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Status of Fruit Trees Farming among Small Scale Farmers: A Case Study of Busia, Bungoma and Siaya Counties of Kenya

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Abstract: In Kenya, more than 60% of the population depends directly on forests and woodlands for their energy needs, wood for furniture and construction, as well as food and other non-timber forest products such as fruits, nuts and medicinal plants among others. Even though fruits are widely planted and consumed in the daily diet of local people and also as a source of income, little attention has been given to enhancing their production and commercialization. This study examined the adopted and grown fruit tree among small holder farmers and challenges they face in undertaking this agroforestry practice. The study employed a survey research design, which entails the description, recording, analyzing and reporting of current status of on-farm fruit trees. A multistage sampling was employed for household survey selection, where 906 households were randomly sampled within Busia, Siaya and Bungoma counties. The results indicated that major fruit trees grown include *Persea america* and *Mangifera indica* in both Bungoma and Busia counties, while *Citrus sinensis* and *Mangifera indica* fruits are common in Siaya. There were significant differences (F= 4.724, d.f = 16, p=0.02<0.05) between the different numbers of preferred fruits among small scale farmers. From the study, it is evident that there is a great potential fruit production leading to improved income generation through sale in local as well as export markets, food security and improved livelihoods for communities.

Keywords: Agroforestry; Fruit trees; Nutritional benefits; Western Kenya.

INTRODUCTION

Forests and trees play an important role in the lives of people through their multi-uses such as foods, medicines, fodder, fibers and fuels, construction, fencing and furniture (FAO, 2010). In fact, forests and other tree-based production systems have been estimated to contribute to the livelihoods of more than 1.6 billion people worldwide (World Bank, 2008). Globally, it is estimated that 50 percent of all fruit consumed by humans originate from trees (Powell *et al.*, 2013), most of which come from cultivated sources. Fruit consumption in Sub-Saharan Africa is on average low with mean daily intake, of between 36 g and 123 g in East African countries; 70 g and 130 g in Southern Africa; and 90 g and 110 g in West and Central Africa, respectively, (Lock *et al.*, 2005). These figures add up to considerably less than the international recommendation of 400 g in total per day to reduce micronutrient deficiencies and chronic disease (Boeing *et al.*, 2012; FAO, 2012; WHO, 2004). The World Health Organization (WHO) recommend a healthy diet to include a balanced energy intake and expenditure, consumption of fruits, legumes, nuts and whole grains and low intake of free sugars, fats and salt (WHO, 2014). Trees, especially fruit trees, act as an important insurance policy against food consumption shortfall, securing stable food availability in exceptionally bad years, when other crop components fail. Tropical continents of the world possess rich variety of fruit trees with about 1,000 species identified in Americas, 1,200 species in Africa and 500 species in Asia (Paull, *et al.*, 2011; Sthapit, *et al.*, 2012). In Kenya, about 400 indigenous fruit tree species occur (Chikamai *et al.*, 2004), which are said to contribute much to livelihoods of rural communities, particularly during the frequent periods of food shortage.

However, detailed studies on diversity of IFTs and their consumption in Kenya are scarce. A study in the drylands, Mwingi sub-county, Eastern Kenya (Simitu *et al*. (2009) showed that a total of 57 IFT species were mentioned as being consumed by the respondents where the most frequent species were *Balanites aegyptiaca* (desert date) occurring on 58 per cent of the surveyed farms, *Adansonia digitata* (baobab; 50 per cent) and *Berchemia discolor* (50 per cent). The objective of the study was to examined the adopted and grown fruit tree among small holder farmers and challenges they face in undertaking this agroforestry practice.

MATERIALS AND METHODS

Study area

This study is pegged on promoting the production and utilization of fruit trees to ensure on farm tree production intensification and diversification. The study was carried out in three counties of Busia, Siaya and Bungoma in Western Kenya. Bungoma County borders Uganda on the Northwest, Busia County to the West and South West, Kakamega County to the East, and Trans-Nzoia County to the Northeast. The county has nine sub-counties, according Bungoma County Integrated Development Plan 2018–2022. The county lies between 1200 and 4321 m above sea level abnd cover about 3032.4 km^2. The county receives bimodal rainfall pattern that ranges between 400 mm (lowest) to 1,800 mm (highest) per annum. Siaya County borders Busia, Kakamega, Vihiga, and Kisumu Counties (CGOS, (2018)). The total land area of the County is approximately 2,496 km^2. It lies between latitude 26′S to 18′N and longitude 58′E and 33′W. The County lies at approximately 1,318 above sea level. The County receives bi-modal rainfall of approximately 1,572 mm per annum. Long rains are received between March and June while the short rains are received between September and December. Bungoma County borders Uganda to the West, Busia County to the South West, Trans-Nzoia, and Kakamega to the North East. The County covers an area of 3,032.2 Km^2. It lies between 1,200 and 1,800 m above sea level and lies between latitude 0.57 and longitude 34.56. The County experience mean annual temperatures of 23 degrees centigrade.

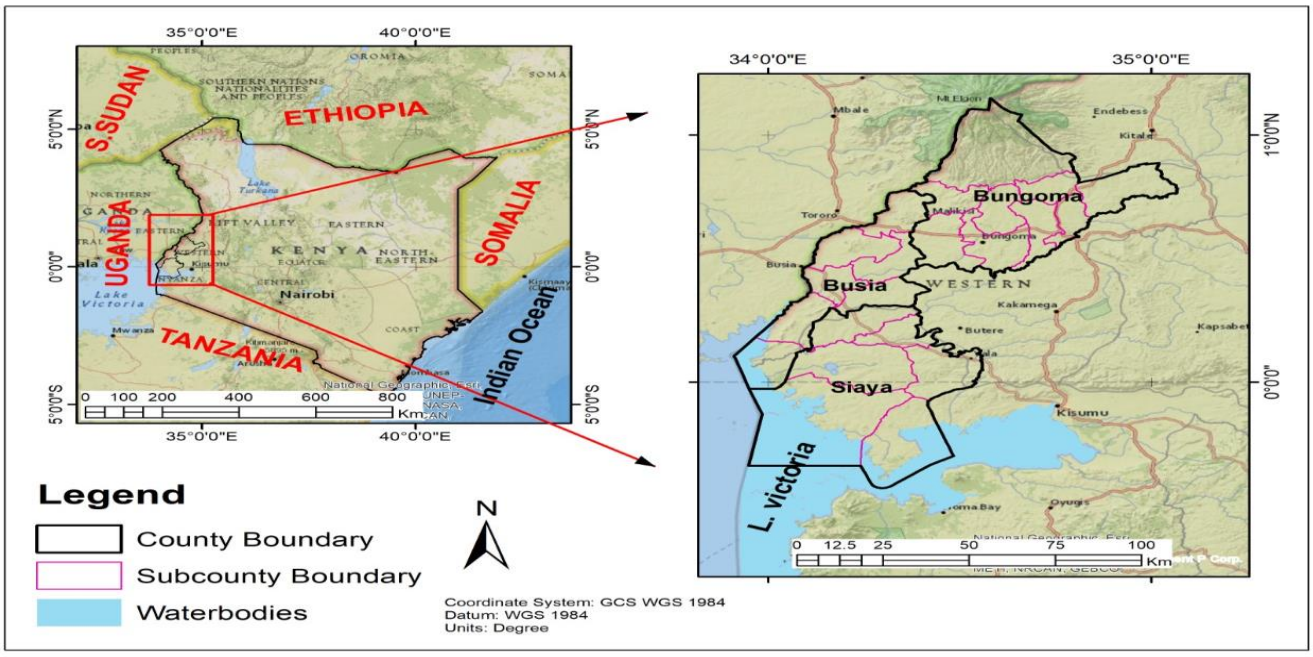

Figure 1. Map of the study area by GIS department KEFRI, 2022

Sampling Technique

The study employed a survey research design (Orodho, 2005) which entails describing, recording, analyzing and reporting of current status of on-farm fruits trees. The study sample comprised of farmers selected using a multistage sampling technique. In the first stage, Busia, Bungoma, and Siaya Counties were selected purposively since they constituted the project area. In the second stage, sub-counties with the highest number of farmers were selected with the help of County Government Agriculture Departments. In the third stage, locations were selected where a target population of 9060 farmers was identified using a probability proportionate to size formula from a list of registered farmer groups in the selected locations. Lastly, a systematic random sampling technique was used to identify the interviewed farmers. The first respondent was picked randomly, and the rest at an interval of ten farmers from the list (population) from every location sampled per County.

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Sampling size

The sample size determination was based on the formula by Cochran (1977). For a finite population, shown in by the Equation (1) below:

Sample Size (SS) = $[Z^2p\ (1-p)]/\ d^2$ Equation (1)

where: *SS* = Sample size, Z is the critical value that is 1.96 achieved at a confidence level of 0.05 in each tail,,*p* = Percentage of population of farmers practicing fruit farming, *d* is the acceptable precision level for data.

From our population the sample size for finite population

$SS = 1.96 * 0.0486(1 - 0.0486)/0.01\text{^}2$

SS = 906.26≡906

According to Kothari (2004) a representative sample was one which was at least 10% of the population thus the choice of 10% was sampled from each of the population of farmers per location was considered as representative.

The sample size of 906 farmers from a list of 9060 farmers from the sampled locations were obtained from the selected locations from the counties as guided by the department of agriculture (Table 1). The sample locations per county were proportionately allocated within each of the sampled counties with Busia having 218 respondents sampled, from 2 locations, Siaya 256 respondents from 2 locations and Bungoma 432 respondents from 3 locations.

Table 1. Probability proportional to size sampling for farmers practicing fruit farming.

County	*Sub-county*	*Location*	*Estimated fruit farmers*	*Number of farmers Sampled*
Bungoma	Mt Elgon	Elgon	2,050	205
	Kanduyi	West Sang'alo	2,270	227
Busia	Butula	Marachi North	1,600	160
	Matayos	Burumba	580	58
Siaya	Rarieda	West Uyoma	1,240	124
	Alego Usonga	South East Alego	1,320	132
Total			9,060	906

RESULTS AND DISCUSSIONS

Demographic characteristics of respondents

The result from household survey indicates that the mean age of the respondents were 46 years with Bungoma having 44 years, Busia 48 years and Siaya 47 years. This is a middle age bracket which is quite encouraging since they are energetic and hence ensures availability of labour required on farms. Majority of the respondents interviewed were male (63.7%) while the female accounted for 36.3% of the respondents (Table 2). The representation of both genders in the survey gives a bigger scope of knowledge about the fruit trees as a factor that influence fruit farming. Gender of the household's head involved in fruit farming was statistically significant ($\chi2$=28.68, df=1, p=0.03), the finding shows most males were involved in fruit farming compared to their female counterparts. The result further shows that the majority of the respondents had primary education in all the counties with Siaya leading at 60.1% of the respondents. A few of the household heads (8.1%) had never attended school while only 2.8% had attained university education. The results show that (χ^2=14.58, d.f =4, p=0.553 >0.05) education level of a farmer may bear no relation in farming fruits trees. Lack of education may not necessarily prevent farmers from adopting fruit farming. A higher level of education may diminish the likelihood to adopt fruit farming since their involvement in farm work may be important as well. Yaron *et al*. (1992) pointed out that the relationship between adoption and education is positive up to a certain level and then becomes a negative.

Table 2. The demographic characteristics of fruit farmers -Busia, Bungoma and Siaya Counties.

		Knowledge of fruit farming/ areas				**Test statistics (df)**	**p-value**
Variable	**Categories**	Total	Bungoma	Busia	Siaya		
Demographic characteristics							
Gender of Household head (%)	Male	63.7	68	72.6	49.4		
	Female	36.3	32	27.4	50.6		
Age	Complete years	46	44	48	47	$\chi2=28.68_{(1)}$	0.03
Level of education frequency (%)	None	8.1	4.4	15	8.6		
	Primary	53	47	54	61		
	Secondary	29	34.6	20	25		
	Tertiary college	7.8	10	7.2	4.7		
	University	2.8	3.5	4.1	0.8	$F=14.58_{(4)}$	0.55

Mean Number of tree planted (Number)							
	None	2.9	3.7	3.3	1.7		
	Primary	3.5	3.3	5.2	2.2		
	Secondary	3.3	3.5	5.1	2.0		
	Tertiary college	4.0	2.1	8.3	2.0		
Education level	University	4.0	1.8	6.8	2.0	$F=1.768_{(4)}$	0.13
	Male	2.8	2.5	4.8	2.0	F=3.01 (1)	0.08
Gender	Female	3.2	3.5	5.2	2.2		
	Salaried	2.5	2.4	3.6	2.0		
	Work on farms	3.2	3.4	5.1	1.8		
	Casual labour	3.8	2.0	11.0	3.2	F=2.46(4)	0.04
	Business	2.8	3.1	3.5	2.0		
Occupation of the respondents	Trader on forest product	2.9	2.0	5.0	0.0		
	Agricultural crops	3.1	2.4	4.8	2.1		
	Livestock rearing	3.3	0.0	6.5	0.0		
	Fodder crops cultivation	2.7	0.0	0.0	0.0	F=26.26 (5)	0.01
	Homestead	4.7	0.0	9.1	0.0		
	Fruit orchard	6.5	2.4	4.0	2.1		
Land use	Woodlots/forests	5.3	0.0	0.0	0.0		
	Individual	3.2	2.0	7.1	2.1		
	Family	2.8	4.5	3.3	2.0	1.10 (2)	0.33
Land ownership	Rental	0.0	0.0	0.0	0.0		

Land ownership, use and types under different systems practices

The mean land size for different land use per household varied per county with land set for agricultural crop cultivation and woodlots/forest having the largest area of 1.42 and 1.34 acres respectively. Siaya County had the lowest portion of their land set apart for forest (0.98 acres) while Bungoma had the largest land set for forest/woodlots (1.56 acres) per household. The results showed that over 98% of the household respondent's own land. The mean land size holdings for Busia were 3.07±0.26 acres, Bungoma was 3.21±0.16 acres and lastly Siaya with 2.24±0.08 acres, which was significantly different (p= 0.01) within the three counties. The majority of the respondents from the three counties owned land individually with 78 % (Bungoma), 53% (Busia) and 86% (Siaya). The mean land size per ownership type for those who had individual was 3.11 acres, family had 2.36 acres while rental owners was 1.0 acres. There were significant differences ($\chi2$= 5.524, d.f = 2, p=0.04) between the land sizes per ownership type in the three counties. Majority of the households (over 79%) owned land individually while only 21% were under family ownership while quite a few (0.1%) were renting (Table 2). The chi-square test shows that there were significant differences ($\chi2$ = 130.406, d.f = 2, p=0.01) between the proportion household land sizes in the three counties. The individual land ownership status for the three counties is as follows: Bungoma (78 %), Siaya (86%) and Busia (53%).

Table 3. Mean land use size in acres for fruit farming and other practices.

		Mean land use size in acres per County (acres)				**Chi-square**	**P-value**
Variables	Categories	***Bungoma***	**Busia**	**Siaya**	**Total**		
Mean land uses (acres)	Agricultural crops	1.63	1.34	1.29	1.42	30.59 (df=5)	0.01
	Livestock rearing	0.51	0.16	1.56	0.74		
	Fodder crops cultivation	0.53	1.87	0.16	0.85		
	Homestead	0.37	0.66	0.66	0.56		
	Fruit farming	0.14	1	0.61	0.58		
	Woodlot/ forest	1.47	1.56	0.98	1.34		
Land size (acres) per county	Mean holding size	3.21±0.16	3.07± 0.26	2.24±0. 08	2.90±0.10	130.41 (df=2)	0.01
Type of land ownership (%)	Individual	78.30	53.20	85.90	78.80	5.52 (df=2)	0.04
	Family	21.70	46.30	14.10	21.10		
	Rental	0.00	0.50	0.00	0.10		

Significance level at 95%.

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There were significant differences (χ_2 = 130.406, d.f = 2, p=0.01) between the proportion household land sizes in the three counties. Majority of the households (over 24%) had more than three acres of land. There were significant differences (χ_2= 5.524, d.f = 2, p=0.04) between the land sizes per ownership type in the three counties. The type of land ownership can greatly influence the type of agricultural activity a farmer can undertake. Nair (1993) argued that the relationship between a farmer and his land determines the type of crops to be grown and in instances when and individual is renting a land, he/she is not permitted to plant trees and other perennial crops on that land.

The number of fruit planted by the farmers per county

The results showed that the highest number of fruits per household were high for *Artocarpus heterophyllus* with 13 within Bungoma, Busia *Ananas comosus* and *Musa spp* were 26.8 while in Siaya we had *Carica papaya* with 5 fruits per household (Table 4).

Table 4. The number of fruits planted per households within different counties sampled.

County	Botanic name	Common names	Fruits number per household	Number of fruits farmers (N)	Std. Deviation (SD)
Bungoma	*Mangifera indica*	Mangoes	2.0	20	0.01
	Persea americana	Avocado	3.4	128	2.45
	Musa spp	Banana	3.2	62	2.50
	Artocarpus heterophyllus	Jackfruit	13.3	12	33.10
	Psidium guajava	Guava	3.5	65	2.21
	Citrus limon	Lemon	3.5	2	0.71
	Vitex payos	Mfudu	11.7	3	15.95
	Passiflora edulis	Passion Fruit	4.7	10	8.91
	Carica papaya	Pawpaw	2.2	17	1.39
	Ananas comosus	Pineapple	26.8	8	20.76
	Citrullus lanatus	Watermelon	3.2	62	2.51
	Syzygium cumini	Jambolan	13.3	12	33.11
Busia	*Mangifera indica*	Mangoes	3.2	62	2.51
	Carica papaya	Pawpaw	13.3	12	33.11
	Persea americana	Avocado	3.5	65	2.21
	Passiflora edulis	Passion Fruit	3.5	2	0.71
	Citrus sinensis	Oranges	11.7	3	15.95
	Artocarpus heterophyllus	Jack fruit	4.7	10	8.91
	Psidium guajava	Guavas	2.2	17	1.39
	Musa spp	Bananas	26.8	8	20.76
	Vitex payos	Mfudu	1.0	1	0.01
	Mangifera indica	Mangoes	3.0	2	2.83
	Ananas comosus	Pineapple	26.8	8	20.76
	Citrullus lanatus	Watermelon	1.0	1	0.00
	Syzygium cumini	Jambolan	1.0	2	0.00
Siaya	*Mangifera indica*	Mangoes	1.9	154	0.11
	Carica papaya	Pawpaw	4.4	14	3.67
	Persea americana	Avocado	3.0	1	0.01
	Citrus sinensis	Oranges	1.3	32	0.78
	Psidium guajava	Guava	4.4	14	3.67
	Musa spp	Bananas	4.0	4	0.01

Test statistics, F= 6.53*, d.f = 2, p=0.01 at 95% significance level*

There were significant differences (F=6.53,d.f=2, p=0.01) between the mean number of fruit trees of different species among the three different counties. *Mangifera indica numbers per household were (n=2.0, SD=0.01*) in Bungoma*, (n=3.2≈3, SD=2.51)* in Busia and *(n=1.9≈2, SD=0.11)* in Siaya county per households.

Fruits trees distribution and preference

The major fruit trees per county include *Persea americana* and *Mangifera indica* in both Bungoma and Busia and *Citrus sinensis* and *Mangifera indica* in Siaya (Table 5).

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Table 5. Preferred fruit trees per within Busia, Bungoma and Siaya Counties.

Botanical name	Common names	Family	Proportion of farmers (%) per County		
			Bungoma	Busia	Siaya
Persea americana	Avocado	Lauraceae	34.6	27.4	0.6
Musa spp	Banana	*Musaceae*	3.5	4.8	13.2
Artocarpus heterophyllus	Jackfruit	Moraceae	4.8	8.3	0
Psidium guajava	Guava	Myrtaceae	14.2	9.1	0.1
Citrus limon	Lemon	Rutaceae	0.4	1.1	0
Mangifera indica	Mango	Anacardiaceae	24	27.2	34.4
Vitex payos	Mfudu	Lamiaceae	0.1	0.2	0
Citrus sinensis	Orange	Rutaceae	2.4	4.4	39.1
Passiflora edulis	Passion Fruit	Passifloraceae	1.7	1.4	0
Carica papaya	Pawpaw	Caricaceae	10.1	11.1	12.4
Ananas comosus	Pineapple	Bromeliaceae	1.1	1.2	0
Citrullus lanatus	Watermelon	Cucurbitaceae	0.3	0.2	0
Syzygium cumini	Jambolan	Myrtaceae	2.1	3.0	0.2

Test statistics, F= 4.72, d.f = 16, p=0.02 at 95% significance level.

There were significant differences (p=0.02) between the different number of preferred fruits in the three counties. Fruit tree production has a great potential for improving the income earnings, food security and living standards of local communities. On the global scale, considerable potential exists for Kenya to increase fruit production and exploit export markets by capitalizing on the out of season markets in the temperate countries. For this to be successful, however, reliable production of high-quality fruit must be guaranteed and the necessary infrastructure must be put in place to ensure that farm-fresh quality fruit is delivered to markets on time. This calls for increased level and efficiency of production.

Preferred niche and location for fruit tree farming

Majority (83.3%) of the respondents had plans for future tree planting while only 16.7% had no plan. For tree species encountered on a farm, its abundance (the total number of trees) and their preferred niche (see below) were recorded by participatory interviews with household heads involving farm walks, tree counting by the interviewer and data recording on a species-by-species basis. The following table outlines the trees enumerated and their location/preferred niche within the farms.

Table 6. Preferred fruit tree species and system configuration within homestead

Botanic name		Proportion (%) of farmers Preferences and configuration			
	Common names	Boundaries	Homestead	Woodlot	Intercropping
Mangifera indica	Mangoes	2.8	94.4	0.0	2.8
Citrus sinensis	Oranges	4.0	96.0	0.0	0.0
Persea americana	Avocado	7.8	90.2	0.0	2.0
Psidium guajava	Guava	0.0	71.3	28.7	0.0
Citrus limon	Lemon	100.0	0.0	0.0	0.0
Artocarpus heterophyllus	Jackfruit	0.0	100.0	0.0	0.0
Syzygium cumini	Jambolan	0.0	0.0	100.0	0.0
Vitex payos	Mfudu	2.8	94.4	0.0	2.8

Fruits harvesting seasons

The fruiting and ripening of various fruit tree at different times of the year, makes particular nutrients such as vitamins to be available year-round by switching from one species or/and to another over the seasons (the "portfolio" approach; Jamnadass *et al.*, 2011). To incorporate fruits for increased consumption and nutritional benefits in more diverse diets, while addressing the challenges of seasonal food availability, the World Agroforestry Centre (ICRAF) has developed the *fruit tree portfolio* approach (Jamnadass *et al*., 2011). This is used to select ecologically, socio-cultural and nutritionally suitable fruit tree species for production on farms.

Training needs on fruit farming

The majority of the respondents 94.7% in Bungoma, 89.0% in Busia and 75% in Siaya indicated that they had not attended any training on on-farm fruit tree (Figure 2).

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Table 7. Preferred fruit tree species fruiting periods.

Month	Fruiting period
January	*Mangifera indica, Citrus limon, Citrus sinensis, Passiflora edulis*
February	*Mangifera indica, Citrus limon, Citrus sinensis, Passiflora edulis*
March	*Mangifera indica, Carica papaya, Artocarpus heterophyllus, Persea americana*
April	*Mangifera indica, Carica papaya, Artocarpus heterophyllus, Persea americana, Psidium guajava*
May	*Mangifera indica, Carica papaya, Artocarpus heterophyllus*
June	*Carica papaya, Eriobotrya japonica*
July	*Eriobotrya japonica*
August	*Persea americana, Psidium guajava, Eriobotrya japonica, Annona reticulate*
September	*Persea americana, Psidium guajava, Eriobotrya japonica, Annona reticulate*
October	*Persea americana, Psidium guajava,*
November	*Psidium guajava*
December	*Citrus limon, Citrus sinensis, Passiflora edulis, Psidium guajava, Vitex doniana*

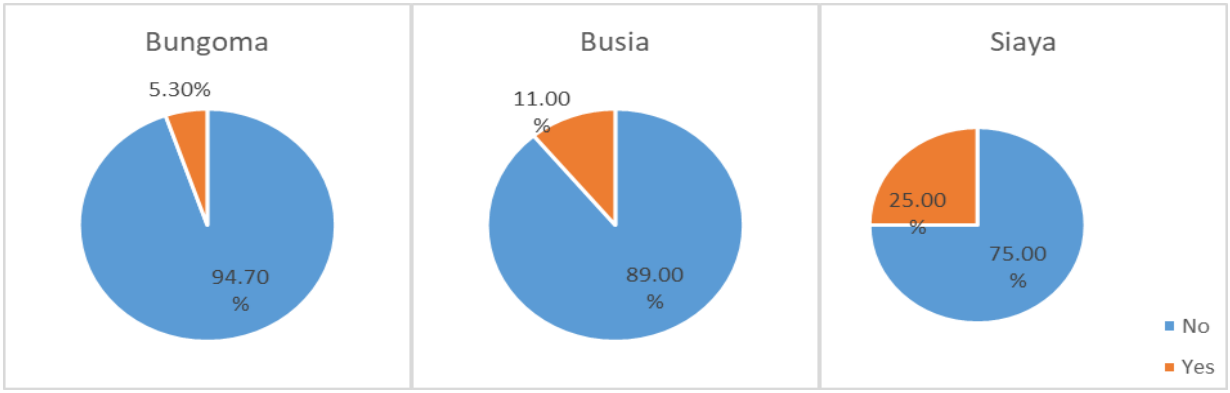

Figure 2. The proportion that have not been trained on fruit farming within counties.

The farmers enumerated that they require the skills on fruit tree farming in the following areas: knowledge on propagation techniques, training on attitude change towards fruits farming, value addition, marketing and pricing of products, adoption of indigenous fruit species and exotic fruit tree seedling production. The farmers also need awareness on management of fruit trees, training on fruit tree grafting, propagation of tree seedlings in tree nurseries and value addition on fruits after harvesting.

Constraints to Productivity of fruit farming

The major constraints associated with fruit farming in the region include insect attack, abortion and/or decay of fruits before maturity, drought and destruction by children in that order of importance (Figure 3).

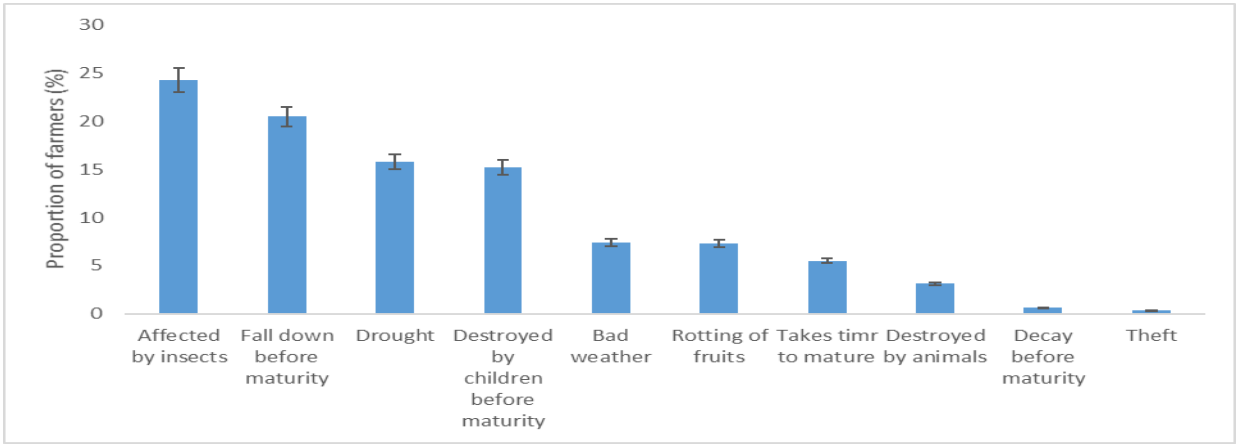

Figure 3. Challenges of fruit farming within different counties.

CONCLUSION

The fruit farming in the study areas was evident, with a diversity of tree species as well as non-woody plant species. The major fruit trees in the three areas included *Persea americana* and *Mangifera indica*. *Citrus sinensis* featured prominently in Siaya County. It was also noted that there were mature fruits to be harvested throughout the year, but on varying quantities and degrees of maturity. The major challenges to be overcome to boost fruit farming in the study areas include control of insect pests, premature falling of fruits before maturity, destruction by children and lack of rainfall or drought. The study also revealed the need to train farmers on fruit farming since majority has never been trained on the propagation, management and marketing of fruit trees among other issues.

REFERENCES

Boeing, H., Bechthold, A., Bub, A., Ellinger, S., Haller, D., Kroke, A., Leschik-Bonnet, E., Müller, M. J., Oberritter, H., Schulze, M. S., Stehle, P., and Watzl, B., 2012.Critical review: Vegetables and fruit in the prevention of chronic diseases. Eur J Nutr. 2012; 51(6):637–663. http://dx.doi.org/10.1007/s00394-012-0380y

Chikamai, B., Eyog-Matig, O., Mbogga, M., 2004. Review and appraisal on the status of indigenous fruits in Eastern Africa, A report prepared for IPGRI-SAFORGEN in the framework of AFREA/FORNESSA, IPGRI (International Plant Genetic Resources Institute) SSA, Nairobi, Kenya.

Cochran, W.G.,1963. Sampling Techniques, Wiley, New York.

County Government of Bungoma (CGOB), 2018, Bungoma County Integrated Development Plan 2018-2022.

County Government of Siaya (CGOS),2018, County Government of Siaya Strategic Plan

Current, D., Scherr, S.J., 1995. Farmer costs and benefits from agroforestry and farm forestry projects in Central America and the Caribbean: implications for policy. *Agroforest Syst* 30 (1), 87–103. https://doi.org/10.1007/BF00708915

Food and Agriculture Organization (FAO), 2012. The West African Food Composition Table. Rome: FAO.http://www.fao.org/infoods/infoods/tables-and-databases/africa/en/

Food and Agriculture Organization (FAO), 2010. Global forest resources assessment: progress towards sustainable forest management. Rome: FAO. http://www.fao.org/docrep/013/i1757e/i1757e09.pdf

Keil, A., Zeller, M., & Franzel, S., 2005. Improved fallows in smallholder maize production in Zambia: do initial testers adopt the technology? Agroforestry Systems, 64, 225-236.

Kothari, 2004. Research Methodiology.methods and techniques. New Age International (P)Ltd, New Delhi

Lock, J., Agras, W. S., Bryson, S. and Kraemer, H., 2005. A comparison of short-and long-term family therapy for adolescent anorexia nervosa. *Journal of the American Academy of Child and Adolescent Psychiatry 44(1):632-639.*http://dx.doi.org/10.1097/01.chi.0000161647.82775.0a

Nair, P.K.R., 1993. An Introduction to Agroforestry. Kluwer Academic Publishers, Dordrecht. http://old.worldagroforestry.org/Units/Library/Books/PDFs/32_An_introduction_to_agroforestry.pdf?n=161

Orodho, J. A., 2005. Elements of Education and Social Science Research Methods, Kanezja Publishers

Paull, R.E. and Duarte, O., Eds. 2011.Tropical Fruits. 2nd Edition, CAB International, London, 1-10.

Phiri, D., Franzel, S., Mafongoya, P. L., Jere, I., Katanga, R., & Phiri, S., 2004. Who is using the new technology? The association of wealth status and gender with the planting of improved tree fallows in Eastern Province, Zambia. Agricultural Systems, 79(2), 131-144.

Powell B, Ickowitz A, McMullin S, Jamnadass R, Padoch C, Pinedo-Vasquez M and Sunderland T., 2013. The role of forests, trees and wild biodiversity for improved nutrition-sensitivity of food and agriculture Systems. Expert background paper for the International Conference on Nutrition 2. Rome, Italy. https://www.cifor.org/knowledge/publication/4913/

Simitu, P., Jamnadass, R., Kindt, R., Kungu, J., Kimiywe, J.,2009. Consumption of dryland indigenous fruits to improve livelihoods in Kenya, The case of Mwingi District, *Acta Horticulturae*, vol 806, pp.93–98.

Sthapit, B., Rao, V.R. and Sthapit, S., Eds. 2012. Tropical Fruit Trees Species and Climate Change. Bioversity International, New Delhi, 15-26, 97-125.

World Health Organization (WHO), 2004. Global Strategy on Diet, Physical Activity and Health. Geneva: WHO. http://www.who.int/dietphysicalactivity/ strategy/ eb11344/strategy_english_web.pdf

World Health Organization (WHO), 2014. Healthy Diet. WHO Fact Sheets. http://www.who.int/mediacentre/factsheets/fs394/en/

World Bank, 2008. Implementation, Completion and Results Report (TF-50612) on a Grant in the Amount of SDR 3.7 Million Equivalent (US $ 4.5 million) to

Author Contributions

All authors conceived and designed the field sampling protocols; R. O. Nyambati, S. O. Ojung'a, P. Gachie. P. Gachie and M. M. Okeyo collected field data; while S. Ojunga analyzed the data; all the authors contributed to the write-up.

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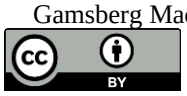
Conflicts of Interest

The authors declare no conflict of interest.

Centro Agronomico Tropical De Investigacion Y Ensenanza (CATIE) for the Integrated Silvopastoral Approaches to Ecosystem Management Project in Columbia, Costa Rica, and Nicaragua. Washington DC: World Bank

Yaron G., Janssen G., Maamberua U., 1992. Rural development in the Okavango Region of Namibia: an assessment of needs, opportunities and constraints. Gamsberg Macmillan Publishers, Windhoek



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