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A Novel *Circa situm* Approach to Conserve Forest Genetic Resources of the Western Ghats

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The Western Ghats of India is a rich repository of forest genetic resources in terms of wild flora, wild relatives of crop plants, edible fruits, medicinal plants and myriad agro-forestry systems. This paper discusses the importance and potentiality of novel approaches such as 'Forest gene banks' and '*circa situm* conservation'. It also emphasizes creation of range-wide, spatially explicit big-database on *circa situm* conservation value of agro-forestry systems as well as to develop guidelines for establishment of *circa situm* gene banks across the country.

Key Words: Big-data, Forest gene bank, Medicinal plants, On farm conservation

Western Ghats: Region with Outstanding Universal Value for Biological Diversity

India harbours four of the 34 hotspots of biological diversity of the world. The Western Ghats, a rolling ribbon of mountains spread along the Southern-Western part of India, is regarded as one of the world's eight 'hottest hotspots of biological diversity'. Geologically, it is older than the Himalayas. This mountain range contains unique flora and fauna and is declared as one of Worlds' Natural Heritage Sites by the UNESCO. The Western Ghats of India is also a rich repository of about 5000 species of flowering plants; over 200 tropical edible fruit species, 200 undomesticated vegetable species and also well-known for harbouring a rich variety of medicinal plants and wild relatives of crop plants. It is regarded as the "world's best pharmacy" as it supports several coded systems of local health traditions. The agro-forestry systems of the Western Ghats have some of the most amazing diversity of tropical fruit trees (Vasudeva *et al*., 2015).

Forest Genetic Resources of the Western Ghats and its Valuation

Forest Genetic Resource (FGR) is a component of the genetic diversity which is of actual or potential use either for production systems or for the ecosystem functioning in a forest. Conservation of FGRs is fundamental to the sustainable and productive management of the forest ecosystems. Genetic diversity occurs at various levels of organization from the ecosystem, their sub-specific populations, and individual genotypes to the molecular level, of the gene. Hence, it is essential that all levels of genetic diversity be considered in the utilization and conservation prioritization process.

Although the economic value of the products derived from forest genetic resources (e.g., NTFPs, genes for the development of new crops and bio-molecules as a source for the development of new drugs) is difficult to assess, their value has been estimated to touch many billions of dollars annually (Vasudeva, 2016). One of the earliest rough estimates of global value of the myriad uses of genetic resources was at US $ 500 to 800 billion (Kate and Laird, 1999). The volume of global medicinal plants market has been estimated at US$ 60 billion per year, growing at a rate of 7% annually. Global demand for herbal products, mostly derived from forest ecosystems in recent years has experienced a quantum jump in volume of plant material traded within and outside the countries of origin. Further, globally, NTFPs generate social benefits and play an important role to improve livelihoods of local communities which are involved in their harvesting, processing and trade.

Further, the forest ecosystems contain many potentially useful new resources. Genetic resources derived from forest ecosystems represent a rapidly growing and highly promising source of new drugs, agricultural products, and other fruits of biotechnology. For instance, ants found in forests may provide novel

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antibiotics that are important for human medicine, silk from spiders may provide the lightest but high tensile fibre which may be stronger weight-for-weight than steel, *etc* (Kate and Laird, 1999). Services provided at free of cost by forest ecosystems around the globe are benefiting humankind. Examples include oxygen production, climate control by forests, nutrient cycling, water purification, natural pest control, and pollination of crop plants. In 1997, these services were valued at US$ 33 trillion per year, almost double the US$18 trillion annual global national product.

Converting Biodiversity into the Biological Resources: Prerequisite for Utilization

Today biological diversity of a country is regarded as its "resource capital". Understanding spatial distribution of this plant resource is a prime pre-requisite for its conservation and sustainable utilization. Unfortunately, primary data on quantitative estimates of the resources, their geographical spread and the levels of regeneration in their natural habitats did not exist even for an important eco-region such as the Western Ghats till recently.

Further, the impact of unscrupulous extraction of some of these resources is also not very well understood. Earlier work on understanding the occurrence and distribution of plant resources are scanty, isolated and never done adopting a uniform sampling strategy throughout the Western Ghats at a fine geographic scale. Hence there was a critical need to map the plant resources at local, regional and national levels throughout the country adopting uniform sampling strategy and develop a database.

In this context, mapping of these resources reflecting the spatial distribution would greatly help in understanding their structure and dynamics in natural habitats, allow assigning conservation values of different sites/recognizing hotspots of plant diversity within an eco-region, and eventually in formulating strategies for sustainable utilization of plant resources (Ganeshaiah, *et al*., 2012). Most importantly this would also offer a perspective on the economic value of forest resources in the Western Ghats.

Realizing this importance, National Bio-resource Development Board (NBDB), of the Department of Biotechnology, New Delhi commissioned a national initiative which broadly aimed at: a) quantitatively assessing the geographic distribution and population status of the plant resources of the Western Ghats, b) identifying the threats to these plant resources and c) setting up a Western Ghats eco-region specific database of plant resources (Ganeshaiah, *et al*., 2012).

The programme also aimed at developing thematic maps of the density and distribution for all the economically important species along the Western Ghats as well as analyzing the spatial and temporal patterns of change in specific plant resources along the Western Ghats. A survey of 3132 grids, each of 6.25 km x 6.25 km geographical area along the Western Ghats, undertaken in the project period perhaps represents one of finest-scale vegetation surveys of any hotspot of biological diversity in the world. This is the largest primary data ever assembled on the Western Ghats vegetation in the Indian history which can be accessed at https://betaibin.iirs.gov.in. A total of 3132 kilometer-transects of grueling field work spreading across six states has been undertaken. The overall gamma diversity for the entire Western Ghats eco-region as computed by Shannon's diversity was at 5.31 (Ganeshaiah, *et al*., 2012). However, there is a critical need to map and generate such fine scale spatially explicit big-database on the agro-forestry resources of the country.

Novel Approaches Conserve Forest Genetic Resources

Central to the genetic resource utilization and conservation is the maintenance of sufficient inter and intra-specific genetic variability. However it is a challenge in those species that are subjected to intense harvesting pressures. There have been number of isolated approaches proposed to address the utilization and conservation of genetic resources. Unfortunately, most approaches are aimed at conserving the "resources" *per se* and have seldom taken into account the genetic diversity. *Ex-situ* and *in-situ* methods followed in the conservation of crop genetic resources have been extended to forest genetic resource conservation without critically evaluating their appropriateness.

New approaches are therefore needed to integrate national conservation activities for maximum effect in both production forests and fully protected area systems. Complementary Conservation Methods (CCM) are increasingly being viewed as newer approach to utilize and conserve genetic resources, which is essentially a decision-making process to adopt an appropriate method, protocol to achieve a lasting conservation. In CCM, *in situ* conservation of genetic resources are reinforced with

the efforts of *ex situ* and vice versa while an enabling policy environment is created. Newer approaches such as 'Forest Gene Banks' and '*circa situm* conservation' of resources is far more participatory in nature and effective in involving communities for domestication and utilization.

Forest Gene Bank

Forest Gene Bank (FGB) is an alternative strategy to the existing conventional *ex situ* and *in situ* methods of conservation. FGB is essentially an *in situ* site where a target species occur naturally that has been augmented and genetically upgraded through introductions of individuals from other populations. Essentially this technique enhances the genetic diversity through interventions and thus enables the population to survive for a longer time periods (Uma Shaanker and Ganeshaiah, 1997). This approach takes into account the spatial distribution of the species and the underlying genetic variability of a species.

In this model, the forest gene banks would be located within the distributional space of the species. These *in situ* sites would serve as sink sites and would have the propagules introduced from the neighboring source sites which harbor unique and rare alleles. Further, this model would also take into account the phenotypic variations existing within each of the species and bring them to the sink sites. Thus, these sites would maintain a regional set of both genotypic as well as phenotypic variations. These sites would, serve as gene banks for facilitating continuous turnover of the genetic material within and among populations (Uma Shaanker and Ganeshaiah, 1997). Forest gene banks for two endangered tree species *viz*., *Dysoxylum malabaricum* and *Semecapus kathalekanensis* have been established near Sirsi in the Central Western Ghats.

Circa Situm Conservation

Circa situm conservation is the preservation of planted and/or remnant trees and wildlings in farmland where natural forest or woodland containing the same trees was once found, but where natural vegetation has been lost or modified significantly through agricultural expansion (Dawson *et al*., 2013). *Circa situm* conservation emphasizes on maintaining higher tree species diversity to conserve the processes of evolution and adaptation (Jarvis, 1999). Forest remnants in cleared agricultural landscapes, sacred groves and coffee plantations may be extremely important as tree breeding stocks and are the places for *circa situm* conservation (Boshier *et al.* 2004).

Circa situm conservation has a very important role in agricultural areas with high demographic pressure and significant deforestation where alternative approaches to conservation are limited and traditional agroforestry systems like coffee/areca agro-forests, home gardens and sacred groves are known to harbour high levels of plant diversity (Maxted *et al*., 1997). Motivation to adopt *circa situm* conservation by farmers is largely based on the perceived use value of the species. Maheswarappa *et al*. (2021) have shown small farmers of Kodagu region of Karnataka tend to conserve highest number of useful tree species and 95 per cent of them retain native tree species than big and medium category farmers.

In a study by Maheswarappa *et al*. (2019), the extent of genetic diversity of tree populations of *Acrocarpus fraxinifolius* occurring in natural forests, sacred groves and coffee plantations of Kodagu in Southern Karnataka was analyzed using ISSR markers. Interestingly, populations of sacred grove and coffee plantations recorded higher diversity than natural forest population. This pattern was also similar in two other tree species. The authors have also shown that the traditional agroforests host substantial diversity of useful trees suggesting a huge potential to be considered as *circa situm* sites. Understanding the pattern of tree diversity, species conservation concern, genetic diversity of *Circa situm* areas of different agroforestry areas is poorly attempted in India (Maheswarappa *et al.* 2020).

Apart from recognizing potential sites for *circa situm* conservation, augmenting these sites with additional diversity to convert them as gene banks can be attempted. In an attempt to establish the first *circa situm* gene bank of trees in the country, Maheswarappa *et al*. (2021) have planted *Ficus racemosa*, *Ficus reliogiosa*, *Pongamia pinnata*, *Toona ciliata, Pavetta indica, Artocarpus hirsutus, Oroxylum indicum, Kydia calysina, Erythrina indica, Artocarpus heterophyllus, Mangifera indica, Terminalia tomentosa*, *Dalbergia latifolia, Acrocarpus fraxinifoilus and Ficus racemosa* in a coffee farm near Ponnampet, Kodagu, Karnataka, India.

New tools, technologies, protocols are required to rapidly and precisely characterize/monitor diversity, assess the dynamics/loss across landscapes and as well as to achieve lasting conservation. New technologies offer unprecedented abilities to monitor change, create new

ways of collecting data. Information and virtual tools, space technologies, and genomic data are some of the newer and rapidly evolving technologies. Ubiquitous devices such as cell phones and people connected to cloud computing systems will revolutionize the types of data we collect for effective utilization and conservation.

Action Research Points

There is a need for the establishment of a key technical secretariat that involves practicing foresters, scientists, technocrats, information scientists, policy makers, *etc*. to build a range-wide, spatially explicit big-database on *circa situm* conservation value of agro-forestry systems as well as to develop guidelines for establishment of *circa situm* gene banks across the country.

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