A SYSTEMS APPROACH TO MECHANIZATION TO COMMERCIALIZING CASSAVA VALUE CHAIN IN KENYA

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ABSTRACT

Cassava is produced in Kenya mainly as subsistence and is the second most important food crop after maize in the Country’s Western and Coastal regions. Its production and use as human food, animal feed and industrial starch is low due to poor agronomic practices postharvest handling and processing, bulkiness and low application of mechanised operations to scale production to commercial levels. An average yield of 15.3 MT/ha on 0.2 to 1 ha household units was realised against a potential of 90 MT/ha in 2014 producing 935,089 MT of cassava valued at $ 168 million. Kenya is a low mechanized country with a mechanical power usage indicated at 30%, hand power at 50%, and animal draught power at 20%. Mechanisation models that apply a systems approach by taking into account the value chain cycle is muted as feasible a pathway for ascertaining the technical and economic sustainability of the cassava enterprise in the country. Commercialization of the cassava value chain requires household production at scales beyond 4 ha. Such scales require mechanised production and primary processing for technical feasibility. A system that will provide mechanised tillage, planting, weeding, harvesting and processing through organised delivery and technical back up support is projected as the best entry to address this limitation. This would unleash the commercial viability of the cassava value chain and grow the livelihood system of producers and processors beyond subsistence thresholds.

Keywords: Commercialisation; cassava; value chains; mechanisation; subsistence; systems approach.

INTRODUCTION

Cassava, Manihot esculenta Grantz (Euphoabiaceae), is produced in Kenya mainly as a subsistence crop (KIPPRA, 2016) and is the second most important food crop after maize in the Country’s Western and Coastal regions (Mwa’ngombe, 2013). It is a drought tolerant crop that grows on poor soils with 400-1700 mm rainfall (FAO, 2013, GOK, 2007). The production and use of cassava tubers for food, animal feed and starch production is low in the country due to poor agronomic practices, postharvest handling and processing. This, in turn, significantly affects the commercialization of its tubers and by-products. Cassava is a bulky crop that requires intensive labour necessitating the use of improved machinery and technologies in production activities, transportation, and processing to allow for continuous cultivation and processing to meet the demand for cassava in the country and the population’s food security needs. Kenya has not yet reached its national potential yield of 90 MT/ha. National yields are at about 15.3MT/ha (Farm Concern) compared with Nigeria at 15, Malawi; 21.5, Rwanda; 12.3, Thailand; 14 and India at 21.5 (FAO, 2013). Production rose steadily from 388,713 MT in 2004 to 935,089 MT in 2014. This was worth USD 168 million. The rise was mainly due to improved productivity growing from a low of 7 MT/ha in 2004 to 15.3MT/ha in 2014 while scale of production stabilized at 64,000 ha mainly in Western (Busia, Siaya and Homabay).
contributing 63%, Coast (Kilifi, Kwale, Lamu and Taita Taveta), 30% and Central and Eastern regions (Meru, Kirinyaga, Kitui, Machakos and Makueni) 7% of the Country. Kilifi and Busia were the main cassava producing counties in Kenya (Table 1, Figure 1). Household production averages 0.2 to 1 ha in Kilifi and Busia Counties.

Table 1: Cassava production in Kenya, Busia and Kilifi Counties in 2014

| County  | Harvested area (ha) | Total production (MT) | Yields (MT/ha) |
|---------|---------------------|-----------------------|---------------|
| National| 63,725              | 858,461               | 13.5          |
| Busia   | 19,580              | 321,835               | 16.4          |
| Kilifi  | 5,779               | 207,060               | 35.8          |

(Source: http://www.kilimo.go.ke/wp-content/uploads/2015/10/Economic-Review-of-Agriculture_2015-6.pdf)

Cassava consumption in Kenya stands at 1.1 million MT annually with per capita use rising from 11.4 to 19.6 kgs between 2004 and 2008. Figure 1 shows the various by-products obtained from cassava tuber that accounts for the national consumption. Cassava products include fresh cooked, boiled, baked or fried roots used at household level, to highly processed starch as a food additive and ingredients in animal feeds and confectionaries. A greater prospect exists for increasing consumption of cassava if its industrial use in the confectionery, ethanol and paper industry were fully exploited. Commercialization of the cassava value chain hinges on increasing demand to spur household production to scales beyond 6 ha per household. Such scales require mechanised production and primary processing for technical feasibility. This paper reviewed existing practices from secondary data to underscore the need for mechanization to champion cassava commercialization in the Counties of Busia and Kilifi.

Mechanization of cassava value chain

Agricultural mechanization is the replacement of human labour sources with mechanical power or technology to perform agricultural operations to reduce drudgery and increase efficiency. In any area, mechanization is categorized into three levels: low, fair, and high. Low mechanization means that manual labour exceeds 33%, fair mechanization means that animal power use ranges from 34% to 100%, while high means that use of mechanical power ranges from 67% to 100%. Kenya is a low mechanized country because the use of mechanical power stands at 30%, hand power at 50%, and animal draught power at 20%. Mechanisation models in the country should therefore apply a systems approach by taking into account the value chain cycle to increase their technical and economic feasibility. Analysis that concentrates on segmented node approach makes mechanized services unsustainable since the scales of application in subsistence-based agriculture cannot support mechanised operations.

A system approach to operations that looks at tillage, planting and fertilizer applications, spraying, weeding, and harvesting, along with how those operations are delivered, are the necessary conditions for satisfying the need for mechanised development of the cassava value chain. The later condition cannot be underscored, most machinery suppliers in Kenya are located in major towns like Nairobi, Mombasa, Eldoret and Kisumu, Ease of access to machinery and technology suppliers becomes an additional challenge especially for smallholder producers in marginal areas like Busia and Kilifi.

Access to mechanised units and services must however be matched with a robust access to information on critical functions like markets and marketing, processing and value addition, post-harvest handling and losses by the value the chain actors. With the emergence of Information Technology, a robust cassava value chain would function optimally based on the proportion of actors with access to critical information. A major constrains observed in the study area was the lack of information flow especially on critical technology issues that affect production, processing and value-addition technology, marketing and markets for the cassava commodity (Table 2).
A key constraint to increasing cassava production in Kenya has been linked to the low utilization of production and processing tools. The use of cassava as an industrial crop would spur demand to levels that would require a commensurate application of appropriate tools at the farm production and primary processing levels. A contextual review of the required economic scales of production, transportation and primary processing to sustain commercial and financial viability of the cassava value chain at the rural level demands application of mechanized systems. The average household size in Kilifi and Busia Counties stood at six people in 2009 with mean household expenditure per adult equivalent of US$ 29 and US$ 21 per month for the respective counties. Within these counties 11% and 21% of the respective households depended solely on agriculture for their livelihoods. A gross margin analysis for a vertically integrated cassava value chain actor in Kilifi with production and primary processing facilities gave a return of US$ 1258 over a 14 month (Table 2) production period. Among the agricultural households this translates to USD 3 per day or USD 0.5 per capita per day. This corroborates the baseline survey information presented by Agricultural Sector Development Support Program corroborating the current subsistence outlay of the enterprise.

Conceptually, to transition these agricultural households to surpass the World Bank threshold of living above US$ 2 per capita per day would mean increasing production units fourfold. Therefore, commercialization of cassava value chain with a commensurate livelihood improvement for the low-end producers requires expansion of the land production units to a base level of 4 ha per household. Alternatively, the net value of the produce should increase fourfold; a process that would require improved values of the primary processed products.

The level of poverty of the cassava value chain actors at the production and primary processing levels limits their capacity to save and access credit for capital investment on mechanisation equipment and technologies. Access to credit in Kilifi was in only 3% for the male-headed households, while for the female-headed households it was less than 1%. The youth-headed households had no access to credit.

In 2010, the cost of one locally fabricated cassava processing machine was US$ 600. In 2012, the cost-in-freight (CIF) for a 4-wheeled tractor at Mombasa was US$ 215,000, while that of a 2-wheel tractor was about US$ 1000. This situation was compounded further when the Government...
of Kenya, introduced a 16% VAT levy on all imported agricultural machinery in 2013 and imposed import duty on all machinery and raw materials imported into the country. For households with annual on-farm incomes of between US$ 170–430 in Kilifi and US$ 540–970 in Busia, the cost of mechanisation equipment was not only out of reach but their meagre incomes truncated their credit worthiness as illustrated by the low 3% access statistic.

The limitations imposed by poverty, small land sizes and low access to credit have reinforced the low scales of production and application of rudimentary primary processing techniques. These have worked together to constrain commercialisation of the cassava value chain reducing it to a subsistence poverty actuating enterprise.

To expand production and processing to livelihood and commercialisation transitioning thresholds, there is need for the application of appropriate technologies and mechanization units using a systems development approach. Monk, 2015, asserts that application of mechanized systems to scale would drive major improvements in productivity across the value chain.

Table 2: Proportion of producers with access to information on agricultural technologies

| Activity                                      | Teso South % | Kilifi % |
|-----------------------------------------------|--------------|----------|
| Crop production and marketing technology      | 50           | 64       |
| Soil fertility management technology           | 97           | 77       |
| Pests and disease control technology           | 88           | 77       |
| Weed control technology                        | 85           | 73       |
| Improved varieties technology                  | 88           | 73       |
| Post-harvest technology                        | 82           | 70       |
| Value-addition processing and handling         | 85           | 68       |

Source: KENFAP Services Limited (2012)

Table 3: Gross margin analysis, Ganze District

| Activity                                      | Gross margins (KES) |
|-----------------------------------------------|---------------------|
| Production of raw cassava roots (6 MT/acre = 14.8 MT/ha) | 108,300             |
| Processing cassava roots into cassava flour (on-farm)    | 17,548              |
| Processing cassava roots into cassava flour (off-farm)    | –82,252             |
| Processing cassava roots into cassava crisps            | 60,840              |

Source: KENFAP Services Limited (2013)

Harvesting operations

Harvesting is one of the most labour and cost-intensive field operations in cassava cultivation. It is one of the main constraints to cassava commercialisation. Mechanisation of cassava harvesting is very low in Kenya due to inappropriate planting methods and scale of cultivation. Kenya’s cassava production is mainly small scale covering between 0.25 to 3 acres (GoK, 2007). This coupled with the intercropping practices among most producers makes application of mechanised operations untenable. In the study undertaken by EAPP, 72% of the respondents indicated that they harvested their tubers using hand labour confirming this assertion. The field capacities of mechanical cassava harvesters range from 0.2 to 0.8 ha/hr. This is significantly different from recorded field capacities obtained by improved manual harvesting tools that range from 49.9 to 156 man-h/ha with root tuber breakage of 4.32 to 19.55% and harvesting energy consumption of 470.34 to 773.72 W (Amponsah, 2017). Mechanical harvesters operate by lifting tubers and shaking them out of the soil (Figure 5) and have been
found to reduce breakage losses from 32% to 2.6% (Itodo and Daudu, 2013) and harvesting costs by 50% (Bosrotsi; et al., 2017).

**Transportation**

Fresh cassava roots are highly perishable under ambient conditions, becoming unmarketable in 3 days or less. However, with proper handling, fresh roots can be stored up to 30 days. Fresh roots should therefore be transported to cassava chip or starch factories on the same day of harvest to avoid losses. The bulky nature of the tubers imply that only limited amounts of the produce can be handled by un motorized transport systems. This in turn caps the scale of production constraining commercialisation prospects. The use of machinery to transport produce to the market the counties of Kilifi and Busia was low. Only 11% of the producers interviewed utilised motor vehicles, and 20% used motor-cycle taxis to ferry their produce to the market with distance to markets being as high as 10 km in Kilifi, and 4 km for Teso South, in Busia County.

The low application of motorized transport was governed by the low production scales at household levels and lack of an organised structure for produce collection and consolidation by the small holder actors in this value chain. To address this gap, Farm Concern International piloted a process in Busia where it organized producers into commercial villages (CVs) structuring them to take advantage of the cassava market within and outside Busia County. Other than market linkages, the value chain actors were provided with basic technologies for chipping and solar drying cassava. The actors were also trained on best practices that expanded their product base to include cassava planting materials and processed products. Examples of functional commercial villages exist including The Tangakona and Aten Commercial Villages. For instance, the Tangakona Commercial Village earned US$ 109, 200 from a supply of 1,365 bags of cassava cuttings, in 2013. In 2014, they sold 4.8 MT of cassava chips and earned US$ 169,000, while in 2015 the village earned a monthly average of US$ 250, 000 from cassava chunks and chips. Aten Commercial Village increased their sales to US$ 150,000 per month after adopting improved cassava varieties and proper drying technologies. These hall marks though impressive at the village level do not translate to significant thresholds at the household levels. However, they illustrate the first steps to gaining commercialisation through consolidation of actions at the value chain nodes. It is the foundational framework that informs the thrust for virtual consolidation of capital and land resources to foster technical feasibility and financial viability of mechanised cassava value chain actions as laid in this paper.

![Figure 2: Cassava transport systems](image)
On-farm primary processing:

Cassava processing using mechanised systems increases labour efficiency, incomes, and living standards of cassava value chain actors and consumers, as well as enhance the shelf life of products, facilitate their transportation, increase marketing opportunities, and help improve human and livestock nutrition (FAO, 2017). Various processing methods are used to detoxify cyanide...
in the roots and to transform the tuber into a range of products for household and industrial use. The primary processes involve peeling, washing, grating, fermentation, drying and milling into flour which can then be used in making bread, starch, beer and animal feeds among other products.

Primary processing at the farm level provides the first step towards translation of cassava value chain into an industrial crop. Possibilities exist for applying it as subsidiary flour for the confectionary and bakery industry, raw material for paper manufacture, and feedstock in alcohol and ethanol production plants. It can also be used as carbohydrate concentrate in animal feeds. Such opportunities would create sufficient local market to spur its commercialization across the entire value chain.

Currently the form of processing practiced in Kilifi and Busia include the use of hand-tools and solar driers. Of the respondents interviewed, 64%, use hand tools, 31% apply unspecified tools, while 1% had improved solar driers. Majority of the producers relied on sun-drying, confirming the subsistence nature of their actions. Commercialisation of the cassava value chain would therefore require a strategic reorganisation of the processing segment with a matched investment on acquisition and application of appropriate processing equipment and technologies.

The need for primary processing was however evident in both Kilifi and Busia with 48% of the producers interviewed in Kilifi and 88% in Busia County applying one or another form of processing. This state was illustrated in the EAPP baseline survey that found 98% of producers across seven districts engaged in some form of processing at primary activity level undertaking tasks like washing, peeling, fermenting, chopping, and peeling of the fresh tubers.

Some primary processing enterprises were however found unsustainable due to low throughputs and high costs of operations. A study in Busia observed that most processors exited the flour processing enterprise because of the high losses generated. Primary processing of tubers into flour did not translate into increased value of the product. The price of flour (at US cents 20/kg) was found to be the same as the price of dried tubers at the farm gate.

![Figure 6: Primary processing elements and equipment](image)
Above this handling and processing losses reduced the volume of flour by a factor of 3:1, meaning that 4 kg of raw tubers gave 1 kg of freshly ground cassava flour. For off-farm processors to breakeven their operations they needed raw roots priced at US cents 6.3/kg. Alternatively, they needed to increase the price of cassava flour from US cents 40/kg to US cents 95/kg and compromise its competitiveness against the highly preferred maize flour.

**Proposed development pathways to commercialise cassava**

Machines, equipment and technologies exist that could be applied to mechanise cassava value chain across all nodes to increase productivity with a commensurate improvement in chain competitiveness. Much focus has been put on production activities leading to a fair level of mechanization on land preparation operations. However, adoption at the other levels remains poor making the whole chain ineffective and therefore subverting cassava commercialisation and reducing to a subsistence crop. Constrains on mechanised planting and weeding, low application of value-adding technologies, lack of product differentiation and minimal use of information technologies to guide marketing and access to markets inhibit expansion and growth of cassava chain enterprises. These factors have slowed prospects for creating new and more competitive products for the market, diminished flow of capital and compromised the industrial potential of the cassava value chain. In this review; the low scale of operations, poor access to credits, inadequate and non-existent machinery support services, lack of market information, low application and use of information technology have been cited as issues of concern that when addressed could grant transformation of the cassava value chain into commercial industry. The review proposes a systems approach to mechanisation as a feasible model for unlocking the latent industrial potential of the cassava value chain. The model considers the whole value chain as a functional system whose efficiency and effectiveness are grounded on assigning tools, equipment, machinery and technologies across all the nodes. The functions must also be rolled at a scale that makes each node individually and collectively feasible in technical and economic terms, commercially viable and financially and environmentally sustainable. The model underpins financial sustainability to a household livelihood index pegged on either the World Bank’s US$ 2 per capita per day basic poverty transition line or Kenya’s Vision 2030 middle income aspiration daily per capita income base rate of US$ 11 (KES 1116) as illustrated in Figure 7.

Mechanization along the cassava value chain still has a long way to go before the interventions can lead to commercialization of cassava products in Kenya. The following actions are recommended to effectively improve on the levels of appropriate mechanization along the cassava value chain in Kenya:

1. **Resources should be allocated into research and development of the cassava value chain in Kenya.** A collaborative effort by all the stakeholders along the value chain should be made to collect and document reliable and accurate information on the status of the value chain, which should then be made easily accessible to all actors along the chain.

2. **A public-private nationwide awareness campaign is needed to promote the ascension of the cassava crop from the “poor man’s crop” group, and market its multiple by-products both as a viable industrial raw material that can catalyse income generating activities in rural areas, and as a healthy food.** Creating a market demand for cassava for especially non-food industries such as the animal feeds industry and the bioethanol industry would boost the market competitiveness for cassava by-products and create an incentive for local producers.

3. **Collaboration between the private sector and the public sector to boost research and development of locally made labour-saving technology, as well as simple processing machinery and equipment is necessary.**
Capacity building for local “juakali” fabricators to not only manufacture simple and high-quality production and processing technology, but also to provide quality maintenance services especially in the rural/marginalized production areas.

4. Technology training and knowledge transfer: This can be done through demonstration farms and/or farmer field schools to help boost the knowledge transfer and adoption process of production, transport and processing technology options among producers and other key chain actors. Innovative learning and sharing platforms can be organized through extension service providers in major cassava producing areas throughout the country.

5. Access to credit through common interest groups and/or cooperatives: Producers and processors could organize themselves into Common Interest Groups. These groups can address community needs through technology support and partial financing of priority projects such as processing of cassava roots in areas where it is a priority crop. They can also help secure linkages with key players in the domestic and foreign cassava market.

These common interest groups, such as the cassava commercial village-based processing units can help meet the transportation challenges by processing and adding-value to the cassava tubers, in bulk, at or near the farms, thereby reducing losses (increasing the shelf life) and increasing the competitiveness of the cassava products in the market.

6. To help ease the challenges of the appropriateness of the available land preparation machinery in the market to small land sizes, producers owning small land sizes could contractually and temporarily consolidate their lands for purposes of a joint utilization of the available land preparation and production technology. Research into the social and economic impact of this course of action should be conducted.

7. Public and private partnerships in establishing and promoting machinery hiring and lending service groups should be promoted. Tech-savvy youth groups and women’s self-help groups could be empowered to engage in affordable machinery service provision especially in the areas that do not have quick and easy access to mechanization services. These groups can receive capacity building through financial support as well as technical knowledge and training of appropriate production and processing machinery.

8. Proper extension services and materials should be made readily available to stakeholders along the value chain. Access to improved, high-yielding, disease and pest resistant varieties, as well as fertilizers, herbicides, etc, where needed, should be facilitated to improve on production capacities and overall productivity of the
producers. This will then, in the long run, create capacities that will potentially meet the annual demand for both food and non-food uses of cassava tubers, and consequently, drive the demand for labour-saving technology in the country.

CONCLUSION

A systems approach to mechanise farm and primary processing operations complete with a structured back up support augmented by guaranteed market outlets could spur cassava production in at least 4 ha households units and thereby transform this value chain into a commercially viable and livelihood support system in Kenya. In its current state it remains a labour intensive, low yielding enterprise with untapped potential.

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