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Constraints and opportunities of the Tamil Nadu industrial cassava value chain and market

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Abstract

Cassava (Manihot esculenta Crantz), a tuber crop, known to support rural communities for its caloric value and vast industrial applications, supports over 10,000 smallholder farmers in Tamil Nadu, India. Using quantitative and qualitative data collected from key informants along the industrial cassava market chain in Tamil Nadu, this paper analyses the market structure, supply, demand and market trends for industrially utilized cassava. This analysis is used to identify market constraints and opportunities amongst the value chain actors to support market growth, with the goal of ultimately improving the livelihoods of smallholder farmers in Tamil Nadu. Clear constraints were observed influencing market functions and actors. The industrial cassava industry is undergoing continual transition amidst pressure in an unregulated and fluctuating marketplace, additionally impacting demand trends. The market, composed of diverse production units relative to size and economical value, has become highly competitive resulting in constraints related to product quality and production methods. These constraints have direct impacts on farmers, who often take the greatest economical risk along the value chain. Key recommendations resulting from this research include further exploration of a regulated market, establishing industrial production standards, improving quality standards, and further development of marketing methods. Essential to these recommendations is a collaborative effort towards innovation along the entire value chain, as growth needs to be collectively pursued to ensure sustainable market function and fair distribution of rents.

Keywords: Cassava, smallholder farmers, Tamil Nadu, value chain, sustainable agribusiness, inclusive development, starch, sago.

INTRODUCTION

Cassava (Manihot esculenta Crantz) is grown by smallholder farmers around the world for its high yield and significant caloric content, tolerance to inconsistent and low water availability, capacity to grow in poor soil conditions, and the ability to propagate the crop through stem material reuse. Today, cassava supports food security and income for over 800 million people worldwide (Howeler et al. 2013).

Based on various production statistics, it is estimated that cassava is presently produced by over 10,000 farmers in Tamil Nadu. Cassava production in India has shifted from being primarily produced for direct food consumption along the Southern Coast, where it was first introduced in the 17th century, to industrial-use focused production centered around the Salem District in Tamil Nadu (Edison et al. 2006). The primary use of cassava in Tamil Nadu has transitioned from being a food security crop to a cash crop for industrially produced products (Premkumar et al. 2000). The cassava starch and sago industries grew out of Salem as a result of favorable climatic conditions and the availability of cheap labor (Thamburaj 1996).

India is known to achieve the highest cassava productivity in the world. Cassava became a major crop in Tamil Nadu in the 1940’s with the growth of the starch and sago markets; however, production volume is more recently characterized by minimal growth and high fluctuation (Srinivas and Anantharaman 2005). Cassava starch is consumed throughout India, while sago is
characterized by production centering around the Salem District of Tamil Nadu, with consumption primarily occurring in Northern Indian; approximately 2% of sago remains for consumption in Tamil Nadu (Sabu 2015).

Since the initial establishment and growth of the industrial cassava sector, the area under cassava production in India has reduced from 274,000 ha in 1961 to 207,000 ha in 2013 (FAO STAT 2013). However, when considering annual production volume, there has been a significant increase, from 1,969,000 t to 7,236,600 t over the same period (FAO STAT 2013). The average yield of cassava dramatically increased from 7.19 t/ha in 1961 to 34.96 t/ha in 2013. In 2013, Indian cassava productivity ranked first in the world, at 34.96 t/ha, 2.62 times greater than the world average of 13.35 t/ha (FAO STAT 2013).

The productivity in India can be attributed to climatic conditions, strategic use of irrigation, development of high yielding varieties, and strategic cropping methods used by farmers (Nair and Unnikrishnan 2006). Howeler et al. 2013, and Hershey et al. 2001). These practices and methods are driven by value addition opportunities supported by the industrial markets.

Indian cassava is primarily produced in the southern states of Kerala, Tamil Nadu, and Andhra Pradesh. Over the past four decades, the production area within these states has shifted; decreasing in Kerala from 85.7% of total Indian production to 45.5%, and increasing from 12.5% to 42.5% in Tamil Nadu (Agriculture, Centre for Monitoring Indian Economy 2005 and Edison et al. 2006). These production data indicate direct consumption reduction, the primary use in Kerala, and an increase in the production for industrial use in Tamil Nadu. Between 2013 and 2014, Tamil Nadu produced the largest volume of cassava in India by state; 4,975,600 t, with the world’s highest productivity; 41.3 t/ha, versus a world average of 9.77 t/ha (Indiastat 2016 and FAO STAT 2013).

This study investigates the market structure, supply, demand and market trends for industrially utilized cassava in Tamil Nadu. The results are used to identify market constraints and opportunities amongst the value chain actors to support market growth, with the goal to increase the income of small holder farmers in this area.

Cassava market in Tamil Nadu

The cassava market in Tamil Nadu functions as a free market system; market supply and demand, with no government intervention, dictate market prices for cassava tubers and value-added products. Raw tuber price is therefore determined by a backward price function relative to starch and sago prices, resulting in a market heavily controlled by processors and dominant traders (Srinivas and Anantharaman 2005). Cropping duration, water availability, rainfall, and farm level cropping decisions drive seasonal and annual variation of supply. Within a free market, backward pricing system this variable supply characteristic results in highly fluctuating farmgate prices (Srinivas and Anantharaman 2005).

In 1999, it was estimated that 20% of cassava production in Tamil Nadu was utilized for human consumption purposes, the remaining 80% for industrial purposes; 33.5% for sago, 33.11% for starch, and the remaining 13.41% for dried chip production (Srinivas and Anantharaman 2005). Native starch, used in the textile, food, paper, adhesive, animal feed, and pharmaceutical industries, can also be modified through chemical addition to cater industry specific needs, offering further value addition. Supply and demand forecasts for cassava starch, based on population and industrial growth projections, are shown in table 1. The greatest demand growth is projected for the adhesive industry, followed by the paper, textile, food, and pharmaceutical industries (Srinivas and Anantharaman 2005). Supply projections are based on the growth rate of starch sales at SagoServe1 and the greater Indian cassava starch industry. This projection forecasted demand to grow by 90% between 2005 and 2016, whereas supply was predicted to increase approximately 33% (Srinivas and Anantharaman 2005). Table 2 shows the forecasts for sago, with demand predicted to increase 15% between 2005 and 2016, and supply predicted to increase 31%; reducing the demand-supply gap by 42% (Srinivas and Anantharaman 2005)3.

METHODOLOGY

Research was carried out using qualitative and quantitative survey data from 52 key informant interviews conducted with a broad selection of value chain actors in Tamil Nadu, followed by focus group discussions. The quantitative survey was developed to measure business performance metrics for sago and starch producers, including present and trending production costs, input and output volumes, and profitability. The qualitative survey was developed to measure market function, relationships, opportunities, and constraints. Initial data analysis utilized conceptualization, coding, and categorizing techniques, allowing for thematic concepts common throughout the greater data set to be identified, organized, and finally used to postulate conclusive aspects relative to the research objectives (Schutt 2004). Market mapping and rapid market appraisal methodologies were additionally used to support this research (Tiago et al. 2012 and Beebe 1995).

RESULTS

Tamil Nadu cassava production is heavily concentrated within the Salem, Namakkal, Erode, Dharmapuri and Viluppuram Districts. A key aspect of the Tamil Nadu industrial cassava value chain is the function of a production network cluster hub positioned around Salem (Humphrey and Schmitz 2000). Both industry and farmers rely on sourcing proximity due to transportation costs and the perishable nature of cassava tubers. Cassava is uniquely characterized by post-harvest physiological deterioration (PPD), requiring consumption or processing of tubers within approximately 24 hours of harvest.
Table 1. Demand-supply projections for cassava starch in India. Numbers in parentheses indicate cassava tubers equivalent volume of starch in tonnes. Source: Srinivas and Anantharaman 2005.

<table>
<thead>
<tr>
<th>Projected period</th>
<th>Demand (t)</th>
<th>Supply (t)</th>
<th>Gap (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>312,897 (1,564,485)</td>
<td>265,387 (1,326,936)</td>
<td>47,510 (237,549)</td>
</tr>
<tr>
<td>2010-11</td>
<td>430,148 (2,150,740)</td>
<td>309,791 (1,548,957)</td>
<td>120,357 (601,783)</td>
</tr>
<tr>
<td>2015-16</td>
<td>605,113 (3,025,565)</td>
<td>354,196 (1,770,978)</td>
<td>250,917 (1,254,587)</td>
</tr>
</tbody>
</table>

Table 2. Demand-supply projections for sago in India. Numbers in parentheses indicate cassava tubers equivalent volume of sago in tonnes. Source: Srinivas and Anantharaman 2005.

<table>
<thead>
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<th>Projected period</th>
<th>Demand (t)</th>
<th>Supply (t)</th>
<th>Gap (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>264,793 (1,625,245)</td>
<td>209,441 (1,256,644)</td>
<td>55,352 (368,601)</td>
</tr>
<tr>
<td>2010-11</td>
<td>285,341 (1,751,372)</td>
<td>241,724 (1,450,342)</td>
<td>43,617 (301,030)</td>
</tr>
<tr>
<td>2015-16</td>
<td>305,819 (1,877,054)</td>
<td>274,007 (1,644,040)</td>
<td>31,812 (233,014)</td>
</tr>
</tbody>
</table>

Figure 1. Industrial production uses for cassava and further processing options, including storage of starch for later production of sago.

Cassava starch production lies at the base of the value-added product chains. Carbohydrate properties of starch allow for technical application across a wide spectrum of uses. The highest valued market chains on an industrial scale by volume are starch and sago. Sago, is a starch based food product, which is made by forming starch into a pearl and then is roasted and polished. Thippi, the byproduct of cassava starch production made up of tuber peel and fibrous material, presents a further market chain including direct sales for animal feed, dried for valued added animal feed, or processed into thippi flour, a low-grade starch-like product.

Starch can be processed into modified starch prior to entering the same industrial market channels as native starch. Modified starch is produced with chemical addition, certain properties of the starch are transformed, allowing for improved efficiency and application for industry specific uses. Although starch and sago value chains could be individually distinguished, the functions and actors in each chain are nearly parallel. This results from the unique cassava processing condition that although starch and sago are two separate products, most industrial processors have the capacity to produce both, as sago is a secondary product resulting from the initial production of starch. Figure 1 outlines the options which producers have following initial starch production.

Because of the interrelated processing of starch and sago, to best understand how the industrial cassava market functions, it is beneficial not to explicitly separate the products for analysis of the general cassava market. Complexity does arise as each product has unique end markets and demand characteristics.

The industrial cassava market chain is notably stratified; having many chain levels. This aspect of the chain serves a unique purpose, allowing the physical movement of products to function efficiently, while adding complexity to the equally important aspect of information flow. Figure 2 outlines the industrial cassava supply chain market map, inclusive of both starch and sago products.

Expanding upon the market chain, and furthering exploring the market system, the value chain takes into consideration the enabling environment and support activities, figure 3. The enabling environment includes infrastructure, knowledge providers, and systems which support the function of the market system. Support activities, including extension service providers, business service providers, and member cooperatives directly support the various value chain actors. These service providers are aimed to provide access to knowledge and tools which support actors’ individual market function; for example, extension services for farms and banking services for processors, as well as horizontally across entire value chain levels in the case of member cooperatives.
**Industrial cassava value chain relationships**

Value chain relationships and linkages along the industrial cassava value chain are outlined and summarized in table 3. The PPD characteristic of cassava tubers demands an efficient farm to processor link. Farm level brokers provide harvesting and transportation of tubers to link the farm production and tuber processing. Depending on the brokers capacity, they will individually link approximately 50 to 1000 farms to the industry level, where industrial actors will source from multiple brokers. Depending on the industrial processor’s production volume, starch or sago will either be sold to an industry level broker or enter directly into the wholesale market in the case of large-scale producers. SagoServe provides a government supported, regulated marketplace, including quality control, and serves as a basis for market price determination.

SagoServe further provides access to credit, storage, and government supported tax breaks. Regardless of the services provided by SagoServe, the industrial level broker to trader/merchant link, or “outside” sales channel, circumventing SagoServe still exists. The outside sales channel provides additional market opportunities, and can be utilized to evade tax and quality control aspects. Starch or sago purchased through the SagoServe market by merchants or traders provides the benefit that merchants have access to a variety of product qualities, government supported tax breaks, and can deal in the context of industry benchmark prices. One limitation for traders sourcing through SagoServe can be supply levels, which are often not enough to fulfill the market demand, in which case traders need to source directly from industry level brokers to maintain their desired volumes.

SagoServe and industry level brokers also provide a purchasing channel for large-scale producers who sell sago and or starch directly to wholesalers, who ultimately bump their own production stock with external supply. These producers operate on a significantly larger scale, producing branded products; strategically managing their supply based on market conditions.

**Industrial cassava value chain composition and function**

The number of farm level brokers sourcing from farmers is not easily discernable, operating on a village level, brokers source from anywhere between 50 to 1000 farms, making the approximation of actual brokers unclear. The number of small-medium sized industrial producers is estimated at 394, with 308 of those producers actively producing starch or sago in 2015. 20 industrial level brokers exist in Salem who source from the small-medium scale producers. Approximately 15 to 20 large-scale industrial units are estimated to be operating, producing both starch and sago. Finally, there are estimated to be 250 merchant-traders and 160 primary wholesalers who purchase starch and sago products from the Salem industrial production hub.

Industrial producers operate across a wide spectrum of production capacity; with small-scale industrial producers capable of producing approximately 60 to 70, 90 kg bags of sago per day, medium-scale producers are capable of...
producers operate and process cassava for a maximum of 10 months per year. Some units only produce when fresh tubers are available, other units may crush tubers for the longest period possible and save starch to later process into sago. Other small-scale units may even operate on a seasonal basis, for durations such as three months. These differences in daily and seasonal processing capacity highlight a significant difference between small to large-scale production units in the context of market output and purchasing power.

Scale of industry output is not the only defining aspect of producer size. Small-scale producers will process tubers mechanically; cleaning, crushing, and starch separation, however, starch extraction, drying, and roasting will be performed by hand. In the case of sago, this processing scale does not achieve the greatest efficiency of production, but results in a product attributed with a high market value, relative to taste and texture. Hand roasting and sun drying of sago are traditionally regarded to support the highest product quality. Sun drying does introduce unique challenges, limiting production to environmental constraints and opening risk to product fouling. As the scale of the industry increases, mechanized components such as centrifuge starch extractors, dryers, and roasters will be utilized. These mechanized components allow the processor to reduce labor costs and increase processing efficiency. In the case of starch, especially for industrial non-food starch use, production methods attributed to consistency and efficiency of output become more valuable, if not essential to achieve profitable margins.

As mechanization and access to credit increase with scale, processors are more likely to diversify their production and or integrate their supply chain. Larger scale producers not only are manufacturing starch and sago products, but often adding further value to their products. In the case of large-scale sago producers, sago will not only be produced but additionally purchased through the value chain, to increase inventory, and allow
for them to grade, package, brand, and sell their sago directly to wholesalers. In the case of starch, modified starches will also be produced in addition to native starch. Further strategic development will include the production of substitute products, such as the production of corn starch in the case of starch producers, or processed millets in the case of sago producers.

### Production shift and decline of industrial producers

A large majority of the processors operating within the Salem industrial production hub are small-scale, utilizing processing technology which has had little development over the past 50 years. Over the past decade a shift in industry composition has been ongoing, driven by producers with better access to market knowledge and credit. These producers seek to reduce labor needs, improve efficiency, and increase their production scale.

Since the mid-90’s, the industry composition has been largely impacted by the growth of a select portion of producers and a reduction in starch demand. A select group of producers have emerged as large-scale players, which have capitalized on economies of scales in a market characterized by low margins. Simultaneously, cassava starch demand has been significantly diminished due to competition from corn starch.

Traditionally, half of the industrial units processed sago and the other half processed starch, with a further 50% of the starch units processing for food-use and the other 50% processing for non-food industrial use. Presently, only 10% of the processors in the Salem area are producing starch as an end product (Sivakumar 2016). Sago presents an opportunity to achieve greater value addition, making it a more attractive product to produce for smaller units as the starch industry requires significant volume and efficiency to achieve profit. Smaller scale sago producers still have the possibility to achieve profitability, utilizing methods focused towards quality parameters best achieved in small batch production.

The shift in demand dynamics, industrial scale development, and a shift in production focus towards sago has had a clear impact on the number of processing units in the Salem area, with a clear decline. Between 1982, when SagoServe began operating, and 1995 the industry grew from approximately 168 units to 1000 units currently operating in 2016, figure 4. This rapid growth can be attributed to the ongoing economic reform and liberalization that occurred in India through the 80’s (Kochhar et al. 2006). However, since 1995, the number of units has been in decline, with approximately 308 units currently operating in 2016.

Industry experts believe this decline in the number of operating industries will continue, with an estimated 66% reduction in the number of operational units over the next four years (Sivakumar 2016). This trend in composition ultimately has resulted in intensified market competition, stimulating increased production and differentiation of operational scale; allowing some producers to integrate their position in the value chain, and access more direct markets.

### Table 3. Industrial value chain relationships; links, purpose, challenges, and benefits.

<table>
<thead>
<tr>
<th>Value Chain Link</th>
<th>Purpose</th>
<th>Challenges</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmer – Farm Level Broker</td>
<td>Provides rapid harvesting and transport resources.</td>
<td>Distrust of honest price/value provided for tubers.</td>
<td>Removes costs risks from farmer, overcome cassava rapid perishability.</td>
</tr>
<tr>
<td>Farm Level Broker – Industrial Producers</td>
<td>Removes complexity for industry (networking between 50-1000 farms).</td>
<td>Bargaining for optimal price from both parties, correct measurement of starch content.</td>
<td>Industry can streamline supply reliability and reduce additional investments.</td>
</tr>
<tr>
<td>Industrial Producers – Industry Brokers</td>
<td>Provides market knowledge to achieve optimal prices, increase scale of purchase.</td>
<td>Sample-product quality mismatch, negotiating and bargaining of prices.</td>
<td>Provides expert knowledge in market mechanics and quality grading of sago.</td>
</tr>
<tr>
<td>Industry Brokers – SagoServe</td>
<td>Provides a marketplace which allows for more control over sales prices.</td>
<td>Outside sales seeking lower quality standards, tax evasion, or transport costs.</td>
<td>Provides tax breaks, high quality standards, and improved sample to delivered product consistency.</td>
</tr>
<tr>
<td>SagoServe – Merchants/Traders</td>
<td>Provides market knowledge to achieve optimal prices for producers, increase scale of purchase for merchants.</td>
<td>Not always enough quality available for large volume channels.</td>
<td>Provides choice of qualities, representative samples, lower taxes. Acts as industry price benchmark.</td>
</tr>
<tr>
<td>Merchants/Traders – Wholesalers</td>
<td>Provides advanced market access, and a link across language barrier between market regions.</td>
<td>Competition from larger producers who sell directly to wholesalers at below market prices.</td>
<td>Provides access to otherwise unreachable markets.</td>
</tr>
</tbody>
</table>
sales channels. Ultimately the market volume of sago is predicted to remain stable although the number of producers declines.

Value chain actors’ opportunities and constraints

The following section presents a qualitative assessment of the common constraints and opportunities for the actors at each level of the value chain.

Small-scale farmer

The industrial cassava value chain presents notable opportunity for the small-scale farmer as a high yielding crop which is drought resistant, demands no planting material costs, and is supported by a well-established market channel. The primary constraint to the small-scale farmer is high market price fluctuation. Although farmers can achieve high yields it is possible that at times profitability is not possible due to market conditions. Current market information is accessible to the farmers, but with a 10-month crop duration, the market conditions may drastically change between planting and harvesting. Cassava farmers throughout the Salem production area significantly vary in field size, functionality, caste position, and socioeconomic status. This diversity inhibits organization and cooperative development at the farm level. This lack of organization threatens the small-scale farmer’s ability to achieve a profitable market position.

Small-medium scale industrial producer

The small-medium scale producers within the industrial cassava production value chain have traditionally provided the backbone for the supply of starch and sago. Small-medium scale producers have a well-established market channel, particularly in the case of sago. Long-term establishment has given rise to notable organization between producers, with nearly all producers being active members within producer associations, and a large majority participating in the SagoServe market sales channel. The small-medium scale producers have the opportunity for growth through production modernization.

These producers are constrained by highly fluctuating prices, for both the purchasing of tubers and the sales of starch and sago. Competition is particularly heightened as more producers have shifted towards the sago market, as well as pressure stemming from large-scale producers. Large-scale producers are financially better equipped to overcome periods of low profitability in adverse market conditions.

Other noteworthy constraints for the small-medium scale producers are a lack production standardization and formal production regulations. The constraint is further heightened by a strong diversity amongst groups of producers with varying interests. Pressure in the industry along with a lack of standardization has resulted in the use of chemical additives to improve production yield and market value; encouraging non-traditional production methods. Producers’ outlook on these practices are highly divided, impacting the industry’s ability to develop standard practices, further resulting in a negative impact on the end product and demand.

Large-scale industrial producer

Although the small-medium scale producers have traditionally been the backbone of the Salem industrial production hub, over time a small number of producers have emerged as industry leading large-scale producers. These firms not only process significantly greater quantities of starch and sago, but they also produce further value-added products.
Their advanced position allows them to brand their own product and sell directly to end users and wholesalers. They have a more integrated position within the value chain and therefore greater market knowledge. Large-scale producers utilize their position to secure more reliable tuber supplies. These producers are more likely to play a greater role at the farm level of the value chain, potentially providing direct farm level brokerage services, loans, and supplying or taking a role in the development of the seed system.

Large-scale producers often utilize dual supply channels, via production and external purchasing of the same product, allowing them to strategically shift their operations, reducing risk. Large-scale producers still face competition from substitutes and global competition. Price fluctuations still significantly impact the large-scale producers as they are not exempt from the gambling like conditions caused by intensive tuber price fluctuation.

The biggest limitation and constraint to the large-scale producer is the lack of growth and innovation within consumer channels; demand being the primary limitation to their business growth. Larger asset ownership and investment capital provide strength allowing for proper investment in water sourcing and wastewater disposal, allowing for the mitigation of these constraints which are more common for the small-medium scale producer.

**SagoServe**

SagoServe faces common constraints with value chain actors, primarily impacted by price fluctuations which inherently do not support sustainable business practices required of a stable marketplace. Although high quality standards are typically maintained in the SagoServe market channel, a strong difference amongst producers regarding quality regulation and industrial standardization remains. Member producers vary in their capacity and power at this level, which can act as a barrier to the resolution of common issues amongst members of SagoServe. Some manufacturers pursue sales through less regulated outside sales channels to avoid quality standards and or taxes, reducing the volume of the SagoServe market. SagoServe is predominately active in the sago market, a clear trend since 2007, as the volume of starch traded via SagoServe has continually declined, while the sago market maintains a consistent volume.

**Retail/end market consumer**

Ultimately the end market provides limited growth opportunities amongst the current conditions, constraining all actors. The growth of sago demand does not appear to be imminent and will require product innovation and improved consumer confidence. Food consumption trends and concerns regarding product quality, purity, and cleanliness have reduced customer demand. Starch market demand, including non-cassava starch, is characterized by large growth potential as starch based product innovation and demand is undergoing continual growth, however cassava starch faces strong pressure from substitute products considering the highly fluctuating market prices.

**Supply: production area, volume, and prices**

To evaluate supply, cassava production data for the districts which compose the Salem production hub have been evaluated. Data for these districts, including production area and volume are available from 1996 through 2013, figure 5. During this 17-year period the average production area per year for the five districts was 78,198 ha with an average annual yield of 2,860,980 t. The production area and volume peaked in 2007 at 107,543 ha, with a production volume of 4,488,359 t; representing a productivity of 41.74 t/ha. Prior to 2006, the production area fluctuated and since 2007 the production area has been in near continual decline. In 2013, the productivity reached its minimum over the course of this 17-year record at 27.44 t/ha, approximately 65% of the productivity achieved in 2007. A linear regression for productivity data does not give strong statistical support for a linear trend, with an R^2 value of 0.1834. However, there is a clear trend since 2007, productivity having declined every year, except for 2011.

The critical aspect driving the farm level decision to cultivate cassava is market value and price stability. Price data for cassava tubers was collected monthly from January 1995 to August 2013, figure 6. From January 1995 through December 2004, a consistent tuber price pattern can be observed. A cyclical price structure occurs, with an average variation between harvest and non-harvest periods of 95 INR/quintal.

Following 2004, the cassava tuber prices entered a state of strong and drastic fluctuation. Although some seasonal trends may exist, the overall consistent price pattern no longer exists as it had prior to 2005. Between January 2005 and September 2013, prices oscillated up to 800 INR/quintal annually and seasonally, from a low in February 2012 of 206 INR/quintal to a high of 1,018 INR/quintal in February 2013. Although data were not provided beyond August 2013 in this data set, prices observed during the field survey work in 2015 and 2016 validate that prices have again significantly declined since the 2013 peak to as low as 450 INR/quintal. Between January 1996 and September 2013, the minimum price observed for cassava tubers was 164 INR/quintal in 2002. At that time, production area also reached an observable minimum of 44,629 ha.

Following 2003, production area continually increased along with price until November 2006, when the price reached 719 INR/quintal, and production area was observed to be 106,884 ha. Production area again slightly increased in 2007 to 107,543 ha, however this level could not be supported by the market as the price crashed to 300 INR/quintal during the peak harvest season in 2007. Following 2007, production area continually decreased through 2012, to 63,209 ha and only slightly increased in 2013 to 66,425 ha.
with strong price fluctuation occurring over this period.

In 2015, many discussions and protests regarding the need for tuber price fixation occurred. Those initiating the protests and discussions suggested that the price instability is not necessarily related to supply-demand relationships; farmers state these fluctuations are driven by traders and middlemen, leveraged by the PPD characteristic of cassava. Farmers state that buyers offer low prices due to claims of oversupply, while traders state that low prices are a result of the low market prices available for value added products. Actors stated that further discussions need to occur between government officials, farmers, and SagoServe to achieve a resolution. Some talks have accomplished local price fixation, as was the case in Namakkal District. However, these fixed prices were still considered unfair by farmers, not well regulated, and with no inclusion of large-scale manufacturers.

One leading large-scale industrial producer stated that the price instability of the market primarily is a result of supply variation due to annual rainfall disparities. Other leading large-scale producers did not want to participate in the research.

**Figure 5.** Cassava production yield and production area 1996-2013, data for Erode, Dharmapuri, Namakkal, Viluppuram, and Salem districts. Data source: Season and Crop Report 2016.

**Figure 6.** Cassava tuber price and annual cassava production area, 1996-2013. Data source: Department of Agricultural Marketing and Agribusiness 2016 and Season and Crop Report 2016.
DISCUSSION

Considering the history of the industrial cassava value chain, the farm-level production parameters, and the documented knowledge of actors' perspective on the value chain function, clear opportunities exist. Value chain opportunities and their relative relations are summarized in figure 7.

Value chain opportunities for cassava stem from the high productivity that has been achieved in Tamil Nadu, particularly in the Salem industrial hub. Cassava presents an opportunity to support the livelihood for a vast community of smallholder farmers, particularly in a relatively challenging production environment, where water availability and substitute production crops are limited. Based on these production characteristics and their development over the past six decades, the Salem industrial processing hub has been well established. A well-coordinated market exists, allowing for the efficient production of cassava and value-added products. Logistically, the market functions efficiently, supporting market access and local livelihood beyond the farm level.

Cassava production, supporting various market chains, offers vast commercial opportunities. The variety of market channels has the potential for continued development, to support market access and provide opportunities to overcome constraints when specific market channels may weaken. Stemming from the highly diverse application potential for cassava-based products, innovation opportunities continue to arise as industrial and consumer markets grow and simultaneously innovate. The prospects for product innovation also support development opportunities which lie closer to the consumer. Improving communication and marketing strategies to better reach customers presents an immense opportunity to develop demand.

The industrial cassava value chain has a strong grounding and basis relative to the opportunities, but the current value chain function and market face notable and defining constraints which not only have a negative impact on the market function, but are also agents of transformation. Value chain constraints and their relative relations are summarized in figure 8.

Ultimately the constraints of the value chain are rooted in the instable market price function. The lack of regulation facilitates severe price fluctuations along the value chain, especially for farm-gate tuber prices. This price volatility impacts market demand, profitability at the producer level, and results in market structure shifts and transformation. Price fluctuations have drastically reduced cassava starch demand, an aspect that underlines the producer marketplace shift away from starch production towards sago.

The transformation of the marketplace composition transformation has increased competition amongst sago producers. This competition has resulted in industrial producers seeking methods to improve their competitive performance, both by modifying and modernizing their operations, as well as in some cases utilizing production methods considered to be product adulteration by the Food Safety Board. Although these strategies are pursued to support firm level profit, they lack consideration for holistic value chain impact, risking a negative influence on demand due to quality reduction and market over supply conditions; ultimately further aggravating the unregulated market conditions. These conditions increase the risk taken on by farmers and their ability to achieve profitable operations, reducing farm level interest in cassava production. Srinivas and Anantharaman (2005) predicted cassava starch demand growth to significantly outweigh supply growth between 2005 and 2015, with a rate of demand outgrowing supply
by a factor of 3.29, leading to a predicted supply gap deficit of 250,917 t of starch. However, in 2005 at the time of these demand and supply predictions, the cassava market tuber price entered a new period of high fluctuations, ultimately transmitting price fluctuations along the entire value chain.

Value chain actors consistently reflected that the demand for cassava starch was not experiencing growth. Cassava starch demand has not experienced the expected growth predicted by Srinivas and Anantharaman (2005) due increased corn starch substitution, resulting from the intensification of price fluctuations, as validated by all value chain actors who spoke on this topic. Corn price has greater stability relative to cassava, resulting from greater production technology and shorter cropping duration; corn starch production is typically conducted by large-scale units enabling efficient high-volume production capacity (Vilpoux 1997 and FAO 2004). This relationship between corn and cassava starch is not unique to Tamil Nadu, and has been well documented in an earlier case in Brazil (Vilpoux 1997), where higher variability of cassava starch price was documented relative to corn starch.

Amidst a growing demand in starch consuming industries, ample opportunities exist for the cassava starch market. To access this demand, price stability needs to improve. Greater use of technology at farm and processing levels of the value chain, as well as improved end market consumer knowledge should be considered. Improved consumer knowledge may enable opportunities to capitalize on cassava starch qualitative aspects which are superior to corn starch.

Market trends predicted for sago in 2005 were different than those made for the starch market; a supply gap reduction from 55,352 t to 31,812 t of sago between 2005 and 2015 was predicted (Srinivas and Anantharaman 2005). Srinivas and Anantharaman (2005) did not provide any reference to market forces that would drive this predicted sago market trend, however the market metrics observed during this study align well with their prediction. The large producer transition from starch to sago supports the growth in the supply trend predicted between 2005 and 2015, while many actors across the sago value chain stated that demand for sago had minimal to stable growth. Value chain actors stated lack of innovation, quality concerns, and cultural shifts away from traditional consumption patterns as drivers for demand reduction.

Many value chain actors stated that there is a need for new sago product development and innovation, as little change has occurred over the past 40 years. However, none of these actors suggested who should be responsible for leading these innovations. The sago market has many stratified levels between market and production levels, making it difficult for producers to be aware of or react to consumer’s interests.

Reduced demand and increased supply give rise to heightened competition amongst sago producers. In response, small-medium scale units with financial capacity to invest were often observed to be improving their production technology, reducing labor costs, and increasing efficiency and volume. Increased supply volume threatens to establish excess supply conditions, aggravating market instability.

Price instability is not new to the industrial cassava market, Edison et al. (2006) also reported on this issue, addressing the need for guaranteed tuber prices to support the sustained production of cassava, farmer livelihood, and future market growth. Small-medium scale industrial producers indicated that they have been advocating for fixed prices for approximately 10 years. Although some price fixation has occurred on local levels, due to lack of formality, industry size, and variability, this type of price fixation has had little to no success. Participation from large-scale industrial producers in the pursuit of fixed prices was not apparent. Value chain actors often remarked that large-scale producers do not advocate for a regulated marketplace.
Market disturbances caused by volatility have an impact on firm level operations relative to the size of the firm. Producers can be better absorbed by larger producers, and may support their growth, as competitors who can no longer operate within these conditions will cease to exist.

Key informants reported that action must be taken from the Central Government in Delhi for the entire market to be regulated. Requests for action from the state level have not received any response. The imperative need for market stabilization clear, and has the potential to support the entire value chain. Systems to reduce price fluctuations must be further explored, with further consideration for government regulatory action.

One unique example of how the market structure and volatility impact actor's actions is the practice of chemical addition in processing, or product adulteration as referred to by the Food Safety Board, particularly within the sago market. Chemicals can be used when processing starch and sago to improve product value and processing yields. This practice reduces consumer confidence and demand, while creating conflict amongst producers as a strong divided opinion towards this practice exists. The divided opinion reduces collaborative efforts towards market innovation. Chemical use is a strategical pursuit to improve firm level profit in a market where production standards are not regulated and product safety standards are not well accepted by the industry.

CONCLUSION

Over the past six decades, the Salem industrial production hub has been well established. A coordinated market has been logistically developed, allowing for the efficient production of cassava and value-added products, ultimately providing strong local livelihood support well beyond the farm level. The industrial cassava industry is undergoing continual transition amidst pressure in an unregulated and highly fluctuating marketplace, constraining demand. The industrial producer community is composed of highly diverse production units relative to size and economic value. Beyond lack of price regulation, constraints are primarily related to product quality and production methods.

Market fluctuations, detrimental both to farmers and small-scale

Since 2005, cassava price volatility has been severe. This market is complex, and ultimately results from the unregulated conditions and governance structure of the value chain. Price fluctuations have resulted in producers shifting away from starch towards sago. There is also stricter enforcement of food safety norms by Government authorities, contributing to the reduction of small-scale production units.

An immediate recommendation to support the value chain is to further explore opportunities to pursue market stabilization, including price regulation. Additional action is recommended to address demand constraints, including product innovation and improved marketing methods. Demand is opportunistic as population and income growth in India serve to support market growth and product innovation.

NOTES

1. Production statistics on a collective, long-term, state basis were not found in literature for a more recent time period, records may exist on a governmental platform. Local Tamil Nadu production data was to a higher degree more accessible, as access was supported via TNAU partners.
2. SagoServe is a public entity, organised and managed by the State of Tamil Nadu, established in 1982. SagoServe facilitates marketing of sago and starch for small and medium enterprises. The members of SagoServe are dealers and manufacturers. SagoServe provides access to a regulated marketplace, quality control, storage facilities, credit, and market information.
3. Access to supply and demand data for the industrial cassava market in Tamil Nadu following 2005 were not attainable. Although more recent literature is available on this topic, the literature refers to the same data, (Srinivas and Anantharaman 2005). Market complexity, size and variability across the multiple cassava based market chains are primary reasons for the lack of documented data available for supply and demand characteristics.

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