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Article

Sustainable Food Production Systems and Food Security: Economic and Environmental Imperatives in Yam Cultivation in Trelawny, Jamaica

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Abstract: Members of the genus *Dioscorea*, food yams, were introduced to Jamaica from Africa during the slave era and have remained a staple in local diets and national cuisine. Yam cultivation has also been an important economic activity providing employment for thousands of rural Jamaicans. Until the 1960s yams were grown for local use by subsistence growers for home consumption or by commercial growers for sale in local produce markets. Since then, however, yam has also grown to become an important export crop. With its value added potential virtually untouched, this crop possesses intriguing possibilities from the standpoint of food security and rural livelihoods in yam growing areas of Jamaica. At the same time there are concerns about the ecological and economic sustainability of yam farming under current conditions. In this paper we will analyze the sustainability of yam cultivation and consider concrete strategies for increasing the environmental sustainability and enhancing its contribution to food security.

Keywords: yams; yam sticks; sustainability; small-scale farmers; food security

1. Defining Food Security and Sustainable Agriculture

The Food and Agricultural Organization (FAO) defines food security as a condition where "… all people at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" [1]. Four broad dimensions of food security are usually identified: availability—the supply of food in an area, access—the physical and economic ability of people to obtain food, utilization—the proper consumption of food and stability—the sustainability of food supplies [1]. Food insecurity is the absence of food security implying that hunger exists as a result of problems with availability, access and utilization or that there is susceptibility to hunger in the future [1].

There are many views of sustainable agriculture and different types of agriculture have been described as exponents of sustainability in agriculture [2-4]. Examples include "fertility agriculture, organic agriculture, biodynamic agriculture, biological agriculture, integrated agriculture, agro-ecological engineering, bio-ecological agriculture, ecological agriculture, scientific ecological agriculture, regenerative agriculture, and conservational agriculture" [4]. In this paper we define sustainable agriculture as farming practices which limit and mitigate the degradation and depletion of resources while increasing local food production, enhancing food security, and securing rural livelihoods and quality of life through employment and income generation. Sustainable agriculture therefore, has both environmental and economic impacts as it alleviates rural poverty, and promotes rural development while conserving natural resources and protecting and restoring the environment. We argue that commercial cultivation of crops inevitably causes alterations of natural resources and ecosystems. Sustainable agricultural practices must therefore, include activities which attempt to restore and rehabilitate degraded farmland and environments.

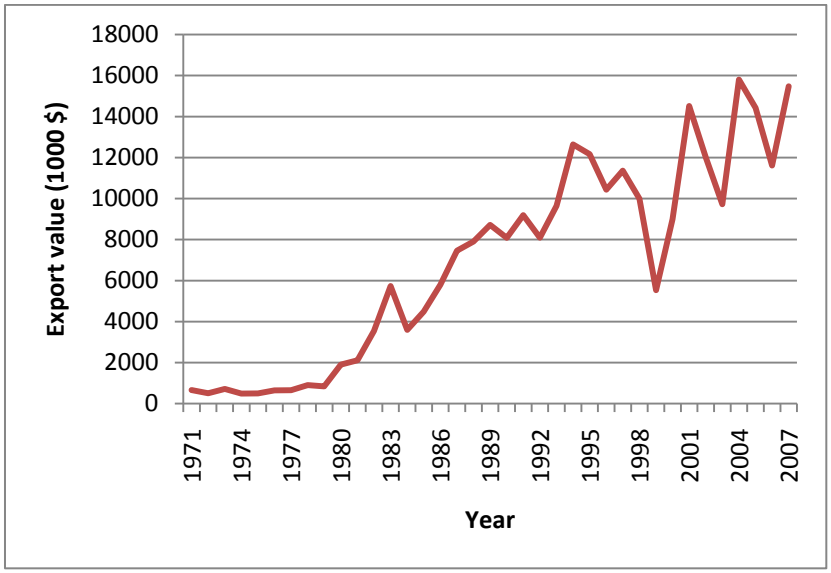
2. Importance of Yams in Jamaica

Food yams were introduced to Jamaica during the slave era from West Africa and have been grown on the island for over 300 years. Yams were first grown on the pieces of land slave owners allowed their slaves to cultivate called *provision grounds*. Since the first days of cultivation, yams have been an important food crop in Jamaica and serve several vital purposes all with food security implications. First of all it is an important part of the diet of millions of Jamaicans and a proud element of Jamaica's internationally acclaimed cuisine. Jamaican yams got international attention during the 2008 Beijing Olympic Games when Jamaican sprinter Usain Bolt won the one hundred and two hundred meters races in world record times. Bolt's family hail from the heart of Jamaica's 'Yam Country" region and when asked about his son's blinding speed the elder Bolt attributed it to the yams which had been an integral part of his diet almost since birth. From a local cultural ecological point of view yams are seen as a food which provides power and stamina. This ethno-scientific view has western scientific credibility as yams are high in energy providing carbohydrates.

Yams also serve a critical employment role with thousands of rural families making a living from yam cultivation. There are no reliable figures on the number of commercial yam farmers in Jamaica but an FAO estimate in 1994 put the number in the main yam growing region at 8,000 [5]. The main yam growing area of Jamaica is located in the central hilly areas of the island and in these areas small

farming is the main employer of labor and yam is the dominant crop. In these areas yam cultivation absorbs a great deal of surplus labor much of which is undereducated and unskilled with limited employment prospects elsewhere. In this study farming was the only source of employment for 30 percent of the farmers and the main source of income for 60 percent and 100 percent of the sample grew yams as their most important crop. Over the last 50 years but especially in the last 30, yams have become an important export crop and hence an important earner of foreign exchange. Up until the 1970s, Jamaica's export sector was dominated by a relatively narrow range of agricultural produce mainly sugar, bananas, and coffee. Since then there has been policy shifts and changes within the agricultural sector. In the 1970s there was a largely successful effort by the Jamaican government to focus on domestic food production with an emphasis on root crop production. This led to the increase in root crop production and export with yams taking center stage in terms of both production and export [6]. Today yam makes an indispensable contribution to the national coffers and has tremendous untapped potential (Figure 1).

Figure 1. Trends in Jamaican yam exports 1971–2007 ($US).



Yams also serve important foreign exchange saving function. As an important component in the diet of so many Jamaicans, yam performs an important import-substitution role.

The importance of yams to food security is, therefore, quite evident and the need for a viable yam production sector is underlined. Yams are a source of food, a source of income to access food, leads to reduction in imported food and thus adds to local food self-sufficiency. This is even more significant when the untapped potential of yams is considered. Jamaica grows and exports several varieties of yams but the most popular and lucrative is yellow yams (*dioscorea cayenesis)* which displaced Negro yam (*dioscorea rotundata*) as the main yam variety by the mid 1970s. Yellow yams currently account for close to 60 percent of total yam production and perhaps as much as 90 percent of all Jamaican yam exports. Jamaica is the world's leading yam exporter accounting for 16 percent of the global yam trade but has a monopoly of the yellow yam market. Considering that Jamaica only exports roughly five percent of the yams it produces the possibilities seem quite positive. Consider too that Jamaican yams are basically sold as fresh produce with no noteworthy value added agro-processing. The tourism and

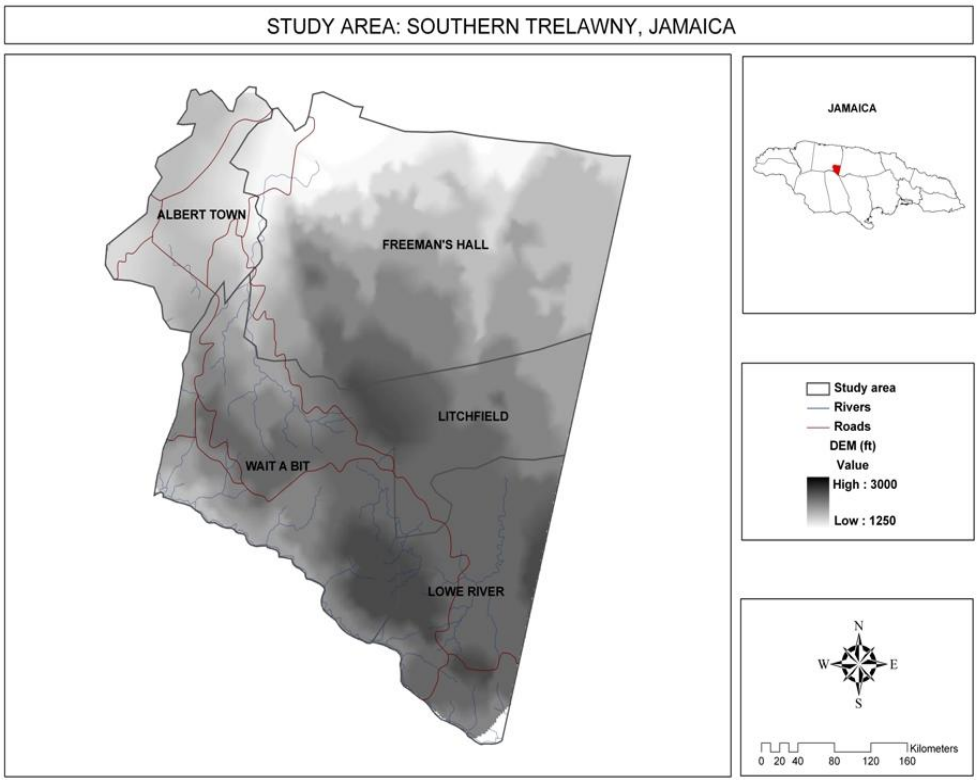
hospitality industry has experimented with exotic cuisine with yams but very little progress has been made processing yams into consumer products like flour, drinks, pastry, snacks just to name a few, which would add value and raise farm incomes. We would argue that given its export potential and value added prospects yams could play an even more important role in food security and rural development in Jamaica.

The cultivation of yams in the area is often tied to special events and projects. For example, one farmer who had a son in medical school showed off the 2000 yam hills which would provide the resources for his next year of study. Other farmers planted extra quantities of yam for special purposes like sending children back to school after the summer holidays or for Christmas celebrations and other like events. But yam cultivation is more than just an economic activity in the study area. It has become a way of life. Residents proudly proclaim that there is not a day of the year when yams are not planted or reaped in the area.

3. Study Area and Methodology

This paper reports the findings of a recent study of 40 yam farmers in south Trelawny in a convenience sample (Figure 2). Trelawny is the most important yam growing parish in Jamaica accounting for over 40 percent of production and yam cultivation is mainly concentrated in a belt along the southern boundary stretching from Lowe River in the southeast to Troy which is northwest of Albert Town. Data collection was done using a questionnaire instrument administered in the field. Interviews were conducted with farmers in their fields which made it possible to observe their operations and seek explanations for their practices. Thirteen of the respondents were females and all farmers in the survey planted yams. The paper also draws on previous research in the area [6-13].

Figure 2. General location map of the study area.



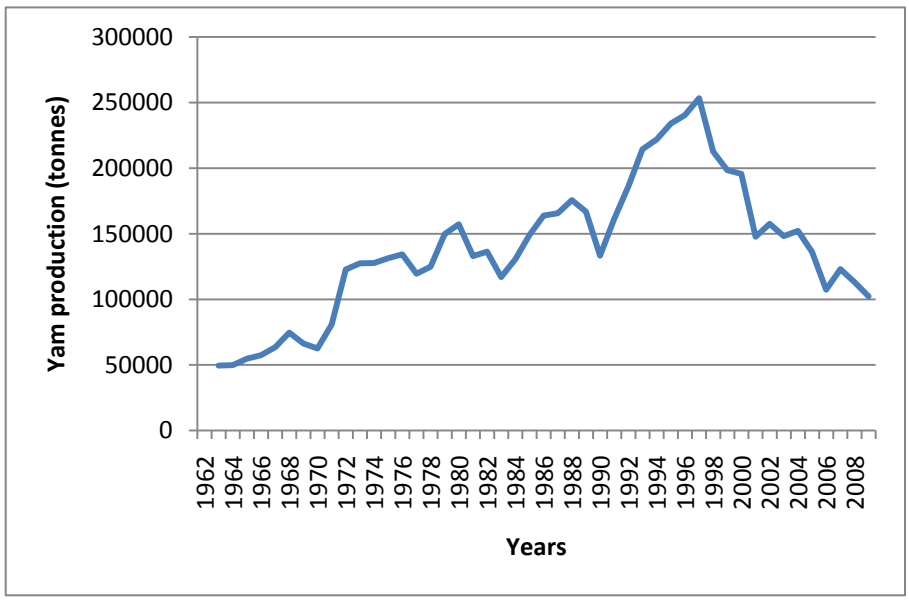
4. Trends and Challenges in Yam Production in the Area

Over the last 50 years national trend in yam production has shown fluctuations but until the mid-1990s there was a general increase in yam production. For example, between 1962 and 1996 when yam production peaked at 253,371 tons, production increased by 411.34 percent. However, between 1996 and 2008 yam production declined by 147.7 percent, to 102,282 tons (Figure 3). The reasons for this dramatic decline are not entirely clear. Extreme climatic events are a factor as the island has been ravaged by a number of tropical cyclones and droughts during that period. Market forces are also at play and the interplay between high production costs and modest financial returns might be affecting the economic viability of yam production and impacting production. In this study we calculated the cost of production and returns on the investment and found that farmers actually lost money growing yams.

Consider the following breakdown for cultivating 100 hills of yam:

100 yam sticks = $2,500;
Preparing land-digging yam hills = $3,000;
1 bag of fertilizer = $3,000;
Harvest yams: 2 worker + farmer = $2,000;
Carrying sticks and staking yam hills = $3,000;
Total cost of production = $13,500.

Figure 3. Yam production in Jamaica (tones) 1961–2008.



Yield from 100 yam hills is approximately 500 weights (700 lbs). At the time of the survey yams were being sold for $25/lb. Therefore, 500 weights = $12,500. The farmer would therefore experience a loss of $1,000. Thus, for 1000 yam hills or an acre of land the farmer would lose $10,000. Most small-scale farmers do not engage in this kind of business analysis and so might not have a precise view of their balance sheet. It is important to point out that almost all farmers meet some of their labor needs through informal customary labor arrangements which do not involve cash payments and so

would not incur all the costs included above. Also yam is a fairly low maintenance crop in terms of attention required once established. Initially there is a lot to be done with land preparation including the digging of yam hills, preparing yam sticks, and staking yams. After the yam sprouts and the vines start to grow farmers make sure they wrap around the sticks. Most farmers like to keep their plots clean and so while the plants are establishing themselves there will be some weeding. Once the plants are established, however, there is very little maintenance to be done except applying fertilizers and weeding if necessary. Most male farmers will do most of this routine maintenance themselves depending on the size of their operations. Some female farmers will incur some costs but might also have unpaid assistance from their spouses, sons and other farmers if they are members of an informal labor cooperative. Irrigation is not a consideration as yam farming in the area occurs under entirely rain-fed conditions. Yams mature in seven to eight months but most of the costs are incurred in the first three to four months and at the time of harvest.

Still, farmers contend that they make a less than satisfactory return from their enterprise and are at a disadvantage in terms of the conditions under which yams are cultivated and marketed in Jamaica. For example, yams are sold by *weights* rather than pounds. At the time of the survey, 500 weights was 700 lbs. Farmers made mention of the '*long 100*' (mainly used by higglers) and the '*short 100'* (used by exporters). According to the farmers 100 weights = 140 lbs (long 100) or 120 lbs (short 100). This means that farmers give up an extra 20 lbs of yams when they sell to exporters and 40lbs to higglers. At J$25.00/lb that's $500–1,000 depending on who they sell to. Some farmers mitigate this disadvantage by retailing some of their yams in local produce markets themselves but most farmers utilize exporters, higglers or both. Of the 40 farmers interviewed 13 sold only to exporters, six sold to higglers only, and 21 sold to both.

Farmers were asked to indicate if their cultivation of yam was increasing or decreasing. Sixty percent reported they were planted less yams while 27.5 percent said they were planting more. A major reason given for planting less yams was the overall cost of production but the issue of *yam sticks*—a critical input—was specifically mentioned by farmers. Yam cultivation in Jamaica employs the yam stick method with planting material called yam heads buried in individual mounds of earth called *yam hills* (Figure 4). This system is dependent on the use of tree branches or saplings 3–4 meters in height called yam sticks (Figure 4). The yam plant is a climber and the vines form an aerial biomass (Figure 5) which facilitates good yields [10].

During the halcyon years of yam production most farmers had difficulty procuring adequate quantities of yam sticks [6]. Even with the drastic decline in yam cultivation today farmers are still having difficulties procuring all the sticks they need. Over twenty seven percent of the farmers interviewed said they had difficulty meeting their yam stick needs while 7.5 percent said they sometimes had trouble meeting their needs. Of the 40 farmers 24 or 60 percent reported that ability to procure yam sticks and the high price of sticks were factors which influenced how much yams they cultivated.

Farmers used to be able to cut their own yam sticks from local woodlands but intensification of yam cultivation over the years led to the depletion of local supplies and now even though a few sticks are still cut locally, farmers mainly depend on informal yam stick traders from whom they purchase sticks (see Figure 6a, b) [11].

Figure 4. Yam hills with sticks in the field.

Figure 5. Aerial biomass of yam plants.

Figure 6. (a) Trucks lined up to sell yam sticks; **(b)** Sellers offload sticks for a farmer.

The sticks are delivered in large trucks and sold to farmers at the side of the road before being transported to the fields often with donkeys or mules (Figure 7a, b).

The problem surrounding yam sticks has three related elements. One is the inability of farmers who want to plant large quantities of yams to obtain adequate supplies of yam sticks. A second is the high price of sticks and a third is the poor quality of sticks [7]. The depletion of local sources of yam sticks combined with the inability of informal yam stick dealers to supply adequate number of sticks creates a scarcity which has negative impacts on yam farming. Dealers are finding it increasingly difficult to procure adequate and suitable sticks as their traditional sources are drying up as well. The cutting of sticks from some areas now carry legal consequences and dealers say they have to be going further afield to find sources of good sticks. Typically these are free sources of wood which are removed without a license or consent mainly state owned woodlands and forests and lands owned or controlled by bauxite mining companies. One dealer to whom we spoke reported that he removed 17 truckloads of yam sticks from bauxite lands in one year before the company destroyed the access roads to deter trespassers.

Figure 7. (a) A farmer loads yam sticks on a mule; **(b)** Farmer navigates his way to his farm.

The second issue is the high price of sticks which now seems to be a bigger problem than procuring adequate quantities due to the drastic decline in yam cultivation. At the time of the survey yam sticks were being sold for J$2,500.00 per hundred, an increase of over 100 percent in the last eight years. This means that to plant one acre of yams requires an expenditure of J$25,000 if the recommended planting density of 1,000 hills were acre is adhered to and if each hill has only one stick. However, due to scarcity of land many farmers intensify cultivation and exceed this planting density and often use more than one stick per hill depending on the quality of available sticks. The high price of yam sticks was identified as a major barrier to yam cultivation by the FAO as far back as 1994. Then the FAO cautioned that the price of yam sticks might increase to the point where it is uneconomical for small farmers to cultivate yams [5]. We mentioned earlier in the paper that this was a specific issue farmers raised as a factor determining quantity of yams planted. The FAO's concern came at a time when yam production was close to peaking. At the peak of yam cultivation in 1996 annual yam stick use was estimated to be between 43 and 60 million [6,14] but even at current levels of cultivation its concerns were clearly justified.

The first two problems are exacerbated by the third-poor quality of sticks. Generally the sticks which are currently available are inferior with short life-spans. Most of the sticks will last for only one growing season and many won't even last that long. This requires the constant replacement of sticks making procurement of yam sticks an annual recurring expenditure. This has significant impact on profitability and long term viability of yam cultivation. It has been estimated that replacement rate of yam sticks—the number of sticks used in one season which cannot be used the next—is in excess of 60 percent [6,15]. Farmers have responded to the yam stick problems in an ingenious way. They have resorted to the multiple staking of yam plants by combining two or more sticks which would stand on their own individually (Figure 8). This is a very sustainable practice which conserves wood resources while reducing the need for new sticks considerably thus cutting production costs. Multiple staking increases the workload as for each hill anywhere between two and as many as six sticks must be prepared and planted but without this practice most farmers could only afford to plant modest quantities of yams.

Figure 8. Example of multiple staking of yam hills.

We make the point, therefore, that resolving the yam stick issues is fundamental to viable yam cultivation and production. This does not mean that farmers do not have other challenges. As we discussed earlier there are some challenges around the arrangements for the marketing and distribution of yams. Farmers have also identified the cost of other inputs especially fertilizers. Forty percent of the farmers interviewed cited price of fertilizers as an issue. Also the geography of Jamaica in terms of location and the topography of the area render Yam Country vulnerable to the ubiquitous natural disasters. Hurricanes and tropical storms wreak havoc on yam farms through high winds which snap and blow over yam sticks and can affect yields depending on the stage of growth and maturity. The nature of yam farming makes it difficult to mitigate against hurricanes and strong winds. In a different study one farmer was encountered who lowered yam sticks in his field when faced with an impending hurricane but this is hard to do when large quantities of yams are planted or when the aerial biomass

has developed too far. In addition, the area is susceptible to landslides which are triggered by heavy rainfall during storms and at other times of the year as well. Yam is seen as a hillside crop and most yam plots in the study area occur on slopes which can exceed 30 °. This is a historical situation dating back to period of slavery and immediately after emancipation. The coastal alluvial plains and valleys and other most arable lands were controlled by sugar plantation owners [16]. They provided their slaves with small plots of land to grow food which was usually the most marginal lands unfit for other lucrative plantation crops. After emancipation in 1838 slaves left the plantations and set up free villages in the remote hilly interiors of the island and established the independent peasantry which became the backbone of the agricultural sector and the economy. With mainly hillside land available small-scale farming therefore came to be established as a hillside crop. Within this scheme root crops and tubers like yams were planted on the steepest land with flatter land reserved for vegetable cultivation. Farmers often lose hundreds of yam hills as entire yam plots slide to the bottom of unstable slopes during hurricanes and heavy or prolonged rainfall episodes.

5. The Yam Stick Issue and the Viability of Yam Cultivation

There are two fundamental issues related to yam stick use and yam cultivation. First there is an economic issue related to the long term viability of yam cultivation and the implications for food security and rural development. A second issue we would like to address relates to the ecological sustainability of current yam stick use and procurement. There have been long standing concerns about the role of yam stick cutting in forest resource depletion in Jamaica [11,17-19]. This is important because many of the sources of yam sticks are sensitive ecosystems including the Cockpit Country tropical rainforest and inland and coastal watershed areas. Also field observations and measurements have indicated that methods of harvesting yam sticks could have long term negative impacts on in terms of vegetation regeneration in exploited areas [6]. Tropical forests generally have high natural coppice rates but these are reduced when trees are cut too close to the ground [5]. It is suggested that ideally cuts should be made at least forty five centimeters from the ground to maximize re-growth. However, in an effort to get as much length from a sapling yam stick cutters often cut sticks almost at ground level.

The solutions we discuss here are conceptualized in the context of food security and the economic viability of yam cultivation while improving ecological integrity and sustainability of yam cultivation. Much of the alternatives we discuss are directly related to the issue of yam sticks given its impact on the viability of yam cultivation in the study area. In some cases we will show how ecological sustainable options are also the most economically viable. We will focus the discussion around two broad areas: issues related to yam cultivation systems and issues related marketing and distribution and agro-processing. We will start with yam cultivation systems.

6. Yam Cultivation Systems

There are two clear categories of viable options here. One relates to cultivation systems which eliminate the use of yam sticks and another which relates to the sustainable use of yam sticks.

6.1. Non Yam Stick Systems

There are two possibilities here:

1. Planting yams in hills without sticks; and
2. Promoting minisett yams

6.1.1. Planting Yams in Hills without Stakes

In some parts of the Eastern Caribbean yams are planted in hills which are not staked. In Jamaica, yam stick use has always been a fundamental component of the agronomic practices in yam cultivation. It would therefore require a major cultural shift to convince farmers to consider this option. In a survey conducted between 2000 and 2002 farmers were dismissive of the idea [20,21] with only one of 100 farmers willing to try it. The farmers reasoned that yields would drastically decline and it would not be worthwhile to grow yams. This issue was raised in the present study with interesting results. When asked if they thought yams could be grown in hills without sticks 27 farmers (67.5%) answered yes while 13 (32.5%) answered no. When asked if they would be willing to try this system 14 (35%) said no but 26 (65%) answered yes. The reasons given by the farmers willing to try it were related to reduced costs and increased profitability. Growing yams without stakes would eliminate certain significant costs including purchasing sticks, carrying them to the field, trimming and preparing them and staking yam hills. We estimate that this could cut production cost in half. In addition the need for weeding would decrease if a grass cover was used which would keep down weeds further reducing production costs. Grass mulch would also help to reduce soil runoff on steep slopes. Our experience from another small-farming system in Jamaica in which grass mulching is indispensable, however, shows that some grass would have to be bought adding to expenditure [22,23]. A more serious consideration is the viability of this system on some slopes. Farmers have argued that systems which do not use yam sticks would not work on shadowed back ridges (ubac slopes) [9].

6.1.2. Minisett Yams

The minisett system does not require the use of sticks. Small planting pieces are instead planted in continuous mounds which are then covered with a plastic or grass mulch. The vines trail along the mulch which also keeps down weeds and eliminates weeding and attendant costs. Farmers in the area have shown an abiding resistance to minisett over the years [8]. In this study however, a shift in attitude was evident. Eighty-five percent of the farmers were aware of the system and 55 percent said they would consider using it while 45 percent were still not ready to make that move. Younger farmers are typically more open to giving the minisett system a chance. A number of factors seem to be at play here. The main attraction of minisett identified were that the yams “look better” and it would lower production cost by eliminating the cost of purchasing sticks and associated costs of yam stick use thereby increasing profitability. The appearance or look of the yam refers to the shape of minisett yams which produces a very straight yam with no “toes”. This has been advanced as an advantage of minisett over the traditional stick method as the shape is not only more pleasing but also better facilitates grading and packing for export [14]. Traditionally, miniett has been very unpopular among

yam farmers. A major concern usually raised by farmers relates to the size of yams produced in the different systems. Smaller minisett yams were eschewed by farmers even though its advocates claimed it had more market appeal. Yam farmers in general are unconvinced about the market advantages of minisett yams. In this study we asked farmers their views about which kind of yams was most desirable. Ten farmers (25%) said big yams; nine (22.5%) said small yams; while eight farmers (20%) said straight yams were most desirable. Seven farmers had no preference and six were unsure. It would appear then, that the prospects for promoting widespread use of the minisett yam production system have never been brighter.

6.2. Sustainable Yam Stick Systems

6.2.1. Hedgerow and Alley Cropping System

This agro-forestry system is essentially a soil conservation and conditioning technique using fast growing leguminous trees or shrubs planted at very high densities along the contour of a slope. Bush and trees may be pruned to provide surface mulch and so the hedgerow helps to bring minerals up from the lower soil profile and restoring fertility similar to traditional bush fallow [24,25]. Also nitrogen-fixing leguminous vegetation adds significant quantities of nitrogen to the soil from the decaying vegetation. In this system trees are planted 14 centimeters apart in rows, but the system can and be modified to produce yam sticks by leaving individual trees to grow at intervals of two meters and then harvest yam sticks from the branches of mature trees. The South Trelawny Environmental Agency (STEA) has attempted to introduce and disseminate the hedgerow and alley cropping system among farmers in some south Trelawny communities. *Calliandra calothynus,* a fast growing tree with nitrogen fixing properties has proved effective for use. The stems of calliandra are sturdy and make very good yam sticks when mature with a minimum two year life-span according to the FAO [5].

With its capacity to incorporate a cut and carry yam stick system, the hedgerow and alley cropping system could provide farmers with a practical cost effective way of procuring yam sticks. The total demand for yam sticks is unlikely to be met for most farmers, but for small growers in particular, the system could represent a useful source of yam sticks given that the cost of obtaining yam sticks is well over 40 percent of overall yam production cost. Widespread use of this system could also reduce the need for yam sticks from other sources and lead to a reduction of pressures on natural forests and woodlands. However, one problem which could be significant for some farmers is the reduction in arable land and reduced cultivation densities as the hedgerows will take up some land. This would be problematic as some farmers already do not have enough land to farm. Despite the benefits this system is uncommon in yam farming systems in Jamaica.

6.2.2. Planting Trees for Yam Sticks on Farms

Farmers could also integrate agro-forestry into their farming systems by cultivating yam stick trees on their farms. This would only be feasible for farmers who own the land they operate. During the early 1990s an FAO project encouraged landowning farmers to plant trees for yam sticks on marginal farm land. The trees were planted on land which in all likelihood would not be planted with crops due to terrain or soil constraints. One farmer who was involved indicated that he was using in excess of

500 sticks from the trees planted during the FAO project. That is a saving of over J$12,500 at the going yam stick price in March, 2010. This farmer further indicated that the sticks were performing very well with most lasting over at least three years. The species planted were *luceana* and *calliandra* and both were performing well. The farmer explained that his trees would be producing more sticks if he had cared for them properly. To maximize production from the system growers were to selectively remove branches leaving the six or seven strongest ones to grow to maturity. However, he lapsed in the maintenance regimen and his trees basically grow wild. The economic and ecological benefits of this system are clear and this system should be an important part of a multifaceted approach to revitalizing yam cultivation.

6.2.3. Live Yam Stick System

In this system yam sticks would be managed to remain green and alive year after year without the 'live' stick making any significant increase in size or length. The method would reduce the need for new yam sticks which would have positive implications for natural forest and woodland resources as well as eliminate expenditure on yam sticks after the first year. In this system, preferred size yam sticks are cut and transported to the field where they must be placed in the ground within three days to ensure they remain alive. The sticks should be sharpened to a point and sunk about twelve inches in the ground to facilitate easy lifting the next year. When the crop is reaped and planting the next season begins the sticks are lifted and the roots and leaves which sprout shaved off and the stick replanted immediately. If these sticks are being used during the dry season a little water should be applied to enhance their chances of survival. Managed in this way, sticks will remain alive year after year with no need to replace them. The economic and ecological merits of this system are obvious with reduction in yam stick purchasing costs and reduced dependence on sticks from natural forests and mangroves. Tree species considered to be appropriate for the live stick system include *spathodia companulata* (Waterman tree), *gliricidia sepium* (Quick Stick), and *erythrina corallodendrum* [5].

Ninety-five percent of farmers who were asked about this system thought that it had great merit. However, only 59% were willing to try it on their farms without some evidence that it in fact works. It should be explained here that in a very small field trial of the live stick system using Quick Stick a major issue was identified. The branches of the tree do not grow straight but curve prodigiously (Figure 9) making it difficult to handle in the field which was a major deterrent for farmers. Some farmers also expressed concerns about a species like Quick Stick which they know very well growing so quickly that it would be difficult to lift the next year. This is a very fast growing tree hence its local name. However, if the right species could be found this system would work very well for farmers with minor adjustments in their usual farm routine and scheduling.

Figure 9. Gliricidia sepium (Quick Stick) tree. The curved branches make it unsuitable for use.

Other appropriate tree species for the live stick system should be researched. The ideal situation would be to try indigenous species including those suggested by farmers and rural elders, but tropical species from outside Jamaica should be explored as well.

6.2.4. Yam Stick Plantations

Yam farmers in the study area have expressed great interest in the development of yam stick plantations which would supply good quality sticks at affordable prices [21]. In the early 1990s the FAO suggested the establishment of high density plantations for the production of yam sticks but this recommendation has never been acted upon by the Ministry of Agriculture [5]. Tree species' planted should be carefully selected with durability and healthy life-spans in mind. The FAO project identified tree species which would be appropriate for this system with *Eucalyptus robusta* rated as having the greatest potential. Farmers know this stick and regard it highly. It has a life-span of three to four years and can be coppice managed. *Causarina equisetfolia* was also thought to be an excellent choice as it coppiced well in central Jamaica and produced a good quality yam stick.

It has been suggested that these yam stick plantations could become part of the efforts of Government and bauxite mining companies to rehabilitate mined bauxite lands [6,11]. Currently mine lands are restored mainly to pasture. There was also an experiment to establish fruit orchards and food forests on some of these lands and more recently some have become sites for housing development. We would suggest that mined lands be turned over to agro-forestry activities for yam stick production. This would have significant ecological benefits as it would restore these lands to a semblance of their pre-mining state while reducing the need for sticks from natural forests, woodlands and coastal mangroves. This system could also be integrated into Jamaica's efforts to rehabilitate the many degraded watersheds. Trees for yam sticks could be part of forest restoration and some marginal state lands could be used in this way as well.

6.2.5. Harvesting Trees from Bauxite Company Land Earmarked for Mining

Lands owned or controlled by bauxite companies are a major source of yam sticks for many farmers and yam stick dealers who for the most part harvest sticks illegally. When lands are cleared for mining, however, hundreds of thousands of trees which could be put to diverse productive uses (lumber, charcoal production, fish pots, yam sticks, *etc*.) are destroyed. One dealer recounted how he took thousands of sticks from bauxite lands before access was cut off and other farmers and yam stick cutters have described how the clearing of land for a new highway wiped out a lucrative source of sticks and firewood. In this context bauxite mining seems unnecessarily wasteful and unsustainable. We would suggest that a system should be devised which would allow farmers to cut yam sticks from lands which are about to be mined. In fact, until they are mined, bauxite lands are essentially idle and companies could consider allowing some controlled sustainable cutting of yam sticks even where mining is not imminent. In both scenarios this could be free or at a nominal charge.

These activities could be integrated into a program to promote sustainable cutting of yam sticks for farmers and yam stick cutters. As we mentioned earlier yam sticks are often cut too close to the ground which affects re-sprouting. In the context of being good corporate citizens bauxite companies could collaborate with the Ministry of Agriculture and forestry officials to organize field days and demonstrations on proper yam stick harvesting which could be tied to the initiatives discussed in the previous paragraph.

7. Agro-Processing and the Yam Industry

At its peak in 2004, Jamaican yam exports earned over US$16 million. All of this came from the selling of yams as fresh produce. Currently there is no processing of yams which means that no value is added which means that the earning potential of yams has probably barely been scratched. Also yams are eaten in one form-boiled or cooked. Its use is therefore basic and unimaginative. We argue here that for the economic and food security potential of yams to be realized value added agro-processing must become a priority.

There are a variety of potential value-added products which could be explored. The first and most basic is perhaps flour from yams especially yellow yams. Currently there are a number of packaged agro-processed yam flour products in West Indian, African, and International food stores in cities Canada, the United States and the U.K. with large immigrant populations (Figure 9a, b). All of these are African products made from African yams which are all various shades of white. We believe that yellow yam flour could be a winner on the international market and could eventually become popular at home as well. Female farmers who also run households were confident that they could create many interesting dishes from yams apart from the usually cooking methods. It was argued for example, that mashed yams could be as tasty as mashed potatoes and so a packaged mashed yam mixture could also be considered.

A number of female farmers thought that yams could be used to make chips and other snacks similar to bananas, plantains and potato chips and other fruit and vegetable bits which have found themselves on the market in recent years. They reported that having experimented with frying yams at home they could see this as a popular snack locally and internationally.

It has also been suggested that yams can be used to make pastries. At the annual Yam Festival held in Albert Town a few years ago there was an exhibition of yam cakes which went over very well with patrons. Other possibilities like pies and puddings could also be explored.

There also seems to the prospective of processing beverages from yams. Wines and other alcoholic drinks have been suggested and experiments with a yam based fruit punch are also seen as worthy of research.

Whatever products are experimented with, the economic advantages of adding value to yams are likely to be enormous. It would lead to market expansion and better prices which would lead to increased incomes for rural farm families. Increased profitability of yams would likely lead to more young people being involved in yam farming with obvious implications for rural to urban migration and the associated problems.

8. Other Priorities for Sustainable Yam Cultivation

8.1. Marketing and Distribution of Food

We would argue that much more could be done to market and distribute yams both locally and internationally to increase profitability. The marketing and distribution of domestic foods have been identified as a major obstacle to production in several studies in Jamaica. There is no regulated system in place and small-scale farmers are basically left to their own devices in marketing farm produce locally. One of the great paradoxes of Jamaican agriculture has to be what can only be described as the estranged relationship between the island's world famous tourist industry and its local agriculture. So there has exists a situation where local tourism is booming while local agriculture stagnates and declines [26,27].This was recognized from the 1970s and 1980s by researchers who lamented the limited benefits the small-scale domestic food sector enjoyed from the tourism industry [28-30]. In more recent work it has been suggested that several changes including more openness towards serving local cuisine in resort facilities and globalization of food consumption habits and the desire of tourist to eat local foods, could serve to strengthen the link between local agriculture and tourism [31-34]. However, recent research into the role of tourism in local food supply chain suggests that there are still considerable problems for farmers [34]. We believe that the tourism sector is an area where the potential for creative use of yams in the cuisine could be harnessed and successfully promoted. The extent to which yams are used in the hotel kitchens requires research but indications are that its use is limited. Creating greater synergies between the yam farming sector and tourism requires more imaginative ways of using yams and creating yam dishes which would appeal to tourists. In terms of the marketing and distribution of yams to the hospitality industry, farmers would be better off organizing themselves into a cooperative rather than working as individuals.

Generally, a more proactive State role in the marketing and distribution of domestic food crops like yams could enhance viability by providing stable markets and fair prices. Farmers have consistently identified the collapse of the government agency the Agricultural Marketing Cooperation (AMC) as a watershed event in their declining fortunes. Farmers should also be encouraged and educated in the establishment of local marketing cooperatives. Examples of successful marketing by small-scale farming cooperatives can be found in Jamaica and used as models [34,35].

Figure 10. On the left, a farmer prepares yams for sale by the roadside. On the right, he explains something to a University of the West Indies researcher. The yams will be picked up by either an export agent or a higgler.

8.2. Storage of Yams

A major problem within the small-scale food production sector in general is the lack of knowledge about proper food storage, absence of proper storage facilities for farmers, and knowledge and experience of general advanced post harvest management of farm produce. This means that farmers have to market their crops all at once and within their normal shelf life. There is no effort to store produce during periods of over-supply and releasing food to market at different times. Also, there is a high level of post harvest losses due to spoilage. The economic viability of yam cultivation can be significantly enhanced by improvements in post harvest management and by the development of facilities to stockpile or store yams on a long term basis rather than being forced to market produce as soon as they are harvested. This would allow farmers to increase production knowing that they would have a much longer window on marketing their produce as well as regulate market supply. Lack of post-harvest storage is a general problem in small scale food production not just in Jamaica but the CARICOM region. Farmers lack both the technology and facilities and education in this area is seriously needed. Without post harvest treatment and proper storage yam has a short shelf life in its raw form. This problem needs to be addressed.

9. Conclusions

Yams are an important domestic food crop with significant economic and cultural cache. Yam is a mainstay of local diets, provides employment for thousands of farmers and provides employment and livelihood for thousands of rural households. In addition, yams have grown to become a significant export crop with substantial untapped earning potential. With its success on the international scene and global potential yams could become an even more important player in national food security. Profitable yam cultivation will help to increase food self sufficiency while earning income and closing

the import and export trade gap. Yam cultivation should be an agricultural policy priority with the creation of value added from yam cultivation should a major strategy.

The economic viability of yam cultivation is inextricably linked to finding solutions to the yam stick problem. Furthermore, the most ecologically sustainable yam stick solutions also have the most economic potential. We would argue that this provides an excellent example of how the potential conflict between two fundamental agricultural goals-increased agricultural production to enhance food security and maintaining environmental integrity can be reconciled. Our research shows that the attitude of farmers to innovative ideas to which there had been long standing resistance is changing as farmers become more convinced of the advantages and benefits to be enjoyed. More farmers are now prepared to consider growing yams without sticks and trying minisett yams. Farmers are also generally positive about agro-forestry options of yam stick production with the potential to drastically reduce expenditure on yam sticks thereby reducing production cost and increasing profitability. This is important as small-farming systems in Jamaica are increasingly characterized by intensification productive modes which will increase environmental pressures [36]. However, translating this goodwill into more sustainable farming practices will require education for farmers who will require concrete evidence of the feasibility of different practices. Thus there is a need for field trials, demonstrations and experimental plots established in the communities under typical farm conditions. These should be established with farmer input and involvement at every stage. Despite the decline in yam cultivation over the last fifteen years export income has continued to rise and yam cultivation remains one of the few success stories in Jamaican agriculture over the last three decades. But its potential if recognized by local authorities has not been given a real chance to materialize. The solutions we have offered here can help to change this in a significant way.

We conclude by making the point here that sustainable agriculture in Jamaica and other resource poor farming environments must be linked to a broader mission of economic and social change [37]. Food security and rural livelihoods should be fundamental in agricultural planning and it is important for vulnerable small-scale food producers to realize that the goals of food security and reduction of food poverty are not incompatible with sustainable agriculture. Research evidence from our study and others prove that sustainable agricultural practices will bring increased income to rural farm families while increasing food production and conserving agricultural resources [38].

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