Original Research Article

STATUS AND CHALLENGES FACING PINEAPPLE (*Ananas comosus)* PRODUCTION IN MAGARINI SUB-COUNTY OF KILIFI COUNTY IN COASTALKENYA

ABSTRACT

Pineapple (*Ananas comosus)* is one of the five important value chains in Kilifi County and is grown under small scale farming and under rain-fed conditions. There are six distinct pineapple growing areas and CBOs in Magarini namely Changoto, Danisa, Faith, Chamari, Bore-Singwaya and Baricho-Mwanazi. This crop has a big market share but the region can hardly meet the market demand. The pineapples are cultivated in special soils indicated by the presence of certain virgin forests and vegetation types. However, these pineapple farmers face a myriad of challenges that limit full exploitation of the 20,000Ha pineapple growing potential. It is in this regard that a rapid rural appraisal (RRA) study was conducted facilitated by MESPT with the funding of Danida to establish the current situation on pineapple cultivation in Magarini Sub-County to inform the type of intervention strategies to use. Methodology used involved sampling of 60 farmers out of the total population of 600 pineapple farmers in the six growing areas. The 60 farmers represented 10% sample size. These farmers were selected for focus group discussions and interviews. Methods and tools used for data collection included transect travels across and through the six pineapple growing areas, making observations, taking photographs, meeting key informants and farmers for focus group discussions, and individual interviews. Obtained data was subjected to descriptive analysis. Frequency charts obtained were used to make inferences for discussion. The findings indicated that capital investment required for pineapple establishment was too high. Planting material constituted over 50% of the total investment. Pineapple cultivation is conducted under shift cultivation system, where farmers move to open new virgin forests every 3-4 years since the farmers do not use inorganic fertilizers as contract buyers prefer organically produced fruits. Sokoke (loamy clay) soils were the best soils for pineapple growing unlike Soso (sandy loam) soils or Ngama (clayey) soils. Grabs, beetles, birds, mealy bugs and millipedes were the major pests of pineapples. The MD2 pineapple variety being introduced was susceptible to pests and diseases that caused death of the central apical stem inducing production of tillers (suckers).

Key words: Pineapple, cultivation, challenges, Magarini, Sokoke niche, soils

1.0 Introduction

Pineapple(*Ananas comosus)* is one of the five important commodity value chains in Kilifi County. It is grown under rain-fed conditions by small scale farmers. There are six distinct pineapple growing areasand therefore CBOs working with MESPTin Magarini-Sub-County, namely Chamari, Adu-Mbuuni (Changoto), Danisa, Baricho-Mwanazi, Bore-singwaya, and Faith. This important cash crop is produced in specific soil niches in Coastal region of Kenya that cover over 20,000Ha, of which only 5% has been exploited[1].The land in these niches cannot successfully sustain other cultivated crops due to limitations of rainfall and soil fertility,except cassava.Therefore, any efforts that would assureits full utilization will facilitate cultivation and production of morepineapples, renowned for their fresh sweet fruits, juice and canned products.These products have a huge demand in both local and export markets,includingin tourist hotels[2]. Expansion of pineapple cultivation in these niches can generate extra employment, income opportunities and improve livelihoods of the local communities in these areas, who rely on charcoal burning, logging, and overgrazing.These niches are home to certain flora and fauna species such as sandal wood, rare birds and animal species which currently are in danger of extinction due to continuous charcoal burning, logging, and overgrazing (Figure 1).

Figure 1: a) Virgin Forest vegetation bearing niche soils for pineapple cultivation, b) Charcoal burning and logging, a booming business for the youth.

These methods of generating a source of livelihood have proved unsustainable, and the only solution is to put the land back to its most sustainable use, pineapple cultivation. Pineapple production has a huge potential and affords more benefits and income opportunities than charcoal burning and logging. To be able to understand the area fully and the challenges inhibiting sustainable use of the natural resources in the area, a rapid rural appraisal (RRA) was conducted during the month of November, (2023) with the aim of establishing the current state of pineapple production in MagariniSub-County.Specifically, the study intended to find out the challenges facing pineapple farmers in the area.

2.0 Methodology

The rapid rural appraisal was conducted in the six pineapple growing areas of MagariniSub-County, represented by pineapple growingCBOs in the names of Chamari, Danisa, Adu-Mbuuni (Changoto), Baricho-Mwanazi, Faith and Bore-Singwaya. The Baolala growing CBO was omitted inthestudyduetologisticalreasons. However, itwas notable that most ofthe pineapple growing farms of this group are in Magarini area, and farmers must cross river Sabaki that separates Magarini and Malindi to reach their farms. Out of the population of 600 pineapple growing farmers, 60 farmers representing 10% sampling [3] were randomly selectedfor data collection. Methods used to obtain information from the farmers included use of questionnaires, focus group discussions,key informant, interviews, and observations in the cultivated and non-cultivated pineapple growing fields.

At first, a week to the visits of the concerned areas for RRA exercise, appointments were madeby local extension officers who made appointments with the local Administration officials,Area chiefand theSub-CountyAgriculturalofficer (SCAO).This was facilitated by two local extension officers conversant with the local terrain and area. Questionnaires used during the study were developed by Pwani University Fourth year students of Bachelor of Science in Agriculture and fine-tuned by the Principal leaders in the pineapple technology. Methods and tools used for data collection duringthe study included doing transect travels across and through the six pineapple growing areas, making observations and taking photographs, meeting farmers at specified sites to conduct focus group discussions and also doing individual interviews with the farmersandkeyinformants (Figure 2). The data obtained was subjected to descriptive analysis.Frequency charts obtained were used to make inferences for discussion.

Day one of the visit involved a reconnaissance survey.It entailed traveling across and mapping out all the pineapple growing areas and CBO groups, distances between them and meeting the group leaders, and booking appointments for interviews and discussions with the group members on the days of their choice for meetings (Figures2 and 3).

Figure 2: Day 1 of reconnaissance survey: Meeting CBO group leaders in a) Danisa and b) Bore-Singwaya to make appointments to meet pineapple farmers.

The meetings and discussions were held in the open under tree shades and or classroom shades (Figure 3).

Figure 3: Conducting a Rapid Rural Appraisal sessions with Faith and Changoto CBO groups.

During the reconnaissance, the types of soils, vegetation, fauna and flora and economic activities in each of the six pineapple growing areas were noted (Figure 1).

3.0 Resultsand discussions

3.1 Spatial distribution of the pineapple growing areas and CBO groups

The pineapple growing areas were found to be far removed from each other and sparsely distributed. Apart from Faith and Bore-Singwaya who were neighbors by of 3-4 kilometers between them, all the others were distantly placed requiring at driving of not less than one to three hours (20-50km apart). The earthen roads were rough, full of potholes and narrow in some sections and offered a lot of challenges in absence of a local guide(Figures 1 and 4). These areas especially Chamari and changoto are separated by a large extensive indigenous forest in which are found pockets of vegetation and niche soils that support pineapple cultivation (Figures 1 and 4).

Figure 4: a)The main road to major pineapple growing areas of Chamari and Changoto. They are characterized by being narrow and difficult to pass during rainy seasons. b) Note the Miombo wood-like virgin forests in the background that bear Sokoke soils, ideal for growing pineapples.

Among the vegetation that were noted to be indicators of soil that support pineapple cultivation include, the Miombo-like wood-lands, sandal wood and associated hardwood shrubs (Figure 1).The long distances between the pineapple growing areas have implication in terms of sharing and offering both support and extension services among the pineapple farmers. Since the farmers source their planting material from their neighbors in other villages, the poor roads offer a big challenge especially during the rainy planting and harvesting season (Figures 1 and 4a).
The major mode of transport in these areas is motor bikes especially for transportation of charcoal and other farm produce in the region (Figure 1). Pineapple producedin these areas is mainly transported by use of canter lorries(Figure 4b), pick-ups,station wagons, donkey-drawn carts and motorbikes most of which break down due to poor roads resulting in spoilage of most pineapple produce since they are highly perishable (Figure 4b). This calls for local processing factories once requisite quantities of produce are attained.

3.2 Crop and livestock enterprises undertaken in the area,(first fourprioritized)

3.2.1 Crop enterprises

During the interviews, farmers enumerated the following crops as being grown in the area: Pineapple, Cassava, maize, green grams, cowpeas, watermelons, citrus, mangoes, cashew nuts, casuarina, dragon fruit, passion and moringa.The CBO groups ranked first four crop enterprises,indicating the importance farmers attached in these crops in terms of their economic importance and as sources offood for their wellbeing (Table 1).

Table 1:Crop enterprises undertaken in the area, first four prioritized.

S/ N0	Chamari	Faith	Baricho-Mwanazi	Danisa	Changoto	Bore-Singwaya
1	Pineapple	Pineapple	Pineapple	Pineapple	Pineapple	Pineapple
2	Cassava	Cassava	Vegetables	Cassava	Cassava	Green gram
3	Maize	Green gram	Maize	green gram	Maize	cowpea
4	Greengram	cowpea	Greengram	Cowpeas	Green gram	maize
5	Cowpea	Maize	Cassava	Watermelon	cowpea	Cassava
6	Watermelon	Bean	Cowpea	Maize	Pigeon pea	Bean
7	Citrus	Cashewnut	Banana	Sweetpotato	Dolicoslablab	Cassava
8	Mango	Mango	Castor	Banana	Groundnut	Mango
9	Cashew nut	Citrus	Water melon	Bean	Sorghum	Citrus
10	Casuarina		Passion	Sorghum	Pawpaw	Melon
11	Dragon fruit		Sweet potato		Pumpkin	
12	passion		Cashewnut		Millets	
13	Moringa		Coconut		Amaranthus	

The ranking in Table 1 suggests that the farmers would be willing to invest their energies and resources towards their successful cultivation and would, support and embrace any interventions towards improving the crop enterprises. Pineapple was ranked the first by all groups, implying it is of highest economic importance in terms of monetary returns to the families. Therefore, in terms of interventions, pineapple should be given the priority after which others would follow.

3.2.2 Livestock enterprises

The following livestock enterprises were enumerated by farmers as being reared in the area (Table2). The types of livestock kept reflected the ability of each type of livestock kept being able to meet the farmers' immediate, short term and long term needs relative to the magnitude of the problems facing them. These livestock provided an immense source of wealth and opportunity in terms of being able to continuously supply the much-needed soil amendments in form of farmyard as organic fertilizer for the crops grown by the farmers. When the livestock were fed on the resultant crop residues, this facilitated recycling of nutrients, thus increasing efficiency of resource use and therefore sustainability of the farming system. This is so especially given that continuous use of inorganic fertilizers in Coastal soils has been observed to result in increased soil acidity, and therefore poor health of the soil with consequent reduction in crop yields[4].The following were prioritized by CBO farmers as important livestock enterprises in the pineapple growing areas.

Table 2: **Livestock enterprises undertaken in the area.**

S/N0	Chamari	Faith	Baricho-Mwanazi	Danisa	Changoto	Bore-Singwaya
1	Chicken	Goats	Goats	Goats	Goats	Goats
2	Goats	Cattle	sheep	Cattle	sheep	Chicken
3	Cattle	Chicken	Chicken	Chicken	Cattle	Ducks
4	Guinea fowl	Cattle	Geese	Ducks	Chicken	sheep
5	Ducks	Chicken	Ducks	Sheep	Ducks	Donkey
6	Geese	Ducks		Rabbits	Donkey	
7	Bees			Donkey		

3.3 The type of soils in the pineapple growing areas.

Three types of soils were distinctly identified and described by the farmers in all the six pineapple growing areas of Magariniand the crops they support (Figure 5 and Table 3). These wereSoso, Sokoke and Ngama soils.The attributes of these soils are described in Table 3.

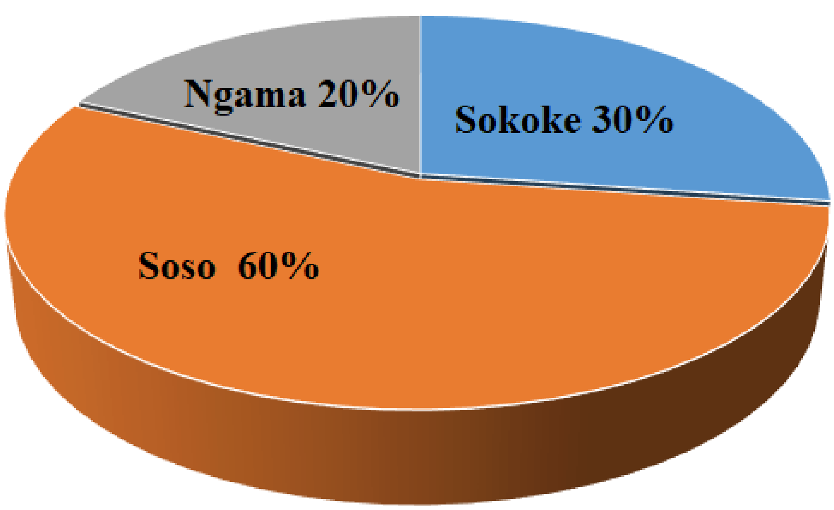

Figure 5: Major types of soils identified and their coverage in all the six pineapple growing areas of Magarini.

It is well known that each type of soil best supports given types of vegetation and crops based on their fertility status, inherent nutrients and physio-chemical properties[5]. According to [6] vegetation type and lithology have a significant impact on vegetation and soil physio-chemical and biological characteristics, and that vegetation type is the primary factor affecting vegetation and soil characteristics, while lithology affects vegetation leaf area index (LAI). In this regard farmers were right in relying on vegetation types to identify Sokoke soils for pineapple production (Figure 7).
Thus, the farmers' Indigenous technical knowledge (ITK) on the inherent properties and capability of the soils made them experts in their own rights which enabled them to make the right choice of crop enterprise mix for maximum returns. The farmers were able to describe the attributes of the soils and associated vegetation as detailed in Table 3. This is important in that the farmers know where to find the different types of soils and where to allocate their meagre resources. Thus, of all the interviewed farmers, 97% perfectly described the best soil for growing pineapple as Sokoke soils (Table 3 and Figure6) and those best for growing maize and green grams as Ngama soils. The Sokoke and Soso soils (Figures 6c, d) were noted to be deep and well drained, and they supported trees crops, vegetables, and pineapples cultivation. Ngama soils in most cases were shallow especially the black cotton soils and supported shallow rooted crops like maize and green grams. Therefore, it is possible to guide and plan with the farmers on acreage of each crop to afford diversification for cash crops and food crops, without compromising food security at family level.

Table 3: Major soils in pineapple growing areas of Magarini, their attributes and crops they supported.

Soil type	**Soil description by farmers**	**Soil color by farmers**	**Some important properties**	**Crops grown**	**Soil depth**
Sokoke	Loamy clay	Yellowish brown	Well drained and good water holding capacity, fair amounts of organic carbon	Pineapples Cassava	Deep friable soils more than 5m deep
Soso	Sandy loam	Reddish brown/greyish	Free draining, poor water holding capacity, low in organic carbon	Cassava, Cowpeas Cashew nuts	Deep loose soils more than 4 m deep
Ngama	Clay	Black cotton soil/Yellowish clay	Poor in drainage, sticky when wet, hard to work when dry, good water holding capacity, rich in nutrients.	Maize, Green grams, Cowpeas	Shallow, 2-3m depth, with coral concrete as parent rock

Figure 6: Soso and Sokoke soils. Soso soils (a and b) are sandy soils, whitish to greyish in color and poor in organic matter. Sokoke soils (c and d) are ideal for pineapple cultivation. They are deep, brownish yellow and well drained.

3.4 The soil types and associated vegetation

3.4.1 The Soso soils vegetation

This soil is sandy loam in nature and support large trees of expansive canopies with limited thicket. Most of these trees are neither good for high quality charcoal nor good for building material. These trees were described to be of limited use to the community since they were also prone to wood pests and beetles. However, the local people underrated these soils as having unreliable soil fertility, hence the name Soso (Figure 7).

Figure 7: Soso soils (a) and (b) at Faith group. They are sandy loam in nature and reputed to have unreliable soil fertility. They are free draining, low in organic matter and therefore poor in plant nutrients.

3.4.2 The Ngama soils vegetation

These soils supported dense thickets and scattered hard wood trees. The thicket was probably because of continuous cultivation since they were fertile black or red cotton soils of good water holding capacity. These Ngama soils forms the maize-belt of Magarini Sub-County. These thickets are cleared and trashes burnt every planting season to have clean fields for maize and green gram planting. The only fallow period is during the prolonged dry spell that starts from August after harvest of long rains crop to March. It is during this dry period when the resultant vegetation is assumed to restore some fertility from the newly grown bushes and thickets through the process of nitrogen fixation and decomposition of roots increasing soil organic matter. While the Sokoke soils provide for pineapple and cassava as cash crops, the Ngama soils are heavily relied on for food supply and security as well as legume cash crops such as green grams. It is notable that for most pineapple farmers, the dwelling places are in most cases far removed from the pineapple cultivation areas.

3.4.3The Sokoke soils vegetation

It was notable during the reconnaissance survey, that in most un-disturbed forest vegetation, the type of vegetation varied depending on the underlying soil type (Figure 1). Sokoke soils supported Miombo wood-land type of hard wood vegetation characterized by a mix of indigenous woody trees and thicket vegetation with spots or patches of sandal wood (Figure7). Thisvegetationwas observed tobehighly preferred for charcoal burningsinceitscharcoalwashighquality (Figure 1). The same vegetation was a major indicator of presence of Sokoke soils for pineapple cultivation (Figure 7).

3.4.1.1Sokoke soils and pineapple cultivation

Prospective pineapple farmers normally locate the vegetation associated with Sokoke soils by looking for certain hard wood treespecies (Figure 8). Establishment of pineapple orchard normally starts with bush clearing using pangas,followed by some de-stumping using jembes, after which the dried bushes and vegetation are set on fire until they burn to ashes (Figure 8). The farmers then move in and make planting holes (in lines) after which they plant by inserting the suckers half-way into the holes and cover with soil. Most farmers make holes and plant in the burnt ashes without de-stumping to cut down on costs. On average one acre is normally planted a population of 10,000 suckers, which is similarto that reported in Guyana by [7]. However, [8] have reported plant populations of 17,000 to 23,000 per acre.

In MagariniSub-County pineapple cultivation is normally conducted for a period of 2-3 cropping or seasons. During the first season of cultivation farmers claim they obtain the highest yields of high-quality pineapple fruits (Figure 10).

The farmers reported that the weight of most quality fruits ranges between 2.5-4kg per fruit or between 30-40 tons per acre. However, a capacity to achieve 80-90 tons per acre exists if important recommendations on spacing are adopted [8]. The farmers must look for buyers early enough before the peel color shows signs of changing toward yellowish green. However, several farmers are contracted and it is upon the buyer to decide stage of harvest and provide labour for harvesting.

Figure 8: The process of land preparation for pineapple cultivation in Magarini. a) Virgin forest identified; b) Bush clearing; c) Burning the dry vegetation; b) De-stumping to obtain clean field and digging holes.

Figure 9: The process, from seed (planting material) to pineapple crop.

Figure 10: Maturing pineapple andcrop yield during first cropping

During subsequent cropping,theyieldsdecreasetoaminimal due to decline in soil health and fertility since pineapple is a heavy feeder [9](Figure 11).

Figure 11: Pineapple orchard abandoned after the a) 3rd and b) 4th season of cultivation. The exhausted soil can no longer support successful pineapple crop growth due to decline in soil health and fertility.

By this time, the farmers must identify and cultivate new virgin forest for pineapple orchards. This cycle has continued over the years until the initial pineapple growing areas have been left bare with little or minimal vegetation since the soils become exhausted of nutrients. Such areas are Bore-singwaya and Faith.

The foregoing is a description of activities in shift cultivation type of farming system. Thus, pineapple cultivationinMagariniSub-Countyforms a good case study of shiftcultivation as a farming system in modern day Kenya.Similar observationshave been reported by[10] who opined that in shifting cultivation systems, fallow duration is seen as the key determinant of vegetation and soil dynamics and that long fallows renew soil fertility, biomass, and biodiversity. However, overtime, shifting cultivation may erode soil fertility and biodiversity levels even if long fallows are allowed to persist. While the decline in soils fertility may be slowedusingsoil amendments, however biodiversity declines and species compositional changes may be much harder to reverse.In Magarini pineapple growing areas, themajor imminent challengeis exhaustion ofthesevirginforestsbearing the Sokoke niche soils (Figures 8a, b and11).AlreadyfarmersinBore-Singwaya observed that pineapple cultivationstartedthereinthe1980's.However, todaylimitedorno pineapple cultivationtakes place in that area. Mostpeoplehavenowmovedto far distant newhorizonsthatmakeuptheChamariandChangotoareasnearGalana-Kulaluranch.Therefore, there is need to conduct studies and find sustainable ways of restoring the soil fertility of the post pineapple cultivated areas as the virgin forests that bear the Sokoke soils are finite and not a renewable resource. The studies would require doing comprehensive soil analysis of both the virgin and exhausted Sokoke soils to establish the limiting nutrients and other affected soil physio-chemical and biological properties, and methods of replenishing them.

4.0 Challenges affecting pineapple production in MagariniSub-County

This section investigated various aspects affecting pineapple value chain with specific emphasis on challenges limiting pineapple expansion.

4.1 Availability of pineapple planting material

Over 98% of interviewed farmers indicated thattheyplantsmooth cayenne variety.ItisonlyonefarmerinBarichowhohad about one acre of MD2 being grown as asource of MD2 planting material.Theseplanting materialof smooth cayenne inmostcasesaresourcedfromneighboring farmers,butmostlyfromChamariandChangotowherethereishighconcentrationof pineapple cultivation.Chamari and Changotoare recently opened pineapple growing areas. The planting material used are suckers and splits (Figure 12).

Farmersindicatedthatthebiggest draw-back in expansion of pineapple cultivation is availability of adequate planting material since splits and suckerstakebetween12-18monthstobe ready forplanting (Figure 12).Thus, asthefruitsstartforming,thisisthesame periodthesplitsandsuckersalsostartcomingoutsuchthatbythetimethefruitsarereadyforharvesting,thesuckersalsohaveattainedtherightsizeforplanting,of about35-50cm in length (Figure 12).The farmers observed that a single pineapple plant gives on average 3-4 suckers and an equal number of splits. This at most gives 8 seedlings of planting material. Planting a single acre of pineapple orchard was said to require about 10,000 suckers/splits, a plant population density also practiced in Guyana [7].

Thus, in terms of seedlings production at farm level, a single acre would thus generate about 60,000-80,000 suckers and splits, planting material capable of establishing 6 to 8acres of new orchard. Thus, it would take a longer time to provide adequate number of planting material for establishment of new orchards unless new sources of planting material are identified or imported from up-country regions. Yet, there still exists expansive virgin forests bearing Sokoke soils which forms enormous potential and new frontiers for expansion of pineapple cultivation (Figures 1 and 11).

Figure 12: Pineapple planting material on land ready for planting. The huge quantitiesof bulky suckers require large vehicles such as lorries to transport.

Thus, there is need to introduce anewtechnologyonmass generation ofplanting material to alleviate the shortage of planting material and bring down the cost of establishing new pineapple orchards.

4.2Bulking of MD2 pineapple variety (at Baricho farmer) for supply of planting material to farmers

Two important observations were noted about this noble variety.

a) Apical stem attack led to production of more suckers per plant.

MD2 is one of the varieties highly awaitedbythefarmersin the region.It is said to have been brought from Central Kenya where it is widely grownby Delmonte Kenya ltd [2]. It is beinggrownforprovisionofplanting material byaBarichofarmer for distribution to other farmers in the pineapple growingareas of MagariniSub-County (Figure 13). This variety is able to produce high quality fruits and having shorter maturity period[11]. It also has the ability to produce a lot of planting material (suckers) even before fruit formation. A close look at the growing MD2 plants at Baricho farmer revealed that the plants have a tendency of producing multitudes of 3-4 tillers (suckers) per plant from the base of the growing plant (Figure 13). This is what the farmers were referring to as the ability of the MD2 plants to produce more planting material. However, this production of the suckers in MD2 plants had similarities akin to tillering in sorghum plants where the central stem was attacked and destroyed by sorghum shoot fly (*Atherigonasoccata)*, causing dead-heart [12]. Death of the central stem eliminates apical dominance, and the plants respond by producing more tillers (suckers) (Figure 13b, c). Thus, all the MD2 plants that were "tillering" had their central apical meristem destroyed and dead, either as a result of attack by an insect pest (pineapple stem borer), bacterial *(Dickeya* spp, that causes bacterial heart rot) or fungal (*Phytophthora spp. that causes pineapple heart rot)*[13]. Whereas production of more suckers by MD2 plants can be viewed as advantageous since it is expected to supply more planting material, there is need to closely monitor its performance under Coastal Kenya climatic conditions. This is because while farmers can have well established orchards of MD2, the proportion of the plants in the orchard that can be subject to destruction of the central stem by the pest/disease needs to be ascertained. This is because if the pest adversely attacks a sizable proportion of the growing plants in the field, it can lead to negative effects on final yields or non-uniformity of ripening fruits.

Figure 13: (a) MD2 pineapple variety beingbulked at Baricho-Mwanazi farmer; (b) and (c), shows tillering (sucker production) induced after death of central apical meristem due to pest attack.

Thus,if thesuckersarethefinalproductfromtheMD2bulking sites,thenthecentralstemattack bythepest/diseaseisanadvantagesincetheplantsrespondbyexhibitingover-compensatoryresponse[14].However, if the MD2 plants in the orchards are established for purposes of commercial production of pineapple fruits (Figure 13a), then thereisneedtobecautious and take measures to controlthepest/diseasecausingdestructionofthecentralstem.

b) The second important observations noted on MD2 was: What acreage of MD2 and after how long will it take to supply adequate planting materialfrom the one acre bulking site for at least a sizeable number of farmers.

The current half an acre of bulking site at Baricho was said to contain about 1000 plants of MD2 (Figure 13a). Thecurrentrateof ‘tillering’ observedwasatbest 3-4 tillers (suckers) per plant (Figure 13b, c).Thus, 2000-3000 suckers if 75% of these plants do tillering. The (2000-3000 suckers are about enough for establishing a quarter ofan acre of MD2). Assuming that these suckers take about 9 months to be ready for transplanting into a new field, then only a quarter ofan acre ofMD2canbeestablishedeachyear. It would therefore take ages to have a sizable number of farmers growing MD2 variety. Thus,tobeableto supply more farmers with MD2 variety, three approaches are feasible. Either:

i) import more MD2 planting material in the form of suckers or slips from up-country.

ii) Supply more farmers in the pineapple growing areas with more suckers to increase bulking sites

iii) Explore the possibility of obtaining and using MD2 pineapple crowns for rapid mass generation of planting material.

4.3Non uniformity of planting materialleading to un-evenripening of pineapple fruits.

Itwasearlierobservedthatasingleacreof pineapple orchard in Magarini is normally planted with a population of 10,000 pineapple plants whichcanatbest generate a total of between60,000-80,000 newsuckersandsplits, planting material capable of planting 6-8 new orchards. Thus,itisonlyfarmerswithlarge farmsofover20acreswhocan be able to produce their own planting material and afford extra for sale to other farmers. This implies that the farmers must obtain planting material from different sources (which in most cases are of varied ages), to be able to satisfy their needs.Therefore, whenplanting materialofdifferentagesandsizesareplantedinthesamefarm,thisresultsin pineapple fruitsthatare of different sizes and matureatdifferenttimes, an issue expressed by most farmers as affecting marketing of their produce and income. Thus, pineapple fruit buyers must scavenge from different farms which are also distantly placed to obtain and fill their cargo of merchandise. Similar sentiments were expressed by[15] who reported that the main constraints to pineapple production in Benin were availability of appropriate planting material, heterogeneity in weight, age and leaf number of planting material, and availability and high costs of fertilizers.This calls for introduction and adoption of the technology on mass generation of pineapple planting material so that adequate amounts of planting material of the same size and age are available.

4.4High initial capital requirementfor pineapple establishment

All farmers interviewed decreed the high capital investment required for establishing pineapple orchards as a major deterrent to expanding pineapple productioninMagariniSub-County.This high capital investment was enumerated as outlined in Table 4 and Figure 14.From this, it is evident that the item constituting the highest percentage cost of pineapple production is planting material, at 40.4% (Figure 14).

Table4: Capital requirement items and activities in establishing One acre of pineapple orchard in MagariniSub-County of Kilifi County.

	Item/Activity description	**Quantity required for 1 acre**	**Unit cost (Ksh.)**	**Total cost**	**% of total cost**	**Remarks**
1.	Planting material (suckers)	10,000	10	100,000	40.4	Sourced from fellow farmers
2.	Transportation for suckers	10,000	2	20,000	8.1	Canter lorries /pickups used
3.	Bush/vegetation clearing	9,000	9,000/acre	9,000	3.6	Hired labor used
4.	Bush/ vegetation burning	7,000	7,000/acre	7,000	2.8	Hired labor used, others use family labor
5.	De-stumping	8,000	8,000/acre	8,000	3.2	Hired labor used
6.	Hole digging	10,000	3	30,000	12.1	Hired labor used
7.	Planting	10,000	3	30,000	12.1	Hired labor used
8.	Weeding	10,000	10,000/acre	10,000	4.0	Hired labor used
9.	Birds scaring	4,000	4,000/acre	4,000	1.6	Hired labor used
10.	Harvesting	4,000	4000/acre	4,000	1.6	Hired labor used
11.	Transportation	10,000	2	20,000	8.1	Lorries, pickups, motorbikes, carts used.

12.	Cess tax	Lorry load pickup	750 350	750 350	0.3	Paid as cargo passes every County
13.	Weigh bride tax	Lorry load	4,500	4,500	1.8	Paid at Mtwapa weigh bridge
14.	Cartels	Un-official	Un-official	Un-official		At Kongowea or Mtwapa wholesale markets
15.	Police roadblocks pay offs	Un-official	Un-official	Un-official		Un-official charges
				Grand total cost	**100%**	**247,600**

Coincidentally it is also the most critical item in the whole pineapple value chain, without which no pineapple orchard can be established.

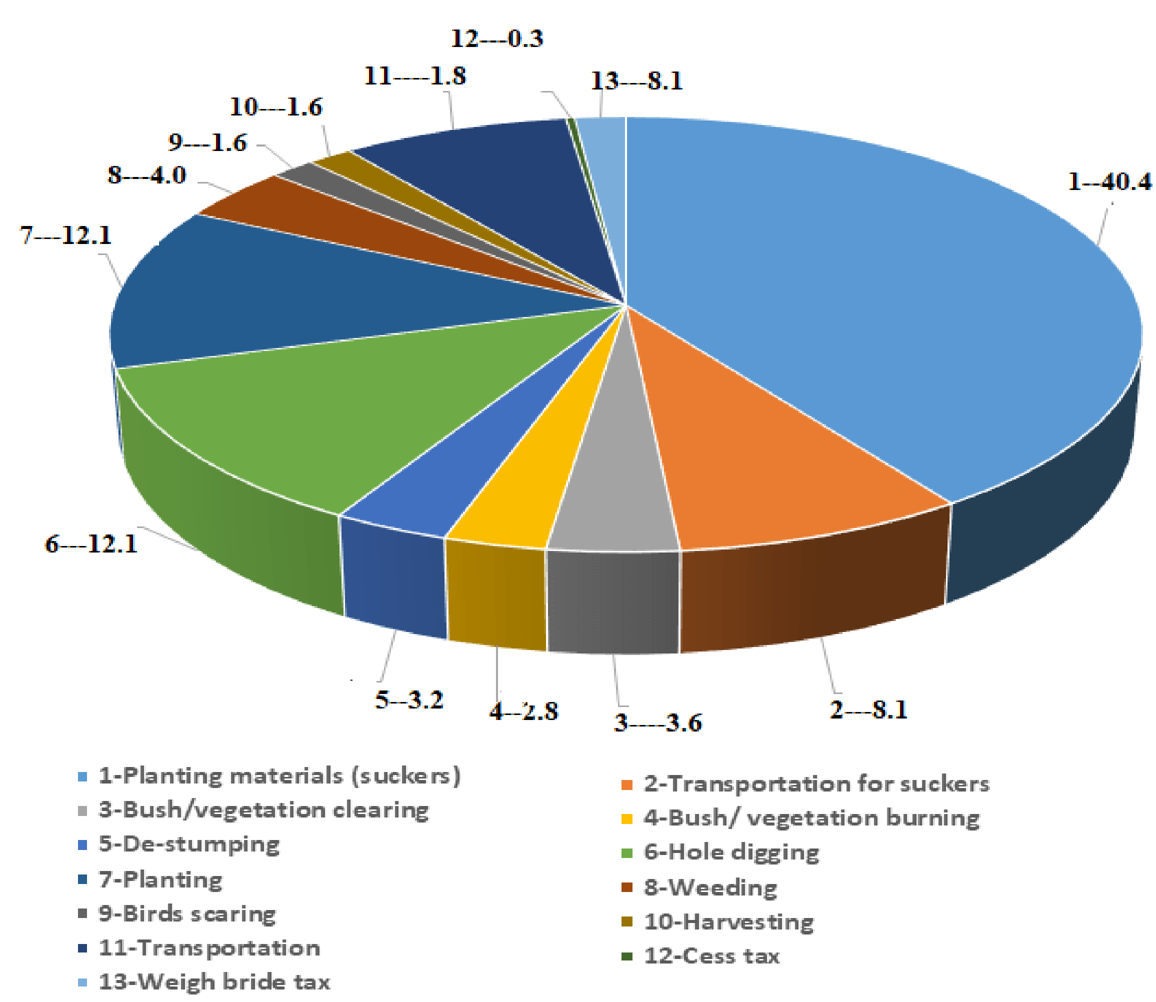

Figure 14: Capital outlay for activities involved in production of 1 acre of pineapple orchard in MagariniSub-County.

Hole digging and planting activities constituted the second highest percentage costs both at 12.1% and the second most critical activities in establishment of pineapple orchard. The third highest cost item is transportation of both the planting material and produce each standing at 8.1% (Figure 14).

From the foregoing, it is therefore certain that if the farmers can be empowered through capacity building on mass generation of clean pineapple planting material at their farms, these critical costs of planting material and transportation would reduce the cost of production by 48.6%. This would be a big saving for the farmers and would enhance sustainability of the pineapple value chain. With increased acreage and production of more pineapple fruits, this would attract investors for establishment of processing facilities within the pineapple growing areas thereby reducing the cost of transportation, weigh-bridge tax, Cess tax and avoid cartels and brokers at main Kongowea or Mtwapa markets. The fact that the initial capital investment required to establish an acre of pineapple is over 247,000 calls for concerted effort to rope in other cheaper credit lenders on board to assist farmers fully exploit the pineapple value chain and Sokoke niche soils in the region.

4.5 Managementofthe pineapple plant

After crop establishment, important management practices were highlighted by farmers as including, weeding (manually using a jembe or uprooting the weeds by hands), getting rid ofofftypes,andscaringofbirds.Severalfarmershadmentionedscotchingofmaturingfruitsbythesunof whichtheyappliedsomeshadeusingdry grass. Farmers requested capacity building of good agricultural practices on pineapple value chain.

4.6Harvesting,postharvest handling, transportation,and marketing of pineapple fruits

Since the pineapple fruit has high levels of inherent sugars that enhance their perishability mostfarmersharvest the fruits onlywhenthereisareadymarketforconsumption.Thisisbecausethe pineapple fruitscannotbe keptforlongafter harvest (4-6 days) andarealsobulky. The farmers normally harvest the fruits manually by cutting the stock at the base of the fruit. This is when the ripening fruits show signsofcolorchange,by turningfrom green to golden yellowandwhenthefruit on tapping the sides with a finger or palm produces a unique sound.In most cases, the buyers arrange for labor for harvesting. Some farmer groups produce the pineapples under Contract terms where they are offered a specific price at planting. In contract farming some buyers dictate the conditions on how the crop should be managed. Thus, some buyers demand organically produced fruits where there is no application of any pesticides or inorganic fertilizers. Afew mentioned Contract buyers were named as Goshen and Bio-farm enterprises who were said to offer good farm gate prices, among other incentives.

4.7Other challenges facing pineapple value chain

Other challenges facing pineapple value chain are summarized under the following narrative.
The following observations and findings were observed and constitute gaps that can be addressed and improve productivity and sustainability of the pineapple value chain in the region (Figure 15).

4.7.1 Reduced or decline in soil fertility

Most farmers reported to have observed reduction or decline in soil fertility over the growing seasons resulting in small fruits.

4.7.2 Pineapple production is mainly practiced under shift cultivation system

Pineapple production in these pineapple niche areas is practiced under shift cultivation system, where farmers, identify a virgin forest, clear the vegetation, set the dried bushes and trashes on fire and then plant the pineapple suckers during the rainy season (Figures 8--12). After 2-3 seasons of cultivation, the pineapple yields decline drastically (Figure 11) and farmers shift to another virgin forest, and the cycle continues.

From an ecological point of view, this system is not sustainable in the long run since it impacts the soil health negatively and alters the entire natural ecosystem. With increased population pressure coupled with, effects of climate change and demand for more food, effective available land for food production is bound to drastically shrink. Besides, given that the pineapple plant is a heavy feeder, after three seasons of cultivation the soil is left depleted of nutrients. This is the reason few crops do well in these soils after pineapple cultivation. While it is appreciated that organically produced pineapples are in high demand and fetch good prices, it is notable that the pioneer niche soils areas where pineapple cultivation started in the 1980s to 1990s through to 2000s have been abandoned due to poor soil fertility.

Figure 15: Expression of challenges in pineapple production by Faith and Bore-Singwaya CBO groups.

Examples of these areas include Bore-Singwaya where farmers requested to be trained in methods of restoring soil fertility to allow them to grow pineapple since it is a profitable enterprise. This calls for new strategies in improving and sustaining soil fertility in the current and abandoned niche soils while taking cognizance of ensuring organically produced pineapple fruits.Demand for organically produced pineapples is fueling retention of shift cultivation as a system of pineapple cultivation where use of inorganic fertilizers is outlawed.Thebiggestquestion remains unanswered.Whatarethebestalternativestouseinstead of inorganic fertilizers? Whatwillhappenwhenallthevirgin forestsbearing Sokokesoils are exhausted and depleted?(Figure 11).This calls for collaboration with the affected farmers to test run a variety of environmentally friendly fertility restoration trials toevolve the best cost-effective options that can be adopted in these areas.

4.7.3Pineapple fruits do not all ripen at once

Most farmers reported that the pineapplefruits do not ripen all at onceand this affectedmarketing of their produce.They wished something could be done to ensure the crop ripens at once to facilitate instant marketing and obtain instant income. This uneven ripening compels buyers to move from one farm to the other in search of ripe pineapples to fill their cargo.This issue can be resolved through collaboration with the farmers, buyers, and other stakeholders by adopting measures that assure availability of adequate and uniform planting material or inducing flowering of the crop. This would ease marketing of the crop and help stagger the ripening of the crop to align production with market demand and reduce seasonality of the crop.

4.7.4Grabs, beetles, mealy bugs and stem borers as major pests of pineapples

Most farmers reported the occurrence of grabs, beetles, mealy bugs, and stem borers in the roots of pineapples as the major pest affecting pineapple crop yields since they destroy the roots leading to stunted growth and therefore poor yields.Similar types of pests have been reported by [16], who recommended use of integrated approach towards theirmanagement.This forms a good vine-yard and entry point for conducting IPM trials to control the grabs, beetles, stem borers and other pests such as mealy bugs, ants, whiteflies, hoppers, millipedes, birds, monkeys, and porcupines to assure increased pineapple production.

4.7.5 Poor planting methodsand agronomic practices

Poor planting methods such asi) planting the suckers in close spacingleads to overcrowding and therefore pooryields; ii) Shallow planting of the suckers has been observed to lead to stunted growth and therefore poor yields; iii) Non-pruning of the sucker roots was observed to lead to stunted growth and therefore poor yields; iv) Farmers had no knowledge which spatial arrangement (single, double or triple row)giveoptimum yields. This calls for conducting demonstrations on good agricultural practices for maximum yields and returns.

4.7.6Weeds and high weeding costs reduce farmers' profit margins

Weeds and high weeding costs were reported to reduce farmers' profit margins. This calls for undertaking test trails in farmers' fields on various cost-effective methods of controlling and managing weeds in pineapple fields.

4.7.7Prolonged drought spells during growing seasons lead to small fruits and poor yields

Most farmers reported the occurrence of prolonged drought spells during the growing season as a major hindrance to increased pineapple yields, resulting in small sized pineapple fruits. Thus, there is need to conductdemonstrations on water harvesting and conservation technics and technologies for crop production in the pineapple growing areas.

4.7.8Sun-scotching of pineapple fruits affected quality and therefore marketability

Most farmers reported sun-scotching as the major factor affecting the quality of pineapple fruitsand therefore marketability. This invites the introduction ofdemonstrations on sun-screening technologies on pineapple fruit during the ripening period to assure uniformity in fruit quality and peel color.

4.7.9High rates of perishability and spoilage of pineapple fruits

Most farmers reported high rates of perishability and spoilage of pineapple fruits due to shorter shelf-life as a result of high brix content. This also calls for test runningdemonstrations on ways of: i) increasing the shelf-life of pineapple fruits using appropriate techniques; ii) running varietal demonstrations of other high yielding varieties with longer shelf-life but still having high market demand such as MD2; Del Monte Gold®; Extra Sweet; Honey-glow® and Pinkglow®, among others[11][9]; iii) Training the farmers on local processing and value addition of left-overs or rejected pineapples.

4.7.10Other stated problems /challenges

Other stated problems /challenges includeimpassable feeder roads which are impassable during rainy harvest season, theft of suckers and fruits during ripening period, seasonality of

production, stray alien livestock, marketing and wildlife such as monkeys,porcupines, among others.
The above stated issues constitute indicators on areas of intervention to improve pineapple value chain in MagariniSub-County of Kilifi County in Coastal region of Kenya.

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