

# Progress and Prospects of Agricultural Biotechnology and Biosafety in Nepal: Present Status, Challenges and Way Forward

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## Abstract

*Genetic engineering has been considered as the most advanced technology for increased productivity. However, issues have been raised against this technology and their products pertaining to risk to humans and biodiversity. To minimize the risk associated with Genetically Modified Organisms (GMOs), the Government of Nepal approved the National Biosafety Framework comprising Biotechnology Policy in 2006. Both framework and policy need to be implemented more effectively. None of the GMOs and their products has been reported in Nepal and most of the legal documents have a provision of regulating GMOs and allowed for research. Tissue culture (particularly micro-propagation) and DNA marker technology have been utilized to advance agriculture in more than 15 institutes. The major challenge in biotechnology research is dependency for requirements of biotechnological research including genetic materials on foreign countries. Policy restricts the direct entry of GMOs and their products; however there is high risk of entry of GMOs and their products from India and China. Genetic engineering has been poorly understood by most of the Nepali people and therefore, education or training is the prime concern for initiating R&D on GMOs. Research on GMOs should be started in confined areas (controlled structures) along with developing a clear roadmap for research and development using genetic engineering.*

**Keywords:** Agricultural biotechnology, GMO, biosafety regulation, biotechnology policy, food safety

## 1. Introduction

Agriculture remains the life of Nepali people. Until 1980s Nepal was a food self-sufficient country. As population has increased and different agricultural technologies made available, Nepal has become a food and nutrition insecure country. The government of Nepal has given high priority to agriculture since the third Five Year Plan (1975-80) to address food and nutrition security. About 71,387 tons of food in 2015 was deficit in Nepal and 35 districts (MoAD, 2016) are food deficit. Nepal ranked 72<sup>nd</sup> among 119 countries in Global Hunger Index (GHI) with GHI value of 21.1 (<https://www.globalhungerindex.org/nepal.html>). Nepal is rich in agrobiodiversity; however, she depends about 95-100% on foreign

germplasm for agricultural research (Joshi et al., 2016). With the objective of increasing productivity and sustainable management of agrobiodiversity, Government of Nepal has approved many international movements, agreements, and developed and introduced different agricultural technologies.

The Convention on the Biological Diversity (CBD) was ratified by Nepalese parliament on 23 November 1993 and enforced in Nepal since 21 February 1994. As a party to CBD, Nepal has made its commitment to biosafety by signing the Cartagena Protocol on Biosafety on 2 March 2001. The main objective of the protocol is to pay special attention to the transboundary movement of GMOs, produced by using modern biotechnology, because of its trade between nations, and regulate the export and import of such goods only based on the advanced informed agreement. Nepal also ratified ITPGRFA 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.

Nepal is located between India and China (Figure 1) with a total area of 147181 km<sup>2</sup>. Topographically there are three Agro-ecological zones, 35% is mountain, 42% is hill and 23% is lower flat land, also known as Tarai. The total cultivated agricultural land is 30, 91,000 ha (21%) and 10, 30,000 ha (7%) is uncultivated agricultural land. The best strategy for increased food production is vertical expansion for which genetic enhancement is needed. Biotechnology has the potential to address problems not solved by conventional agricultural research. In addition, biotechnology may speed up research processes and increase research precision. Owing to the development of biotechnology in the global scenario and richness of diversity in plant genetic resources in Nepal, there is a great potential of using biotechnology tools for increasing food production and promoting sustainable agriculture. Tissue culture has been applied in agriculture since 1989 and DNA marker technology since 2000 (Joshi 2017) in Nepal. Genetic engineering, though one of the most debatable technologies is considered most important for food and nutrition security. There are many things to do for making the environment conducive for research on genetic engineering and biosafety framework is one among them.

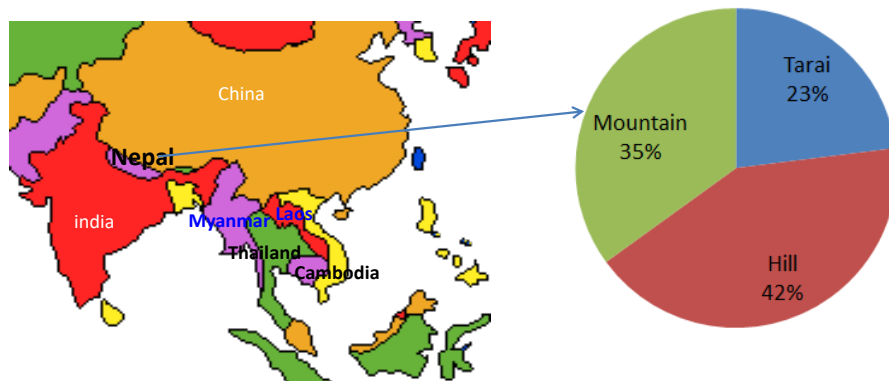


Figure 1. Location of Nepal in South Asia and areas under three agro-ecological zones.

Source: MoAD, 2014

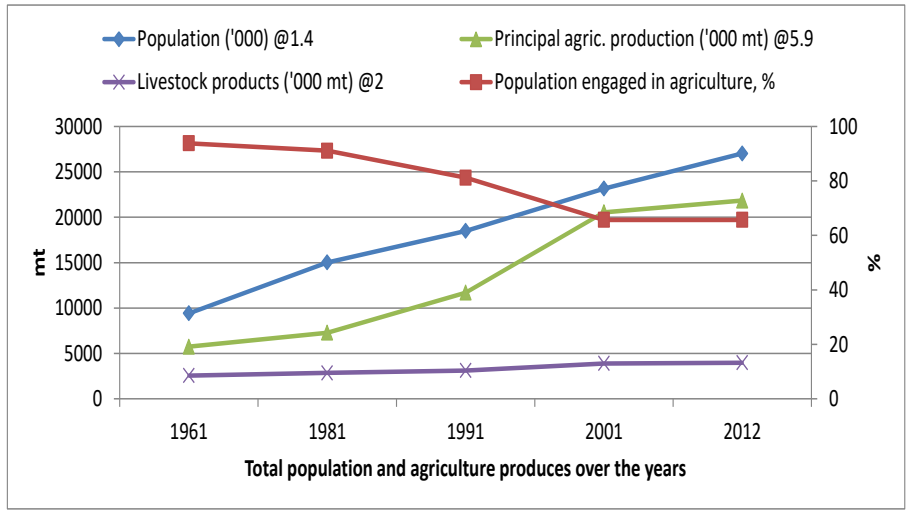
## 2. Agricultural Scenario and Status of Agricultural Biosafety and Biotechnology

### 2.1. Agricultural Scenario

Despite many efforts, the rate of country's economic growth has remained slow (<4% after 2007), and the Human Development Index (0.574) and Gender Inequality Index (0.480) were below the South Asian average in 2017 (UNDP, 2018). The population growth rate is 1.4% per year with a growth rate of 5.9% per year for principal agriculture production (Figure 2). The economy of Nepal is very much dependent on the use of natural resources, including agricultural lands, forests, water resources and protected areas. Share of agricultural sector in the national GDP (NRs. 1,789,767 million) is 32.6% (MoAD, 2014). Agriculture is the primary occupation for a vast majority of the people and remains the country's principal economic activity. About 21% (3.2 million hectares) of the total land area of Nepal is used for cultivation and the principal crops are rice (45%), maize (20%), wheat (18%), millet (5%) and potatoes (3%), followed by sugarcane, jute, cotton, tea, barley, legumes, vegetables and fruits (MoAD, 2014).

Agriculture in Nepal is characterized by very small land holdings scattered to different plots, where high input agriculture is difficult to adopt. Land size owned by farmers is the most important economic asset for food and nutrition security. Sixty five percent of the population in Nepal is engaged in Agriculture (MoAD, 2014), though the average size of land owned by the household is only 0.7 ha (CBS, 2013). Holding without land is 3% and 10% of the land-owning households have less than 0.1 ha and 53% of the land-owning households have less than 0.5 ha (CBS, 2013).

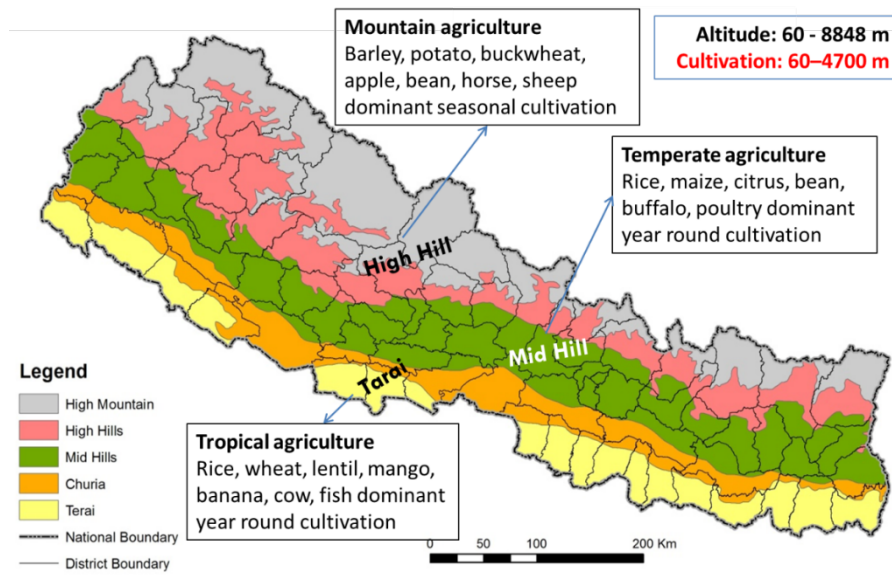
The practices of agriculture (cultivation of crops) range from 60 M to 4700 M altitude in Nepal (Joshi et al., 2017). Nepal experiences a wide range of climatic variation and broadly there are three agro-ecological zones, namely High Hill (mountain agriculture), Mid Hill (Temperate agriculture) and Tarai (Tropical agriculture) (Figure 3). High Hill is located in more than 2,000 m altitude and covers an area of 51,817 km<sup>2</sup>. Only 9% of the area is used for agriculture and the rest belongs to other categories. Hence, only a small proportion of the population dwells in this zone. The agriculture is livestock based with little cropping. Conditions are extreme and food deficits are common.



**Figure 2. Total population and agriculture production over the years.**

Source: MoAD, 2013

Mid Hill is located between 330-2,000 m altitudes and covers an area of 61,345 km<sup>2</sup>. It has around 42% of the agricultural land. The area is characterized by high ridges and steep slopes around numerous streams giving rise to many microclimates. The Hill accounts for about 50% of the population. Tarai is located in less than 330 m altitude and covers an area of 34,019 km<sup>2</sup>. Around 66% of the total land is under cultivation. Since, this zone alone produces 60% of the total food production in the country it is known as the granary of Nepal. About 45% of the total population dwells in Tarai. Over 33% of the arable land is irrigated.



**Figure 3. Three agro-ecological zones based agriculture and dominant crops and livestock in Nepal.**

Source: Joshi et al 2017

## 2.2. Agricultural Biosafety

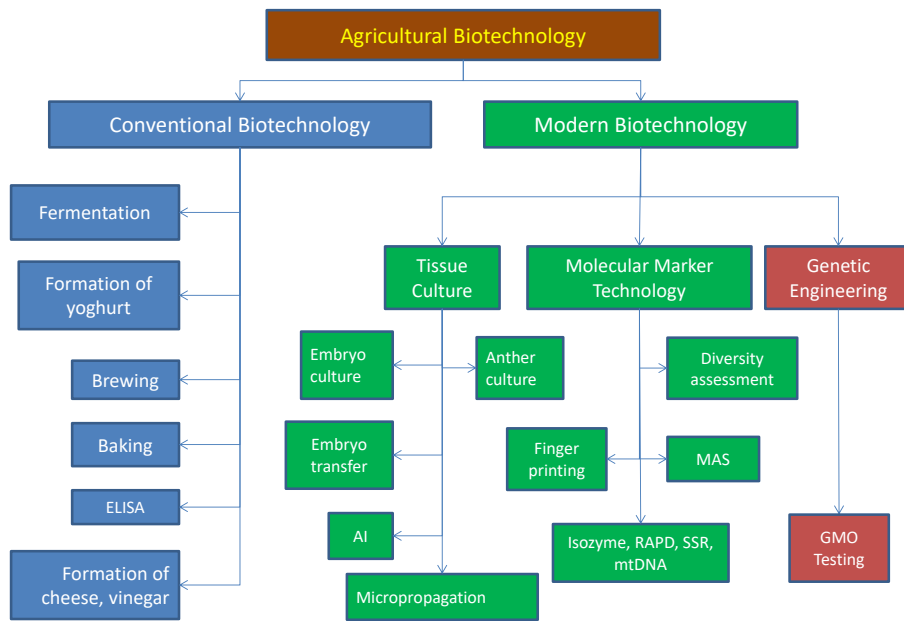
Biosafety Guidelines 2004 have been developed and these guidelines focus on regulating laboratory safety and GMO safety. These guidelines point out the step by step processes for release of GMOs or their products in the environment by taking due precaution, prior to releasing GMO or products. Further progress for the implementation of this guideline is not available. National Biosafety Framework 2006 authorizes the concerned agencies for regulatory measures and guidelines to avoid or minimize potential risks of genetically modified (GM) plants and their products, GM microorganisms and their products and GM animals and their products. Though, it has not been effectively implemented. Probably this situation occurs because of non-existence of any GMOs and their products in the country. Nepal's biosafety policy is to contribute to poverty alleviation through the development and application of biotechnology in sectors where comparative benefits can be achieved.

## 2.3. Agricultural Biotechnology

Existing agricultural biotechnology tools that are being used in Nepal are depicted in Figure 4. There are three broad categories under modern biotechnology. Among these, tissue culture is the popular one and both private sector and public sector institutes are using this technique. DNA marker technology is limited only to assess genetic diversity. Most of the Master and

PhD level students of agricultural science include marker technology for their thesis. Results of markers profiles have not been further used in breeding and crop improvement program. Some of the products of biotechnology that farmers are getting benefits are virus-free potato, banana and greening free citrus saplings. DNA marker-based products mainly in rice, wheat and potato have been tested and evaluated in collaboration with IRRI, CIMMYT and CIP. After extensive testing, IRRI bred rice varieties tolerant to submergence (Swarna Sub-1 and Samba Masuli Sub-1) and drought tolerant varieties (Sukha Dhan 1 to 6) were released in Nepal. These rice varieties were developed following Marker Assisted Selection (MAS) in IRRI. Biotechnological tools are also used in livestock and fish research and details of tools and species are given in Table 1.

Among the modern biotechnological tools, artificial insemination (AI) was the first tool used in Nepal in 1952 followed by tissue culture in 1976 (Figure 5). Major initiatives are sand rooting in 1988, virus-free potato production in 1989, DNA marker technology in 2002, GMO testing in 2005, biosafety and policy formulation in 2006 and conservation biotechnology in 2012. Different approaches have been applied for conservation of agricultural genetic resources in Nepal and they are categorically explained in Figure 6.



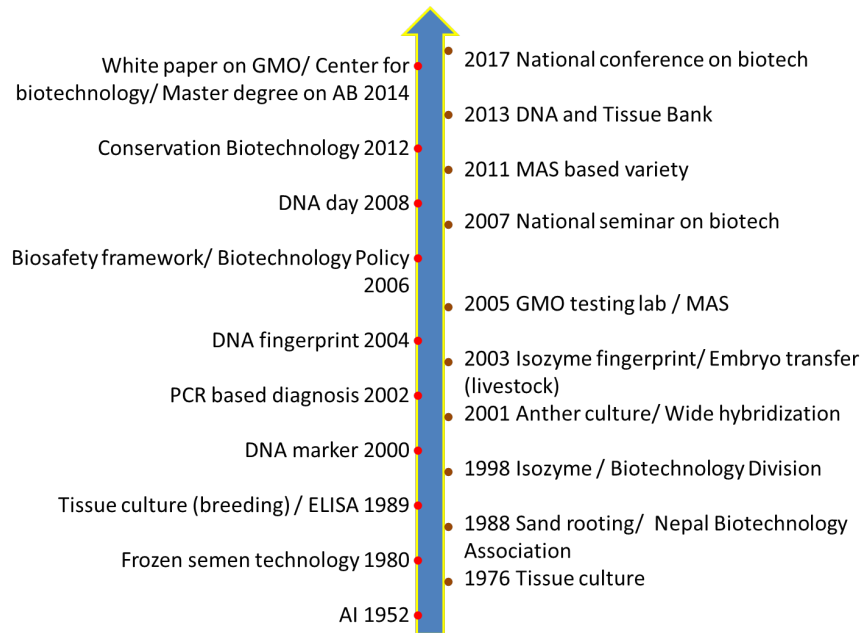
**Figure 4. Agricultural biotechnological tools using in Nepal under conventional and modern biotechnology.**

Adapted: Joshi, 2017

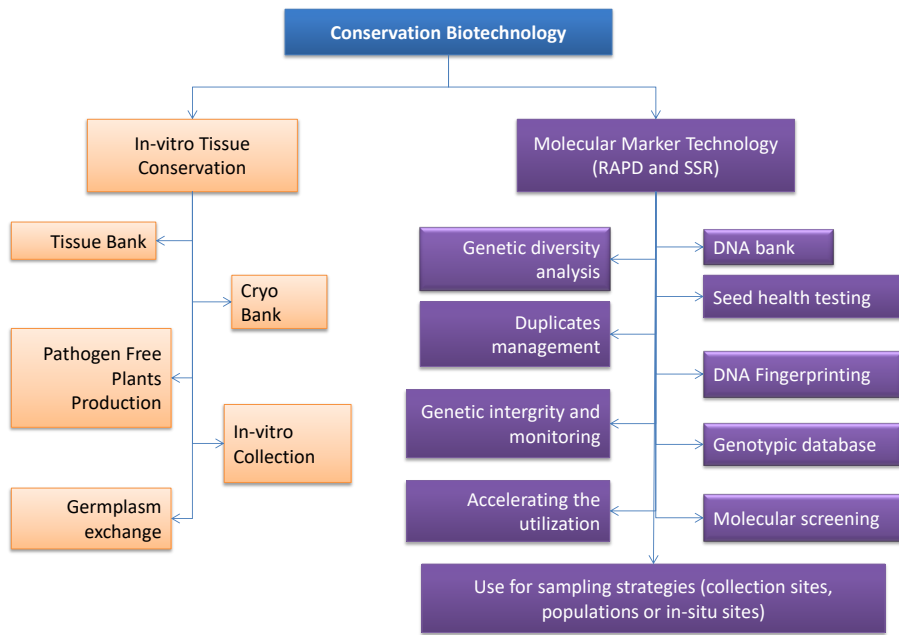
**Table 1. Biotechnological tools and their application in different species in Nepal**

SN	Biotechnological tool	Applied species
<b>Crop</b>		
1.	Anther culture	Rice, wheat
2.	Micropropagation	Sugarcane, potato, banana, citrus, cardamom
3.	MAS	Rice, wheat, maize, potato, buckwheat,
4.	RAPD	Wild buckwheat, tite buckwheat, cardamom chayote, finger millet
5.	SSR	Rice, barley, maize, upland rice, wheat, finger millet, rice bean, citrus, bean, jute, soybean
6.	GMO testing	Maize, soybean
7.	Isozyme	Mango, barley, rice, pigeon pea, taro, swertia, tite buckwheat, citrus, wild rice
8.	KASP	Rice
9.	Embryo rescue and culture	Wheat x maize, rice, buckwheat
10.	DNA bank	Rice, wheat, rice bean, maize, chayote, garlic, cardamom, mango, buckwheat, finger millet
11.	Tissue bank	Potato, sweet potato, citrus, cardamom, sugarcane
<b>Livestock and fish</b>		
12.	Marker based disease diagnosis	Farm animals and poultry
13.	Embryo transfer	Cattle
14.	mtDNA	Cattle, buffalo, goat, sheep, yak, pig, poultry
15.	RAPD	Poultry
16.	SSR	Buffalo, wild buffalo, cattle, fish
17.	Isozyme	Fish, goat
18.	AI	Cattle, sheep, pig, buffalo, goat
19.	eDNA	Fish
20.	Cryo bank	Cattle, goat, pig

Source: Joshi et al., 2009; Joshi, 2017; NAST and MoEST, 2008



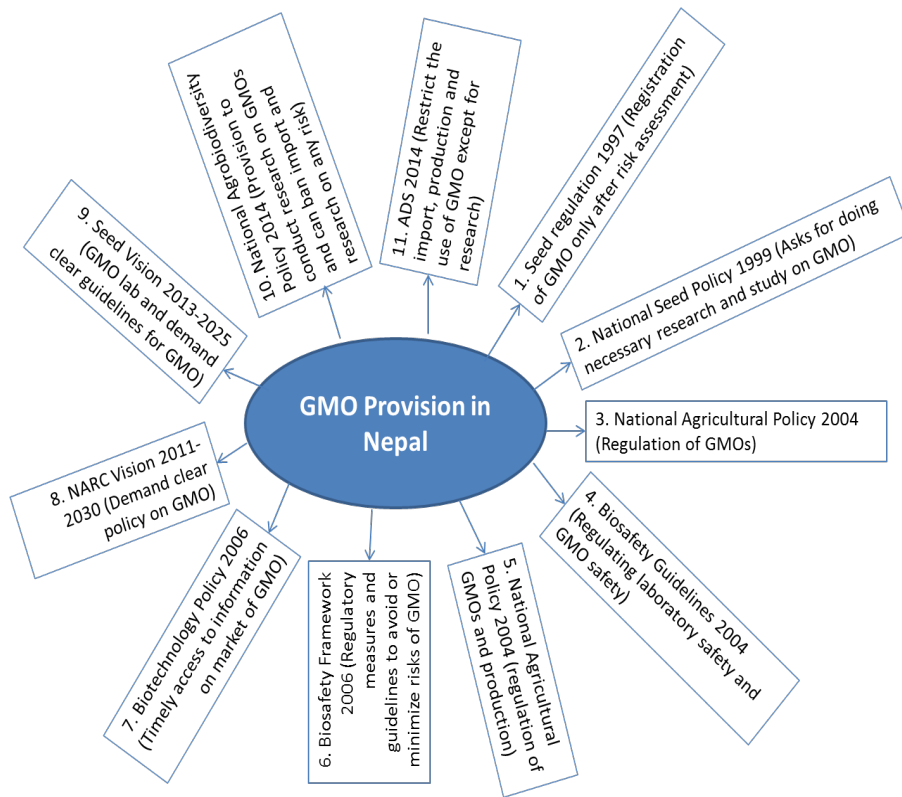
**Figure 5. Major biotechnological events in Nepal.**



**Figure 6. Potential use of biotechnological tools for conservation of agro biodiversity.**

Source: Joshi, 2017

There are more than 15 policies, acts, regulations and strategies and action plans that have considered biotechnology as an important tool for effectively and efficiently achieving the targets. Eleven such legal documents have mentioned GMOs (Figure 7). All these documents have provisions of regulating GMOs and their products. There is no restriction for research on GMOs and their products. Nepal Agricultural Research Council's (NARC) Vision 2011-2030 has considered biotechnology as one of five broad based thematic areas of interventions. In Biotechnology Policy 2006 (MoEST, 2006), increment of production and productivity through the biotechnological research, development and technology transfer is expected. Identified priority areas are tissue culture and plant improvement. This does not specifically spell more on agriculture biotechnology, rather is an umbrella policy for similar works across several other sectors. The National Wetland Policy 2002 has emphasized on taking concrete steps in banning unwarranted entry of alien GMOs.



**Figure 7. Legal documents about GMOs along with provisions.**

The objectives of Biotechnology Policy 2006 are to (i.) Conduct study and research to develop GMOs and transgenic plants employing genetic engineering and tissue culture technology; (ii.) Obtain permission to import

GMO and transgenic seeds only after verification report of authorized government agencies on biosafety through study and research activities; and (iii.) Formulate biosafety regulation as suitable to the situation in Nepal.

Biotechnology Coordination Committee (BCC), National Biotechnology Research and Development Centre (NBRDC), and National Biotechnology Central Laboratory (NBCL) have been visualized in the policy. Under NBRDC, a Biotechnology Scientific Committee will be established. Other provisions are to establish one-window system for transportation, import and export of biotechnology-based production; to set up a fund at national-level in order to promote research and development of biotechnology; to obtain membership of the International Centre for Genetic Engineering and Biotechnology (Nepal is a signatory country now) and establish relation with regional and international organizations.

### **3. Biosafety Regulatory Policy and Framework**

A regulatory mechanism has been developed on biosafety in line with CBD to manage or control the risks related to hazardous chemicals and GMOs. National plan of action for biotechnology was formulated as part of Biotechnology Policy 2006. This plan is not in existence anymore. In the past, it was planned to establish a National Biotechnology Center to promote research and development in agriculture, health, environment and industry by Nepal's Ministry of Science and Technology, but it could not be implemented.

Currently, there are Biosafety Guidelines 2004 (MoFSC, 2005) and National Biosafety Framework 2006 (MoFSC, 2006) in Nepal for regulating GMOs and their risk. The guidelines are focused on regulating laboratory safety and GMO safety. This has come up with an agreement with the Nepal Government ratifying the Cartagena Protocol on Biosafety 2000 on March 2001.

National Biosafety Framework 2006 authorizes the concerned agencies to develop regulatory measures and guidelines to avoid or minimize potential risks of genetically modified (GM) plants and their products, GM microorganisms and their products and GM animals and their products. The framework is applicable to the development, production, contained use, field test, intentional introduction into the environment, and import and export of GMOs that may have an adverse effect on the conservation and sustainable use of biological diversity, and environment taking also into account the risks to human health. The framework covers the existing or potential use of GMOs in laboratory or in an open space; human health, biodiversity, natural environment, agricultural products, foods and drinking products, animal feed and areas of sewerage management; regulation of experiment, flow of information, review, assessment of risks including socio-economic and ethical effects; monitoring of import and export, laboratory and field test; research

and development in academic and industrial sectors; safety of the place where functions relating to GMOs are carried out; public participation on the issues of modern biotechnology and biosafety.

Scope of risk assessment is risk to environment from the use of GMOs, and risk from the consumption of food containing GMOs. The risks of GMOs or products thereof have been classified into four levels as follows:

Level 1: No risk to human health, biological diversity and environment.

Level 2: Low risk to human health, biological diversity and environment.

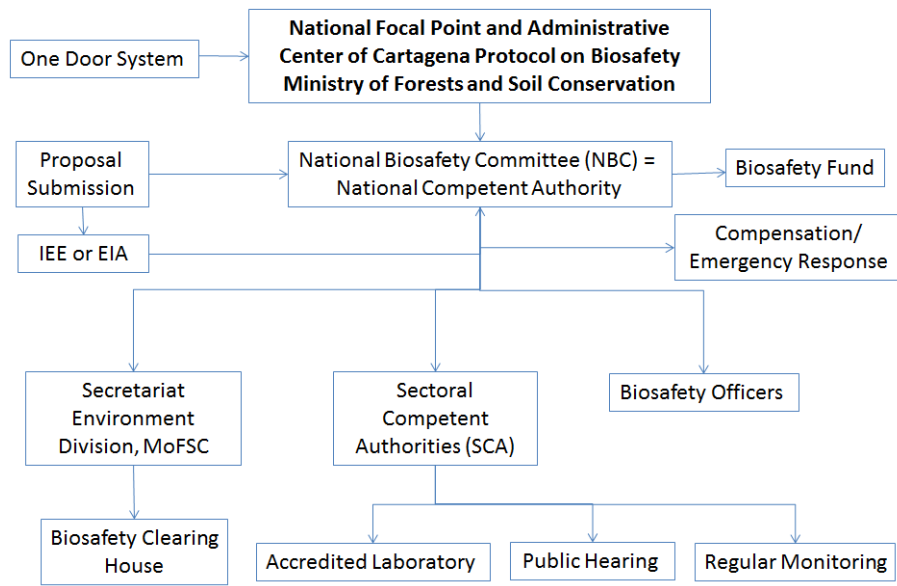
Level 3: Medium risk to human health, biological diversity and environment.

Level 4: High risk to human health, biological diversity and environment.

The technical framework of biosafety mainly covers the scientific research and testing of seed, plants, food, feed and animals with GMOs, which may be imported or produced within the country. The tests aim to identify the components of GMOs and identify whether the tested GMOs pose any adverse risks to biological diversity and human health. On these grounds, decision will be made whether to allow or restrict the import of the tested GMOs.

The provisional mechanism in the framework is depicted in Figure 8. Nepal has made provision of National Focal Point of CBD and Biosafety Clearing House (BCH), for Ministry of Forest and Soil Conservation (MoFSC). In addition, Government of Nepal also formed National Biosafety Committee (NBC)/ National Competent Authority (NCA) and six Sectoral Competent Authorities (SCA) for effective monitoring and regulation of GM products. These competent authorities are supposed to fulfill the procedures in respective sectors as per prescribed process for the response of civil society and other stakeholders. The SCA evaluates a proposal on GMOs and products thereof, and the risk assessment report in consultation with experts. Any tests of the GMOs must be carried out in an accredited laboratory. The SCA submits its comments to the NCA. It is mandatory to submit biosafety report for registration of GMO seed and labeling of GMOs.

The functions of the NBC are to draft policies, guidelines, legislations, and cooperate with national and international bodies on biosafety, establish standards and procedures for risk assessment and labeling of GMOs, make decisions on all proposals on GMOs and products thereof. The NCA determines the biosafety standard and the GMOs Free Zone can be declared by publishing in the Nepal Gazette.



**Figure 8. Biosafety working mechanism envisaged in National Biosafety Framework 2006.**

Source: MoFSC, 2006

#### 4. Updates on Important Agri-biotech Products

GMOs have not been registered, introduced and grown in Nepal (Thapa, 2013). Research on genetic engineering (GMO, recombinant DNA technology) has not started yet. Many interactions and discussions though have been taking place across the country since 2000. Many tissue culture and DNA marker based agricultural products are available. Neither GMO nor GM foods are reported in the country. Some level of understating and efforts on following agri-biotech products are given below.

- a. Bt Cotton: Because of being a non-food crop and being widely grown in India, many growers and agriculturists are in favor of Bt cotton in Nepal. Bt cotton is considered safer than using pesticides. However, research has not been initiated.
- b. GM Mustard: There have been no discussions on GM mustard.
- c. Golden Rice: It is the most discussed GMO in Nepal. Some efforts were made to initiate research on it, but due to opposition and lack of proper policy, no progress was made.
- d. Late blight resistant potato: Late blight is one of the most devastating diseases of potato. Therefore, considerable efforts are being made to develop late blight resistant potato using conventional breeding. There

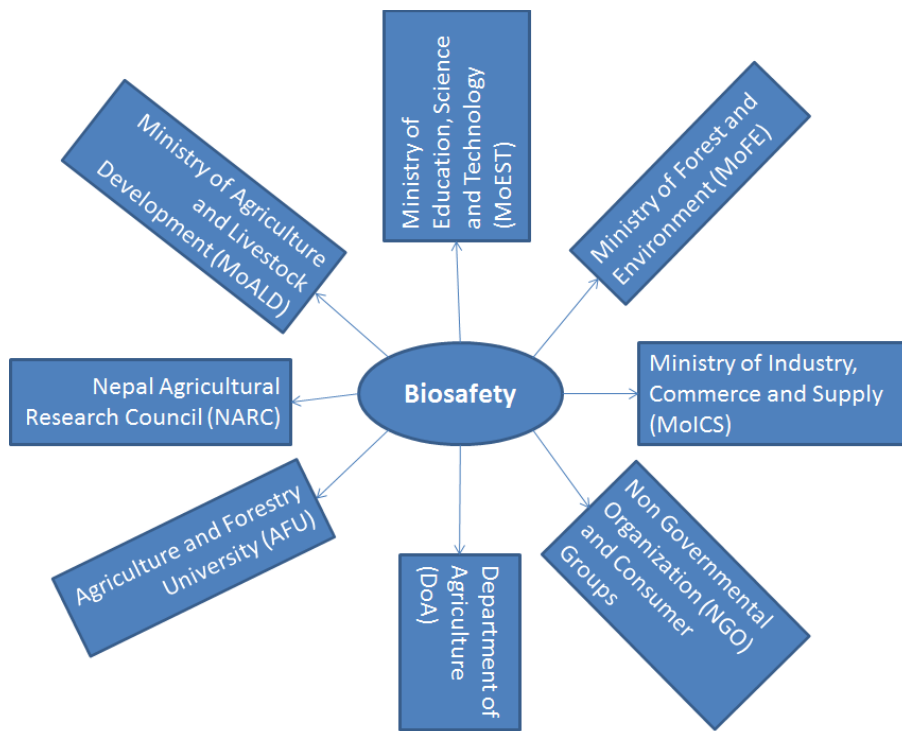
have been no discussions or activity regarding research on developing GM potatoes resistant to the disease.

- e. Iron fortified rice: World Food Program has initiated an awareness program in Nepal and it is expected that project on iron fortified rice will be implemented in 2019.

## **5. Harmonization Efforts**

Harmonization is the process of minimizing conflicting standards which may have evolved independently. The goal is to find commonalities and provide a common standard. All stakeholders in Nepal (Figure 9) are working closely with regards to biosafety. Regular discussions and interaction meetings are held to harmonize policy and regulation. Regular reviews of existing policy and regulation and subsequent revisions accordingly in the new documents are being practiced in Nepal. Currently, there are many acts and policies under formulation and revision, therefore, these acts and policies are not contradictory to the National Biosafety Framework.

- a. Food Safety Assessment: Department of Food Technology and Quality Control (DFTQC) is the organization for regulating food safety in the country. Expert teams regularly monitor the food quality based on existing guidelines. However, they do not have any lab and policy for GMO testing. Formally, foods have not been so far tested whether they are GMO based. Currently, Food Act is under revision and it is expected to cover GMOs.
- b. Environmental Risk Assessment (ERA) has not been started because of non-existence of GMOs. Ministry of Forest and Environment (MoFE), Ministry of Agriculture and Livestock Development (MoALD) and NARC are the relevant ministries and research organization for ERA. Forest Act 1993 and Environment Protection Act 1997 have provisions for environment impact assessment but do not contain regulations for GMOs.
- c. Import of Agricultural Biotechnology for Food, Feed and Processing: There is no legal provision for importing any agricultural biotechnology products for food, feed and processing. Import export act also needs to be revised for inclusion of GMOs.
- d. Food and Feed Products derived from Biotechnology: Food and feed products derived from technologies other than genetic engineering are being regularly imported following provision in regulation. Food related acts and policies need revision for inclusion of GMOs.



**Figure 9. Responsible organizations related to biosafety and working on harmonizing polices and agreements.**

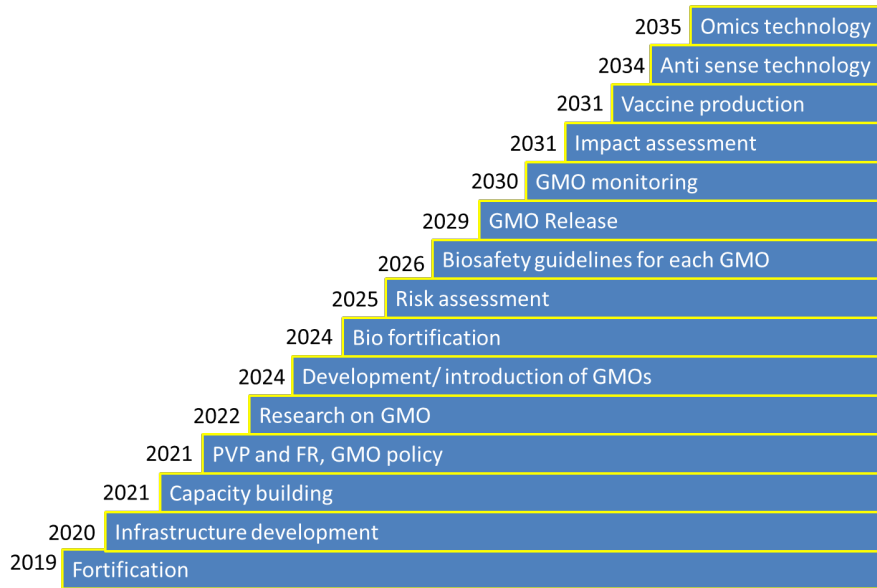
There are, however, some acts, policies, regulations and guidelines which were formulated before the Biosafety Framework. For example, acts relating to export, import, plant protection, food, feed, drug, national parks and wildlife protection, and aquatic animal protection have been formulated and enacted before the emergence of issues of modern biotechnology. The Seed Act need to be harmonized with GMOs related policies and guidelines.

## **6. Challenges and the Way Forward of Agricultural Biosafety**

Everything for biotechnology research needs to be imported from outside the country and it therefore becomes very costly. Nepal is very rich on agricultural genetic resources; however, their use in R&D is very poor. Both Biotechnology Policy and Biosafety Framework have not been effectively implemented. Biosafety covers only the GMOs but there are many cases of eroding local diversity through modern varieties. Farmers and consumers still have not experienced the benefits from biotechnological products. Steps should be taken to educate the public and make them aware of benefits and potential risks of GMOs. There is a high demand of budget for developing infrastructure and capacity development. Mechanism is necessary to setup one window system for the transport, import and export of biotechnology

products especially GMOs. Before releasing any GMOs for certain areas, all the local genetic resources should be conserved. Another challenge is the implementation of Biosafety Framework and Biotechnology Policy, and initiation of research on genetic engineering as these framework and policy are under the Ministry of Forestry and Environment, and Ministry of Education, Science and Technology respectively, but MoALD and NARC are the implementing organizations.

Road map for overall development of agricultural biotechnology in the country is given in Figure 10. Awareness programs need to be extensively organized across the country. There should be enough facilities and capable human power. All necessary acts, policies, regulations and guidelines should be in place. Evidences with respect to risk and advantage of genetic engineering should be generated within the country. Major focus on developing trained human resources, well-equipped laboratories and operational procedures is needed. Strong support is necessary from respective quarantine and custom offices along with strengthening such offices. At the regional level, access and benefit sharing standards for GM germplasm should be developed. An information portal for free exchange of biosafety and biotech information within South Asian Association for Regional Cooperation (SAARC) needs to be developed. Provisions should be made to use GMO related data generated by other countries. SAARC standard for biosafety and genetic engineering needs to develop along with the provision of capacity enhancement and SAARC road map preparation.



**Figure 10. Roadmap for advancing agricultural biotechnology in Nepal.**

## 7. Conclusion

Nepal is far behind on implementation of biosafety and genetic engineering. Because of open border both in south and north, there is a high risk of GMOs and their products entering the country. Low productivity and insecure food and nutrition in the country demand the adoption of genetic engineering technology that could develop high yielding, nutrition dense and climate resilient genotypes. GMOs are poorly understood by consumers, farmers, policy makers and agriculturists. Research should therefore be started on GMOs after establishing controlled environments and developing manpower. Biosafety framework and biotechnology policies are in place however, further acts, policy, regulations, directives and guidelines on genetic engineering and their products are necessary to be developed. Advantages of genetic engineering have not been experienced so far by farmers, consumers and researchers. Initiatives need to be taken to establish facilities so that research could be carried out on GMOs.

## 8. References

- CBS. 2013. *National Sample Census of Agriculture Nepal 2011/12, National Report*. Central Bureau of Statistics, National Planning Commission Secretariat, Government of Nepal, Kathmandu.
- Joshi BK, Acharya AK, Gauchan D, Bhatta MR. 2017. Agrobiodiversity status and conservation options and methods. In Joshi BK, KC HB, Acharya AK. Editors. *Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal*. Proceedings of 2nd National Workshop, 22-23 May 2017, Dhulikhel (pp. 21-38). NAGRC, FDD, DoA and MoAD; Kathmandu, Nepal. [http://moad.gov.np/public/uploads/855517450-Plant%20Genetic%20Resources\\_CUAPGR\\_Nepal-min.pdf](http://moad.gov.np/public/uploads/855517450-Plant%20Genetic%20Resources_CUAPGR_Nepal-min.pdf)
- Joshi BK, Bimb HP, Upadhyay MP. 2009. Status and prospects of agricultural biotechnology for crop improvement and management in Biotechnology Unit-NARC. In *Proceedings of the National Seminar on Present Status and Future Prospects of Biotechnology in Nepal*, 14-15 March 2007 (pp.21-36). NAST and MOEST, Kathmandu.
- Joshi BK, Bhatta MR, Ghimire KH, Chaudhary P, Singh D. 2016. Mapping and measuring the flow and interdependence of plant genetic resources. In Joshi BK, Chaudhary P, Upadhyay D, Vernooij R. Editors. *Implementing the International Treaty on Plant Genetic Resources for Food and Agriculture in Nepal: Achievements and Challenge* (pp. 28-52). LIBIRD, Pokhara; NARC, MoAD, Kathmandu and Bioversity International, Rome; Nepal. <https://www.bioversityinternational.org/e-library/publications/detail/implementing-the-international-treaty-on-plant-genetic-resources-for-food-and-agriculture-in-nepal/>
- Joshi BK. 2017. Biotechnology for conservation and utilization of agricultural plant genetic resources in Nepal. *Journal of Nepal Agricultural Research Council*, 3:49-59. DOI: <http://dx.doi.org/10.3126/jnarc.v3i1.17276>.

- Mahto BN, Joshi BK, Dhital SP, Ghimire TB, Gorkhali NA, Khanal DR, Magar PB. 2018. Country Status Report –Nepal. In Tyagi RK, Anitha K, Agrawal A, Varaprasad KS, Khetarpal RK. Editors. *Regional Expert Consultation on Agricultural Biotechnology - Scoping Partnership to Improve Livelihoods of Farmers in Asia- Pacific* (Strategic Papers and Country Status Reports, 29-31 May 2018 (pp.150-160). Asia-Pacific Association for Agricultural Research Institutions (APAARI), Bangkok, Thailand.
- MoAD. 2013. *Statistical information on Nepalese agriculture 2012/13*. Ministry of Agricultural Development, Government of Nepal, Singh Durbar, Kathmandu, Nepal.
- MoAD. 2014. *Statistical information on Nepalese agriculture 2013/14*. Ministry of Agriculture and Development, Government of Nepal, Singh Durbar, Kathmandu, Nepal.
- MoAD. 2016. *Nepal: Zero Hunger Challenge National Action Plan (2016 - 2025)*. Ministry of Agricultural Development, Nepal.
- MoEST. 2006. *National Biotechnology Policy (2006)*. Ministry of Environment, Science and Technology, Kathmandu, Nepal.
- MoFSC. 2005. *Biosafety Guidelines. Department of Plant Resources*. Ministry of Forests and Soil Conservation, Thapathali, Kathmandu, Nepal.
- MoFSC. 2006. *National Biosafety Framework*. Ministry of Forests and Soil Conservation, Thapathali, Kathmandu, Nepal.
- NAST and MoEST. 2008. *National State-of-the-Art Report on Biotechnology for Nepal*. Nepal Academy of Science and Technology (NAST), and Ministry of Environment, Science and Technology (MoEST), Government of Nepal, Kathmandu, Nepal.
- Thapa M. 2013. Regulatory framework of GMOs and hybrid seeds in Nepal. *Agronomy Journal of Nepal*, 3: 128-137.
- UNDP. 2018. *Human development reports*. United Nations Development Program. <http://hdr.undp.org/en/content/human-development-index-hdi>

# Agricultural Biotechnology and Biosafety in South Asia: Progress and Prospects

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