Decision Support to Maharashtra Turmeric Farmers to increase Farm Profits

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THESIS CERTIFICATE

This is to certify that the thesis titled **Decision Support to Maharashtra Turmeric Farmers to increase Farm Profits CLASS FOR DISSERTATIONS SUBMITTED TO IIT-M**, submitted by **Aman Verma**, to the Indian Institute of Technology, Madras, for the award of the degree of **Dual Degree (B.Tech and M.Tech)**, is a bona fide record of the research work done by him under our supervision. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

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ABSTRACT

The present study was carried out to mathematically formulate the cost and socio-economic factors against the farm productivity and provide decision support to farmers to market the turmeric produce better for increased farm profits. The study is focused in the districts of Maharashtra, namely Sangli, Hingoli and Nanded, where turmeric is cultivated as a major crop. The findings show that education acts as an important socio-economic factor which is directly proportional to farm productivity. Data collection from 40 farmers each from the three districts reveals relevant comparative factors in which the three districts practice turmeric farming. Sangli presents the best benefit-cost ratio of 1.93 compared to Hingoli with the least (1.45). The data collected is modelled using Cobb Douglas production function which highlights to increase expenditure on seed and nutrient management in order to further enhance the productivity/ profitability of turmeric. Sangli market offers the best turmeric rates. Benefit-cost analysis is performed to speculate increasing cost incur of transportation from one district to different district's market which offers better turmeric rate. Results showcase, if Hingoli farmers sell their turmeric produce in Sangli market, on they can increase farm profit by 20% and by a minimum of 7% without any risk. Similarly, Nanded farmers can earn an increment in profit by 18% if they sell their turmeric produce in Sangli market. The major concern in the marketing of turmeric is still that its quality is judged via extrinsic metrics like length, thickness, the colour of the core and hardness of the turmeric finger or difficulty in breaking apart. Turmeric should be rated as per its curcumin content for transparent and regulated pricing. This is practiced only by the pharma or oil industry and yet to be practiced at the marketyard level.

KEYWORDS: Farm profits, Benefit-Cost ratio, Turmeric, Market, Maharashtra

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CHAPTER 1

Introduction

India is the world′s largest producer, consumer, and exporter of turmeric. In the last 30 years, the area, production, and productivity of turmeric exhibited an increasing trend, and the production has moved up at an annual growth rate of 7.6% and area at 2.8%. The productivity also doubled during this period. Indian turmeric is regarded as the best in the world market because of its high curcumin content.

Turmeric farming leads to different grades of turmeric which can be marketed at different levels of processing. The post-harvest turmeric can be marketed in form of wet-seeds, dry turmeric seeds, polished dry fingers or powdered dry turmeric. For every stage of turmeric to be marketed involves investment costs in terms of processing i.e. drying, polishing and grinding. These processes are carried out by equipment of high capital costs; proxy for which are the rental services available in villages to carry out different processes. As per the stage and grade of turmeric, it avails different price in the market, for say, dry turmeric powder is priced more than wet-seeds because of the inherited processing costs. With increasing cost incur at every process, however delivering better price for turmeric, turmeric farmers face various trade-offs in marketing turmeric farm produce. Different markets provide different rates. The markets which offer better turmeric rates are often located farther from the near markets available to the farmers. There is a tradeoff between the increasing cost of transportation and the better rate which could be availed from the farther market. Farmers incur various types of costs in order to successfully complete a crop season. Land preparation, equipment on lease, labor, nutrient management, transportation and various other factors require farmers to invest in money. Some farming families are large with large number of family members while some are nuclear ones. Not many farmers invest in their education or even if they do, continue to follow patriarchal or traditional farm practices.

Lacking is any statistical or mathematical view of eyeing the scenario. Formulation of cost factors and revenue generation, analyzing these factors with respect to farm productivity can lead to meaningful findings. Analyzing majorly turmeric growing areas

and major turmeric markets can result in simple decisions whether the turmeric farmers can increase their farm profits in anyway. Whether or not the socio-economic factors affect the farm productivity and accordingly if any relevant findings of the study could be passed on to the farmers so that they could increase their farm profits.

The study is focused in the few of the major turmeric growing districts of Maharashtra namely − Hingoli, Sangli, Nanded. Firstly, know−how of turmeric farming is gained with the help of online literature available, on-ground research by talking to various focus groups involved in turmeric farming. Secondly, all the cost factors and socio-economic factors with respect to an individual turmeric farm is analysed against the farm productivity. Thirdly, benefit-cost analysis of new market selection for turmeric marketing for an individual turmeric farmer is carried in lieu of increment in farm profit.

Objectives−

- Studying the know-how of turmeric farming and turmeric marketing with focus on turmeric farmers along with other involved groups: turmeric traders, turmeric marketyard, and vendors for post-harvest turmeric procedure.
- Analyzing cost-factors w.r.t farm productivity.
- Analyzing socio-economic factors w.r.t. farm productivity.
- Decision Support to farmers for better farm profits via Cost-Benefit analysis of shifting to new turmeric markets.

CHAPTER 2

About Turmeric and On-ground Research

2.1 About Turmeric

Turmeric is an important spice grown in India since ancient times. It is referred as Indian saffron and commonly called as Haldi in India. It is reported to have originated in India. It is scientifically known as Curcuma longa. India is the largest producer and consumer of turmeric.

Turmeric is a perennial shrub grown for its underground rhizomes. The roots have a unique flavour and colour that are used for various purposes ranging from culinary uses, food processing and pharmaceutical industry.

2.1.1 Economic Importance

Rhizomes are economically important part and they are dried, powdered and marketed for various culinary other purposes. It is a common ingredient of Indian curry and other food preparations particularly in south Indian cooking. Turmeric is also known for its medicinal value and it′s used as an antiseptic in India since ancient times. It is widely used in dye, drug and cosmetic industries. It is also used in pujas and religious ceremonies.

2.1.2 Climate and Cultivation

Turmeric is a plant that is cultivated and propagated with the help of its rootstalk. It needs hot and humid climate. Well suited for light black or red soils that are clayey in nature. It comes up well at temperature between 20°C to 30°C and an annual rainfall of about 150 cm. It is grown from the sea level to 1200 meters above mean sea level. The harvesting of this plant is done when the leaves of this plant start turning yellowish after 7 to 10 months of plantation. The plant is harvested by digging the rootstalks up.

2.1.3 World Scenario

India is the largest producer of turmeric and apparently accounts for more than 80% of the world′s production. As per the report published by the APEDA, apart from India, China contributes for about 8% of world′s turmeric production followed by Myanmar with 4%, Nigeria and Bangladesh with 3% each share in total turmeric production in the world.

2.1.4 Domestic Scenario

India is apparently the largest producer, consumer and exporter of turmeric in the world. Turmeric is the third largest spice produced in the country and it accounts for about 14% of total spices produced in India. Turmeric production has been rising steadily but slowly during the past decade particularly due to rise per hectare yields despite near stagnation in area under cultivation. As per the latest available estimates from the Spices Board of India, turmeric output rose to about 12.5 lakh tons in 2011-12 from about 7-8 lakh tons in the middle 2000s. However, the estimates of Horticulture Board are lower than that of Spices Board at about 10.6 lakh tons in 2011-12 but indicate a similar growth trend.

2.1.5 State-wise production

Turmeric production is largely concentrated in southern states Andhra Pradesh and Tamil Nadu accounting for nearly 80% of total output in the country. Andhra Pradesh is the single largest producer of turmeric accounting for more than 60% of total turmeric produced in the country. Tamil Nadu is the second largest producer contributing for about 17% of output in the country followed by Maharashtra, Odisha, West Bengal and Karnataka.

2.1.6 Major Markets

The key varieties come from Erode in Tamil Nadu and Kadapa, Dugirala and Nizamabad in Andhra Pradesh. However, all such volumes of turmeric go to Sangli in Maha-

rashtra as it is one of the biggest centres for processing and polishing turmeric in India. Although good quality turmeric is grown in Sangli, it is more famous for processing and that has been in vogue for generations. Sangli accounts for almost 40-50% of India′s total turmeric processing. Sangli turmeric sells as Sangli brand all over the country and also in foreign countries and no other person or any institution can sell their turmeric with the label of "Sangli Halad" in the market and Sangli Halad is recognised as Sangli brand in international market. Duggirala, Tenali, Cuddapah, Adilabad, Medak, Nizamabad, Guntur, Sangli serve as the major physical markets. NCDEX contributes for the future trading.India is the largest and net exporter of turmeric. On average India exports about 50 thousand tons of turmeric every year.Major export destinations for Indian turmeric are UAE, Sri Lanka, Bangladesh, US, Malaysia, Japan, UK and Iran.

2.2 Turmeric post-harvest process

Turmeric is harvested wet and stuck with mud. Fresh rhizomes are in bunch of fingers attached to the parent finger. This parent finger is 4-5 times thicker than the finger and called as mother rhizome. The curcumin content in the mother rhizome is higher than the finger. The harvested turmeric is grouped into mother and fingers. The wet muddy rhizomes are washed off with water to remove the dirt. With the help of boilers− steam, water, electric; the turmeric is boiled to remove the attached dirt. Post boiling the turmeric fingers are sorted as per length and thickness and dried using natural process or dryers. The dried turmeric is later polished for market ready. The turmeric powder is made by grinding the turmeric dry fingers.

2.2.1 Preparing for Reaping

Post 8-10 months, the turmeric leaves start to appear yellowish in colour. Approximately on the 240th day, the water is terminated to the crop. 15 days after termination of water, the leaves are cut off. The farm is left in this state for 8 days in order to make ready for reaping turmeric rhizomes.

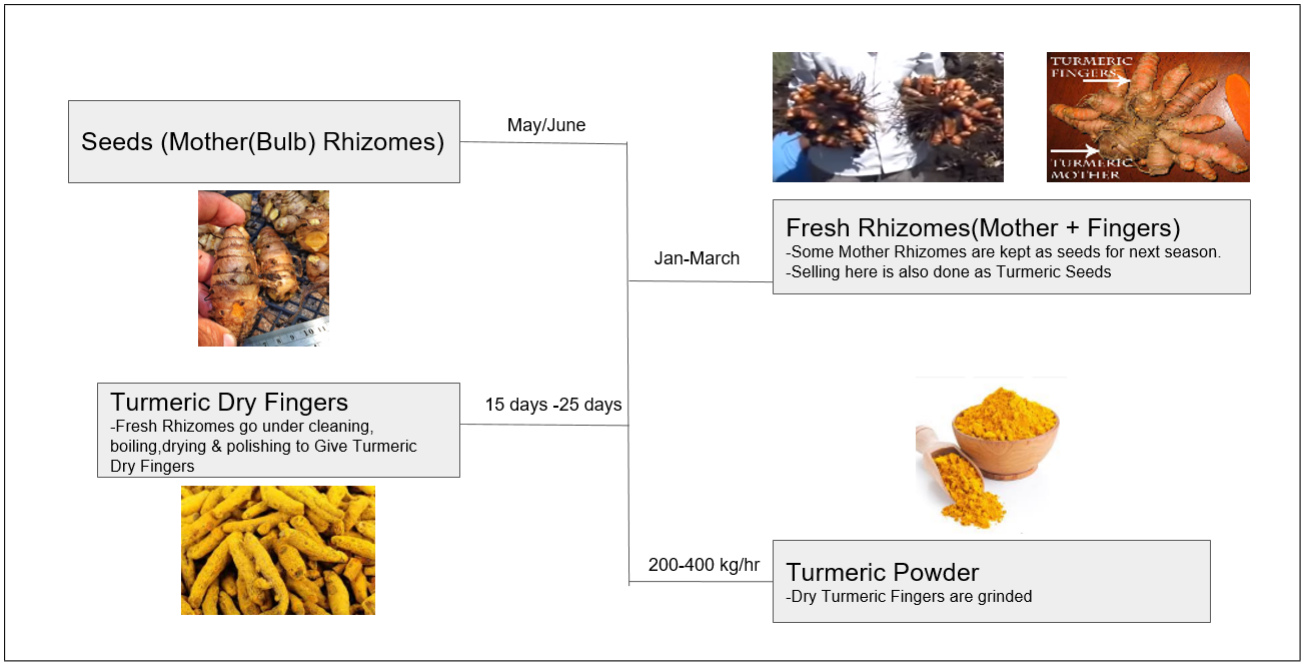

Figure 2.1: Turmeric Phase (*Turmeric post-harvest process*)

2.2.2 Reaping Out

Using tractor or labour the turmeric with mud stuck around is reaped out. Tractor assisted with turmeric digger blades takes 3-4hours while labour takes 3-4 days which includes cleaning and segregation into mother and finger rhizomes.

2.2.3 Cleaning and Removing Dirt

Manually cleaning off the dirt using labour takes 1-2 days. There are few innovative ways practiced by large processing units using the washing line. All the mud is removed and the rhizomes are segregated into mother (bulb) and fingers. These rhizomes are ready to be sold in market as seeds. Depending on the type of turmeric, the seeds range from 3000 rupees to 8000 rupees per quintal.

2.2.4 Preservation and Storage of Seed Rhizomes

The reaped out rhizomes are stored in heaps covered with dry turmeric leaves in well ventilated rooms. The other common way to store turmeric is to keep in pits with saw dust, sand and along with the leaves of karjiram. The pits are covered with wooden planks with 1 or 2 openings for aeration. The rhizomes are to be dipped in quinalphos

(0.075%) solution for 20-30 minutes if scale infestations are observed and in mancozeb (0.3%) to avoid storage losses due to fungi. Boiling is carried out within 3-4 days post harvesting.

2.2.5 Boiling

The rhizomes separated into mother and finger rhizomes are boiled separately. Earlier boiled using water, with the new method founded by TNAU, steam boilers are used which are capable of delivering 10 tons/day. The boiler consists of drums which contain turmeric. Fodder or wood or animal waste is used as a common source for fuel. The completion of the boiling process is tested by pricking the turmeric with a matchstick, turmeric easily breaks by fingers, and it is yellow from inside instead of darker colour/red with a tar. Boiling process is also indicated by the white fumes and typical odour of turmeric is received. The Boiler types depends on the capacity and number of drums used. The Boiler costs varies between 2-4 lakhs.

2.2.6 Drying

The boiled turmeric is to be dried. Sarees or jute bags are spread on the floor over which the turmeric is laid to dry. Mother and Finger Rhizomes are separately dried. Rhizomes are covered with heap of leaves in the night. Drying this conventional way usually takes 3-4 weeks. Artificial drying is available using Solar Tunnel Dryers which completes the entire process in 3-4 days. The solar tunnels can be used as warehouse too. A 500 square feet solar tunnel costs around 1.2 Lakhs. These solar dryers also act as warehouses with some ventilation available. No harm occurs even if it is stored for long.

2.2.7 Polishing

The dried hard turmeric is polished for shine and enhanced golden-yellowish. The turmeric fingers are put in the polisher′s drum and allowed to rotate, rubbing turmeric against each other and the inner walls of the drum. 1-2 Kg of turmeric powder is poured in the drum amplifying the yellow bright colour of the dry turmeric seeds received. Pol-

ishing machine drums are able to polish 2 quintals of turmeric in every 25-30 minutes. Post polishing only 20-25% of the rhizome yield is produced. After polishing, turmeric is marketed without any delay, if not, it is kept in clean sacks and stored over wooden pallets in stores to avoid any moisture catch.

2.2.8 Grading

By manual handpicking dry turmeric fingers are segregated into less than 2-3 cm, 2-3 cm and more than 2-3 cm fingers. Turmeric is packed in jute bags/gunny bags and sent to market for trading.

2.2.9 Grinding

Various types of turmeric is grinded together to get the right golden/yellowish market ready colour. Powdering or grinding is done by the large scale industries or small companies which are into selling turmeric powder or turmeric products. Some households also grind turmeric fingers to consume unadulterated turmeric. Depending on capacity, grinding machines are able to powder 50-400kg of turmeric per hour.

2.3 On-ground Research

In order to strengthen the know-how of turmeric farming, post-harvest process and marketing, on-ground research was conducted. Sangli, Maharashtra was chosen as the research site. Sangli is acknowledged as the biggest turmeric market in India. Nearly 40-50% of turmeric processing and marketing is carried out in Sangli market. The entire supply chain of turmeric could be identified in Sangli which includes the following focus groups: turmeric farmers, turmeric input supplier, post-harvest machinery vendor, turmeric traders in the marketyard and wholesale buyers bidding for turmeric. Post-harvest machinery vendor, few turmeric traders in the marketyard, auction in the marketyard and handful of turmeric farmers were talked to. Researched online using Indiamart and sites alike, meetings were set with turmeric traders via call who later post meeting provided the contacts of other aforementioned focused groups. Findings and

information collected from each group or experience at the turmeric auction is follows-

2.3.1 Post-Harvest Machinery Vendor

Processing Manufacturing Unit - Atharva Industries

Set up in 10000 square feet space, the post-harvest processing machinery manufacturing unit was specialised in making machinery required at various stage of turmeric farming.

Harvesting Unit

Harvesting unit is placed at the mouth of the tractor and used for reaping out turmeric rhizomes. It requires high amount of maintenance in terms of oiling and greasing. Within 3-4 hrs, it′s capable of harvesting the complete field (1 Acre). Although, it executes at a far better speed of manually harvesting the field with the help of labour, it is not so recommended by farmers. Firstly, the teeth of the harvester break the rhizomes at indefinite length. Secondly because of turmeric contains more mud attached and firmly rooted, wear and tear of the harvester is high. Farmers consider it to be fragile and high maintenance. It comes in two models depending on tractor. For a 27 HP tractor, it costs 70 thousand rupees while for a 35 HP tractor, the cost clocks upto 1 lakh rupees.

Boiler

With a life of 5-6 years, the boiler comes in 2 or 4 drums. Working on steam boiling procedure, the steam takes 1-1.5 hr to build up and then in every 20 minutes every barrel yields out boiled turmeric. The best boiler could yield 800kg in an hour. Each year the boiler needs to oiled and greased costing around 1000 bucks. Depending on the capacities, the cost of boiler range from 2 -4.5 lakhs. Available from 250-3000 litre capacity, the 3000 litre boiler costs 4.3 Lakhs.

Dryer

Drying turmeric seeds can be done using solar UV sheds, kept in open with few measures to follow and by dryer. Dryer has a steel body which using electricity dries the turmeric. Costing up-to 8-10 lakhs rupees blackens the turmeric if not done in the optimised way.

Polishing Drum

Polishing drum comes in two types: inside wall with bamboo sticks or steel. Operating on energy conversion basis using tractor/motor/engine, the drum polishes 2 quintals in every 25-30 minutes and about 5-8% turmeric loss is found. Steel polishing drum is avoided since it blackens the dry turmeric. The polishing drum costs in the range of 1.2-1.5 Lakhs.

Pulveriser

Households or Farmer Producer Organization utilise pulveriser to grind turmeric to prepare turmeric powder. As per the capacity pulveriser ranges from five thousand rupees to 1 lakh.

2.3.2 Turmeric Auction at Sangli Marketyard

All the turmeric bought by the trader from the farmer is auctioned. Bidding is raised by the wholesale buyers who are usually associated to brands like Patanjali, ITC and other various scale companies. Auction takes place every day in the harvest season. Every street in the marketyard is given a slot in the week and the duration of the slot is a 3-hr window. Commission rates of traders in Sangli Marketyard is 3%. Best period of auction is April. Real-Time auction takes place. There are several quality metrics checked by the buyer. These quality metrics decide the rate of the turmeric. These quality metrics are:

- Length of the Turmeric Finger- More the length of the finger, higher the rate. More than 3-4 cm long fingers are the rated highest, 2-3cm rated moderately and less than 2cm is rated poorly.

- Thickness of the Turmeric Finger- More the thickness of the finger after its length, more the rate.
- Colour of the core of the Turmeric Finger- Turmeric Finger is broken to quickly observe the colour of the core of the finger. Darker the saffron colour, better is the curcumin value in the turmeric and rated higher.
- Shine of the Turmeric Finger- Better polished the turmeric, better its shine, and better its rate in the market. More the golden yellowish colour of the turmeric, better its rate.
- Uniformity in the produce- Homogeneity in the produce should be there. The above metrics should be uniform in a stock.

Bidding starts with a ground rate and as the buyers bid higher and higher the rates rises up. Once no one bids any higher within a time frame (counting from 1 to 3), the produce is sold to that buyer at that particular rate. Traders in the market claims, any turmeric brought in Sangli marketyard is definitely sold and at a healthy price.

2.3.3 Meeting Traders at Sangli Marketyard Traders

In order to understand how to grow best turmeric, meetings were arranged with few traders. Apart from the information collected from research papers and literature, few tips and advice were received from the experience of the traders.

Shivam Traders

Shivam traders deals in polishing, powdering and trading turmeric. According to him, boiling rate is around 120 rupees per drum and it takes 95 number of drums per acre summing up 12 thousand rupees for boiling turmeric. Polishing unit price is 130 rupees per bag. One bag had 70-75 kg. Polishing can help in increasing the rate by 5-6 rupees. Powdering incurs a cost of 4-4.25 rupees per kg. In order to sell powdered turmeric in packet direct to consumer, few licenses are required. Humid climate is bad for turmeric farming.

Dilip Traders

Dilip traders deals in trading and selling powdered turmeric direct to consumers. Dilip differentiated between Pragati and Selam turmeric types. Because pragati is a 6 month crop, it deteriorates fast. The yellow-saffron colour of the dry turmeric blackens/reddens. Pragati catches moisture faster and curcumin percentage falls. Good thing

about Pragati is that it can be sown twice a year with marketing it as soon as it is harvested and increase the yield of any other crop harvested on the previous turmeric field. Pragati is rated around Rs.75-80/kg. Selam is an 8-10 months turmeric and does not deteriorates making its storage easies. Powdering is done by mixing 2-3 types of turmeric with flavouring and other colour adding for the perfect market fit turmeric. Organic test lab report is required to prove the produce is organic which yields high turmeric rate. About 25% recovering post boiling and drying, 3-5% loss in polishing, 3-5% loss in powdering.

Khimji

Another trader in the market, candidly stated the market values the colour and the girth of the turmeric fingers and hardly cares about curcumin value. More the golden colour and harder it is to break the finger, higher the rate.

Spectrum

Spectrum trader practices dry turmeric to powder supply chain business. Curcumin is not highly valued in powder. 2-3% received post drying and grinding is good to go. Further processes including refining testing and polishing turmeric. Mixing with particular oil and yellow turmeric to receive go-to-market product. Pharma and oil sector best values the curcumin content.

2.3.4 Meeting Farmers at Shirgat Village

With the help of traders, Shirgat village was targeted to meet few turmeric farmers in order to visit turmeric farms and understand more about turmeric farming.

Few of the farmers with whom meetings were done- Vitthal Desai (Ph. No. - 8830006110), MaanSingh Desai (Ph. No. 9049326950), Arun Madhav Desai (Ph. No. 8806637642), Yashwant Pandit (Ph. No. 8605960492).

Seeds are sown in April. Cleaning and boiling is done and simultaneously drying is carried out. Boiling requires 4 drums at 120-130 rupees per drum. The boiling vendor is hired along with the labour. Takes around 1.5hrs time for steam to get boiled and then in every 20 mins each barrel gives out boiled turmeric. 1 ton of log wood is used for fuel for steam. Post boiling, the turmeric is spread on ground for 20 days.

Farmers don′t value or know very little about curcumin. Neither about the water waste of turmeric which is highly valuable.

Like traders, farmers also concentrate on the outside metrics of turmeric i.e. the girth of the inner core of turmeric and brighter saffron colour of turmeric. Harder it is to break the turmeric finger, better the price.

Mother rhizome sown in the previous season is harvested as *Chaura* for the next season and yields highest price, even clocked 250 rupees per kg. Mother rhizome (*Angta*) harvested for the current season is re-sown and some sold at 110-150/kg rate. Long length turmeric (*Kandka*) and smallest turmeric (*Kuni*) are sold in to the trader which later gets auctioned in the marketyard.

Finding labour and getting secured rates is the biggest challenge for the farmers. Best season clock the profit at 1.5-1.8 Lakhs while when the market is low breaking-even is also a challenge. Unfair investment in nutrient management was observed. Some farmers only used manures and no fertilisers or pesticides. Some farmers did not even conducted soil test and did not improvements in the farm activities as per the soil conditions. Subsidized fertilisers were bought more often and in larger quantities by the farmers.

CHAPTER 3

Methodology and Analysis

3.1 Model Selection

The decision making process or mathematical analysis of any production involves the analysis of the relationship of Factor-Product (output) or input-output relationship. The production is observed with respect to its input factors. Cobb Douglas production function is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs (particularly physical capital and labour) and the amount of output that can be produced by those inputs. In its most standard form for production of a single good with two factors, the function is

$$Y = AL^{\beta}K^{\alpha}$$

Where:

- Y = total production (the real value of all goods produced in a year or 365.25 days)
- L = labour input (the total number of person-hours worked in a year or 365.25 days)
- K = capital input (a measure of all machinery, equipment, and buildings; the value of capital input divided by the price of capital)[clarification needed]
- A = total factor productivity and your usual depreciation by utility in day after[clarification needed]
- α and β are the output elasticity of capital and labour, respectively. These values are constants determined by available technology.

Output elasticity measures the responsiveness of output to a change in levels of either labour or capital used in production, ceteris paribus. For example, if α = 0.45, a 1% increase in capital usage would lead to approximately a 0.45% increase in output.

Sometimes the term has a more restricted meaning, requiring that the function display constant returns to scale, meaning that doubling the usage of capital K and labour L will also double output Y. This holds if

$\alpha + \beta = 1$,

If

$\alpha + \beta < 1$,

returns to scale are decreasing, and if

$\alpha + \beta > 1$,

returns to scale are increasing. Assuming perfect competition and $\alpha + \beta = 1$, α and β can be shown to be capital′s and labor′s shares of output.

In its generalized form, the Cobb-Douglas function models more than two goods.

The Cobb Douglas function may be written as:[2]

$$f(x) = A \prod_{i=1}^{L} x_i^{\lambda_i}, \qquad x = (x_1, \ldots, x_L).$$

where:

- A is an efficiency parameter
- L is the total number of goods
- x1, ..., xL are the (non-negative) quantities of good consumed, produced, etc.
- λ_i is an elasticity parameter for good i

The Cobb Douglas production function is especially notable for being the first time an aggregate or economy-wide production function had been developed, estimated, and then presented to the profession for analysis; it marked a landmark change in how economists approached macroeconomics from a microeconomics perspective.

The function can be written in logarithm format:

$$LogY = LogA + \beta LogL + \alpha LogK$$

This can be compared to a a multivariable regression function:

$$y = a_1x_1 + a_2x_2 + ... + a_nx_n + c$$

Here

$$y : LogY, x_1 : LogL, x_2 : LogK, c : LogA, a_1 : \beta, a_2 : \alpha$$

3.2 Survey Form Preparation

To analyse the cost factors and socio-economic factors with respect to farm productivity, this study also utilises Cobb-Douglas function to model the data.

After understanding know-how of turmeric farming with the help of online literature, on-ground research and Cobb-Douglas production function, different cost factors, farmer details and revenue streams from the turmeric production is jotted down. Starting from land preparation to seeds bought, labour charges, equipment lease, cost incur in nutrient management, and transportation costs are included. Farmer details involves basic contact details, family size and education. Revenue streams includes revenue generated from marketing turmeric at various stages. In order to collect data from the farmers, a single page survey form is prepared.

3.3 Data Collection

Hingoli, Nanded and Sangli are the top three districts in Maharashtra which cultivate turmeric. With an aim of meeting 10 farmers each day, a two week long plan was made to meet 120 farmers. To avoid any skewness in the data collection following constraint was followed -4-5 villages from each district and meeting only 8-10 farmers from each village.

All the government schemes or policies are incorporated using the system of Farmer Producer Organization. Farmer Producer Organization (FPO) is a group of farmers which enables the farmers to form a collection benefitting them to avoid any exploitation from the market traders, easy dissemination of government schemes to the farmers. Basically FPOs act as a top down approach to reach out to farmers. The FPOs are led

Name:	Ph. No:
Village:	District:
Farming Experience:	Education:
Family Size:	#Dependents:

Turmeric Type			
Farm Area			Total Area:
Irrigation Type	☐ Rain-Fed	☐ Drip	☐ Well Other:

Land	☐ Lease Amt: Rs.		☐ Own #Old:	Land Rate:	
Land Preparation		Irrigation System			
Equipments/MC till Harvest	Rental: Rs.		Own: Rs.	#Yrs:	var.cost:
	Items:				
Storage Facility ☐	Area:	Lease: Rs.	☐ Own	#Yrs:	Fix.Cost: Var. Cost:
Washing/Cleaning	Labour:	☐ Equipment	Rent:	#Yrs:	Fix.Cost: Var. Cost:
Boiling	Labour:	☐ Equipment	Rent:	#Yrs:	Fix.Cost: Var. Cost:
Drying	Labour:	☐ Equipment	Rent:	#Yrs:	Fix.Cost: Var. Cost:
Polisher	Labour:	☐ Equipment	Rent:	#Yrs:	Fix.Cost: Var. Cost:
Grinding	Labour:	☐ Equipment	Rent:	#Yrs:	Fix.Cost: Var. Cost:
Seed/rhizomes	Type:	Rate:	Amt:	Where:	Transportation:
Nutrient Mgnt	Fertilizers:		Manures:		Pesticides:
Labour	Pre-Sowing:	Sowing	During	Harvesting	Postharvest Misc.
	Rate: Rs.				
	Hrs				
Loan	Amount:	Rate:	Timeperiod:	Type:	
Transportation					
Miscellaneous					

Seed Stage	Rate	Amt. Total	Quantity Sold (Min-Max)	Quantity Retained	Sold where?	Time Period
Rhizomes/Wet						
Dry Rhizomes						
Polished Fingers						
Polished Fingers II						
Powdered Turmeric						
Best Turmeric Stage to Prep. and Sell						
Quality Metrics of Turmeric						

Figure 3.1: Survey Form to collect data from farmers

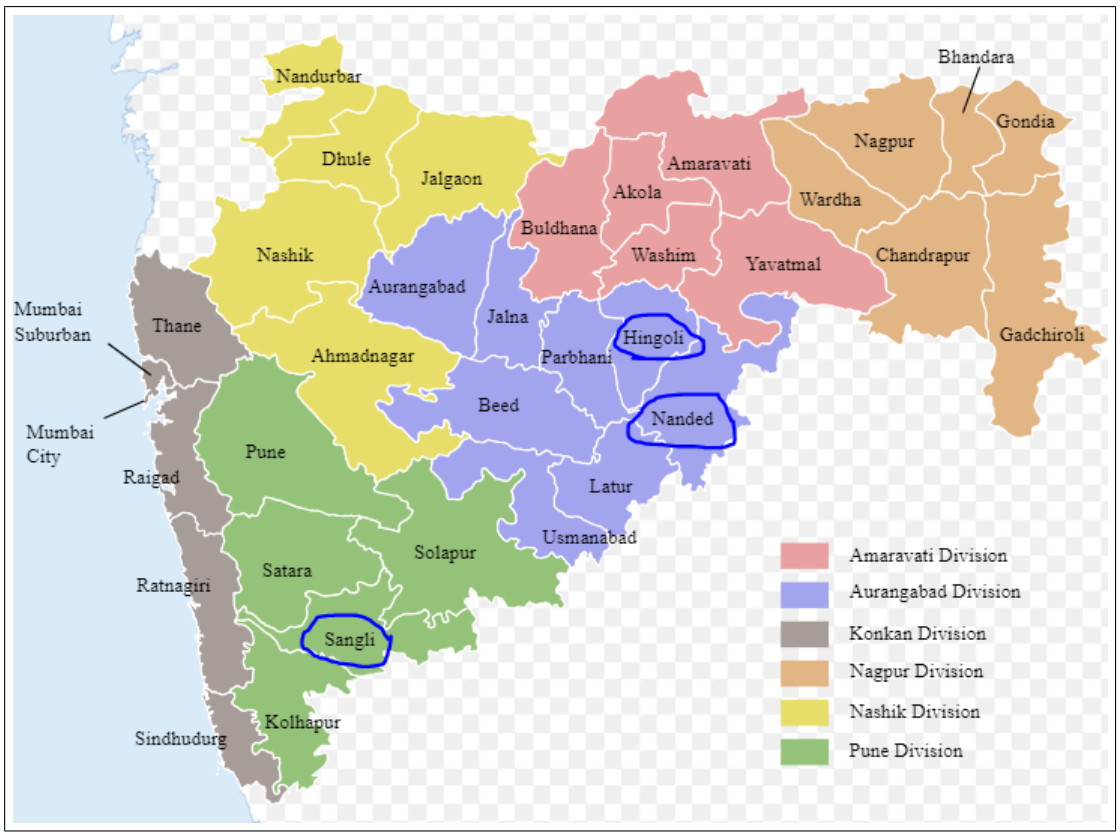

Figure 3.2: Focused Districts for the study

by the FPO leader who is also a farmer. The FPO leader initiates the formation of FPO and registers the farmers. The FPO is registered with its name and the FPO leader gets a nominal remuneration for the service carried out. The FPO strength varies from group of 50 farmers to 500 farmers. The farmers of the same FPO generally grow similar crops. In order to reach out to FPOs, state government generate an easy to reach out directory of FPOs containing name of the FPO, contact details, village name, districts, crops grown and number of farmers associated.

From the FPO directory, meetings were arranged with FPOs in the three districts. Marathi language as a barrier, intern (Swapnil) for the data collection was hired. 120 farmers were interviewed from the 3 districts travelling across 15 villages.

In order to create decision support for farmers to earn better farm profits by shifting to better markets, transportation vendors were approached to collect best quotes for transporting one farm acre produce.

The Time-Interview Quality Bias

During data collection, hard constraints were followed to interview the farmers in-

dividually and avoid answers in groups. Finding and interviewing individual farmers at their farms or homes yielded dissimilar data. However, consumed fair amount of time. When approached group of farmers for data collection, time consumed was drastically lesser but the answers were similar and generated bias while providing the information. Constant efforts were made to avoid as much as it can be avoided to generate dissimilar, unbiased and non-chorused data. Factually evident, there were few farmers who led the farming activities in the village and other farmers just followed which these lead farmers performed.

3.4 Data Cleaning and Preparation

120 survey forms were digitalized to the excel sheet. Missing values while interviewing farmers were averaged out for that particular district. Subjective information was coded in numerical value. For example, education, following rating was given with respect to the milestone of education:

- 1-7th Standard : 1
- 8th -9th Standard : 2
- 10th -11th Standard : 3
- 12th Standard : 4
- Bachelors or any education further : 5

While collecting data, farmers were not able to tell exact per acre calculation for different factors. Information was collected as told and later per acreage calculation was done. While data cleaning, factors versus the dependent variable productivity were plotted to investigate any outliers are present. When back checked, few of the data points were not calculated per acre. Data cleaning involved investigating such data points and respective measures were performed to correct the data for further modelling.

Data was further divided into two categories: Cost Factors Data and Socio-Economic Data. The two different datasets were modelled to analyse factors versus farm productivity. Various cost factors which received less amount of data were removed. Similarly for revenue streams factors, farmers sold only dried rhizomes in the market. Very few

sold wet rhizome seeds amongst their group of farmers. Farm productivity is only accounted for amount of dried rhizomes processed from an acre of farm.

3.5 Data Modelling

3.5.1 Modelling Cost Factors Vs Farm Productivity

Cobb- Douglas production function which finds its application in modelling product vs inputs factors is used to model the data collected for turmeric farming. R is used for data modelling.

If productivity is modelled against the various input factors using Cobb-Douglas production function, then:

$$Log\textbf{Productivity} = coefficient_1 Log\textbf{InputFactor}_1 + coefficient_2 Log\textbf{InputFactor}_2 + ...$$

$$coefficient_n Log\textbf{InputFactor}_n + intercept$$

Modelling using 15 cost factors (maximum): Model 1

Model 1 Cost Factors:

Irrigation System cost, Equipment Lease cost, Seed Rate, Seed Amount, Harvesting Labour cost, Sowing Labour cost, During Season Labour cost, Pesticides cost, Ferilizer cost, Manure cost, Washing Cleaning cost, Boiling cost, Drying cost, Polishing cost and Transportation cost.

Correlation heat map of all the 16 factors; 15 cost factors and productivity factor is created to observe correlation and if few variables can be combined.

Model 1 is summarised to observe the coefficients and R-square.

In order to test further models, similar factors were grouped together to model using 10 cost factors- Model 2

The labour factors ie. Sowing Labour Cost, During Season Labour Cost and Har-

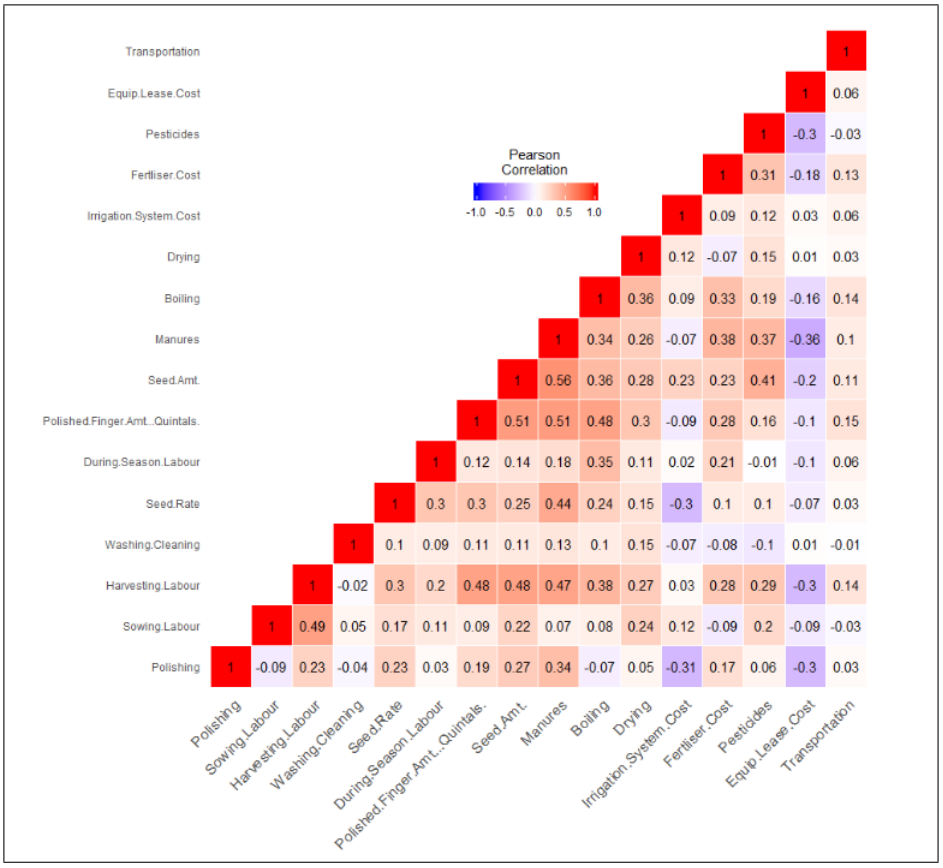

Figure 3.3: Correlation Heat Map for Model 1

Coefficients:

	Estimate	Std. Error	t-value	Pr(>|t|)	Significance
(Intercept)	-0.424644	0.7698	-0.552	0.58291	
log(train$**Irrigation.System.Cost** + 1)	-0.013927	0.011682	-1.192	0.237087	
log(train$**Equip.Lease.Cost** + 1)	0.032497	0.031823	1.021	0.310582	
log(train$**Boiling** + 1)	0.04105	0.067226	0.611	0.543366	
log(train$**Drying** + 1)	0.007902	0.01437	0.55	0.584109	
log(train$**Polishing** + 1)	-0.048661	0.053149	-0.916	0.362953	
log(train$**Seed.Rate** + 1)	0.089559	0.085747	1.044	0.299769	
log(train$**Seed.Amt.** + 1)	0.32998	0.10525	3.135	0.002486	**
log(train$**Pesticides** + 1)	-0.033004	0.014995	-2.201	0.030942	*
log(train$**Harvesting.Labour** + 1)	0.234867	0.065929	3.562	0.000656	***
log(train$**Sowing.Labour** + 1)	-0.015259	0.033035	-0.462	0.645552	
log(train$**During.Season.Labour** + 1)	-0.012752	0.018181	-0.701	0.485329	
log(train$**Washing.Cleaning** + 1)	0.015292	0.007244	2.111	0.038249	*
log(train$**Transportation** + 1)	0.022298	0.061704	0.361	0.718879	
log(train$**Fertliser.Cost** + 1)	0.056043	0.020579	2.723	0.008105	**
log(train$**Manures** + 1)	0.007416	1.097	0.276162		

Multiple R-squared:	0.5553
Adjusted R-squared:	0.4627
p-value:	7.14E-08
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1	

Figure 3.4: Summary Model 1

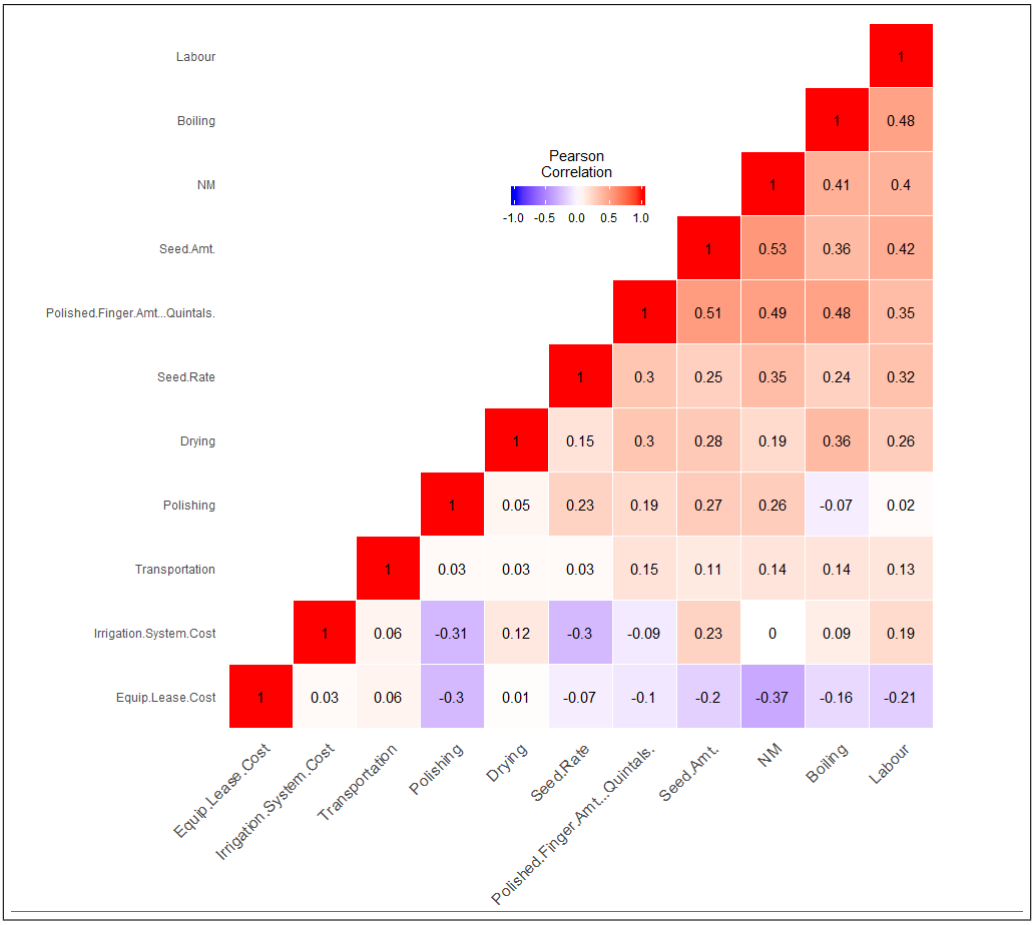

Figure 3.5: Correlation Heat Map for Model 2

vesting Labour are clubbed together to form a single factor Labour Cost. Similarly, Fertiliser cost, Pesticides cost and Manure Cost factors are clubbed together to form nutrient management cost (NM cost).

Model 2 Cost Factors- *Irrigation System cost, Equipment Lease cost, Seed Rate, Seed Amount,Labour cost, NM cost, Boiling cost, Drying cost, Polishing cost and Transportation cost.*

Correlation heat map of all the 11 factors; 10 cost factors and productivity factor is created to observe correlation and if few variables can be combined.

Model 2 is summarised to observe the coefficients and R-square.

The R-square observed for this model is worse than the model 1. The factors are further grouped to reduce the factors to 8- Model 3

Post harvest processing factors i.e. boiling, drying and polishing factors are clubbed together to form Post Harvest Treatment cost factor.

Coefficients:

	Estimate	Std. Error	t-value	Pr(>|t|)	Significance
(Intercept)	-0.361452	0.840968	-0.43	0.66855	
log(train$**Irrigation.System.Cost**	-0.011288	0.014002	-0.806	0.42265	
log(train$**Equip.Lease.Cost** + 1)	0.038488	0.040669	0.946	0.34697	
log(train$**Boiling** + 1)	0.186326	0.071243	2.615	0.01075	*
log(train$**Drying** + 1)	0.016376	0.015129	1.082	0.2825	
log(train$**Polishing** + 1)	0.032928	0.057133	0.576	0.56609	
log(train$**Seed.Rate** + 1)	0.187035	0.116366	1.607	0.11214	
log(train$**Seed.Amt.** + 1)	0.26704	0.090585	2.948	0.00425	**
log(train$**NM** + 1)	0.00685	0.014738	0.465	0.64342	
log(train$**Labour** + 1)	-0.002084	0.019857	-0.105	0.91669	
log(train$**Transportation** + 1)	0.025495	0.071456	0.357	0.72224	

Multiple R-squared:	0.3617
Adjusted R-squared:	0.2777
p-value:	9.03E-05
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1	

Figure 3.6: Summary Model 2

Model 3 cost factors- *Irrigation System cost, Equipment Lease cost, Seed Rate, Seed Amount,Labour cost, NM cost, Post Harvest Treatment cost and Transportation cost.*

Correlation heat map of all the 10 factors; 9 cost factors and productivity factor is created to observe correlation.

Model 3 is summarised to observe the coefficients and R-square.

The R-square observed for this model is worse than the model 2.

Summarising the R-Square, Adjusted R-Square and p-value received using the three models.

With best R-Square, least difference between R-Square and adjusted R-Square and very small p-value, model 1 (R-Square = 0.5553, Adj. R-Square = 0.463 and p-value = 7.13E-08) suits best to model this data. Constructing the function from the model:

<Equation Received âĂŞ short form for the variables to express it better >

3.5.2 Modelling Socio-Economic Factors Vs Farm Productivity

Socio-Economic factors taken in consideration: Family Size, Dependents, Education, Farming Experience and Farm Area.

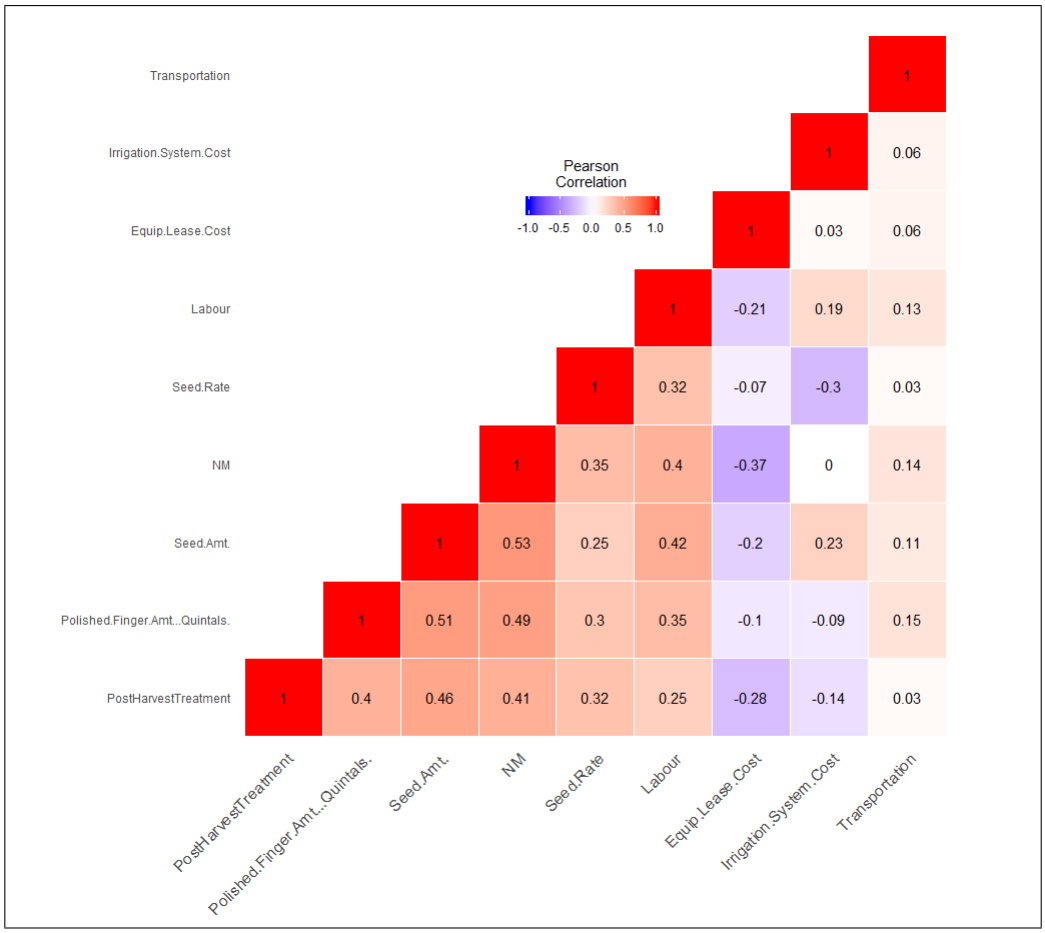

Figure 3.7: Correlation Heat Map for Model 3

Coefficients:

	Estimate	Std. Error	t-value	Pr(>|t|)	Significance
(Intercept)	0.797072	0.634958	1.255	0.212887	
log(train$**Irrigation.System.Cost** + 1)	-0.014914	0.013885	-1.074	0.285872	
log(train$**Equip.Lease.Cost** + 1)	0.005371	0.035683	0.151	0.880722	
log(train$**PostHarvestTreatment** + 1)	0.015056	0.021182	0.711	0.479217	
log(train$**Seed.Rate** + 1)	0.17927	0.101895	1.759	0.082201	
log(train$**Seed.Amt.** + 1)	0.327384	0.08874	3.689	0.000401	***
log(train$**NM** + 1)	0.018747	0.01178	1.591	0.115308	
log(train$**Labour** + 1)	-0.003049	0.022067	-0.138	0.890442	
log(train$**Transportation** + 1)	0.103957	0.069128	1.504	0.136419	

Multiple R-squared:	0.3476
Adjusted R-squared:	0.2847
p-value:	1.32E-05
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1	

Figure 3.8: Summary Model 3

Model	R Square	Adj. R- Square	p-Value
Model 1	0.5553	0.4627	7.13E-08
Model 2	0.3617	0.2777	9.03E-05
Model 3	0.3495	0.2875	9.96E-06

Figure 3.9: Summarising the Models for Cobb Douglas Function

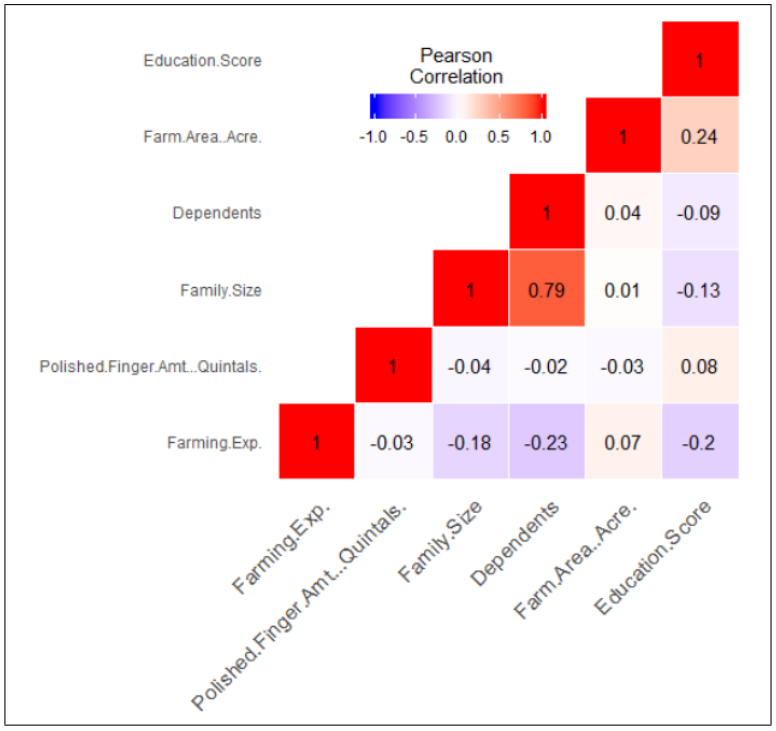

Figure 3.10: Socio-Economic Factors Correlation Heat Map

The data is modelled using linear regression to observe following:

Correlation heat map is created to observe correlation among the 6 factors:

Model:

The values of socio-economic factors are very small or vary a lot among the factors. Logarithm is taken over the factors to model it better. The model is summarised for observing the resulting R-square and coefficient of the variables.

A very poor R-Square value of 0.08012 is received. A positive significance is found

Coefficients:

	Estimate	Std. Error	t-value	Pr(>|t|)	Significance
(Intercept)	2.68695	0.36751	7.311	2.75E-10	***
Farming Exp.	0.08214	0.04372	1.879	0.0643	.
Family Size	-0.04714	0.20083	-0.235	0.8151	
Dependents	0.04089	0.13313	0.307	0.7596	
Farm Area	-0.04563	0.07925	-0.576	0.5665	
Education Score	0.21091	0.10385	2.031	0.0459	*

Multiple R-squared:	0.08012
Adjusted R-squared:	0.01712
p-value:	0.2854
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1	

Figure 3.11: Summary of Socio-Economic Model

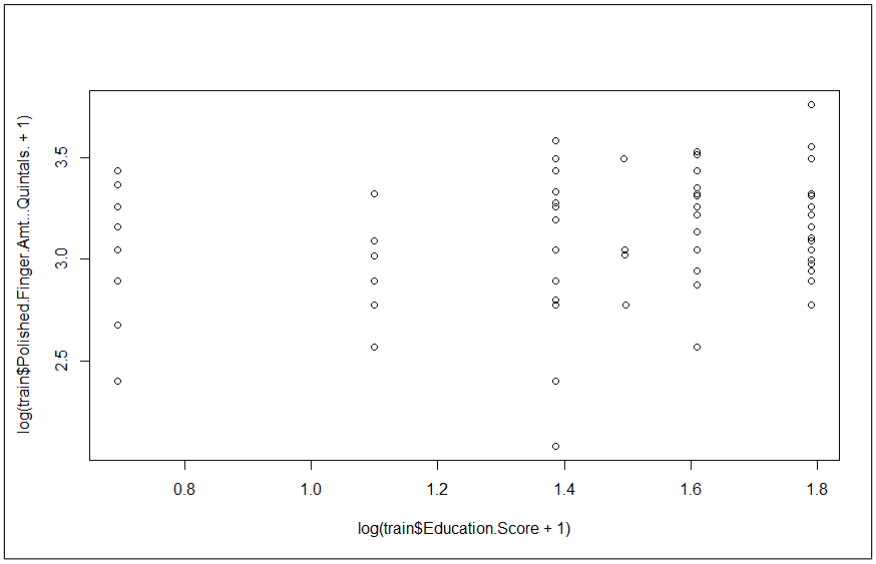

Figure 3.12: Log-Log plot for Education vs Farm Productivity

between education factor and farm productivity.

Education Vs Farm Productivity:

Log (Farm Productivity) $\propto$ Log (Education Score) by factor of 0.21091.

CHAPTER 4

Results and Inference

4.1 Modelling Cobb Douglas Production Function for Turmeric Farming

Modelling the data with the help of Cobb Douglas Production function involving 15 cost factors delivers R-Square of the model at 0.555, closer to its adjusted R-Square value (0.463) with a very low p-value 7.13E-08.

Harvesting Labour significance rates highest. It varies positively with farm productivity. Investment in fertiliser/nutrient management increases farm productivity. Equally important is seed amount for improving farm productivity quantity. Washing and cleaning, although very less farmers invest in washing and cleaning of turmeric seeds after they are reaped out, it directly related with farm productivity.

Few disparity is also observed in the modelling. Pesticides is negatively correlated with farm productivity. Increasing Irrigation system cost reduces farm productivity. Many of the labour factors also correlate negatively with farm productivity. From the correlation heat map, it is fairly evident that many factors correlate strongly with each other. Yet they cannot be grouped together because that does not correlate with the physical interpretation. Given more data points, the function could deliver a better significance between the factors and the dependent variable.

4.2 Analysing Socio Economic Factors Vs Farm Productivity

With no strong R-Square received in the linear regression multi-variable model, only education factor showed slight significance with farm productivity.

Farm Productivity $\propto$ Education Score by factor of 0.98607.

Coefficients:

	Estimate	Std. Error	t-value	Pr(>|t|)	Significance
(Intercept)	-0.424644	0.7698	-0.552	0.58291	
log(train$**Irrigation.System.Cost** + 1)	-0.013927	0.011682	-1.192	0.237087	
log(train$**Equip.Lease.Cost** + 1)	0.032497	0.031823	1.021	0.310582	
log(train$**Boiling** + 1)	0.04105	0.067226	0.611	0.543366	
log(train$**Drying** + 1)	0.007902	0.01437	0.55	0.584109	
log(train$**Polishing** + 1)	-0.048661	0.053149	-0.916	0.362953	
log(train$**Seed.Rate** + 1)	0.089559	0.085747	1.044	0.299769	
log(train$**Seed.Amt**. + 1)	0.32998	0.10525	3.135	0.002486	**
log(train$**Pesticides** + 1)	-0.033004	0.014995	-2.201	0.030942	*
log(train$**Harvesting.Labour** + 1)	0.234867	0.065929	3.562	0.000656	***
log(train$**Sowing.Labour** + 1)	-0.015259	0.033035	-0.462	0.645552	
log(train$**During.Season.Labour** + 1)	-0.012752	0.018181	-0.701	0.485329	
log(train$**Washing.Cleaning** + 1)	0.015292	0.007244	2.111	0.038249	*
log(train$**Transportation** + 1)	0.022298	0.061704	0.361	0.718879	
log(train$**Fertliser.Cost** + 1)	0.056043	0.020579	2.723	0.008105	**
log(train$**Manures** + 1)	0.007416	1.097	0.276162		

Multiple R-squared:	0.5553
Adjusted R-squared:	0.4627
p-value:	7.14E-08

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Figure 4.1: Summary Model 1

Log (Farm Productivity) $\propto$ Log (Education Score) by factor of 0.21091.

Farmers with a better education resulted in better farm productivity. This could be possibly of the farm practices carried out by them. Gaining better education would have built a better sincerity and which reflects in the above plots. Decision Support to farmers for better farm profits via Cost-Benefit analysis of shifting to new turmeric markets.

4.3 Benefit-Cost Analysis for shifting to better Turmeric Market

The turmeric farmers of the three districts, Hingoli, Nanded and Sangli approach their respective district's marketyard to sell their turmeric produce. Hingoli farmers sell their produce at Basmat market, Nanded farmers in Nanded marketyard while Sangli farmers at Sangli marketyard. However, the three marketyards offer different turmeric rates even though the three districts are part of the same state.

If the farmers of Hingoli or Nanded try to transport their produce to markets where

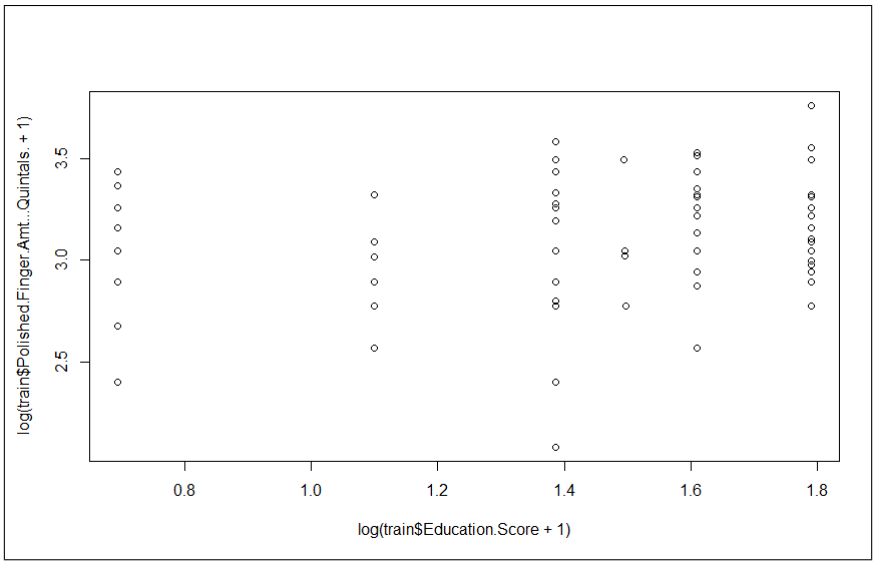

Figure 4.2: Log-Log plot for Education vs Farm Productivity

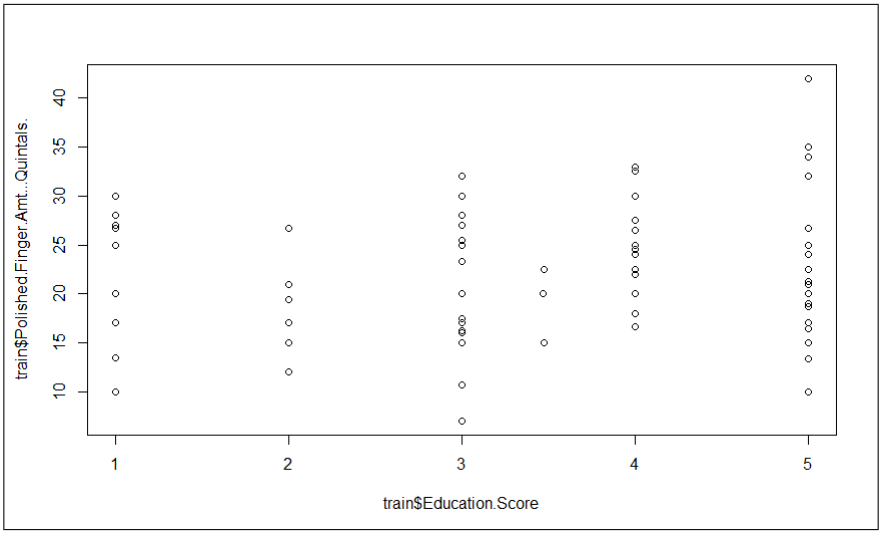

Figure 4.3: Education vs Farm Productivity

Marketyard	Turmeric Rate (Rs./Kg)		
	1st Q**	3rd Q	Avg
Basmath	65.000	75.000	71.378
Nanded	68.500	76.750	72.833
Sangli	85.000	95.000	89.260

Figure 4.4: Turmeric Rates in the three available markets

From (Farmer Place)	Marketyard	Transportation Cost*
Hingoli	Basmat	1530
	Nanded	2500
	Sangli	9000
Nanded	Nanded	2130
	Sangli	8000
Sangli	Sangli	1870

*Transportation Cost (Rs.)/30 Quintals Truck~ 1 Farmer)

Figure 4.5: Transportation cost from one district to other district's market

From (Farmer Place)	Marketyard	Transportation Cost*	Productivity (Quintals)			Extra Cost (Rs./Kg)		
			1st Q	3rd Q	Avg	1st Q	3rd Q	Avg
Hingoli	Basmat	1530	16.063	20.750	18.580	N/A	N/A	N/A
	Nanded	2500	16.063	20.750	18.580	0.604	0.467	0.522
	Sangli	9000	16.063	20.750	18.580	4.651	3.600	4.020
Nanded	Nanded	2130	17.232	24.000	20.755	N/A	N/A	N/A
	Sangli	8000	17.232	24.000	20.755	3.406	2.446	2.828
Sangli	Sangli	1870	22.500	30.500	26.190	N/A	N/A	N/A

Figure 4.6: Extra transportation cost incur/kg of produce

they could avail better price, how much extra cost will they incur for kilogram of the turmeric produce? The transportation costs for 25 quintals of produce via a 3 ton truck among the three districts.

If the Hingoli farmers plan to transport their produce to markets other than Basmat. Similarly, Nanded farmers plan to shift the selling of produce to Sangli marketyard. The extra cost incur in terms of Rs./kg of their district turmeric productivity:

Comparing the new rates at new market keeping in analysis the extra incurring cost of transportation, the cost-benefit analysis of shifting to a market offering better price:

If Hingoli farmers transport their turmeric produce to Sangli market, without any risk they will earn a minimum profit increment of 7% to a maximum of whopping 40%.

From (Farmer Place)	Marketyard	%Benefit Shifting to new Market incurring extra Transportation Cost		
		Min.	Max	Avg
Hingoli	Basmat	N/A	N/A	N/A
	Nanded	-9.47	17.36	1.31
	Sangli	7.13	40.62	19.42
Nanded	Nanded	N/A	N/A	N/A
	Sangli	6.31	35.12	18.67
Sangli	Sangli	N/A	N/A	N/A

Figure 4.7: Benefit-Cost Analysis of new market vs transportation cost

If the Nanded market rates are their lowest, Hingoli farmers may face a loss percentage of 9.5%. Average increment in profit is also not so significant, just 1%. Nanded farmers without risk can shift marketing of turmeric produce to Sangli marketyard and earn an average increment in farm profit by 18.5%. The farm profits can be much better if farmers group together in a bunch of 5/10 and try to transport together to the new markets offering better rates. Truck′s capacity to carry the turmeric produce will be the major constraint. Increased amount of turmeric in a single market at the same time can also reduce the turmeric rate. However, judging such dynamics at a raw stage is just hypothetical and left on trying and analysing the economies of scale.

CHAPTER 5

Summary and Conclusion

Farming in India is considered as a poor business and an occupation of hope. Lot of crop success for a season is dependent on climate. More than 60% farming is still rain-fed in India. Over the decades continuous efforts and development has been done by both the government and corporate sector to curb the dependency on rain-fed irrigation and several irrigation programs have been initiated. Rain dependent farmer has been affected ever since and sees the success of the crop directly in relation with the quality of monsoon. Poor monsoon seasons have left crops damaged and so affected the farmer financially in a drastic way. Failed crops have doomed the farmers with huge debts and cosmic interest rates to be paid to the lenders. It is no news and we are aware of the big numbers of farmers's suicides. Government has come into play in clearing off the dues of the farmers resulting in financial crisis for the banks and popular debates both politically and tax payers complaining about the least impact use of their money not supporting development. Coming to rescue are few companies which predict climate and weather conditions and communicate to farmers for them to take necessary precaution and measures to minimise the effect. If the climate is not in the hands of human power and rain-fed irrigation will still take another few decades to solve, what are the other dimensions we can see through to improve the agriculture sector of the country resulting in uplifting the lifestyle of a farmer which would further boost the rural economy empowering the other sectors?

Large percentage of farmers do not even conduct soil tests. Farmers in India lack access to reliable agricultural information. A nationally representative survey suggests that less than 41% of farmers have access to any source of agricultural information, and less than 10% have access to government sponsored sources of agricultural information, such as extension agents, farmer information centres and agricultural universities (NSSO, 2013). Farmers tend to follow patriarchal and traditional techniques. The farm activities and any decisions are reliant on the leading farmer in the village who often times, is himself webbed in the traditional way of practice. Traditional way of farming

activities are not straightforward wrong but lack new techniques which science and research developed over the years. Subsidies on farm inputs are a key driver for farmers. Subsidies given on urea resulted in excess use of the same and even when the soil did not require Nitrogen fixing nutrition, it was repeatedly fed to the land. Surplus use of fertilisers of only some handful types which later only affected the land to damage the crops but also left hundreds of residents around to cancer, depicts the lack of knowledge available with the farmers. Poor decision making and dearth of knowledge with the farmers lays down the opportunity for those with better education and skills to research on the sector and eye the scenario with a mathematical, scientific or an economical view. What if mathematical analysis, market research and basic unit economics could provide some decision support to the farmers helping them to optimise their resources and invest in some dimensions in order to increase the farm productivity or farm profits.

This study is an effort to speculate the agriculture sector by focusing on turmeric farming. Understanding the know-hows of post-harvest procedure to marketing procedure in turmeric farming with the help of online literature and on-ground research. Maharashtra is chosen as the state of study and then major turmeric growing districts are identified. Followed by interviewing 120 plus turmeric farmers to collect data around socio-economic factors, cost incur factors and revenue streams. Comparison study of selected districts mapped with their respective markets is carried out to see if any price difference is offered. Data collection and on-ground research is carried out covering 15 villages across the districts of Hingoli, Nanded and Sangli, all part of Maharashtra.

The findings of the analysis of data collected from 120 farmers is as follows. Harvesting Labour significance rates highest. It varies positively with farm productivity. Investment in fertiliser/nutrient management increases farm productivity. Equally important is seed amount for improving farm productivity quantity. Washing and cleaning, although very less farmers invest in washing and cleaning of turmeric seeds after they are reaped out, it directly related with farm productivity. Farmers with a better education resulted in better farm productivity.

An average turmeric farmer of Hingoli spends nearly 18 thousand rupees per acre per season on nutrient management which include fertilisers, manures and pesticides. While Nanded farmers spend twenty six thousand rupees on nutrient management. Sangli farmers invest a whopping forty thousand rupees on nutrient management in which

Districts	Fertilizers	Manures	Pesticides	Nutrient Management	Farm Productivity	Labour	Seed Amt	Total Cost	Revenue	Profit
Hingoli	10919.41	5435.02	4948.41	18392.52	18.58	19015.80	9.42	91397.05	132621.03	41223.97
Nanded	17329.82	7922.99	2941.18	26007.89	20.76	17544.74	6.72	80689.05	151168.41	70479.36
Sangli	16138.80	20591.53	7991.70	40601.44	26.19	23422.02	11.89	121115.39	233771.94	112656.55

All figures are Average values (Rs./Acre/turmeric farmer)

Figure 5.1: Turmeric Farming per acre profit comparison for three districts

large amount is spent on manures (Rs. 20,591) and pesticides (Rs. 7,991). Also Sangli farmers sow maximum amount of seed per acre i.e. 11.8 quintals, Nanded farmers use only 6.72 quintals while Hingoli farmers use 9.4 quintals of turmeric seeds. All the three districts farmer cultivate selam turmeric type. Expenditure on labour is maximum by Sangli farmers (Rs. 23422), least by Nanded farmers (Rs.17544) and Hingoli farmers spend nineteen thousand rupees. These labour costs include labour requirement right from sowing, during season to harvesting and cleaning-washing mudded wet turmeric rhizomes. Sangli farmers (Rs. 1,21,115) spend the most during the season, followed by Hingoli farmers (Rs. 91397) and then Nanded farmers (Rs. 80689.05). Yet for every 1 rupee spent, a Sangli farmer earns 1.93 rupees, a Nanded farmer earns 1.87 rupees and the Hingoli farmer just make 1.45 rupees. Season profit earned by Sangli, Nanded and Hingoli farmer is Rs.112656.5, Rs.70479.36 and Rs.41223.97 respectively.

Cost-benefit analysis of extra transportation cost versus better turmeric rates churns out helpful decisions for farmers to increase their farm profits. If Hingoli farmers transport their turmeric produce to Sangli market, without any risk they will earn a minimum profit increment of 7% to a maximum of whopping 40%. If the Nanded market rates are their lowest, Hingoli farmers may face a loss percentage of 9.5%. Average increment in profit is also not so significant, just 1%. Nanded farmers without risk can shift marketing of turmeric produce to Sangli marketyard and earn an average increment of 18.5%. These findings when shared with the farmers who participated in the study could help them earn better profits.

This study also motivates others to take up a chunk of a problem in the sector displayed and contribute via their own approach to help farmers gain better perspective which could be mathematically, economically or scientifically backed and improve their incomes not much but by atleast some margins.