TROPICAL FRUIT TREES AND OPPORTUNITIES FOR ADAPTATION AND MITIGATION

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ABSTRACT

The agriculture and land use sector is a major contributor to global GHG emissions, and it is also a sector that has great potential to remove carbon from the atmosphere and contribute to climate mitigation (Scherr and Sthapit 2009). The perennial trees found in forests and agricultural lands, in the form of agroforests, home gardens and orchards are important sources of mitigation from this sector. Trees, especially tropical fruit trees, also have the additional benefit of augmenting rural income sources, providing physical materials, and adding to ecosystem services and resilience.

Key words: Tropical fruits, climate change, green house gases, mitigation and adaptations

Introduction:

Diversification is a strategy used to minimize risk and build resilience, be it in investments or in farming systems. While monocultures may deliver bumper harvests during favourable weather and market conditions, they also expose producers to the risk of absolute failure. On the other hand, production systems with high agricultural biodiversity can bring stability in yield, limit pest and disease outbreaks and increase resilience to disturbances (Frison et al. 2011).

Consequently, farming communities across the world, from Sub-Saharan African to Himalayan high mountain ecosystems maintain diversity of species and income sources to deal with variation and uncertainty in their production. Farming communities rely on the diversity of emergency root crops, animal breeds and farm trees to buffer their food supply during lean periods. For these communities, it is important to have options that take advantage of various niches and the extreme growing conditions they face from year to year (Sthapit et al. 2009). Tropical fruit trees provide one important option in diversifying a household's or a community's livelihood strategies.

Fruit trees add resilience to farming systems as they can withstand climate adversity better than annual crops. Depending on the species, they also provide multiple use values in addition to fruits, such as timber, firewood, fodder, nitrogen fixation and windbreaks. For instance, during the Indian Ocean tsunami of 2004, agricultural crops and many trees were destroyed, topsoil was swept away and the land became too saline for cultivation. However, coconut trees did much better at surviving the winds and the waves due to their flexible trunks. Being adapted to saline conditions they also continued to bear fruits during this period of need. Coconuts in Sri Lanka have multiple uses for food, raw materials and construction materials.

Reproductive stages of fruit trees are most susceptible to climate change with implications on quantity and quality for fruits produced (Ramos et al. 2011). Winter chilling temperature requirements (Leudeling et al. 2011) and timing of water stress and rainfall (Dinesh and Reddy, and Rajan in this book) have repercussions on flowering and fruiting. One way to deal with this risk is to use fruit trees that provide multiple benefits or uses or to devise multiple uses for the existing trees. For example, *Garcinia* spp. fats can be used for high quality facial soaps. In Thailand, *Garcinia* twigs, which have resin, are used to provide distinct flavour to local chicken recipes. In Sirsi of Western Ghats in India, the rind from *Garcinia* is used as an active ingredient in anti-obesity medicine, which fetches lucrative prices in the western markets.

For farmers to reap benefits from novel tree crops or from new products made from existing crops, they need to improve production and in parallel develop post-harvest, processing technologie and develop market linkages like fresh lime and lemon fetch very low prices because, unlike mandarin and sweet lime, they are not eaten as fresh citrus fruits. As such, the community invested in a small processing plant for juicing lime and lemon into squash (a juice concentrate that is mixed with cold water for a refreshing drink) and chuk (a thick dark form of traditional vinegar used both for food and medicine). The leftover rind and pulp from the juicing process is used to make pickles. These three products are now flying off the shelves in the local markets. As a result, in one season the farmers have recognized the potential for these new fruit products and planted over a thousand new saplings each of lime and lemon (Sthapit et al. 2010).

However, changing or adapting varieties of longer lived fruit trees to rapidly occurring climate change is an emerging challenge. Fruit trees have long productive lives ranging from over two to four decades. Hence, any change in variety happens over this long period (Lobell et al. 2006). Short duration crops such as cereals and vegetables are attractive to farmers as they give income in the first season. And if change in variety is needed, it can be done quickly with annual crops compared to fruit trees.

There are, however, techniques to speed up varietal change in fruit trees such as grafting. Selection of strong rootstocks in fruit trees can provide the necessary resilience to climate change. By grafting desirable varieties to these resilient rootstocks farmers can try new varieties without replanting. Side grafting on existing rootstocks can help speed up the process of changing varieties. In fact, a farmer near Lucknow in India, the place of origin of the famous Dussaheri variety of mango, has grafted over 150 varieties onto a single rootstock (Sthapit pers. comm.).

Practiced to showcase rich diversity, this innovation also allows farmers to assess and compare which varieties do well in a given climate and to maintain a large amount of diversity in a relatively small area. However, without replication, there is a risk of putting all eggs in one basket. From a production perspective, selecting a resilient rootstock and grafting on it a couple of varieties that bear at complementary times may ensure production even in seasons with erratic climate patterns.

Tropical fruit trees for mitigation In addition to their role in adaptation, fruit trees are also an important part of the perennial based solutions for climate change mitigation. In a year, perennial crops can sequester between 320 to 1,100 kg of soil carbon per hectare, as compared to 0 to 450 kg of annual crops, and are more likely to get better yields than annual crops at higher temperatures (Glover et al. 2007). Breeding for perennial cereals, especially for use in fodder and feed is one promising path, and the Land Institute has been working towards that aim. Transitioning to more perennial trees, such as fruit trees, is an existing solution.

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For existing orchards, the challenge is in changing to an appropriate variety in the context of changing climate. While annual crops and vegetables can be replaced every season to match variety with the changing climate, the same process can take at least a few years during which production is foregone. However, farmers in India as well as Thailand have started carrying out top working and grafting with scions of suitable varieties to speed up the transition of varieties.

Without access to a market outlet, the increase of fruit trees in agroforestry systems also seems to have limited scope. For example, in Africa fodder and fuel trees tend to outnumber fruit trees in agroforests by more than 10 times. This is simply due to the fact that a household's need for fuel and fodder are greater in terms of volume than the household's capacity to consume fruits (Place pers. comm.).

As such, without an ability to sell the surplus fruits produced, there is no need to have more fruit trees on farm. Several initiatives around the world are now looking at carbon finance as a way to achieve climate mitigation whilst generating co-benefits for rural communities. In the compliance markets of the Kyoto Protocol's Clean Development Mechanism, forestry based credits play a very limited role (only 1% in 2008). Most of the innovations in land use based carbon credits are taking place in the voluntary carbon markets (Ecosystem Marketplace 2012). Standards such as Voluntary Carbon Standard, CCB (Climate, Community and Biodiversity) project design Standard and Plan Vivo allow for carbon credits to be generated from agroforestry and perennial trees because of their focus on co-benefits.

For the traditional *ex situ* conservation of field genebanks, the current carbon prices might be too low to make a difference. For example, the annual maintenance cost of CATIE's nine hectare coffee field genebank in Costa Rica with 1992 accessions is US$ 30,343 per year on top of the initial establishment cost of US$ 138, 681 (Dullo et al. 2009). The potential carbon sequestration of agroforestry systems in the tropics is between 1.5 to 3.5 tons of carbon per hectare per year, i.e. 5.5 to 13 tons of CO2eq. per hectare per year (Trumper et al. 2009). With average credit prices of US$ 5.2 per ton of CO2eq for agroforestry or US$ 7.3 per ton of CO2eq for forest management (Hamilton et al. 2010), carbon finance is unlikely to make these field genebanks more economically viable. However, devolving the management of field genebanks to communities and integrating it with homegardens in the community can significantly increase the carbon sequestration in the landscape.

Farmers in the community-based biodiversity management programme in Nepal are maintaining small field genebanks of banana and citrus. Due to low labour costs and basic management practices, even the modest carbon credit prices could make a difference for these farmer managed field genebanks, especially if the financing is paid to the farmers' group's core funds rather than to individuals.

For on-farm conservation with community participation, carbon finance under these standards can play a stronger role in increasing tree density on-farm. In this case too, carbon finance is unlikely to be the main benefit due to low price of carbon. But they can financially help the farmers achieve transition in their land management practices (Shames et al. 2011). Carbon finance can play a strategic role in helping establish more fruit tree saplings in the farming system.

Once the transition to a more fruit tree based farming system is achieved, the productivity and resilience of the new system itself is likely to be the principle benefit for the farmers. From the above discussion, we can conclude that carbon financing can meet the additionality criterion (i.e. without carbon financing the activities would not have been undertaken) by helping address the barriers to the establishment for fruit orchards, field genebanks and promotion of fruit trees in homegardens. For commercial fruit orchards, additionality of carbon payments will continue even after the period of initial establishment. This is because without appropriate adaptation measures, changing climate will make the year to year production highly variable subject to the temperature and timing of rainfall. However, despite losses in productivity, the standing trees in the orchard***s*** will continue to provide carbon sequestration services. If commercial orchards are established in previously degraded and abandoned lands, the sequestration benefits can be really significant. To really take advantage of this opportunity, a higher and stable carbon price, and research on fruit tree systems with high carbon sequestration will be necessary.

Conclusion

Despite the importance of tropical fruits in terms of nutrition and food security, very little work has been done on it compared to cereal crops. Many studies so far have focussed on the impact of climate change on cereals and major crops only. This book tries to bring together the current status of knowledge regarding tropical fruit trees and climate change. As woody perennials, tropical fruits trees are perceived to be less susceptible to the changing climate. But this book finds that there are idiosyncratic ways in which tropical fruit trees are affected.

Although the tree might itself be left standing, there are risks of production losses. Being long lived trees, adapting to climate change through varietal change is also a challenge. However, climate modelling and GIS can help match fruit trees to probable future climate scenarios and open up avenues for production in new areas. Being a perennial crop that can stay productive for decades and in the process sequester carbon, commercial fruit tree orchards, field genebanks and fruit trees in homegardens, can be options for using both agricultural and degraded lands for carbon sequestration.

Since the trees continue to provide mitigation services, even while suffering production losses, they also fulfill the additionality criterion of carbon financing. However, for the carbon financing to really have an impact, the global carbon pricing needs to go up. Finally, knowledge gaps in terms of tropical fruit trees and climate change need to be urgently addressed to strengthen humanity's toolkit for building climate resilient agriculture systems that also mitigate climate change.

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