SAWTEE)
- Network for Agro Biodiversity Conservation (NABIC), Nepal
- Centre for Legal Services (CLS), Nepal
- Agro-biodiversity Conservation and Development Society, Bara
- Farmers' organization
- Participatory Plant Breeding (PPB)-Begnas, Kaski
- Agriculture Development Conservation Society (ADCS), Kachowa, Bara

- A freelance policy expert
- Biodiversity Conservation and Development Committee (BCDC)
- Food and Agriculture Organization (FAO)
- Bioversity International
- NGO Federation of Nepal (NFN)
- Pro-Public

The survey was administered between September 2012 and February 2013 by well-trained interviewers selected by the national research team. Face-to-face interviews were conducted using a survey instrument designed to collect data in the field on laptops. Interviewers were able to refer to questions and input data using SSI Web CAPI (Sawtooth Software Inc., Orem, Utah, USA). Data were then compiled by the team leaders, packaged, and sent to the Science, Technology and Environment Policy Lab at the University of Illinois, Chicago, where they were cleaned and organized.

The first round of interviews was conducted with 22 people: 2 from international organizations, 10 from national governmental organizations, 1 from regional, three from non-governmental, and 2 each from private, academic institutions, and local organizations. They included 3 women and 19 men: 13 from Kathmandu, 6 from Pokhara, and 3 from other locations. They traced 72 other actors (organizations) within the ITPGRFA policy network, and 19 organizations currently not part of the ITPGRFA network, but who interviewees considered should be involved for its effective implementation.

Interviewees were asked about their perspectives on the ITPGRFA and the MLS; for example, how beneficial the ITPGRFA and the MLS are to the country. They were also asked about constraints that might exist with regard to ITPGRFA implementation.

To collect network data, respondents were asked: We would now like to ask you about the organizations that you believe are currently involved in implementing the ITPGRFA or the MLS. We will also ask you about organizations you believe should be involved but are not currently. In identifying these organizations, please consider the different aspects of the policy development process, including policy design and implementation. Specific organization categories included: (1) international; (2) national level government; (3) regional, provincial, or county government; (4) farmer or community; (5) private sector or consultancy; (6) non-governmental; (7) other important organizations (universities, media, etc.); and (8) other organizations that should be involved but are not currently involved. Each respondent could name a total of 40 possible organizations.

## Resource exchange

Several questions asked respondents to indicate policy-relevant resource flows. Types of resources examined here included: legal expertise, policy or administrative direction, scientific expertise, and financial resources. For each type of resource, respondents were asked about resources he or she provides to the named organization and resources received from the named organization, allowing us to collect information on the direction of resource flows.

Respondents were also asked to indicate, in their opinion, the extent to which the organizations they named consider the ITPGRFA and the MLS to be a low, moderate, or high policy priority, or they do not know. Because many respondents identified the same organizations, responses were averaged.

### Data analysis

Both descriptive statistics and network maps and metrics were used to analyze data. Data generated from first-round interviews were analyzed through descriptive methods, such as frequencies, percentages, and means. Network maps and metrics were employed to analyze overall information generated from all actors in the network. Analysis was conducted using SPSS, Stata, and UCINET software packages.

## Familiarity with the ITPGRFA and the MLS

The survey results show that members of the policy network vary in their level of knowledge about the ITPGRFA and the MLS (**Figure** 5.1). Most respondents (about 59%) reported that they are either very familiar or extremely familiar with the treaty, and about 45% claimed a high level of familiarity with the MLS. About 36% and 55% reported that they were "somewhat familiar" with the ITPGRFA and MLS, respectively. Few respondents were unfamiliar with the ITPGRFA and all had at least heard about the MLS.

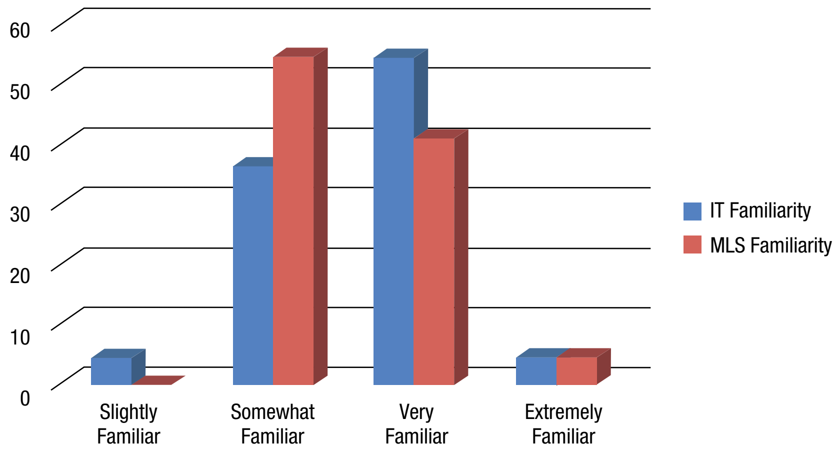


**Figure 5.1**. Proportion (%) of respondents familiar with the ITPGRFA (IT) and the MLS.

## Prioritization of the ITPGRFA and MLS

Respondents were asked about the level of priority that implementation of the ITPGRFA and MLS received in their organization. Most (about 68%) reported that ITPGRFA implementation is either a very high or high priority for their organization (**Figure** 5.2). About a quarter of the respondents (27%) believed that implementation was neither a high nor low priority in their organization.

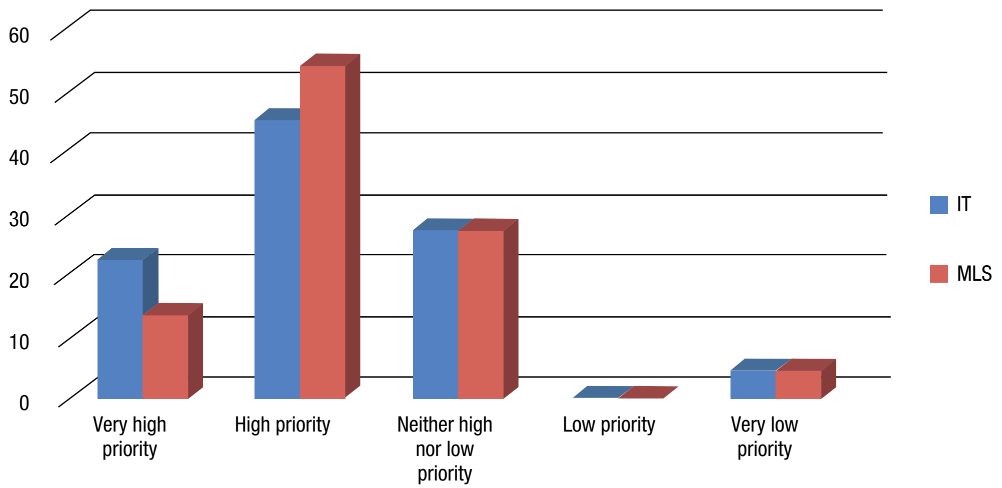


**Figure 5.2.** Perceived organizational priority placed on implementation of the ITPGRFA (IT) and the MLS reported by survey respondents (%).

## Benefits and negative consequences of the ITPGRFA and MLS

When asked about the possible benefits or negative consequences of the ITPGRFA and the MLS, most (about 68%) said they believed that the ITPGRFA would be beneficial for their country and about 59% indicated the same for the MLS (**Figure** 5.3). A considerable portion (about 27%) of the respondents stated that the ITPGRFA would be somewhat beneficial, while relatively more (about 36%) indicated that the MLS would be somewhat beneficial for the country. A few actors (about 5%) thought that the ITPGRFA and MLS might be somewhat harmful for the country.

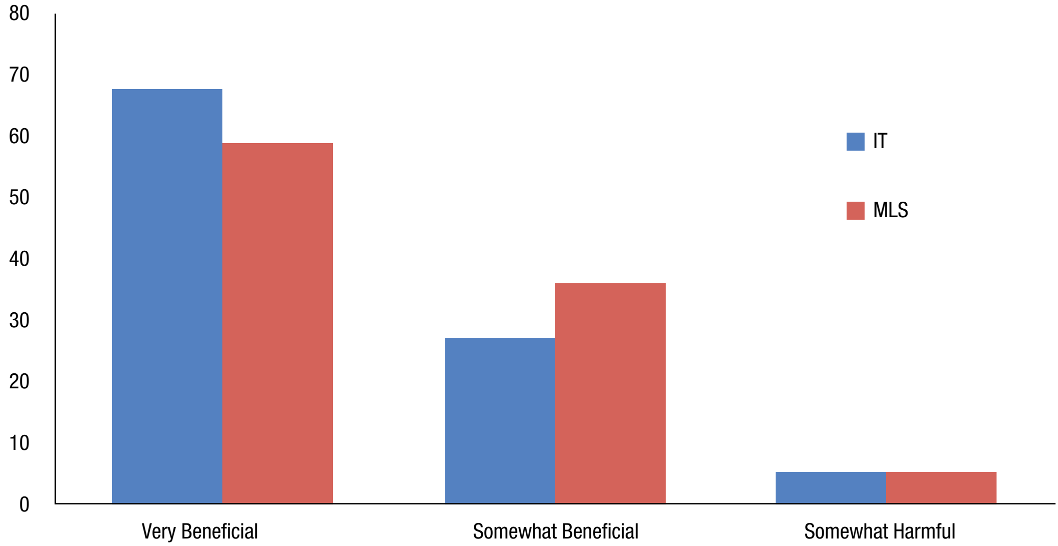


**Figure 5.3.** Respondents' perspectives on the benefits of the ITPGRFA (IT) and MLS (%).

As discussed above, the provisions of the ITPGRFA include facilitated access to genetic resources through the free exchange of genetic material under the MLS, as well as fair and equitable sharing of benefits arising from the use of those resources. The benefit-sharing components of the ITPGRFA include capacity-building, technological transfer, information sharing, and financial support for conservation and sustainable use of genetic resources. The topic of benefit-sharing is elaborated in chapter 8. To understand policy actors' perspectives on the benefits of the ITPGRFA and MLS, we asked respondents to indicate the importance of each of seven possible benefits for Nepal. Responses ranged from 1 to 5 (not important at all, slightly important, important, very important, and extremely important). Although respondents' ratings of most benefits fell between "important" and "very important," improving access to information about PGRs in MLS, facilitated access to germplasm, access to technologies, and financial support for conservation and use of PGRs rated highest (**Figure** 5.4).

An open-ended question asked respondents to explain the possible benefits and negative implications of the MLS. Based on the responses, three categories of benefits were identified: strengthened national capacity to address food insecurity and adaptation to climate change; facilitated conservation and use of genetic resources; and realization of other economic benefits.

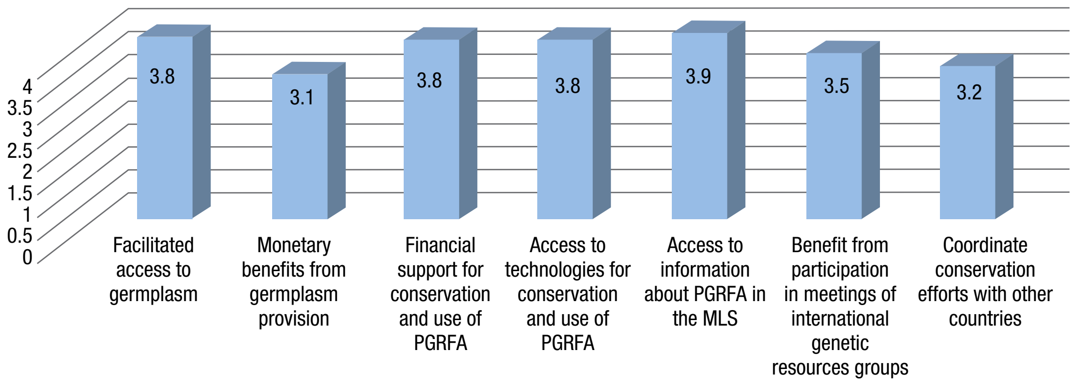


**Figure 5.4.** Respondents' ratings (average rating of 22 individuals, scored from 1 to 5) of the benefits of the ITPGRFA and MLS.

Respondents indicated that effective implementation of the MLS could facilitate access to core germplasm and enable its integration into national crop improvement programs, thereby increasing the capacity of the country to address food security and adapt to climate change. Access to elite accessions and information under the MLS would decrease duplication of efforts and save resources that would otherwise be spent on screening and characterization of local crops for breeding and genetic knowledge. Respondents also emphasized the importance of implementation of the MLS in the context of climate change, as it would allow access to adaptable crop varieties.

Respondents believed that effective implementation of the MLS could play an important role in the conservation and use of genetic resources. The MLS recognizes farmers' rights, which enable communities to benefit from the use of genetic resources and, in turn, create incentives for conservation of biodiversity. They also mentioned that recognizing the rights of local farming communities helps to increase national commitment to conservation and the sustainable use of PGRs.

Respondents mentioned monetary and non-monetary benefits, such as capacity-building and access to information, that would arise from implementation of the treaty. They also said that the benefit-sharing scheme of the MLS could help build national capacity at the institutional and local level for farmers, scientists, and other stakeholders and strengthen global networking and information sharing. Respondents recognized that funds generated for conservation were a monetary benefit of the MLS.

Reported negative consequences of the MLS included weak monitoring and enforcement and lack of transparency; equity concerns; and gene pollution and biosafety concerns. Respondents mentioned that weak monitoring and enforcement and lack of transparency in implementation of the MLS could lead to a situation in which genetic resources and products from a country may be patented by multinational companies elsewhere, particularly if providers do not have the capacity to take legal action. One respondent mentioned that the MLS may also lead to undue access, biopiracy, and misappropriation of traditional knowledge. Moreover, weak enforcement of national and international legal mechanisms could jeopardize the benefit-sharing objectives of the ITPGRFA and, in turn, reduce the viability of the multilateral approach to access to plant genetic resources. Communities might also demand rights, especially to those genetic resources obtained from indigenous groups.

Respondents mentioned that inadequate documentation of exchanged genetic material can lead to gene piracy. They also noted that access to unique and rare genetic resources might undermine farmer and community rights if adequate legal mechanisms are not developed and implemented to enforce effective monitoring and compliance. Without such assurances, farmers may not be motivated to continue their in-situ conservation efforts. Moreover, respondents indicated that the MLS does not pay sufficient attention to PGRs held under in-situ conditions.

Respondents noted equity concerns. They thought that Nepal may not be ready to benefit from facilitated access to genetic material from other countries because of a lack of capacity and the absence of a national plan and policy to mobilize resources. The lower capacity of developing countries could result in fewer benefits relative to their contribution of genetic resources, compared with higher capacity countries. Thus, weak national capacity may prevent developing countries from realizing benefits from the MLS as envisioned in the treaty.

Respondents indicated that developed countries and private companies will receive greater advantages from the MLS than developing countries. Some respondents thought that tangible benefits to indigenous communities from implementation of the MLS would not be easy to realize. They said that farmers would not be able to reap benefits without proper and strong implementation mechanisms.

In addition, respondents raised concerns about biosafety. They thought that the MLS could lead to gene pollution and the loss of local varieties. They pointed out that, in developing countries where there are no strong quarantine systems, the MLS might increase the chance of disease transfer.

In general, most of the potential negative consequences of the MLS were related to the lack of national capacity to benefit from the system and weak monitoring, transparency, and enforcement at the international level.

## Roles and responsibilities in implementing the ITPGRFA and the MLS

Another aspect of the implementation of the ITPGRFA and MLS concerns the extent to which policy-related activities and roles are defined. Respondents were asked about the extent to which the roles, responsibilities, and guidelines regarding implementation of the ITPGRFA and MLS are clearly defined for their organization.

There was strong agreement on all categories related to the ITPGRFA. Combining the "agree" and "strongly agree" responses, approximately 68% of survey respondents affirmed that the organization's roles are defined while about 64% indicated that specific people had been identified to undertake implementation. Similarly, 59% either strongly agreed or agreed that activities for implementation of the ITPGRFA were written down. Approximately 41% of respondents also either agreed or strongly agreed that organizational responsibilities have not yet been discussed. Similar results hold for the implementation of the multilateral system (**Table** 5.1).

**Table 5.1. Respondents' (*n* = 22) perspectives on their organization's responsibility regarding implementation of the MLS (%)**

| | Strongly agree | Agree | Neither agree nor disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| Organization role clearly defined | 22.7 | 36.4 | 9.1 | 31.8 | 0 |
| Activities are written down in guidelines, laws, etc. | 18.2 | 31.8 | 9.1 | 40.9 | 0 |
| Responsibilities are distributed appropriately | 22.7 | 27.3 | 13.6 | 36.4 | 0 |
| Organization's MLS responsibilities increased in recent past | 22.7 | 40.9 | 9.1 | 27.3 | 0 |
| Organization's responsibilities have not been discussed | 4.5 | 36.4 | 4.5 | 40.9 | 13.6 |
| People in the organization have been identified for MLS implementation | 22.7 | 40.9 | 4.5 | 27.3 | 4.5 |

## Resource constraints on implementing the ITPGRFA and the MLS

We asked respondents whether any shortage of resources constrains their organization's ability to implement the ITPGRFA or the MLS effectively. Resources were broken down into six types (legal and policy expertise, skilled administrative staff, scientific expertise, information about the ITPGRFA, financial resources, and capital resources) and respondents rated constraint on a four-point scale: no constraint (1), minimal constraint, moderate constraint, and significant constraint (4). **Figure** 5.5 shows the mean values for these items. Lack of financial and capital resources was the greatest perceived constraint to implementation, followed by human resources, i.e., lack of legal and policy expertise, scientific expertise, and skilled administrative staff. In general, lack of capital and financial resources was rated as a moderate constraint, while the other categories were identified as minimal constraints.

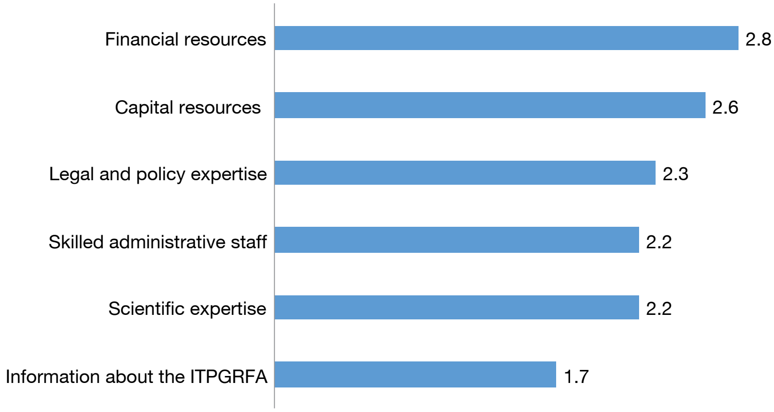


**Figure 5.5.** Constraints to implementing the ITPGRFA and the MLS provide period.

## Integration of the ITPGRFA and MLS with other national policies

The need to integrate the ITPGRFA with other national policies increases the complexity of the implementation process. Respondents were asked to name related polices with which they were involved. They were then asked to indicate the extent to which those policies were in conflict or in harmony with implementation of the ITPGRFA. The response scale ranged from one to five: absolutely in conflict (1), somewhat in conflict, neither in conflict nor in harmony, somewhat in harmony, and absolutely in harmony (5).

Survey results show that those involved in ITPGRFA policy are also working on numerous other types of policies (**Table** 5.2). For example, a large number of respondents indicated that they contributed to the formulation and drafting of the national Agro-biodiversity Policy. A considerable number were also engaged in the Access and Benefit Sharing Policy, National Seed Policy, farmers' rights, and National Agricultural Policy.

**Table 5.2. Policies in which survey respondents were also involved and their level of harmony with the ITPGRFA**

| Policy | Number of respondents involved | Average level of alignment with ITPGRFA implementation |
|---|---|---|
| Access and Benefit Sharing Policy | 7 | 3.88 |
| Association for Plant Breeding for the Benefit of Society (APBREBES) | 1 | 4 |
| Biosafety Policy | 2 | 3.5 |
| Climate Change Policy | 4 | 3 |
| Convention on Biological Diversity | 4 | 2.75 |
| Environment management | 1 | 4 |
| Farmers' rights | 6 | 4.33 |
| Herbs and Non-Timber Forest Products Development Policy | 1 | 5 |
| Kailash Sacred Landscape Conservation Strategy | 1 | 2 |
| National Agriculture Policy | 6 | 4 |

| Policy | Number of respondents involved | Average level of alignment with ITPGRFA implementation |
|---|---|---|
| Agro-biodiversity Policy | 10 | 3.9 |
| National Biodiversity Strategy | 3 | 4 |
| National Seed Policy | 7 | 3.14 |
| Pesticide Management Policy | 1 | 3 |
| Plant Variety Protection Policy | 5 | 1.2 |
| Seed Sector Development Strategy | 2 | 3 |
| Trade and Investment Policy | 1 | 1 |
| United Nations Framework Convention on Climate Change | 1 | 5 |
| Wetland Policy | 1 | 5 |
| World Intellectual Property Organization's development agenda | 1 | 1 |

For the most part, respondents indicated that these other policies were somewhat in harmony or absolutely in harmony with ITPGRFA implementation activities. Although it appears that the policy environment is complex, in only a few cases were polices (e.g., Plant Variety Protection Policy and Trade and Investment Policy) perceived to be in conflict with the ITPGRFA.

## Policy network structure and interactions

We constructed network maps based on resource flows, communication frequency, and policy priority data collected in the survey. We also examined measures that capture various dimensions of the network. Finally, we identified organizations that respondents believed were not currently in the network but should be.

During policy implementation, it is useful to understand the connections among key actors and the characteristics of their interactions. This part of our research was designed to aid decision-makers and facilitate the process overall. Network graphs can demonstrate, for example:

- Which organizations are key national actors in the policy implementation process.
- Which organizations provide critical supporting roles as bridges for information or resources.
- Which organizations are not involved, but perhaps should be (or vice versa).
- The types of resources that flow to and from organizations.

The figures that follow allow us to visualize the exchange of resources. They include resource type, direction of resource flow, level of priority, and organization type. Nodes represent respondent organizations and the organizations they named. Lines indicate that respondents answered "yes" when asked whether their organization received or provided resources to each of the organizations they named. Arrowheads indicate the direction of resource flow; in some cases, the organization both receives and provides a resource as part of its relation with another organization. The size of the node is a measure of the total number of lines leading out of it; larger nodes provide resources to more organizations. Node shape reflects the type of organization and shade denotes the level of perceived priority placed on ITPGRFA policy. **Table** 5.3 presents a key for reading the figures that follow.

## Table 5.3. Key to policy network graphs

| | |
|---|---|
| Node shape | • Square: international organization<br>• Triangle: national government organization<br>• Two connected triangles: regional organization<br>• Square with cross: national NGO<br>• Square with circle: private-sector organization<br>• Diamond: provincial or county organization<br>• Circle: farmer organization<br>• Upside down triangle: other type of organization |
| Node shade | • Black: high priority<br>• Dark grey: moderate priority<br>• Light grey: low priority<br>• White: don't know |
| Node size | • Depends on number of connections leading out of the node |

Key observations of this overall network (**Figure** 5.6) show that there are multiple key players, such as LI-BIRD, Bioversity International, NARC, MoAD, SAWTEE, and FAO, in the overall policy network. Most of these major players are perceived to consider ITPGRFA policy implementation a high priority. Agricultural Development Conservation Society (ADCS)-Bara and the NGO Federation of Nepal (NFN), are farmer organizations and only middle priority in terms of policymaking, but they play key roles in the Nepal ITPGRFA network.

In addition, some organizations were identified as key bridging organizations. For example, SAWTEE, which is a regional organization, is the only connection to several organizations including five high-priority ones (Action Aid, FNI-Norway, Radio-Sagamatha, Seed Quality Control Center (SQCC), and Oxfam-Novib) and two moderate priority ones (LA, and LE_DP, which are private). These seven organizations are not well integrated into the network, even though they place high or moderate priority on the MLS policy. LI-BIRD, a national NGO, was considered by respondents to place a high policy priority on implementation of the ITPGRFA. Other observations are possible from this graphic.

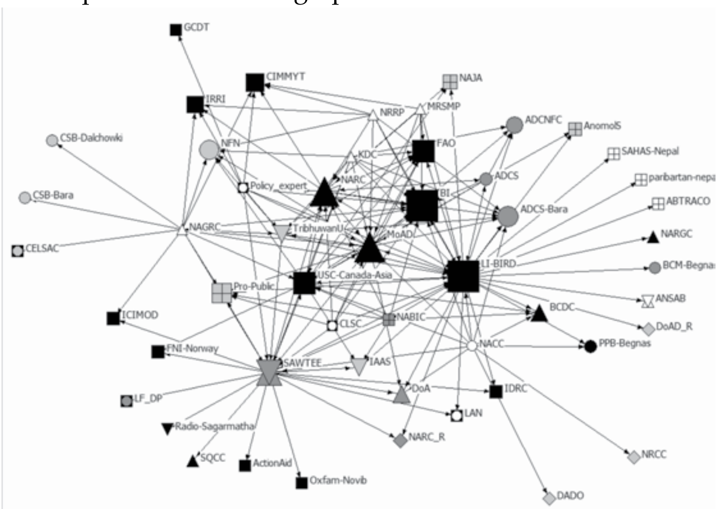


**Figure 5.6.** Relations among organizations identified by survey respondents as being involved in implementation of the ITPGRFA. Shapes and colours are defined in Table 5.3.

## Frequency of interaction among network members

One of the survey questions asked respondents to indicate the frequency with which they communicate with people in the organizations they named. Answers were based on a five point scale: about daily (1), about weekly (2), about monthly (3), several times a year (4), and less often (5). **Figure** 5.7 illustrates the findings.

Thicker lines represent more frequent communication. For example, the thickest lines (daily communication) occur between LI-BIRD and Bioversity International; LI-BIRD and the Network for Agro-biodiversity Conservation (NABIC); LI-BIRD and Anomolbiu Seed Company; NACC and BCDC; NACC and PPB-Begnas. Frequent communication often represents the strength of the relationship. In the figure, frequent communication does not necessarily occur among densely interconnected groups. Rather it is more bilateral in nature. Finally, a number of organizations were reported to be involved in the ITPGRFA, but they were not identified in communication networks (see list at left of **Figure** 5.7).

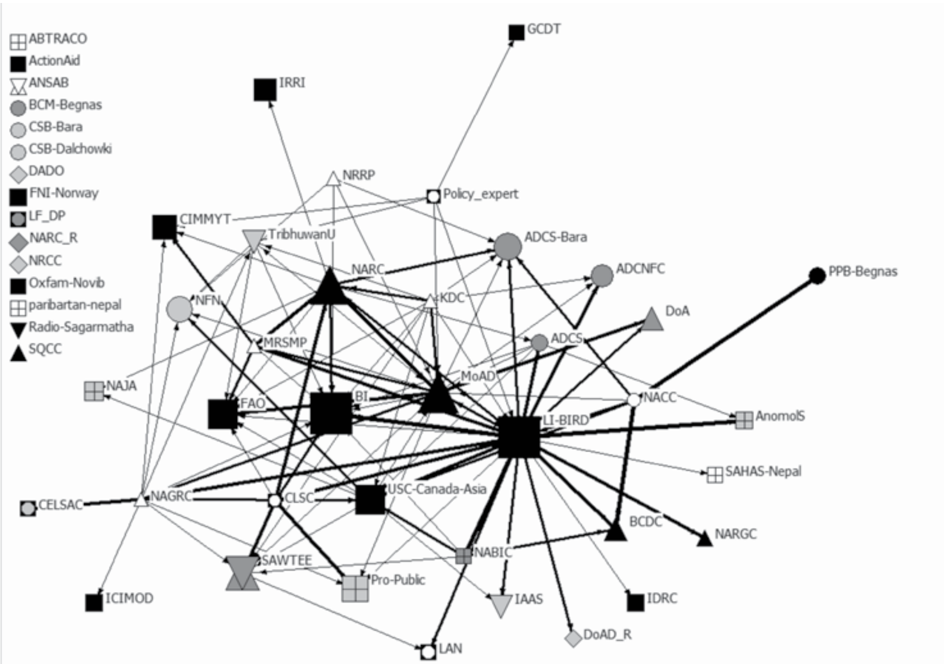


**Figure 5.7.** Frequency of communication among organizations involved in implementing the ITPGRFA and MLS. Organizations listed at left are involved in implementation, but their communications were not reported.

## Policy prioritization network

**Figure** 5.8 depicts connections among organizations that were identified as placing a low, moderate, or high priority on implementation of the ITPGRFA. Organizations for which the level of priority was unknown are listed at the left. LI-BIRD, Bioversity International, USC-Canada-Asia, NARC, and MoAD are positioned in the centre as they place a high priority on ITPGRFA implementation. SAWTEE plays important roles in the other networks, but its level of policy priority was recognized as moderate by other organizations. Government organizations, such as RAB, and international organizations, such as CRS, CIP (Centro Internacional de la Papa), International Fertilizer Development Center (IFDC), International Aqua-Tech (IAT), and World Agroforestry Center (ICRAF), are positioned in the centre of the graph as they place a high priority on ITPGRFA policy.

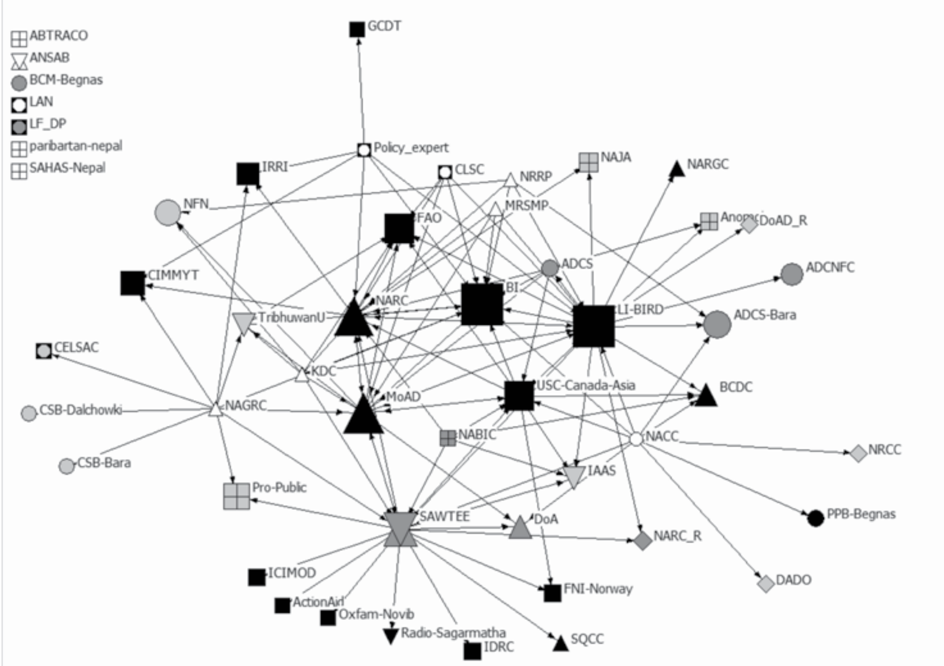

**Figure 5.8.** ITPGRFA implementation priority network.

## Network metrics

Although the network maps provide a visual representation of the data, it is also useful to refer to statistics that capture various dimensions of the network structure. **Table** 5.4 shows measures of centralization, density, and average degree of centrality. Centralization is a measure of the extent to which the network is concentrated around one or more key nodes. Density is a measure of interconnectedness among nodes. Average degree of centrality measures the average number of ties for any node in the network.

**Table 5.4. Degree of centralization and density of the policy network, in total and in terms of various resources**

| | No. of ties | No. of connected nodes* | Centralization (%) | Density | Average degree of centrality |
|---|---|---|---|---|---|
| All relationships | 165 | 52 | 47.64 | 6.22 | 3.17 |
| Legal expertise | 63 | 31 | 33.56 | 2.38 | 1.21 |
| Policy and administrative direction | 90 | 37 | 34.53 | 3.39 | 1.73 |
| Scientific expertise | 109 | 38 | 15.24 | 4.19 | 2.14 |
| Financial resources | 49 | 32 | 26.11 | 1.85 | 0.94 |

* Total number of nodes = 52.

Among the 52 organizations identified by the respondents, there were 165 connections among them for an average of 3.17 connections per node. The network (first row) has a high density, indicating that many organizations are connected. Centralization scores are generally moderate, indicating that resource flows are less concentrated around the most central actor.

## Uninvolved important actors

A final area of analysis concerns individuals and organizations that may be missing from the network. We asked respondents to identify up to five organizations that are not currently involved in the ITPGRFA implementation process, but should be involved to ensure effective policy implementation. Of the 52 involved organizations, 11 are international and 10 are national government organizations (**Table** 5.5). In addition, respondents named 19 organizations that should be involved, but currently are not; these include six national government organizations.

**Table 5.5. Organization types and its involvement in ITPGRFA policy implementation**

| Type of organization | Involved | | Not involved | | Total | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| International | 11 | 21.15 | 0 | 0 | 11 | 15.49 |
| Regional | 2 | 3.85 | 0 | 0 | 2 | 2.82 |
| National government | 10 | 19.23 | 6 | 31.58 | 16 | 22.54 |
| National NGOs | 8 | 15.38 | 2 | 10.53 | 10 | 14.08 |
| Provincial/county govt. | 4 | 7.69 | 2 | 10.53 | 6 | 8.45 |
| Farmers organizations | 9 | 17.31 | 0 | 0 | 9 | 12.68 |
| Private sector | 5 | 9.62 | 3 | 15.79 | 8 | 11.27 |
| Others (university, media) | 3 | 5.77 | 6 | 31.58 | 9 | 12.68 |
| Total | 52 | 100 | 19 | 100 | 71 | 100 |

In some cases, a respondent indicated that an organization was not involved, while others reported that their organization had a relationship with it. **Table** 5.6 shows which organizations were named by at least one respondent as not involved and which were named by all respondents as not involved, but should be.

**Table 5.6. Organizations identified by survey respondents as “not involved in implementing the ITPGRFA but should be”**

| Organization | Identified by at least one respondent | Identified by all respondents |
|---|---|---|
| Agriculture and Forestry University | ✓ | ✓ |
| Centre for Environmental and Agricultural Policy Research, Extension and Development | ✓ | ✓ |
| Department of Plant Resources, MoFSC | ✓ | ✓ |
| FM radio | ✓ | ✓ |
| Federation of Nepalese Chambers of Commerce and Industry | ✓ | ✓ |
| Forum for Rural Welfare and Agricultural Reform for Development | ✓ | ✓ |

| Organization | Identified by at least one respondent | Identified by all respondents |
|---|---|---|
| Gate Seed Company | ✓ | ✓ |
| Himalayan College of Agricultural Science and Technology | ✓ | ✓ |
| Kathmandu University | ✓ | ✓ |
| Ministry of Federal Affairs and Local Development | ✓ | ✓ |
| Ministry of Forest and Soil Conservation | ✓ | ✓ |
| Ministry of Law and Justice | ✓ | ✓ |
| Ministry of Science, Technology and Environment | ✓ | ✓ |
| Nepal Biotechnology Association | ✓ | ✓ |
| Nepalese Forum of Environmental Journalists | ✓ | ✓ |
| Nepal-Television | ✓ | ✓ |
| Purbanchal University | ✓ | ✓ |
| Seed Entrepreneurs' Association of Nepal | ✓ | ✓ |
| Village development committees | ✓ | ✓ |
| Anomolbiu Seed Company | ✓ | |
| International Maize and Wheat Improvement Centre | ✓ | |
| Institute of Agriculture and Animal Science | ✓ | |
| International Centre for Integrated Mountain Development | ✓ | |
| International Rice Research Institute | ✓ | |
| Nepal Agriculture Journalists' Association | ✓ | |
| National Farmers' Network | ✓ | |
| Pro-Public | ✓ | |
| South Asia Watch for Trade, Economics and Environment | ✓ | |
| Tribhuvan University | ✓ | |

## Summary and implications

Although only half the respondents were very familiar with ITPGRFA and MLS issues, those who were believed their implementation would result in great benefits for Nepal in terms of ensuring food security and the livelihoods of people. However, many believed that implementation was not a high priority for their organization.

Respondents indicated that effective implementation of the MLS would facilitate access to core germplasm and enable integration of that germplasm into the national crop improvement programs, thereby improving Nepal's capacity to address food security and adapt to climate change. Access to elite accessions and information under the MLS would prevent duplication of efforts and save resources that would otherwise be spent on screening and characterization of local crops for breeding and genetic knowledge. Respondents emphasized the importance of implementation of the MLS in the context of climate change, as it would allow access to crop varieties of wide adaptability. They believed that effective implementation would provide both monetary and non-monetary economic benefits. Respondents recognized that funds for conservation and capacity building were a monetary benefit of the MLS and could contribute to Nepal's ability to address the food insecurity challenge. They also mentioned the potential for the MLS's benefit-sharing scheme to help build national capacity at the institutional and local levels among farmers, scientists, and other stakeholders and strengthen global networking and information sharing.

Respondents raised equity concerns. They thought that Nepal may not be ready to benefit from facilitated access to genetic material from other countries because of the lack of capacity and a national plan and policy to mobilize resources. Negative consequences of the MLS that were mentioned included weak monitoring and enforcement and lack of transparency; equity concerns; and gene pollution and biosafety concerns. The major perceived constraint to implementation of the ITPGRFA and MLS was lack of financial and capital resources, although this was rated as a moderate constraint. Human resources constraints, including lack of legal and policy expertise, scientific expertise, and skilled administrative staff, were identified as minimal. A limited initiative has been taken to enhance the capacity of key ITPGRFA stakeholders in the country.

Integration of the ITPGRFA policy with other national policies may prove complex. Survey results show that ITPGRFA policy network members are also involved in implementation of numerous other related policies.

The policy network includes a wide range of organizations: universities, government, business, international organizations, media, etc. Although there are a number of key players, such as LI-BIRD, Bioversity International, NARC, MoAD, SAWTEE, and FAO, respondents reported that most of these consider ITPGRFA policy implementation to be a high priority. LI-BIRD, NARC, and MoAD are the top three organizations providing scientific expertise. However, communication among various actors on ITPGRFA and MLS issues is infrequent; rather communication is more bilateral in nature. LI-BIRD, Bioversity International, USC-Canada-Asia, NARC, and MoAD are positioned in the centre of networks with a high policy priority. Overall, the network has a high density, indicating that many organizations are interconnected.

We found that coalitions have not been sufficient to allow national teams to conclude data collection and analysis. Although ITPGRFA policy networks are larger than expected, some important organizations who should be involved in ITPGRFA and MLS implementation are missing because of lack of awareness, expertise, and resources. Further efforts to improve communication and formally integrate unconnected organizations, such as universities and private-sector organizations, are likely important to ongoing ITPGRFA and MLS implementation efforts.

The results of this policy network analysis have been useful in terms of improving the effectiveness of implementation of the ITPGRFA by targeting appropriate actors and identifying constraints. Strong policy awareness, strengthening networks of policy actors through the flow of information, increasing policy action research capacity, and human resource development for agro-biodiversity policy are essential for the effective implementation of the ITPGRFA and MLS in Nepal.

## References

Borzel TA. 1998. Organizing Babylon – On the Different Conceptions of Policy Networks. Public Administration, Vol. 76, Summer 1998, pp.253–273.

Coleman W and G Skogstad. 1990. Policy communities and policy networks. **In** *Introduction and Policy Network: A Structural Approach*. W Coleman and G Skogstad (eds). Toronto Policy Communities and Public Policy in Canada, Copp Clark Pittman.

Gauchan D, and M Upadhyaya. 2006. International Treaty on Plant Genetic Resources for Food and Agriculture: Prospects and Challenges for Nepal: a Summary Report of the Study carried out under the Regional Program on Securing Farmers' Rights to Livelihood in the Hindu-Kush Himalayan Region. Forum for Protection of Public Interest (Pro-Public), Kathmandu, Nepal. x + 42 pp.

Gauchan D, BR Sthapit, and DI Jarvis. 2003. Agrobiodiveristy Conservation on-farm: Nepal's Contribution to a Scientific Basis for National Policy Recommendation. International Plant Genetic Resource Institute, Rome, Italy.

Hirschi C, A Widmer, S Briner, and R Huber. 2013. Combining policy network and model-based scenario analyses: an assessment of future ecosystem goods and services in Swiss mountain regions. *Ecology and Society* 18(2): 42.

Parag Y. 2006. A system perspective for policy analysis and understanding: the policy process networks. *The Systemist* 28: 212–224.

Rhodes RAW. 2006. Policy network analysis. **In** *The Oxford Handbook of Public Policy*. M Moran, M Rein and RE Goodin (eds). Oxford University Press, Oxford, UK. pp. 423–445.

Sabatier PA. 1988. An advocacy coalition framework of policy change and the role of policy-oriented learning therein. *Policy Sciences* 21: 129–168.

Smith A. 2000. Policy networks and advocacy coalitions: explaining policy change and stability in UK industrial pollution policy? *Environment and Planning C: Government and Policy* 18(1): 95–114.

Sudman S, and G Kalton. 1986. New developments in the sampling of special populations.*Annual Review of Sociology* 12(1): 401–429.

Subedi A, P Chaudhary, B Baniya, R Rana, RK Tiwari, D Rijal and B Sthapit. 2003. Who maintains genetic diversity and how? Policy implications for agro-biodiversity management. **In** *Agro-Biodiversity Conservation On-Farm: Nepal's Contribution to a Scientific Basis for National Policy Recommendation*. D Gauchan, BR Sthapit and DI Jarvis (eds). International Plant Genetic Resources (IPGRI), Rome, Italy, pp.24-26.

Thatcher M. 1998. The development of policy network analyses: from modest origin to overarching frameworks. *Journal of Theoretical Politics* 10(4): 389–416.

Vignola R, TL McDaniels, and RW Scholz. 2013. Governance structures for ecosystem-based adaptation: using policy-network analysis to identify key organizations for bridging information across scales and policy areas. *Environmental Science and Policy* 31: 71–84.

# Chapter VI : Linking farmers to the multilateral system to increase the exchange of plant genetic resources

Pashupati Chaudhary, Bal Krishna Joshi, Pitambar Shrestha, Rachana Devkota, Deepak Upadhya and Ronnie Vernooy

## Key messages

- Problems faced by community seed banks (CSBs) include lack of clarity about concepts, objectives, and sustainability; lack of awareness of policy support for CSBs; inadequate seed and fund management; weak leadership, management, and coordination; inadequate facilities and infrastructure; and poor links and coordination with the National Agricultural Genetic Resources Centre (the national genebank).
- Farmers have become aware of international policies and are ready to share their genetic materials with the national genebank. However, they have mixed feelings about sharing material with people outside the country.
- No national policy documents have explicitly mentioned the need and strategies for linking in-situ/on-farm resources with ex-situ resources or linking CSBs with the national genebank.
- A CSB cannot survive without the support of strong, well-governed local institutions that are aware of day-to-day activities and committed to avoiding unnecessary mishandling of seeds and conflict among members and with non-members.
- Implementation of the ITPGRFA could be carried out efficiently if overall responsibility for monitoring and coordinating the exchange of PGRs through the multilateral system (MLS) is given to the national genebank.
- A “one window” system for exchanging PGRs through the MLS would be most appropriate for Nepal.
- Farmers must be made aware of the benefits they may receive through use of the MLS.
- CSBs must be established and strengthened in strategic locations.
- CSBs and the national genebank must work together and have a common understanding on their roles.
- Farmers’ consent must be obtained before listing in-situ/on-farm material in Nepal’s Annex I.
- In the case of in-situ and on-farm materials, benefit-sharing mechanisms must be established and monitored to properly acknowledge and reward custodian farmers who are maintaining or preserving such rare resources.

Conserving and using agricultural plant genetic resources (PGRs) that are maintained on-farm by farmers is key to securing food and livelihoods and improving community resilience to climate change (Frankel et al. 1995, Jarvis et al. 1998, FAO 2010). Conservation, management, and sustainable use of PGRs has become possible because of gene flow from one location to another or from one farmer's field to another (Hardon 1997, Subedi et al. 2003), either naturally or through informal and formal seed supply systems that have evolved over generations.

In informal seed systems, farmer-to-farmer seed exchange plays a pivotal role in the maintenance of agrobiodiversity, mainly in smallholder settings in remote, isolated, and inaccessible geographic regions (Jarvis et al. 1998, Sthapit and Jarvis 1999, Sperling and Cooper 2003). However, farmer-to-farmer exchange of PGRs is being replaced by formal seed supply systems that often emphasize modern varieties. This is threatening PGRs that have evolved under the traditional system. For example, in 2014, the contribution of formal systems to the global distribution of rice seeds was four times what it was in 1999 (Hodgkin et al. 2007, SQCC 2014). Thus, it is important to further strengthen farmers' relations with other farmers and with the formal systems, so that a continuous flow of high-quality genetic materials can take place — at both the national and international levels.

In response to the diminishing role of farmers' seed systems, the concept of community seed banks (CSBs) emerged and evolved as a way to empower communities and to protect, maintain, and make available locally valuable PGRs to needy farmers (Joshi 2013, Vernooy 2013). CSBs aim to improve access to seeds, conserve agricultural biodiversity and associated traditional knowledge, facilitate adaptation to climate change, and protect farmers' rights (Shrestha et al. 2012). CSBs are also recognized as a reservoir of seeds that rescues farmers during times of seed scarcity resulting from various social, economic, political, and environmental factors. In addition, they can be a platform for social learning, as farmers exchange knowledge and skills with each other.

The role of CSBs is also important in the exchange of PGRs and associated knowledge with national genebanks and international organizations (FAO 2014) through the multilateral system (MLS) provisioned under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). CSBs are also expected to be effective in implementing the access and benefit sharing agreement proposed by the Nagoya Protocol to promote one of the goals of Convention on Biological Diversity: "the fair and equitable sharing of the benefits arising out of the utilization of genetic resources" (CBD 1992, Article 1).

In Nepal, farmers' groups that manage the more than 100 CSBs are becoming empowered and increasingly self-sustaining in maintaining, supplying, and conserving important genetic materials within certain geographic regions. However, in the changing national and international policy contexts, there is still lack of clarity regarding the roles CSBs can play, how they can function most effectively, and what policy support is needed and from whom (scientists, extension workers, civil society organizations, and policymakers). There are no clear-cut policies or guidelines to aid and strengthen links between CSBs and the national genebank, the Seed Quality Control Centre (SQCC), and other government bodies performing similar roles, nor with relevant international agencies. This, despite the fact that Nepal's agrobiodiversity policy clearly emphasizes these issues (MoAD 2014).

It is important to understand what plant material farmers hold, their knowledge, and their management practices to determine how these resources can be conserved sustainably. Strong links must be created between governmental and nongovernmental organizations, between farmers growing crops in-situ and the national genebank, and between farmers and the MLS. Last, the issue of CSBs and farmers' rights requires attention.

We made an attempt to document two case studies of CSBs in two locations: terai and hills. We identified the challenges they faced and opportunities available in relation to their operation and management. We also examined possible modes of collaboration and agreement between CSBs and the national genebank with respect to the MLS and identified options concerning in-situ materials under Article 12.3.h of the ITPGRFA (FAO 2004).

For this study, we chose the CSBs operated by the Biodiversity Conservation and Development Centres at Kachorwa, Bara (see Yadav 2013), and Tamaphok, Sankhuwasabha (see Jimi et al. 2015). Study methods included direct observation, review of existing records, and interviews with CSB members, curators, and staff. Some information was also collected through interactive discussions during meetings and a CSB workshop jointly organized by GRPI-II and Community-based Biodiversity Management (CBM)-Nepal projects run by the Nepal Agricultural Research Council (NARC), Local Initiatives for Biodiversity, Research and Development (LI-BIRD), and the Ministry of Agricultural Development. CSB members from various parts of the country participated in the workshop and provided their input.

## Challenges in operating CSBs

Although the concept of CSBs is gaining ground in various parts of the country, communities maintaining them continuously face a multitude of problems. Challenges include lack of clarity about concepts, objectives, and sustainability; lack of awareness of policy support for CSBs; poor integration of goals, themes, and disciplines; insufficient knowledge of the science of PGRs, especially plant breeding; inadequate seed and fund management; weak leadership, management and coordination; inadequate facilities and infrastructure; and poor links and coordination with the National Agricultural Genetic Resources Centre (the national genebank).

CSB groups, practitioners, policymakers, conservationists, and development workers all lack clarity about the core concept and objectives of a CSB and knowledge of how to operate them effectively and sustainably. As a result, CSBs receive poor policy support, and integration into government systems is not occurring at the desired pace.

CSB groups and practitioners do not have adequate knowledge of advanced breeding science (e.g., genetics, molecular techniques) and, thus, technical integrity in the management and maintenance of CSBs is poor. This has led to a high level of dependence on government agencies and a handful of NGOs for technical support. For certain crops, especially cross-pollinated ones, farmers have difficulty maintaining pure lines of seeds.

CSB groups find it difficult to manage seeds and funds efficiently and to ensure equity in terms of sharing both the burden of responsibilities and benefits among members. Youth are losing interest in farming in general and in maintaining local varieties in particular; their lack of involvement in agriculture is seldom addressed by many CSBs. There is a need to train dynamic leaders with a long-term vision and good management and leadership skills. Linking CSBs with research and extension services offered by the government and NGOs has also not received enough attention.

## Opportunities for promoting CSBs within the existing policy framework

Agricultural research in Nepal dates back to the early 1920s when the Department of Agriculture was established. In early 1970, the National Rice Improvement Program was founded. Later, in late 1980s, the Seed Act (1988) was passed (and revised in 2008) to facilitate certification of "distinct, uniform, and stable" seeds. Two representatives of seed entrepreneurs and two representing seed producers and farmers can be invited to be members of the national-level seed committee, a body responsible for providing advice on the formulation and implementation of seed-related policies.

The Seed Regulation (1997, revised in 2013) was developed to effectively implement the Seed Act. It allows for the promotion of local landraces and varieties improved by farmers or jointly by farmers and scientists. CSBs can play an important role in identifying promising landraces and do the necessary work to register them in the name of farmers or their representative groups (Chaudhary et al. 2015).

The Seed Policy (1999) emphasizes the organization and management of programs related to the formation of farmers' groups; revolving fund support; and management, technical service, and transportation subsidies for seeds with a focus on remote areas of the country. As CSBs manage such groups and provide revolving funds to sustain their work, there are opportunities to create synergy between the various policies and leverage resources. However, the mechanism for revolving fund management is not well described in the Seed Policy, and misunderstandings may lead to CSB failure.

The Plant Variety Protection Act (2004) recognizes plant breeders' efforts and farmers' knowledge and resources (e.g., farmers' own varieties) used in developing new varieties. It allows farmers to register, control, reproduce, and market their varieties if they meet the distinct, uniform, and stable criteria. The act also promotes the export and import of farmer-released seed varieties and allows farmers to receive remuneration from sales. There is room for CSB members to test promising local varieties and release them in their own name. For instance, the CSB in Kachorwa, Bara, has played a pioneer role in developing and releasing new varieties.

As a signatory country of the Convention on Biological Diversity, Nepal is obliged to pass a law on access and benefit sharing to establish the rights of local communities to indigenous knowledge and PGRs and ensure fair and equitable sharing of benefits arising from their use. The first draft of such a law was prepared in 2002, but negotiations reached a stalemate over some of its provisions, mainly issues related to indigenous rights. The draft version states that indigenous knowledge of genetic resources belongs to the community and that prior informed consent is necessary if such knowledge is to be used in variety development. CSBs from around the country have met to form a network and discuss a strategy for securing their rights as defined above. This network could play a vital role in presenting and defending their concerns before the access and benefit sharing law is passed.

Seed Vision 2025 is a policy document that has put forward a strong agenda regarding CSB development, genebanks, community-based seed production, and capacity-building of seed producers and producer groups to promote production of and access to quality seeds. The document also envisions identifying, mapping, and developing seed production pockets within the country and emphasizes investment by the private sector. If implemented properly, this policy can contribute greatly to the growth of CSBs in the country.

The Agro-biodiversity Policy, first developed in 2007 and revised in 2014, focuses on enhancing agricultural growth and food security by conserving, promoting, and sustainably using agrobiodiversity; securing and promoting farming communities' rights and welfare in terms of their indigenous knowledge, skills, and techniques; and developing appropriate options for fair and equitable sharing of benefits arising from access to and use of PGRs. The revised policy acknowledges community-based biodiversity management and approaches, such as community biodiversity documentation, biodiversity fairs, CSBs and biodiversity management funds. These community-led initiatives can contribute to the exchange of in-situ materials. The policy also aims to promote links among international ex-situ genetic resources, the national genebank, public and private national research institutions, seed multipliers, extension agents, and farmers engaged in in-situ conservation and use of PGRs. Emphasis is on strengthening the traditional seed production and distribution system to protect farmer-to-farmer seed exchange and improve access to genetic resources. To guard against false advertisement of the quality of seeds, fraudulent sales of spurious seeds, and theft of farmers' varieties, the policy provides penalties for such activities.

The CSB Guideline (2009) was developed to guide planning, implementation, and monitoring of CSB activities on a regular basis. It focuses on marginalized, subsistence, indigenous peoples and war-affected households that often have poor access to PGRs. The guideline presents a clear vision and outlines strategies to coordinate and collaborate with various governmental and nongovernmental institutions; describes the complementary roles communities need to play; and includes a plan for capacity building and community empowerment.

- The exchange of in-situ and on-farm materials can lead to the following benefits.
- Farmers can get access to PGRs originating and developed elsewhere in exchange for their own genetic materials.
- If farmers' materials are made available to scientists through the MLS, they will be improved by appropriate breeding techniques.
- In certain cases, royalties will be received.
- Farmers' varieties that are no longer cultivated locally or that have become threatened will be conserved on farm elsewhere.
- Genebanks can play a role as a safety reservoir for many PGRs that are under threat.
- Information and skills will be distributed globally along with PGRs.
- Networks of scientists and farmers will be strengthened.

## Remedies for the challenges faced by CSBs

There is no cure-all or one-time solution to the challenges that CSBs are facing. To conserve their traditional varieties over the long term, farmers and CSB groups must continuously engage in the collection, regeneration, and multiplication of seeds, especially of rare, endemic, and endangered crop varieties that are more vulnerable than the common, more widespread ones. The participants at our national workshop discussed a variety of tools, techniques, methods, strategies, and policy issues related to sustainability.

To foster sustainability, it is important to address both conservation and livelihood goals and set clear objectives and pathways to reach them, taking into account the local production system, access to technologies and markets, and policy leverage. Although local varieties have priority, in regions where food security cannot be achieved by maintaining local varieties only, the adoption of modern varieties should not be excluded. In high production systems, some rare, endangered, and lost varieties might still be found around villages and could be collected or, if there is local interest in maintaining them, they could be borrowed from the national genebank.

A CSB can only be sustained with the support of strong, well-governed local institutions. Collective effort is a must. Transparency, accountability, and equitable sharing of burdens and benefits are important factors in managing CSBs efficiently. A community-based management fund can provide incentives for CSB groups to unite while they maintain or promote local varieties.

It is important that the government and its line agencies working in the districts accept, integrate, and institutionalize CSBs in their minds, programming, and practices. This requires appropriate policy and legal support at the central level. Proper incentives should also be developed to promote CSBs and encourage practitioners and CSB groups to continue operating. CSBs and farmers managing rich agrobiodiversity on-farm should be clearly recognized in policies and linked with ex-situ organizations or the national genebank. Current efforts are not linked to participatory breeding despite the potential of this approach for conserving local biodiversity and developing locally viable, economically beneficial, and ecologically resilient varieties. CSBs can be strengthened through links and coordination of farmers with national and international like-minded institutions, including private agencies, working in the field of agrobiodiversity conservation and food security.

## Mode of operation of CSBs in relation to the MLS

Recently, the SQCC was given responsibility for monitoring the import and export of genetic materials, but this has not been implemented strictly. Scientists have been collecting seeds from farmers and transporting them to research stations in the country and abroad without using any standard procedure. Inspection of imported and exported material at transaction points is poorly done. None of the policy documents we reviewed explicitly mentions the need or strategies for linking in-situ with ex-situ conservation or linking CSBs with the national genebank. The issue of securing farmers' rights is raised in some of the documents without practical recommendations for devolving rights.

Questions remain; How do farmers perceive the law that allows them to share all genetic materials that are in public domain and in genebanks? Do farmers want to share their material with the national genebank and under what conditions in a changing policy context? How do farmers want to share materials with fellow farmers living in their own locality and other regions? How do farmers understand the signing of material transfer agreements and having others sign them when materials are exchanged?

Farmers have become aware of international policies and are ready to share their genetic materials with the national genebank. However, they have mixed feelings about sharing materials with people outside the country. Several CSBs have already shared their PGRs with the national genebank and have shown interest in acquiring material from the genebank to test on their farms. So far, the National Agricultural Genetic Resources Centre has received more than 250 accessions from farmers, and about 100 more have been committed by a CSB.

## Mechanisms of exchange of in-situ/on-farm materials with respect to the MLS and Article 12.3.h

Consultations with scientists, government officials, and NGO representatives indicate that a "one-window system" would be the most appropriate way to exchange PGRs through the MLS. This would allow for effective monitoring of the flow of PGRs and minimize theft and illegal supplies of PGRs. The most appropriate institution to take the lead and coordinate a one-window system would be the national genebank, given that it is the main institution dealing with farmers' varieties. Most professionals working on PGRs fully support this idea.

However, the following prerequisites must be met before sharing in-situ and on-farm materials.

- Farmers must be made aware of policies and the benefits they might receive by using the MLS.
- CSBs must be established and strengthened at strategic locations in the country. CSB members should be educated about the MLS, the Standard Material Transfer Agreement, and other relevant issues. A network of CSB members is also necessary to ensure a collective voice and effort to protect their rights, preserve their PGRs, and acquire appropriate benefits from the use of such PGRs — nationally and internationally.
- CSBs and the national genebank must work together and have a common understanding of their roles. Their relationship must be strengthened. Support for the CSBs is necessary for preserving seeds and documenting knowledge and essential information about the accessions that are transferred to the genebank. Exchange of PGRs between CSBs and the national genebank must be promoted.
- National policies and legislation must be prepared and strictly enacted. A material transfer policy should be clearly outlined and strictly followed. A proper monitoring mechanism must be in place to ensure that regulations are followed and materials are not exchanged illegally or without proper documentation.

- NGO support may be necessary for documenting and regenerating material preserved in the CSBs. Thus, a tripartite relationship is essential for successful implementation of relevant policies and law.
- Article 11.2 of the ITPGRFA does not distinguish between materials maintained under ex-situ and in-situ conditions. Therefore, in-situ and on-farm materials are generally considered to be part of the MLS. However, in-situ materials should be treated separately from those in the public domain. It is clearly stipulated that in-situ material will be exchanged in compliance with national legislation, if available; otherwise, the rule of the governing body of the ITPGRFA may prevail.
- Those PGRs undergoing development/improvement, including material being developed by farmers, remain in the domain of the breeder during the period of development (Article 12.3.e). There is a clear need for national legislation in relation to the ITPGRFA and MLS to avoid confusion in this regard.
- Farmers' consent must be received when including in-situ/on-farm materials under the ITPGRFA and, subsequently, when exchanging them in and outside the country.
- In the case of in-situ material, benefit-sharing mechanisms must be established and monitored to properly acknowledge and reward custodian farmers who are maintaining or preserving such rare resources.

Because CSBs are the local-level institutions handling PGR exchange and dealing with individual farmers, strong, enduring links between them and genebanks must be established, so that information and materials may be continuously exchanged between the two institutions. CSB group members must be trained in effective handling of PGRs and in the legal issues pertaining to the exchange of material with other farmers and professionals at the national and international levels. Some support from the government will also be necessary to improve CSB initiatives in preserving important local germplasm. At the district level, agriculture development offices can be made responsible for the monitoring and preventing the illegal exchange of materials. There should be a mechanism to punish both natural and legal organizations if they violate the rules or fail to comply with national policies and laws.

## References


Chaudhary P, R Devkota, D Upadhya and K Khadka. 2015. Government policies and laws related to Community Seed Banks. **In** *Community Seed Banks: Origin, Evolution and Prospects.* R Vernooy, P Shrestha and B Sthapit (eds). London and New York, Routledge 2 Square, Milton Park, Abingdon, OxonOX 14 4 RN. pp.243-247.

FAO. 2004. *International Treaty on Plant Genetic Resources for Food and Agriculture.* Food and Agriculture Organization (FAO), United Nations, Rome, Italy. Available: http://www.planttreaty.org/content/texts-treaty-official-versions

FAO. 2010. *Climate-smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation*. Food and Agriculture Organization (FAO), United Nations, Rome, Italy.

FAO. 2014. Community seed banks: Junior farmer field and life school- facilitator's guide, Viale delle Terme di Caracalla. Food and Agriculture Organization (FAO), United Nations, Rome, Italy.

Frankel OH, AHD Brown, and JJ Burdon. 1995. *The Conservation of Plant Biodiversity*. Cambridge University Press, Cambridge, UK.

Hardon JJ. 1997. Ethical issues in plant breeding, biotechnology and conservation. **In** *Ethics and Equity in Conservation and Use of Genetic Resources for Sustainable Food Security*. Proceedings of a workshop to develop guidelines for the CGIAR, 21–25 April 1997, Foz do Iguacu, Brazil. IPGRI, Rome, Italy. pp.43–50.

Hodgkin T, R Rana, J Tuxill, D Balma, A Subedi, I Mar, D Karamura, R Valdivia, L Collado, L Latournerie, M Sadiki, M Sawadogo, AHD Brown and DI Jarvis. 2007. Seed systems and crop genetic diversity in Agroecosystems. **In** *Managing Biodiversity in Agricultural Ecosystems.* DI Jarvis, C Padoch, and DH Cooper (eds). Columbia University Press, New York, USA. pp.77–116.

Jarvis D, T Hodgkin, P Eyzaguirre, G Ayad, B Sthapit and L Guarino. 1998. Farmer selection, natural selection and crop genetic diversity: the need for a basic dataset. **In** *Strengthening the Scientific Basis of In-Situ Conservation of Agricultural Biodiversity On-Farm: Options for Data Collecting and Analysis*. D Jarvis and T Hodgkin (eds). Bioversity International, Rome, Italy. pp.1–8.

Jimi D, M Jimi and P Shrestha. 2015. The community seed bank in Tamaphok. **In** *Community Seed Banks: Origin, Evolution and Prospects*. R Vernooy, P Shrestha and B Sthapit (eds). London and New York, Routledge, 2 Park Square, Milton Park, Abingdon, Oxon OX 14 4 RN. pp.144-147.

Joshi BK. 2013. A brief overview of community seed bank initiatives in Nepal. **In** *Community Seed Banks in Nepal: Past, Present, Future*. Proceedings of a national workshop, 14-15 June 2012, Pokhara, Nepal. P Shrestha, R Vernooy, and P Chaudhary (eds). LI-BIRD, Pokhara, Nepal, and Bioversity International, Rome, Italy. pp.41–46. http://www.bioversityinternational.org/uploads/tx_news/Community_seed_banks_in_Nepal__past__present_and_future_1642.pdf.

Shrestha P, S Sthapit, R Devkota, and R Vernooy (eds). 2012. Workshop summary report. National workshop on community seed banks, 14–15 June 2012, Pokhara, Nepal. LI-BIRD, Pokhara, Nepal, and Bioversity International, Rome, Italy.

Sperling L, and DH Cooper. 2003. Understanding seed systems and strengthening seed security. Background paper for effective and sustainable seed relief. A stakeholder workshop, Rome, Italy, 26–28 May 2003. Food and Agriculture Organization, Rome, Italy.

Sthapit BR, and DI Jarvis 1999. Participatory plant breeding for on-farm conservation. *LEISA* 15:40–41.

Subedi A, P Chaudhary, BK Baniya, RB Rana, RK Tiwari, DK Rijal, DI Jarvis, and BR Sthapit. 2003. Who maintains crop genetic diversity and how: implications for on-farm conservation and utilization. *Culture and Agriculture* 25:41-50.

United Nations. 1992. Convention on Biological Diversity. United Nations, New York, USA. http://www.cbd.int/doc/legal/cbd-en.pdf

Vernooy, R. 2013. In the hands of many: A review of community seed banks around the world. **In** *Community Seed Banks in Nepal: Past, Present, Future*. Proceedings of a national workshop, 14-15 June 2012, Pokhara, Nepal. P Shrestha, R Vernooy, and P Chaudhary (eds). LI-BIRD, Pokhara, Nepal, and Bioversity International, Rome, Italy. pp.3-15. http://www.bioversityinternational.org/uploads/tx_news/Community_seed_banks_in_Nepal__past__present_and_future_1642.pdf

Yadav R. 2013. The story of establishment and management of a community seed bank in Kachowa village of Bara district in Central Terai Nepal. **In** *Community Seed Banks in Nepal: Past, Present, Future*. Proceedings of a national workshop, 14-15 June 2012, Pokhara, Nepal. P Shrestha, R Vernooy, and P Chaudhary (eds). LI-BIRD, Pokhara, Nepal, and Bioversity International, Rome, Italy. pp.87-93. http://www.bioversityinternational.org/uploads/tx_news/Community_seed_banks_in_Nepal__past__present_and_future_1642.pdf.

# Chapter VII : Technology transfer: Non-monetary benefit-sharing in support of conservation and sustainable use of PGRs

Devendra Gauchan, Krishna Prasad Pant and Bal Krishna Joshi

**Key messages**

- Non-monetary benefits of the International Treaty on Plant Genetic Resources for Food and Agriculture include germplasm-based and non-germplasm-based technologies.
- The transfer of PGR-related technologies is often on an ad hoc basis.
- Technologies are important for ensuring national and global food security as they facilitate and accelerate the flow, exchange, and use of germplasm.
- South–South and horizontal technology transfers are preferred because of the lower cost of transfer and faster diffusion as well as better adaptation to local contexts, compared with North–South and vertical transfers.
- It is easier and faster to transfer germplasm-based technology than non-germplasm-based technology, but the latter is required for sustainable use of the former.
- Transfer of germplasm-based technologies are accelerated and facilitated by the associated non-germplasm based technologies.
- The flow of non-germplasm based technologies from Nepal's national research organizations to private and farmers' cooperatives is very limited.

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) calls for technology transfer as a primary form of non-monetary benefit-sharing (Article 13.2.b), backed by information exchange (Article 13.2.a) and capacity building (Article 13.2.c) (FAO 2004). Technology transfer is also envisaged by other international agreements, such as the Convention on Biological Diversity (United Nations 1992), and the ITPGRFA reinforces the provisions of the CBD on this subject.

There is concern that although the World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property Rights promotes technology generation, it hinders technology transfer through protection of intellectual property rights (IPRs), especially with respect to transfer to developing countries, such as Nepal. The agreement requires protection of the rights of breeders to new varieties they develop, but does not require transfer of technology to those who provide the genetic resources, i.e., the farmers.

The ITPGRFA provides that transfer of technology to countries shall be carried out through partnerships in research and development (Article 13.2.b.iii). Priority is given to "the implementation of agreed plans and programmes for farmers in developing countries who conserve and sustainably utilize plant genetic resources for food and agriculture" (Article 18.5).

The governing body of the ITPGRFA has called for measures to realize effective technology transfer and has invited contracting parties and other relevant stakeholders to explore innovative benefit-sharing measures in the area of technology transfer. The objective of technology transfer is to promote the co-development of technologies, recognizing that technology transfer requires a range of supporting activities: building individual and institutional capacity; mobilizing in-kind contributions from both the public and private sectors; and supporting implementation of the treaty. The treaty emphasizes that technology transfer is required to enhance the capacity to use PGRs through plant breeding, using modern tools, traditional varieties, and the participation of farmers.

However, there is considerable uncertainty about what is meant by technologies "for conservation, characterization, evaluation and use" and which technologies developing countries are interested in getting access to (or providing). Nor is there much documentation of the experiences of developing countries, such as Nepal, in their past efforts to transfer (as providers or recipients) such technologies, particularly under the framework of the ITPGRFA. To date, there has also been no discussion about how to operationalize Article 13.2.b at the level of the treaty's governing body. In short, very little is being done to take advantage of the technology transfer provisions of the treaty.

This chapter deals with potential and promising technologies that stakeholders in Nepal believe can be transferred to generate non-monetary benefits to farmers, agro-entrepreneurs, and other stakeholders who support the conservation of PGRs. We also describe key organizations and actors involved in developing and transferring these technologies, the mode and pathways of transfer, and the use of the technologies for conservation, characterization, and evaluation. We hope this information will stimulate discussion, both within countries and at the level of the ITPGRFA's governing body, about Nepal's conceptions of what technologies fall within what is described in Article 13.2.b and developing countries' needs or capacities to transfer such technologies and generate non-monetary benefits.

Our study involves three key components: organizational case studies; practical experiences in technology transfer, including mechanisms and their application; and assessment of the need for various types of technologies.

## Research methods

We conducted a literature review, carried out key informant interviews, and held focus group discussions with farmers and a consultation meeting with key stakeholders. We did both organizational studies and technology case studies, conducted a needs assessment among national stakeholders, and examined actual field-level technology transfer status.

### Conceptualization of technology types

First, we reviewed relevant literature and consulted experts to conceptualize and study concepts of technology in relation to conservation, characterization, evaluation, improvement, and use as per the provisions of the ITPGRFA. This process helped us identify and categorize potential technologies to focus on for further study (**Table** 7.1). Two types of technologies were identified: germplasm-based technologies, such as high-yielding crop varieties, hybrids, and pre-breeding genetic materials; and non-germplasm-based technologies, including mainly advanced tools and techniques used in the development, characterization, conservation, and evaluation of germplasm technologies.

**Table 7.1. Characterization of technology types**

| Type of technology | Application | | | |
|---|---|---|---|---|
| | Conservation | Characterization | Evaluation/ improvement | Direct Use |
| Germplasm-based (high-yielding varieties, hybrids, pre-breeding materials) | Yes | Yes | Yes | No |
| Non-germplasm-based (molecular markers, in-vitro propagation techniques, climate analogues tool) | Yes | Yes | Yes | No |

### Organizational case studies

Following the literature review and conceptualization and categorization of technologies used for two important crops (rice and potato), we surveyed the main research organizations involved in accessing technology from international sources. These are research branches of the Nepal Agricultural Research Council (NARC): the National Agricultural Genetic Resources Centre, the Agricultural Botany Division (ABD), the Biotechnology Research Division, the Seed Science and Technology Division, the National Potato Research Program (NPRP), the National Rice Research Program (NRRP), and the Regional Agricultural Research Station (RARS). We also surveyed an extension organization of the Department of Agriculture: the National Potato Development Program. The survey collected information on the organizational mandate, history, strengths, links, experiences, and lessons learned in the types of technologies they use.

### Field surveys of researchers, extension agents, farmers, and private-sector organizations

We conducted key informant interviews of researchers, extension agents, and private-sector organizations (seed companies and tissue-culture laboratories) involved in technology testing, production, and transfer of both germplasm-based and non-germplasm-based technologies. The main private-sector organizations surveyed were Malla Seed Producers Ltd., Chitwan;

Lumbini Seed Company, Rupendehi; Nepal Seed Production Centre, Godavari; and White House College, Lalitpur.

The field survey also included focus group discussions with selected farmers' groups that are involved in the production, multiplication, evaluation, transfer, and use of germplasm-based technologies. They were Sallesh Phulbari Seed Producer Group, Siraha; Bodhimai Seed Producer Cooperative, Kalaiya, Bara; and Unnat Seed Producer Group, Patihani, Chitwan, for rice; and Pragatishil Krishak Samuha, Nala, Kavre, for potato.

In addition, the team also interacted with 20 key informant farmers engaged in seed production, evaluation, and the use of the Swarna Sub-1 variety of rice and pre-basic seed (PBS, also called mini tuber which is equivalent to breeder seed) technologies for potato breeding in Chitwan, Bara, Mahottari, and Siraha. A few seed dealers (agrovets) were also surveyed in Chitwan in the central terai and Kaski, Pokhara, for their perceptions and marketing practices on germplasm-based technologies (rice and potato seeds). The relations between the organizations and actors surveyed are represented in **Figure** 7.1.

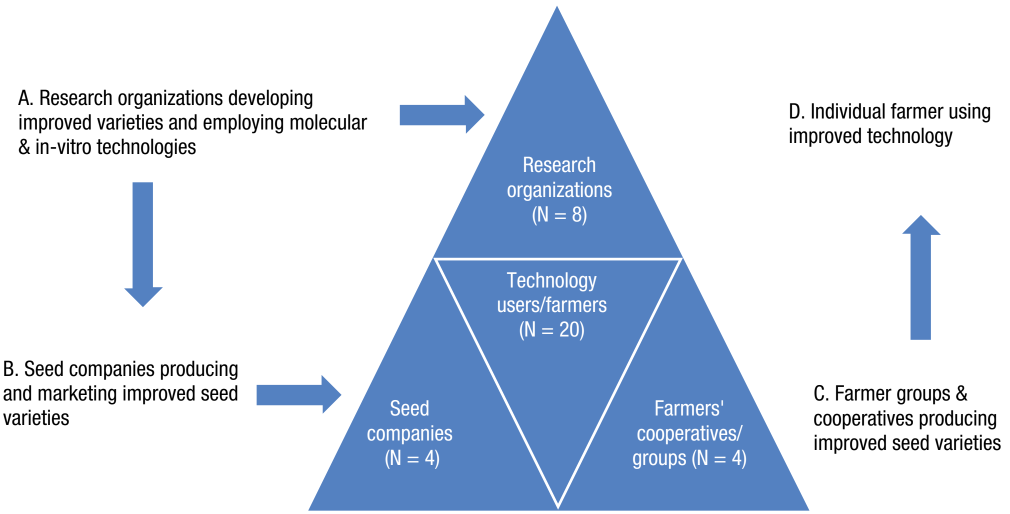


**Figure 7.1.** Organizations and actors involved in the transfer of technology related to plant genetic resources for food and agriculture.

## Technology transfer case studies

Based on the technologies identified in the literature review and organizational studies, we chose one technology used in rice breeding (Swarna Sub-1) and one used in tissue-culture of potato. We studied these for their transfer priorities, mode and pathways of transfer, and experience gained in the country from the transfer process. Both germplasm-based and non-germplasm-based technologies and their transfer process were studied.

As part of the case studies, we also assessed the technological needs of national stakeholders engaged in developing, transferring, and using new technologies.

## Concept of technology and technology transfer

The word "technology" refers to the making, modification, use, and knowledge of tools, machines, techniques, crafts, systems, and methods of organization to solve a problem, improve an existing solution, achieve a goal, or perform a specific function (Wikipedia 2015). The word technology comes from two Greek words: techne meaning art, skill, craft, or the way, manner, or means by which a thing is gained and logos meaning, the utterance by which inward thought is expressed, a saying, or an expression. So, literally, technology means words or discourse about the way things are gained.

"Technology transfer" is the process of transformation of the results of research and development (R&D) into marketable products or services. The National Science Foundation defines technology transfer as the exchange or sharing of knowledge, skills, processes, or technologies across different organizations. It also refers to the process by which science and technology are transferred from one individual or group to another that incorporates it into a new or improved process, product, system, or way of doing something (Marthniuk et al. 2003). It relates to lawful delegation of IPRs to technology developed by one party to another. Technology transfer is a process through which technical information and products developed by the R&D agencies are provided to potential users in a manner that encourages and accelerates their evaluation or use. Technology transfer in relation to the ITPGRFA encompasses commercial and non-commercial aspects of sharing technologies relating to genetic resources and bioprospecting (FAO 2004). The transfer of technology is, thus, a means of sharing the benefits derived from the sharing of the genetic materials under the MLS.

Technology transfer can be done in various ways. Some widely recognized models (Ruttan and Hayami 1973, Tenkasi and Mohrman 1995, Rogers 2003, Sung and Gibson 2005, Choi 2009) are:

- The appropriability model — Purposive attempts are unnecessary for technology transfer because "good" technologies sell themselves.
- The dissemination model — Transfer processes will be successful when experts transfer specialized knowledge to prepared beneficiaries.
- The knowledge utilization model — Emphasizes strategies for effective delivery of knowledge to beneficiaries.
- The contextual collaboration model — Accentuates the idea that knowledge cannot be simply transmitted, but must be subjectively constructed by its recipients.
- The design transfer model — Focuses on the transfer of blueprints and specifications, along with the technology itself.
- The capacity transfer model — Stresses the transfer of knowledge to give recipients the capability to design and produce a new technology on their own.
- The material transfer model — Transfer of new materials, such as machinery, seeds, tools, and the techniques associated with their use.

In this study, we focus mainly on the material transfer model, related to the transfer of PGRs and information, techniques, knowledge, and skills associated with their use. This model is the main driver of innovations related to bioprospecting. Such innovations can create new knowledge and technology that can be transferred through a model appropriate to agricultural development (Biggs

1989). Theories of international technology transfer often focus on the transfer of production-related technologies that are of immediate benefit to the users (Tsang 1997). International technology transfer is mainly concerned with transferring technology related to livelihoods from developed to developing countries to contribute to the reduction of poverty. The MLS is envisaged as a pool of intangibles and a system for the exchange of technologies. Under this system, members are urged to facilitate access to genetic material and related technologies and to improved varieties and genetic materials developed through the use of this system (Article 13.2.b.i).

However, the transfer of technology requires a trade-off regarding the IPRs of its creators. The form of the technology transfer depends on contractual arrangements between the creators and users of the technology and differs from case to case. Contracts identify the technology to be transferred and delineate the terms and conditions of the transfer. Transfer can involve documents, technical services, assistance, or skills training. Contracts for the transfer of PGR technology can be an agreement concerning the licensing of IPRs, such as plant variety patents, *sui generis* protection, plant related trademarks; or a know-how agreement involving the transfer of data, information, manuals, instruction, breeding methods, protocols, or production skills that are not in the public domain.

## Categorization of technologies

Technologies can be categorized based on their nature, use, and transfer process. Moore and Tymowski (2005) suggest two broad types: soft and hard technologies. Soft technologies include knowhow, techniques, and skills, such as conservation techniques used in a particular farming community or new biotechnological techniques developed by researchers. Hard technologies include tangible goods, such as equipment, hardware, or seeds from a particularly plant variety developed by a farmer or breeder. Hard technologies are rarely transferred without some form of accompanying soft technology. These technologies may be transferred through research collaboration, reforming foreign direct investment laws, tax and other incentives, joint ventures, grants, expanding IPRs, establishing a technological clearinghouse, or other mechanisms.

## Technology transfer under the ITPGRFA

The ITPGRFA envisages the transfer of technology through crop-based thematic groups, research and development partnerships, and commercial joint ventures (FAO 2004). The treaty also emphasizes that the process should be “on fair and most favorable” and “concessional and preferential” terms that also recognize and are “consistent with the adequate and effective protection of IPR.”

Article 7.2 of the treaty mentions international cooperation in sharing, providing access to, and exchanging PGR-related information and technology. Likewise, Article 13.2 requires that benefits arising from the use of PGRs under the MLS be shared fairly and equitably through one or more of four mechanisms: exchange of information; access to and transfer of technology; capacity-building; and sharing of benefits arising from commercialization. Some mechanisms are stipulated for access to and transfer of technology relating to PGRs.

First, access to technologies for the conservation, characterization, evaluation, and use of PGRs will be provided and/or facilitated under the MLS. Second, access to and transfer of technology to countries, especially developing countries "shall be carried out through a set of measures, such as the establishment and maintenance of, and participation in, crop-based thematic groups on utilization of plant genetic resources for food and agriculture, all types of partnership in research and development and in commercial joint ventures relating to the material received, human resource development, and effective access to research facilities." Third, access to and transfer of technology relating to PGR under the MLS, including that protected by IPRs, to developing countries shall be provided and/or facilitated under fair and most favourable terms. This applies especially to conservation technologies as well as technologies that benefit farmers in developing countries through increased crop production. It also includes technology transfer on concessional and preferential terms through partnerships in R&D under the MLS. However, transfer must respect applicable property rights and access laws and be in accordance with national capabilities. In addition, the terms of access and transfer will recognize and be consistent with adequate and effective protection of IPRs.

Weak regulations governing property rights and delay in the development of laws surrounding access to PGRs make developing countries like Nepal vulnerable to pressure from other members. In recognition of this, the ITPGRFA includes the issue of national capabilities. However, it is not clear how weak national capabilities will be respected by other members in the case of technology transfer. The treaty also requires adequate and effective protection of IPRs during technology transfer. Such conditions facilitate the transfer of the technology from a country whose technologies are in the public domain or have weak IPR laws to a country whose technologies are in the private domain, but not vice versa. This puts Nepal, a country whose technologies are mainly in the public domain, at a disadvantage under the international system of technology transfer envisaged by the treaty.

## Selected technologies

As described above, germplasm-based technologies include improved seed varieties, hybrids, pre-breeding genetic materials, such as PBS technologies for potato breeding, submergence-tolerant rice varieties (Swarna Sub-1), etc. Non-germplasm-based technologies include those related to processes, tools, and techniques, such as biotechnological tools and advanced techniques for germplasm characterization, conservation, improvement, and use. These may include molecular markers (e.g., simple-sequence repeat [SSR], Random Amplified Polymorphic DNA [RAPD], and single-nucleotide polymorphism [SNP]) and in-vitro/micro propagation of food and horticultural crops. The transfer of many important germplasm-based technologies under the MLS is accelerated or facilitated by non-germplasm-based technologies.

For the case studies, we selected a combination of germplasm and non-germplasm-based technologies, as both types are needed for better promotion and transfer (**Table** 7.2). The specific non-germplasm-based technologies were the application of molecular markers to drought and flood tolerant varieties and in-vitro propagation for PBS production of improved potato varieties from the national commodity research programs at NARC.

**Table 7.2. Cases of technologies and commodities selected and investigated**

| Commodity | Technology for transfer | |
|---|---|---|
| | Germplasm-based | Non-germplasm-based |
| Rice | Drought and flood tolerant rice varieties (e.g., Swarna Sub-1) | Molecular marker (e.g., SSR marker) technique |
| Potato | PBS-improved potato varieties | Micro-propagation (in-vitro) technique |

## Mechanisms and pathways of technology transfer

National laws in Nepal do not identify the entity with the authority to grant access or authorize transfer of genetic materials; thus, the transfer of PGR-related technologies is done on an ad hoc basis. We documented profiles of key research organizations, their current research mandate, technology development, conservation, characterization, and evaluation processes and studied the mode and pathways of transfer of important technologies. We prepared:

- Profile of NPRP's work in in-vitro propagation covering PBS technologies for improved potato varieties.
- Profiles of rice research institutions, such as NRRP and the Agricultural Botany Division of NARC in terms of access and transfer of flood-tolerant Swarna Sub-1 along with its marker assisted selection technology.
- Profiles of private-sector and farmers' organizations in terms of their access to and availability of technologies and their modes of transfer and use.
- Successful cases, transfer trends, and activities of the organizations and modes of technology transfer with other organizations and actors.

Technology transfer is a complex and dynamic process that is affected by many factors and actors and occurs through various modes, pathways, channels, and networks (Gauchan 2008). Transfers may be vertical or horizontal, direct or indirect, from North to South or South to South (**Table** 7.3). They may include the transfer of technologies from public to private or private to private organizations. They may also include, through collaborative agreements, foreign direct investment in the form of special projects, crop-based thematic groups, consortia, exhibitions, training, workshops, etc.

**Table 7.3. Modes of technology transfer for various technology types**

| Technology | Donor | National institution/ recipient | Local institution/ recipient | Transfer mode / mechanism |
|---|---|---|---|---|
| Swarna Sub-1 rice | IRRI | NARC (NRRP/ABD) | Seed companies | SMTA |
| Molecular marker | USA/Japan to IRRI | NARC (ABD) | Other public research organizations (e.g., NARS) | FDI/interna-tional project support |
| Kufri Jyoti and Janakdev potato varieties | CIP | NARC (NPRP) | Extension organizations (DADO) | Free |
| In-vitro propagation | CIP/SDC | NARC (NPRP) | Farmers' groups, cooperatives, private institutions, seed companies | MoU with SDC for technical project support |

Note: ABD = Agricultural Botany Division, CIP = Centro Internacional de la Papa, DADO = District Agriculture Development Office, FDI = Foreign Direct Investment, IRRI = International Rice Research Institute, MoU = Memorandum of Understanding, NARC = Nepal Agricultural Research Council, NARS = Nepalese Agricultural Research System, NPRP = National Potato Research Program, NRRP = National Rice Research Program, SDC = Swiss Agency for Development and Cooperation, SMTA = Standard Material Transfer Agreement, USA = United States of America.

The generic mechanisms currently being adopted for technology transfer related to PGRs for food and agriculture in Nepal are represented in **Figure** 7.2. Most advanced and scientific technologies (molecular markers, in-vitro propagation, and other biotechnological techniques) and products derived from their applications (e.g., PBS potato production, Swarna Sub-1 rice, etc.) are being transferred from international to national research organizations and, with some modifications or testing, they are then being transferred to extension organizations and /or cooperatives and private-sector organizations (seed companies, private laboratories, etc.). Finally the technological products are transferred to farmers and users.

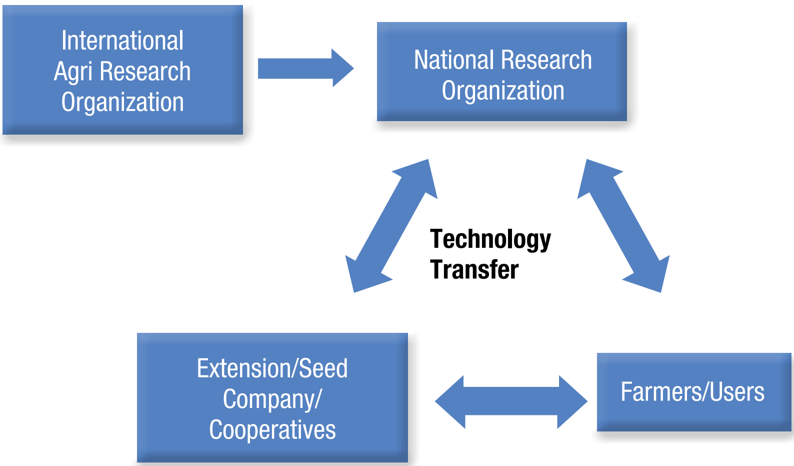


**Figure 7.2.** Mechanisms of current technology transfer of PGRs for food and agriculture in Nepal.

## North–South and South–South transfers

Many advanced technologies, both germplasm-based (e.g., high-yielding crop varieties, pre-breeding materials) and non-germplasm-based (e.g., molecular markers, in-vitro propagation) are currently being transferred from developed to developing countries, mainly through international research centres and universities. For instance, molecular marker technology for the development of Swarna Sub-1 was transferred from the United States to the IRRI, then to a national research institution, such as NARC, and, finally, to users (farmers) through various pathways and channels. Similarly, in-vitro propagation techniques for PBS potato production in Nepal was transferred from Switzerland to NARC through a project funded by the Swiss Agency for Development and Cooperation. Some of these technologies, once adapted, are also being transferred from South to South. For example in-vitro PBS potato propagation technology is being transferred from Nepal to Bhutan and the Swarna Sub-1 rice variety from India to Nepal.

## Vertical transfers

Vertical transfer is mainly from international centres to national research centres and laboratories, and then to extension organizations and, finally, farmers. This type of transfer has been observed commonly for PBS improved potato varieties in Nepal. Molecular marker technology, currently adapted and promoted by NARC research bodies, was first introduced from international research organizations and developed countries of the North.

Currently, NPRP develops PBS of improved varieties in its research laboratory at Khumaltar, Lalitpur, which are then provided to district agriculture development offices, the agricultural extension system in Nepal. The district offices then distribute the PBS potatoes to farmers' groups and cooperatives through their regular extension methods and district network.

## Horizontal transfer

Horizontal transfer takes place from one national organization to others at the local level within the country. This is common in the case of transfer of molecular-marker technologies (e.g., SSR marker) in rice and in-vitro propagation technology for potato. For instance, molecular-marker technology currently in use by NARC was first introduced and adapted by its Agriculture Botany Division in 1998. Gradually, this technology was transferred to other NARC research organizations (e.g., National Agricultural Genetic Resources Centre, the Biotechnology Research Division, and the Seed Science and Technology Division) as well as other institutions in Nepal. Similarly, in-vitro potato propagation technology is being transferred from NPRP to other research organizations, including private-sector and farmers' groups. The in-vitro technology being adopted for PBS production at the Nepal Seed Production Centre, Godavari, White House College, Lalitpur, and Pragatishil Yuba Krishak Samuha, Nala, Kavre, was transferred from NPRP in the last few years.

## Direct and indirect pathways

Direct pathways for technology transfer include collaborative research as well as foreign direct investment agreements or contracts between organizations, institutions, and stakeholders. For example, inbred parental material for hybrids is being transferred from private multinational companies to national research centres under research agreements. Currently, germplasm is being transferred from CGIAR organizations to the Nepalese agricultural research system through Standard Material Transfer Agreements implemented under the ITPGRFA.

Some germplasm-based technologies (e.g., new crop varieties) are also being transferred from international and national research institutions to community-based organizations through participatory action research, such as participatory plant breeding and participatory variety selection. The pathway was through training and PhD work by NARC researchers at IRRI and subsequent training provided by these researchers to farmers, seed companies, and extension workers in Nepal in seed production and participatory varietal selection.

Both germplasm- and non-germplasm-based technologies are also transferred through indirect pathways. The most common include research publications, training, and information flow through mass media and networking.

### Transfer through public–private partnerships

Many germplasm-based technologies related to crop varieties developed in public research organizations (e.g., NARC) are being transferred to private organizations (e.g., seed companies) through this partnership mode. Currently, NARC has initiated transfer of parental inbred lines of maize hybrids to private companies (e.g., the Seed Entrepreneurs' Association of Nepal) through formal agreements or memoranda of understanding. Technology for hybrid vegetable seed production and genetic materials, such as the Srijana tomato developed at NARC has also been transferred to private organizations and NGOs, such as in Gorkha Seed Company, Anamolbiu, and Center for Environmental and Agricultural Policy Research, Extension and Development (CEAPRED).

## Technology transfer case studies

### PBS tissue culture of potato

Tissue culture is one of the most popular technologies in Nepal as it allows production of virus-free potato seeds. Researchers believe that the basic potato seed remains virus free for five generations before becoming susceptible. Tissue culture (or in-vitro propagation) of potatoes was first started in 1989 by the National Potato Development Program (NPDP) with the technical and financial assistance of the Swiss Agency for Development and Cooperation. Research on varietal development and testing was later supported by the Centro Internacional de la Papa, Peru.

NPRP was established in 1992 to carry out the research activities of NPDP. Since then, NPRP has been the main organization involved in the development of new varieties and the production of disease-free potatoes through in-vitro propagation. The technology has been transferred to farmers by various modes and pathways, mainly through the district agricultural extension programs of the Department of Agriculture, in which NPRP plays facilitating role. In-vitro propagation technology has also recently been transferred from NPRP to private-sector organizations and farmers' groups who are supplying PBS potatoes to farmers through the agricultural extension system. In the early 1990s, the technology was also transferred from Nepal to neighbouring Bhutan, through technical support and training of Bhutanese researchers at NPRP in Kathmandu (B Khatri, NPRP, personal communication). A recent example of technology transfer of PBS technology from NPRP to a farmers' group is presented Box 1.

**Box 1. PBS technology transfer: Pragatishil Yuba Krishak Samuha, Nala, Bhaktapur**

Pragatishil Yuba Krishak Samuha (13 members: 11 men and 2 women) was established in 2007. It has been producing pre-basic potato seed since 2008 in a greenhouse with the support of NPRP. The group has built a tissue-culture laboratory, which was completed in 2012, with financial support from the District Development Committee, Kavre, and the Project for Agriculture Commercialization and Trade. In 2013, the group produced 17500 potato cultures, which are being stored in a rented facility, Bagmati Cold Storage, Bhaktapur. The varieties in production are Janakdev, Kufrijyoti, Cardinal, Disere, Khumal Laxmi, Khumal Seto.

In 2014, the group aimed to produce 100000 cultures in two seasons. The potato varieties produced were supplied to district agricultural extension offices through NPRP based on demand at the remote mountain district offices of Humla, Jumla, Mugu, and Solukhumbu. The group estimates that almost 80% of potato growers in the Nala area use basic seeds, which can produce almost double the crop of traditional varieties. The tissue-culture lab is supervised by a technician with a master's degree in biotechnology.

PBS potato technology has recently also been transferred from NPRP to private organizations, such as the Nepal Seed Production Centre, Godavari; the private White House College, Hattiban. The technology transfer program and operations in the private sector have been functioning well (Box 2).

**Box 2. PBS technology transfer: Nepal Seed Production Centre, Godavari, Lalitpur**

This seed production centre was established in 2002 with technical support and technologies from NPRP. It has a tissue-culture laboratory and has been producing PBS potatoes for the last two years (2012/13–2013/014). The centre is run by 11 women members with technical and managerial support from an NPRP trained staff technician (Mr. Ram Varosa), who also sits on the centre's member advisory group.

The centre's annual production target is 100000 PBS in two seasons. It deals mainly with released and recommended varieties, such as Janak Dev, Desire, Cardinal, Khumal Laxmi, and Khumal Seto. After harvest, PBS is stored at Balaju Cold Storage as the centre does not have its own cold storage facility. The centre plans to sell the PBS in October to the National Potato Development Program of the Department of Agriculture. From there, seeds will be transferred to farmers' groups and cooperatives across Nepal for general cultivation.

Currently, the PBS produced at this centre goes to 19 districts of Nepal where the Potato Seed Self-sufficiency Program is being implemented through district agricultural development offices. The Potato Development Program then collects orders from district agriculture development offices across the country for which different classes of seeds (e.g., foundation seeds, certified seeds, etc.) are produced after PBS. But the current practice is that not more than one generation of seeds is produced as the seed chain is yet to be fully established.

## Swarna Sub-1 rice

Swarna Sub-1, a flood-tolerant variety of rice, was developed at IRRI during the early 2000s (2001–2005) through marker assisted selection (MAS). It was derived by incorporating a submergence-tolerant gene (Sub-1) into a widely grown Swarna variety from India through marker-assisted back-crossing. Swarna Sub-1 rice is tolerant to flooding for up to 2 weeks, an important trait as water stagnation and flash flooding are common problems in Asian lowlands.

Swarna Sub-1 was transferred from IRRI to Nepal and other South Asian countries through various channels as part of IRRI's Stress-Tolerant Rice for Africa and South Asia project. In Nepal, the transfer was to NARC and evaluation was carried out by the NRRP at Hardinath and the RARS in Tarahara in both flood-prone and other areas before its release in 2011. The variety is being promoted by the NRRP and RARS (Tarahara) as well as other NARC research organizations to farmers in flood-prone and other areas through multiple pathways (agricultural extension, seed companies, community-based seed producer groups, and cooperatives). Swarna Sub-1 varieties are being produced and marketed by several private seed companies, farmers' groups, and cooperatives in various parts of Nepal with NARC's technical support and provision of source seeds. Evidence of technology evaluation, multiplication, and transfer at the field level is presented in Box 3.

**Box 3. Transfer of Swarna Sub-1: the Shallesh Seed Producer Group, Siraha**

The Shallesh Seed Producer Group was established in 2008 by the Padariya Village Development Committee in ward 3 of Siraha district as a community-based seed producer group. The group has 25 members who are engaged mainly in rice and wheat seed production. Since 2010, it has been receiving regular technical support and source seeds from RARS, Tarahara.

Using breeder seed of the Swarna Sub-1 variety from RARS, the group has engaged in production, multiplication, and marketing of foundation, certified, and labeled seeds of Swarna Sub-1 and other rice varieties, such as Sukha-2, Sukha-3, Hardinath-1, Sona Masuli, and Kanchhi Masuli. In 2011/12, it produced about 20 Mt of rice seeds, of which about 2 Mt were the Swarna Sub-1 variety. The foundation seed that is produced by the group under technical supervision by RARS is certified by the regional seed-testing laboratory in Sunsari, Jhumka, and sold to farmers' groups and cooperatives in Siraha, Saptari, and Dhanusha for the production of certified and improved seeds with the support of the district agriculture development office, Saptari.

This is one of the few successful community-based seed producer groups in the eastern terai that is engaged in source seed production, multiplication, and the transfer of new variety technology from NARC research centres to farmers' fields.

The indirect transfer of Swarna Sub-1 seeds from NRRP to farmers' groups and a private seed company is presented in Box 4.

**Box4.Transfer of Swarna Sub-1: Unnat Seed Producer Group, Chitwan**

Established in 2007, the Unnat Seed Producer Group is a well-known organization with 300 farmer members specializing in grain seed production. Since 2012, it has been receiving breeder and foundation seeds from the NPRP and is producing, multiplying, and marketing seeds of Swarna Sub-1.

In this case, the mode of technology transfer was more indirect, as the NRRP provides only breeder and foundation seeds on demand. The quality-certified and improved seeds produced by this group are transferred to many farmers across Nepal through various marketing and sales outlets. Because of its success in seed production and marketing, the group has been able to secure grants from various organizations, including funding support from the Directorate of Agricultural Engineering of the Department of Agriculture for infrastructure (storage facilities, equipment, and machinery).

The group is also registered as a private seed company for the purposes of marketing its seed. In 2013, it produced 13 Mt of Swarna Sub-1 seeds (including 0.6 Mt of foundation seed) out of its total 534-Mt production of seeds of other improved rice varieties (Sabitri, Radha-4, Ramdhan, Masuli, Sona Masuli, Makawanpur-1, Hardinath-1, etc.). It markets improved and certified seeds through such outlets as agrovets, cooperatives, and district agriculture development offices, ranging from east of Jhapa to the far west of Bardiya district. In the 2014 season, it sold 65% of the volume of its seed to the National Seed Company under a subsidy scheme. Thus submergence-tolerant technology (in the form of the Swarna Sub-1 variety) is being transferred to general cultivation among farmers in many parts of Nepal.

## Technology transfer opportunities and issues

Various factors and pathways have been instrumental in the flow of these technologies and the sharing of non-monetary benefits to support conservation of PGRs for food and agriculture in Nepal. The nature of the technology itself, favourable international and national policy environments, and institutional capacity, among other factors, have played an important role in facilitation of technology transfer from North to South and between Southern countries and institutions.

International transfer of PBS potato germplasm across developing countries has been facilitated because of its disease-free nature (resulting in less restrictive quarantine regulations) and provisions of the Standard Material Transfer Agreement (SMTA) under the MLS. This in-vitro propagation technique has accelerated the flow, exchange, and use of PBS-based germplasm technologies in Nepal through developed countries under both the MLS and bilateral means.

Although the demand for PBS potatoes is high among farmers across Nepal, the country is unable to maintain a sufficient supply. The flow of associated non-germplasm-based technologies from national research organizations to private and farmers' cooperatives has been minimal because of the need for relatively high technical skills, resources, and investment in the transfer of the technology. International support, in terms of technical capacity-building and funding, is essential to promote large-scale commercialization of this technology in Nepal.

The international transfer of Swarna Sub-1 germplasm across developing countries was also facilitated through SMTA provisions. Molecular-marker (non-germplasm-based) technology has accelerated the flow, exchange, and use of germplasm-based Sub-1 technologies in Nepal and Asia. However, despite the rapid distribution of germplasm, the flow of the marker-assisted selection technique from IRRI to national research institutions in South Asia has been minimal. The trained human resources, institutional capacity, and investment needed to effectively transfer and promote this technology on a large scale is lacking in Nepal. International support in terms of technical capacity building and funding is essential to promote large-scale commercialization and uptake of this technology in Nepal.

These examples illustrate how the transfer of germplasm-based technologies is easier and more successful in Nepal that that of non-germplasm-based technologies.

## Assessment of technology needs, opportunities, and constraints

With the use of traditional farming practices, the low levels of external input, poor-quality traditional varieties, and diverse farm conditions in Nepal, crop productivity is low and the rate of increase is slow. The recommended seed replacement rate for cereals is 25% a year, for example, whereas the existing rate is no more than 12%. Suitable varieties of improved seeds and related technology are necessary to improve the livelihoods of the farmers and grow enough food for domestic consumption. Technology is needed to identify, conserve, and select landraces that can be used to increase productivity and the profitability of farming.

Improved plant varieties and the practices associated with them can increase food production and reduce poverty. However, the low level of education among farmers, the small and scattered nature of their holdings, and the heterogeneity of their farmland are the major constraints on their receiving improved technologies. With such resource constraints, farmers value direct monetary benefits more than technology-sharing in exchange for access to their genetic resources.

## Conclusions and way forward

National laws in Nepal do not identify an entity with the authority to grant access to or authorize transfer of genetic materials. Thus, the transfer of PGR-related technologies is done on an ad hoc basis. The transfer of many important germplasm-based technologies under the MLS and bilateral systems is accelerated by some advanced techniques used for conservation, characterization, evaluation, improvement, and use of PGRs. These are process-related technologies and include mainly specific molecular techniques and in-vitro propagation of food and horticultural crops. These technologies are important for ensuring national and global food security as they facilitate and accelerate the flow, exchange, and use of germplasm-based technologies under the MLS, mainly to developing countries.

However, successful and sustained technology transfer requires adoption of a combination of germplasm- and non-germplasm-based technologies. Trained human resources, financial investment, and modern laboratory facilities are needed to apply non-germplasm-based technologies in developing countries. South–South and horizontal technology transfers are preferred because of the lower cost of transfer and faster diffusion as well as better adaptation of PGRs to the local context.

In summary, our key findings on technology transfers as a means of sharing non-monetary benefits for conservation of PGR in Nepal are:

- Germplasm-based technology transfer is easier and faster than the transfer of non-germplasm-based technology, but the latter is required to ensure sustainability.
- Transfer of germplasm-based technologies, such as improved varieties, is accelerated and facilitated when accompanied by the associated non-germplasm-based technologies, such as molecular- marker and in-vitro propagation techniques, used for their conservation, characterization, evaluation, improvement, and use. Hence, successful and sustained technology transfer requires adoption of a combination of germplasm- and non-germplasm-based technologies.
- Trained human resources, financial resources, and modern laboratory facilities are needed to use non-germplasm-based technologies. Despite a high demand for improved germplasm, such as the PBS potatoes, the flow of the associated non-germplasm-based technology (in-vitro propagation) from national research organizations to private and farmers' cooperatives has been minimal in Nepal because of the requirement for relatively high technical skills and resources.

## References

Biggs JB. 1989. Approaches to the enhancement of tertiary teaching. *Higher Education Research and Development* 8:7-25.

Choi HJ. 2009. Technology transfer issues and a new technology transfer model. *Journal of Technology Studies* 35:49-57.

FAO. 2004. International Treaty on Plant Genetic Resources for Food and Agriculture. Food and Agriculture Organization (FAO), United Nations, Rome, Italy. http://www.planttreaty.org/content/texts-treaty-official-versions

Gauchan D. 2008. Reforming research and extension systems in Nepal: emerging models of technology development and transfer**.** *Agricultural Development Journal* 4:34-44.

Martyniuk AO, RK Jain and HJ Stone. 2003. Critical success factor and barrier to technology transfer: case studies and implications. *International Journal of Technology Transfer and Commercialization* 2:306-337.

Moore G and W Tymowski. 2005. Explanatory guide to the International Treaty on Plant Genetic Resources for Food and Agriculture. International Union for Conservation of Nature, Gland, Switzerland.

Rogers EM. 2003. *Diffusion of innovations* (5th ed). Free Press, New York, USA.

Ruttan VW and Y Hayami. 1973. Technology transfer and agricultural development. *Technology and Culture* 14:199-151.

Sung T and DV Gibson. 2005. Knowledge and technology transfer grid: empirical assessment. *International Journal of Technology Management* 29:216-230.

Tenkasi RV and SA Mohrman. 1995. Technology transfer as collaborative learning. **In** *Reviewing the Behavioral Science Knowledge Base on Technology Transfer.* TE Backer, SL David and G Soucy (eds). Department of Health and Human Services, National Institutes of Health, Rockville, MD, USA. pp.147-167.

Tsang EWK. 1997. Organizational learning and the learning organization: a dichotomy between descriptive and prescriptive research. *Human Relations* 501:73-89.

United Nations. 1992. Convention on Biological Eiversity. United Nations, New York, USA. http://www.cbd.int/doc/legal/cbd-en.pdf

Wikipedia. 2016. Technology. http://en.wikipedia.org/wiki/Technology.

# Chapter VIII : Policy incentives and disincentives for inclusion of material in the MLS

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## Key messages

- Relevant policies and legal and institutional frameworks provide limited incentives for the conservation, exchange, value addition, and wider use of agricultural plant genetic resources (PGRs).
- Biopiracy of PGRs, traditional knowledge, and the perceived absence of mechanisms for benefit sharing are disincentives for researchers, farmers, and private-sector organizations to share PGRs under the Multilateral System (MLS).
- The main incentives for sharing PGRs are secure ownership rights and recognition that the shared material is used for national and global food security.
- Most of the breeders, researchers, farmers, and policymakers we surveyed are not aware of ITPGRFA and MLS provisions concerning incentives and disincentives for providing their materials under the MLS.

Incentives have long been used by governments to manipulate macro and sectoral economies. The aim of establishing both economic and non-economic incentives for biodiversity conservation is to influence people's desire and behaviour to conserve — rather than degrade or deplete — biodiversity in the course of their economic activities. Incentives modify the structure and effects of household utility function and give people the opportunity to choose the best option for them.

Scientists and practitioners began to promote biodiversity conservation after the historic summit that produced the Convention on Biological Diversity (CBD) in 1992. Article 11 of the CBD stipulates that "Each Contracting Party shall, as far as possible and as appropriate, adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity" (United Nations 1992). The multilateral system (MLS) of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) can be implemented only if national governments, international organizations, and individual users of plant genetic resources (PGRs) for food and agriculture worldwide embrace its collaborative spirit and approach to PGR conservation and use as an international effort (Lopez-Noriega et al. 2012). Article 11.2 of the ITPGRFA states that parties agree to invite and encourage holders of the 35 crops and 29 forage species listed in Annex I to include them in the MLS to facilitate their exchange (FAO 2004).

According to the ITPGRFA, the PGRs of the 64 species listed in Annex I that are "under the management and control" of the national government and "in the public domain" are automatically included in the MLS (Halewood et al. 2013). However, for PGRs that fall outside these criteria, ITPGRFA member states agree to encourage "natural and legal persons" (companies, individuals, groups with legally recognized collective identities) to voluntarily include them in the MLS.

In reality, it is unlikely that people will share their PGRs and associated knowledge until they see some form of monetary or non-monetary incentives or direct or indirect benefits. Thus, it is important to understand what incentives are in place and the perceptions of various stakeholders about these incentives and whether they may be motivated to participate in the MLS and voluntarily include PGRs in the MLS. Such information is scanty in Nepal.

It is generally believed that, in rural areas, biological and genetic resources flow between villages according to social custom and through social connections or networks (Subedi et al. 2003) with the help of social capital (Pretty and Smith 2004). In a study to test this hypothesis, Pant (2007) found that 25% of farmers had sent biological and genetic resources to other areas or villages in 2006.

However, policies and incentives that affect the flow, use, and exchange of PGRs under the MLS have not received the same level of attention from national and international decision-makers, despite the fact that those policies affect agricultural and economic development. Thus, we undertook to analyze current incentives and disincentives; identify key policy options to create incentives so that disincentives and factors hindering voluntary inclusion in MLS are eliminated; and provide useful insights and suggest mechanisms and strategies to encourage voluntary inclusion of PGRs in the MLS.

## The concept of incentives and disincentives

Incentives and policies influence the exchange, flow, use, and inclusion of PGRs voluntarily at the international, national, and local levels. International policies, agreements, and legal frameworks guide the development and enforcement of policies and laws at the national level. National policies and laws have a direct impact through related product and input markets, prices, information, and regulations. Regulations under national laws can facilitate or impose restrictions on the access, use, and exchange of PGRs in communities, regions, and beyond national boundaries. National policies (property rights, trade, investment, fiscal, monetary, etc.), as well as sectoral policies (on the environment, forestry, agriculture, commerce, and education), also create incentives and disincentives for the inclusion and use of PGRs (Gauchan et al. 2003, 2005). Similarly, local informal institutions, such as traditional rules, norms, and common and customary practices, may also create incentives or disincentives.

Incentives for inclusion of PGRs in the MLS are mainly of three types: direct, indirect, and perverse incentives (Figure 8.1). Direct incentives include cash and in-kind inducements provided by the state, whereas indirect incentives are sociocultural, market, fiscal, and administrative factors influencing farmers' and stakeholders' choices. Perverse incentives are subsidies and compensation for cultivation and commercialization of high-yielding modern seed varieties that negatively affect the conservation, use, and inclusion of indigenous PGRs in the MLS. In this study, we focus mainly on direct and indirect incentives.

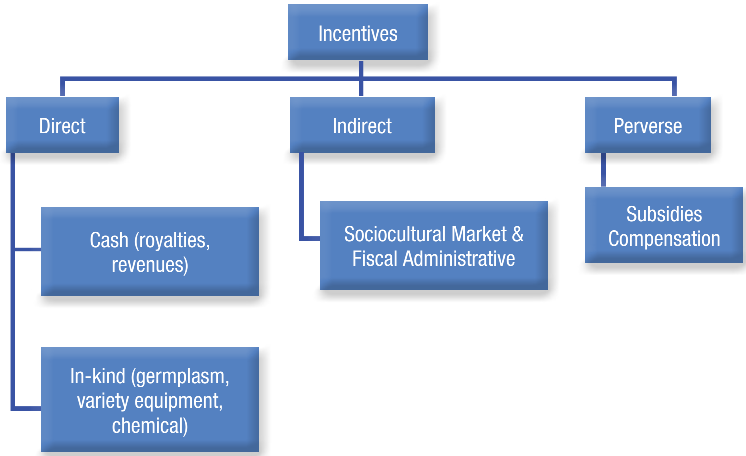


**Figure 8.1.** Types of incentives for including genetic resources in the multilateral system.

## Methods

In this study, we carried out a literature review and held consultation meetings and field surveys of selected key stakeholders of PGRs. First, relevant international and national policy and legal documents that create incentives and disincentives were reviewed to study how such mechanism influence the flow, exchange, use, and voluntarily inclusion of PGRs in the MLS.

An exploratory survey was carried out with key representatives of plant breeders and researchers in the Agricultural Botany Division of the Nepal Agricultural Research Council (NARC); the National Rice Research Program (NRRP), Hardinath, Dhanusha; the National Wheat Research Program (NWRP), Bhairahawa; and the National Maize Research Program (NMRP), Rampur Chitwan. In addition, seed specialists and planners from the Seed Quality Control Centre, the Ministry of Agricultural Development, and the Seed Science and Technology Division of NARC were consulted.

At the community and farm level, community seed bank (CSB) managers; community-based seed producer groups; users of seeds, mainly farmers at Kachorwa, Bara, and Dalchowki, Lalitpur; and representatives of CSB leaders from Dhading and Sindhuplanchowk were interviewed to gather their perceptions on incentives and disincentives and factors that promote or hinder the voluntary inclusion of material in the MLS. The survey of farmers and CSB managers aimed to understand and document local practices, norms, and customs influencing germplasm flow and inclusions. Complementary collection of information was carried out with selected plant breeders and researchers, using focused checklists based on the prioritized list of PGRs.

Information on incentives and disincentives was analyzed, synthesized, and documented. Stakeholder consultations at the national level in Kathmandu and at the regional level (e.g., NMRP, Rampur) were used to obtain input and feedback on the survey findings, which were then incorporated into the draft report.

## Incentives and disincentives for sharing PGRs under the MLS

Several ITPGRFA member countries are still in the process of making decisions regarding the allocation of their PGRs under the MLS. According to Vernooy et al. (2013), to date, there is little information in members' reports to the ITPGRFA governing body about material that has been voluntarily included in the MLS; only six countries, France, Germany, Netherlands, Peru, Switzerland, and the United Kingdom, have provided such details. There is also little information about the measures that member states are taking to encourage such inclusion (**Table** 8.1).

**Table 8.1. Incentives and disincentives for countries to include plant genetic resources (PGRs) in the multilateral system (MLS)**

| Incentives | Disincentives |
| --- | --- |
| • Displays altruism by helping the global community ensure food security<br>• Increases the possibility of benefiting from technology transfer associated with the PGRs<br>• Helps conserve genetic resources by creating a global backup<br>• Enhances the reputation of countries that contribute significantly to the MLS<br>• Increases moral pressure on other member countries to increase their contribution<br>• Creates satisfaction from contributing to the work of fellow breeders all over the world and allowing them to breed better varieties | • Loss of national control over genetic resources<br>• Resources become pubic and can be used even by non-contributors and small contributors<br>• Liability attached to providing related information<br>• Putting superior genetic resources into the MLS may hurt export interests of the contributing country<br>• Erodes negotiating power of the country in future exchanges of PGRs that are not put under the MLS by other countries<br>• Feeling of let others go first in sharing PGRs<br>• Poor understanding of the importance of the MLS in increasing food production for the growing world population<br>• Countries with superior PGRs gain less from sharing with those with fewer and lower-quality PGRs |

The real custodians of PGRs for food and agriculture are the farming communities. Some such communities have formed CSBs to protect genetic resource that are under threat from agricultural modernization. Farming communities and their committees governing CSBs may have several incentives and disincentives for sharing their PGRs under the MLS (**Table** 8.2). See also chapter 6.

**Table 8.2. Incentives and disincentives for community seed banks to include plant genetic resources (PGRs) in the multilateral system (MLS)**

| Incentives | Disincentives |
|---|---|
| • Altruistic feeling from helping farmers in other parts of the world<br>• Chance to obtain advanced materials or developed and released seeds for ready use<br>• Opportunity to receive technology related to varieties<br>• Feeling of comfort knowing their resources are safe and can be retrieved in time of need<br>• Recognition as a donor of PGRs to the MLS<br>• Opportunities to receive materials from the MLS in exchange for their contribution, thus increasing options for future breeding<br>• Material (quality seeds) and non-material (subsidies) benefits through working with the national authority for MLS implementation | • Fear that their PGRs will be exploited by others for commercial purposes<br>• Failure to understand the importance of the MLS<br>• Fear that sharing materials in the MLS may require surrendering their traditional knowledge about the resources<br>• Sharing superior genetic resources can increase competition in the market and reduce the price of their products<br>• Sharing superior PGRs can decrease their value<br>• Temptation to share low-quality local landraces and retain superior materials for their own future use<br>• Reliance on the global gene pool may reduce motivation to invest financial and human resources in conservation of PGRs<br>• Fear of losing their uniqueness (e.g., unique variety) |

## Incentives and disincentives in key policies

Currently, there are no clear, well-defined policies or regulations that provide incentives for the voluntary inclusion of materials in the MLS in Nepal. However, some key existing policies have directly or indirectly created incentives or disincentives for the exchange of PGRs. Some of these are highlighted below.

### Seed policy

The current seed policy and legislation provide incentives for putting improved crop varieties and released and registered landraces that are already in public domain into the MLS. Once a landrace is released or registered, it is considered a public good; it comes under the management and control of the national government and its genetic materials are freely sold and exchanged without restriction. However, registration of a few landraces has only recently been initiated with the National Seed Board despite the increasing trend to register hybrid varieties by the private sector.

In the last 4 years, the registration of hybrids has increased significantly following a favourable shift in policy (2008 amendment of the Seed Act 1988) (MoAD 2008). So far, 245 exotic hybrid vegetables and 17 rice and 35 maize hybrids have been registered (MoAD 2013). This trend in registration of hybrids is a result of incentives available to the private sector, which perceives great benefits from the hybrid seed business. In addition, plant breeders and other scientists in the public sector receive better recognition (officially or from their peers), rewards, international links, and academic career advancement if their improved varieties and hybrids are tested, released, and registered.

In contrast, farmers and other plant breeders do not have clear incentives to register and release local landraces. Even though legislation has made it easier to register landraces, stakeholders see no commercial benefit from doing so because of their low yields, lack of uniformity, and low market demand except for few high-quality varieties, such as Basmati rice. Hence, there are limited incentives for farmers, community seed bank groups, and private companies to put their landraces and traditional PGRs into MLS through the registration and release process. Moreover, the current Seed Act has the provision for stakeholders to obtain breeders' or ownership rights for improved varieties. Therefore, as a rule, unless ownership rights and recognition are given, individuals have no incentive to share PGRs voluntarily in the MLS.

### Plant variety protection and farmers' rights

The draft Plant Variety Protection and Farmers' Rights Bill (MoAD 2005) does not recognize or include provisions for Annex I crop species. It awards ownership rights to farmers for their local varieties as well as new plant varieties (farmers can claim intellectual property rights and act as breeders); hence, if anyone wants to access and share PGRs, prior informed consent must be obtained. However, breeders' rights to new varieties are not applicable for private, non-commercial uses, study, academic and research purposes, and breeding and development of new varieties. Hence, the breeders' exemption clause could be used to motivate breeders to voluntary include PGRs in the MLS. Individuals and institutions also have the right to transfer or sell such rights for a specified period.

### Agro-biodiversity Policy 2007

The original Agro-biodiversity Policy (2007) had no provision for sharing genetic resources voluntarily in the MLS, as it had not been harmonized or formulated in the context of the ITPGRFA. However, it has recently been revised and provisions for the MLS included. The policy now includes:

- Provisions for facilitating two-way access and sharing of PGRs as per provisions of the ITPGRFA.
- Provision of a designated authority to facilitate inclusion in the MLS (discussions are underway among stakeholders).
- Strengthening the national genebank and provision of links with CSBs to facilitate access to and exchange of PGRs.
- Provision for prior informed consent in the form of a Standard Material Transfer Agreement (SMTA) from farmers and communities holding PGRs required by international institutions (provides room for negotiating incentives or benefits).

However, the revised Agro-biodiversity Policy makes no explicit mention of provisions and mechanisms for encouraging individuals to put their PGRs into the MLS as envisaged by ITPGFRA Article 11.2 (FAO 2004).

## Perceptions of community seed bank managers and farmers

Although there are about 115 CSBs in Nepal, few of them are strictly conservation oriented (Joshi 2013). A survey of conservation-focused CSB managers and farmers revealed that they are not very aware of ITPGRFA and MLS provisions, including incentives and disincentives to put their material into the MLS.

### Views of knowledgeable CSB managers and members

CSB managers who are more aware of the importance of local genetic resources feel that the landraces and other farmers' varieties that are being conserved and used in the local community should not be shared with national and international organizations without their prior consent. Ownership and recognition of their genetic materials should be provided if they are shared with other organizations and outside the country. For sharing with the national gene bank, managers need some form of evidence that their material is stored, such as a certificate of deposit, and a guarantee that the material can only be shared with prior consent and due recognition.

However, increased awareness of the creation and exchange of genetic resources among the national gene bank, international agricultural research centres, and communities might increase confidence and encourage communities to share their local genetic resources under the MLS. This may be possible only after developing trust and collaborative relations with R&D programs, as evident from the current field studies conducted in local CSBs in Kachorwa, Bara, and Dalchowki, Lalitpur. A national workshop held in 2013, in which CSB members discussed various management and policy-related issues, including the sharing of PGRs, also revealed that farmers seem willing to share their materials provided they also receive a fair share of benefits and their roles are properly recognized.

### Views of general farmers outside the CSB system

Many subsistence farmers outside the CSB areas and on-farm conservation project areas did not object to their seed materials being freely shared with outsiders in small amounts. Many of these farmers have been exchanging and sharing small quantities of seeds over generations, whenever outsiders request them. Indeed, they feel honoured to be able to exchange their local seed materials and other genetic resources with outsiders. This practice occurs in many remote rural areas where farmers lack awareness, knowledge, and information about their rights to genetic resources. As a result, biopiracy is increasing.

Biopiracy is the use or appropriation of genetic resources without the necessary access permits or fulfilling agreed conditions and is, therefore, illicit (Biber-Klemm and Martinez 2006). Biopiracy has also been defined as the use of intellectual property laws (patents, plant breeders' rights) to gain exclusive ownership and control of biological resources and knowledge, without recognition, reward, or protection to informal innovators (RAFI 1996).

Farmers face a tradeoff between compromising food production by restricting the flow of genetic resources and risking biopiracy by allowing freer movement (Pant 2007). Adequate legal provisions and implementation mechanisms are required to increase the flow and use of genetic resources and reduce the chances of their misappropriation for commercial purposes.

## Perceptions of plant breeders and researchers

Many of the plant breeders and researchers we consulted had little knowledge and awareness of the ITPGRFA and the provisions of the MLS. They have some knowledge of intellectual property rights and SMTA, but not of the specific provisions of facilitated access under the

MLS and ITPGRFA. Plant breeders and researchers are willing to share their own released and registered varieties voluntarily in the MLS. However, they are not willing to share the materials they are in the process of breeding and developing.

Breeders and researchers are very cautious about sharing pre-breeding materials and landraces, especially with private seed companies and especially multinational ones. In sharing material under development, they want to secure ownership rights and recognition of their work. International links, exposure visits, and increased capacity building among young researchers provide some incentives for sharing and exchange of genetic resources for the global benefit. Many plant breeders and researchers feel that some form of royalties is needed to encourage them to develop, exchange, and share their genetic resources with other researchers within the country and around the globe.

Increased biopiracy of genetic resources and traditional knowledge and the possible lack of fair and equitable benefit-sharing due to inadequate information and lack of well-documented traits-related information on PGRs are perceived as disincentives for researchers and plant breeders to share PGRs under the MLS. In some cases, lack of financial and human resources and poorly coordinated institutional mechanisms have also been disincentives for plant breeders to deposit material with the MLS.

Assured access to important germplasm from the MLS and to the international system is a motivation for breeders in both public and private sectors to share their genetic resources, expertise, skills, and time. They see this leading to greater opportunities to develop varieties that are adapted to various production environments, including adverse environments. As many plant breeders and researchers have poor knowledge and awareness of ITPGRFA and MLS provisions and the importance of facilitated access and exchange to national and global food security, more information on the MLS and its benefits may provide incentives to breeders and communities.

## Conclusions

Providing evidence of ownership of PGRs and recognition in the form of acknowledgement and certificates of deposition of shared material, as well as some form of benefit (e.g., exchange of materials) are important incentives for stakeholders to share materials through the MLS.

Lack of awareness of the importance of the MLS in maintaining national food security is the greatest disincentive to individuals voluntarily sharing PGRs through the MLS. Improved understanding and awareness of the role of MLS in national and global food security among policymakers, plant breeders, research and development professionals, farmers, and local communities is, therefore, essential to initiate and accelerate the process of voluntary inclusion of PGRs.

Under the ITPGRFA, member states agree to encourage "natural and legal persons" (companies, individuals, groups with legally recognized collective identities) to voluntarily include PGRs of the 64 crops and forage species listed in Annex I in the MLS. In this context, the Government of Nepal can consider mechanisms to encourage this practice, for example by requiring recipients of public funding for research to make their PGRs available through the MLS.

Equally important is the need to consider the means by which materials can be voluntarily included and made available. For example, the national genebank could accept deposits of PGRs that a CSB, company, or individual wishes to make voluntarily and, subsequently, make them available under the SMTA. Alternatively, those companies, individuals, and communities could be allowed to provide the materials directly using the SMTA, by developing special mechanisms and incentives to encourage and allow voluntary inclusion of PGRs in the MLS. This will require the development and implementation of adequate incentives and benefits through policy, legislation, and programs.

The following key policies and incentives might encourage communities and countries to participate in the MLS.

- Recognize donors and provide evidence of the deposition of PGRs in the MLS, even those that are not commercialized. Pedigree records and other documents can help trace the initial contributors.
- Ensure clear mechanisms for sharing benefits from the commercial use of PGRs provided by any country or community. Technological advancements, such as DNA fingerprinting, are necessary to trace the flow of genetic resources put into the MLS to ensure that they are not used for commercial purposes without sharing the benefits.
- Ensure providers of PGRs that the resources they share through the MLS will not be misused, and develop and revise legislation to protect the rights of the donor against misuse of their resources. The MLS should ensure that PGRs in the MLS will be used only for food security and not for trade interests.
- Develop a reporting system so that donors of PGRs are regularly informed and updated about the use and further development of the PGRs they provide.
- Educate custodians of the resources that their work contributes to food security of people all over the world.
- Develop national legislation that provides custodian farmers and other owners and donors with rights over their PGRs so that they have authority to provide PGRs to the MLS and negotiate benefit-sharing.

## References


Biber-Klemm S and S Martinez. 2006. *Access and Benefit Sharing: Good Practice for Academic Research on Genetic Resources*. Swiss Academy of Sciences, Schwarztorstrasse 3007 Bern, Switzerland. Last accessed on December 2014 available at http://www.iisd.org/pdf/2006/abs_swiss_abs_good_practice.pdf.

FAO. 2004*. International Treaty on Plant Genetic Resources for Food and Agriculture.* Food and Agriculture Organization (FAO), United Nation, Rome, Italy. Last accessed on February 2015 available at http://www.planttreaty.org/content/texts-treaty-official-versions.

Gauchan D, BR Sthapit and DI Jarvis (eds). 2003. *Agrobiodiversity Conservation On-farm: Nepal's Contribution to a Scientific Basis for National Policy Recommendation*. International Plant Genetic Resource Institute (IPGRI), Rome, Italy.

Gauchan D, M Smale, and P Chaudhary. 2005. Market-based incentives for conserving diversity on-farm: A case of rice landraces, central terai, Nepal. *Genetic Resources and Crop Evolution* 52:293–303.

Halewood M, P Brahmi, PN Mathur and KC Bansal (eds). 2013. *A Road Map for Implementing the Multilateral System of Access and Benefit-sharing in India*. Bioversity International, Rome, Italy; Indian Council of Agricultural Research and National Bureau of Plant Genetic Resources, New Delhi, India.

Joshi BK. 2013. A brief overview of community seed bank initiatives in Nepal. **In** *Community Seed Banks in Nepal: Past, Present, Future: Proceedings of a National Workshop, 14–15 June 2012, Pokhar, Nepal*. P Shrestha, R Vernooy, and P Chaudhary (eds). Local Initiatives for Biodiversity, Research and Development, Pokhara, Nepal; Bioversity International, Rome, Italy. pp.41–46.

Lopez Noriega I, M Halewood and I Lapena. 2012. *The Multilateral System of Access and Benefit Sharing: Case Studies on Implementation in Kenya, Morocco, Philippines and Peru*. Bioversity International, Rome, Italy.

MoAD. 2005. Proposed plant variety protection and farmers rights draft bill (2005). Ministry of Agricultural Development (MoAD), Kathmandu, Nepal.

MoAD. 2008. *Seed Act (1988) Amended in 2008*. Ministry of Agriculture Development, Singhadarbar, Kathmandu, Nepal.

MoAD. 2013. *Statistical Information on Nepalese Agriculture*. Ministry of Agriculture Development (MoAD), Government of Nepal, Singh Durbar, Kathmandu, Nepal.

Pant KP. 2007. Access to genetic resources and benefit sharing: perceptions, practices and expectations of farming communities. Farmers' Rights Programme, *Forum for Protection of Public Interest (Pro Public)*, Kathmandu, Nepal.

Pretty J and D Smith.2004. Social capital in biodiversity conservation and management. *Conservation Biology* 18(3):631–638.

RAFI. 1996. Biopiracy update (communiqué). Rural Advancement Foundation International (RAFI), Ottawa, Canada.

United Nations. 1992. Convention on Biological Diversity. United Nations, New York, USA. http://www.cbd.int/doc/legal/cbd-en.pdf

Vernooy R, M Halewood, G Otieno, I López-Noriega and A Wedajoo. 2013. *Strengthening National Capacities to Implement the International Treaty on Plant Genetic Resources for Food and Agriculture.* Report of the mid-term review workshop, 16–19 July 2013. Bioversity International, Rome, Italy.

# Chapter IX : Creating the legal environment for implementing the multilateral system in Nepal

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## Key messages

- Nepal has limited enabling policy environment for implementing provisions of the ITPGRFA.
- Nepal's Agro-biodiversity Policy of 2007 has been revised in accordance with the provisions of the ITPGRFA.
- The National Biodiversity Strategy and Action Plan 2014–2020 has considered strategic implementation of the ITPGRFA in harmony with the Convention on Biological Diversity.
- New instruments, such as an agro-biodiversity conservation and utilization act, including regulations, are necessary to implement the ITPGFRA. Such an act and regulations have now been drafted.

Nepal is an agricultural country rich in biodiversity, including agro-biodiversity. Like other countries, Nepal is an active member of the international community and party to various conventions and treaties of international importance. The Convention on Biological Diversity (CBD), the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), and agreements related to membership in the World Trade Organization are the most relevant ones. In terms of food security and sustainable agriculture, the ITPGRFA is particularly important. Approved by the United Nations Food and Agriculture Organization Conference in November 2001, it came into effect on 29 June 2004, and Nepal became a signatory on 19 October 2009.

For a least-developed, agriculture-based country, such as Nepal, the ITPGRFA offers a number of benefits in terms of ensuring national food security and supporting agricultural research and development. However, so far Nepal has not received many benefits, in particular from the treaty's multilateral system (MLS) of access and benefit-sharing.

One of the reasons for this has been the still poorly developed national policy and legal framework needed to adopt the main components of the ITPGRFA and the MLS. The Interim Constitution and Nepal Treaty Act provide a policy and implementation framework for international treaties and conventions, but have not been operationalized in the case of the ITPGRFA. Regulations have been formulated for implementation of the Seed Act, Plant Protection Act, National Parks and Wildlife Conservation Act, Protection of Environment Act, and Forest Act, but they do not explicitly deal with ITPGRFA/MLS implementation.

In practice, various people and organizations in Nepal have been obtaining plant genetic resources (PGRs) from various sources and through a variety of mechanisms, and have facilitated access to Nepalese genetic resources by other countries. A large number of Nepal's PGRs, especially seeds, have been deposited at various seed banks abroad. Nepal's agricultural research institutions and some NGOs have access to various genetic resources from the CGIAR seed banks and research centres. They have been developing new varieties of crops, fruits, forage species, and livestock with the use of these genetic materials.

Such activities are carried out using the Standard Material Transfer Agreement (SMTA) of the ITPGRFA or through informal channels and on an ad hoc basis. No formal regulatory mechanism has been developed, and no institution has been mandated to keep records of Nepal's PGRs sent abroad or foreign PGRs accessed from Nepal. To be able to implement the ITPGRFA and other international agreements more effectively and efficiently, a coherent and strong national institutional framework must be developed for access and benefit-sharing of genetic resources, and PGRs in particular.

Although the National Agriculture Genetic Resources Centre (NAGRC) has been designated as a depository of genetic materials, it is still not clear whether the institution will be responsible for facilitating MLS implementation as envisioned in the ITPGRFA. This chapter focuses on how best to deal with these institutional gaps. It includes the identification of a competent authority for the implementation of the ITPGRFA/MLS, an analysis of the environment, and suggestions for the revision of the relevant policies and laws to make proper implementation possible.

This chapter is based on a literature review and input from policy meetings, consultations with stakeholders, and interviews with the relevant ministers and CBD and ITPGRFA focal points. The project team members also participated in revision of the National Biodiversity Strategy and Action Plan and were directly involved in the amendment of the Agro-biodiversity Policy 2007.

## Nepal's legal environment

It is clear that the purpose, scope, and jurisdiction of the CBD and ITPGRFA are different from each other. Adequate legal enactment, institutional arrangements, and administrative set up should be introduced to implement both international agreements properly and in a harmonious way in the Nepalese context. A large number of existing policies and acts have some bearing on both international agreements. We review them briefly below.

## Interim Constitution of Nepal 2007

The constitution is the supreme law of the land and the policy document that provides the general framework of governance and guidance on national and international affairs of the state. It confers the power and functions of the executive, legislature, and judiciary; it stipulates the rights of the citizens and the power and functions of the administration and oversight agencies (NLC 2007a). With respect to biodiversity, agriculture, and technology, the Interim Constitution includes the following provisions:

The State shall make arrangements for the protection of forest, vegetation, and biodiversity, their sustainable use and for equitable distribution of the benefits derived from them (Article 35 (5)).

The State shall develop the agriculture sector as an industry by creating conditions for economic progress of the majority of the people who are dependent on agriculture and raising productivity in the agriculture sector through encouragement to the farmers (Article 35 (6)).
The State shall, for the progress of the country, pursue a policy of giving priority to the development of science and technology and also pursue a policy of developing local technology (Article 35 (11)).

Article 35 has special significance for the conservation of biological resources and for issues concerning access and benefit-sharing. According to the Interim Constitution, equitable distribution of benefits from the use of natural resources is a responsibility of the state, rather than a fundamental right of all citizens. Furthermore, if the state fails to fulfill these responsibilities, the matter cannot be taken to court by private citizens.

Although the Interim Constitution does not mention PGR exchange, the MLS, or related provisions, it does mention equitable distribution of benefits arising from the use of forests, vegetation, and biodiversity, which also includes PGRs for food and agriculture. It is clear that the constitution has accorded high priority to implementation of the international treaty provisions by making necessary the amendment of existing laws and policies or mandating the enactment of new laws, if required, to fulfill the obligations of the state.

## Nepal Treaty Act 1990

The objective of this act is to make legal provisions for signing, ratification, accession, acceptance, or approval of treaties or agreements to which Nepal is a party, as well as their implementation (NLB 1990).

The act defines "treaty" as an agreement concluded in writing between two or more states, or between any state and any intergovernmental organization and this term also includes any document of this nature, irrespective of how it is designated.

The act gives treaty provisions the force of national laws (Section 9). Where a matter covered by a treaty conflicts with any law in force, the provisions of the treaty are to prevail over national legislation to the extent of the inconsistency (Section 9.1). This principle has been upheld by the Supreme Court with respect to the Convention on the Rights of the Child (*Paudel* v. *Ministry of Home Affairs* (2058) 43 NKP 423 (1989).

It is clear that this act gives supremacy to international treaties over national legislation; in the case of a conflict between an international treaty that Nepal has ratified and a national law, the treaty provisions prevail (Belbase and Thapa 2007). Moreover, this law acts as a bridge between national laws and international laws. The act also obliges Nepal to enact necessary legal and policy instruments to implement the provisions of the ITPGRFA.

## Protection of Environment Act 2053 (1997)

The objective of this act is to "make legal provisions in order to maintain clean and healthy environment by minimizing, as far as possible, adverse impacts likely to be caused from environmental degradation on human beings, wildlife, plants, nature and physical objects, and to protect environment with proper use and management of natural resources, taking into consideration that sustainable development could be achieved from the inseparable interrelationship between the economic development and environment protection" (MoPE 1997: preamble).

The act defines "biological diversity" as ecosystem diversity, species diversity, and genetic diversity, and "national heritage" as any such object, site, plant, and animal related to the environment in Nepal that is likely to be important to humans from a natural, cultural, historical, archaeological, scientific, spiritual, esthetic, or social point of view (Section 2(j) and (k)).

The government of Nepal is empowered by this act to delineate as an environment protection area, any area that contains biological diversity, rare wildlife, or plants and places of cultural and historical significance that are considered extremely important from the point of view of environment protection (Section 10) (Belbase 1998).

Thus, this act seems to attempt to cover most aspects of the environment, but it fails to provide a framework for conservation and use of biological resources and does not include provisions related to ITPGRFA.

## Environment Protection Rules 2054 (1997)

The Environment Protection Rules (NLC 1997) framed under the Protection of Environment Act prohibit research without permission. Rule 31 prohibits foreign organizations or associations, or any affiliated person or institution from collecting samples of any living being, bacteria, and plant, or undertake any activity relating to research in biodiversity without obtaining prior approval from the concerned body. ("Concerned body" is defined as any ministry of the government of Nepal connected with the functions set forth in the environmental protection act or rules.)

Thus, Rule 32 describes how to obtain permission. Any foreign organization or person wishing to collect samples for biodiversity research must submit an application to the concerned body, mentioning the objectives of the research. The concerned body must "conduct necessary investigations" before granting permission to collect samples of any living being, bacteria, or plant, or to take any action relating to research in biodiversity. It may also stipulate conditions. The concerned body is obliged to inform the Ministry of Science, Technology and Environment about any permission granted. These regulations are also relevant to the ITPGRFA and should be used to regulate access to PGRs and benefit-sharing.

### National Parks and Wildlife Conservation Act 2029 (1973)

The National Parks and Wildlife Conservation Act (NPWCA) is one of oldest laws of Nepal in terms of biodiversity conservation. It focuses on habitat conservation. Under it, various regulations, such as the National Parks and Wildlife Conservation Regulations, the Chitwan National Park Regulations, the Bardiya National Park Regulations, Wildlife Reserve Regulations, Elephant Management Regulations, Mountain Protected Areas Regulations, Conservation Area Management Regulations, Conservation Area Government Management Regulations, Khaptad National Park Regulations, Kanchenjunga Conservation Area Regulations, and Buffer Zone Management Regulations have been promulgated and applied to the management of protected areas especially to conserve wilderness, biodiversity, and the landscape (National Panchayat 1973).

Although this act is focused on wildlife conservation and related uses, it also includes provisions regarding the collection of samples of biological resources for scientific research other than the protected wildlife listed in its Schedule 1. Samples can only be collected after obtaining permission from the appropriate official (Section 15).

### National Parks and Wildlife Conservation Regulations 2030 (1974)

These regulations constitute the major tool for implementing the NPWCA, and include various provisions related to conservation and use of biological resources under in-situ conditions.

Rule 22 relates to the collection of samples of wildlife, birds, insects, fish, or any other natural products for scientific research (except the wildlife listed in Schedule 1 of the act); fees are charged for such collection, as listed in Annex 2 of the regulations (NLC 1974). However, Annex 2 does not include fees for the collection of samples of plants and their products. Thus, the regulations do not consider the conservation of PGRs or access and benefit-sharing through the MLS.

It is important to note that the provisions, procedures, and institutional arrangements established under the NPWCA and its regulations are more focused on protecting extinct, rare, threatened, and vulnerable species of wild fauna and flora, as envisaged in the Convention on International Trade in Endangered Species, the World Heritage Convention, the Ramsar Convention, and the CBD.

### Seeds Act 2045 (1988) and the 2008 amendment

The objectives of the Seeds Act include making standard-quality seeds available in a well-planned system of production, processing, and testing to increase production and productivity of various crops (National Panchayat 1988).

The act includes provision for establishment of a National Seed Board (NSB), subcommittees under the board, a seed certification organization, and a central seed-testing laboratory. It gives the NSB the power to "notify" types and varieties of seeds appropriate for various regions (by publishing a notification in the *Nepal Gazette*), and prescribe the minimum level of purity and germination for these seeds. The act requires truthful labeling of notified types and varieties. In terms of regulation and technical back up, provisions for seed analysts and inspectors have been included. Permission is required for import and export of notified seeds. In addition, the act also includes a provision for recognizing national and international organizations for seed testing and certification.

The NSB formulates and implements seed-related policies and advises the government on seed-related matters. The role of the NSB includes seed program planning and coordination; policy formulation and support; variety approval, release, and registration; preparation of balance sheets based on national seed demand and supply; guidance, coordination, and leadership of all seed-related programs; ensuring the availability of breeder, foundation/source seeds to all seed growers; support for seed-related agencies in developing infrastructure and human resources; breeders' rights (incentives to breeders); and regular monitoring of the impact of seed-related regulations.

In 2008, the act was amended to bring it into line with international practices in the context of the World Trade Organization. Major amendments were provisions for mandatory inclusion of women on the NSB; establishment of the Seed Quality Control Centre (SQCC) in place of a seed certification organization (with the head of SQCC as an ex officio member of the NSB and the SQCC acting as secretariat to the NSB); licensing of private and public seed-testing laboratories; establishment of crop inspectors; a licensing system for seed traders/businesses; and involvement of the private sector in seed testing (NLC 2008).

The act recognizes the ownership rights of breeders to varieties, but does not specify what such rights entail. It is surprising that the government is prepared to protect breeders' rights, but completely ignores farmers' rights to the seed they have been improving, modifying, and conserving for generations. To strike a balance between plant breeders' rights and farmers' rights, the government must either make appropriate changes to the Seeds Act or enact new legislation protecting farmers' rights.

Further, in relation to the MLS, the Seeds Act views seeds as a market commodity rather than a genetic resource. It tries to regulate the import, export, production, certification, release, and supply of seeds that are ready to sow on farms and in nurseries, but does not look at such issues as breeding, conservation, and safeguard of PGRs for the future.

### Seed Regulations 1997

The Seed Regulations were formulated to define rules and regulate the production and marketing of quality seeds (MoAC 1997). They include provisions for institutional arrangements, such as formation of subcommittees under the NSB. They also establish processes for the approval, release, and registration of new plant varieties and provisions for documentation and certification of released varieties by the concerned authority. Ownership of new plant varieties is a key provision that promotes and encourages individual breeders.

## Forest Act 2049 (1993)

Under the Forest Act, the government is empowered to impose restrictions on the collection, cutting, use, transport, sale, and distribution or export of forest products. The objective of these restrictions is to protect biodiversity and conserve the environment. It may do so by publishing a notice in the *Nepal Gazette* (Section 70A). However, this act does not mention access to genetic material or resources (NLB 1992).

## Forest Regulation 2051 (1995)

The regulations include provisions related to timber and non-timber forest products, including herbs, herbicides, and fodder but do not contain provisions relating to PGRs (HMGN 1995).

## Plant Protection Act 2064 (2007)

The objectives of this act are to prevent the introduction, establishment, prevalence, and spread of pests during the import and export of plants and plant products (HMGN 2007). Note: "plant product" is defined in Section 2(b) of the act.

The act empowers the government to designate any central-level office related to plant protection as the National Plant Protection Organization (NPPO) (Section, 6(1)). The powers and functions of the NPPO include

- preparing standards related to the sanitation of plants or plant products to be imported or exported.
- developing manual and enforcing rules covering the examination, testing, inspection, and treatment of plants, plant products, biological control agents, beneficial organisms, and other articles.
- identifying endangered areas and protecting plants and plant products in such areas through quarantine.
- prescribing terms and restrictions related to the trafficking and use of plants and plant products, biological control agents, and beneficial organisms.
- enforcing approved standards regarding the sanitation of plants or plant products to be imported or exported.
- coordinating with phyto-sanitary bodies in other countries and working to recognize each other's permits and phyto-sanitary certificates.

Any person or organization who wishes to import plants, plant products, biological control agents, beneficial organisms, or means of growing plants such as soil, moss, etc., is required to obtain an entry permit (Section 7(1)). Those who wish to import such materials for their personal use or for research must also obtain an entry permit (Section 7 (3)). The Ministry of Agricultural Development (MoAD) may designate any employee with the appropriate qualifications as inspector of plants, plant products, biological control agents, beneficial organisms, or other articles.

The act requires the NPPO to undertake pest risk analysis and identify "controlled pests" (Section 17 (1); see Section 2(e) for definition of controlled pest). On recommendation from the NPPO, the MoAD must publish a notice of controlled pests in the *Nepal Gazette*.

Any infected material to be imported or transported pursuant to this act must be treated. Those found to be still infected after treatment must be seized and destroyed (Section 24). However, the act is silent about who is responsible for destroying infected plants, plants products, etc. The act requires approval by the government to import, among others, any plant or plant products for the purpose of personal use or research.

### Plant Protection Rules 2031 (1975)

The regulations regarding plant protection require a licence to import plants or plant products and payment of a fee (HMGN 1975: Rule 3). Applications are made to the Plant Quarantine Officer.

The export of plant and plant products requires a certificate (Rule 7). Applications are submitted to the Plant Quarantine Officer along with a detailed description of the products. The officer is empowered to issue a phytosanitary certificate, if he/she does not see any obstacle.

## Draft bills

The existing laws do not provide for access to PGRs through the MLS. They allow for export of PGRs through an import permit from the receiving country or CGIAR centres and provide for phytosanitary certification.

Thus, a new piece of legislation is needed to implement the ITPGRFA. In this regard, the following bills must also be reviewed to determine whether they meet the requirements. Although, the current plant quarantine law does not mention the ITPGRFA or MLS, the existing system does allow the import and export of PGRs to contracting parties and CGIAR centres through an SMTA.

### Access to Genetic Resources and Benefit Sharing Bill 2002

The Ministry of Forest and Soil Conservation (MoFSC), the focal ministry for the CBD, drafted a bill on Access to Genetic Resources and Benefit Sharing in 2002 (MoFSC 2002a). This bill has gone through a series of reviews and revisions, but has yet to be tabled in parliament.

The bill includes provisions related to access and benefit-sharing as stipulated in the CBD:

- *Ownership of genetic resources and genetic material*: There are three categories of owners: individual persons or organizations, local communities, and the government of Nepal if the material does not belong to anyone in the first two categories.
- *Rights to traditional knowledge*: Local communities have rights to their traditional knowledge.

- *Biodiversity register to claim ownership*: Any individual, local community, organization, local government body, or the government of Nepal can separately or jointly register genetic resources and associated knowledge. However, this will require obtaining prior informed consent from the owners of such genetic resources and associated knowledge.
- *Access provisions and conditions*: To obtain access to genetic resources and materials, two procedures must be followed: first, application for preliminary and scientific research and sample collection; second, submission of a proposal for obtaining a licence for access, use, and export.
- *National Genetic Resource Coordination Council (NGRCC)*: This council has been proposed to coordinate issues related to access and benefit-sharing.
- *Consent*: Prior informed consent will be provided through a public hearing. Village development committees and municipalities have been given authority to organize such public hearings, make decisions, and submit them for approval to the NGRCC.
- *Benefit-sharing*: Benefits arising from the access to and use of genetic resources and materials are proposed to be shared among four parties: (i) the local community, individual, or organization; (ii) the NGRCC; (iii) the government of Nepal; and (iv) local bodies.

Although the bill addresses bioprospecting, commercialization of products, and sharing of benefits from the outcomes, it does not provide for food security and conservation of PGRs for the common good, especially to meet the food demands of current and future generations as envisaged in the ITPGRFA.

### Plant Variety Protection and Farmers' Rights Bill

The major objectives of this bill are to develop agriculture, promote food security and biodiversity, conserve plant varieties, and secure the rights of breeders and farmers (MoAD 2008). It defines seeds, plants, plant species, farmers, local varieties, local communities, and traditional knowledge and provides for registration of new varieties and breeders' rights over new varieties.

## The policy environment

### Agro-biodiversity Policy 2007

The National Agro-biodiversity Policy aims to promote conservation and sustainable use of agricultural genetic resources, traditional knowledge, skills, and practices and fair and equitable sharing of benefits to ensure food security and reduce poverty (NLC 2007b). The objectives of the policy are to:

- Strengthen food and nutrition security, as well as support agricultural development through conservation, management, and sustainable use of agro-biodiversity.
- Protect and promote farmers' traditional knowledge, skills, innovations, technology, and practices.

- Establish an equitable and judicious distribution system of opportunities and benefits arising from access to and use of agricultural genetic resources and materials.
- Contribute to enhancing ecological balance by protecting and promoting agro-biodiversity in the long term.

The policy provides for undertaking research and studies, supporting the traditional seed supply system, developing diversity-based links with markets and industry, and incorporating traditional knowledge and skills into the generation of scientific knowledge and technology for conservation, management, and sustainable use of agro-biodiversity. It also mentions ways and means to protect traditional knowledge, skills, and innovations and maintain biodiversity registers. The policy supports the principle of prior informed consent in accessing genetic resources and benefit-sharing under mutually agreed terms. It also emphasizes the need for a one-window system for access and benefit-sharing. A gene bank has been established in line with the objectives of the agro-biodiversity policy.

This is a major policy in terms of implementing the ITPGRFA. However, it was adopted before Nepal became a signatory of the treaty, and it must be amended to incorporate some of the key provisions of the treaty. If that were done, the government could move forward with implementation of those provisions.

## National Agriculture Policy 2004

The National Agriculture Policy aims to improve livelihoods by transforming subsistence agriculture into a commercialized and competitive system (NLC 2004). The major objectives of the policy are to:

- Enhance overall agricultural production and productivity.
- Transform Nepalese subsistence agriculture into competitive agriculture.
- Conserve, promote, and sustainably use natural and environmental resources and biological diversity.

It encourages the conservation and sustainable use of natural resources and biological diversity. It also identifies the role of in-situ and ex-situ conservation in the agriculture sector to promote the sustainable use of genetic resources.

## Nepal Agriculture Extension Strategy 2007

The Ministry of Agriculture and Cooperatives approved this strategy in 2007 to set up participatory, cost-effective, and results-oriented agricultural extension services (MoAC 2007). The goal of the Nepalese agricultural extension service is to contribute to the overriding national poverty reduction goal by increasing the efficiency and productivity of agriculture and competitiveness in the agricultural system's value chain (from production to marketing) within the sustainable livelihoods framework. This strategy is consistent with the goal of the National Agriculture Policy. It assigns high priority to food and nutrition security, income generation, environmental conservation, biodiversity, equity and inclusion, value addition and quality products, commercialization, and sustainable livelihoods.

## Agriculture Perspective Plan

This plan is an accounting framework for generating agricultural growth in the country (NPC 1995). It focuses on agriculture-led economic growth for food security, poverty reduction, and economic development. The plan is technology driven and based on priority inputs such as fertilizer, irrigation, roads, electrification, and technology. It does not directly address seeds, PGRs, or germplasm exchange.

## Three Year Plan (13th Plan)

The 13th plan is a long-term vision to upgrade Nepal, which is still a least-developed country, to a developing country by 2022 (NPC 2013). The objective of the plan is to bring a feeling of direct positive change in the living standards of common people by reducing economic and human poverty. One of the priority areas of the plan is increasing productivity, diversification, and commercialization of the agricultural sector.

In the approach paper, the objectives for the agriculture sector include developing and expanding environment-friendly agricultural technologies that mitigate the negative effects of climate change; and conserving, promoting, and using agro-biodiversity. The plan clearly emphasizes the conservation of agro-biodiversity in the country. Detailed programs to implement the provisions described in the approach paper are expected to be laid out in the 13th plan document.

## Agriculture Development Strategy 2014

This strategy, developed by the government, envisions a self-reliant, sustainable, competitive, and inclusive agricultural sector that drives economic growth and contributes to improved livelihoods and food and nutrition security. It has four components: governance, productivity, commercialization, and competitiveness (MoAD 2015). Through inclusiveness, sustainability, private sector engagement and cooperative development, and market infrastructure, the plan is to achieve food and nutrition security, poverty reduction, agricultural trade competitiveness, higher and more equitable income for rural households, and strengthened farmers' rights.

Promoting community-based seed production and agro-biodiversity in remote areas is a way to implement Seed Vision 2025 and increase agricultural productivity. The Agricultural Development Strategy (ADS) emphasizes strengthening the gene bank and animal genetic resource program to allow establishment of intellectual property rights. To implement a biodiversity policy, the ADS proposes strengthening the collection, classification, and assessment of diversified bio-resources relevant to agriculture; initiating a system of registration of agro-biodiversity; developing regulations for the research and experimentation with respect to biodiversity and genetic resources; and developing regulations to prevent genetically modified organisms from having a negative impact on biodiversity, genetic resources, and human health. However, the ADS does not address the exchange of genetic materials.

The ADS impact framework proposes strengthening farmers' rights, and these are not limited to rights over their PGRs. In the ADS, farmers' rights include ensuring farmers' participation in policy formulation, planning, decision-making, implementation, and monitoring of the strategy. In addition, the ADS also proposes formulating legislation related to food rights and food sovereignty consistent with the principles of the Interim Constitution. Although the ADS recommends a farmers' commission to help advance farmers' rights, its mandate, composition, and regulation are not clearly laid out. The rights of farmers over genetic resources may be included in the mandate of the commission.

### National Seed Policy 1999

The National Seed Policy focuses on seven areas of the seed sector (NLC 1999): variety development and maintenance, seed multiplication, quality control, increased involvement of the private sector, seed supply, institutional strengthening, and biotechnology. Its main objective is to provide a policy framework and guidelines to ensure production and distribution of good-quality seeds, promote the export of such seeds, make seed commerce effective in terms of existing world trade, and conserve and protect rights over seeds of local crop varieties with distinctive genetic traits.

### Climate Change Policy 2011

One of the goals of this policy is to improve livelihoods by mitigating and adapting to the adverse impacts of climate change (MoE 2011). In the technology development, transfer, and utilization section, it includes a provision for identifying, developing, and using agricultural species and varieties that tolerate drought and flooding. This provision is relevant to PGRs and can be taken as a realization of the need that the ITPGRFA has tried to address and meet.

## Institutions dealing with PGRs in Nepal

Nepal has several institutions working in the field of genetic materials and resources (see chapter 1). The major ones are listed here.

### Ministry of Agricultural Development and its agencies

The MoAD is responsible for agricultural development and has various wings for this purpose.

- Department of Agriculture is the largest user of modern plant varieties released by the NARC and also through the import of seeds. This department has a network all over the country to assist farmers in the adoption of modern varieties. However, it has limited programs for in-situ and on-farm conservation of PGRs.
- SQCC is responsible for controlling the quality of seed. It has the capacity to test the quality of seeds and to identify living modified organisms.
- NARC is the major user of PGRs in the country. Its plant breeding programs use domestically available PGRs as well as those received from the CGIAR system. In addition to several research programs related to the conservation of PGRs in situ, it also conserves endangered PGRs through ex-situ collection via the NAGRC, which has more than 10000 accessions.
- National Agro-biodiversity Conservation Committee is an apex body formed under the MoAD and chaired by the secretary of MoAD with multistakeholder and multisectoral representation to implement the Agro-biodiversity Policy 2007.

## Ministry of Forest and Soil Conservation and its agencies

The MoFSC is the national focal point for implementing the CBD, the Cartagena Protocol on Biosafety, the National Clearing House Mechanism for CBD, and the National Biosafety Clearing House for the Cartagena Protocol. The government has recently endorsed the Nepal Biodiversity Strategy and Action Plan 2014, and the MoFSC has overall responsibility for formulating and implementing policies and programs related to the conservation, sustainable use of biological diversity, and equitable sharing of the benefits arising out of their use, keeping records of relevant activities, and communicating with the CBD Secretariat and other conventions related to biodiversity. The MoFSC implements its plans and programs through five departments, but the following are relevant to PGRs.

- Department of Plant Resources is responsible for research, exploration, identification, and providing technical inputs to the ministry on plant resources in the country. It operates botanical gardens, maintains tissue cultures, and uses other traditional technologies.
- Department of National Parks and Wildlife Conservation conserves animal and plant resources in in-situ conditions and is the regulating authority for PGRs in protected areas, which amount to a significant share of biodiversity in Nepal.
- Department of Forest is responsible for regulating and conserving PGRs in forest areas.
- National Biodiversity Coordination Committee has been formed under the MoFSC to mainstream biodiversity in development programs, projects, and policies. This committee is a multisectoral apex body in terms of biodiversity conservation. It has established five thematic subcommittees — Forests and Protected Areas, Agro-biodiversity, Biosecurity, Genetic Resources, and Sustainable Use of Biodiversity — to provide scientific and technical input. The work of the thematic subcommittees on Agro-biodiversity, Genetic Resources, and Sustainable Use of Biodiversity is similar and may overlap. In relation to the ITPGRFA, these three subcommittees may be mutually relevant.

## Agriculture and Forestry University

This newly established university has a Department of Plant Breeding and a Biotechnology Centre, which both use PGRs for breeding.

## Tribhuvan University

Three departments of this university — Botany, Biotechnology, and Microbiology — deal with PGRs. The Institute of Agriculture and Animal Sciences, a major institute of the university, is particularly engaged in research and teaching of PGRs.

## Nepal Academy of Science and Technology

This academy conducts research, including work in biotechnology and plant-based products.

### Ministry of Science, Technology and Environment

This ministry deals with environment, and biodiversity is one of its areas.

## Policy amendments, strategy, and action plan

### Agro-biodiversity Policy

In terms of implementing the ITPGRFA, the Agro-biodiversity Policy of 2007 is an important document, but it had to be amended to incorporate some of the ITPGRFA's key provisions. We drafted such content. The revised Policy (20014) was widely circulated and discussed, comments and suggestions were incorporated, and the draft was approved by parliament.

Major achievements of the revision are the incorporation of MLS-related provisions and a commitment to an implementation mechanism, including the need for a separate law to comply with the ITPGRFA and implement its provisions. Specific issues related to ITPGRFA that are addressed in the Agro-biodiversity Policy 2014 are:

The policy focuses on identification, conservation, promotion, development, and sustainable use of agricultural biological diversity.

- The MLS, the national gene bank, and "on-farm" are defined.
- Necessary arrangements for the registration of agricultural biodiversity and traditional knowledge are to be made at the national and local levels after such traditional knowledge is documented, recorded, or registered.
- Access to genetic materials and resources in the custody of international gene banks will be through the NAGRC.
- In-situ conservation, restoration, research, and development related to Nepal's genetic material and resources conserved at the international level will be promoted, and partnerships among the NAGRC, semen bank, community seed bank, agriculture, horticulture, and livestock farms, and other research institutions will be strengthened.
- Farmers involved in agricultural biodiversity conservation will be identified and encouraged to conserve, promote, and use agro-biodiversity.
- Technical and financial support at the national and international levels will be mobilized or generated to strengthen institutions and expand the network of the NAGRC by including the conservation of livestock, aquatic life, and bird genetic resources.
- Arrangements will be made to make proper use of the MLS under the ITPGRFA.
- Necessary arrangements will be made to ensure that farmers receive their share of the benefits from access to agriculture genetic materials and resources including associated traditional knowledge.
- Nepal's Annex I PGRs and resources will be developed in accordance with the ITPGRFA to implement, coordinate, and operate the MLS and to obtain maximum benefits from the system. In this connection, competent national authorities will be designated through legal arrangements, and the authorities will have a clear mandate and be well equipped with resources.

- A one-window system will be adopted to regulate various aspects of the ITPGRFA.
- Necessary arrangements will be made so that laws and policies related to intellectual property rights will not have an adverse impact on farmers' rights.
- To enforce and monitor the policy, necessary laws, rules, and guidelines and procedures will be formulated and essential institutional arrangements will be made.

### National Biodiversity Strategy and Action Plan

In 2014, Nepal's Biodiversity Strategy (MoFSC 2002b) was revised and renamed National Biodiversity Strategy and Action Plan (NBSAP) 2014–2020 (MoFSC 2014). The new version includes strategies and plans related to agro-biodiversity conservation and use, particularly with respect to the ITPGFRA, including the following.

- Identification of the gaps in policy, legislation, and institutional mechanisms required for implementation of the ITPGRFA.
- The need for coherent guidelines to promote synergy among biodiversity-related multilateral environmental agreements, such as the CBD, the Convention on International Trade in Endangered Species, Ramsar, World Heritage Convention, and the ITPGRFA, to ensure ease of implementation.
- Designation of the Food Security and Environment Division of MoAD as a focal point and implementing agency for the ITPGRFA.
- Establishment of an efficient system for the exchange of information on all types of agricultural genetic resources and implementation of the ITPGRFA and MLS.
- The need to facilitate access to genetic resources and materials and associated traditional knowledge with prior informed consent and on mutually agreed terms.
- Establishment of a one-window system for regulating the provisions of international treaties related to genetic resources (both plant and animal).
- Establishment and strengthening of the functional link between the NAGRC (gene bank) and community-based seed or gene banks.
- Development and implementation of incentives for on-farm conservation of agro-biodiversity and elimination of perverse incentives (if any).
- Development and implementation of a plan for effective collaboration among national and international research organizations, the private sector, and academic institutions for conservation of agro-genetic resources.

## A new instrument

Considering the current uncertain national scenario, a separate legal instrument is essential to regulate and facilitate adoption of the MLS in Nepal. A competent authority with legal power and capabilities to initiate the necessary legal and administrative steps is essential. Executive orders, guidelines, or rules are not sufficient to introduce, operate, and regulate the MLS in Nepal; therefore, a new law is needed to implement the treaty nationally and to regulate and facilitate the MLS process. In accordance with the conclusions of various level meetings, an agro-biodiversity conservation and utilization act has been drafted to implement the ITPGRFA. This draft document was discussed at several meetings and in other consultation forums.

## Problems

The Interim Constitution of Nepal, 2007 obligates the state to implement international treaties. Along the same lines, the Nepal Treaty Act, 1990 provides an opportunity for implementation of international treaties of which Nepal is a party. It obliges Nepal to enact national legislation and provides supremacy of treaty provisions over national laws in case of contradictions. Some sectoral laws and policies related to these treaties and conventions exist and are in force, but they do not cover all aspects. Approval of some bills, such as the Access to Genetic Resources and Benefit Sharing Bill and the Plant Variety Protection and Farmers' Rights Bill, has been pending for years. No legislation has been enacted to implement the ITPGRFA. A national focal point has been designated to implement the provisions of the treaty, but institutional mechanisms to enforce such provisions are lacking. Likewise, not a single policy related to agriculture and biodiversity mention the treaty or address its provisions.

### Institutional framework

Various institutions and organizations have been working in the field of PGRs for food and agriculture. Some are oriented toward research and development, others toward service and extension, and others toward regulating, policymaking, and decision-making.

Two ministries, i.e., MoAD and MoFSC, are relevant in terms of implementing the ITPGRFA. According to the government's Allocation of Business Regulations, responsibility for implementing the ITPGRFA rests with the MoAD, which has been made the national focal point for the treaty. The MoFSC is the national focal point for the CBD, which also has provisions regarding access to genetic resources and benefit-sharing. Legislation, such as the Protection of Environment Act, National Parks and Wildlife Conservation Act, Forest Act, Seed Act, and Plant Protection Act, are also relevant to biodiversity conservation and use, but none of these includes institutional provisions or a mandate to deal with the MLS.

The NAGRC has established a safety duplication process for some accessions of PGRs at various CGIAR centres, but the accessions have not yet been deposited in the seed vault in Norway (the global facility where many countries and organizations have deposited duplicates). The issue of ownership of these genetic materials collected from farmers' fields is an emerging policy issue. Until now, these materials have been exchanged with international gene banks and researchers on the basis of the SMTA, assuming them to be the property of the state. Without institutional arrangements at the national and local levels, identifying both the concerned government and community institutions, it will be complicated to maintain or enhance access to PGRs and benefit-sharing (Gautam 2008).

Strong and useful local institutions, such as the biodiversity conservation and development committees and community seed banks (CSBs) have emerged and are operating in Nepal. Since the establishment of the national gene bank, CSBs have been asking for their share of credit through proper links and coordination of material transfers between the national gene bank and CSBs. In principle, such links provide benefits to the communities and link ex-situ conservation with in-situ on-farm conservation, but, in practice, the details have not been worked out and a strong research base and stakeholder agreement are lacking.

## Legal framework

Nepal began to draft legislation on access to genetic resources and benefit-sharing in 2001, but it has not yet been enacted. If such legislation were enacted, the situation would have been different with respect to the ITPGRFA, despite the fact that the scope of the access legislation under the CBD and ITPGRFA is different. Under the CBD, legislation must cover issues related to access to genetic resources for bioprospecting, commercialization of products, and sharing of benefits arising thereof, mostly of a bilateral nature and having monetary benefits. Laws implementing the ITPGRFA must cover facilitated access to PGRs for the sake of food security and agriculture to meet present and future needs.

The Protection of Environment Act, National Parks and Wildlife Conservation Act, Forest Act, Seed Act, Plant Protection Act are some of the sectoral laws that are relevant to biodiversity conservation and use, but none includes provisions to deal with access to genetic resources and benefit-sharing. The ITPGRFA obliges Nepal to designate a competent authority to facilitate these processes, administer requests, grant permissions, and keep records of the flow of PGRs. However, no existing institution can do that without a legal mandate. A law is required to explicitly create environment for the establishment, composition, powers, functions, and duties of an institution to discharge the nation's commitments and responsibilities under the ITPGRFA.

## Conclusion

Nepal ratified the ITPGRFA on 2 January 2007 and became party to it on 19 October 2009. The MoAD is the focal ministry for the treaty responsible for taking the initiatives required to fulfill commitments under it. Nepal is also a party to the CBD, which has been in force since 1993. The MoFSC serves as the focal ministry for the CBD. The ITPGRFA and CBD both include provisions related to access to genetic resources and benefit-sharing, and both multilateral environmental agreements oblige the national parties to enact necessary laws to facilitate implementation of their provisions.

Currently, there is no formally designated competent national authority to make decisions or coordinate implementation of the ITPGRFA in Nepal. A competent national authority can only be designated by law, and there is no legal basis in Nepal's current regulatory framework to make such an appointment, because there is no law regarding access and benefit-sharing.

In the absence of national legislation, access to PGRs conserved and managed under in-situ and on-farm condition by farmers and farming communities, as well as those held in ex-situ conditions in the national gene bank remain unregulated. The NAGRC has been, ad facto, providing access to PGRs held in its gene bank as well as new plant varieties and PGRs under development.

In the political system and legal culture of Nepal (and other countries), there is a tradition of confirming rights and obligations through explicit enactment of laws, including executive orders, regulations, and legislation. In the absence of such legal confirmation, actors can feel uncertain about what they can and cannot do and vulnerable to accusations that they have done the wrong thing. As soon as possible, Nepal must enact two laws addressing the ITPGRFA and CBD to facilitate use of the MLS in PGR flow from and to the country, provide access to genetic resources for the purpose of bioprospecting, and fulfill its obligations under the treaties.

In summary, implementing the ITPGRFA is urgent, as the country can benefit enormously from the MLS, can secure ownership of the genetic resources deposited in international gene banks, and can make accessing parties accountable for sharing both ownership and benefits.

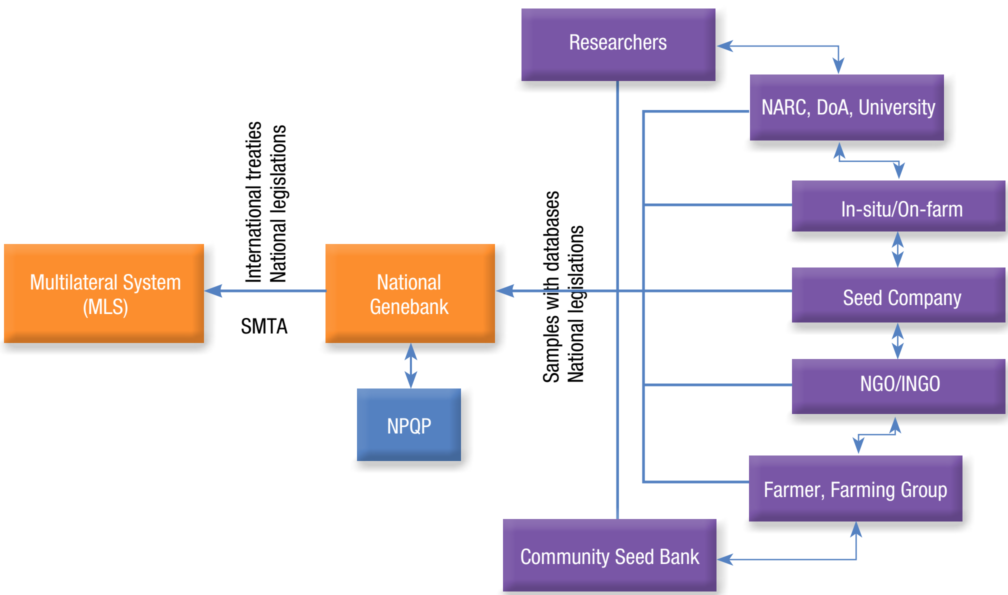
## Recommendations

Based on assessment of Nepal's national laws and policies and consultations with concerned stakeholders, Nepal must take the following steps to implement the ITPGRFA.

### Institutional/administrative framework

The competent authorities for implementing the ITPGRFA at the national level are the NAGRC and relevant institutions: MoAD, MoFSC, National Biodiversity Coordination Committee, National Agro-biodiversity Conservation Committee, SQCC, and quarantine offices.

A one-window system for exporting PGRs and a multiple-window system for importing PGRs are suggested (Figure 9.1, A and B).

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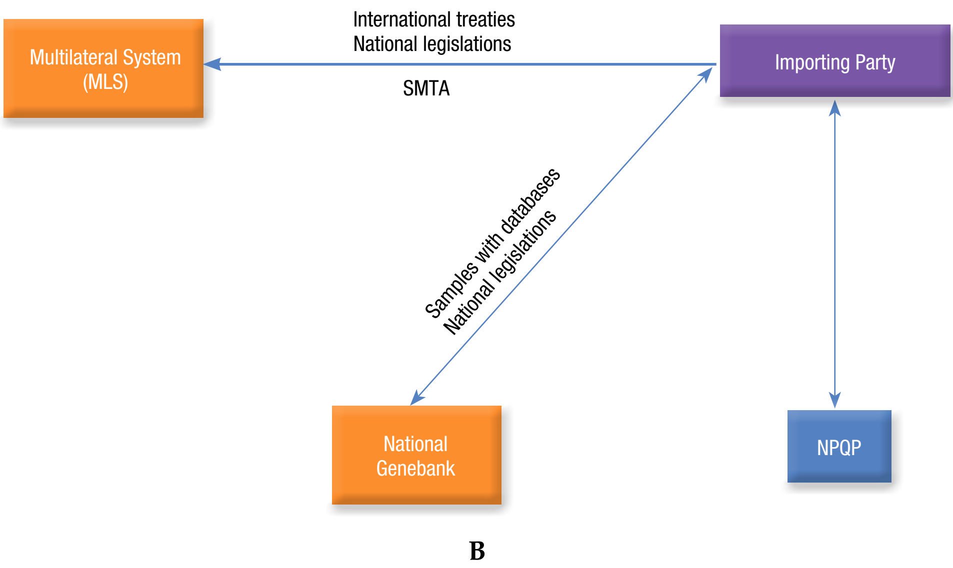


**Figure 9.1.** Proposed system for exporting (A) and importing (B) plant genetic resources in Nepal.

## Legal framework

Nepal should enact a new law on PGRs for food and agriculture that is in harmony with other laws. It should also spell out that the PGRs under its scope are not subject to intellectual property rights and not to be used for business or profit, to ensure that the International and Tribal Peoples Convention (ILO 1989) does not conflict with the ITPGRFA.

Likewise, if the pending Access to Genetic Resources and Benefit Sharing Bill is to move ahead, it should exclude PGRs from its scope, in line with the Nagoya Protocol under the CBD, which is yet to be ratified by Nepal.

## Policy framework

- There is a need to develop an ITPGFRA–MLS implementation strategy and action plan to implement the Agro-biodiversity Policy 2014.
- Based on the Agro-biodiversity Policy, an agro-biodiversity conservation and utilization act and regulations must be developed.
- Immediate action to implement the NBSAP is necessary for harmonizing the ITPGRFA.
- Nepal should ratify the Nagoya Protocol, which clearly spells out the ITPGRFA and limits the scope of access to genetic resources and benefit-sharing provisions of the CBD for bioprospecting by excluding PGRs to be used for food and agriculture.

## References


Belbase N. 1998. Notes and commentaries on the Environment Protection Act, 1997 of Nepal. *Asia Pacific Journal of Environmental Law* 3:66–67.

Belbase N, and LB Thapa. 2007. Environmental justice and rural communities, Nepal. **In** *Environmental Justice and Rural Communities, Studies from India and Nepal*. P Moore and F Pastakia (eds). International Union for Conservation of Nature and Natural Resources, Bangkok, Thailand and Gland, Switzerland. p.75.

Gautam JC. 2008. Country report on the state of the Nepal's plant genetic resources for food and agriculture. Submitted to Commission of Genetic Resource for Food and Agriculture, Food and Agriculture Organization, Rome, Italy. p.38. Available: ftp://ftp.fao.org/ag/agp/countryreports/NepalFinalReport.pdf

HMGN. 1975. Plant Protection Rules 2031. His Majesty's Government of Nepal (HMGN), Kathmandu, Nepal. Available: http://faolex.fao.org/docs/pdf/nep9217.pdf

HMGN. 1995. Forest Regulation, 2015 (1995). His Majesty's Government of Nepal (HMGN), Kathmandu, Nepal. Available: http://www.forestaction.org/app/webroot/js/tinymce/editor/plugins/filemanager/files/Forest_Regulation_1995%20_2_.pdf

HMGN. 2007. Plant Protection Act, 2064 (2007). Ministry of Law, Justice and Parliamentary Affairs, His Majesty's Government of Nepal (HMGN) Kathmandu, Nepal. Available: http://www.vertic.org/media/National%20Legislation/Nepal/NP_Plant_Protection_Act.pdf

ILO. 1989. Indigenous and Tribal Peoples Convention (C169). International Labor Organization (ILO), Geneva, Switzerland. Available: http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C169

MoAC. 1997. Seed regulation. Ministry of Agricultural and Cooperatives (MoAC), Kathmandu, Nepal.

MoAC. 2007. Nepal agriculture extension strategy. Ministry of Agriculture and Cooperatives (MoAC), Kathmandu, Nepal.

MoAD. 2008. Plant variety protection and farmers' right bill (draft). Ministry of Agriculture Development (MoAD), Kathmandu, Nepal.

MoAD. 2015. Agricultural development strategy. Ministry of Agriculture Development (MoAD), Kathmandu, Nepal. Available: http://www.moad.gov.np/downloadfile/ADS%20Final%20Report%20-%20as%20of%2023%20september,%202014_1411534253.pdf

MoE. 2011. Climate Change Policy, 2011. Ministry of Environment (MoE), Kathmandu, Nepal. Available: https://ldcclimate.files.wordpress.com/2012/05/climate-change-policy-eng-nep.pdf

MoFSC. 2002a. Access to genetic resource and benefit sharing (AGRBS) bill (draft). Ministry of Forest and Soil Conservation (MoFSC), Kathmandu, Nepal.

MoFSC. 2002b. Nepal biodiversity strategy. Ministry of Forest and Soil Conservation (MoFSC), Kathmandu, Nepal.

MoFSC. 2014. National biodiversity strategy and action plan 2014–2020. Ministry of Forest and Soil Conservation (MoFSC), Kathmandu, Nepal.

MoPE. 1997. Protection of Environment Act. Ministry of Population and Environment (MoPE), Kathmandu, Nepal. Available: http://faolex.fao.org/docs/pdf/nep52633.pdf

National Panchayat. 1973. National Parks and Wildlife Conservation Act, 2029 (1973). National Panchayat, Kathmandu, Nepal. Available: http://www.aec-fncci.org/wp-content/uploads/2014/12/National-Parks-and-Wildlife-Conservation-Act-2029-1973.pdf

National Panchayat. 1988. Seeds Act, 2045 (1988). National Panchayat, Kathmandu, Nepal. Available: http://faolex.fao.org/docs/pdf/nep21975.pdf

NLB. 1990. Nepal Treaty Act. National Legislative Bodies/National Authorities (NLB/NA), Kathmandu, Nepal.

NLB. 1993. Forest Act, 2049 (1993). An act made for proper management and conservation of forests. NLB/NA, Kathmandu, Nepal. Available: http://faolex.fao.org/docs/pdf/nep4527.pdf

NLC. 1997. Environment protection rules, 2054 (1997). Nepal Law Commission (NLC), Kathmandu, Nepal. Available: http://faolex.fao.org/docs/pdf/nep100343.pdf

NLC. 1974. National parks and wildlife conservation regulations. Nepal Law Commission (NLC), Kathmandu, Nepal.

NLC. 1999. National Seed Policy 1999 (2056 BS). Nepal Law Commission (NLC), Kathmandu, Nepal. Available: http://sqcc.gov.np/media/publication/National_Seed_Policy_1999.pdf

NLC. 2004. Nepal agriculture policy. Nepal Law Commission (NLC), Kathmandu, Nepal.

NLC. 2007a. Interim Constitution of Nepal. Nepal Law Commission (NLC), Kathmandu, Nepal.

NLC. 2007b. National agro-biodiversity policy. Nepal Law Commission (NLC), Kathmandu, Nepal. Available: http://www.farmersrights.org/pdf/asia/nepal/nepal-agrobiodivpolicy07.pdf

NLC. 2008. Seeds Act (amendment). Nepal Law Commission (NLC), Kathmandu, Nepal.

NPC. 1995. Agriculture perspective plan. NPC, Kathmandu, Nepal

NPC. 2013. Three year plan (13$^{th}$). National Planning Commission (NPC), Kathmandu, Nepal

# Appendix I. Major food and forage crops in Nepal

## Food Crops

| SN | बालीको नाम | Common Name | Scientific Name | IT Annexing | Distribution Frequency |
|---|---|---|---|---|---|
| **Cereals** | | | | | |
| 1. | जौ | Barley | Hordeum vulgare L. | Y | WC |
| 2. | धान | Paddy | Oryza sativa L | Y | WC |
| 3. | गहुँ | Wheat, Bread Wheat | Triticum aestivum L. | Y | WC |
| 4. | मकै | Maize, Corn | Zea mays L. | Y | WC |
| **Pseudocereals** | | | | | |
| 1. | लट्टे | Amaranth | Amaranthus spp | N | WC |
| 2. | फापर, मिठे फापर, तोन्दा | Common Buckwheat, Sweet Buckwheat, Cultivated Buckwheat | Fagopyrum esculentum Moench. | N | WC |
| 3. | तिते फापर | Tartary Buckwheat, Bitter Buckwheat, Indian Wheat, Duck Wheat, Mountain Buckwheat | Fagopyrum tataricum Gaertn. | N | L |
| **Millets** | | | | | |
| 1. | कोदेा, रागि, मरुवा | Finger Millet, African Millet, Bird's Foot Millet | Eleusine coracana Gaertn. | Y | WC |
| 2. | चीनु, चिनु, ठूलो कागुनो | Proso, Common, Hog, Broom Corn, French Millet | Panicum miliaceum L. | N | L |
| 3. | कागुनो, कागुनु | Foxtail, Italian Millet | Setaria italica Beauv. | N | L |
| **Sugar and Starch Crops** | | | | | |
| 1. | सखरखण्ड | Sweet Potato | Ipomea batatas Lam. | Y | WC |
| 2. | उखु, गन्ना | Sugarcane | Sacharum officinarum L. | N | WC |
| 3. | आलु | Potato, Irish Potato, White Potato | Solanum tuberosum L. | Y | WC |
| **Pulses** | | | | | |
| 1 | घ्यू सिमि | French bean/ Snap bean | Phaseolus vulgaris | Y | WC |
| 2. | रहर | Pigeon Pea, Red Gram, Cajan Pea, Congo Pea, No-eye Pea | Cajanus cajan Millsp. | Y | WC |
| 3. | चना | Chickpea, Gram, Bengal Gram, Gram, Garbanzo | Cicer arietinum L. | Y | WC |
| 4. | गहत | Horse Gram | Dolichos biflorus Roxb. | N | WC |
| 5. | सिमि, राज सिमि | Hyacinth Bean, Indian Bean, Carpet Bean, Lablab, Bovavis t,Egyptian kidney bean | Dolichos lablab L. Lablab purpureus | N | WC |
| 6. | भटमास | Soybean | Glycine max L. | N | WC |
| 7. | मसुरो | Lentil | Lens culinaris Medic. | Y | WC |
| 8. | मस्यांग | Rice Bean, Red Bean | Phaseolus calcaratus Roxb. Vigna umbellate | Y | WC |

| SN | बालीको नाम | Common Name | Scientific Name | IT Annexing | Distribution Frequency |
|---|---|---|---|---|---|
| 9. | सिमि | Beans, Common Field Bean | Phaseolus spp | Y | WC |
| 10. | राज्मा, असारे सिमि, डालो सिमि | Red Kidney Bean, Common Bean, French, Dwarf, Haricot, String Bean | Phaseolus vulgaris L. | Y | WC |
| 11. | मटर, सानो केराउ | Pea, Field Pea | Pisum sativum var arvense. | Y | WC |
| 12. | केराउ, मटर | Pea, Garden Pea | Pisum sativum L. | Y | WC |
| 13. | बकुल्ला | Broad Bean, Field Bean, Faba Bean, Horse Bean, Windsor Bean | Vicia faba L. | Y | WC |
| 14. | मास, उराद | Black Gram | Vigna mungo L. Hepper | Y | WC |
| 15. | मुंग | Green Gram, Mung Bean, Golden Gram | Vigna radiate | Y | WC |
| 16. | बोडी, कात्तिके बोडी | Cowpea | Vigna unguiculata L. | Y | WC |
| 17. | तने बोडी | Yard Long Bean | Vigna unguiculata L. var. sesquipedalis Ohashi | Y | WC |
| **Oilseed Crops** | | | | | |
| 1. | रायो | Broad leaf Mustard | | Y | WC |
| 2. | बदाम, मुङ्गफलि | Groundnut, Peanut, Goober | Arachis hypogaea L. | N | WC |
| 3. | सरस्यूं | Sarsyun, Sarson, Yellow Sarson, Indian Colza, Field Mustard | Brassica campestris var. sarson Prain. | Y | WC |
| 4. | तोरी | Mustard, Rape, Indian Rape | Brassica campestris var. toria Dutch. | Y | WC |
| 5. | नरिवल | Coconut | Cocos nucifera L. | Y | L |
| 6. | फिलिंगा, भुसेतिल, रामतिल | Niger | Guizotia abyssinica Cass. | N | L |
| 7. | आलस | Linseed, Flax | Linum usitatissimum L. | N | WC |
| 8. | सिलाम | Perilla | Perilla frutescens L. Britton | N | L |
| 9. | तिल | Sesame | Sesamum indicum L. | N | WC |
| **Vegetables** | | | | | |
| 1. | ब्रोकाउली | Broccoli | Brassica oleracea var italic | Y | WC |
| 2. | कुरिलो | Asparagus, Common, Garden Asparagus | Asparagus officinalis L. var. altilis L. | Y | L |
| 3. | बरेला | Balsam Apple | Momordica balsamina L. | N | L |
| 4. | भिण्डी, रामतोरिया, चिप्ले भिण्डी | Okra, Lady's Finger, Gumbo | Abelmoschus esculentus Moench. | N | WC |
| 5. | कुभिण्डो | Ash, Wax, White Gourd, Ash Pumpkin | Benincasa hispida | N | L |

| SN | बालीको नाम | Common Name | Scientific Name | IT Annexing | Distribution Frequency |
|---|---|---|---|---|---|
| 6. | फुलगोबी, कोबि, काउलि | Cauliflower | Brassica oleracea L. var. botrytis L. | Y | WC |
| 7. | बन्दा, बन्दागोवि, बन्दाकोपि | Cabbage | Brassica oleracea L. var. capitata L. | Y | WC |
| 8. | ग्याठ गोभि | Knol-Khol | Brassica caulorapa | Y | L |
| 9. | सलगम, गान्टे मुला | Turnip | Brassica oleracea var. rapa L. | Y | WC |
| 10. | बेथे | Goosefoot, Common Pig Weed | Chenopodium album L. | N | WC |
| 11. | मेथि | Fenugreek | Trigonella foenum-graecum L. | N | WC |
| 12. | कर्कलो, पिण्डालु | Cocoyam, Taro, Arvi, Arum, Elephant Ear | Colocasia antiquorum Schott. var. esculenta L. | Y | WC |
| 13. | फर्सि | Summer Squash, Pumpkin, Vegetable Marrow | Cucurbita pepo L. | N | WC |
| 14. | कांक्रो, असारे कांक्रो, खिरा | Cucumber, Common Field Cucumber | Cucumis sativus L. | N | WC |
| 15. | फर्सि | Pumpkin, Red Gourd | Cucurbita moschata Duch. | N | WC |
| 16. | गाँजर | Carrot | Daucus carota L | Y | WC |
| 17. | घर तरुल, कुकुर तरुल | Greater Yam, Yam, White Yam | Dioscorea alata L. | Y | WC |
| 18. | जिरिको साग | Lettuce | Lactuca sativa L. | N | L |
| 19. | लौका, अलावु, लोकि | Bottle Gourd, Calabash, White Flower Gourd | Lagenaria siceraria Standl. | N | WC |
| 20. | चमसुर | Garden Cress | Lepidium sativum L. | Y | WC |
| 21. | पाटे घिरौला, तिराई, पाते तो रिया | Ridge Gourd, Ribbed Gourd, Vegetable Sponge | Luffa acutangula Roxb. | N | L |
| 22. | घिरौंला | Sponge Gourd, Ghiya Tori, Smooth, Bath Sponge, Dish Cloth Gourd | Luffa cylindrica Roem. | N | WC |
| 23. | गोलभैंडा, रामभैंडा, टमाटर | Tomato, Love Apple | Lycopersicon esculentum L. | N | WC |
| 24. | करेला, तिते करेला | Bitter Cucumber, Balsam Pear, Bitter Gourd | Momordica charantia L. | N | WC |
| 25. | चटेल, झुसे करेला, खेक्सा | Chathel Gourd | Momordica cochinchinensis Spr. | N | L |
| 26. | मुला | Radish | Raphanus sativus L. | Y | WC |
| 27. | स्कुस | Chayote, Christophine, Squash, Pipinella | Sechium edule (Jacq.) Sw. | N | WC |
| 28. | भाण्टा, वैगुन | Brinjal, Eggplant, Aubergine, Guinea Squash | Solanum melongena L. | Y | WC |

| SN | बालीको नाम | Common Name | Scientific Name | IT Annexing | Distribution Frequency |
|---|---|---|---|---|---|
| 29. | पालुंगो | Spinach, Prickly Seeded Spinach | Spinacia oleracea L. | N | WC |
| 30. | चिचिण्डो, चिचिण्डा | Snake Gourd, Serpent Gourd | Trichosanthes anguina L. | N | WC |
| 31. | परवल | Pointed Gourd, Potol | Trichosanthes dioica Roxb. | N | L |
| **Fruits** | | | | | |
| 1. | कटहर | Jack Fruit | Artocarpus heterophyllus Lam. | N | WC |
| 2. | मेंवा, पपिता | Papaya, Tree Melon, Pawpaw, Papaw | Carica papaya L. | N | WC |
| 3. | तरबुजा | Water Melon | Citrullus vulgaris Schrad. | N | WC |
| 4. | कागति | Lime | Citrus aurantifolia Swingle | Y | WC |
| 5. | चाक्सि | Sweet Lime | Citrus limettioides Tanaka | Y | R |
| 6. | निबुवा, ज्यामिर | Lemon, Otaheite Orange | Citrus limon (L.) Brm. F. | Y | WC |
| 7. | बिमिरो | Citron | Citrus medica L. | Y | L |
| 8. | भोगटे | Pumelo, Shaddock, Melon Fruit, Pompelmous | Citrus maxima Merr.<br>Citrus grandis | Y | WC |
| 9. | सुन्तला | Mandarin, Tangerine, Loose Skin Orange | Citrus reticulata Blanco. | Y | WC |
| 10. | मौसम, जुनार | Sweet Orange, Malta Orange, Nepal Sweet Orange | Citrus sinensis Osbeck. | Y | WC |
| 11. | ट्राइफोलिएट | Trifoliate (Poncirus) | Poncirus trifoliata | Y | L |
| 12. | मुन्तला | Kumquat | Fortunella Japonica | Y | L |
| 13. | लिचि | Litchi | Litchi chinensis Sonn. | N | WC |
| 14. | आँप | Mango | Mangifera indica L. | N | WC |
| 15. | केरा | Banana, Plantain, Adam's Flag | Musa paradisiaca L. | Y | WC |
| 16. | आरुबखडा, आलुबखडा | Plum, Common Plum, European Plum | Prunus domestica L. | N | WC |
| 17. | खुर्पानि | Apricot | Prunus armeniaca L. | N | WC |
| 18. | आरु | Peach | Prunus persica Batsch | N | WC |
| 19. | अम्बा, बेलौति | Guava | Psidium guajava L. | N | WC |
| 20. | स्याउ | Apple | Pyrus malus L.<br>Malus sylvestris Mill. | Y | L |
| 21. | नासपति | Pear | Pyrus communis L. | N | WC |
| 22. | हलुवावेद | Persimon | Diospyros virginiana L. | N | WC |
| 23. | भुइकटहर | Pineapple | Ananas comosus L. Merr. | N | WC |
| **Spices** | | | | | |
| 1. | भेडे खुर्सानी | Bell Pepper, Sweet Peppery, Bull-nose Chilly | Capsicum annum | N | WC |
| 2. | प्याज | Onion | Allium cepa L. | N | WC |

| SN | बालीको नाम | Common Name | Scientific Name | IT Annexing | Distribution Frequency |
|---|---|---|---|---|---|
| 3. | | Leek , Garlic chive | Allium tuberosum | N | L |
| 4. | जिम्बु | Nepal Aromatic Garlic | Allium hypsistum stearn | N | L |
| 5. | छ्यापी | Shallot | Allium cepa var aggregatum | N | L |
| 6. | लसुन | Garlic | Allium sativum L. | N | WC |
| 7. | अलैचि | Greater Cardamom, Large Cardamom | Amomum subulatum Roxb. | N | L |
| 8. | ज्यानमारा खुर्सानी | Cherry Peppery | Capsicum frutescens L. var. cerasiforme Bailey | N | WC |
| 9. | जिरे खुर्सानी | Bird's Eye Chilly, Bird Pepper | Capsicum frutescens | N | R |
| 10. | खुर्सानी | Chilly, Red Pepper, Bell Pepper | Capsicum annum | N | WC |
| 11. | धनिया | Coriander | Coriandrum sativum L. | N | WC |
| 12. | बेसार, हलेदो | Turmeric | Curcuma longa | N | WC |
| 13. | मेथी | Fenugreek | Trigonella foenumgraecum L. | N | WC |
| 14. | अदुवा | Ginger | Zingiber officinale Rosc. | N | WC |
| **Beverages** | | | | | |
| 1. | चिया | Tea | Camellia sinensis L. | N | WC |
| 2. | कफि | Coffee | Coffea arabica L. | N | WC |

WC = Widely cultivated, L = Localized, R = Rare, N = No, Y = Yes.

## Forages

| SN | घांसको नाम | Common Name | Genera | IT Annexing | Distribution frequency | Local/ introducing |
|---|---|---|---|---|---|---|
| **Legumes forages** | | | | | | |
| 1. | बरसिम | Berseem | Trifolium Alexandrium cv wardan | Y | C | Int |
| 2. | सेन्ट्रोसोमा | Centrosema | Cnentrosema pubesens | N | L | Int |
| 3. | भेच | Common Vetches | Vicia Sativa var namoi | N | C | Int |
| 4. | डेसमोडियम हरियो पात | Desmodium Green Leaf | Desmodium introtum | N | L | Int |
| 5. | ज्वाइन्ट भेच | Joint Vetch | Aeschynomene Americana | N | C | Int |
| 6. | कोते | Kote (Mustang Local ) | Medicago falcata | Y | L | Local |
| 7. | कुड्जु | Kudzu | Peuraria thumbergiana | N | C | Int |
| 8. | लुसर्न | Lucerne (Alfalfa) | Medicago sativa | Y | C | Int |
| 9. | रातो क्लोभर | Red Clover | Trifolium Pretense | Y | C | Int |

| SN | घांसको नाम | Common Name | Genera | IT Annexing | Distribution frequency | Local/ introducing |
|---|---|---|---|---|---|---|
| 10. | सतफल | Saftal Clover | Trifolium resupinatum | N | L | Int |
| 11. | सेन्जी | Senji | Sweet clover Melilotus indica sub.spp-parviflora | N | | Int |
| 12. | सिरेट्रो | Siratro | Macroptiliu m atropurpueum | N | L | Int |
| 13. | स्टाइलो | Stylo | Stylosanthes Guianensis cv cook | N | L | Int |
| 14. | प्याउली घाँस | White Clover | Trifolium repens | Y | C | Int |
| 15. | केराउ | Pea | Pisum sativum | Y | C | Local/Int |
| **Non legumes forages** | | | | | | |
| 1. | अम्रिसो | Amriso | Thysal onaena maxima | N | C | Local |
| 2. | ब्लू पेनिक | Blue Panic | Panicum Antidotale | Y | L | Int |
| 3. | कक्स फूट | Cooks Foot | Dactylis Glomerata | N | L | Int |
| 4. | दिनानाथ | Deenanath Grass | Pennisetum Pedicellatum | N | WC | In t |
| 5. | डिम्चि | Dhimchhe (Mustang Local) | Pennisetum flaccidum | N | WC | Int |
| 6. | डुस | Dhus | Saccharum spp | N | L | Local |
| 7. | दुबो | Dubo | Cynodon dactylon | N | C | Local |
| 8. | गीनी घाँस | Guinea Grass (Buffalo grass) | Panicum maximum | N | C | Int |
| 9. | किकियु | Kikiyu | Pennisetum clandestinum | N | WC | Int |
| 10. | लोटस | Lotus, Maku | Lotus pedenculatus | N | L | Int |
| 11. | मोलासस | Molasses | Melinis minutiflora | N | C | Int |
| 12. | नेपियर | Napier NB-21 (Elephant Grass) | Pennisetum purpureum | N | WC | Int |
| 13. | जै | Oat | Avena sativa | Y | C | Int |
| 14. | पारा घाँस | Para Grass | Brachiaria mutica | N | C | Int |
| 15. | पास्पालम | Paspalum | Paspalum dialatatum | N | C | Int |
| 16. | बाज्रा | Pearl Millet (Bajra) | Pennisetum amricanum | N | WC | Int |
| 17. | फुर्के खर | Phurke Khar | A. nepalensis | N | C | Local |
| 18. | रोड्स | Rhodes Grass | Chloris gayana | N | L | Int |

| SN | घांसको नाम | Common Name | Genera | IT Annexing | Distribution frequency | Local/ introducing |
|---|---|---|---|---|---|---|
| 19. | राइ घाँस | Rye Grass | Lolium perenne | Y | L | Int |
| 20. | सेटेरिया घाँस | Setaria Grass | Seteria anceps | N | C | Int |
| 21. | सुडान घाँस | Sudan Grass | Sorghum sudanensis | Y | L | Int |
| 22. | टियोसेन्टी | Teosinte | Euchlaena maxicana | N | C | Int |
| 23. | नेपियर | Thin Napier | Pennisetum polystachyon | N | WC | Int |
| **Fodder trees** | | | | | | |
| 1. | बडहर | Badahar | Artocarpus lakoocha | N | C | Local |
| 2. | बैंस | Bains | Salyx babylonica | N | C | Local |
| 3. | बकाइनो | Bakaino | Melia azedarach | N | C | Local |
| 4. | बाँझ | Banj | Quercus glauca | N | L | Local |
| 5. | बारो | Barro | Terminalia bellerica | N | C | Local |
| 6. | बाँस | Bhans | Dendrocalamus sp | N | C | Local |
| 7. | भटमासे | Bhatmase | Flemingia congesta | N | C | Local/Int |
| 8. | चुलेत्रो | Chuletro | Brassaiosis spp | N | C | Local |
| 9. | दबदबे | Dabdabe | Garuga pinnata | N | C | Local |
| 10. | दुधिलो | Dhudhilo | Ficus nemoralis | N | C | Local |
| 11. | डुमरी | Dumri | Ficus glomerata | N | C | Local |
| 12. | गायो | Gayo | Bridelia retusa | N | C | Local |
| 13. | गीधरी | Gidhari | Premna Latifolia | N | C | Local |
| 14. | गोगन | Gogan | Saurauria nepalensis | N | C | Local |
| 15. | हररो | Harro | Terminalia chebula | N | C | Local |
| 16. | इपिल इपिल | Ipilipil | Leucaena leucocephala | N | C | Local |
| 17. | काभ्रो | Kabro | Ficus lacor | N | C | Local |
| 18. | कटुस | Katush | Castanopsis indica | N | L | Local |
| 19. | खनायो | Khanayo | Ficus cunia | N | C | Local |
| 20. | खस्रु | Khasru | Quercus semicarpifolia | N | L | Local |
| 21. | खन्यु | Khanue | Ficus semicordata | N | | Local |
| 22. | किम्बु | Kimbu | Morus alba | N | C | Local |
| 23. | कोइरालो | Koiralo | Bauhinia variegata | N | C | Local |
| 24. | कुटमिरो | Kutmiro | litsia polyantha | N | C | Local |

| SN | घांसको नाम | Common Name | Genera | IT Annexing | Distribution frequency | Local/ introducing |
|---|---|---|---|---|---|---|
| 25. | लहरे पिपल | Lahare Pipal | Populous ciliate | N | L | Local |
| 26. | निगालो | Nigalo | Arundinaria intermedia | N | L | Local |
| 27. | निमारो | Nimaro | Ficus roxburghii | N | C | Local |
| 28. | पाखुरी | Pakhuri | Ficus glaberrima | N | C | Local |
| 29. | फलेदो | Phaledo | Frythrina Arborescence | N | L | Local |
| 30. | पिपल | Pipal | Ficus relgoisa | N | C | Local |
| 31. | राइ खनियो | Rye Khanayo | Ficus semicordata | N | C | Local |
| 32. | साज | Saj | Terminalia alata | N | C | Local |
| 33. | सिन्दुरे | Sindure | Mallotus philippinensis | N | L | Local |
| 34. | टाँकी | Tanki | Bauhinia purpurea | N | C | Local |
| 35. | ठोट्ने | Thotane | Ficus hispida | N | C | Local |
| 36. | भिमल | Vimal | Grewia optiva | N | L | Local |

WC = Widely cultivated, L = Localized, C = Common, Int = Introduced, R = Rare, N = No, Y = Yes

## Appendix II. List of crops covered under the multilateral system (IT Annex I Crops)

### Food Crops = 52 genus (35 crops)

| SN | Crop | नेपाली | Genus | Species | Observations |
|---|---|---|---|---|---|
| 1. | Breadfruit | रामफल | Artocarpus | altilis Fosb. | Breadfruit only |
| 2. | Asparagus | कुरिलो | Asparagus | officinalis L. var. altilis L. | |
| 3. | Oat | जै | Avena | sativa L. | |
| 4. | Beet, Mangelwargel | चुकन्दर | Beta | vulgaris L. | |
| 5. | Brassica complex | | Brassica | | Comprises oilseed and vegetable crops (cabbage, apeseed, mustard, cress, rocket, turnip |
| 6. | | | Armoracia | | |
| 7. | | | Barbarea | | |
| 8. | | | Camelina | | |
| 9. | | | Crambe | | |
| 10. | | | Diplotaxis | | |
| 11. | | | Eruca | | |
| 12. | | | Isatis | | |
| 13. | | | Lepidium | | L. meyenii is excluded |
| 14. | | | Raphanobrassica | | |
| 15. | | | Raphanus | | |
| 16. | | | Rorippa | | |
| 17. | | | Sinapis | | |
| 18. | Pigeon Pea, red gram, cajan pea, congo pea, no-eye pea | रहर | Cajanus | cajan L. Huth | |
| 19. | Chickpea, gram, garbanzo | चना | Cicer | arietinum L. | |
| 20. | Citrus | | Citrus | | |
| 21. | Citrus | | Poncirus | | As rootstock |
| 22. | Citrus | | Fortunella | | As rootstock |
| 23. | Coconut | नरिबल | Cocos | nucifera L. | |
| 24. | Major aroids, cocoyam, taro, arum | कर्कलो, पिण्डालू | Colocasia | antiquorum Schott. Var. esculenta | Taro, cocoyam, dasheen and tannia |
| 25. | Dasheen | गवा | Colocasia | esculenta L. Schtt. | ? |
| 26. | Major aroids | | Xanthosoma | | |
| 27. | Carrot | गाजर | Daucus | carota L. var. sativa DC. | |
| 28. | Yams, greater yam, white yam | घर तरुल | Dioscorea | alata L. | |
| 29. | Finger Millet, Agrican Millet, Bird's food millet | कोदो, मरुवा | Eleusine | coracana L. Gaertn. | |

| SN | Crop | नेपाली | Genus | Species | Observations |
|---|---|---|---|---|---|
| 30. | Strawberry, alpine strawberry | भूई ऐंसेलु | Fragaria | nubicola Lindl. Ex Lacaita | |
| 31. | Sunflower | तारामण्डल, सूर्यमुखि | Helianthus | annus L. | |
| 32. | Barley | जौ | Hordeum | vulgare L. | |
| 33. | Sweet potato | सखरखण्ड | Ipomoea | batatas L. Lam. | |
| 34. | Grass pea, chuckling vetch jarosse | खेसारी | Lathyrus | sativus L. | |
| 35. | Lentil | मुसूर | Lens | culinaris Medic. | |
| 36. | Apple | स्याउ | Malus | ? | Pyrus malus L. |
| 37. | Cassava, Tapioca, Manioc | सिमल तरुल | Manihot | esculenta Crantz | |
| 38. | Banana, Plantain, Adam's flag | केरा | Musa | paradisiacal L. | Except M. testilis |
| 39. | Rice, Paddy plant | धान, चामल | Oryza | sativa L. | |
| 40. | Pearl Millet | वाजरा | Pennisetum | typhoidis L.C. Rich. | |
| 41. | Beans | असारे सिमि, डालो सिमि | Phaseolus | vulgaris L. | Except P. polyanthus<br>? |
| 42. | Pea, garden pea, | कला, केराउ, मटर | Pisum | sativum L. | |
| 43. | Potato | आलु | Solanum | tuberosum L. | |
| 44. | Rye | | Secale | | Section tuberosa included, except S. phureja |
| 45. | Eggplant, brinjal, aubergine, guinea squash | भाण्टा, वैगुन | Solanum | melongena L. | |
| 46. | Sorghum, great millet | जुनेलो | Sorghum | vulgare Pers. | |
| 47. | Triticale | | Triticosecale | | |
| 48. | Wheat | गहूँ | Triticum | aestivum L. | |
| 49. | Wheat | | Agropyron | | |
| 50. | Wheat | | Elymus | | |
| 51. | Wheat | | Secale | | |
| 52. | Faba Bean, Vetch, broad bean, horse bean | बकुला | Vicia | faba L. | |
| 53. | Cowpea et al. | बोडि | Vigna | unguiculata L. Walp. | |
| 54. | Maize, Indian corn | मकै | Zea | | Excluding Z. perennis, Z. diploperennis and Z. lusurians |

## Forages = 81 species (29 forage crops)

| SN | Forage | नेपाली | Genus | Species |
|---|---|---|---|---|
| **Legume forages** | | | | |
| 1. | | | Astragalus | chinensis |
| 2. | | | Astragalus | cicer |
| 3. | | | Astragalus | arenarius |
| 4. | Sword bean | तरवारे सिमि | Canavalia | ensiformis |
| 5. | | | Coronilla | varia |
| 6. | | | Hedysarum | coronarium |
| 7. | | | Lathyrus | ciera |
| 8. | | | Lathyrus | ciliolatus |
| 9. | | | Lathyrus | hirsutus |
| 10. | | | Lathyrus | ochrus |
| 11. | Sweet pea | केराउ फुल | Lathyrus | odoratus |
| 12. | Grass pea, chickling vetch jarosse | खेसरि | Lathyrus | sativus |
| 13. | | | Lespedeza | cuneata |
| 14. | | | Lespedeza | striata |
| 15. | | | Lespedeza | stipulacea |
| 16. | | नखर सिम्बी | Lotus | corniculatus |
| 17. | | | Lotus | subbiflorus |
| 18. | | | Lotus | uliginosus |
| 19. | | | Lupinus | albus |
| 20. | | | Lupinus | angustifolius |
| 21. | | | Lupinus | luteus |
| 22. | | | Medicago | arborea |
| 23. | Yellow Lucerne, falcate Lucerne, yellow clover | भिरिन साग, कोते मान्द्रो | Medicago | falcata |
| 24. | | | Medicago | sativa |
| 25. | | | Medicago | scutellata |
| 26. | | | Medicago | rigidula |
| 27. | | | Medicago | truncatula |
| 28. | | | Melilotus | albus |
| 29. | | | Melilotus | officinalis |
| 30. | | | Onobrychis | viciifolia |
| 31. | | | Ornithopus | sati vus |
| 32. | | | Prosopis | affinis |
| 33. | | | Prosopis | alba |
| 34. | | | Prosopis | chilensis |
| 35. | | | Prosopis | nigra |

| SN | Forage | नेपाली | Genus | Species |
|---|---|---|---|---|
| 36. | | | Prosopis | pallid |
| 37. | Tropical kudzu | कडुजु धास, विदारि लहरो | Pueraria | phaseoloides |
| 38. | | | Trifolium | alesandrinum |
| 39. | | | Trifolium | alpestre |
| 40. | | | Trifolium | ambiguum |
| 41. | | | Trifolium | angustifolium |
| 42. | | | Trifolium | arvense |
| 43. | | | Trifolium | agrocicerum |
| 44. | | | Trifolium | hybridum |
| 45. | | | Trifolium | incarnatum |
| 46. | | | Trifolium | pretense |
| 47. | White clover, ladino | प्याउलि, बेउलि | Trifolium | repens |
| 48. | | | Trifolium | resupinatum |
| 49. | | | Trifolium | rueppellianum |
| 50. | | | Trifolium | semipilosum |
| 51. | | | Trifolium | subterraneum |
| 52. | | | Trifolium | vesiculosum |
| **Grass forages** | | | | |
| 1. | | | Andropogon | gayanus |
| 2. | | | Agropyron | cristataum |
| 3. | | | Agropyron | desertorum |
| 4. | | | Agrostis | stolonifera |
| 5. | | | Agrostis | tenuis |
| 6. | | | Alopecurus | pratensis |
| 7. | | | Arrhenatherum | elatius |
| 8. | | | Dactylis | glomerata |
| 9. | | | Festuca | arundinacea |
| 10. | | | Festuca | gigantea |
| 11. | | | Festuca | heterophylla |
| 12. | | | Festuca | ovina |
| 13. | | | Festuca | pratensis |
| 14. | | | Festuca | rubra |
| 15. | | | Lolium | hybridum |
| 16. | | | Lolium | multiflorum |
| 17. | | | Lolium | perenne |
| 18. | | | Lolium | rigidum |
| 19. | | | Lolium | temulentum |

| SN | Forage | नेपाली | Genus | Species |
|---|---|---|---|---|
| 20. | | | Phalaris | aquatica |
| 21. | | | Phalaris | arundinacea |
| 22. | | | Phleum | pratense |
| 23. | | | Poa | alpine |
| 24. | | | Poa | annua |
| 25. | | | Poa | pratensis |
| 26. | | | Tripsacum | laxum |
| **Other forages** | | | | |
| 1. | | | Atriplex | halimus |
| 2. | | | Atriplex | nummularia |
| 3. | | | Salsola | vermiculata |

# Index

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This book,well researched, masterly explains the importance of plant genetic resources for food and agriculture (PGRFA) at global, regional and national levels. The interlinked chapters provide the necessary evidence for the creation of policy and legal space required to effectively implement the International Treaty on Plant Genetic Resources for Food and Agriculture and its multilateral system in particular. The book can also be used to create awareness and stimulate national interest in the global PGRFA system. I highly recommend the book to all countries, especially developing countries, as a useful resource to design a systematic process for the implementation of the ITPGRFA and to strengthen national capacities for the conservation and sustainable utilization of plant genetic resource for food and agriculture.

Godfrey Mwila, Deputy DirectorTechnical Services,
Zambia Agriculture Research Institute, Ministry of Agriculture,
Chair of the Second Session of the Governing Body of the ITPGRFA.

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This book pays in-depth attention to the plant genetic resources richness of Nepal, ways to maintain and further use that richness in the face of climate change, and the role that smallholder farmers play in maintaining and using diversity for national food and nutritional security. The book also provides an exemplary analysis of how the International Treaty on Plant Genetic Resources for Food and Agriculture can and should be made to work at the national and local levels. In doing so, it highlights the need to strengthen Farmers' Rights. I recommend the book to all those involved or interested in strengthening smallholder agricultural production systems and to others who wish to use the Treaty as an instrument to maintain agricultural biodiversity and improve smallholder livelihoods.

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