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A Preliminary Appraisal of Mango Biodiversity in Kerala, India

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Mango (*Mangifera indica* L.) is a keystone species in homestead gardens across Kerala, India. This study was conducted in two village sites in Kerala to assess their richness and evenness values of mango diversity, document farmers' motivations for maintaining this diversity, and record pertinent indigenous traditional knowledge (ITK). Four Cell Analysis (FCA) in the context of Focus Group Discussions (FGDs) was used to generate biodiversity data and gauge farmer rationale for cultivation. The average household (HH) richness in the Erippadam village was r=6.29 and the average HH evenness was λ=0.64, whereas the average HH richness in the Maruthampadam village was r=2.84 and the average HH evenness was λ=0.40. These variations were attributed to the presence of different forms of agricultural commercialization in the two village sites. Drawing on FGD results, several suggestions were offered that may serve to enhance and maintain mango biodiversity in the Kerala region.

Key Words: Agricultural biodiversity, *In situ* (on-farm) conservation, Mango biodiversity, Home gardens, Kerala

Introduction

South Asia in its entirety contains more than 500 different species of fruits, and the Indian subcontinent itself is home to over 300 of them (Malik *et al*., 2010). This vast reservoir of genetic resources is a vital asset for future global food and nutritional security as well as maintaining ecosystem health. A combination of trends including deforestation, the proliferation of monoculture farming systems, and the economic incentives commercialized agriculture offers has contributed to the worldwide erosion of valuable genetic resources and associated traditional knowledge. This loss of agricultural biodiversity threatens world food security, ecosystem health, and the economic security of more than one billion people who rely on agriculture for a means of livelihood (FAO Statistical Yearbook, 2013).

Two primary conservation strategies – *in situ* (on-farm) and *ex situ* (external storage of seeds in seed banks, research facilities, *etc*.) conservation have been adopted by the international community as a means of safeguarding this wealth of genetic diversity. That said, the capacity, availability, and long-term sustainability of *ex situ* conservation efforts are constrained by a host of factors that make sole reliance on them unreliable at best. As such, in recent years *in situ* or on-farm conservation has begun to grow in popularity and importance due to its global applicability, relatively low capital input requirement, and its ability to build, maintain and strengthen relationships between the formal scientific research sector and rural communities worldwide.

Mango, hailed as "the most important fruit crop in India" (Dinesh *et al*., 2012), is no exception to this global trend of genetic erosion. However, not only does mango play an important economic role in India as a cash crop sold domestically and internationally, it has also penetrated and influenced the country's culinary, religious, and ethnic culture for thousands of years. Furthermore, this fruit exhibits a startling array of diversity, with over 1000 recognized varieties of the *M. indica* species alone in India (Dinesh *et al*., 2012). In Kerala, a province located in the southwestern corner of the Indian subcontinent, a wide variety of mango species and cultivars are maintained by local communities for commercial and domestic purposes (Kumar and Nair, 2006). Many locals keep mango trees in home-gardens and semi-commercial orchards, and the fruit figures prominently in the area's food culture.

Notwithstanding its importance to local communities and markets, there is a marked research gap concerning the status of mango biodiversity in south India in general and in Kerala in particular. This current study is both descriptive and normative. It strives to fill the current lack of participatory research devoted to this topic by

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assessing the state of mango biodiversity in two village sites in Kerala. Furthermore, it investigates the reasons for richness and distribution values of mango diversity and the state of associated indigenous traditional knowledge (ITK) on mango biodiversity in the region. Lastly, this study concludes by providing suggestions for good practices that will help maintain and enhance mango diversity in Kerala in the context of increasingly widespread agricultural commercialization.

Materials and Methods

Site Description

Two villages were selected as research sites for this study, both located in the state of Kerala, India. Maruthampadam village is located in Thrissur District, Pazhayannur gramapanchayat (GP, term for a smaller local administrative unit). The total geographical area of Pazhayannur GP is 59 sq. km with altitudes ranging from 30-220 m. The average annual rainfall is 2972 mm, and the climate type is monsoon tropical. The average yearly temperatures range from a high of 36°C in April to a low of 19°C in December and January. The area is known for its lush green tropical landscape characterized by red lateritic soil. The lowlands of this GP are cultivated with a range of fruit crops such as coconut, areca nut, and banana while the commercial cultivation of teak and rubber is rapidly spreading.

Erippadam village is located in Palakkad District (which borders Thrissur District to the west), Muthalamada GP. The total geographical area of Muthalamada GP is 67 sq. km, with an altitude range of approximately 75-250 m. Though displaying nearly identical average temperature patterns, this GP exhibits a drier climate than Pazhayannur GP, with an average annual rainfall of 2269 mm. The soil types vary across the GP, from black soil with clay content to red soil to lime rocks, etc. The plain regions of Muthalamada GP are characterized by the cultivation of paddy, groundnut, coconut, and an increasingly semi-commercialized mango industry. Though showing slight variations in terms of geography, climate, and agriculture preference, the cultural makeup of the two GPs is relatively similar and no drastic differences in custom or way of life were noted.

Selection of Participating Farmers

Data on local mango biodiversity and the target communities' ITK was collected by means of participatory collaboration between researchers and locals. Village notables were initially reached externally in order to establish baseline contacts in the target sites. Representative homesteads thought to maintain rich mango varietal diversity were then contacted via a socio-metric survey employing the snowball sampling method. This method operates by having existing study subjects (*i.e.* those with whom initial village contact was established) recruit future subjects with whom they are personally or professionally acquainted at the village level, thus creating an expanding web of interlinking participants.

Participatory Identification of Local Biodiversity

Focus group discussions (FGDs) were held with selected farmers in the two target villages. FGDs were held in Maruthampadam and Erippadam villages on 10/11/2010 and 27/12/2010, respectively. In these FGDs, four-cell analysis (FCA) was used as the primary means of gauging local biodiversity via accessing the ITK resources possessed by the farmers. Four-cell analysis is a participatory method that engages with knowledgeable local populations in order to: (1) identify common, unique, and rare crop varieties, (2) document the reasons why these crops/varieties are found in a dynamic state, and (3) devise and identify conservation strategies that can be implemented at the village level to conserve local biodiversity (Sthapit *et al*., 2012a).

In this study's two project sites, the FCA technique conducted during FGDs consisted of several steps. Prior to the discussions, farmers were asked to assess the types of mango species and varieties maintained in their home-gardens and orchards and to bring this information with them to the planned FGDs. The discussions were then initiated on an introductory note stressing the importance of maintaining *in situ* varietal diversity. Participating farmers were subsequently asked the following four questions that form the basis of the FCA technique: (1) what are the mango types cultivated in large areas in many homesteads, (2) what are the mango types cultivated in large areas in few homesteads, (3) what are the mango types cultivated in small areas in many homesteads, and (4) what are the mango types cultivated in small areas in a few homesteads? The parameters of what constitutes a small *vs.* large area and many *vs.* few homesteads are a qualitative measure agreed upon by farmers during the FGD, thus differing slightly between the two research sites. These research questions are critical for developing deeper understanding of farmer's decision on choice of mango varieties and their conservation efforts.

Once these questions were fielded and a set of local parameters mutually agreed upon, farmers assigned the mango species and varieties found in their home-gardens into the specific cells of the FCA grid (Table 1). This was done interactively and visually in order to keep the farmers engaged and aware of the ongoing process. Following the placement of local mango species and varieties into the aforementioned FCA grid, the different characteristics and qualities of these types were discussed and analyzed by the group. The different varieties were classified as common, other distinct, or rare depending on their placement in the grid (Table 1). The FGD was concluded with remarks regarding the diversity status of the local mango population and various strategies that could help to preserve and enhance this diversity in the future.

Diversity Estimates

Richness and evenness are two measures useful for gauging the biodiversity of a given site (Jarvis *et al.*, 2008). Richness describes the total number of genotypes (in terms of this study, species or varieties) found within a specified area. Richness was determined at the household level and was calculated by counting the total number of different farmer-named mango varieties per household unit.

Likewise, evenness details the frequency of given types within a total population. For instance, a low evenness value indicates the dominance of an agricultural system by one or few species or varieties, whereas a high value indicates a more uniform distribution of types in a given unit area (which, in this study, was the household unit). Evenness was calculated using the Simpson Diversity Index defined as:

$$\text{Evenness } (\lambda) = 1 - \frac{\sum_{k=1}^{n} V_k^2}{N^2}, V_k = \text{Number of trees per variety k, } N = \text{Total number of trees}$$

Results

Choice of Fruit Crop

FCA is also used to measure the importance of crops to the community. The importance value is measured by the number of households (HHs) growing given crops and/or varieties (Fig. 2a and 2b) in a project site. In both villages, mango was recognized as the most important crop (cultivated by 21-29 HHs). With respect to other locally grown commercial and food crops, rubber, coconut, rice, vegetables and banana were important in Maruthampadan village whereas coconut and rice were other important crops in Erippadam village.

FCA Classification Status of Mango Diversity

Mango varietal data collected from the FCAs performed at the two village sites were organized into the above-specified categories, namely common, other distinct or rare varieties. Table 2 displays the data collected from the Maruthampadam and Erippadam village sites. Though Maruthampadam village showed a relatively low richness value for common mango varieties (r=3), nine different rare varieties were maintained in the home gardens and orchards, and six other distinct varieties were recorded during the session. Erippadam village maintained more than twice the number of common varieties than Maruthampadam village, with a richness value of r=7. Conversely, only four rare varieties were recorded during the FCA held in Erippadam village, less than half the number was recorded in Maruthampadam. Overall, Maruthampadam village displayed a tendency to maintain a greater number of rare varieties and other distinct varieties, while Erippadam village exhibited a preference for common varieties at the expense of rare varieties. Both villages contained similar numbers of other distinct mango varieties. Lastly, popular varieties common across Kerala such as Olour, Bapakai, and Kurukan were not reported in these two villages.

Richness and Evenness Diversity Values

The overall varietal richness of the Maruthampadam village site was r=17 with a household level range of 1-13 varieties. The average richness per household in the village was r=2.84 while the average evenness per household was λ=0.40. Evenness values for this site of each recorded mango variety are presented in Fig. 3a.

Table 1. Participatory four-cell analysis diversity grid

Mango Types	Considered as
Mango types grown in large areas (many trees) in many households	Common type
Mango types grown in small areas (few trees) in many households	Culturally important but endangered type
Mango types grown in large areas (many trees) in few households (few orchards)	Other distinct commercial type
Mango types grown in small areas (few trees) in few households (few home gardens)	Rare or unique type

Table 2. Comparative mango varietal distribution status and key traits in project sites

Variety	Village	Conservation Status*	Notable Traits
Gomanga	Maruthampadam	Common	Regular bearer
Muvandan	Maruthampadam	Common	Regular bearer, good for processing, disease tolerant and good for marketing
Pulimanga	Maruthampadam	Common	Acidic variety, tender mango pickling purpose, regular bearer
Kilimook	Maruthampadam	Other Distinct	Widely grown in south India, regular bearer, preferred for processing
Nadasala	Maruthampadam	Other Distinct	Regular bearer, dual purpose variety
Neelum	Maruthampadam	Other Distinct	Pollinizer for orchards and used for table purposes
Priyur	Maruthampadam	Other Distinct	Profuse bearer
Puliyan	Maruthampadam	Other Distinct	Culinary purpose, pickling purpose, high fiber content
Chandrakaran	Maruthampadam	Rare/Unique	Popular variety of Kerala, used in traditional households for making *mambazha pulissery*
Ganapatimookan	Maruthampadam	Rare/Unique	Big fruit, sour taste
Karpuramanga	Maruthampadam	Rare/Unique	Turpentine flavor, regular bearer, pickling purposes
Kilichundan	Maruthampadam	Rare/Unique	Local seedling, used for pickling purposes
Kottamavu	Maruthampadam	Rare/Unique	Local land race, regular bearer, pickling purposes
Marathakam	Maruthampadam	Rare/Unique	Dark green color
Mundappa	Maruthampadam	Rare/Unique	Attracts fruit flies when rains; best before rainfall
Sindhura	Maruthampadam	Rare/Unique	Deep reddish tinge, different taste and texture, early bearer
Alphonso	Erippadam	Common	Export quality, retains quality good, alternate bearer, firm pulp, fibreless and of excellent quality
Banganapalli	Erippadam	Common	Early variety cultivated widely in southern states, moderate and regular bearer, high quality fruit
Kilichundan	Erippadam	Common	Local seedling, used for pickling purposes
Muvandan	Erippadam	Common	Regular bearer, good for processing, disease tolerant and good for marketing
Nadasala	Erippadam	Common	Regular bearer, dual purpose variety
Neelum	Erippadam	Common	Regular bearer, heavy yielder, late season variety with wide adaptability
Sindhuram	Erippadam	Common	Taste good, good keeping quality
Gomanga	Erippadam	Other Distinct	Common variety of North Kerala, dual purpose, used for instant pickling
Gudadath	Erippadam	Other Distinct	Culinary purposes, regular bearer
Himapasanth	Erippadam	Other Distinct	Taste good, table type
Kalepad	Erippadam	Other Distinct	Regular bearer, popular in Kerala, fruit small to medium, fibreless flesh
Mulgoa	Erippadam	Other Distinct	Late season variety, shy bearer, pulp very sweet, melting and with pleasant flavor
Nadanmanga	Erippadam	Other Distinct	Tangy taste, not eaten ripe, used for curry preparation
Priyur	Erippadam	Other Distinct	Profuse bearer
Chandrakaran	Erippadam	Rare/Unique	Poly-embryonic variety
Kilimook	Erippadam	Rare/Unique	Widely grown in south India, regular bearer, preferred for processing
Mallika	Erippadam	Rare/Unique	Hybrid
Mundappa	Erippadam	Rare/Unique	Attracts fruit flies when rains; best before rainfall

*In terms of FCA analysis, 'Common' denotes mango varieties grown in large areas (many trees) by many households (home gardens); 'Other Distinct' represents mango varieties grown in large areas (many trees) by few households (few orchard); 'Rare/Unique' represents mango varieties grown in small areas (few trees) by few households (few home gardens).

Similarly, the overall varietal richness of the Erippadam village site was r=18 with a household level range of 1-15 varieties. The average richness per household in the village was r=6.29 while the average evenness per household was λ=0.64. Evenness values for this site of each recorded mango variety are presented in Fig. 3b. Overall, Erippadam displayed higher total richness, average richness per household, and average evenness per household values than Maruthampadam village.

Relationship between Plot Size and Mango Diversity

During the FGD and data collection process, home-garden plots were divided into four distinct categories: a) >1 acre, b) 1 – <5 acres, c) 5 – <7 acres, and d) 7≤ acres. Average varietal richness was then plotted against home-garden size for the two villages (Fig. 4). Maruthampadam village showed a direct positive relationship between richness and plot size for size categories a) through c). However, richness decreased dramatically in the largest size category, dropping from r=14 to r=5. Erippadam village showed a consistent direct positive relationship for all size categories, though the most significant jump in richness was between size categories b) and c).

Discussion

Potential Reasons for Mango Diversity Differences

With the exception of an approximately 25% difference in annual average rainfall between Maruthampadam

Fig. 1. Map of Kerala state showing the location of the selected gram panchayats

and Erippadam villages (2972 mm *vs*. 2269 mm, respectively), the most significant distinction between the two sites is that while the former village is located in an area dominated by commercial rubber and teak cultivation, the latter is located in an area dominated by semi-commercial mango cultivation. This difference in the areas' commercial agricultural foci may be one factor that explains the mango diversity disparity between the two sites. With respect to the FCA diversity categories (*i.e.* common, other distinct, and rare), as was noted above, the Maruthampadam village maintained a total of nine rare mango varieties compared to only three common varieties. In Erippadam village, where commercial mango cultivation has become increasingly widespread, seven common varieties were maintained as opposed to only four rare varieties. These figures seem to imply that commercialized mango farming and common varietal diversity are directly positively related, whereas subsistence mango farming and rare varietal diversity are inversely related. In other words, the data suggests that in areas where common varietal diversity dominates, specific types are cultivated to cater to wider consumer and market preferences, whereas areas dominated by rare varietal diversity are more focused on raising the crops for household and local use. Such a conclusion would be expected, as commercialized mango cultivation places emphasis on a limited number of common varieties that have broader consumer demand, fetch higher market prices, and maintain stable production potential.

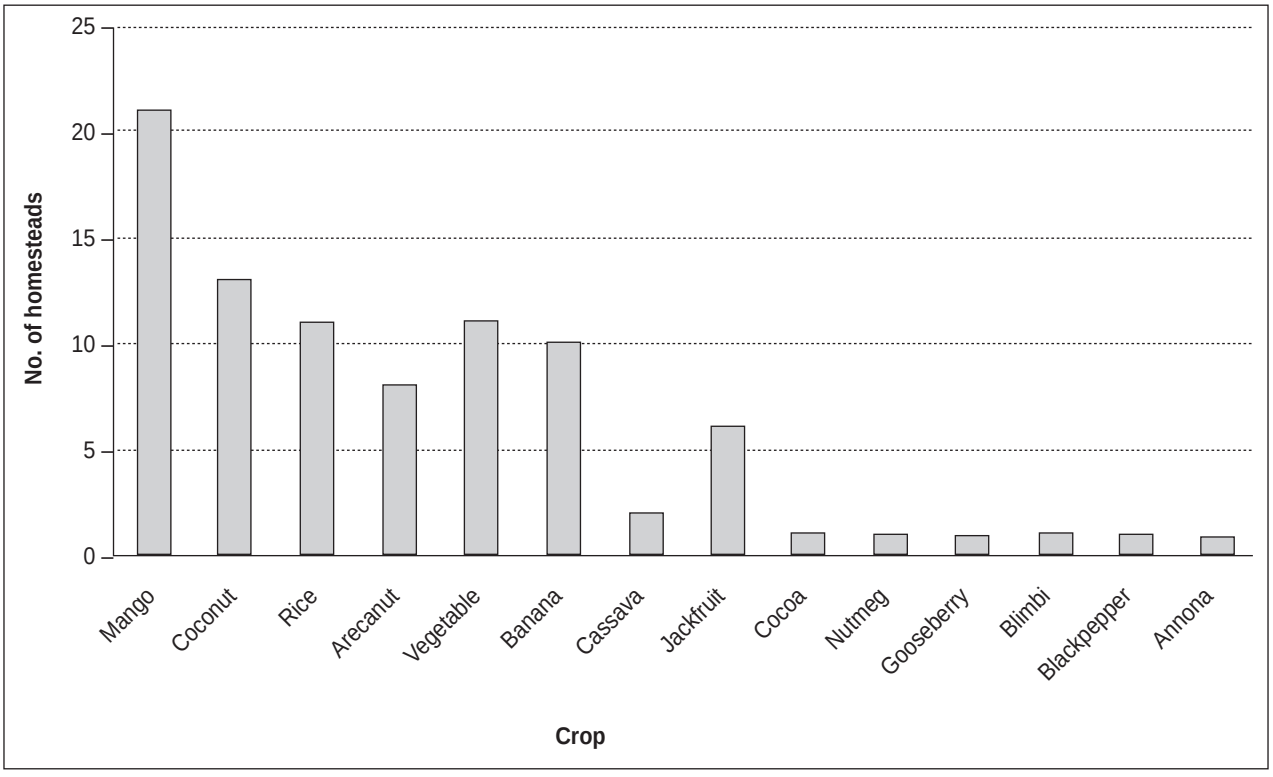

Fig. 2a. Crop diversity status of Maruthampadam village (Pazhayannur GP)

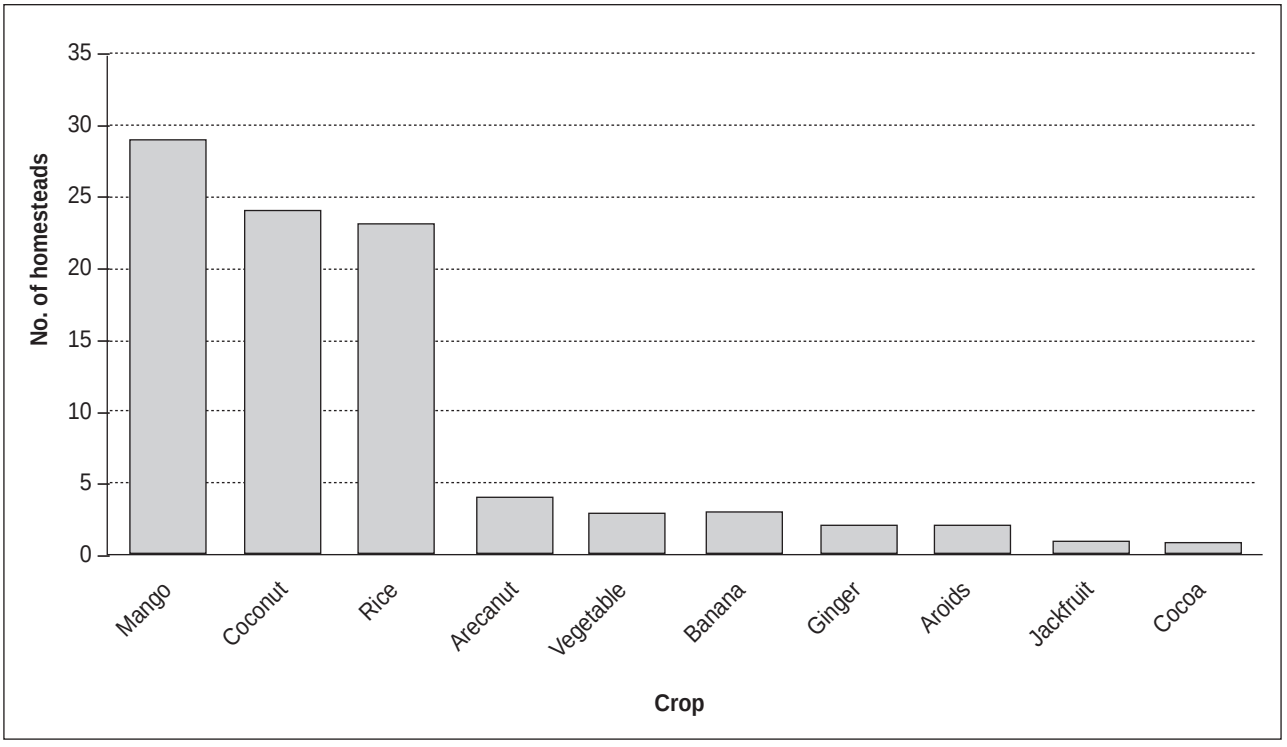

Fig. 2b. Crop diversity status of Erippadam village (Muthalamada GP)

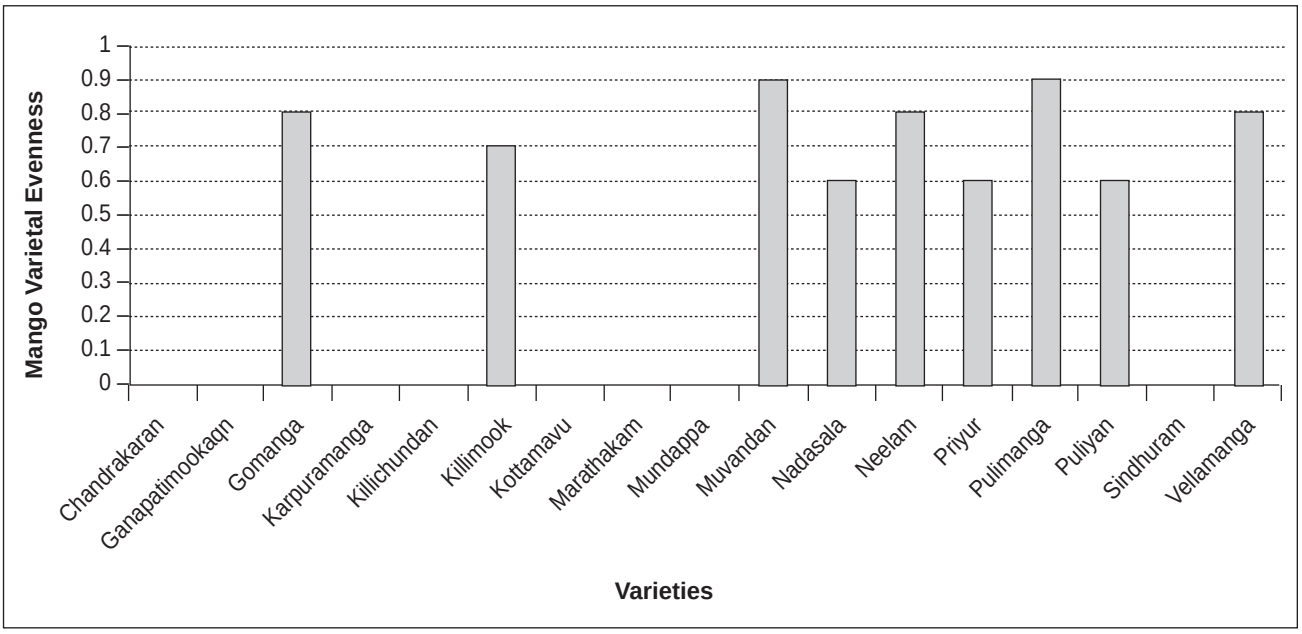

Fig. 3a. Varietal evenness for Maruthampadam village

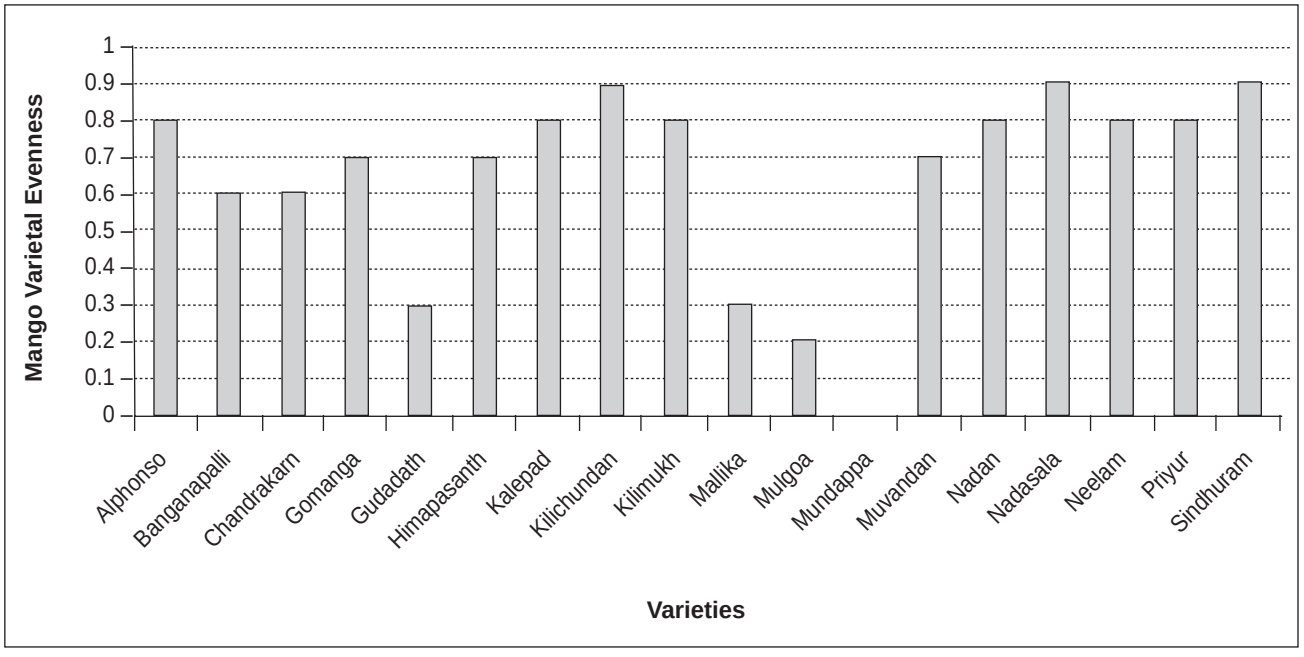

Fig. 3b. Varietal evenness for Erippadam village

In addition, the two villages displayed significant differences with respect to average HH varietal richness and average HH evenness (r=[2.84 cf. 6.29], λ=[0.40 cf. 0.64] for Maruthampadam and Erippadam, respectively). Erippadam village was richer in mango diversity and the varieties were distributed relatively evenly, likely in order to enhance resilience capacity. In Maruthampadam village, on an average only two to three mango varieties were grown in homestead gardens for home consumption. One potential explanation for this marked variation in average HH richness and evenness is that in areas where agricultural commercialization including

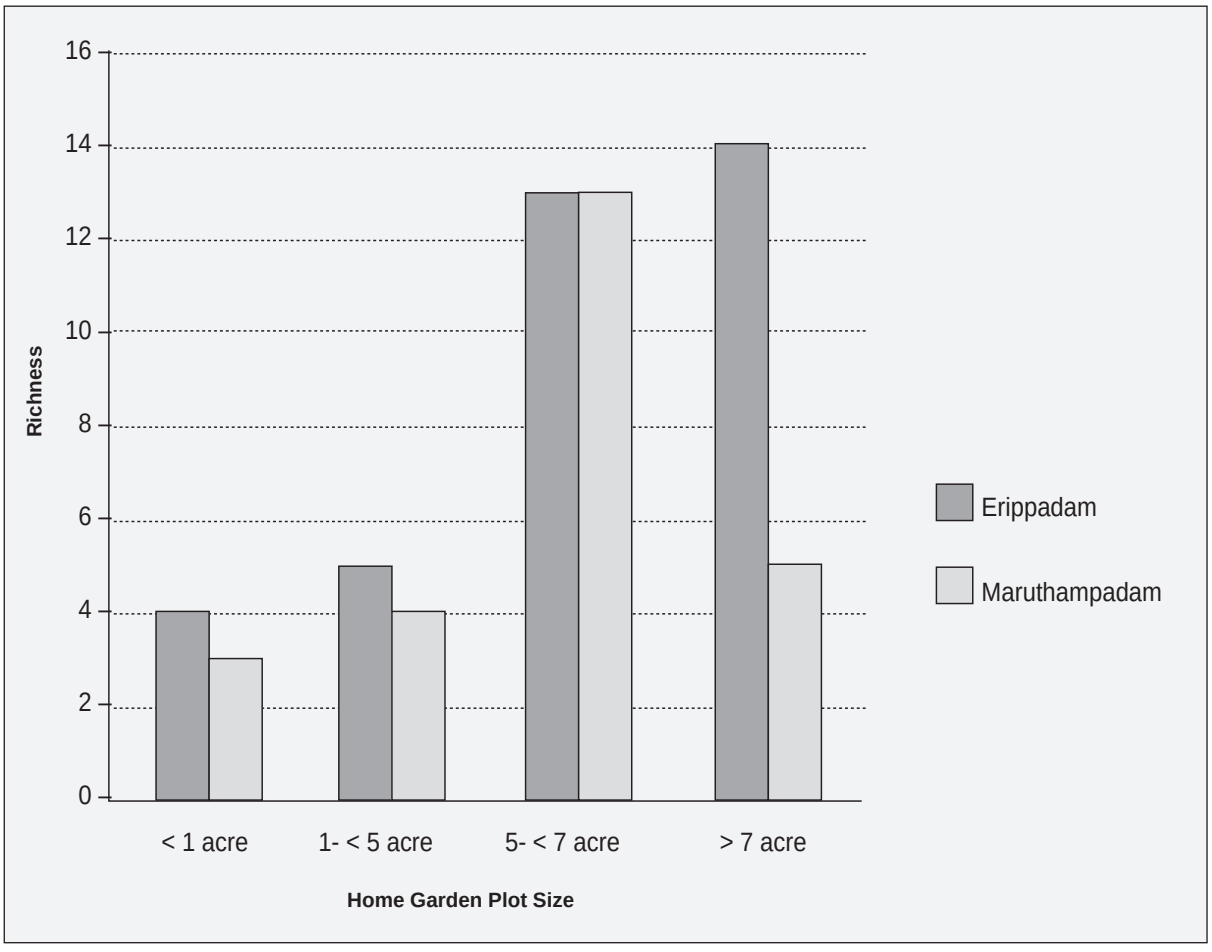

Fig. 4. Relationship between home-garden size and average varietal richness

of a non-food crop is rapidly spreading, the result is the overall erosion of food-crop diversity including mango. In Maruthampadam, where teak and rubber monocropping is an established and spreading industry, average household richness and evenness are markedly lower than in Erippadam village, where the primary commercial agricultural industry is mango cultivation. It thus appears that though commercial mango cultivation has a negative impact on the conservation of rare mango varieties, it is an effective means for maintaining common varietal diversity. Furthermore, in areas where commercial cultivation of non-food is dominant, average household varietal richness and evenness values will be lower than those of households located in areas where commercial food-crop cultivation is more common, due to general food-crop genetic erosion. This speculation calls for additional study, due to the fact that the degree of commercial mango cultivation in a given area may be influenced by factors not discussed in this study, such as proximity to markets and the strength of local commercial linkages.

This set of inferences could also explain the significant difference in overall varietal richness values between both villages for the largest home-garden size category, *i.e.* $\leq$7 acres. In both sites, it is highly probable that the largest home-gardens were used not simply as a supplement for kitchens and household use, but rather were for commercial purposes as well. As such, in Maruthampadam, rubber and teak may have come to dominate these large holdings, leading to the observed drop in varietal richness in larger plots. In Erippadam, where large gardens most likely served as semi-commercial mango orchards, varietal richness continued to increase.

Strategies for Future Diversity Management

As Malik (2010) argues, "*in situ* on-farm conservation would be an ideal approach for conserving local natural

selections, cultivars, and farmer's varieties." Given that the practice of maintaining home-gardens is a deeply entrenched cultural tradition in South India, the village sites of this study proving no exception, the most productive method of promoting *in situ* mango diversity in the region would be to focus on the home-gardens of local villagers. In an area such as Kerala, where genetic diversity is already threatened, home-gardens would provide an ideal setting for the maintenance of rare and unique varieties (Gautam *et al*., 2008; Watson and Eyzaguirre, 2002). The first step towards maintaining and enhancing mango diversity in local home-gardens would be to conduct further FGDs with target communities about the cultural, environmental, and economic importance of conserving rare landraces and varieties. If not already in place, the creation of a village diversity register that would record the different species and varieties maintained by the community could aid this campaign of raising local awareness on the importance of varietal diversity (Dinesh *et al*., 2014). Likewise, an assessment of the local informal seed-exchange system would be undertaken in order to track the flow of genetic material between farmers and correspondingly optimize its functioning.

Lastly, the promotion of local value-added processing industries has been shown to have a positive impact on both rural livelihoods and biodiversity (Sthapit *et al*., 2012b). Using the above mentioned local fruit diversity register, village level value-added processing could create a range of products that could be stored for long term use and supplement the communities' diets year-round. In addition, it would help to preserve ITK on mango diversity and the ways that different varieties can be used, which is an invaluable asset for the ensuring the perpetuity of traditional life and culture as well as maintaining local mango diversity (Boef *et al*., 1993). Products could also be sold in local markets to help increase incomes and improve local livelihoods. If wider market connections were established by means of a value chain analysis, the villages could even manufacture products for export to neighboring districts or states. This would provide villagers with an economic incentive to maintain and enhance mango diversity, as a range of varieties are required for specific value-added products. That said, there a number of constraining factors on the development of value-added processing at the local level. Small-volume production using inputs from home gardens carries a high transaction cost. Generally speaking, such ventures require initial capital investment from external sources that may be difficult or impossible for the target communities to access. Also, the performance of a value chain analysis could be potentially costly and logistically problematic, and its conclusions regarding market potential uncertain.

Recommendations for Future Research

Though the FGD held in Maruthampadam village touched on relevant and interesting ITK covering topics such as customary fruit processing techniques, recipes, and cultivation methods, the discussions held in Erippadam village did not yield significant information on the state or nature of ITK in the village. As was mentioned previously, ITK is an important asset for villages wishing to preserve local fruit diversity by means of *in situ* conservation and value-added processing. Understanding local motivations for the cultivation of specific varieties is critical for the continued maintenance of useful mango trees in home gardens. As such, one area of future research would be to comprehensively document ITK on fruit diversity (mango in particular) from the two project sites. This data could subsequently be employed by future researchers and market actors focusing on a value chain assessment of mango value-added products in Kerala, how this industry draws on ITK, and the manner in which it affects varietal diversity.

This study has hoped to draw attention to the state of mango varietal diversity in Kerala, India through data collected from two village sites. Though no definitive conclusions can be drawn without confirmation by future studies, this study suggests that agricultural commercialization effects local mango diversity in different ways depending on the specific cash crop(s) under cultivation. Nonetheless, the preservation of ITK, raising local awareness regarding the multifold importance of fruit genetic diversity, and the implementation of strategies such as the creation of a local diversity register and the promotion of value-added processing can contribute to the maintenance and enhancement of mango varietal diversity for use by current and future generations.

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