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On-farm diversity of Malaysia fruit species and their determining factors

(Kepelbagaian spesies buah-buahan Malaysia di ladang dan faktor penentuan)

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Key words: fruit species, diversity, on-farm, determining factors

Abstract

A primary survey involving 424 households was carried out in selected districts of Peninsular Malaysia. A total of 127 fruit species were identified from a total of 62,336 trees counted in the survey. The average number of species conserved by each household was 8. More than 60% of the species were considered as underutilised. The average Shannon and Simpson diversity indices for each farm were 0.64 and 0.68 respectively, which is considered as moderately rich. Ulu Perak, Kuala Kangsar, Alor Gajah, Jerantut and Kuala Lipis districts were found to be relatively richer in diversity compared to the other districts. Based on their frequencies, the minor fruits; *salak*, *pulasan* and *petai* were found to be as dominant as the major fruits. For *salak* and *pulasan,* market and socio-economic factors were both found to be significant in influencing the number of trees conserved on-farm. Therefore, the markets and market infrastructures should be developed for the minor and rare fruit species, and poor farmers should be given appropriate incentives for their willingness to conserve the species to ensure their sustainability. On the other hand, the richness of the species on-farm was influenced more by the agro-climatic factors rather than the socio-economic and market factors. Therefore, future development of rural areas should be more selective by taking into consideration the richness of species diversity, to ensure the sustainability of the species on-farm.

Introduction

Malaysia is rich in tropical fruit tree species. At present, it has been estimated that 370 edible fruit species exist in the country. These fruit species play an important role in providing nutrition and as sources of income to farmers. These fruits are categorised as either major, minor, rare or wild fruits.

Major fruits are those, which are commercially grown and are of economic importance. These fruits are cultivated either in large acreages, in mixed orchards, in large estates or in group farming. At present, 17 species are considered as major fruits. In 2002, the total area planted with the major fruits was estimated to be around 300,000 hectares (Anon. 2002). The fruit areas are scattered around the country with certain species concentrating in specific districts or locations.

Other than for local consumption, a substantial number of fruit species are being exported and becoming important contributors of foreign exchange earnings

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to the economy. Among these are durians, starfruits, pineapples and watermelons. The government recognised the importance of these major fruits and significant amount of allocations have been provided into R&D and promotions.

The Department of Agriculture Malaysia (DOA) has developed zoning maps for fruit areas based on their agro-ecological suitability. This map provides guidance for the department to recommend the best fruit species to be planted in specific areas, and at the same time, consistently monitor the development of the fruit industry in the country.

Unlike the major fruits, minor and rare fruit species are usually found growing in home gardens and orchards in villages and at jungle fringes, while wild fruits are found in the forests. About 65 fruit species are domesticated, while the remaining species are considered to be rare or wild.

There is no proper documentation on the status and distribution of the rare and wild fruit species in the country. Some of the species however, are rapidly declining and in danger of being lost forever. For example, the acreage under kuini (*Mangifera odorata* Griff.) has decreased by 18% between the year 2000 and 2001 (Anon. 2002). The values of many of these fruit species which have not been fully exploited are enormous, as they provide the local community with many economic benefits. For example, some farmers indicated good prospects and potentials for some minor fruit species such as petai *(Parkia speciosa)*, asam gelugur *(Garcinia atroviridis)* and pulasan *(Nephelium ramboutan-ake)* (Raziah et al. 2005). The diversity of the species also contributes substantially towards the sustainability of the ecosystem.

Efforts in conserving the land races of indigenous plant species, such as the rare fruit species are inadequate, and these land races are being eroded at a rapid rate (Anon. 1998). Currently, there is no proper procedure or guideline to protect these materials, especially those fruit species grown in home gardens and orchards, as opposed to *in situ* conservation measures that have been instituted for forests, animals, marine parks etc. Therefore, an on-farm conservation for the indigenous fruit species with the proper management should be able to provide realistic alternative *in-situ* conservation. Land races, traditional varieties of the under-exploited fruit species grown and maintained by farmers in their home gardens and orchards can then complement institutional collections.

The methodology for applied studies of an on-farm crop genetic resource conservation is currently being developed for a variety of crops by academic researchers working in collaboration with the International Plant Genetic Resources Institute (IPGRI), now known as Bioversity International (BI). The starting point for this paper is to target interventions for on-farm conservation, after understanding the social and economic forces that characterised the households' decisions in maintaining diversity. The focus of analysis and discussion would be at the species level.

The objectives of this paper are to present the socio-economic scenario of the households involved with the cultivation/conservation of the fruit species on-farm, to determine the fruit species diversity at the household level, to assess the factors that determined the on-farm species diversity and to recommend policies that could ensure the sustainability of future on-farm conservation of species with households participation.

Materials and methods

Source of data

This study relied on secondary information for basic data on the status of all fruit species cultivated in the country. In cases of inadequate data, the DOA at the federal and state levels was consulted, particularly for data on district identification and household population for sampling.

Based on the above information, primary surveys were conducted in 9 states in Peninsular Malaysia. Stratified sampling of the fruit growing districts was used and 17 districts were selected. The unit of sampling was the household and the data was first used

to explore the overall household diversity. The estimated sample size was 424 households. Primary surveys were carried out by personal interviews using structured questionnaires.

Theoretical framework

Diversity There are various forms of diversities. Richness refers to the count of species, evenness refers to the equitability in the areas shared for distribution among species and dominance refers to the percentage of species distribution (Anon. 2002).

Various indices have been employed in the literature to indicate the degree of diversity of plant genetic materials. In this study, the Shannon and Simpson diversity indices were employed to show the degree of diversity of the fruit species grown by the households. All fruits species were included in the computation of diversity indices, irrespective of major, minor, rare and wild species.

Shannon diversity index (D') was adapted from the information theory literature for use in ecology and agronomy. It combines a number of qualitative and quantitative traits into a single index (Magurran 1988). The formula is:

$$D' = -\sum_{i=1}^{n} p_i \ell n\, p_i \qquad \text{(Equation 1)}$$

Simpson diversity index (D") on the other hand is related to the Herfindahl index used by economists to measure industry concentration. The formula is:

$$D'' = 1 - \sum_{i=1}^{n} p_i^2 \qquad \text{(Equation 2)}$$

A basic unit for the calculation of the shares (p_i) of the species is the proportion of the fruit area that is planted to each species. Since a few species are usually cultivated in home gardens and mixed orchards, the shares are indicated by frequency of occurring or number of trees for each species.

Determinants of crop diversity on-farm The approach used in this study would address the questions of, which are the factors that explain high levels of crop diversity maintained at the farm level and what are the social and economic profiles of the farmers who are most likely to maintain high levels of crop diversity.

The general reduced form of diversity equation suggested by Van Dusen (2002) [Equation 3] and the rice genetic diversity model as suggested by Devendra (2002) [Equation 4] were adapted to model factors that determined the fruit species diversity on-farm.

$D = D[Q^*(\rho, \Phi_{HH}, \Phi_{Farm}, \Phi_{Market})]$ (Equation 3)

Where,

D = Species diversity;
Q^* = Household demand;
ρ = Price;
Φ_{HH} = Socio-economics of households;
Φ_{Farm} = Production technology; and
Φ_{Market} = Market access and transaction costs.

$D = D(\rho, \Omega_{HH}, \Omega_{Farm}, \Omega_{Market}, \Omega_{Var})$ (Equation 4)

Where,

D = Species diversity;
ρ = Price;
Ω_{HH} = Socio-economics of households;
Ω_{Farm} = Production technology;
Ω_{Market} = Market access and transaction costs; and
Ω_{Var} = Variety specific characteristics.

Model specification The model adapted for this study is shown in Equation 5.

$D_i = f(\beta_{SE}, \beta_{Market}, \beta_{AC})$

(Equation 5)

Where,

D_i = Species diversity (D_1 = number of species on-farm, D_2 = frequency of species distribution, and D_3 = Shannon diversity index);
β_{SE} = Socio-economic factors;
β_{Market} = Market factors and
β_{AC} = Agro-climatic factors.

Results and discussion

Socio-economic scenario of households

The summary of the respondents' background is presented in *Appendix 1*. Almost all of the respondents involved in the survey were Malays. The majority were old citizens aged 50 years old or more and had gone through primary levels of education. Those involved in the fruit cultivation were mainly full time farmers (53%) while the rest were mostly involved in other jobs.

The cultivation of fruit species has been the activity of the low-income group since the majority of the respondents earned less than RM500 per month (64%). Agricultural activities are confined mainly to rural areas involving poor farmers. However, some farmers (29%) managed to earn RM501–RM1,000 monthly. Besides their fixed monthly incomes earned from agricultural activities, the fruit growers also obtained side incomes from part-time jobs, contributions from their children or returns from other sources. Many of them (35%) received <RM100 per month from other sources of incomes.

The majority (51%) of the respondents have average family sizes of 5–8 members. About 47% of the respondents occupied 80–100% of their time on agriculture activities. Those who are involved in fruit cultivation are mostly farmers who may have other agriculture sources of income from rubber, oil palm, paddy and others.

Background of farms

The farm sizes owned by the majority of the respondents (>50%) were small and ranged from <1 to 2 hectares *(Appendix 2)*. The land area cultivated for the majority of the households (56%) were also the same. The sizes of the home gardens and orchards mostly ranged from <1 to 2 hectares for each household. The land size owned may influence the diversity of fruit species planted. Small land size may limits chances for an on-farm conservation to be realised, as the farmers need to maximise returns from their limited land, given a better alternative for land use. Most of the home gardens and orchards have been owned by the respondents for a long time, between 21 and 40 years (45%).

Most of the farms (88%) were situated in an area with alleviation of <100–500 m above sea level *(Appendix 3)* and with average annual rainfall of >2000 mm. Most of the farms were located on flat land (51%). The soils are mainly sandy clay (51%). Generally, the drainage systems in the area were good (52%). Most of the home gardens and orchards received plenty of sunshine during the day (84%) although some of the farms were not.

Status of species cultivated

A combination of land races, farmers' selection, and wild species were the most frequent mixture of species grown in home gardens and orchards (33%), followed by farmers' selections (32%), land races (12%), wild species (11%) and advanced cultivars (8%) *(Appendix 4)*.

The farmers' own selection usually are from their relatives, friends or neighbours' farms. For example, the selection criteria for *kuini* were bigger fruits, thick flesh with orange and yellow flesh, sweet, juicy and resistance to pests and diseases (Raziah et al. 2004). They are usually propagated from seeds, cuttings or grafting. Some farmers planted superior fruit species selected from the wild and grew them in their farms. Some fruit species from the wild were spread by animals, birds or human beings and grew on the farmers' farms. Only a small percentage of the farmers used registered clones supplied

through private nurseries or government agencies.

Distribution of fruit species on-farm based on frequency

From the survey, a total of 127 fruit species were identified, of which 18 species were major fruits and the rest were either minor or rare fruits *(Appendix 5)*. The distribution of the fruit species could be analysed based on their frequencies. The total number of fruit trees counted from the survey was 62,336. The species could be classified or divided into six categories based on their frequencies, which ranged from >1% for the very common species to <0.01% for the very rare species.

From the survey, 16 fruit species were identified as very common, 8 species as common, 16 species as moderately common, 9 species as quite common, 27 species as rare and 51 species as very rare *(Figure 1)* based on *Appendix 6*.

Other than the major fruits, some minor fruits that were included in the first two categories (very common and common) based on their frequencies were more than 0.5%, which were *salak, petai, pulasan, jering* and *rambai*. It is interesting to note that three minor fruits; *salak, petai* and *pulasan*, were found to be equally important as the major fruits and are well conserved by the farmers. These three species are gaining popularity among farmers due to their potential in generating income for the households.

Most of the fruit species identified from the study (61%) were categorised as very rare and rare. Most of the species were underutilised and contributed minimally to the well being of the society. The species are becoming extinct and need to be conserved for future exploitations. Although markets are limited for such species, there is an urgent need to conserve them for the benefit of future generation. Without proper programmes and incentives, farmers would replace them with commercial crops for economic reasons.

Distribution of fruit species on-farm based on popularity

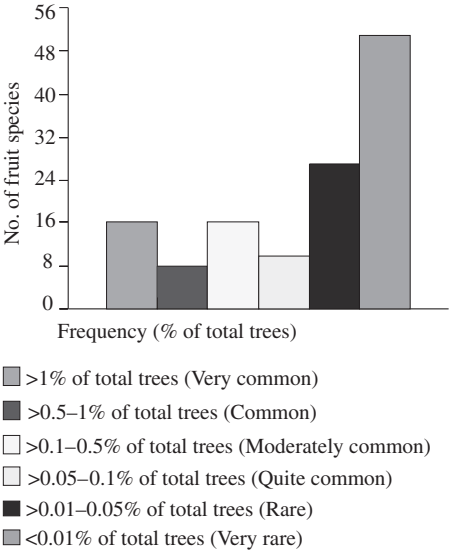

Figure 1. The distribution of fruit species in home gardens and orchards based on frequency (Total no. of trees = 62,336)

The distribution of the fruit species could be analysed based on their popularity among the households. The total number of households involved in the survey was 424. The distribution of fruit species based on the percentage of households conserving them ranged from >30% for the very popular species to <0.5% for the not popular at all species *(Figure 2)* based on *Appendix 7*.

From the survey, 7 species were categorised as very popular, 11 species as popular, 8 species as moderately popular, 34 species as quite popular, 20 species as not popular and 47 species as not popular at all. It is interesting to note again that *petai* fall into the very popular category together with other popular major fruits, where more than 30% of the farmers are maintaining the species. For the popular category, 8 out of 11 species were minor fruit species namely *bacang, jering, kuini, pulasan, rambai, gelugur, kundang* and *salak* where >10–30% farmers were maintaining them on their farms.

Fruit species diversity and diversity indices

From the survey, the average number of fruit species conserved by each household was 8 species. The number of species conserved

ranged from 1 to 19 species with a standard deviation of 2.8. The summary statistics of the species conserved by each household in terms of districts is presented in *Table 1*. The average number of species conserved was highest in Ulu Perak district (11.24 species), while the lowest was in Jempol district (5.42 species).

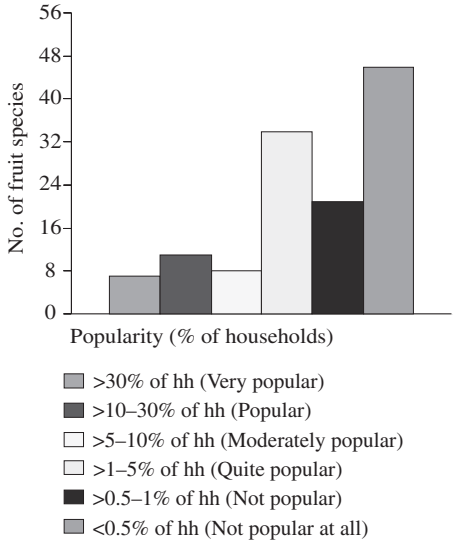

Figure 2. The distribution of fruit species based on popularity to households (Total no. of respondents = 424)

The summary statistics of Shannon and Simpson diversity indices of fruit species conserved by each household in Peninsular Malaysia is shown in *Table 2*. The average Simpson diversity index calculated for individual household was found to be a little bit higher than that of the Shannon diversity index at 0.68 and 0.64 respectively, which is considered as moderately rich.

The diversity indices for the fruit species conserved by the households in terms of districts are shown in *Table 3*. Ulu Perak, Kuala Kangsar (both in Perak), Alor Gajah (Melaka), Jerantut and Kuala Lipis (both in Pahang) districts were found to be the richest in fruit species diversity based on the survey with both indices (Shannon and Simpson) calculated at ≥0.70.

Factors determining fruit species diversity on-farm

Richness of species In this analysis, richness refers to the number of species available on the farms. The higher number of species means richer in on-farm diversity. Ordinary least square procedure (OLS) was performed

Table 1. The summary statistics of the number of fruit species maintained on-farm according to districts

Districts	Species			Std.
	Minimum	Maximum	Average	deviation
Ulu Perak	7	16	11.24	2.86
Kuala Kangsar	2	10	6.79	2.04
Kuala Lipis	1	19	9.80	4.19
Jerantut	3	12	8.04	2.53
Kluang	2	10	6.84	2.53
Pontian	4	13	8.08	2.02
Alor Gajah	3	11	7.68	2.51
Sik	4	10	7.60	2.14
Alor Setar	3	9	6.80	1.66
Kemaman	2	12	6.96	2.03
Setiu	1	10	5.68	2.25
Tanah Merah	3	14	8.36	2.50
Jeli	3	13	8.44	2.93
Kuala Pilah	3	13	7.00	2.36
Jempol	1	10	5.42	2.52
Hulu Selangor	2	15	7.24	3.13
Hulu Langat	3	11	6.56	1.61
Peninsular Malaysia	**1**	**19**	**8.00**	**2.80**

Table 2. Summary statistics of Shannon and Simpson diversity indices of fruit species grown by each household in Peninsular Malaysia

Variables	Shannon diversity index (D')	Simpson diversity index (D'')
Minimum	0.04	0.03
Maximum	1.08	0.91
Mean	0.64	0.68
Std. deviation	0.20	0.17

Table 3. Fruit species diversity according to districts and states

States and districts	Diversity indices by districts		Diversity indices by states	
	Shannon	Simpson	Shannon	Simpson
Pahang				
Kuala Lipis	0.71	0.70	0.70	0.71
Jerantut	0.70	0.72		
Selangor				
Ulu Langat	0.58	0.65	0.61	0.66
Ulu Selangor	0.63	0.67		
Kedah				
Kota Setar	0.56	0.60	0.61	0.65
Sik	0.66	0.69		
Terengganu				
Setiu	0.63	0.68	0.64	0.70
Kemaman	0.66	0.71		
Kelantan				
Tanah Merah	0.61	0.67	0.53	0.60
Jeli	0.44	0.52		
Johor				
Kluang	0.59	0.61	0.55	0.60
Pontian	0.52	0.59		
Negeri Sembilan				
Kuala Pilah	0.67	0.70	0.64	0.67
Jempol	0.61	0.65		
Perak				
Ulu Perak	0.78	0.75	0.74	0.74
Kuala Kangsar	0.72	0.75		
Melaka				
Alor Gajah	0.73	0.75	0.73	0.75

to determine the factors that were affecting the richness of the fruit species diversity on-farm. The number of species maintained on-farm (D_1) was regressed against three factors that were hypothesized to influence them, namely; market, socio-economic and agro-climatic factors. The summary results of the OLS procedure is presented in *Table 4*.

From the analysis, both the socio-economic factors; monthly income (INCOME$_{SE}$) and family size (FAMILY$_{SE}$), were found to be significant in determining the number of species conserved on-farm. Higher income and bigger family were associated with higher diversity on-farm. On the other hand, the non-availability of established drainage system was associated with higher diversity. This could be explained

Table 4. Parameter estimates of factors that determined the number of species maintained on-farm

Parameters	Coefficients	t-values
INTERCEPT	4.9736	2.0273
$INCOME_{SE}$	0.0037**	2.2715
$FAMILY_{SE}$	0.4707*	1.9416
$DRAIN_{AC}$	0.7692**	2.4779
$OINCOME_{SE}$	–0.0019	–1.5132
$EDUCATE_{SE}$	–1.0865	–1.2961
R^2	0.4932	
F-value	5.06	
N	32	

Dependent variable: No. of species on-farm
SE = Socio-economic factor
AC = Agro-climatic factor
*p <0.10
**p <0.05
***p <0.01

Table 5. Parameter estimates of the factors that determined the diversity of fruit species maintained on-farm by the households

Parameters	Coefficients	t-values
INTERCEPT	0.512***	8.177
$RAINFALL_{AC}$	4.77E-005**	2.550
$TOPOG_{AC}$	0.020**	2.498
$OINCOME_{SE}$	–9.82E-005**	–2.282
$CTRAN_{MARKET}$	0.004*	1.770
R^2	0.2230	
F-value	5.38	
N	80	

Dependent variable: Shannon diversity indices
MARKET = Market factor
SE = Socio-economic factor
AC = Agro-climatic factor
*p <0.10
**p <0.05
***p <0.01

by the remoteness of the farms which were associated with higher diversity that lack established drainage facilities although they might have natural drainage system. The model was quite satisfactory to represent diversity determinants with R^2 value of 0.4932 and F-value 5.06.

Evenness distribution of species The Shannon index takes into account both the number of species and the evenness of their proportional abundance on the farm. Having higher number of species and the evenness of planting to different species can both increase the diversity index. OLS was performed to determine the factors that caused the evenness of the distribution of the species on-farm. The dependent variable was specified as Shannon diversity indices (D_2) and the dependent variables were rainfall ($RAINFALL_{AC}$), topography ($TOPOG_{AC}$), other income ($OINCOME_{SE}$) and transportation costs ($CTRAN_{MARKET}$). The summary result of the regression analysis is shown in *Table 5*.

The agro-climatic factors were found to be most important in determining the evenness of the distribution of the species on-farm. More rainfall and higher topography were associated with higher diversity. On the other hand, both the market ($CTRAN_{MARKET}$) and socio-economic ($OINCOME_{SE}$) factors were also significant in determining the evenness of the diversity of the fruit species on-farm but to a lesser extent. For a cross-sectional data, the model was able to indicate directions on factors that determined the evenness of the on-farm species distribution with R^2 value of 0.2230 and F-value 5.38.

Dominance of species Dominance reflect the relative share of each particular species on the farms. In this study, the species dominance was determined by counting their frequencies. Higher frequencies would indicate the dominance of a particular species as compared to the others. Based on the analysis, three minor fruit species namely *salak, pulasan* and *petai* were found to be as dominant as the major fruits with their frequencies recorded at >1% of the total number of trees *(Appendix 6)*.

For the three fruit species *(salak, pulasan and petai)* OLS procedures were performed separately to determine the factors that influenced the number of trees maintained on-farm. The dependent variable was specified as the number of fruit trees (D_3) and the explanatory variables include farm-gate price ($PRICE_{MARKET}$), distance to the nearest market ($DISTANCE_{MARKET}$), family size

Table 6. Parameter estimates of factors that determined the number of trees maintained on-farm

Parameters	Coefficients	t-values
Salak		
INTERCEPT	–633.607	–1.767
PRICEMARKET	116.265**	2.652
DISTANCEMARKET	–18.713**	–2.241
EDUCATESE	178.166	1.828
R^2	0.5650	
F-value	3.46	
N	12	
Pulasan		
INTERCEPT	–1.299	–0.205
DISTANCEMARKET	–0.176	–1.312
EDUCATESE	–2.334	–1.084
FAMILYSE	3.815***	5.384
R^2	0.5930	
F-value	10.67	
N	26	
Petai		
INTERCEPT	12.696***	3.404
DISTANCEMARKET	0.158	1.413
EDUCATESE	–1.686	–1.117
INCOMESE	–0.002	–0.761
R^2	0.7100	
F-value	1.07	
N	46	

Dependent variable: No. of trees for the species
MARKET = Market factor
SE = Socio-economic factor
*p <0.10
**p <0.05
***p <0.01

(FAMILYSE), education level (EDUCATESE) and monthly income (INCOMESE). The summary result of the regression analysis is shown in *Table 6*.

From the analysis, the market factors (PRICEMARKET and DISTANCEMARKET) were found to be significant that influenced the number of *salak* trees conserved by the households. For *salak*, higher prices were associated with more trees being maintained by the households. Less *salak* trees were planted when the distance to the nearest markets were further.

For *pulasan*, family size was found to be very significant in determining the number of trees maintained on-farm. Bigger family was associated with more trees being maintained by the households. Bigger family could be translated into more mouths to be fed and more family labour to contribute to farm maintenance.

For *petai*, none of the explanatory variables had influenced the number of trees maintained on-farm by the households. This could be due to earlier establishments of the trees by earlier generation of the households. The present households had not been involved in decision making to establish the crop. They would just continue maintaining the trees as *petai* are highly demanded by consumers and that could generate good and sustainable income to the households.

For *salak* and *pulasan*, the models were fairly good to represent the factors that influenced the number of trees maintained on-farm with R^2 values of 0.5650 and 0.5930 respectively, and F-values of 3.46 and 10.67 respectively.

Conclusion and policy recommendations

The results presented in this paper illustrated the situation for on-farm diversity of fruits in Peninsular Malaysia. Home gardens and orchards were diverse with relatively high species diversity. The minor fruits; *salak, pulasan* and *petai* were found to be as dominant as the major fruits in terms of their distributions on-farm.

Market factors were found to be most important in determining the number of fruit trees maintained on-farm by the households. To support the on-farm conservation of the indigenous fruit species, the strategies that could be adopted is to increase demand of local materials through market and infrastructure development, community awareness, diversity fairs or community biodiversity registers.

The above three fruit species *(salak, pulasan and petai)* were found to have potential in generating good and sustainable income to the households and should be systematically developed and commercialised. Therefore, R&D should be geared towards their sustainable utilisation by generating

new technologies in their cultivation, post-harvest handling, processing and marketing and at the same time, promoting the crops to potential farmers.

Higher diversity on-farm was associated with agro-climatic and socio-economic factors. To ensure the sustainability of future on-farm conservation, participation should come from the relatively wealthy households. For poor households, the relevant authorities should think about appropriate incentives that should be given to the farmers to maintain diversity. However, the transfer payment mechanism should only be implemented after analysing the costs and benefits of the programmes and prioritizing the species.

Future development in rural areas should be more selective, by taking into consideration the richness of the species diversity available, to ensure the sustainability of the on-farm species diversity. Furthermore, the evenness of the species distribution were more influenced by the agro-climatic factors than the markets and socio-economic factors and thus, the natural surrounding should be preserved to ensure that the species diversity could be sustained.

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Abstrak

Bancian primer yang melibatkan 424 isi rumah telah dilaksanakan di daerah terpilih di Semenanjung Malaysia. Sejumlah 127 spesies buah-buahan telah dikenal pasti daripada sejumlah 62,336 pokok yang dibilang dalam bancian itu. Purata bilangan spesies yang dipulihara oleh isi rumah ialah 8. Lebih 60% spesies adalah terdiri daripada buah-buahan yang kurang digunakan. Purata indeks Shannon dan Simpson bagi setiap kebun ialah masing-masing 0.64 dan 0.68 dan boleh dikategorikan sebagai sederhana kaya. Daerah Ulu Perak, Kuala Kangsar, Alor Gajah, Jerantut dan Kuala Lipis didapati lebih kaya dalam kepelbagaian spesies berbanding dengan daerah-daerah lain. Berdasarkan bilangan pokok yang dikira, buah-buahan minor; salak, pulasan dan petai didapati lebih dominan setanding dengan buah-buahan utama. Bagi tanaman salak dan pulasan, faktor pasaran dan faktor sosio-ekonomi didapati signifikan dalam mempengaruhi bilangan pokok yang dipulihara oleh isi rumah. Oleh itu, pasaran dan infratruktur pasaran perlu dibangunkan bagi buah-buahan minor dan buah-buahan nadir dan petani miskin perlu diberi insentif yang munasabah bagi menggalakkan mereka terus memulihara spesies buah-buahan bagi menjamin kelestariannya. Sebaliknya kekayaan dan keserataan taburan spesies lebih dipengaruhi oleh faktor agro-iklim berbanding dengan faktor sosio-ekonomi dan faktor pasaran. Oleh yang demikian pembangunan daerah luar bandar pada masa hadapan harus dilaksanakan secara terpilih dengan mengambil kira kekayaan kepelbagaian spesies yang ada bagi menjamin kelestarian spesies buah-buahan di ladang.

Appendix 1. Socio-economic scenario of the respondents

Variables	Categories (%)	No. of respondents
Age (years)		
<50	22.6	424
51–60	27.8	
61–70	35.6	
>71	13.7	
Education level		
Never been to school	4.4	411
Primary school	60.3	
Secondary school	27.0	
Others	8.3	
Occupation		
Farmers	53.1	424
Private/government servants	4.5	
Pensioners	7.1	
Others	27.1	
Unemployed	8.3	
Family members		
1–4	19.9	423
5–6	25.5	
7–8	25.8	
9–10	14.4	
>10	14.4	
Agriculture activities (percentage time)		
1–20%	9.3	398
21–40%	11.8	
41–60%	16.3	
61–80%	16.1	
81–100%	46.5	
Monthly income		
<RM500	63.5	394
RM501–RM1,000	29.4	
RM1,001–RM1,500	5.3	
>RM1,500	1.8	
Other income		
<RM100	35.2	369
RM100–200	10.8	
RM201–300	9.5	
RM301–500	14.6	
>RM500	29.8	

Appendix 2. Summary of the background of the farms

Variables	Categories (%)	No. of respondents
Land areas cultivated (ha)		
<1	31.6	424
1–2	24.1	
2.1–3	16.0	
3.1–4	12.5	
4.1–5	5.7	
>5	10.1	
Land ownerships (ha)		
<1	26.5	392
1–2	23.7	
2.1–3	19.6	
3.1–4	16.6	
4.1–5	3.3	
>5	10.2	
Acreages of home garden (ha)		
<1	82.0	405
1–2	13.6	
2.1–3	3.2	
3.1–4	0.2	
>4	0.9	
Acreages of orchards (ha)		
<1	55.9	367
1–2	26.7	
2.1–3	9.0	
3.1–4	3.5	
>4	4.9	
Age of the home gardens/orchards (years)		
<20	32.4	411
21–40	44.5	
41–60	16.1	
>60	7.1	

Appendix 3. Summary of the agro-ecological condition of the farms

Variables	Categories (%)	No. of respondents
Land alleviation from sea level (m)		
<100	48.0	269
100–500	39.8	
>500	12.3	
Average annual rainfall (mm)		
1000–2000	14.4	396
2001–3000	60.1	
>3000	25.5	
Topography		
Flat	51.2	422
Undulating	17.5	
Mountainous	17.8	
Others	13.5	
Soil structure		
Sandy	5.7	420
Clay	14.5	
Loam	8.3	
Sandy clay	50.5	
Sandy loam	4.5	
Sandy clay loam	12.1	
Others	4.4	
Drainage		
Good	52.0	423
Fairly good	23.2	
Not good	3.3	
No drainage	18.0	
Others	3.5	
Sunshine		
Clear	83.5	423
Shady	15.6	
Others	0.9	

Appendix 4. Summary of the species status

Variables	Categories (%)	No. of respondents
Wild species	10.8	315
Land races	12.1	
Farmers' selection	32.4	
Advanced cultivar	8.3	
Land races, farmers' selections and wild species	32.7	
Wild, land races, advanced cultivar	1.9	
Others	2.0	

Appendix 5. List of fruit species identified growing in home gardens and orchards in Peninsular Malaysia

No.	Local name	Scientific name	Family
1	Asam jawa	*Tamarindus indica*	Leguminosae
2	Bacang/macang	*Mangifera foetida*	Anacardiaceae
3	Bangkong	*Artocarpus integer* ssp. *sylvestris*	Moraceae
4	Belimbing/belimbing batu	*Averrhoa carambola*	Oxalidaceae
5	Belimbing buluh/belimbing telunjuk	*Averrhoa bilimbii*	Oxalidaceae
6	Beluluk	Unidentified sp.	
7	Berangan	*Castanopsis* sp.	Fagaceae
8	Betik	*Carica papaya*	Caricaceae
9	Bidara	*Ziziphus mauritiana*	Rhamnaceae
10	Binjai	*Mangifera caesia*	Anacardiaceae
11	Buah keras	*Aleurites moluccana*	Euphorbiaceae
12	Buah naga	*Hylocerus undatus*	Cactaceae
13	Cedong/ara	*Ficus auriculata*	Moraceae
14	Cempedak	*Artocarpus integer*	Moraceae
15	Cerapu	*Garcinia prainiana*	Guttiferae
16	Ceri	*Muntingia calabura*	Elaeocarpaeceae
17	Cermai	*Phyllanthus acidus*	Euphorbiaceae
18	Cerperai	*Champeria manillana*	
19	Ciku	*Manilkara zapota*	Sapotaceae
20	Dedaru	Unidentified sp.	
21	Delima	*Punica granatum*	Punicaceae
22	Delum	Unidentified sp.	
23	Dokong	*Lansium domesticum*	Meliaceae
24	Duku	*Lansium domesticum*	Meliaceae
25	Duku langsat	*Lansium domesticum*	Meliaceae
26	Durian/klon/biji	*Durio zibethinus*	Bombacaceae
27	Durian belanda	*Annona muricata*	Annonaceae
28	Durian burung	*Durio lowianus*	Bombacaceae
29	Durian hutan	*Durio* sp.	Bombacaceae
30	Durian menggal	*Durio* sp.	Bombacaceae
31	Epal merah	Unidentified sp.	
32	Gajus/janggus	*Anacardium occidentale*	Anacardiaceae
33	Gelugur	*Garcinia atroviridis*	Guttiferae
34	Gertam/gertak tangga	*Castanopsis megacarpa*	Fagaceae
35	Jambu air	*Syzygium aqueum*	Myrtaceae
36	Jambu batu	*Psidium guajava*	Myrtaceae
37	Jambu bertih	*Syzygium densiflorum*	Myrtaceae
38	Jambu bol	*Syzygium malaccense*	Myrtaceae
39	Jambu gagak	*Syzygium* sp.	Myrtaceae
40	Jambu galah	Unidentified sp.	
41	Jambu kepal	Unidentified sp.	
42	Jambu madu	*Syzygium samarangense*	Myrtaceae

(cont.)

Appendix 5. *(Cont.)*

No.	Local name	Scientific name	Family
43	Jambu merah	*Syzygium* sp.	Myrtaceae
44	Jambu padang	Unidentified sp.	
45	Jambu penawar	*Syzygium* sp.	Myrtaceae
46	Jangkas	Unidentified sp.	
47	Jentik-jentik	*Baccaurea polyneura*	Euphorbiaceae
48	Jering	*Pithecellobium jiringa*	Leguminosae
49	Kabong	*Arenga pinnata*	Palmae
50	Kandis	*Garcinia griffithi*	Guttiferae
51	Kasai	*Pometia pinnata*	Sapindaceae
52	Kedondong	*Canarium litorale*	Anacardiaceae
53	Kejijak	Unidentified sp.	
54	Kekabu	*Ceiba pentandra*	Bombacaceae
55	Keledang	*Artocarpus lancefolius*	Moraceae
56	Kelapa	*Cocos nucifera*	Palmae
57	Kelubi	*Salacca conferta*	Palmae
58	Kembang semangkuk	Unidentified sp.	
59	Kemenyan	*Styrax benzoin*	Styracaceae
60	Kepayang	*Pangium edule*	Flacourtiaceae
61	Kerandang	*Carissa karandas*	Apocynaceae
62	Keranji	*Dialium indum*	Leguminosae
63	Kerdas	*Pithecellobium confertum*	Leguminosae
64	Kerian	*Syzygium cumini*	Myrtaceae
65	Kerkup	*Flacourtia jangomas*	Flacourtiaceae
66	Ketapi	Unidentified sp.	
67	Koko	*Theobroma cacao*	Sterculiaceae
68	Kopi	*Coffea robustum*	Rubiaceae
69	Kuini	*Mangifera odorata*	Anacardiaceae
70	Kulau	Unidentified sp.	
71	Kulim	Unidentified sp.	
72	Kumbar	Unidentified sp.	
73	Kundang	*Bouea macrophylla*	Anacardiaceae
74	Laici	*Nephelium litchi*	Sapindaceae
75	Laka/melaka	*Phyllanthus emblica*	Euphorbiaceae
76	Langsat	*Lansium domesticum*	Meliaceae
77	Limau madu	*Citrus reticulata*	Rutaceae
78	Limau bali	*Citrus grandis*	Rutaceae
79	Limau besar	*Citrus maxima*	Rutaceae
80	Limau kasturi	*Citrus microcarpa*	Rutaceae
81	Limau kerat lintang	*Citrus nobilis*	Rutaceae
82	Limau nipis	*Citrus aurantifolia*	Rutaceae
83	Limau purut	*Citrus hystrix*	Rutaceae
84	Longan	*Dimocarpus longan*	Sapindaceae
85	Mangga	*Mangifera indica*	Anacardiaceae
86	Manggis	*Garcinia mangostana*	Guttiferae

(cont.)

Appendix 5. *(Cont.)*

No.	Local name	Scientific name	Family
87	Masta	*Garcinia mangostana*	Guttiferae
88	Mata kucing	*Dimocarpus longan*	Sapindaceae
89	Matoa	*Pometia pinnata f. macrocarpa*	Sapindaceae
90	Menara	Unidentified sp.	
91	Mendamak	Unidentified sp.	
92	Mengkinang	*Elaeocarpus* sp.	Elaeocarpaceae
93	Merapoh	Unidentified sp.	
94	Mertajam	*Lepisanthes rubiginosa*	Sapindaceae
95	Nam-nam/katak puru	*Cynometra cauliflora*	Leguminosae
96	Nangka	*Artocarpus heterophyllus*	Moraceae
97	Nanas	*Ananas comosus*	Bromeliaceae
98	Nenering	Unidentified sp.	
99	Nerang	Unidentified sp.	
100	Nerap	Unidentified sp.	
101	Nona	*Annona squamosa*	Annonaceae
102	Pala	*Myristica fragrans*	Myristicaceae
103	Perah	*Elateriospermum tapos*	Euphorbiaceae
104	Perian/tempunik	*Artocarpus rigidus*	Moraceae
105	Petai	*Parkia speciosa*	Leguminosae
106	Petai jawa	Unidentified sp.	
107	Pinang	*Areca catechu*	Palmae
108	Pisang	*Musa* sp.	Musaceae
109	Jarak	Unidentified sp.	
110	Pulasan	*Nephelium ramboutan-ake*	Sapindaceae
111	Rambai	*Baccaurea motleyana*	Euphorbiaceae
112	Rambutan	*Nephelium lappaceum*	Sapindaceae
113	Remia	*Bouea oppositifolia*	Anacardiaceae
114	Rokam	*Flacourtia inermis*	Flacourtiaceae
115	Salak	*Salacca* sp.	Palmae
116	Segarat	Unidentified sp.	
117	Sengkuang	*Dracontomelon dao*	Anacardiaceae
118	Sentul/setoi	*Sandoricum koetjape*	Meliaceae
119	Songo lutong	*Nephelium cuspidatum* var. *eriopetalum*	Sapindaceae
120	Sukun	*Artocarpus communis*	Moraceae
121	Taban	*Baccaurea reticulata*	Euphorbiaceae
122	Tampoi	*Baccaurea macrocarpa*	Euphorbiaceae
123	Tampoi tunggol/tungau	*Baccaurea velutina*	Euphorbiaceae
124	Terap	*Artocarpus elasticus*	Moraceae
125	Terap nasi	*Artocarpus* sp.	Moraceae
126	Terpai	Unidentified sp.	
127	Terua	*Hodgsonia capniocarpa*	Cucurbitaceae

Appendix 6. The distribution of fruit species in home gardens and orchards based on frequencies of occurrence (Total number of trees = 62, 336)

>1% of total trees (very common)	>0.5–1% of total trees (common)	>0.1–0.5% of total trees (moderately common)	>0.05–0.1% of total trees (quite common)	>0.01–0.05% of total trees (rare)	<0.01% of total trees (very rare)
1. Durian	1. Duku langsat	1. Limau bali	1. Belimbing buluh	1. Sentul	1. Ceri
2. Salak	2. Kopi	2. Pinang	2. Kasai	2. Kerkup	2. Jambu padang
3. Dokong	3. Jering	3. Durian belanda	3. Bidara	3. Kedondong	3. Laici
4. Pisang	4. Rambai	4. Bacang	4. Tampoi	4. Berangan	4. Pala
5. Rambutan	5. Jambu madu	5. Kuini	5. Buah naga	5. Jambu bol	5. Sengkuang
6. Manggis	6. Koko	6. Asam gelugur	6. Cermai	6. Kepayang	6. Limau purut
7. Duku	7. Limau kasturi	7. Ciku	7. Perah	7. Masta	7. Tampoi tungau
8. Langsat	8. Longan	8. Kundang	8. Cerapu	8. Mengkinang	8. Binjai
9. Cempedak		9. Nangka	9. Remia	9. Taban	9. Delima
10. Petai		10. Mata kucing		10. Nam-nam	10. Buah keras
11. Belimbing		11. Jambu air		11. Asam jawa	11. Kelubi
12. Limau madu		12. Nanas		12. Cedong	12. Kerian
13. Kelapa		13. Jambu batu		13. Merapoh	13. Cerperai
14. Pulasan		14. Kerdas		14. Bangkong	14. Keledang
15. Mangga		15. Sukun		15. Kemenyan	15. Jambu gagak
16. Limau nipis		16. Kabong		16. Nerang	16. Jambu merah
				17. Terpai	17. Jambu penawar
				18. Terua	18. Jangkas
				19. Nona	19. Kandis
				20. Petai jawa	20. Mertajam
				21. Jambu kepal	21. Nerap
				22. Jentik-jentik	22. Rokam
				23. Kekabu	23. Terap
				24. Gajus	24. Beluluk
				25. Keranji	25. Betik
				26. Ketapi	26. Dedaru
				27. Perian	27. Durian burung
					28. Durian hutan
					29. Jambu bertih
					30. Kembang semangkuk
					31. Kumbar

(cont.)

Appendix 6. *(Cont.)*

>1% of total trees (very common)	>0.5–1% of total trees (common)	>0.1–0.5% of total trees (moderately common)	>0.05–0.1% of total trees (quite common)	>0.01–0.05% of total trees (rare)	<0.01% of total trees (very rare)
					32. Laka/melaka 33. Delum 34. Durian menggal 35. Epal merah 36. Gertam 37. Jambu galah 38. Kejijak 39. Kerandang 40. Kulau 41. Kulim 42. Limau besar 43. Limau kerat lintang 44. Matoa 45. Menara 46. Mendamak 47. Nenering 48. Jarak 49. Segarat 50. Songo lutong 51. Terap nasi

Appendix 7. The distribution of fruit species based on popularity to households (Total no. of respondents = 424)

>30% of hh (very popular)	>10–30% of hh (popular)	>5–10% of hh (moderately popular)	>1–5% of hh (quite popular)	>0.5–1% of hh (not popular)	<0.5% of hh (not popular at all)
1. Durian	1. Bacang	1. Ciku	1.Asam jawa	1. Berangan	1. Beluluk
2. Manggis	2. Duku	2. Nangka	2. Bangkong	2. Binjai	2. Betik
3. Rambutan	3. Jering	3. Jambu air	3. Belimbing	3. Ceri	3. Buah keras
4. Dokong	4. Kuini	4. Sukun	4. Belimbing buluh	4. Gajus	4. Cedong/ara
5. Langsat	5. Pulasan	5. Mata kucing	5. Bidara	5. Jambu kepal	5. Dedaru
6. Cempedak	6. Rambai	6. Limau nipis	6. Buah naga	6. Jambu padang	6. Delima
7. Petai	7. Gelugur	7. Duku langsat	7. Cerapu	7. Kabong	7. Delum
	8. Kelapa	8. Cermai	8. Durian belanda	8. Kekabu	8. Durian burung
	9. Kundang		9. Jambu batu	9. Kerian	9. Durian hutan
	10. Mangga		10. Jambu bol	10. Koko	10. Durian menggal
	11. Salak		11. Jambu madu	11. Laici	11. Epal merah
			12. Jentik-jentik	12. Limau purut	12. Gertam
			13. Kasai	13. Masta	13. Jambu bertih
			14. Kedondong	14. Mertajam	14. Jambu gagak
			15. Kepayang	15. Nanas	15. Jambu galah
			16. Keranji	16. Nona	16. Jambu merah
			17. Kerdas	17. Tempunik	17. Jambu penawar
			18. Kerkup	18. Petai jawa	18. Jangkas
			19. Kopi	19. Tampoi tungau	19. Kandis
			20. Limau madu	20. Terap	20. Kejijak
			21. Limau bali		21. Keladang
			22. Limau kasturi		22. Kelubi
			23. Longan		23. Kembang semangkuk
			24. Mengkinang		24. Kemenyan
			25. Merapoh		25. Kerandang
			26. Nam-nam		26. Ketapi
			27. Perah		27. Kulim
			28. Pinang		28. Kumbar
			29. Pisang		29. Laka/melaka

(cont.)

Appendix 7. *(Cont.)*

>30% of hh (very popular)	>10–30% of hh (popular)	>5–10% of hh (moderately popular)	>1–5% of hh (quite popular)	>0.5–1% of hh (not popular)	<0.5% of hh (not popular at all)
			30. Remia		30. Limau besar
			31. Sengkuang		31. Kulau
			32. Sentul		32. Limau kerat lintang
			33. Taban		33. Matoa
			34. Tampoi		34. Menara
					35. Mendamak
					36. Nenering
					37. Nerang
					38. Nerap
					39. Pala
					40. Jarak
					41. Rokam
					42. Segarat
					43. Songo lutong
					44. Terap nasi
					45. Terpai
					46. Terua
					47. Cerperai

hh = Households