

IMPACT OF SOIL MINERALS AND OTHER FACTORS ON THE PADDY PRODUCTION WITH A SPECIFIC FOCUS ON THE SEVEN BLOCKS OF TIRUVARUR DISTRICT, TAMIL NADU

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Abstract

"Agriculture is the backbone of the livelihood security system of nearly 700 million people in the country and we need to build our food security on the foundation of home-grown food. – M. S. Swaminathan "

Even though we observed a decline in the agriculture's share in India's economy to less than 15% due to the tremendous growth rates of the industrial and other services sectors, this sector's importance in India's economic and social fabric goes well beyond this indicator. The one good reason for that is still most of the rural economy is depending on the agriculture as the key livelihood factor. India's food security closely depends on producing food crops, cereal crops, as well as increasing its production of fruits, vegetables and milk to meet the demands of a growing population with rising incomes. To meet this demand, lots of research has been carried out to make it more profitable.

In the current study, we selected the agriculture prominent areas in the Thiruvarur district of Tamil Nadu to identify the most influential factors of paddy production. For this research, we considered some of the soil-related factors as well as financial factors together and compared that with the output. The output of this study might be useful to the farmers as well as agricultural departments to implement new programs or to make changes in the existing programs in the agricultural sector.

Keywords: Paddy production, influential factors, Multiple linear regression analysis

Introduction:

India is a global agricultural powerhouse. It is the world's largest producer of milk, pulses, and spices, and has the world's largest cattle herd (buffaloes), as well as the largest area under wheat, rice and cotton. It is the second largest producer of rice, wheat, cotton, sugarcane, farmed fish, sheep & goat meat, fruit, vegetables and tea. The country has around 195 m ha land under cultivation of which about 63 percent are rainfed (roughly 125m ha) while 37 percent are irrigated (70m ha). In addition, forests cover roughly 65m ha of India's land.

The prominence attributed to food systems both globally and locally is an ever-increasing phenomenon in the economic and political paradigms. The importance around it is growing exponentially every year with rise in the population levels. One of the major challenges faced by all the countries the World across is, to achieve food sustainability and equitable food distribution systems. From being a mere primitive skill, Agriculture today has evolved into a scientific study in which advanced technologies and applications are adopted. Today it is possible to produce enormous quantity of crops within a small area of land. Scientific techniques like Hydroponics, Aquaponics, Vertical Farming, Precision Farming etc. are proven techniques to achieve good crop yield. Notwithstanding that, meeting the quality and safety standards for the crops is a bigger challenge in the present circumstances. There is an imminent need to transform the food systems along the value chain both at micro and macro-economic levels. Food systems are compound structures that has sizable impact on human diets, public health and can lead to failure of entire economies if not managed properly. The most recent example being Sri Lanka, which faced huge antagonization from the public for their indecisive step in the usage of domestic fertilizers in their agriculture. This has led to abnormally huge crop failure that decimated staple crops like paddy and other grain crops. Similarly, agriculture faces distressing threat calls from climate and environmental changes, wherein if handled properly, agriculture can be a solution to climate change problems that Earth is facing today.

Initially, agriculture was a subsistence behaviour which slowly turned into an economic activity. It is connected closely with civilizations across the globe. From Indus valley to Mesopotamian civilizations, agriculture was a major category of Socio-economic activities. In India, agriculture is an integral part to its culture and economy since ages. It was opined by experts that ancient India implemented technologies in various fields including agriculture that are far more advanced than any other region. The Indus and the Harappan civilizations between 2600-1900 BCE practiced eco-friendly agriculture that adapts itself to diverse climatic conditions. In the present era, at the outset of sophisticated technology and advancements in the field of agriculture, improvements have taken place in terms of addressing the modern challenges of over-population, climates change etc. Today the quality of the food we consume is dubious in nature which means, people are not sure whether they are provided with nutritious, healthy and safe food. And this situation has led to the serious argument among farming communities and general people alike, that the traditional farm practices are better than modern practices or not? Several countries are trying to implement a mix of traditional knowledge with modern technology and are coming up with best from of farming that is called Natural farming. India is a leading performer in Natural farming practices; especially the southern states of India are active in this format. From 2015-2021, the Government of India has introduced a multi-part series of schemes related to Organic and Natural farming formats by incentivizing farmers

and crops. Schemes such as Paramparagat Krishi Vikas Yojana, Bharatiya Prakritik Krishi Paddhati, Pradhan Mantri Krishi Sinchai Yojana mainly focus on farmer welfare and Natural farming practices in India.

Rice is a principal diet for more than 3.5 billion people all over the planet. Especially in Asia, Latin America, and parts of Africa, rice has been cultivated since ancient times. Scientists believe that the first humans domesticated rice in India, or Southeast Asia. Rice was brought to Japan about 3000 years ago. The Portuguese may have introduced it to South America during the 16th century. The word "rice" comes from the Latin word "oryza," which is derived from the Greek word "oryza." Rice cultivation is well suited to countries and regions with low labor costs and high rainfall, as it is labor-intensive to cultivate and requires ample water. Despite requiring a lot of water for cultivation, rice produces more food energy worldwide than any other crop. As a result, it has been a major part of human diets across Asia, providing up to 80% or more of calories consumed in many countries.

China, India, and Indonesia are currently the world's top producers of rice. Brazil is the biggest rice grower outside of Asia. In warm, humid climates, rice can grow. It grows well in flooded areas of Asian rivers like the Ganges and Mekong, where the soil is saturated with water. The rice variety known as "Deepwater rice" is grown in eastern Pakistan, Vietnam, and Burma and is adapted to deep flooding. India is the top exporter of rice in the world with a global share of 40 per cent. India is a key player in the global rice market. It exports rice to 150 countries and any disturbance in the Indian rice trade can create global food inflation. Low labour costs and higher domestic stocks make India the preferred exporter of rice at cheaper rates.

Major Countries growing Rice:

The area, production and productivity of top rice producing countries in the world are given below:

Table 1: Major Rice Producers

Area: million ha
Production: million tones
and yield in kg/ha

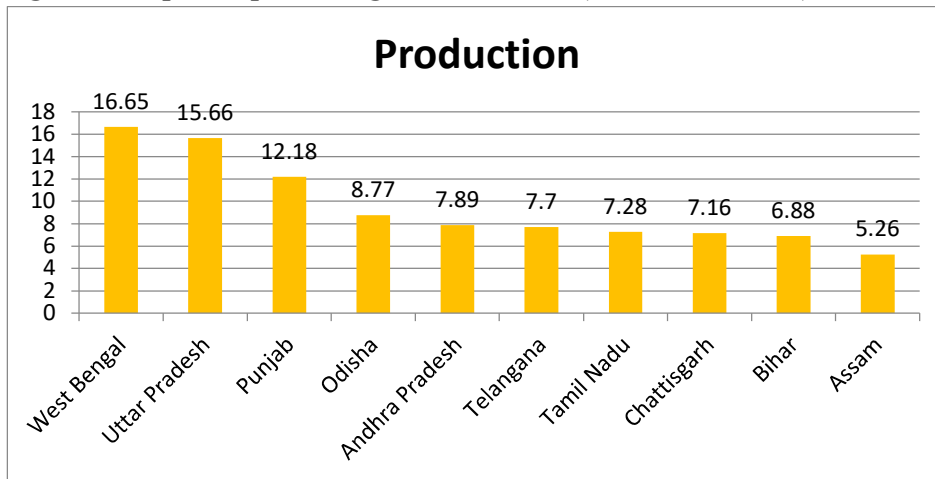
Country	Area	Production	Yield	Production (%)
China	29690	209614	7060	27.98
India	43780	177645	4058	23.71
Indonesia	10678	54604	5114	7.29
Bangladesh	11516	54586	4740	7.29
Viet Nam	7452	43495	5837	5.81
World	161772	749190	4631	

Source: Agricultural statistics at a glance 2021

In India, beyond 60% of the population consume Rice as a staple food and its importance can be understood by the area grown in the country, which stands at 45.07 million ha and by the level of production which is at 122.27 million tonnes in 2020-21. The production levels hit a record number of 132.9 million tonnes of rice in 2021-22, owing to good monsoons. Paddy is the most grown crop in India and it is cultivated in almost all states and being a tropical plant it grows swiftly in hot, humid conditions. India grows 20 different popular rice varieties that include Basmati rice, Indrayani rice, brown rice, Mogra rice etc. It is grown conventionally by

flooding fields with water as it is water intensive crop. Key share of rice production takes place in Kharif season as it is water intensive crop. Major states that produce rice in India are West Bengal, Uttar Prdaesh, Punjab, Odisha, Andhra Pradesh, Telangana, Tamil Nadu, Chattisgarh and so on. Prior to 2014, combined Andhra state was the largest producer of rice in India and it was known as Rice bowl of India. Now the state of West Bengal became the top producer of rice in India. Although all the states in India consume rice, the southern states of Andhra, Telangana, Tamil Nadu, Karnataka and Kerala has rice as the main consumed food item in many different forms.

Figure: 1 Top Rice producing states in India (in million tonnes)



Source: Agricultural statistics at a glance 2021

Rice can grow best on soils that have a high concentration of clay and organic matter and have a good capacity to retain water. Plant growth requires lot of micro-nutrients along with water. Especially, rice requires optimum availability of these resources. The principal plant nutrients are nitrogen, phosphorus, and potassium. Secondary nutrients are calcium, magnesium, and sulphur. Trace elements or micronutrients are iron, manganese, copper, zinc, boron, molybdenum, and chlorine. Major elements are the first and second nutrition elements. This grouping is based on relative abundance rather than relative significance. Although only in minute amounts, the micronutrients are crucial as the primary components of plant nutrition. Agriculture is the predominant sector in the Tamil Nadu state's economy. The primary source of income for almost 70% of Tamil Nadu's rural populace is agriculture. Any small change in this sector has a significant effect on the state's economic growth. The agriculture sector is given the utmost emphasis by this Tamil Nadu government. The state of Tamil Nadu actively takes up the responsibility of farmers welfare by introducing various schemes such as Chief Minister's Dryland Development Mission, Scheme for making youth into Agri-Entrepreneur, All Village Integrated Agricultural Development Programme, Palmyrah Development Mission etc., in 2022 to benefit the farmers. Through the "Nel Jeyaraman Traditional Paddy Varieties Conservation Mission," traditional paddy varieties are being grown on a 200-acre plot of land in government state seed farms, and 59 MT of seeds have been produced thus far in districts of , Pudukkottai, Thanjavur, Mayiladuthurai, Tiruvarur, Theni and Tirunelveli etc., and distributed the seeds to farmers.

In Tamil Nadu, rice, jowar, ragi, bajra, maize, and pulses are the main crops sown. Cotton, sugarcane, tea, coffee, coconut, and a few more crops are also widely grown in Tamil Nadu. In its agricultural section, Tamil Nadu's horticultural sector has also achieved notable success. Cash crops and oil seed crops are among Tamil Nadu's horticultural outputs. Mangoes and bananas are commercial crops, whereas groundnuts, sesame, and sunflower are grown for their oil seeds. The most important crop in Tamil Nadu is paddy, which comes in three varieties: Kuruvali, Thaladi, and Samba. These varieties vary from season to season. The primary sources of irrigation are wells and river tanks.

Literature review

The issues with rice marketing in the Thoothukudi district of Tamil Nadu, such as insufficient storage facilities, price volatility, and a lack of effective transportation infrastructure in the villages, were noted by Bhavani and Ashok (2014). They recommended Government should expand financing options and offer reasonably priced, improved transportation and storage options. C.C. Launio et al., (2015) in their article 'Economic Analysis of Rice Straw Management Alternatives and Understanding Farmers' Choices' highlighted the importance of nutrients in the soil and how they are helpful for the growth of paddy. It has been observed from this study that if the soil is replenished with the crop residues like rice straw and stubble properly, it will enrich and maintain the soil health, quality and productivity by retaining essential nutrients thus favouring positive effects and life support process. Unfortunately, farmers from rural as well as urban areas are not aware about the importance of soil health and how to replenish food with good nutrients. Despite having a tremendous potential to earn money and make a great business, Agriculture today is not considered as a serious form of profession. In addition, Agriculture is skill required work that involves prediction, assessment and analysis of crop, soil, climate, market etc. A lot of thinking and decision making has to go into management of Agriculture.

Dr. Anandaraj. P in his paper, Cost, Returns and Marketing Channels of Paddy in Thiruvarur District, submitted that the cultivation of paddy shows that the marginal value of product exceeds the cost of the respective factor. This suggests that there is untapped economic potential and an opportunity for optimal use of resources in paddy cultivation for both farmer groups to increase their yield.

In a study conducted by R. Vasanthi et al.(2017) in the southern region of Tamil Nadu, the Stochastic Frontier production approach was used to identify factors that could enhance rice production. Data collected over two years (2009-10 and 2010-11) from the Cultivation Expenditure Plan of the Tamil Nadu Center were analyzed. The results indicated that input variables, including seed, fertilizer (NPK), labor time, machine time, and pesticide, were significant and played a crucial role in rice production. The study found that reducing the use of seeds in irrigated farms can lead to better yields, as the seed coefficient was negative and highly significant. Furthermore, decreasing pesticide use can also increase yields, as the pesticide coefficient was negative and had the most significant impact. However, excessive pesticide use can lead to soil damage. In tank irrigated farms, increasing labor and machine time can result in the best yields. In their research paper 'Impact of natural disaster on agriculture and economy: a study of Rayalaseema region of Andhra Pradesh' Dr Anitha Manne and Swarna Pragathi (2018) quoted that Arid zones like Rayalseema region of Andhra Pradesh, where droughts and famines are endemic, economy of farmers majorly depends on allied farm

activities, even though the farmers have invested lot of money in cultivating crops. In this region Paddy, millets, Red-gram, Black-gram, Bengal-gram are some of the major crops grown extensively. But majority of the rural populace still clings on to farming due to lack of enough opportunities in other sectors of economy. The authors in the article are of the opinion that agriculture may not be a feasible employment option for the people. But if one can think the other way around it may be a lucrative opportunity if it is practised in a scientific manner. In the study 'Agricultural Productions and Its Implications on Economic Growth in Ivory Coast: The Use of the Econometric Approach' by Kouakou Kouakou Paul-Alfred (2020), it is iterated the importance of Food processing Industry and its impact on the economy. It was observed from the study that a 1% growth in the agricultural manufacturing can have a 0.569747% increase in economic growth. This implies that if the Government takes necessary steps to industrialize the agriculture or in terms of terms of growth and prosperity if the activity of agriculture is commercialized to an extent of privatization then there would be positive outcome in the economy of that country. According to the article 'What Is Natural Farming?' by Shreehari Paliath (2022) there is fear that natural farming may result in lower yields because 59% of Indian soils are nitrogen-deficient, 49% are phosphorus-deficient, and 48% are potassium-deficient. "Organic or ZBNF approaches do not replace enough nutrients in soils as much as the plants ingest them every season," the study found. The article underlines the fact that there is no proper comprehensive action plan from the goverents to augment Organic or Natural farming, dependency on costly organic certification for agri-products, which the small and marginal growers cannot afford, insufficient finance, target-driven and timeline-based regulations for natural farming, among others as the key hindrances for the promotion of soil health and organic farming.

Paddy is the principle crop cultivated in Thiruvavarur district. Three seasons are observed to grow paddy: Kuruvai (June-August), Samba (August-January), and Thaladi (January – March). The district also grows cumbu, ragi, maize, korra, and varagu as cereal crops. Red gram, green gram, and black gram are the pulses grown in the area. Fruits, vegetables, sugarcane, and species are some additional food crops. Cotton/fibre, edible oil crops (groundnut, gingelly, and coconuts), and non-edible oil crops (castor, despite being grown on a very limited scale) are the most significant non-food crops. The three most significant crops grown in the region are cereals, pulses, and oil seeds.

Table 2: Paddy Production in Thiruvavarur district

Productivity (in kg/ha)												
S. No.	Block Name	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	Average
1	Tiruvavarur	750	800	148	800	643	428	428	477	653	596	572
		0	0.00	1.00	0.00	9.00	3.66	3.66	6.00	6.00	0.00	5.93
2	Thiruthurai	750	800	148	800	593	501	501	477	653	596	582
		0	0.00	1.00	0.00	3.00	6.50	6.50	6.00	6.00	0.00	1.90
3	Muthupettai	750	800	148	800	550	507	507	477	653	596	579
		0	0.00	1.00	0.00	0.00	9.00	9.00	6.00	6.00	0.00	1.10

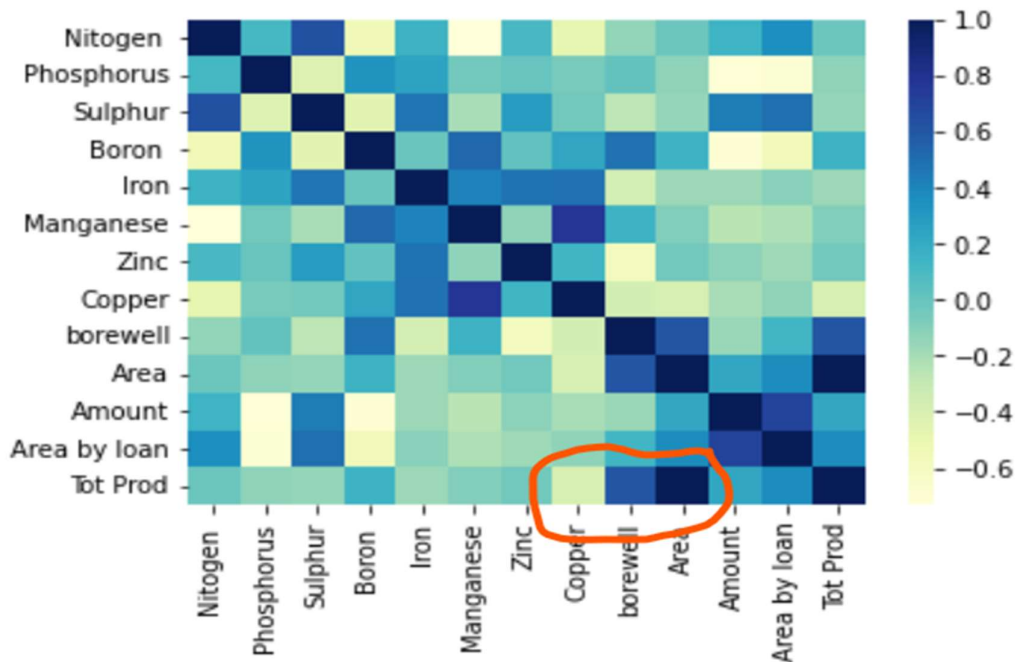
4	Mannargudi	750	800	148	800	724	557	557	477	653	596	606
		0	0.00	1.00	0.00	1.00	1.00	1.00	6.00	6.00	0.00	3.60
5	Kottur	750	800	148	800	592	464	464	477	653	596	574
		0	0.00	1.00	0.00	0.00	2.00	2.00	6.00	6.00	0.00	5.70
6	Nannilam	750	800	148	800	686	500	500	477	653	596	591
		0	0.00	1.00	0.00	1.00	8.00	8.00	6.00	6.00	0.00	3.00
7	Needamangalam	750	800	148	800	753	596	596	477	653	596	617
		0	0.00	1.00	0.00	0.00	4.33	4.33	6.00	6.00	0.00	1.17
8	Kudavasal	750	800	148	800	741	476	476	477	653	596	592
		0	0.00	1.00	0.00	7.00	6.50	6.50	6.00	6.00	0.00	0.30
9	Koradacheri	750	800	148	800	537	589	589	477	653	596	594
		0	0.00	1.00	0.00	8.00	2.75	2.75	6.00	6.00	0.00	1.65
10	Valangaiman	750	800	148	800	725	525	525	477	653	596	600
		0	0.00	1.00	0.00	4.00	1.00	1.00	6.00	6.00	0.00	0.90
Total		7500	8000	1480	8000	6540	5144	5144	4770	6530	5960	5905

Source: Department of Statistics, Thiruvarur

The empirical analysis:

1. To analyze the impact of the most influence variables, the paddy production data from Thiruvarur district is collected along with some of the impactful variables like.....
2. To analyze the internal relations, we first plot the correlations between them to check which the factors have highest correlation with the production variables.

Figure – 2: Correlation heat Map



Interestingly, we can see that total production of paddy is highly positively correlated with number of borewells in the area and total area under cultivation. So, wherever water facilities are made available, the paddy production significantly increases for all the districts.

To gain more insights we can check the numerical values of correlation coefficients in the following table.

Table – 3: Correlation Table

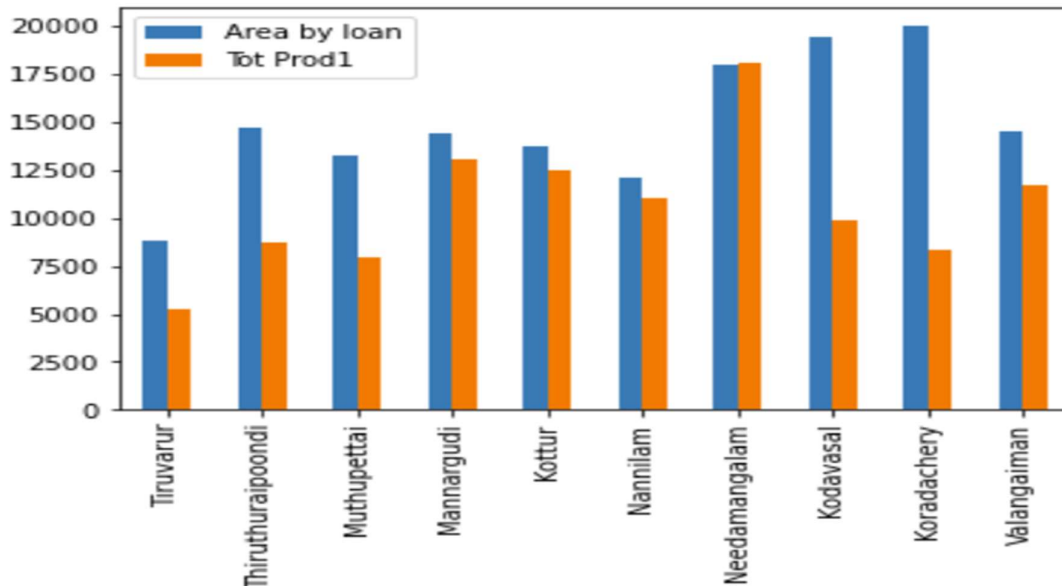
Correlation between the variables													
	Nitrogen	Phosphorus	Sulphur	Boron	Iron	Manganese	Zinc	Copper	borewell	Area	Amount	Area by loan	Tot Prod
Phosphorus	0.12												
Sulphur	0.63	-0.42											
Boron	-0.55	0.33	-0.46										
Iron	0.15	0.24	0.47	-0.01									
Manganese	-0.73	-0.04	-0.21	0.52	0.41								
Zinc	0.10	0.00	0.29	0.02	0.47	-0.12							
Copper	-0.48	-0.06	-0.04	0.23	0.48	0.77	0.13						
borewell	-0.14	0.01	-0.27	0.49	-0.37	0.15	-0.59	-0.36					
Area	-0.01	-0.12	-0.14	0.15	-0.17	-0.09	-0.04	-0.39	0.60				
Amount	0.15	-0.72	0.43	-0.70	-0.17	-0.26	-0.12	-0.21	-0.16	0.22			
Area by loan	0.36	-0.69	0.49	-0.56	-0.11	-0.23	-0.17	-0.12	0.13	0.37	0.71		
Tot Prod	-0.01	-0.12	-0.14	0.15	-0.17	-0.09	-0.04	-0.39	0.60	1.00	0.22	0.37	

Between the minerals in the soil, Boron, Sulphur and manganese are closely correlated for the reason that they can be available from single source to the soil.

Alongside, we can also see the negative correlation with copper content on the soil. Pot soil experiments showed that copper (Cu) is highly toxic to rice. Rice grain yields decreased exponentially and significantly with the increase of soil Cu levels (Jiakuan Xu et.al., 2006)

From the exploratory data analysis, we also find area where cultivation is carried by loan from the government institutions is interesting highly influencing the output

Figure – 3: Bar-chart for Production and loan disbursement

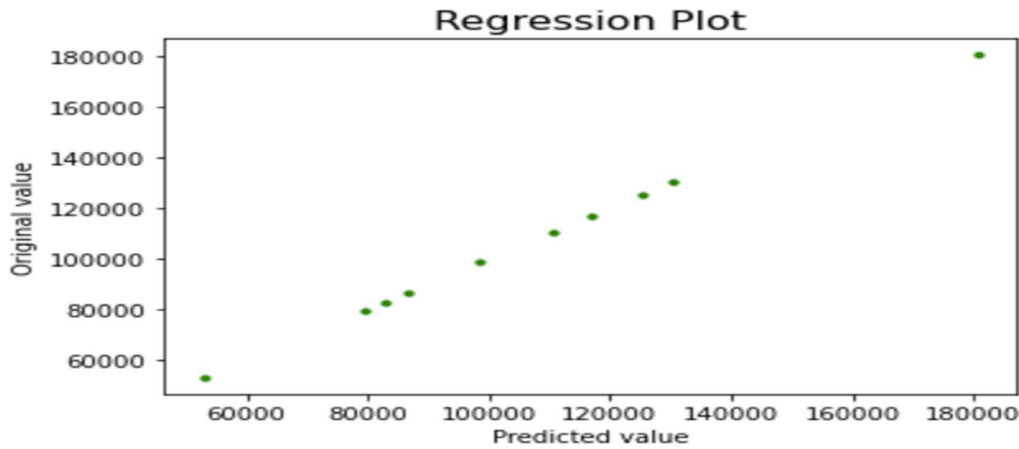


In the above chart, except two districts, wherever the loan issue is more, we can observe that paddy out is also significantly growing.

Further, to confirm the results from correlation, multiple regression model being planned where total production is taken as dependent variable and all remaining soil as well area variables taken as independent variables to check the impact.

First, we checked the multiple linear regress is a good fit as predicted Vs. Actual values lying on the diagonal line as follows.

Figure: 4



Further now we can focus on regression coefficients and the following table shows the beta coefficients as follows.

Figure: 5

	column	coeff
0	Nitogen	8.553320e-06
1	Phosphorus	-6.176273e-06
2	Sulphur	-1.763787e-05
3	Boron	8.621883e-05
4	Iron	5.880377e-05
5	Manganese	-7.103575e-05
6	Zinc	9.705629e-05
7	Copper	1.020320e-04
8	borewell	5.433579e-08
9	Area	5.960000e+00
10	Amount	4.735523e-08
11	Area by loan	-8.274203e-09

Apart from the known fact that the area under cultivation is one good variable that constantly influences the total paddy production, from the soil minerals point of view, we can see that Boron and Zinc have good beta coefficients. This result has been in line with the results stating Boron and Zn interacted synergistically to boost yield of rice crop resulting in additional yield of 7.1 q/ha of grain and 6.28 q/ha of straw. (P. Debnath , S.K. Pattanaaik et all, 2015)

Additional factors that impact Paddy production in the Thiruvavarur district

There are eight regulated markets currently operational in the Thiruvavarur district. They are Tiruvarur, Kudavasal, Mannargudi, Poonthottam, Thiruthuraipoondi, Vaduvur, Valangaiman. In Notified Area of Tiruvarur Market Committee in Tiruvarur District 12, Agriculture

producers are identified. They are Paddy, Cotton, Coconut, Black gram, Groundnut, Sesame, Redgram, Red Chilly, Sugarcane, Cashew nut, Tobacco, and Green gram. Although paddy is the most significant agricultural product that is being produced, the remaining products also contribute substantially to the agriculture sector in the region.

Table: 4 – Block-wise Infrastructure, Market Arrivals and receipts in regulated markets

	Blocks	Infra capacity in Mt	Arrivals in Mt	Revenue in Lakhs
1	Kudavasal	1100	281.85	2.8
2	Mannargudi	5202	755.1	2.95
3	Poonthottam	1600	143.714	0.5
4	Thiruthuraiipoondi	2000	47.2	0.65
5	Tiruvarur	3700	2338.333	2.27
6	Vaduvur	2100	179.72	0.58
7	Valangaiman	1100	145	1.75
8	Koradacherry	0	119.38	1.18
	Total	16802	4010.297	12.68

The above table shows block-wise infrastructure details like godowns, cold storage, drying yards etc. at regulated markets, their respective arrival of agro-commodities, and their transactional receipts. The total production capacity of Thiruvarur district during 2019-20 was nearly 365000 Metric tonnes for paddy alone. When a correlation coefficient was calculated between the Infrastructural capacity for each block and regulated market arrivals of agro-products, the outcome was 0.59, meaning a moderate to high positive relationship exists between the two variables. Similarly, a correlation coefficient of 0.47 arrived when it was calculated between Infrastructural capacity and revenue generated by the agro-products at the regulated markets, indicating a weak to moderate positive relationship between the variables. The rest of the market surplus in the district is distributed to various segments like exports, trade mills, and direct selling methods. Based on the observations from table 2 and table 4, it can be inferred that for a large proportion of paddy production, there is a minimal amount of infrastructure available. So if the infrastructure facilities were to be improved, it might boost the farmer's motivation to increase the paddy production in the district. From the observations above, it could be deduced that the infrastructure facilities provided by the Government affect not only the amount of productivity but could also reduce the cost of sales, thus improving operating profit for farmers. And nevertheless, teaching farmers technical know-how and providing them with scientific farming methods would be a win-win situation for both the Government and the farm community, which is not ardently seen in the district of Thruvarur.

Summary and Conclusions:

This study conclusively proves that regulated markets are necessary for selling farm products. More farmers must be encouraged to sell at the regulated markets. In India, the regulated market is subject to regulations to control and prevent undesirable activities. The accuracy of weight measurement is maintained by conducting regular inspections and verification of scales

and weights at the regulated markets. Appropriate would be taken to resolve disputes that may arise in the market. Even though the current empirical analysis is based on data from Thiruvapur districts, the results could be generalized to other districts of Tamilnadu where uniform agricultural programs are being implemented. The study finding reveals the fact the mineral content in the soil is one major factor that will cause huge changes in the paddy output. The other important factor turns out to be the agricultural subsidies or loans provided by the Government to the farmers, which is valid for all other agricultural products as well.

Based on the above analysis, the following recommendations were made as conclusive remarks.

1. The total paddy production is impacted by the soil's nature. In other words, the mineral components present in the soil are one of the important factors of agriculture output be it paddy or any other crop.
2. As for as paddy production is concerned, copper content in the soil produces a toxic impact on the output. In other words, for a reason lot of copper content is found in the soil, then we can expect low levels of paddy production from that soil.
3. On the positive impact variables side, we can see the proper combination of Boron and Zinc in the soil (Naturally or through manures) will give a huge increase in paddy production.
4. There is also a moderate correlation between storage capabilities available and paddy production. If infrastructure related to storage of paddy crop increases, then the production of paddy crop also significantly increases in this region.
5. Finally, we also observed that the government loans to the formers is one of the factors that influence the total output. Proper financing to the agricultural sector will increase the overall out of the production of food crops in the country.

Future scope for the study:

The study can be extended further with the following future scope.

1. The current study is focussed on paddy crop which is major food product especially in south India. But wheat is also one of the major food crop and study of influential factors for wheat output also very useful for farmers as well as policy makers of India.
2. In the current study, there is no consideration of external data as well as formers demographic information which has major impact on the paddy output. Inclusion of such information might also give a different perspective of the focus area.
3. With addition of more variables to the existing data also open the thoughts for applying more sophisticated and advanced data modelling techniques to get the better accurate results.

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