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Managing Agrobiodiversity through Use: Changing Paradigms

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Preamble

Anthropogenic activities have profoundly re-shaped the earth's land, oceans, air and biodiversity to such an extent that geologists have proposed a new epoch called the 'Anthropocene', marking the end of 'Holocene' (since 12,000 years). This new epoch is being said to begin from 1950, when radioactive elements from nuclear testing were likely spread all over the globe, and characterised by mass extinctions, plastic pollution, and spike in carbon emissions in the atmosphere (Waters *et al*., 2016). Consequently, biological diversity got reduced, the earth became warmer with greater incidence of natural catastrophic events. Whilst all biodiversity is critical for life on earth, the genetic diversity of agriculturally important species have a direct bearing on our food and nutritional security globally. A recent study shows that about 58% of the world's land surface, and 9 out of 14 of the world's terrestrial biomes, have fallen below 'safe threshold' of biodiversity, impacting a wide range of services provided by biodiversity, including crop pollination, waste decomposition, regulation of the global carbon cycle, and cultural services that are critical to human well-being (Newbold *et al*., 2016). Added to this is the concern about projections that global food production will need to be doubled by 2050 to feed the 9 billion plus population, by either intensification of existing agricultural systems or by expansion into new lands, scope for which is very limited.

This current paradox concerning the cause of decline of earth's life-sustaining elements and also having the potential to keep hunger and malnutrition at bay, would require adoption of a new paradigm as to how we manage our natural resources whilst fulfilling the commitments to meet the new sustainable development goals (SDGs). United Nations Conference on Environment and Development was one such major shift in the management of biodiversity subject to the rights of individual nations, which required to be protected with proper legal/*sui generis* instruments. Further, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources, including appropriate access to genetic resources and by using most relevant technologies, also got enshrined in the Convention on Biological Diversity (CBD). The CBD thus envisioned a new paradigm that available genetic resources were to be conserved for posterity. Subsequently it was realized that conservation is not only for 'posterity', but for 'use' for the overall benefit to the society. Hence, 'conservation through use' emerged to be a new paradigm, also known as 'New Mantra'. What we now know is that there is less use of genetic diversity today than what we had previously which led to Green Revolution. The Food and Agriculture Organization (FAO) of the United Nations has, therefore, initiated with the support of Bill and Melinda Gates Foundation, a project to strengthen plant breeding capacity and research on global scale, so that use of genetic resources is enhanced globally. This project, known as the Global Partnership Initiative for Plant Breeding Capacity Building (GIPB), is a multi-partner platform with an aim of improving institutional capacity for effective crop variety development and their distribution through seed systems (http://www.fao.org/in-action/plant-breeding/en/).

In the past, national agricultural research systems, including that of India, had strong national breeding programmes for developing improved varieties. However, there is now greater dependence on pre-breeding materials being provided by many of the international centres, especially those of the CGIAR. For another paradigm shift in agriculture from sustained food security to that of household nutritional security, we now need higher research investments as well as intensified scientific understanding of agriculturally important species (be those of crop, animal, aquatic and microbial).

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Managing Agrobiodiversity in the Geopolitical Landscape

Changes in the perception on genetic resources (GR) during the last three decades of the twentieth century has dramatically transformed the way they are now being managed. Member countries, including India, have either legislated or developed policy frameworks under the obligations of the CBD. In the pre-CBD era, all biodiversity was considered, managed and used as global public goods, with easy access, relatively free exchange and absence of ownership issues. It is now almost difficult to imagine how Nikolai Ivanovich Vavilov could have carried out his historical collection expeditions of genetic resources and identified centres of origin of crop plants in the post-CBD scenario which now demands Prior Informed Consent, and the Access and Benefit Sharing (ABS) mechanisms. However, this paradigm shift is a reality in today's context of biodiversity management. The reality is that all biodiversity is now classified as 'sovereign rights of nations'. This and the concurrent rapid loss of genetic diversity in existing agro-ecosystems are the reasons for initiating short-, medium- and long-term genetic resources conservation programmes at the national, regional and global levels.

Moreover, the conservation and use of genetic resources have many facets including research and development, intellectual property rights, food security and health related issues, which are governed by different institutions and agreements. India was among the first few countries to ratify the International Treaty for Genetic Resources for Food and Agriculture (ITPGRFA) in 2002. The Treaty came into force in 2004. In 2006, the Governing Body of the Treaty also adopted the Standard Material Transfer Agreement (SMTA) as an instrument for carrying out germplasm exchange. Under the CBD, it was envisioned that there would be both multilateral and bilateral systems of germplasm exchange, whereas multilateral exchange would exclusively be the domain under ITPGRFA. Obviously, these processes have not been easy though India tried to move forward by enacting the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act in 2001, the Biological Diversity Act (BDA) in 2002. As a consequence, the process of germplasm exchange got significantly reduced globally, while ensuring a new paradigm shift from no regimentation to that of a new international regulatory regime. Earlier, the genetic resources were being exchanged freely for the welfare of humankind, which helped significantly in expanding our food basket globally. Imagine, what would have been the food options for us had these regulations were in place prior to CBD asking for protection of all available biodiversity.

As a matter of principle, rules and procedures enshrined in ITPGRFA must now be followed by the global community. Also there had been significant debate as to why soybean should not be included in Annex 1 of 64 crops despite being an important food crop in the entire south east Asia. To my utter disappointment, being present in the FAO deliberations then, soybean was not included mainly because of other considerations than the scientific and food security ones. Similarly, a few other crops were also discussed but not agreed upon. Finally, to overcome the stalemate, a decision on the list of crops under Annex 1 was taken almost by four o'clock in the morning on the last day of Treaty negotiations. Also there was an understanding that countries would revisit the list to expand it further, which somehow has not happened over the last 15 years since then. Another unfortunate part is that those countries that were most vocal in getting ITPGRFA adopted have yet not enacted the Treaty and no one knows why? At the same time, even countries like India having ratified the Treaty is not very open to sharing genetic resources. Obviously, therefore, there is an urgent need to review the process of ABS for improved germplasm exchange and management in the overall interest of humanity.

The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture (2010) had reviewed and assessed the developments concerning ITPGRFA. A perusal of the report illustrates that we need build capacity, partnerships, fulfil our legal obligations and need to refrain from putting hurdles in the implementation of the Treaty. What is of greater concern today, particularly for the developing countries, is to ensure that the policy framework regulating access and use of genetic resources, while keeping pace with technological developments, also addresses the livelihood security issues of the poorest of the poor. Another point of concern is that agrobiodiversity policy and legislation are not clearly demarcated and mostly treated under the similar rules and regulations as biodiversity. The fundamental difference between management of biodiversity as compared to agrobiodiversity needs to be understood to deal with them differently. Interestingly, another paradigm change has taken place in the process of exchange of genetic resources, which used to be the domain of scientists earlier. Instead, it is now dealt with by the bureaucrats and legal experts with little appreciation of science that has human face.

Addressing Exchange and ABS Regimes

Studies have clearly shown how nations have historically been dependant on each other for their needs of genetic resources for increased agricultural productivity. This dependence is predicted to increase more in future, given the current trends of climate change, emerging needs for expanding food basket and changing consumer preferences for more healthy foods (Galluzzi *et al*., 2016). Related to this is the existence of international and national legal obligations and Treaties under which exchange of are governed, which dictate how access is to be provided and what benefit sharing mechanisms will be agreed upon. As already stated, administrative, structural, and political compulsions have made the exchange of biodiversity much more complex. Instead of easing the process, the Treaties such as the Nagoya Protocol of the CBD and ITPGRFA have indirectly led to reduced exchange of germplasm between nations, despite clear recognition of multilateral system (MLS) for exchange. Experience tells that neither the MLS has functioned at the anticipated level, nor it has helped in generating financial benefits through the proposed international Benefit-Sharing Fund (BSF). In India, there is still unsettled debate concerning exchange of germplasm even with the local private seed sector organizations engaged in plant breeding. Even SMTA has not yet been put into practice for want of procedural clearances and lack of understanding. During mid-eighties, ICAR, as a policy, allowed free access to the parental lines of hybrids bred by the public system recognising well that seeds of these hybrids would otherwise not reach the end users i.e., the smallholder farmers. This policy decision then not only accelerated the coverage under hybrid seeds resulting in increased crop productivity but on the contrary strengthened existing private seed sector in India. On the contrary, with the advent of Plant Breeders' Rights and the adoption of IPR regime, there is an obvious hesitation to share the germplasm, either for the fear of loss of ownership or for biopiracy. Hence, there is an obvious concern for much needed trust-building and partnership. This would demand an enabling policy environment for sharing the germplasm as well as information between public and private sectors.

In many cases, the farmers are the custodian of traditional varieties and their rights are now being protected through PPV&FRA. The Authority needs to be congratulated for recognising these Rights. The Authority has also been assured of Government support to build initially an Indian Gene Fund of Rs. 50 crores (around $7.5 million) in order to recognise, reward and give incentives to farming communities engaged in conserving valuable genetic resources. It is also expected that benefit-sharing mechanism in future will help in building the proposed Gene Fund. Simultaneously, it calls for developing a clear mechanism to benefit directly the farmers for their invaluable service to the society. It is expected that this fund will soon be around $20 million with the provision of ABS and expected funding support from the seed sector.

Conservation Continuum

The genetic diversity in crops and animals are manifestation of diverse agricultural systems evolved over many centuries by the farmers and breeders. On the contrary, the modern agriculture tends to use mainstream varieties/breeds, resulting in monoculture practice that prevails in modern agricultural landscapes. In this context, preserving available diversity, as a safety-net, is emerging as a big threat to be addressed. Hence, sustainable use of genetic resources would demand both strengthening and expanding of conservation approaches, be those *ex situ* or *in situ*. In fact, complimentary and rather holistic conservation practices that are low cost and sustainable are the needs of the hour. Also there is an urgency to develop a 'conservation continuum', encompassing *in situ*, on-farm, *ex situ*, permafrost and other methods with adequate funding support. Also it is of prime importance today that the farmers, livestock keepers, aquaculture practitioners or foresters engaged in conserving the target varieties, breeds and species derive direct (financial) or indirect (livelihood security) benefits by engaging in such activities. Despite sporadic efforts in this regard, much is still to be done to research and conserve the wild relatives and underutilised species as crops for the future. Programmes and policies are thus warranted both at the national and global levels to move forward rather aggressively in this regard.

Mainstreaming Agrobiodiversity to Meet SDGs

Plant and animal breeding provides an important foundation to address effectively the sustainable development goals (SDGs), and contributes to raising yields, increasing resource use efficiency and reducing the negative environmental impacts on food production. In this context, enhanced and integrated use of genetic resources would be instrumental, not only through breeding better varieties and breeds, but also through smarter deployment of genetic diversity to combat biotic (pests and diseases) and abiotic (drought, heat, cold) stresses, derive greater ecosystems services (pollinators) and reduce the use of costly inputs (e.g. fertilizers, pesticides). It would also demand for exploring new sources for food, nutrition and good healthy foods for ever increasing global population. Sound management of genetic resources will thus be the key to achieve increased food production, without negatively impacting available agrobiodiversity. We now need to ensure up-scaling and out-scaling of innovations to achieve dietary diversity and improved nutrition at household levels. Better information management and accessibility to databases/informed knowledge for policy makers and stakeholders would help in strengthening on-going efforts to use agrobiodiversity for food and nutrition being important SDGs. There is also an urgent need to promote use of more nutritious species such as millets, indigenous fruits, vegetables, roots and tubers, as compared to major emphasis that we gave in the past to only few selected staples.

Harnessing New Science

Scientific advances like CRISPR-Cas would help breeders/researchers to tap new genetic resources more at ease for both food and nutritional security. New technologies pervading agriculture in terms of smart-phones, satellite imaging, automated farm practices, even use of drones, is allowing farmers to grow more food on their land while reducing their water, fertilizer, and pest-control needs. However, the availability of appropriate planting material/breeds remains the most critical factor for productivity, adaptability and resilience of agro-ecosystems. Developments in science and technology in the areas of genetic engineering, genomics, biotechnology, nanotechnology, bioinformatics, synthetic biology etc. have increased the speed, scale and efficiency in research outputs. These technologies are the game changers that will dictate how genetic resources are researched in future and used. Nonetheless, existing agrobiodiversity would remain the "hardware and software codes of nature" requiring systematic deciphering for designing agricultural crops and breeds for their use through new science. An important aspect with application of new technologies for agricultural production would be to generate awareness and dispel fears in the minds of general public about use of new products (*e.g.* golden rice) that are outcomes of cutting-edge technologies as international public goods.

Role of Farmers and Civil Society

To ensure synergy among agrobiodiversity management and agricultural development, the role of stakeholders such as: decision-makers, public administration, civil society, local communities (including farmers, non-government organisations) and even media is crucial, especially in developing countries that are gene-rich. Given the multitude of stakeholders involved in operating/utilising the genetic resources as well as the traditional knowledge associated with genetic resources, capacity building through awareness-raising campaigns would be necessary. Also greater partnership among the stakeholders, including public and private sectors, NGOs and farmers is required. Many farmers do conserve useful collections of different varieties and crops by sheer self motivation and with hardly any funding support. The question, therefore, emerges as to when there is no support, why then the tribal communities protect these resources for others while living at sub-subsistence level? In this context, enhanced efforts are obviously needed to develop community level gene banks and link them with national/international gene bank networks. Also the traditional agricultural systems are linked with traditional knowledge related to agrobiodiversity. Such knowledge systems need to be documented before these are lost forever. Scientific validation of such traditional knowledge is also essential for improved understanding of the ecological functions of agrobiodiversity especially in the context of physical environment and the socio-economic factors. A delicate balance is obviously needed for maintaining agrobiodiversity and ecological processes while optimizing societal benefits, as we move forward.

Conclusion

Managing agrobiodiversity in the present context requires paradigm shifts in our understanding the role and implications of legal instruments for protection and sharing of genetic resources for betterment of humankind. Agrobiodiversity in its own right must now be managed more scientifically through involvement and partnership of all stakeholders at the national, regional and global levels. For meeting the SDGs, efforts to diversify existing food basket through better understanding and use of available genetic resources, using new science, will have to be intensified and supported well. This paper addresses some of the emerging paradigms for effective and efficient management of agrobiodiversity for human welfare.

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