ANALYSIS OF POTATO PRODUCTION AND MARKET STRUCTURE IN INDIA

A Thesis

Presented in Partial Fulfillment of the Requirement for the

Degree of Master of Science

with a

Major in Applied Economics

in the

College of Graduate Studies

University of Idaho

by

Garima Tyagi

December 2014

Major Professor: Christopher S. McIntosh, Ph. D.

AUTHORIZATION TO SUBMIT THESIS

This thesis of Garima Tyagi, submitted for the degree of Master of Science with a Major in Applied Economics and titled "Analysis of Potato Production and Market Structure in India," has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of graduate Studies for approval.

Major Professor: _____Date: _____

Christopher S. McIntosh, Ph.D.

Committee

Members: _____Date:_____

Joesph F. Guenthner, Ph.D.

_____Date:_____

Jason Winfree, Ph.D.

_____Date:_____

Michael K. Thornton, Ph.D.

Department

Administrator: _____Date_____

Cathy A. Roheim, Ph.D.

Discipline's

College Dean: _____Date:_____

Larry Makus, Ph.D.

Final Approval and Acceptance

Dean of the College

Of Graduate Studies: _____Date:_____

Jie Chen, Ph.D.

ABSTRACT

This thesis is comprised of two papers:

"A Production Analysis of Potatoes in India", analyzes the increasing growth rate of potato production in India and its possible impact on other crops in terms of acreage and production. Using a Box-Jenkins model, we predict India's potato production to increase from 45 million metric ton (MMT) in 2013 to 85.51 MMT in 2026.

"The Market Structure of Potato Processing Industry in India", develops a reputation-quality model that explains how it is beneficial for a company to launch only one high quality product in its first period in a specific market. The initial reputation will benefit in launching new products in subsequent periods. In addition, we analyze why quality deteriorates in the last selling period.

ACKNOWLEDGEMENTS

A good teacher can inspire hope, ignite the imagination, and instill a love of learning (Brad Henry). I am grateful to my dear professors, Dr. McIntosh and Dr. Guenthner who have mentored me tirelessly like a guardian, and have given my life a new direction. I will be forever indebted to them for educating me and helping me become a better person. I am also thankful to Dr. Winfree for his valuable suggestions, time, and guidance, and Dr. Thornton for reviewing my thesis, and his helpful inputs.

In addition, I would like to express my gratitude towards my friends and the staff of department of Agricultural Economics and Rural Sociology who have nurtured me with their affection and care. Big thanks to Mahalingam who gave me the status of an elder sister and always treated me like one, and to Hilary Davis who in course of time as my office-mate became my best friend. I am also thankful to Harsimran, Sheila, Gayle Gleason and Chris Darby for being there for me whenever I needed them.

A special note of thanks to Dr. Garth Taylor for his non-academic and academic advises throughout my stay. In addition, I am also thankful to our department head Dr. Cathy Roheim for providing me with an opportunity to work as a Teaching Assistant, and for supporting graduate students in every possible way.

Finally, this would not have been possible without the presence of my husband Rajat who motivated me to pursue further education in the United States, and endless support from my mom Shashi and my dad Ashwani Kumar.

DEDICATION

This thesis is dedicated to my mentors Dr. McIntosh, Dr. Guenthner, and my family.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background

Potatoes (*Solanum* tuberosum) are a staple food crop in most developed and developing nations. The potato originated in South America and was discovered by Europeans when Spanish explorers explored the high Andes in the early 16th century. However, the potato was adapted as a field crop only during the late 16th and early 17th centuries (Hawkes and Francisco-Oetega, 1993). The world potato sector is undergoing major changes (FAO, 2014). Until the early 1990s, most potatoes were grown and consumed in Europe, North America and countries of the former Soviet Union (FAO, 2008). Since then, there has been a dramatic increase in potato production and demand in Asia, Africa, and Latin America. In these continents output rose from less than 30 million metric tons in the early 1960s to more than 165 million metric tons in 2007 (FAO, 2008). In 2005, the developing world's potato production exceeded that of the developed world.

Global potato production reached 324 million metric tons by 2010 (FAOSTAT, 2012). China and India are the first and second largest potato producers respectively, accounting for more than one-third of world's total potato production. India has 1.2 billion people and is ranked as the world's fourth largest economy with the second highest GDP growth rate (World Bank, 2014). Being mainly a vegetarian nation with an 80 percent Hindu population, the potato is already an important part of the Indian diet.

This study is focused on an analysis of potato production in India where the major potato producing states are Uttar Pradesh, West Bengal, Bihar, and Gujarat (figure 1, 2, and table 1). In 2013, these four states together contributed more than 70 percent of the country's total potato production. More recently high economic growth leading to higher per capita income followed by rapid urbanization led the middle class to shift from conventional food to convenience food. These changing food habits led to an increase in consumption of processed food products including frozen potato products like French fries or potato tots (tater tots). This trend for frozen foods is further supported by an expansion of Quick Service Restaurants (QSR). This demand for convenience food allowed many multi-

national companies to thrive in the processing industry taking advantage of the potential growth opportunities coupled with a cheaper availability of inputs.

Figure 1. Map of India

1.2 Problem Statement

Total potato production is consistently increasing in India. Though there has been a noticeable increase in the acreage of potatoes over the years, potato yields are significantly lagging behind other leading potato producing nations (table 1). In addition, local Indian potatoes (desi-aloo[1]) do not meet general standards[2] required by the processing industry. Hence, processing potato quality issues persist. Potato production and processing in India are important sectors to the Indian economy. Assessing the magnitude of this importance, as well as tends in the production and processing sectors is the reason for undertaking these studies.

1.2 Summaries of Subsequent Chapters

Chapter 2 "A Production Analysis of Potatoes in India" discusses the production growth rate of potatoes. This study examines the effect of the increase in potato acreage on other staple foods. In addition, this chapter forecasts, using a Box-Jenkins model, the potential growth in the rate of production of potatoes in India. Data indicates that a slowdown in the growth rate of rice and barley production along with an increase in the production of soybeans has occurred. Potato yields are improving due to access to better technology, fertilizers, and pesticides. In addition, based on current trends, the growth rate in potato production is forecast to double approximately every twelve years. This time-series forecast is however dependent on ongoing government agricultural policies and factors like climate and market demands.

Over six and half decades after independence, India has brought about a landmark agricultural revolution that has transformed the nation from chronic dependence on grain imports into a global agricultural powerhouse that is now a net exporter of food (World Bank, 2014). More than 90 percent of the crops grown in India are grown in the plains during the cooler autumn, winter and early spring seasons; a smaller portion is grown during

[1] Desi aloo is the most commonly grown potato variety in India. It is small in size and usually round in shape with high water and sugar content.

[2] Processing potatoes need to be evenly shaped and of standard size and quality from one end of the tuber to the other with low water and sugar content.

the summer season at higher elevations mostly in the lower Himalayas and some in Karnataka (Wustman et. al., 2011).

The potato is one of the staple foods in India and it is ranked third in per capita availability following the production of rice and wheat respectively. A noticeable increase in the demand of processed potatoes such as French fries, chips, and other processed food products has occurred after the opening of the Indian economy in 1991. New economic rules and strategies, which were the result of liberalization and decontrol, led to significant changes in the demographics of the country. These changes included more private-sector job opportunities for women and college graduates. The introduction of this lifestyle change initiated the concepts of Double Income No Kids (DINK) couples, delay in marriage, and nuclear families.

Higher incomes led to changes in dietary patterns for Indian consumers (FAO, 2004). The consumption pattern shifted away from cereals and towards more expensive foods, such as milk and eggs. The second impact was a shift towards more processed foods which have higher sugar and fat content. Third was the market influence of popular fast foods promoted through advertising by transnational corporations. In urban areas consumption of processed foods and ready-to-eat foods has gone up together with income (FAO, 2004). The consumption of carbonated drinks, pizza, and potato crisps, etc. has increased in the diets of the urban population, as witnessed by the sales increase for these items. This change in diet was attributed to globalization, which facilitated the entry of branded products and outlets into the Indian market. Companies entering the Indian market include Coca-Cola, Pepsi-Cola, Pizza Hut, Domino's Pizza, and McDonald's (primarily for the more affluent consumers). Other local products of a cheaper variety, both by branded and unbranded producers, flooded the market.

Globalization is the main cause of the expanding market for ready-to-eat foods in India (FAO, 2004). Though India already has varieties of local snacks, these were not treated as substitute for full meals. This vacuum, created between snacks and expectation of less time consuming meals or take out, was filled by the emergence of Quick Service Restaurants (QSR) like McDonalds. Though QSRs have expanded rapidly, they still constitute a small part

of the highly unorganized Indian food market. In addition, international food companies who prepare potato-based products face issues such as a lack of quality potatoes and restrictive government policies. Nonetheless, India's government authorized a potato research institute named the Central Potato Research Institute (CPRI) to develop specific potato varieties for processing.

Chapter 3 "The Market Structure of the Potato Processing Industry in India" derives an equilibrium reputation-quality model for experienced goods. In this case, the experience goods are processed frozen potato products whose quality attributes buyers cannot observe prior to purchase. Introducing such products in a new market can be very risky because buyers may be more apprehensive about spending money on unfamiliar goods or services. The assumed seller, McCain India Private Limited, can launch two new products simultaneously in the market. Alternatively, the company can launch only one product in the first period, thereby, developing a reputation in the market on the basis of quality of the first product and introducing the second product in the second period. With the assumption of three period transactions, it is observed that a company would have incentive to reduce the quality of both the products in the last period. However, a company may or may not choose to reduce the quality of any of the products in the second period in order to achieve short-term gains.

This study discusses how following the opening of the Indian economy to international trade in 1991, there has been continued growth in the consumption of processed and fast food, especially potatoes. In addition, it observes how increase in the consumption of processed food and in the number of Quick Service Restaurants, is an indicator of development of an economy. It considers the case study of an American fast food chain that initially faced issues in finding the appropriate potato variety fit for processing and how a Canadian food processing company resolved the issue with research and development of seed potatoes.

CHAPTER 2

A PRODUCTION ANALYSIS OF POTATOES IN INDIA

2.1 Introduction of the Indian Agriculture Sector

Southeast Asia is the second fastest growing region in the world after East Asia and the Pacific. In this region, India is leading the economic boom by producing 80 percent of the region's output and India's estimated growth rate is 6 percent in 2015 and 6.4 percent in 2016 (World Bank, 2014). The other countries in this region are Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka. Agriculture, along with allied sectors like fishing and logging, plays a major role in the economic development of the entire region.

India ranks second worldwide in farm output. It is the world's largest producer of tea, coconut, cashew nuts, black pepper, turmeric, ginger and milk. In addition, India is the second largest producer of sugar, rice, wheat, onions, potatoes and inland fish. India also has the largest cattle population. However, agriculture's share in India's Gross Domestic Product (GDP) declined to 17.40 percent in 2012-2013 from 51.9 percent in 1950-51 though the sector still employs 60 percent of the total workforce (Baldi, S., 2014). A steady growth has been observed in the yields per unit area of all crops over the years because of special emphasis given to agriculture in India's five-year plan. This coupled with steady improvements in application of modern agricultural practices and provision of agricultural credit and subsidies have contributed to the increases in crop yields (Goswami, V.K., 2013). Since the opening of the economy in 1991, India has been in the process of shifting from a traditional agrarian economy to expanding industrial and tertiary sectors. Agriculture has been considered the hallmark of the first stage of development, while the degree of industrialization has been the most relevant indicator of a country's progress along the development path (FAO Corporate Deposit Repository, 1997).

This shift from the agriculture sector to the service sector can be considered a normal trend in the development of an economy (FAO's Economic and Development Department). Despite a decline in the agricultural sector's contribution to GDP, food grain production has increased from 230.8 million metric tons in 2007-08 to 255.4 million metric tons in 2013-14, and productivity has increased from 1,860 kg/hectare in 2007-08 to 2125 kg/hectare in

2012-13 (National Council of Applied Economic Research (India), 2013). Similarly, potato production has increased from 2.7 million metric tons (MMT) to 45 MMT in 2013-14, and productivity has increased from 7,250.67 kg/hectare in 1961 to almost 22,760.6 kg/hectare in 2013-14 (FAO, 2014). Potato production has increased since 1991 by an area expansion into the Indo-Gangetic Plains. Potato consumption has also increased as a result of its popularity as a vegetable in urban diets and because of the growing demand for Western-style fast food. India also plays a leading role supplying potatoes for the growing processing industries of neighboring countries (FAO, 2008).

From a historical perspective, it is evident that India has always paid special attention to its agricultural sector. The Department of Revenue and Agriculture and Commerce was created in 1871. After many transformations, the Department of Agriculture and Cooperation was created under the Ministry of Agriculture in 1979. The Ministry of Food Processing was also created in 1986 to meet the demands of an evolving market. In 2005-06, the Department of Agriculture and Cooperation started a central sector mission known as "Development and Strengthening of Infrastructure Facilities for Production and Distribution of Quality Seeds". The objective of this ongoing mission is to ensure production and multiplication of high yielding certified/quality seeds for all crops in sufficient quantities and to make the seeds available to the farmers, including those in remote areas not easily accessible by rail/road (Ministry of Agriculture, India).

In spite of being the largest potato producer in Southwest Asia and second largest producer in the world after China, India must still import potatoes to meet rising demand. India produced 44.3 MMT of potatoes in the 2013-14 crop year, down 2.3 percent from the previous year. The Ministry of Agriculture has demanded that potatoes be exempt from import duties to boost domestic supplies and also to control the rise in prices. In addition, in October 2014 the potato product companies requested a waiver of the import duty on potatoes; however the government has not taken any action on their request[3]. The current import duty on potatoes is 30 percent (Ministry of Agriculture, 2014). Moreover, in June of

[3] As mentioned in the article "Potato product companies urge government to waive 30% import duty" published in Indian newspaper *Economic Times* accessed on 19 December, 2014.

2014, the government imposed a Minimum Export Price (MEP) of $450 per metric ton to increase domestic availability and stabilize prices.

Both production and consumption of potatoes (including the consumption of processed potato products) in India has been increasing. This is due to increases in the population and changing demographics of the country after the opening of the Indian economy in 1991. In India potatoes are mostly grown during the winter season under short-day conditions and are harvested from January to March when fresh potatoes are not available in most parts of the northern hemisphere. This contra-seasonal production makes potatoes a strategic crop from export standpoint (Dahiya and Srinivas, 1994; Ezekiel et al., 1999; Kumar et al, 2005).

Agricultural production in India has great economic feasibility (Dahiya and Bhati, 1992) and technical excellence (Ezekiel et al., 1999) but it lacks the desired policy framework and infrastructure support (Kumar et al, 2005). This situation indicates that India is capable of producing more potatoes with higher yields, but is dependent on improvements in infrastructure (such as increasing cold storage units) and implementation of favorable government policies.

The recent controversy in West Bengal, which is India's third largest potato producing state, is one example of how government policies are affecting potato production. In 2014 due to a surge in the price of potatoes in West Bengal, the state government curbed potato exports to neighboring states like Orissa. This action resulted in losses to West Bengal potato farmers who had contracts with buyers in other states.

Infrastructure related issues are also of great concern. According to a study conducted by Emerson Climate Technologies India[4], a business affiliated with the US-based manufacturing and technology company Emerson, India is wasting fresh produce of fruits, vegetables and grains worth Rs. 44,000 crore ($7 billion USD[5]) every year. This wastage is primarily happening due to the country's lack of adequate cold storage facilities and

[4] As mentioned in this article "India wastes fruits and vegetables worth Rs 13,300 crore every year: Emerson study" published in Indian newspaper *Economic Times* accessed on 11 December, 2014.
[5] In December 2014, 1 Rupee = 0.016 USD as retrieved from the free currency exchange rate website http://www.x-rates.com/

refrigerated transport. The data from the Central Institute of Post-Harvest Engineering and Technology (CIPHET) was used in Emerson study. This study also mentions that currently India has 6,300 cold storage facilities unevenly spread across the country with an installed capacity of 30.11 MMT. This is half the amount of cold storage facilities that India actually needs. Such issues may interest not only the manufacturing industry but also the foreign potato producers as there is ample scope for improvement in Indian agriculture sector.

2.2 Literature Review and Objectives

There have been few studies examining potato production in India. Major potato related research projects are carried out by Central Potato Research Institute (CPRI) with regional stations located throughout the country. CPRI has monopoly on variety development and seed production. Imports of foreign varieties and seed are banned although processing companies may negotiate exemptions (Wustman et al., 2011).

According to CPRI, the change from traditional seed production in the hills to modern seed production in the plains is one of the greatest breakthroughs in potato production in India. The term 'in the hills' represent the seed potatoes developed in the colder region like Shimla in Himachal Pradesh, and 'in the plains' represents warmer regions like Meerut in Uttar Pradesh (figure 1). The technique of modern seed production led to development of two seed channels with most of its emphasis on production in the plains. This effectively dealt with problems created by temperature, elevation and pest pressures. In addition, development of "seed plot techniques" for multiplying seed potatoes in the plains during periods of low aphid populations revolutionized potato production in India (CPRI, 1988). More than 90 percent of potatoes are grown in the plains, with a steady expansion in yield as well as acreage. Also, planting and harvesting are scheduled to minimize exposure to aphids and reduce transmission of Potato Virus Y (PVY) and Potato Leaf Roll Virus (PLRV). Please refer to appendix B for further information on prevalent potato diseases in India.

CPRI is responsible for seed development and also maintains two independent seed potato production systems, one in the hills and other in the plains. The major focus is on

producing breeder[6] (nuclear) seeds. The major Indian variety of breeder seeds developed by CPRI for fresh consumption are Kufri Chandramukhi, Kufri Badshah, Kufri Bahar, Kufri Sindhuri and Kufri Lalima for the plains and Kufri Jyoti for both Hills and plains. These main cultivars for processing are Kufri Himsona for cultivation in the Himachal Pradesh Hills and Kufri Sadabahar for Uttar Pradesh Plains (appendix D).

The average national yield in India is 19 metric tons per hectare; the yield level in better performing states is more than 22 metric tons per hectare (Wustman, et al., 2011). While in in states of Karnataka and Punjab production was reported to be as high as 40 metric tons per hectare where the crop growing period is about 100 days under short day conditions[7].

Table 1. Potato Acreage, Yield and Production Volume in India

Year	Area harvested (hectares)	Production (tons)	Yield (Hg/Ha)
1991	935,500	15,205,600	162,540
1993	1,240,000	18,479,000	149,024
1995	1,069,400	17,401,300	162,720
1997	1,248,800	24,215,900	193,913
1999	1,280,200	22,494,700	175,712
2001	1,211,300	22,242,700	183,627
2003	1,337,200	23,161,400	173,208
2005	1,523,900	28,787,700	188,908
2007	1,742,800	28,599,600	164,101
2009	1,828,300	34,390,900	188,103
2011	1,863,200	42,339,400	227,240

Source: FAO, US

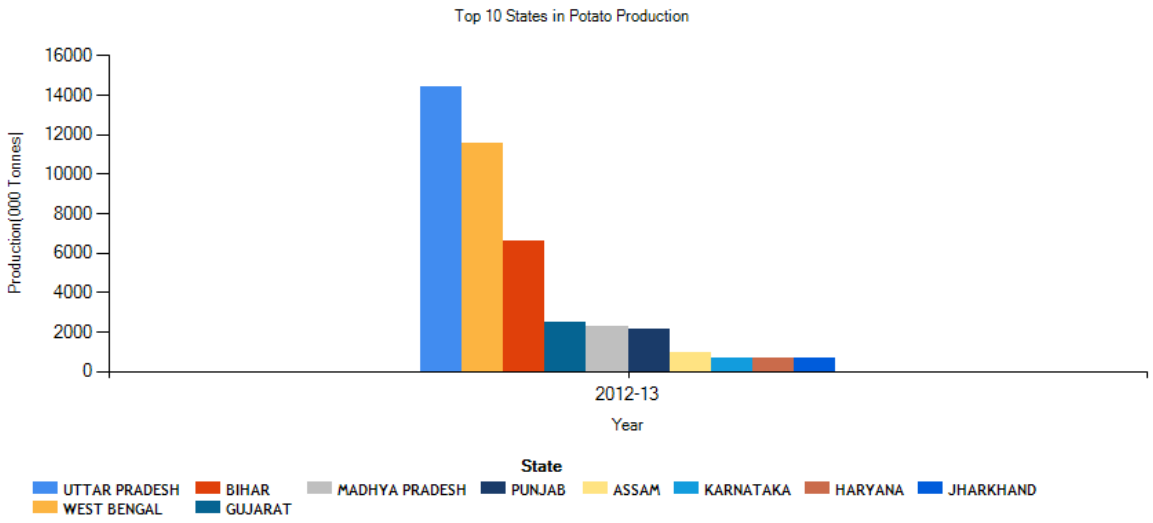
Table 2. Top Potato Producers and their Production in Million Metric Tons (MMT), 2012-13

Country	Production (MMT)
People's Republic of China	86
India	45
Russia	29
Ukraine	23
United States of America	19

Source: FAO, USA

[6] Breeder seed is seed directly controlled by the originating or sponsoring plant breeding institution, or person, or designee thereof. As applied to certified seed, breeder seed is the source for the production of seed of the other classes of certified seed.

[7] The photoperiod of 12 hours or less.



Source: National Horticulture Board (NHB), India

Figure 2. Top 10 Potato Producing States in India (Tons), 2012-13

Table 3. Indian Potato Production, 2012-13

		2012-13	
S. No.	**State**	**Production ('000 Tons)**	**Share (%)**
1	Uttar Pradesh	14430.28	31.82
2	West Bengal	11591.30	25.46
3	Bihar	6640.54	14.64
4	Gujrat	2499.73	5.51
5	Madhya Pradesh	2299.00	5.07
6	Punjab	2132.31	4.70
7	Assam	975.27	2.15
8	Karnataka	698.30	1.54
9	Haryana	676.02	1.49
10	Jharkhand	659.61	1.45
	Total Production	**42602.36**	

Source: National Horticulture Board (NHB), India

Table 4. Countries Delivering 5 Highest Yields, 2012-13

S. No.	**Country**	**Yield (MT/ha)**
1	New Zealand	46.66
2	USA	46.61
3	Belgium	46.14
4	Netherland	43.65
5	France	43.4

Source: FAO, USA

In 2013, India was not in the top five countries when ranked by potato yield. The average yield levels are less than other top ranking countries mainly because Indian potatoes are grown during short day conditions. Short day conditions lead to short cycle crops, implying lower yields as compared to crops grown under temperate conditions such as in the USA and The Netherlands (Wustman et al., 2011).

Production of potatoes in India has been increasing steadily from 2003 at around 23 MMT to 27 MMT in 2004 and 29 MMT in 2006 (FAO). However, the bumper-crop production of 34 MMT in 2008-09 led to an oversupply resulting in a sharp decline of prices. During this phase, many farmers choose to dump their produce rather than selling it, primarily because of additional transportation costs. This also led to temporary decrease in the potato acreage in 2010 in part due to an absence of government support measures (Wustman et al., 2011). Thus, the potato acreage under production was nearly 1.2 million hectares lower in 2010.

The Indo-Dutch Cooperation report (2011) obtained production cost data from the Balaji contract growers and found that production cost was Euro 0.165/USD 0.235, Euro 0.123/USD 0.176 and Euro 0.096/USD 0.137 per kilogram at yield levels 20, 35 and 50 MT per hectare respectively. The report also found that the most expensive cost items were seed and storage costs. Shorter storage periods will result in lower storage costs. Production costs are still relatively less in comparison to non-Asian potato producers and thus offer scope for export and for large scale processing (Wustman, et al., 2011).

Table 5. Price Competitiveness of Potato in Four Countries, 2011

Country	Production cost (Euro/ton)	Production cost (USD/ton)
India	30	42.9
Netherlands	140	200.2
Philippines	228	326.04
USA (Idaho)	120	171.6

Source: Indo-Dutch Cooperation report, 2011

In 2007, India's per capita potato consumption had risen from 12 kg per capita in 1991 to over 16 kg per capita in 2007 (FAO, 2007). In India more than 85 percent of potatoes are used in everyday cooking and with the remainder used as seed potatoes or for

processing. The processing industry has grown from processing 125,000 MT of potatoes in 2001 (Das, 2003) to 1,740,000 MT in 2010 as forecasted by Frito-Lay (Rana, 2007).

Table 6. Potato Usage in India

Usage	Percentage of total production (%)
Table purpose	61.47
Seed	21
Processed	0.5
Export	0.03
Loss in Post-harvest, handling, marketing and storage	17

Source: National Horticultural Research and Development Foundation, 2011

CPRI has identified 16 desi (local) varieties and 16 other varieties of potatoes. The desi varieties are not used for processing. The cultivar Kufri Himsona is used for cultivation in the Himachal Pradesh Hills and varieties like Kufri Chipsona-1, Kufri Chipsona-2, and Kufri Chipsona-3 are used for potato processing, and are produced in the plains regions. Similarly, different varieties have been developed to serve different functions like high-yield, warmer areas or for cultivation throughout the year (appendix D).

There have been many studies on the production analysis of potatoes in India and most of them are published by CPRI. The goal of this study is to provide basic framework for anyone who is interested in learning more about the potato sector in India. The interested areas could be but are not limited to potential business activities, policy decisions, and statistical methods. This study forecasts future potato production and determines which major crops have been replaced by increase in potato production and area planted. Specific objectives are: 1) to forecast potato production growth rate through the year 2026 based on past production trends and 2) to find which crops have been replaced by the increase in acreage of potatoes.

2.3 Empirical Analysis

In this section, we present the empirical model, describe, and discuss data. We also present and discuss the empirical estimates for objective 1, which is to forecast potato production growth rate. Descriptive statistics were used to accomplish the second objective.

2.3.1 Empirical Models

In this study, we undertake two empirical models, one to estimate the supply elasticity of potatoes in India, and the second to forecast total production of potatoes in India based on a past time series data of production. For the former, we use a simple linear regression model to estimate the production of potatoes (Y) against potato price lagged one period as independent variable (P_{t-1}). The one period lagged price is a commonly used naïve producer price expectations model.

The regression equation is given by

$$\ln potatoes_t = a + b \ln p_{t-1}$$

where $\ln potatoes_t$ is the natural log of potato production in MMT for time period t and $\ln p_{t-1}$ is the natural log of is the average price of potato in International dollars[8] lagged one period. The variable t indexes time, α and β are the intercept and slope parameters to be estimated, and ϵ is the error term.

From this model directly we estimate the price elasticity of supply to analyze the impact of prices on the production. The price elasticity of supply is given by

$$\varepsilon_p^s = \frac{\partial \ln potatoes_t}{\partial \ln p_{t-1}},$$

where ε_p^s is the price elasticity of supply for potato, Y is the average potato production in MMT, p. When ε_p^s ranges from $0 < \varepsilon_p^s \leq 1$ implies the supply is inelastic and $\varepsilon_p^s = 1$ implies supply is of unitary elasticity and $\varepsilon_p^s > 1$ implies supply is more elastic i.e. the degree of responsiveness of potato supply is high for a change in price.

Box-Jenkins univariate procedures were used to generate forecasts of future potato production. The data utilized were the annual amount of potatoes produced in India, measured in million metric tons. Forecasts were generated using the ForecastX software (Wilson and Keating, 2009).

The Box-Jenkins model utilized here is a multiplicative seasonal ARIMA model. ARIMA models are a general class of models for forecasting a time series that can be made to be

[8] According to FAO International Dollar prices are international prices expressed in a common currency (usually the US Dollar) that were developed within the framework of GDP international comparisons.

stationary through differencing (Box, *et al.*). The acronym ARIMA stands for Autoregressive Integrated Moving Average. In this model lags of the stationary series are called autoregressive terms and the number of lags is designated by the variable *p.* The moving average terms in the model are based on lags of the forecast errors and are designated by the variable *q*. The number of non-seasonal differences (integration) is designated by the variable *d.* The entire order of the ARIMA model is then collectively described as ARIMA *(p, d, q*).

2.3.2 Data Collection

The secondary data on production, yield, acreage of potatoes and other related crops for the period 1961-2013 were obtained from Food and Agricultural Organization online database, FAOSTAT. In addition, potato producer price data were also obtained from FAOSTAT. The main edible crops of India were further categorized into five categories, namely, cereals, oilseeds, legumes, root crops and sugar crops. Here, cereal crops included subset of rice, wheat, barley, and maize; Oilseed crops included soybean and sesame; Legume crops included chickpeas and lentils, and tuber crops included potato and sweet potato respectively. This study utilizes average yield, production, and acreage over each succeeding decade to derive the growth pattern of all the selected crops. Data on actual prices per hundred-weight of potato tubers (cwt), production in million cwt, harvested acres in thousands, and yield (cwt/acre) were obtained from the Food and Agriculture Organization (FAO) of United States. Data are cumulative for all India uses. There is no separation in production from contracted or non-contracted farming. The actual prices were not adjusted for inflation because this study does not compare price levels and production levels over time.

.

2.3.3 Results and Discussion:

Estimated Price Elasticity

Given the various factors affecting potato production, and also the impact of farm income on the livelihood of the potato growers, it is important to forecast potato production trends. Production forecasts will assist policy makers as well as potato growers in India to formulate strategies to protect their interests against various negative factors like climate change, global supply volatility, pest, and diseases etc. In this study, as discussed above, we had original potato production and price data for 52 years. We took the separate log of each dataset, and lagged price by one period to account for price expectations. Thereafter we used ordinary least squares regression. Here the t-statistics are a measure of whether the coefficients for the slope and intercept are statistically significantly different from zero. For a value lesser than t_c we do not reject the null hypothesis that the coefficient is equal to zero, and for values greater than t_c we reject the null hypothesis. Here the null hypothesis is that b (intercept) is 0, i.e., $H_0: b = 0$ and alternate hypothesis is $H_1: b = 1$.

The estimated regression equation is:

$$\ln Potato\ Production_t = 2.83435113 + 0.93931727\ (\ln p_{t-1})$$
$$(0.36068118)\ (0.025165683)\ Standard\ Error$$
$$(3.147\ E-10)\ (1.190\ E-37)\ P-value$$

Here the intercept is 2.8343, which is the production when the price variable p_{t-1} is zero. The slope coefficient 0.93931727 implies for a unit increase in the price variable p_{t-1} potato production increases by 0.93931727 tons. Here the t-statistics are a measure of whether the coefficients for the slope and intercept are statistically significantly different from zero. The t-statistics are 7.858328314 and 37.32532413, which are greater than 2 indicates that coefficient is significant with 95 percent confidence. P-values are the probabilities that the coefficients are not statistically significant. Here P-values are 3.14786E-10 and 1.19031E-37, which are much lesser than 0.05. These very low P-values for intercept and production coefficient indicate they are very strongly significant. The coefficient of determination (R^2) for the regression was 0.96 indicating that 96 percent variation in production has been explained by the variation in the time variable.

It is of economic interest to determine whether the price elasticity of supply for potatoes in India is inelastic. Since the estimated coefficient is close to one in magnitude, we wish to test whether the elasticity is significantly different from one. The appropriate test statistic is:

$$\frac{(\mathrm{b}-1)}{(\mathrm{SE}\ (\mathrm{b}))} \sim t_{\alpha,(n-1)}$$

If we wish to test whether the price elasticity is unitary our null hypothesis is $H_0 = 1$. Under this null hypothesis our test statistic is:

$$\frac{(0.93931727\ -\ 1)}{0.02516568} =\ -2.41$$

The price elasticity of potato supply i.e., the degree of responsiveness of potato production with respect to change in potato prices is 0.93. Since the calculated t value exceeds the critical value, we reject the null hypothesis. Though this is close to 1 in magnitude, it remains significantly different than 1 as evidenced by this t statistic.

Forecasting Potato Production

The production data indicated that seasonality needed to be considered when forecasting Indian potato production. In the specific case here, seasonality was determined to be multiplicative. When a multiplicative seasonal pattern is evident, a multiplicative seasonal ARIMA model can be specified in which the non-seasonal and seasonal factors work in a multiplicative fashion. The seasonal part of the seasonal ARIMA model may have an Auto-Regressive (AR) factor, a Moving Average (MA) factor and an order of differencing. The seasonal ARIMA model is classified as an ARIMA (*p, d, q*) × (*P, D, Q*) where *p, d,* and *q* are as previously defined and *P* is the number of seasonal autoregressive terms, *D* is the number of seasonal differences and *Q* is the number of seasonal moving average terms. In our application the model estimated is an ARIMA (2, 1, 1) × (1, 0, 1) indicating that we are using a first differenced model with an second order AR and first order MA, there is no seasonal differencing, but we include a first order AR and first order MA seasonal component. The ARIMA (2, 1, 1) × (1, 0, 1) achieved an R^2 of 0.98 and a mean absolute percentage error (MAPE) of 8.2 percent.

We forecast the potato production for the year 2026 at 85.51 million tons which is almost double the production witnessed during 2013. This implies that despite factors such as higher input costs, erratic rainfall and water supply, volatility in market prices, and productivity issues, potato production in India will witness a rapid growth.

As far as revenue implications are concerned, the close-to unitary elasticity implies that potato production responds on a nearly one-to-one basis to changes in potato prices. However various determinants such as availability of raw materials, length and complexity of production, mobility of factors, time to respond, inventories, and spare/excess production capacity affect the magnitude of the response.

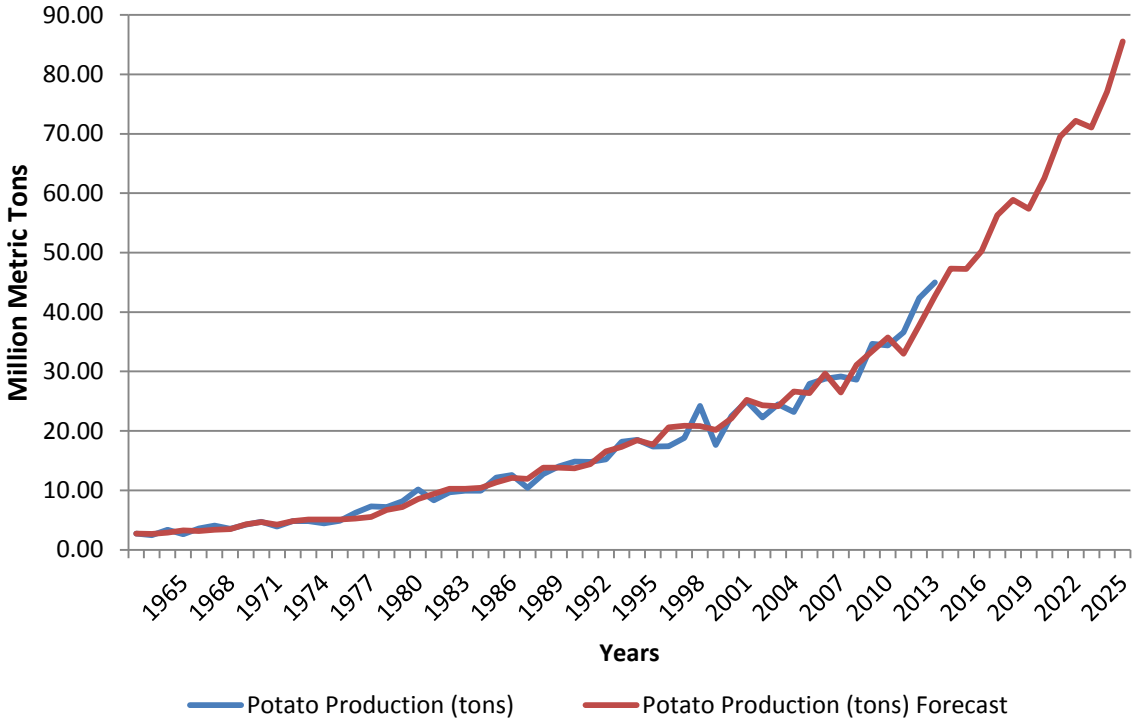


Figure 3. Forecast of Potato Production, 1960-2026

To address the second objective the major edible staple crops of India were selected, and their production, yield, and acreage data were analyzed from 1960-2012. The data for this study is also obtained from FAO from Production domain (FAO, 2014). In total 11 crops were studied and in 1960 India was among the top 20 producers for each of the selected crops. Whether a crop's global ranking improved or deteriorated over the years was

examined for correlation with increases in the plantings of potatoes. Here we examine data for production, area planted and yield.

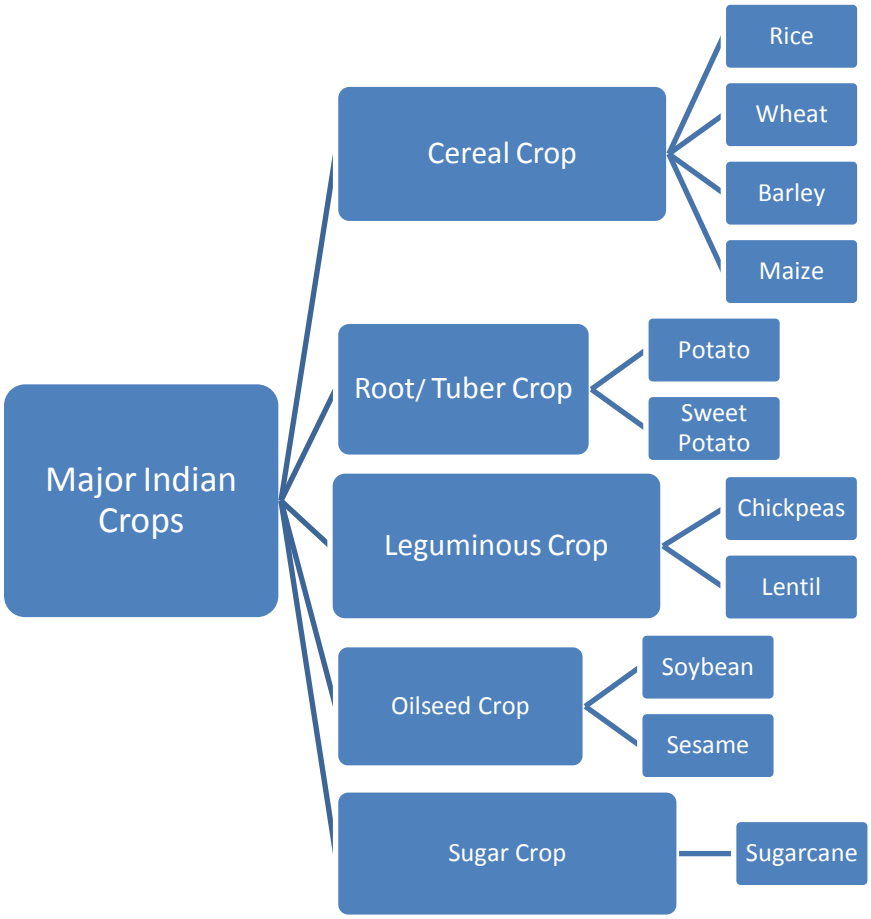


Figure 4. Major Indian Crops

In order to find out which crops have potentially been replaced by the increases in potato acreage, per decade averages are taken in each category as well as separately for each crop from 1970 to 2010. For instance, 1970 represents the average potato production from 1961 to 1970. For each crop, please refer to appendix. This procedure was repeated for production, area harvested and yield.

Table 7. Average Area Harvest, Production and Yield for Five Crop Categories

	10 year Average Area Harvest (Ha)				
Crop category	**1970**	**1980**	**1990**	**2000**	**2010**
Cereals	95610970	101933060	103519660	100530930	98914430
Roots and Tuber Crops	914425	1187330	1306350	1540000	1929040
Leguminous Crops	23095410	22831720	23098300	22388700	22504940
Oilseed Crops	24813490	25715310	28691050	35787620	36487530
Sugar Crops	2442710	2758080	3126760	3891450	4384380
Total Area	**146877005**	**154425500**	**159742120**	**164138700**	**164220320**
	10 year Average Yield (Hg/Ha)				
Crop category	**1970**	**1980**	**1990**	**2000**	**2010**
Cereals	9774	12204	16218	21529	24696
Roots and Tuber Crops	87135	119973	144318	171493	194332
Leguminous Crops	4832	4814	5310	6094	6166
Oilseed Crops	1346	1534	1891	2336	2602
Sugar Crops	451245	506703	593316	686601	663065
Total Acreage	**110866**	**129046**	**152211**	**177610**	**178172**
	10 year Average Production (Tons)				
Crop category	**1970**	**1980**	**1990**	**2000**	**2010**
Cereals	93664870	124571600	167889600	216514700	244476600
Roots and Tuber Crops	8098580	14291180	18873300	26461660	37599160
Leguminous Crops	11157630	10993920	12270480	13604180	13867740
Oilseed Crops	3339399	3945762	5464695	8363937	9557952
Sugar Crops	110420000	140096300	185762100	267614500	291370800
Total Production	**226680479**	**293898762**	**390260175**	**532558977**	**596872252**

Source: FAO, USA

A steady increase has been noticed in area planted, yield and production of roots and tubers along with increase in oil crops and sugar cane. However, there was a decrease in growth rate of Cereals and leguminous crops.

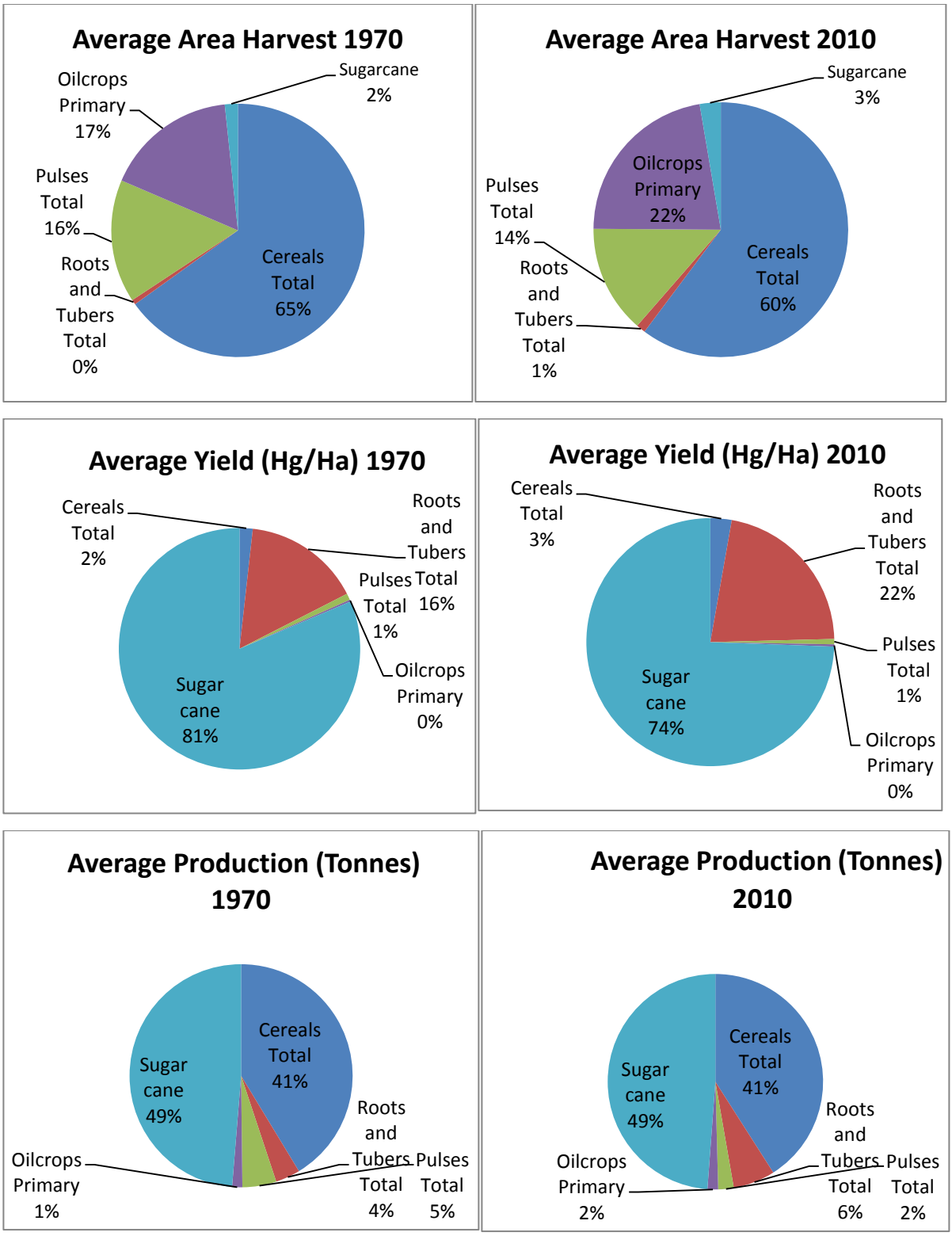


Figure 5. Comparison between Average Area Harvest, Average Yield, and Average Production of Five Major Crops, 1970 and 2010

2.4 Summary and Conclusions

Since India has opened its economy in 1991, potato production in India is at an all-time high and with current growth rate it is doubling almost in every 12 years. However, in spite of development of specialized seeds, processing, potato quality issues persists. As much as almost 80 percent of potatoes in India are meant for fresh (table stock) consumption at home or in restaurants, the lack of quality potatoes for processing is not a grave matter of concern. The Center of Potato Research Institute (CPRI) has developed 8 varieties of potatoes for processing. Due to government restrictions, a company can only import potatoes in special circumstances otherwise import of potatoes is prohibited.

Considering the changing socio-economic conditions in India and increase in the population the demand for processed potatoes will be increasing at an increasing rate. The current average age in India is 27 years (CIA, 2014). By 2020, the median individual in India will be 29 years of age, and very likely a city-dweller. This would make India the youngest country in the world. Moreover, with the continuous expansion of various multinational fast food chains like Subway, KFC and McDonalds and development of organized local food chain like Haldiram and Bikaner, there will be additional demand for processed potato products. In addition, the Indian export market for indigenous potato snacks like aloo-bhujia[9] is also growing. India has also started exporting potato products to neighboring nations, and Middle Eastern countries including Saudi Arabia and the United Arab Emirates. Thus, overall market for processed products is expanding.

This study has found a subtle decrease in the production and acreage of cereals and pulses, such as chickpeas and barley. This decrease can be attributed to the increase in potato acreage along with the change in consumption pattern of the people which could be due to ongoing economic development in India. There has been a noticeable increase in the production of soybeans, wheat and rice. This is not surprising because wheat is the staple crop in northern India and rice is the staple crop in the southern and western India. Potato production and yields have vastly improved; however, the average yield in India is still well below the average yields of other potato producing countries. Lower potato yields could be

[9] Aloo bhujia is spicy potato noodles made with combination of grated potatoes, gram flour and traditional Indian slices.

due to various factors such as, lack of high yielding varieties (HYV), poor access to inputs like pesticides, technological know-how, irrigation facilities, weather, harvesting technology, and non-conducive government policies. The lack of infrastructure including bad roads and insufficient cold storage, coupled with the amount of red-tape faced by new companies, are prohibiting growth as it deters foreign companies from investing in India. Cost competitiveness is still a big advantage in India due to the availability of year-round cheap labor, but the Indian government needs to create more export-import friendly policies. The benefits which the government wants to provide to its local farmers by denying World Trade Organization's export trade agreements are not reaching the small scale farmers.

Considering these positive aspects and challenges, the Indian potato industry has a great growth opportunity for multinational food companies which want to expand in India. This study suggests that the Indian potato industry should promote production efficiency by improving yields and support the multinational companies by introducing new and flexible trade and research related policies.

CHAPTER 3

MARKET STRUCTURE OF POTATO PROCESSING INDUSTRY: A CASE STUDY OF MCCAIN FOODS (INDIA)

3.1 Introduction

India is the second largest producer of potatoes in the world with an estimated annual production of 45 million metric tons (FAO, 2013). As discussed, in the previous paper about potato production in India we estimated that the potato production growth rate has been 6 percent annually. Despite India's ability to produce a large volume of tubers, the quality attributes desirable for processing potatoes were initially lacking. This changed somewhat with the opening of the Indian economy in 1991. Local potatoes were not meeting the set standards for processing in terms of length, width, water content and sugar content. However, after fast food multinational companies entered India and demanded potato variety for processing, the Central Potato Research Institute (CPRI) developed processing varieties, namely, Kufri Sindhuri, Kufri Chandramukhi, Kufri Bahar specifically for this market.

McDonalds was one of the first multinational companies along with its supplier Lamb Weston to start a fast food chain in India. McDonalds entered the Indian market in the early 1990s to conduct pre-launch research. However, due to quality issues with local potatoes Lamb Weston withdrew from an initial market development project. Thereafter, McCain Foods Limited, a Canadian company joined in the ongoing research while McDonalds started its first outlets in India in 1996, using imported frozen potato products. McCain planned to experiment with the production of Shepody potatoes in India, despite the popular belief that the Indian climate was not conducive to the cultivar. Many cited the "heat stress[10]" as a major barrier to successful cultivation of the Shepody variety. McCain eventually started the production of Shepody potatoes in the rich soil of the Himalayas for its manufacturing unit in Mehsana, Gujarat. The original facility, which is a French-fry plant had processing capacity of 40,000 metric tons of potatoes annually. The potatoes were transported via Rohtang pass covering the distance of more than 621 miles, sometimes in extreme weather conditions.

[10] Heat stress is a condition that occurs in orchids and other plants when excessive heat causes an imbalance in transpiration, the process by which moisture evaporates from the plant's tissues.

For McCain the period between 1998 and 2007 was both rough and rewarding. After a 9 years effort India-made French fries became available at most of the 150 McDonald franchises and currently almost 100 percent of Mac fries (French fries) are made in India and used in the almost 300 McDonald outlets around the country. It was a giant leap for McCain from its first contract Gujarat farmer who was growing potatoes on 2.83 hectare to 100 contract farmers now growing Shepody potatoes on more than 1,619 hectare. McCain plans to double this acreage in the near future.

McCain assisted their contract farmers with regular guidance from agronomists regarding cultivation and usage of production technology in the fields. For instance, the introduction of drip irrigation technology benefited producers in the state of Gujarat by reducing ground water usage. Thus, with increased profits to McCain and stable income and employment opportunities to local people, this frozen potato venture is already turning out to be a win-win situation for everyone.

McCain has greatly benefitted from the first-mover advantage in the Indian frozen potato market. The company holds a twenty five percent market share of the $184.8 million frozen food segment, which is growing at 15-20% annually (McCain Foods Ltd, Canada). By 2011 McCain expanded the production capacity of its Mehsana plant by 40% (McCain Foods Ltd., India), thus processing 56,000 metric ton of potatoes annually. During 2013-14 McCain plans to further invest $69 million on its manufacturing facility to meet increasing market demand. This is almost double of its initial investment of $35 million in 2007.

Today McCain is supplying French fries to nearly ten thousand retail outlets including McDonald's, KFC, Subway, leading five star hotels and the local food chains. In addition, it is manufacturing ready-to-eat brands comprising a range of snacks from Wedges, French Fries to Indian style Tandoori Veggie Nuggets. With the famous Indian actress Karisma Kapoor as McCain's brand ambassador these snacks are rapidly taking a place on the urban Indian breakfast menu.

It took McCain more than 10 years of research and investment in manufacturing units to achieve the present level of success. It is now appropriate to examine how McCain developed the price-quality schedule for a new market where its customers could not

observe product quality prior to purchase. Hence, the major objective of this chapter is to analyze whether McCain has any incentive to deviate from set quality-standards to make some short-run gains, and will this deviation hamper its future pricing and strategies.

3.2 Literature Review and Objectives

There have been few studies involving equilibrium price-quality schedule for markets where it is not feasible for buyers to observe product quality before making an actual purchase. One notable exception is Shapiro (1983). This current study follows Shapiro's equilibrium model of product quality and reputation, and applies it in an Indian setting. We examine the specific case of McCain India Limited, which captured the market on the basis of reputation garnered by their first product launch, which were frozen French fries. Thereafter, McCain launched several other products such as Potato Cheese Shotz, Veggie Burgers, and Veggie Fingers etc. This study takes into account the launch of Idli-Sambhar, which is a rice and lentil based product. This particular product is selected because McCain first created its market presence on the basis of its world-famous French fries. After gaining market reputation due to the higher quality French fries, it launched this new product.

In the discussed case, consumers cannot tell the difference between the qualities of products before purchase. The quality can be good as well as bad. In scenarios where product quality goes bad, it is difficult to prove bad quality in court. Moreover, there has been no known law-suit in Indian court cases against food companies for producing bad quality products. This leads to various scenarios. First, how is reputation garnered by the first product due to its superior quality, and how does this generate markets for new products under the same umbrella brand if McCain Foods. Second, a concerned company has a choice to reduce quality to gain short term profits and this may or may not affect its reputation and future sales. It is important to understand that McCain had to make heavy initial investments in research and infrastructure (more than 40 million USD to date), and though the company has captured almost 25 percent of the Indian frozen food market its initial revenue flow does not equate to profits. This is a situation where a company may be tempted to reduce quality for irregular or short periods to recover foregone costs.

This chapter focus on the incentives required for firms to maintain their reputation for supplying high-quality products in situations in which quality cannot be observed until after the product is purchased. If product attributes were perfectly observable prior to purchase, then previous production of high quality items would not enter into consumers' evaluations of a firm's product quality. Instead quality beliefs could be solely from inspection (Shapiro, 1983). Our analysis of the interaction between sales and the firm's quality choices draws on the literature on reputation that shows that, in a multi-period setting, firms may produce high-quality goods in order to maintain their reputations for future sales Klein and Leffler (1981), Shapiro (1982, 1983), Dybvig and Spatt (1983), and Allen (1984).

It is assumed that product is sold over a finite number of periods, which, for the purposes of this study we will assume total three periods. This is similar to a previous study conducted by Maksimovic and Titman (1991) where the basic model contained infinite periods and was then reduced to 3 periods. The reasoning behind using finite period model is that it can lead to a unique equilibrium (Kreps & Wilson, 1982), (Milgrom & Roberts, 1982). This feature of a unique equilibrium distinguished their model from the infinite period reputation models considered by Klein and Leffler (1981), Dybvig and Spatt (1983), and Allen (1984), which generally supported an infinite number of equilibria.

The assumption of imperfect competition distinguishes this model from premium-quality reputation model developed by Shapiro (1983). It is also assumed here that there is imperfect consumer information. High quality items must be sold over the cost of production. The reason being companies making profits will be less tempted to reduce the quality in the short run.

3.3 An Equilibrium Model of Product Quality and Reputation

The model is dynamic, since reputation is fundamentally a dynamic concept. Dynamic-pricing is assumed meaning that pricing changes over time. Pricing is, however, set in discrete time, where the length of the period 't' reflects the lag between successive sales by McCain India Limited.

3.3.1 The Model

It is assumed that the consumer good in this model is an experience good (Nelson 1970). While current quality is unknown the past performance of the product (French fries) can be observed in terms of quantity and quality. The seller's (McCain Foods India limited) reputation is built on the basis of past performance, increasing when the performance of an issue exceeds expectations, and conversely declining when quality expectations are not fulfilled (Simon, 1988). This model assumes that an individual firm has a reputation based on average past quality, and that reputation can be transferred to new products. In this model, there is an incentive to first increase future profits for a specific product (French fries); second, profitably develop other products (Idli-Sambhar) due to their brand reputation. Here quality of the previous product (French fries) sets the expectation of the consumers for the new product (Idli-Sambhar). Consumers cannot know the quality of the new product at the time of purchase; however they can draw inferences based on the experiences set by previous product. Thus reputation is a quality signal.

Here,

Time period = t; Assuming we have three time periods, 1, 2, and 3 respectively.

Products = A, B (There are two products)

Interest rate = r

Quality = k

Quantity = Q, which is either 1 or 0.

Cost = c

Price = p

Reputation = R

Cost of producing an item = $c(k)$

Reputation on time period $t = R_t$

Price on date $t = p(R_t)$ …… (Price depends on reputation on that day).

Minimum quality to produce = k_0

Here, $c'(k) \geq 0$; $c''(k) > 0$

And $p'(R) > 0$; $p''(R) < 0$

Reputation is weighted average of quality, hence,

$$R_t = \frac{Q_{(t-1)A} k_{A\,(t-1)} + Q_{B\,(t-1)} k_{B\,(t-1)}}{Q_{A\,(t-1)} + Q_{B\,(t-1)}}$$

This reputation function holds if t ≤ 2, 3. It is assumed that base reputation $R_1 = \underline{R}$, which is the minimum attainable level of reputation in the first period. In addition, it is assumed that reputation is public information. Consumers communicate with each other to share such information but information comes with a lag. We also assume that product A and product B are identical in the revenue and cost structure.

Our objective is to determine if McCain should launch two products A and B simultaneously in the market or launch product A first and after developing a reputation in the first period subsequently launch product B.

Assuming McCain launches both the products together in the first period itself. Our profit function would be:

$$\pi = [p_A(R_1) - c_A(k_{1A}) + p_B(R_1) - c_B(k_{1B})] + \frac{1}{1+r}[p_A(R_2) - c_A(k_{2A}) + p_B(R_2) - c_B(k_{2B})] + (\frac{1}{1+r})\text{^}2[p_A(R_3) - c_A(k_{3A}) + p_B(R_3) - c_B(k_{3B})]$$

If $p_A(R_1) - c_A(q_{1A}) < 0$ and $p_B(R_1) - c_B(q_{1B}) < 0$, which means there are losses in production of each product A and B respectively in the first period , then it is feasible to produce only one product either Q_A or Q_B .

Now finding first derivative with respect to:

$$\frac{\partial \pi}{\partial k_{1A}}, \frac{\partial \pi}{\partial k_{1B}}, \frac{\partial \pi}{\partial k_{2A}}, \frac{\partial \pi}{\partial k_{2B}}, \frac{\partial \pi}{\partial k_{3A}} \;\&\; \frac{\partial \pi}{\partial k_{3B}}.$$

The optimal quality and quantity decisions are found using backwards induction. The complimentary slackness conditions for k_{3A} and k_{3B} are given by

$$k_{3A} \geq k_0, \left[\left(\frac{1}{1+r}\right)^2 (-c_A')\right] \leq 0$$

And

$$k_{3B} \geq k_0, \left[\left(\frac{1}{1+r}\right)^2 (-c_B')\right] \leq 0$$

Since $\frac{\partial \pi}{\partial k_{3A}} < 0$ and $\frac{\partial \pi}{\partial k} < 0$, the firm will produce the lowest quality possible, k_0. If production is profitable, then they will produce both products, $Q_{3A} = Q_{3B} = 1$. In this period, the firm is generating revenue based on their past quality, but their costs are based on the lowest possible production costs.

The complimentary slackness conditions in the second period are given by,

$$k_{2A} \geq k_0, \frac{1}{1+r}(-c_A') + \left(\frac{1}{1+r}\right)^2 \left(\frac{dp_A}{dR_3} + \frac{dp_B}{dR_3}\right) \frac{\partial R_3}{\partial k_{2A}} \leq 0$$

And,

$$k_{2B} \geq k_0, \frac{1}{1+r}(-c_B') + \left(\frac{1}{1+r}\right)^2 \left(\frac{dp_A}{dR_3} + \frac{dp_B}{dR_3}\right) \frac{\partial R_3}{\partial k_{2B}} \leq 0$$

In this scenario, the firm is weighing the costs of quality versus the discounted benefits of product quality to the consumer. The constraint on product quality will not be binding if consumers sufficiently value product quality.

In this case, it is possible that either the firm produces both products, or they only produce one product, which we will assume is product A. First assume that $Q_{2A} = Q_{2B} = 1$. In this case the first order condition gives us

$$c'(1+r) = p'$$

This is because the revenue and cost curves are identical and $\left(\frac{\partial R_2}{\partial k_{1A}} = .5 \middle| Q_{1A} = Q_{1B} = 1\right)$. We will denote the quality that satisfies this condition as k*. If on the other hand, the firm only produces one product so that $Q_{2B} = 0$, then the first order condition becomes

$$c'(1+r) = 2p'$$

We will denote the quality that satisfies this condition as k**. Therefore, the firm will produce both products if it is profitable to do so,

$$Q_{2B} = 1 \Leftrightarrow \frac{2}{1+r} p(R^*) - c(k^*) > \frac{2}{1+r} p(R^{**}) - c(k^{**}) \qquad \text{(x)}$$

In the first period, complimentary slackness conditions are given by,

$$k_{1A} \geq k_0, -{c_A}' + \frac{1}{1+r}\left(\frac{dp_A}{dR_2} + \frac{dp_B}{dR_2}\right)\frac{\partial R_2}{\partial k_{1A}} \leq 0$$

And

$$k_{1B} \geq k_0, -{c_B}' + \frac{1}{1+r}\left(\frac{dp_A}{dR_2} + \frac{dp_B}{dR_2}\right)\frac{\partial R_2}{\partial k_{1B}} \leq 0$$

Note that in the first period, the quality decision is the same as the second period. The firm is weighing the costs of quality versus the discounted benefits of product quality to the consumer. However, the production of the firm may be different. If it is the case that $p(k_0) < c(k_1)$, then it does not make sense to produce both goods. In this case, the firm will only produce one product, we will assume product A, so that $Q_{1A} = 1, Q_{1B} = 0$. Therefore, the sole point of production in this case is to build a reputation since profits are negative. Furthermore, the impact of the quality will be greater since there is only production for one product; $\left(\frac{\partial R_2}{\partial k_{1A}} = 1 \middle| Q_{1A} = 1, Q_{1B} = 0\right)$.

Note that if $p(k_0) < c(k_1)$, holds, then the first order condition for k_{1A} becomes

$$c'(1+r) = 2p'$$

But if $p(k_0) < c(k_1)$, does not hold, the first order condition for k_{1A} becomes

$$c'(1+r) = p'$$

This implies that if $p(k_0) > c(k_1)$, then the firm will produce a high quality, k** in the first period, and then a lower quality, k*, in the second period. However, if $p(k_0) < c(k_1)$, , then the firm will produce a lower quality, k*, in the first period and a higher quality, k**, in the second period. If the firm expands production in the second period, then the firm will produce a high quality in the first period, and lower quality in the second period, and the lowest quality possible in the third period.

3.3.2 Results and Discussion

In 2008, which can be referred as the first period, McCain decided to cater to the consumer directly. The company started by launching only potato products, namely, French fries, Smileys and Aloo Tikki, and later in the first period it also launched cheese-potato products. For the purpose of this study these potato products can be considered as one product

named product A. The other product named Idli-Sambhar (rice and lentil product) can be considered product B. In the initial period, the company was already supplying potato and cheese products to the other businesses but needed to invest extensively in creating awareness about availability of these products to the direct consumers. Another issue which needed attention was conveying the new concept of homemade frozen food to Indian customers. These objectives could be achieved only by providing high quality products to set the brand identity and meet the customer expectations. Thus creating brand reputation for future product line.

This initial phase can be considered as the first period where the company had a choice of whether to launch both product A and B or one of them. McCain choose to launch only product A, that is, potato products. Hereby, $Q_{1A} = 1 \text{ and } Q_{1B} = 0$. As discussed in the model above, it was not profitable for the company to launch both the products simultaneously. In this period, McCain weighed the costs of quality versus the discounted benefits of product quality to the consumer. Here, the costs associated with quality not only include the cost of purchasing the raw material, but also the cost of manufacturing the product. Moreover, for another 'rice and lentil' product McCain also needed to set up a different production unit. This initial period also marks only the investment since the company will not start making profits immediately. In such a scenario the best strategy for McCain was to produce only one product and build brand reputation. The actual scenario was $p(k_0) < c(k_1)$, and then it did not make sense to produce both goods. The main emphasis in this stage was to build a reputation by providing a high quality product A. Thus, from 2008-2011, McCain just focused on developing the reputation by introducing these high quality potato products to Indian masses by participating in trade shows and airing television ads. McCain also launched trial packs of some of its most popular frozen products - French fries, Smiles and Aloo Tikki priced at Rupee (Rs.) 25 ($0.40[11]). The new trial packs were made available at leading frozen food retail outlets across India. During this time-period McCain was successfully able to establish the reputation for its potato products by selling high quality and reasonably priced potato products. The sample packs were

[11] In December 2014, 1 Indian Rupee (Rs.) = 0.016 US Dollar as retrieved from the free currency exchange rate website http://www.x-rates.com/

introduced at a very low cost of Rs. 25 ($0.40). The cost of McCain Fries was Rs. 35 ($0.57) for 200 gram pack. This company strategy is in complete alignment with the first period of our reputation-quality model.

As discussed earlier, later in the first phase, McCain also introduced cheese appetizers. For the purpose of this study we are assuming them to be similar to potato products. The reason being, consumers were already introduced to these products in various Quick Service Restaurants, such as McDonald's where McCain was supplying frozen products. Thereafter, in period 2, after the market was established and brand recognition was created amongst consumers, McCain decided to launch a completely new product; Idli-Sambhar. Idli-Sambhar had never been introduced in any other market. This product moved McCain from the appetizer category to breakfast items. 'McCain Idli Sambar' is an ice and lentil' product indigenous to India. It was a risky launch considering it could be well accepted or entirely rejected by Indian consumers who were not in the habit of eating frozen local breakfast items. However, it was a well-planned move by the company. Due to its previous product A (set of potato products) consumers trusted the brand and had positive expectations from the company. Hence in 2012, when the product was launched it was again well-received by the consumers. The cost of 360 gram pack was Rs. 60 ($0.97). This rice-lentil product was essentially launched in alignment with the reputation-quality model developed in this study whereby in the first period the company launched one product because two products would be expensive and risky. Thereafter, the company launched this second product on the basis of its reputation developed by the first product. Overall the exact cost of production is not known in any of the scenarios. However, considering McCain India's decision to expand the manufacturing unit in Mehsana (Gujarat) by investing an additional $69 million USD, it can be safely assumed that the company is in a growth stage.

This second period can be extended to similar situations covering different products and thus providing the incentive to not compromise on quality. Compromising on quality prior to the final period is not in the best interest of the company. Hence, on the basis of this study, we can say that in India, McCain has not reached the third or the last scenario. The results of this study are consistent with Shapiro's model since there is reputation building.

Unlike Shapiro's model this study deals in only two products. This study is differentiated from previous studies by the introduction of the concept of expanding product-lines after developing a reputation for one product. It can be concluded that though this study's results align with results procured in Shapiro's model, it is left for future researchers to see if McCain again complies with the reputation-quality model.

References

Allen, F., (1984) Reputation and product quality, Rand Journal of Economics, 15, pp. 311-328

Baldi. S. (2014) Economics Survey of Himachal Pradesh, *Economics and Statistics Department, Himachal Pradesh*, India.

Box, G. E. P., G. M. Jenkins, and G. C. Reinsel. 2008. Time Series Analysis: Forecasting and Control. 4th ed. Hoboken, NJ: Wiley.

CIA (2014) The World Factbook. Retrieved on 15th December 2014 from https://www.cia.gov/library/publications/the-world-factbook/fields/2177.html

Dahiya, P.S. and J.P. Bhati, (1992) Trends and Potentiality of Potato Exports from India, *Agricultural Situation in India,* **47**(1): pp 21-26.

Dahiya, P.S. and K. Srinivas, (1994) Potato: Promising Export Prospects, *The Hindu-Survey of Indian Agriculture*; Madras: Kasturi and Sons Ltd. pp. 35-37.

Dybvig, P.H., and C. S. Spatt, (1983) Does it Pay to Maintain Reputation? Quality Incentives in Financial Markets, unpublished manuscript, revised December 1985, School of Organization and Management, Yale University.

Ezekiel, R., G.S. Shekhawat and N.P. Sukumaran, (1999) India's Competitiveness in Global Market for Potato, *Souvenir, 4th Agricultural Science Congress*, Feb. 21-24, Jaipur: pp. 25-28.

FAO (2008) *Potato World*. Editor: G. Thomas. Translators: M-T Brun, J. Gong, Y. el-Jaber, R. Nunez, UN office in Belarus. Retrieved on 5th July 2014 from www.fao.org/potato-2008.

FAO Corporate Deposit Repository (1997) An Overview of Potato Production in Asia and the Pacific Region: Market Development and Constraints. Author: Ezeta, F.N., Retrieved on 7th December 2014 from http://www.fao.org/docrep/010/i0200e/I0200E06.htm.

FAO Corporate Deposit Repository (1997) The Agroprocessing Industry and Economic Development. Retrieved on 7th December 2014 from http://www.fao.org/docrep/W5800E/w5800e12.htm.

FAOSTAT (2012) Statistics Division. Retrieved on 21st September 2014 from http://faostat3.fao.org/home/E.

FAOSTAT (2014) Statistics Division. Retrieved on 12th March 2014 from http://faostat3.fao.org/browse/Q/*/E.

Goswami, V.K. (2013) Indian Economic Structure:- A View Point, *Shodh Sanchayan*, ISSN 2249-9180 (Online) ISSN 0975-1254 (Print) RNI No.: DELBIL/2010/31292 Vol-4, Issue-1, 15 Jan-2013.

Hawkes, J. G. and J. Francisco-Oetega, (1993) The early history of the potato in Europe, *Euphytica,* Volume 70, Issue 1-2, pp 1-7.

Jwanya, B.A., Mashat I.M., B.S Gojing, and Dawang, N.C (2014) Technical Efficiency of Rain-Fed Irish Potato Farmers in Plateau State, Nigeria: A Stochastic Frontier Approach, *Developing Country Studies*, ISSN 2224-607X (Paper) ISSN 2225-0565 (Online) Vol.4, No.22, 2014. Retrieved 22nd November 2014 from www.iiste.org.

Klein, B., and K.B. Leffler, (1981) The Role of Market Forces in Assuring Contractual Performance, *Journal Of Political Economy*, 89, pp. 615-641.

Kreps, D. M., and R. Wilson, 1982, Reputation and Imperfect Information, *Journal of Economics Theory*, 27, pp. 253-279.

Kumar, N.R., B.P. Singh, S.M. Paul Khurana and N.K. Pandey (2005) Impact of WTO on Potato Export from India, *Agricultural Economics Research Review,* Vol. 18 July-December 2005 pp 291-304.

Maksimovic, V. and S. Titman, (1991) Financial Policy and Reputation for Product Quality, *The review of financial studies*, Vol. 4, No. 1, pp. 175-200.

Milgrom, P., and P.D. Roberts, 1982, Prediction, Reputation and Entry Deterrence: An Equilibrium Analysis, *Journal of Economic Theory*, 27, pp. 280-312. Ministry of Agriculture, India.

National Council of Applied Economic Research (India), 2013 Agricultural Output and Situational Analysis Report. *The National Food Security Mission*, Ministry of Agriculture. India.

Shapiro, C., (1982) Consumer Information, Product Quality, and Seller Reputation, *Bell Journal of Economics,* 13, pp. 20-35.

Shapiro, C., (1983) Premiums for High Quality Products as Returns to Reputations, *The Quarterly Journal of Economics,* Vol. 98, No. 4 (Nov., 1983), pp. 659-680.

Vepa, S.S. (FAO, 2004) Impact of globalization on the food consumption of urban India. Retrieved on 6th December 2014 from http://www.fao.org/3/a-y5736e/y5736e02.pdf

Wilson and Keating (2009) Business Forecasting with ForecastX. 6th ed. Boston : McGraw-Hill/Irwin.

World Bank (2014). India Overview. Retrieved on 31 August 2014 from http://www.worldbank.org/en/country/india/overview.

World Bank (2014). Led by India, South Asia Economic Growth to accelerate. Retrieved on 20 October 2014 from http://www.worldbank.org/en/news/press-release/2014/10/06/led-india-south-asia-economic-growth-accelerate.

Wustman, R. (PPO), A. Haverkort (PRI), Xiaoyong Zhang (LEI) and Geetika Rathee (LEI), (2011) An overview of the potato sector in India and prospects of Indo-Dutch cooperation, *Wageningen, Foundation Stichting Dienst Landbouwkunding Onderzoek (DLO) research institute Praktijkonderzoek Plant & Omgeving*, The Netherlands.

Appendices

Appendix A. India

Political, Economic, Social and Technological (PEST) Analysis

Currently India is one of the target markets for all major corporations around the world ranging from information technology to food giants. It is the seventh largest country in the world in terms of land with an area of 328 million hectares. It is the second largest populated country with population of almost1.25 billion. The currency is Rupee and 1 US Dollar is equal to Rs. 61.59 (as of 25 September 2014). This country with lower middle income is strategically located in South Asia has an eminent scope for new products and services that can help feed its increasing population.

Political: Laws, property rights, corruption, patents, political stability.

India has a federal form of government that is based on English Common Law. The review of legislative acts is done by the judiciary and there are various types of reservations[12] on the basis of gender, caste and religion along with special reservation categories such as Kashmiri migrant reservation. There are numerous small scale parties on the political front but the two major parties that dominate the national front are the Indian National Congress and the Bhartiya Janta Party. The political environment is very much stable. The Prime Minister, who is the head of state, is elected on a five-year basis. The President's position is more about maintaining the image of the country in the international arena. There is a three-tier structure of governments: Union, State and Urban & Rural bodies. The Union government imposes income tax, custom duty, excise, sales and revenue tax; State government decides about principal taxes including stamp duty, land revenue, state excise, and entertainment duty etcetera. The local bodies levy other taxes, such as, octroi and utilities.

Economic: market and trade agreements, currency fluctuation, industry trade cycles, customer preferences and country economic growth forecasts etc.

[12] Reservation in India is the process of setting aside a certain percentage of seats (vacancies) in government institutions for members of backward and under-represented communities (defined primarily by caste and tribe). Reservation is a form of quota-based affirmative action.

The current focus of the government is on divestment of crowded public sector enterprises, liberalization of foreign capital along with granting of permission on foreign technological agreements, and the formation of the Foreign Investment Promotion Board (FIBP) (Chakranarayan 2009). According to World Bank, the Gross Domestic Product (GDP) value of India represents 3.03 percent of the world economy and had reached its all-time high in 2013 of 1,876.80 billion US dollars.

Socio-cultural: National culture, values, religion, language, human rights and population demographics.

With 30 states and 7 union territories, a diverse country like India a slight change in trend might have a profound impact on a business environment. At present, 81 percent of Indian population is Hindu; around 14 percent is Muslim. Christians, Sikhs, Jain and Buddhist constitute rest of the 5 percent. Beef is prohibited and pork is not usually eaten. The average age in India is 29 years, however, due to a lack of proper training and education, the majority of India's young population has insufficient education or training to be classified as skilled labor. Overall, 31.08 percentage of the population is 0-14 years, 63.1 percent is 14-64 years and 5.1 percent are those over 65 years of age. The average life expectancy is 66.21 years. Hindi is the national language, however, 18 other languages are recognized and almost every state has its own language and culture. English is the second language and is widely spoken around the country especially in urban areas. Though India's free media, independent judiciary and vibrant civil society often act as checks on abusive practices, a general reluctance to hold public officials accountable for abuses or dereliction of duty fosters a culture of corruption and impunity (Human Rights Watch).

Technological: Maturity of manufacturing equipment, information system, technology platforms, consumer access to technology.

India is the biggest market for information outsourcing. The strong Information Technology (IT) sector is expanding and there is continuous IT development, funding of technology by the government, software upgrades, as well as technological transfer (Chakranarayan 2009). The successful launch of Mangalyan, a Mars orbiter by India proves its competent yet cost-efficient scientific intellect. However, lack of standardized

infrastructure is a problem. Moreover, rigid government policies regarding foreign investment in technological and financial sector act to constrain economic growth..

Overall, India is a great market for multinationals but there is a need to facilitate easy access to capital, clarification of legislation, development of a culture of entrepreneurship, and development of crucial business support networks (Murthy 2000).

Growth rate and opportunities in India

The frozen food market in India is at a nascent stage with few products, low consumer awareness levels, an underdeveloped frozen food distribution network, and a lack of freezer space at the retail end. The key to grow such markets is a range of high-quality affordable products made available close to consumers. These can help stimulate demand and address other issues like development of cold chain facilities.

In the last few years, consumers in India have gone through a dramatic transformation in lifestyle by moving from traditional spending on food and groceries to lifestyle and convenience food products. This has led to growth in home consumption of frozen foods. This demand for 'convenience food' has also supported growth in frozen foods, with consumers stocking up and keeping easily prepared food at hand. This is evident by the rise in the number of frozen food products being offered in the Indian market today. Moreover, the increasing penetration of organized retail chains has aided in the demand for frozen food products. Apart from convenience in cooking at home, quick service restaurants have also contributed to the growth of frozen food consumption in India.

Challenges for the frozen food sector

First and foremost there are very few players in the frozen food market segment in India. Therefore frozen foods (excluding frozen vegetables) market penetration, as a category, is extremely low.

Second, as mentioned earlier, there is low consumer awareness about frozen foods. For the Indian consumer, frozen food is a new category and consumers are not completely familiar with it. McCain India's research with consumers shows that consumers do have misconceptions about frozen foods, particularly in that they are not aware of the benefits that freezing (as a method of preservation) offers. The fact that freezing is a natural method

of food preservation without the use of any preservatives or chemicals and that it locks freshness and maintains the nutritive value of food is not known to most consumers. Third, the lack of cold chain facilities is proving to be a disadvantage for companies that wish to increase the market for frozen foods. In addition to the above, lack of freezer space at the retail end is also presenting a challenge to frozen food companies. Necessary key points for consideration to tap such markets are QSR infusing growth; customization of food products according to local taste; large scale screening of potato sample's is necessary so that best quality potatoes can be selected, and emphasis needs to be on development of adequate arrangement for cold storage.

The major markets for frozen potatoes are developed economies like United States, Canada, the European Union and Japan. The world's largest frozen potato market (the US) is becoming stagnant in terms of production and capacity, though the Canadian market is still growing. Given the maturity of developed markets the potential for new growth lies in the emerging economies of Asia and Latin America, which are yet to witness the boom of quick service restaurants. McCain is already on growth trajectory by tapping the frozen potato market potential of vast and diverse Indian markets and has shown how continuous research and development with transfer of basic technology can help thriving business even in developing economies.

Appendix B. Important Potato Facts

a) **Potato diseases**

Wustman, et al. (2011) found that late blight and viral degeneration of seed stocks are major problems for potato cultivation in India. Late blight is particularly a problem in the spring crop due to higher levels of moisture; farmers spray fungicides three to four times during the season to combat this disease.

Disease problems are further aggravated by the incidence of a wide range of other biotic stresses and the emergence of new pathogens and pests. The use of large quantities of pesticides has resulted in problems related to environment, residues, and resistance development in pests. Thus, there is a need to develop eco-friendly disease/pest management practices to boost potato production without compromising on environmental quality issues. Moreover, excessive use of chemical fertilizers and irrigation water has led to the development of degraded soils and environmental degradation in many parts of the country.

Major diseases:

a. Fungal: *Phytophthora infestans* causing late blight (spring crops in north-western plains, north-eastern plains and the central plains) and Synchytrium endobioticum causing wart in potatoes is found in the north&eastern hills.

b. Bacterial: *Ralstonia solanacearum* causing bacterial wilt.

c. Tuber and soil borne diseases like *Rhizoctonia solani* causing black scurf and *Streptomyces scabies* resulting in common scab

d. Field and storage: white grubs and potato tuber moth (PTM)

e. Viruses: latent mosaic (PVX and PVS), severe mosaic (PVY), rugose mosaic (PVX + PVY), crinkle mosaic (PVX + PVA), leaf roll (PLRV)

f. Nematode diseases: two potato cyst nematode species *Globobera rostochiensis* and *G. pallida* affect the potato crops in Nilgiri and the Kodaikanal hills (southern India) and have been found in Darjeeling. Soil sampling facilities, expertise and protocols are absent.

India has some Quarantine (Q) diseases within its borders:

• *Synchytrium endobioticum* causing wart

• *Ralstonia solanacearum* causing bacterial wilt

• *Globobera rostochiensis* and *G. pallida*

The occurrence of Q diseases limits potato exports to EU.

Control

Late blight is controlled by application of fungicide chemicals. Control of Rhizoctonia requires the application of chemicals either on the seed tuber surface or through soil application (heavy soil infestation).

Virus spread must be controlled through growing seed crops in low virus pressure regions and seasons, control of aphids (which transmit viral diseases) and planting healthy seed potatoes (viruses are often seed-borne).

Nematode control needs to be conducted through the use of (partially) resistant cultivars.

b) **Seed-plot technique**

Central Potato Research Institute developed a seed plot technique during 1959 which has revolutionized seed potato production in sub-tropical plains of India. The principle of the seed plot technique is growing seed potato crop using healthy seed during low aphid periods from October to the first week of January coupled with integrated pest management, rouging and desiccation of the seed crop during the last week of January before aphids reach the critical limit.

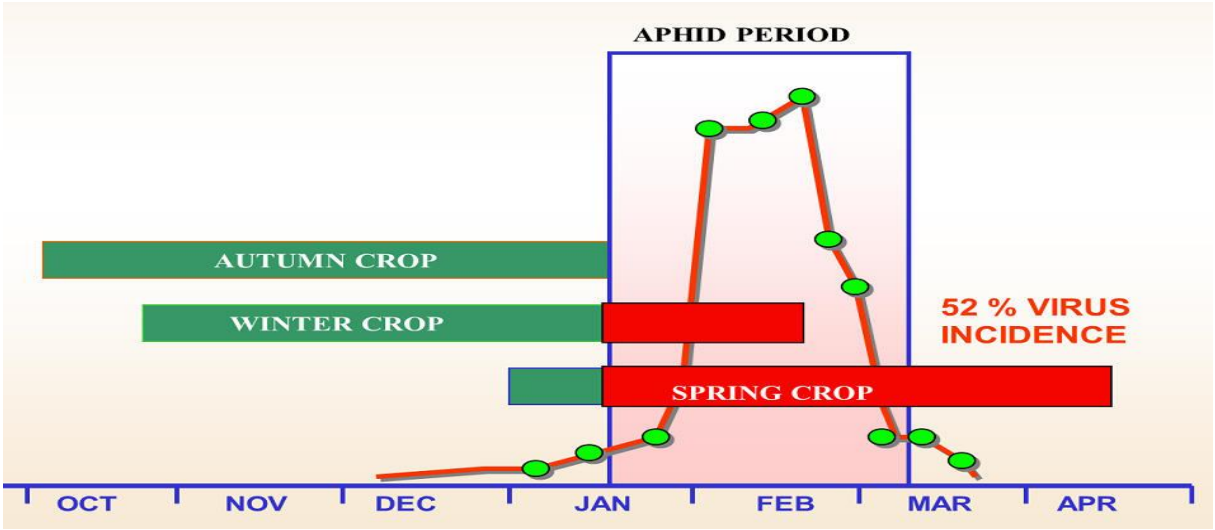


Figure 6. Seed Plot Technique

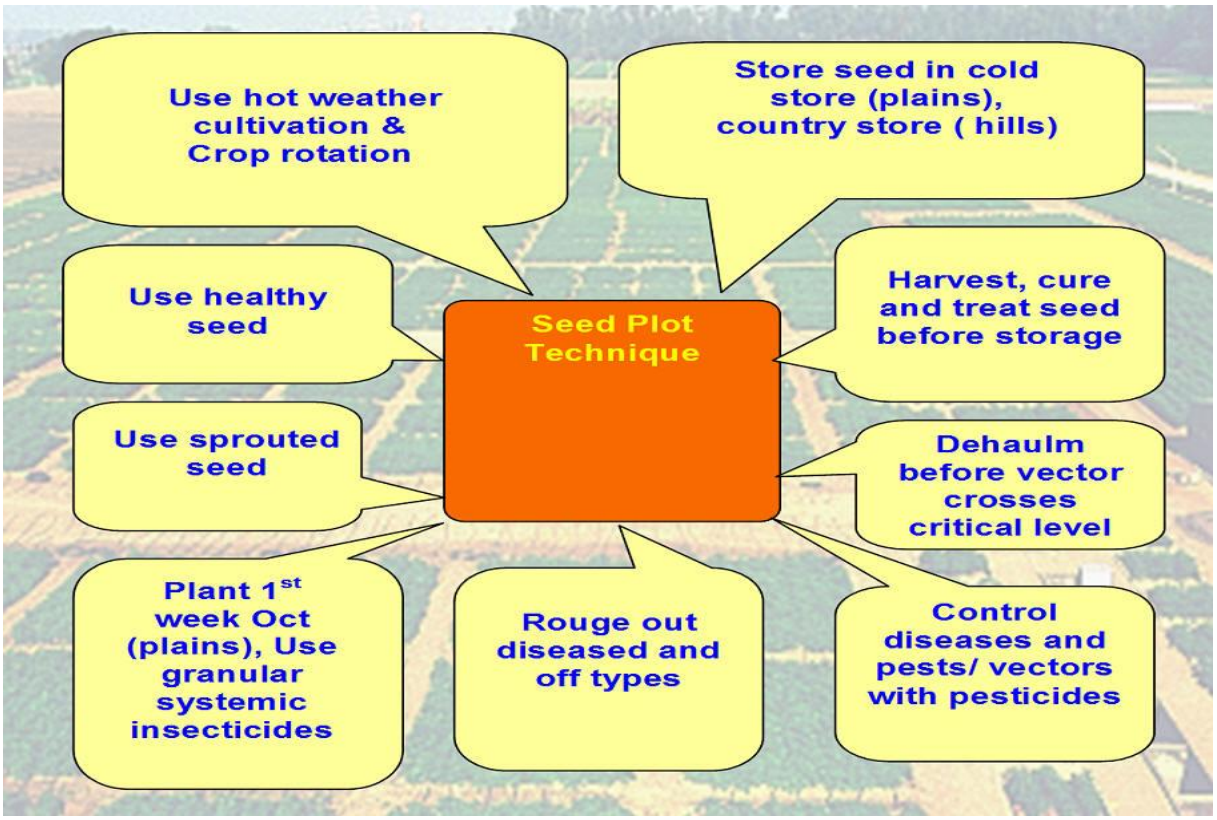


Figure 7: Seed Plot Technique Flow Main Facts

Appendix C. Indian Agricultural Policies for Processing Sector

In India, the Department of Agriculture and Cooperation under the Ministry of Agriculture is the primary organization responsible for development of the agriculture sector. The Ministry of Food Processing Industry is the main central agency of the Government responsible for developing a strong and vibrant food processing sector. It was set up to create increased job opportunities in rural areas, enable the farmers to reap benefit from modern technology, create a surplus for exports and stimulate demand for processed food.

Figure 8: Fruit Products Order Mark

Policies and Schemes

The Ministry of Food Processing Industries is actively engaged in efforts to bolster growth in vegetable processing. These efforts include training of entrepreneurs, creation of infrastructure facilities for fruit and vegetable processing (including mushroom processing), setting up/expansion/upgrading of fruit and vegetable processing units, development of backward linkages through contract farming, market promotion through advertisement, promotion of the FPO symbol[13] ,marketing of small manufacturers' products under a common brand name, setting up of Quality Control Labs, and Research & Development in identifying new techniques and practices including those for packaging.

The Ministries efforts toward setting up of Food Processing and Training Centers in rural areas is providing assistance up to Rs. 2.00 lakhs (approximate $3223.99[14]) for plant, machinery and equipment including quality testing equipment etc. and Rs. 1.00 lakh toward a seed capital/revolving fund for commercial production. In the case of Food Processing &

[13] In India FPO symbol represents *Food Safety and Standards Act* of 2006, which guarantees that the product was manufactured in a hygienic 'food-safe' environment, thus ensuring that the product is fit for consumption.
[14] In December 2014, 1 Indian Rupee = 0.016 US Dollar as retrieved from the free currency exchange rate website http://www.x-rates.com/

Training Centers to be set up for multi-product activities, this assistance is designed to meet the cost of plant & machinery and equipment including quality testing equipment etc. and could be enhanced to Rs. 7.50 lakhs. Assistance for seed capital/revolving fund for commercial production can be enhanced to Rs. 2.00 lakhs. Assistance is available to State/Central Govt. Depts., Joint Sector undertakings/assisted sector undertakings, cooperatives, nongovernmental organizations, and voluntary organizations. These Centers are proposed to identify the entrepreneurs who may set up Food Processing units in rural areas thereby providing employment and reducing the exodus of rural population to urban areas. Investments in this area will also lead to the transfer of technology to rural areas, and increase familiarization with modern processing techniques. Food Processing & Training Centers will provide 'hands on' experience in operating and managing a small unit. The trainees will participate in each activity from book-keeping, manufacturing, and quality testing to marketing of products to gain experience that would instill confidence and lead to establishment of commercial ventures. It is hoped that this type of education will also to generate a spirit of co-operation and encourage food processing cooperatives in rural areas. The Ministry also provides assistance for research and development projects in the fruit and vegetable processing sector. Some of the important projects are:

- Centre for Technology Development, Bangalore for Setting up of an Analytical and Quality Control Lab;
- APEDA, New Delhi for Vapor Heat Treatment Facilities for mangoes and other fruit for exports; and
- M/s. Fresh Marketing Cooperative Society Ltd., Hyderabad, for installation of a Solar Refrigeration Unit received from FAO.
- Post-harvest Institute, Pune.
- Dr. Subhas Mukherjee Memorial Reproductive Biology Research Centre, Calcutta for Twin-Screw Cooker Prototype.
- Regional Research Laboratory (CSIR) Trivandrum, Pilot project for fresh flavored ginger Oleoresin.

- Central Food Technological Research Institute (CFTRI), Mysore- Food Safety Biotechnology Research Center Project.
- Dr. Subhas Mukherjee Memorial Reproductive Biology Research Centre, Calcutta for Twin-Solar Cooker Proto - Type.
- Central Food Technological Research Institute (CFTRI), Mysore, Utilization of Protein from inexpensive Sources for enhancing the Surface properties by physico-chemical and enzymatic modifications.

Appendix D: India's Central Potato Research Institute

India's Central Potato Research Institute, located at Shimla, has developed two new potato varities, Kufri Himsona for cultivation in the Himachal Pradesh Hills and Kufri Sadabahar for Uttar Pradesh Plains.

Kufri Himsona is the first potato processing variety released for cultivation in the hills of Himachal Pradesh. This variety contains more than 22 per cent high dry matter and low sugars i.e. less than 100mg per 100 gm of fresh potato weight. It produces excellent white chips on frying. The variety was released by the H.P. State Variety Released Committee in its meeting held recently. On line' testing of Kufri Himsona in the Industry produced excellent flawless chips. Its cultivation in the hills of Himachal Pradesh will prove to be a boon to the potato farmers particularly in the Kangra region of Himachal Pradesh. Previously they depended on only Kufri Jyoti which has now become totally susceptible to late blight. Kufri Himsona variety produces white, oval, shallow eyed tubers which have creamy flesh. The hybrid has a very high degree of late blight resistance. In spite of the release of three exclusive varieties for potato processing by CPRI for cultivation in the plains (i.e. Kufri Chipsona-1, Kufri Chipsona-2 and Kufri Chipsona-3), there was an urgent need for development of a suitable processing varieties for cultivation in the hills so as to maintain the round the year availability of raw material for processing units located in the plains.

The cultivation of **Kufri Sadabahar** will boost potato production in the state of Uttar Pradesh which has a record of highest potato production in the country. New table potato variety Kufri Sadabahar produces a more than 10% higher yield over Kufri Bahar. The variety produces white, oblong, shallow eyed tubers, having white flesh. The variety is capable of yielding about 35-40 tones/hectare under optimum agronomical practices. The added advantage of this variety is its field resistance to late blight. Kufri Sadabahar is released by the U.P. State Variety Released Committee.

CPRI released the white skin potato variety Kufri Bahar in 1980 for cultivation in plains of Uttar Pradesh. It is the most popular variety of the State occupying as much as nearly 70 per cent of the potato area in the state of UP. Though the farmers are satisfied with the

productivity of this variety, it is susceptible to late blight. The farmers suffered heavily from a case of early appearance of late blight as happened in 2006-07

Figure: Varieties recommended for various agro-ecological zones in India

Agro-ecological Zone	Recommended Variety
North-Western Plains	Kufri Chandramukhi, Kufri Jawahar, Kufri Kuber, Kufri Alankar, Kufri Badsha, Kufri Dewa, Kufri Pukhraj, Kufri Sheetman, Kufri Sutlej
North Eastern Plains	Kufri Ashoka, Kufri Kuber, Kufri Chipsona 1, Kufri Chipsona 2, Kufri Lalima, Kufri Pukhar, Kufri Red, Kufri Sutlej
West Central Plains	Kufri Safed, Kufri Sindhuri, Kufri Chandermukhi, Kufri Jawahar, Kufri Kuber, Kufri Chamatkar, Kufri Kisan, Kufri Sindhuri
Plateau Region	Kufri Chamatkar, Kufri Jawahar, Kufri Jyotir, Kufri Kuber, Kufri Lauvkar, Kufri Pukhraj
North Western Hills	Kufri Giriraj, Kufri Jyoti, Kufri Kundan, Kufri Jeevan, Kufri Kumar
North Eastern Hills	Kufri Giriraj, Kufri Jyoti, Kufri Megha, Kufri Khasigaro, Kufri Naveen
North Bengal, Sikkim Hills	Kufri Jyoti, Kufri Kanchan, Kufri Sherpa, Kufri Giriraj,
and Southern Hills	Kufri Muthu, Kufri Swarna, Kufri Neela, Kufri Neelamani

Source: National Horticultural Research and Development Foundation (NHRDF), Nasik

Appendix E. Pie Chart

What is a Pie-chart?

A pie chart is a circular graph that shows the relative contribution that different categories contribute to an overall total. A wedge of the circle represents each category's contribution, such that the graph resembles a pie that has been cut into different sized slices. Every 1% contribution that a category contributes to the total corresponds to a slice with an angle of 3.6 degrees.

What data can be presented using a pie chart?

1. Pie charts are a visual way of displaying data that might otherwise be given in a small table.
2. Pie charts are useful for displaying data that are classified into nominal or ordinal categories. In this study we are using nominal data which is descriptive in terms of crops.
3. Pie charts are generally used to show percentage or proportional data and usually the percentage represented by each category is provided next to the corresponding slice of pie.
4. Pie charts are good for displaying data for around 6 categories or fewer. When there are more categories it is difficult for the eye to distinguish between the relative sizes of the different sectors and so the chart becomes difficult to interpret. However, the detailed pie charts for each decade have been included in appendix to show performance of each crop over the years.

Design issues in pie charts?

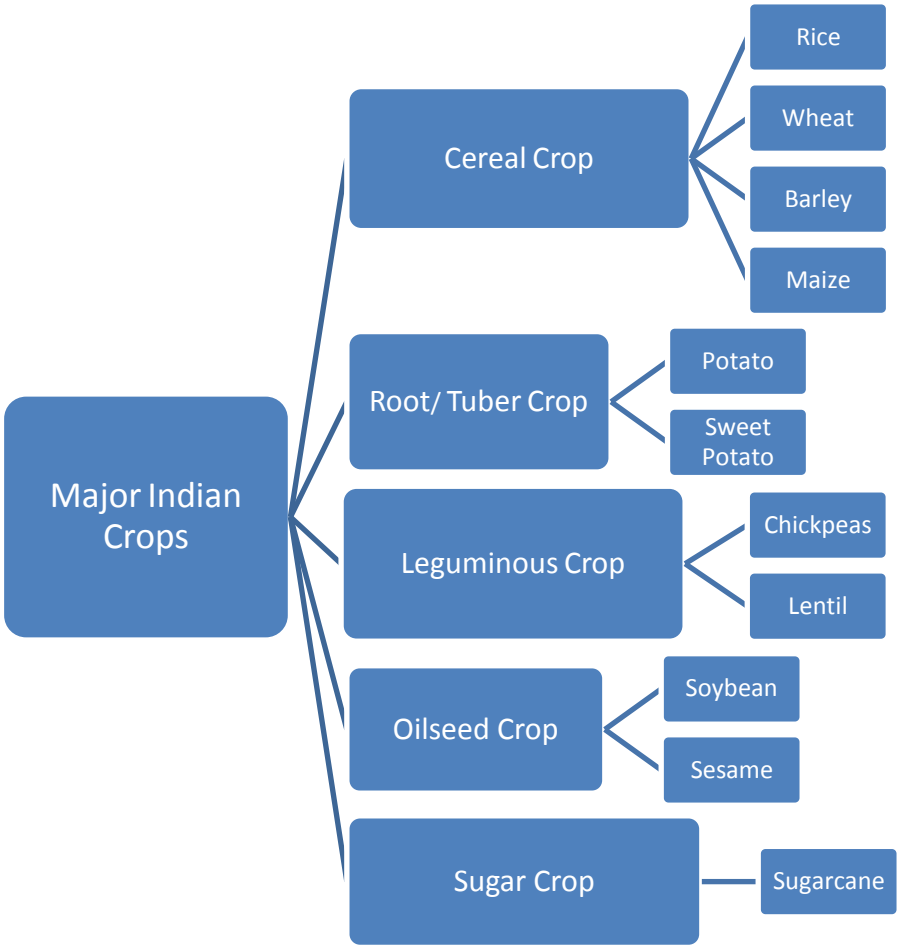
Pie charts provide a good visual representation of the data when the categories show some variation in size. When there are several similar-sized categories, a pie chart can end up looking cluttered and it may be difficult to interpret the data. In such cases consider whether a table would present the information more effectively. This is why only major categories are represented in the result section.

Comparing pie charts

In this study pie charts are used to compare three different sets of data; namely, acreage, yield and production. The same order and color coordination is maintained in each set of data for better understanding and comparison.

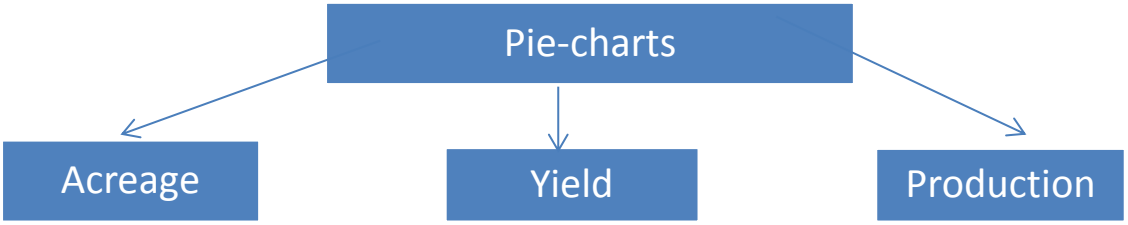
Appendix F: India Major Food Crop Production Data

Data 1960-2013



The data is grouped as per the flow chart. Cereal crops include Rice, Wheat, Barley and Maize; Root/tuber crop includes potato and sweet potato; Leguminous crops includes chickpeas and lentil; Oilseed crops include soybean and sesame; and Sugar crop include Sugarcane.

Appendix G. Pie Chart Data for Acreage, Production and Yield



Area harvest data: per decade average

	Cereal crop				Oilseed Crop		Sugar Crop	Leguminous Crop		Tuber/Root Crop	
Year	10 year Average (Area Harvest (Ha)) Rice	10 year Average (Area Harvest (Ha)) Wheat	10 year Average (Area Harvest (Ha)) Barley	10 year Average (Area Harvest (Ha)) Maize	10 year Average (Area Harvest (Ha)) Soybean	10 year Average (Area Harvest (Ha)) Sesame	10 year Average (Area Harvest (Ha)) Sugarcane	10 year Average (Area Harvest (Ha)) Chickpeas	10 year Average (Area Harvest (Ha)) Lentil	10 year Average (Area Harvest (Ha)) Potato	10 year Average (Area Harvest (Ha)) Sweet Potato
1970	36205670	13999980	2935510	5123650	22200	2482340	2442710	8539090	791853.7	447110	178354.5
1980	38893610	20108020	2363730	5858300	200400	2337140	2758080	7648210	879300	600880	219710
1990	40907270	23302980	1346430	5831080	1428410	2301530	3126760	6975140	1021300	830530	188760
2000	43412080	25546870	847310	6178980	5105260	1931100	3891450	6959810	1268330	1161490	135890
2010	43227320	26897510	662030	7657870	8029569	1765898	4384380	6926440	1434310	1558820	125590

Yield data: per decade average

	Cereal crop				Oilseed Crop		Sugar Crop	Leguminous Crop		Tuber/Root Crop	
Year	10 year Average Yield (Hg/Ha) Rice	10 year Average Yield (Hg/Ha) Wheat	10 year Average Yield (Hg/Ha) Barley	10 year Average Yield (Hg/Ha) Maize	10 year Average Yield (Hg/Ha) Soybean	10 year Average Yield (Hg/Ha) Sesame	10 year Average Yield (Hg/Ha) Sugarcane	10 year Average Yield (Hg/Ha) Chickpeas	10 year Average Yield (Hg/Ha) Lentil	10 year Average Yield (Hg/Ha) Potato	10 year Average Yield (Hg/Ha) Sweet Potato
1970	15149.55	9370.735	8939.738	10291.16	4431.432	1819.812	451245.1	6019.123	4506.403	78044.16	69293.11
1980	17674.39	13748.16	10520.67	10435.81	8008.326	1900.917	506702.7	6345.184	4590.047	108396.8	72116.1
1990	22633.1	19179.79	13515.24	13116.37	7520.573	2602.417	593316	6710.468	5798.505	145054.9	78102.5
2000	28006.13	24956.18	17880.04	16527.41	9856.807	3070.363	686600.8	7730.66	6666.593	167268	85335.49
2010	31293.63	27270.4	20491.52	20792.05	10572.95	3803.143	663064.7	8165.655	6586.681	185840.3	88173.79

Production: per decade average

	Cereal crop				Oilseed Crop		Sugar Crop	Leguminous Crop		Tuber/Root Crop	
Year	10 year Average Production (Tons) Rice	10 year Average Production (Tons) Wheat	10 year Average Production (Tons) Barley	10 year Average Production (Tons) Maize	10 year Average Production (Tons) Soybean	10 year Average Production (Tons) Sesame	10 year Average Production (Tons) Sugarcane	10 year Average Production (Tons) Chick Peas	10 year Average Production (Tons) Lentil	10 year Average Production (Tons) Potato	10 year Average Production (Tons) Sweet Potato
1970	54936200	13302700	2632210	5299090	9800	450490	110420000	5134860	356086.4	3519690	1253700
1980	68900270	27780260	2485880	6120060	155200	444050	140096300	4873890	402860	6624190	1579920
1990	92838830	44760690	1795830	7660890	1118010	601540	185762100	4686300	595310	12109710	1467680
2000	121673900	63909050	1507540	10236140	5101840	588450	267614500	5390630	847200	19487960	1155780
2010	135418500	73421550	1356160	16040720	8601700	673300	291370800	5694980	944590	28997410	1106860