Conservation of Agro-biodiversity : Looking Back and Looking Ahead

MS Swaminathan*
MS Swaminathan Research Foundation, 3rd Cross Road, Institutional Area, Taramani, Chennai-600 113, Tamil Nadu

Looking Back

I began my research in the field of agro-biodiversity in 1947 at the Indian Agricultural Research Institute (IARI), New Delhi. The experimental material consisted of species and varieties of non-tuber bearing *Solanum* (Family Solanaceae). *Solanum melongena,* the eggplant (brinjal) belongs to this group. I was amazed at the variety of eggplants, from different parts of India, in the collections made by my supervisor Dr Harbhajan Singh. The goal of my study was to understand the genetic relationships among non-tuber bearing *Solanum*s. In 1949, Professor JBS Haldane visited my experimental field and observed: 'I have never seen such variability in quantitative characters as in eggplant; this plant is ideal for studies in the field of quantitative genetics.' He further observed that 'while Indian farmers are nurturing genetic heterogeneity in their fields as part of their preference for risk-distribution agronomy, scientists seem to be worshipping genetic homogeneity.' Genetic homogeneity enhances genetic vulnerability to biotic (pests and diseases) and abiotic (drought, salinity and flood) stresses and this is why in the earlier systems of cultivation, mixed cropping and crop variety mixtures were preferred.

In 1949, I went to the Agricultural University, Wageningen, the Netherlands, to continue my work on Solanaceae, but this time on tuber-bearing *Solanum* species, particularly on potato (*Solanum tuberosum*). The Dutch farmers cultivating potato in the polder lands were facing serious damage to the crop from the golden nematode (*Heterodera rostachiensis*). Professors Dorst and Toxopaeus, with whom I was working, suggested that I should work on breeding potato varieties resistant to the golden nematode. I found from literature that the species *S. polyadenium* from Peru possessed resistance to the golden nematode. This species was in the Commonwealth Potato Collection maintained at Cambridge, UK, by Professor JG Hawkes. I obtained seeds of this and several other species from Professor Hawkes and started crossing them with a popular Dutch potato variety, *Beintije*. Since *S. polyadenium* was a diploid (2n = 24), and *S. tuberosum* was a tetraploid (2n = 48), I had to double the chromosome number of *S. polyadenium* in order to cross it with the cultivated potato.

The genetic diversity in *Solanum* species fascinated me and I decided in 1950 to go to Cambridge to work on the Commonwealth Potato Collection. From 1950-52, I did extensive research on tuber-bearing *Solanum* species collected from South America and started to unravel the genetic interelationships among them. I also traced the origin of the cultivated potato, *S. tuberosum*. This work earned for me the Ph.D. degree of the University of Cambridge in 1952.

In November 1952, I was invited by the University of Wisconsin, USA, to join the Department of Genetics in order to assist in the establishment of an Inter-regional Potato Introduction Station at Sturgeon Bay in Lake Michigan, to house the collection made by Dr Donovan Correll of the US Department of Agriculture. From 1952-54, I undertook extensive gene transfer research from the wild species of tuber-bearing *Solanum,* using several novel cytogenetic techniques. One of the crosses involving the front-resistant species, *S. acaule* from the Lake Titicaca region of Peru-Bolivia border, resulted in the variety Alaska Frostless released for cultivation in Alaska (Swaminathan, 2010).

The work during 1947-54 on both tuber-bearing and non-tuber bearing *Solanum* species led to my conviction that we should do everything possible to conserve agro-biodiversity for future generations. On my return to India from Wisconsin in 1954, I joined the Central Rice Research Institute, Cuttack, to work on the breeding of high-yielding varieties of rice based on crosses between *japonica* and *indica* strains. The aim was to transfer genes for fertilizer response from *japonica* varieties to *indica*. This programme gave rise to varieties like ADT-27 in Tamil Nadu and Mashuri in Malaysia. There were however several problems like semi-sterility and the breeding of rice varieties with high yield potential had to wait until 1964, when the Taiwan variety, Taichung Native-1 (TN 1), containing the *Dee-gee-woo-gen* dwarfing gene became available. I was also fascinated by the genetic variability maintained by tribal families of the Koraput

* *Author for Correspondence: chairman@mssrf.res.in*

district in Orissa. In 1954, the Koraput farm families were sustaining nearly 3,000 strains of rice but now it has come down to about 300, as a result of gradual genetic erosion. This emphasises the need for *ex situ* preservation, while not relaxing on *in situ*, on-farm conservation.

I joined the Indian Agricultural Research Institute, New Delhi late in 1954 and initiated work on the breeding of high-yielding varieties of wheat. Dr BP Pal and his associates were then engaged in breeding wheat varieties for resistance to stem, leaf and stripe rusts (*Puccinia* sp.). I tried different methods like crossing the bread wheat (*Triticum aestivun*) with subspecies *compactum* and *sphaerococum* but these crosses yielded dwarf plants with dwarf panicles and consequently had a low yield potential. In 1959, I came to know of the work of Dr Orville Vogel of the Washington State University, Pullman, USA, in breeding the semi-dwarf winter wheat variety Gaines by incorporating the dwarfing gene from Norin-10 (*daruma*), a variety bred by Dr Gonziro Inazuka of Japan. Dr Vogel had given seeds of this material to Dr Norman Borlaug who was working in Mexico in the breeding of high-yielding and rust-resistant varieties of spring wheat. The history of the introduction of Borlaug's material into India and the subsequent development of outstanding wheat varieties like Sonalika and Kalyan Sona are described in the book *Science and Sustainable Food Security*.

The essential point I wish to make is that biodiversity is the feedstock for successful plant breeding. Most of the successful varieties of rice, wheat and other crops may have 50 or more landraces in their pedigree. Because of the availability of genetic variability, a strategy could be developed in the 1960s to checkmate the spread of leaf, stem and stripe rusts in wheat in North India. On becoming the Director of IARI in 1966, one of the first steps I took was to create a Division of Plant Introduction, to strengthen the ongoing work under the leadership of Dr. Harbhajan Singh in the areas of plant exploration, collection and conservation. Both in rice and wheat extensive collections were made to preserve for posterity a sample of the genetic variability now existing in these crops. During this period, I initiated a programme for the collection and conservation of rice varieties from the northeastern region of India. This collection, known as the Assam Rice Collection, had over 7000 varieties and proved to be a veritable mine of valuable genes.

On becoming the Director General of the Indian Council of Agricultural Research (ICAR) early in 1972, I initiated steps to set up a National Bureau of Plant Genetic Resources (NBPGR) at the national level and an International Board for Plant Genetic Resources (IBPGR) at the global level through the Consultative Group on International Agricultural Research (CGIAR). I was then Vice-Chair of the Technical Advisory Committee (TAC) to CGIAR. Sir John Crawford of Australia was the Chair of the first TAC set up in 1971. Both NBPGR and IBPGR (now named Bioversity International) have rendered very valuable service in genetic resources collection and conservation. Also, I took steps to establish National Bureaus of Animal and Fish Genetic Resources and later the National Bureau of Forest Genetic Resources.

I was the Principal Secretary of the Ministry of Agriculture during 1979-80. During that period, the Forestry Division was an integral part of the Ministry of Agriculture and, therefore, I had the overall responsibility for shaping the programmes of the forestry sector. One of the earliest steps I took was to review the permission granted for an electricity project in the Silent Valley area of Kerala. This is a unique tropical rainforest and is the home of rich biodiversity. After a careful study of the benefits which the project could confer in the fields of electricity generation and irrigation, I submitted a report to the Cabinet of the Government of India in 1979 advising that the electricity generation project should be given up. I was aware that the acceptance of this suggestion by the then Government of Kerala would be difficult unless I provide alternative pathways of achieving the goals for which the State Government was willing to sacrifice this unique biodiversity paradise. Therefore, I would like to quote the principal recommendations which I made in 1979, which lead to this project being abandanoned and the whole area set aside as a National Park.

The entire area of 39,000 hectares consisting of (a) Silent Valley forest, (b) New Amarambalam Reserve forests, (c) Kundas forests, and (d) Attapadi reserve forests, should be developed into a **National Rain Forest Biosphere Preserve**. The cost of developing a National Rain Forest Biosphere Preserve may be borne by the Government of India, since the preservation of this unique forest area will be to the benefit of both Kerala and the entire nation. The Silent Valley Environmental Monitoring Committee already constituted by the State Government could become the National Rain Forest Biosphere Preserve Planning and Implementation Committee and start the work immediately under the overall guidance of NCEPC. If developed along proper lines, the Silent Valley Rain Forest Biosphere Preserve can become a sanctuary for valuable

genes in several medicinal and plantation crops, such as pepper and cardamom. This whole region has also been found to be a reservoir of useful genes in rice conferring resistance to some major pests. Therefore, urgent steps should be taken to prevent the erosion of valuable genes from this area.

The Kerala Forest Research Institute at Peechi may be developed into an international research and training centre for the study of tropical rain forest eco-systems. This will be appropriate in view of the widespread interest, particularly in countries in South-East Asia in tropical evergreen rainforest flora and fauna.

A detailed ground water survey of the Palghat and Mallapuram districts should be completed soon and steps should be taken to provide irrigation through the available ground and surface water resources in as much area as possible. I have discussed this with the officers of the Central Ground Water Board and a note on the available knowledge is given in Appendix-VI. The potential for irrigation through mobilizing the available ground water sources seems to be very good. For implementing the irrigation project, **a Palghat and Mallapuram Irrigation Project Committee** may be constituted immediately, jointly by the Central and State Governments. The Central Ground Water Board of the Department of Agriculture and Cooperation can undertake the task of organizing the ground water survey and preparing a blueprint for irrigation in cooperation with the concerned Departments of the State Government. Since the present utilization of draft is only 12 to 15% of annual recharge, arrangements for providing irrigation to 10,000 hectares can be made speedily.

If steps are not taken to satisfy the legitimate socio-economic aspirations of the people of the area. Mere talk about ecology and environment will be met with cynicism and with the question, "Who is more important – man or monkey?" On the other hand, if we proceed with the implementation of SVHEP without taking advantage of alternative methods of providing energy, employment and irrigation, will future generations forgive us for destroying a 50-million year old genetic heritage, particularly at a time when the solar energy option is not an illusion? **The alternative pathways available immediately for providing power, irrigation and jobs at no ecological risk will, in my view, help to achieve the desired social goals more speedily and economically**. It should not be beyond our political, intellectual or financial capability to find solutions which can enable the present day human population of Phalgat and Mallapuram districts to experience a better quality of life without destroying a priceless biological endowment.

Development without destruction will then not be an idle dream, as it will be if the present project is rushed through. If on the other hand, the project is rushed through leading to the destruction of the forests and to the loss of valuable genetic material, SVHEP will become one more testimony to the statement, "Every new source from which man has increased his power on earth has been used to diminish the prospects of his successors. All his progress has been made at the expense of damage to the environment which he cannot repair and could not foresee".

During my tenure as Director General of the International Rice Research Institute, Los Baños, the Philippines (1982-88), I initiated steps to enlarge and streamline the International Rice Germplasm Centre. IRRI now preserves over 100,000 strains of rice. My strategy for conservation was to map the biodiversity hot spots and initiate steps to save the genetic diversity occurring in such endangered habitats. An example is the rice collection made in the interior parts of Myanmar with the help of army personnel since civilians were not allowed to go to some of these areas. The army personnel were trained in genetic resources collection at Yezin. The outstanding rice varieties developed at IRRI under the leadership of Dr GS Khush were the products of an effective use of genetic diversity.

In 1983, I served as a President of the XV International Congress of Genetics held in New Delhi. I chose "Genetic Conservation : Microbes to Man" as the focal theme for the Congress. In my Presidential Address, I suggested that we should establish a global Cryogenic Gene Bank under perma-frost conditions to serve as a "Noah's Ark" in the field of conservation. This proposal fructified when the Government of Norway set up a Global Gene Vault at Svalbard, near the North Pole in 2008. A similar Gene Vault has been set up at Chang La in Ladakh by the Defence Research and Development Organisation of India (DRDO) in 2009. These facilities involve low operational cost and serve as repositories of valuable genetic material. In spite of the growing awareness of the need for conserving biodiversity, its loss is continuing unabated due to habitat destruction, alien invasive species and industrial agriculture. A Biodiversity Literacy Movement is, therefore, an urgent need.

Cryogenic preservation does not allow evolution. *In situ* conservation involves both preservation and evolution.

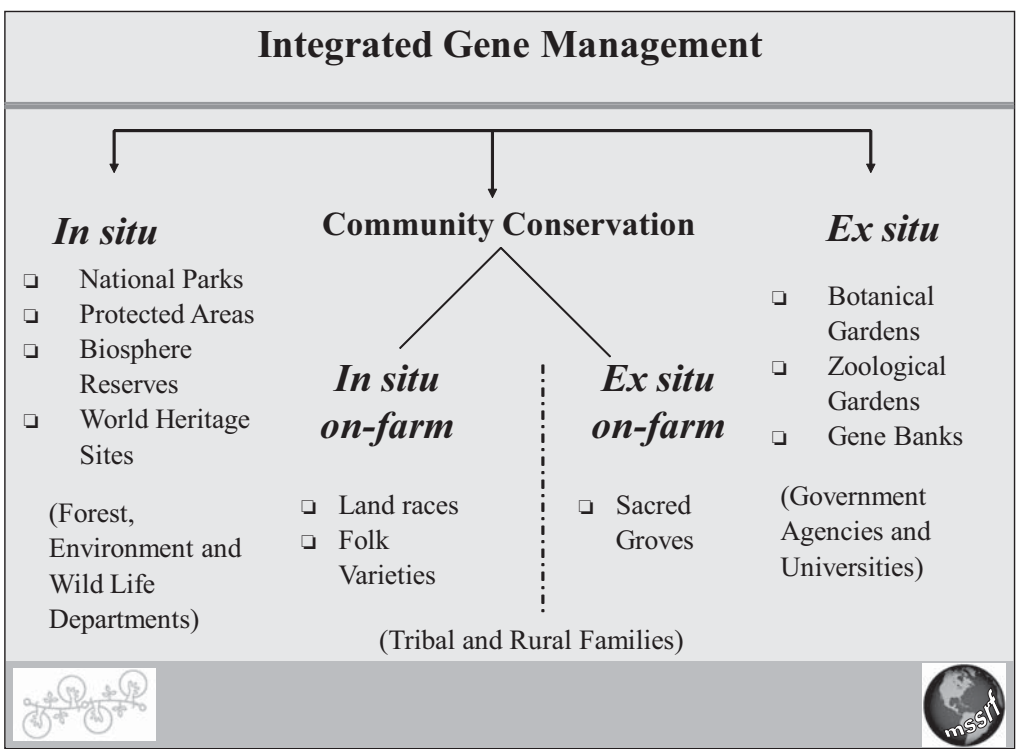
Therefore, *in situ* conservation and *ex situ* preservation are both important. I assisted the Commonwealth Secretariat and the Government of Guyana in establishing the Iwokrama Rainforest Conservation programme in 1 million hectares of prime rainforest made available by the Government of Guyana. In this programme, as well as in many others with which I have been associated, I introduced the "4C principle", *i.e.*, conservation, cultivation, consumption and commerce. The "4C principle" generates an economic and social stake in conservation. In my report on the Silent Valley Rainforest in Kerala, submitted in 1979, I proposed the development of this unique rainforest and adjoining forests as a Biosphere Reserve.

All over the world there is increasing realization of the need to have an integrated conservation strategy involving *in situ* and *ex situ* methods as well as community conservation on the lines I had indicated in my Volvo Prize Lecture (see figure below).

The role of local communities in the conservation and enhancement of biodiversity received inadequate attention and appreciation in the past. Therefore, in the general conference of FAO held in Rome in 1979, I stressed the need for ending the enigma of the poverty of the primary conservers coexisting with the prosperity of those who use their knowledge and material. This led ultimately to the establishment of the FAO Commission on Plant Genetic Resources at a meeting of the FAO Council chaired by me in November 1983. Also, the concept of Farmers' Rights was developed and this was given a legal status under the FAO-sponsored International Treaty on Genetic Resources for Food and Agriculture which came into operation in November 2001.

In the early nineties, MSSRF started the preparation of draft legislation for the integrated protection of farmers' and breeders' rights. My first draft of such a Bill was supported in an international dialogue held at MSSRF, Chennai in 1994 (Swaminathan, 1995). In 1996, I revised this draft by including farmers' rights in the title of the Act. Thus, was born the Plant Variety Protection and Farmers' Rights Act adopted by the Parliament of India in 2002 (Swaminathan, 1996). Following this, the Plant Variety Protection and Farmers' Rights Authority was set up and the Authority adopted and implemented my suggestion for honouring primary conservers with the Genome Saviour Award.

The community conservation methodology involved promotion of a gene bank (*in situ* on-farm conservation of landraces), a seed bank, a grain bank and a water bank in areas rich in agro-biodiversity. This initiative won for the tribal communities of Koraput in Orissa the Equator Initiative Award at the UN Summit on Sustainable Development held at Johannesburg in 2002. Although,



the UPOV convention has not yet accepted the concept of farmers' rights, it is my hope that my plea that UPOV should become a Union for the Protection of Breeders and Farmers' Rights will become a reality in the near future. Breeders and farmers are allies in the struggle for feeding the ever-growing global population and, hence, their rights should not only be not antagonistic, but should be mutually reinforcing.

During my presidentship of the World Conservation Union (IUCN), we took steps to prepare a Draft Global Biodiversity Convention. The Draft was discussed and approved at the IUCN Conference which I chaired and which was held at San Jose in Costa Rica in February 1988. Also, the Keystone Dialogues on Plant Genetic Resources held under my chairmanship during 1989-91, articulated the concept of recognition and reward for primary conservers. The Biodiversity Convention recognises the principles of prior informed consent and benefit sharing. The challenge now lies in getting all nations to accept the concept of farmers' rights and introduce appropriate legislation for the concurrent recognition of breeders' and farmers' rights on the pattern of the Indian legislation.

When I was in the Philippines during 1982-88, I observed that valuable mangrove forests were being removed for establishing aquaculture ponds. Mangroves serve as bio-shields during coastal storms and tsunamis and promote sustainable fisheries. I, therefore, helped to establish an International Society for Mangrove Ecosystem (ISME) in 1989 with the help of UNESCO and the Government of Japan. During my period as Founder-Chairman of ISME (1989-92), a Charter for Mangroves was prepared. In association with the International Tropical Timber Organization (ITTO), MSSRF organised an international training programme on Mangrove Genetic Resources Conservation. Also, research was started in 1992 on the identification and transfer of genes for seawater tolerance from *Avicennia marina* to rice and other crops by a team of molecular geneticists led by Dr Ajay Parida. This work has now yielded several salinity-tolerant rice varieties. Recombinant DNA technology helps in transferring genes across sexual barriers and hence no plant or living organism is useless. For example, *Prosopis juliflora*, considered a noxious weed, has provided genes for drought tolerance. The new genetics has brought to an end the era of reproductive isolation of species.

Looking Ahead

My association with biodiversity conservation and utilisation over 63 years has reinforced my conviction that we must do our best to halt genetic erosion, promote biodiversity literacy and make biodiversity conservation everybody's business. Biodiversity is a public good resource and should not be privatised. The Global Convention on Biodiversity and FAO's International Treaty for Genetic Resources both emphasise the need for recognising and rewarding the invaluable contributions of tribal and rural families to biodiversity conservation and enhancement. This is why delivering the Sir John Crawford Memorial Lecture in Washington DC in 1990, I pleaded for converting the Union for the Protection of Plant Varieties (UPOV) into a Union for the Protection of Breeders' and Farmers' Rights. The farmer is often a breeder and conserver, in addition to being a cultivator. If today, there are nearly 150,000 strains of rice in the world, it is only because of community conservation.

Agro-biodiversity is the result of interaction between cultural and culinary diversity and hence the conservation of cultural diversity and traditional knowledge are equally important. The traditional methods of conservation like sacred groves and temple trees should be revived, since they integrate the spiritual and practical dimensions of biodiversity conservation.

Climate change has reinforced the urgency of conserving traditional crops and wisdom. In October 2010, some 18000 participants, representing the 193 Parties to the Convention on Biological Diversity, who attended the Nagoya Biodiversity Summit in Japan reiterated the urgency of meeting the unprecedented challenges of the continued loss of biodiversity in an era of climate change. The Strategic Plan of CBD and the "Aichi Target" adopted by the meeting includes 20 major targets organised under five strategic goals that address the underlying cause of biodiversity loss, reduce the pressures on biodiversity, safeguard biodiversity at the ecosystem level, enhance the benefits provided by biodiversity and provide for capacity building.

The Nagoya Protocol included a plan to protect biodiversity by setting targets for 2020. Nations agreed to make 17% of the globe's land area and 10% of coastal and marine areas into protected regions, as opposed to the current levels of 13% and 1%, respectively.

When I was President of IUCN, I used to remark that "conservation without resources becomes just conversation". Fortunately at Nagoya, Japan led the resource mobilisation drive by committing a $2 billion fund for achieving the "Aichi Target" of halving the rate of biodiversity loss by 2020. I hope other countries will

follow not only with money but also with emotional, spiritual and political commitment.

When I chaired a Committee of the Union Planning Commission in 1980, which recommended the establishment of a separate Ministry of Environment and Forests under strong professional leadership, I had wanted 10% of our land area to be set aside as protected areas. This, however, was not found feasible by other members of the committee. We should adopt this minimum target and try to achieve it by 2020.

Experience has shown that without education and social mobilisation, regulation alone will not work. I have participated in numerous national and international conferences and workshops during the past 60 years where well-intentioned resolutions and targets have been adopted. Even with reference to the UN Millennium Development Goal No 1, *i.e.*, reducing poverty and hunger by half by 2015, progress has been poor in many countries. Unless community understanding and action is combined with national and global resolutions, preventing biodiversity loss will remain a receding goal. For giving local communities space in the management of Biosphere Reserves and National Parks, we should adopt a trusteeship mode, with people and government becoming trustees of these invaluable assets. I got this done in the case of the Gulf of Mannar Biosphere Reserve in Tamil Nadu, by getting its management placed under a Gulf of Mannar Biosphere Trust, with both government and community leaders serving as trustees.

In 2020, there will be a review of the progress made in achieving the "Aichi Target". Considering past accomplishments, there will be disappointment once again unless there is serious effort for making biodiversity conservation a community-led movement. In most of these conferences, administrators, experts and members of civil society organisations participate. They prepare excellent declarations, but these are not followed up by taking the message to those who are the key actors in the conservation movement at the local level. Reaching the unreached and voicing the voiceless will have to become a mandatory public policy in the area of biodiversity conservation.

The tribal women of Koraput are showing how we can convert **biodiversity hotspots** into **biodiversity happy spots** by launching a biohappiness movement involving concurrent attention to conservation, sustainable use and equitable sharing of benefits. I hope their voices of sanity and hope will be heard in the 2020 Conference, since otherwise targets and resolutions adopted at conferences like Nagoya will continue to remain as desirable but unaccomplished objectives.

References

Swaminathan MS (ed) (1995) Farmers' Rights and Plant Genetic Resources: A dialogue. Macmillan India Ltd., Madras

Swaminathan MS (ed) (1996) Agro-biodiversity and Farmers' Rights. Konark Publishers Pvt Ltd., Delhi.

Swaminathan MS (2010) Science and Sustainable Food Security. World Scientific Publishing Co. Pte. Ltd., Singapore.