Dedicated to

My Beloved Family And

Respected Guide…

ABSTRACT

POST GRADUATE INSTITUTE OF AGRI-BUSINESS MANAGEMENT
JUNAGADH AGRICULTURAL UNIVERSITY
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Name of the student **Advisor**
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TREND AND PATTERNS OF FERTILIZER CONSUMPTION IN SAURASHTRA REGION: AN ANALYSIS

ABSTRACT

Key words: *Demand and supply, Consumption Pattern, Imbalance, Compare and contrast production of fertilizers and food grains*

Agriculture is the backbone of the Indian economy and fertilizer play a key role in agricultural prosperity. The population of India is 1.3 billion. 60 per cent of the population of India depends on agriculture to eke out their livelihood. The possibilities of increasing the net sown area were nearly exhausted; the incremental output from agriculture had to come from a higher yield per unit area. Hence, the green revolution saw an increase consumption of chemical fertilizers namely nitrogenous (N), phosphorus (P) and potash (K). The present study entitled trend and patterns of fertilizer consumption in saurashtra region: an analysis was undertaken with the objectives of studying the fertilizer scenario, analyzing demand and supply of fertilizer distribution in India, analyzing the fertilizer imbalance respective to Saurashtra region and studying to compare and contrast the production of fertilizers and food grains in India. The data of year 2000/01 to 2018/19 was collected for study purpose. The ordinary least squares method, Compound Annual Growth Rate (CAGR), Co-Integration and granger causality test, Augmented Dickey-Fuller test and Johansen Juselius Co-Integration Test, Multiple regression were used for the analysis.

The result revealed that there was fluctuating trend in imbalance use of fertilizer in various district of Saurashtra over the years. Government should play important role for minimizing the overuse of chemical fertilizer for the maintain of soil harness. The total consumption of N P K does not cause the Food grain Production.

Because P value is almost zero. Therefore, In future Food grain production does lead Total consumption of N P K.

POST GRADUATE INSTITUTE OF AGRI-BUSINESS MANAGEMENT
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CERTIFICATE-I

This is to certify that the project work report entitled **"TREND AND PATTERNS OF FERTILIZER CONSUMPTION IN SAURASHTRA REGION: AN ANALYSIS"** submitted by **VAJA KRISHNABEN RAJENDRABHAI** in partial fulfillment of the requirements for the award of the degree of **MASTER OF BUSINESS ADMINISTRATION IN AGRI-BUSINESS** to the Junagadh Agricultural University is a record of bonafide project work carried out by him under my guidance and supervision and the project work has not previously formed the basis for the award of any degree, diploma or other similar title. The candidate has fulfilled all prescribed requirements. The assistance and help received during the course of investigation have been fully acknowledged. She has successfully completed the comprehensive/preliminary examination held on **June 12, 2020** as required under the regulation for post-graduate studies. She has submitted kaccha bound project work report on **March 12, 2021.**

Place: Junagadh

Date: / / 2021

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JUNAGADH

CERTIFICATE-II

Date: / / 2021

This is to certify that the project work report entitled **"TREND AND PATTERNS OF FERTILIZER CONSUMPTION IN SAURASHTRA REGION: AN ANALYSIS"** submitted by **MS. VAJA KRISHNABEN RAJENDRABHAI** to Junagadh Agricultural University, Junagadh in partial fulfillment of the requirements for award of the degree of **MASTER OF BUSINESS ADMINISTRATION IN AGRI-BUSINESS** after recommendation by the project evaluation committee were defended by the candidate before the following members of the evaluation committee. The performance of the candidate in the oral examination was satisfactory. We, therefore, forward with recommendation.

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3.	Course	: MBA (Agri-Business Management)
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7.	Behaviour during Training	: Good
8.	Progress during Training	: Good

Training being part of course curriculum, this certificate is issued for Academic Purpose only.

For GNFC Limited

10/3/2021.

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I start in the name of God, who has bestowed upon me all the physical and mental attributes and skills to cut through and heal a fellow human.

"It is impossible to prepare a project report without the assistance & encouragement of other people. This is certainly no exception."

On the very outset of this report, I would like to extend my sincere & heartfelt obligation towards all the personages who have helped me in this endeavor. Without their active guidance, help, cooperation & encouragement, I would not have made headway in the project.

This project report entitled is not the product of exclusively my efforts. For the completion of this work, I received magnanimous support from many that, a comprehensive acknowledgement is almost impossible.

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A word of apology to all those I have not mentioned in person and note of thanks to each and every one who have blessed me with their prayers.

Needless to say, I solely am responsible for any errors, which may remain.

Place: Junagadh

Date: / /2021 **(Vaja Krishnaben Rajendrabhai)**

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LIST OF ABBREVIATIONS

GDP	Gross Domestic Product
NPK	Nitrogen, Phosphorus, Potassium
TVA	Tennessee Valley Authority
SSP	Single Super Phosphate
MT	Metric Ton
FACT	The Fertilizer & Chemicals Travancore of India Ltd
FCI	The Fertilizers Corporation of India
USD	United States Dollar
CAGR	Compound Annual Growth Rate
INR	Indian Rupee
DAP	Di-Ammonium Phosphate
GNFC	Gujarat Narmada Valley Fertilizers & Chemicals Limited
GSFC	Gujarat State Fertilizers & Chemicals Limited
MOP	Muriate Of Potash
SSP	Single Super Phosphate
HYV	High-Yielding Variety
MNC	Multinational Corporation
TE	Triennium Ending
JV	Joint Ventures
LNG	Liquefied Natural Gas
LPA	Long Period Average
NEP	New Economic Policy
CERES	Crop Environment Resource Synthesis
DSSAT	Decision Support System for Agro Technology Transfer
CO_2	Carbon Dioxide
CO	Carbon Mono-Oxide
SO_2	Sculpture Dioxide
GVA	Gross Value Added
US	United States

CHAPTER I

INTRODUCTION

Agriculture is the backbone of the Indian economy and fertilizer play a key role in agricultural prosperity. The population of India is 1.3 billion. 60 per cent of the population of India depends on agriculture to eke out their livelihood. As the population increased rapidly and since the possibilities of increasing the net sown area were nearly exhausted, the incremental output from agriculture had to come from a higher yield per unit area. Hence, the green revolution saw an increase consumption of chemical fertilizers namely nitrogenous (N), phosphorus (P) and potash (K). One of the reasons for problems of soil salinity and alkalinity in agricultural regions of India is the in discriminant and faulty use of fertilizers. There is a recommended level of fertilizer for each crop and soil, which is known as the optimum level. Fertilizer use above or below this level creates imbalance. Which in turn causes environmental problems (Anon, 2005).

Since independence, Indian agriculture has been significantly progressing; it grew at the rate of one percent per annum for sixty years during pre-independence era 1860-1920. Further, it springs up at the rate of about 2.6 per cent per annum in the post-independence era 1951-56. An increase in total cropped area was the main source of agriculture growth from fifties to eighties. During mid-eighties, a structural change in the production was observed. Area was moderately declined, while per hectare production was increased substantially due to technological transformation. Apart from technological transformation, land reforms, an introduction of agricultural price commission with the objective to ensure remunerative prices to producers, new agricultural strategies, *viz.,* introduction of hybrid seeds, chemical fertilizers, new cultivation & harvesting tools, improved irrigation facilities, agriculture credit & insurance, investment in research and extension services and improvement of rural infrastructure were taking place (Singh, 2020).

Agriculture in India is livelihood for a majority of the population and can never be underestimated. Although its contribution in the gross domestic product (GDP) has reduced to less than 20 per cent and contribution of other sectors increased at a faster rate, agricultural production has grown. This has made us self-sufficient and taken us from being a begging bowl for food after independence to a net exporter of agriculture and allied products. Total food grain production in the country is estimated to be a record 291.95 million tonnes, according to the second advance estimates for 2019-20 (Anon, 2021).

The use of fertilizers is affected by a number of factors like irrigation, high yielding variety seeds, size of the farm credit etc. Increased area under high yielding varieties led to increased food grains production. These high yielding varieties respond more to the use of chemical fertilizers. There exists a large gap between actual and potential level in fertilizers use. Increased fertilizer use efficiency leads to a number of benefits to Indian agriculture. They are economy in use of fertilizers, reduction in unit cost of production, prevention of fall in agricultural productivity, production of environmental quality and efficient use of other inputs such as irrigation and high yielding varieties in developing countries actual fertilizer use is usually below the economic potential (Mala, 2013).

1.1 Concepts and Classification of Fertilizers:

The term fertilizer covers any of a large number of natural and synthetic materials, including manure and compounds containing nitrogen, phosphorus, and potassium, spread on or worked into soil to increase its capacity to support plant growth.

Classification of Fertilizers

According to crop-to-crop need of Nitrogen, Phosphorus and Potassium the fertilizers can be classified as under.

1) **Direct fertilizers**- These fertilizers are directly assimilated by the plants and contain nutrient elements in the form of mineral salts. For Sample super phosphates, nitrates and ammonium compounds.
2) **Indirect fertilizers**- The indirect fertilizers provide not only necessary nutrients to land but also it provides the fertilizer which increases the fertility of land by mixing potash and hydrogen inside the land and it is necessary for the development of plant. That type of fertilizers is termed as indirect fertilizer. Line, silicone and boron are main examples of these fertilizers.
3) **Complete fertilizers-** These fertilizers supply all the essential elements namely N, P and K to the soil, in combine form. These are also known as mixed fertilizers or NPK fertilizers. For example, guano, it is prepared artificially.

4) **Incomplete fertilizers**- These fertilizers contain only one or two elements needed for the growth of plants. For examples Ammonium Phosphate, Potassium Nitrate etc.

5) **Natural fertilizers**

These fertilizers are classified as -

a) **Natural organic fertilizer**- such as plant matter, farmyard manures, animal matter etc.

b) **Artificial organic fertilizer**- Examples are waste materials from animal's excretion, Meat obtained from slaughterhouses, urea etc.

c) **Natural Inorganic fertilizers**- Example being Chile saltpetre, rock phosphates, potassium salts etc.

d) **Artificial inorganic fertilizers**- Examples are Ca (NO3) 2, (NH4)2SO4, NHNO3, NH4Cl, Calcium Cyanamid, Super phosphates etc.

6) **Micro fertilizers**- These contain the elements, Boron, Magnates, Zinc and Copper needed in very small amounts to stimulate the plant growth.

1.2 Fertilizers during ancient period

In the ancient period, there were records that farmers 8,000 years ago knew about this and found an 'organic' solution. The solution was to use animal dung around the plants in order to supply the plant with the necessary nutrients. Until now, there was no evidence of farmers using natural fertilizers earlier than 3,000 years ago.

1.3 History of Fertilizer development

Neolithic man probably used fertilizers, but the first fertilizer produced by chemical processes was ordinary superphosphate, made early in the 19th century by treating bones with sulphuric acid. Coprolites and phosphate rock soon replaced bones as the P source. The K fertilizer industry started in Germany in 1861. In North America the K industry started during World War I and expanded with development of the New Mexico deposits in 1931 and the Saskatchewan deposits in 1958. Modern K fertilizers are more the product of physical than of chemical processes. The first synthetic N fertilizer was calcium nitrate, made in 1903 from nitric acid produced by the electric arc process. The availability of synthetic ammonia after 1913 led to many new N fertilizers, but physical quality was poor. In 1933 TVA was formed with a national responsibility to increase the efficiency of fertilizer manufacture and use. More than 75 per cent of the fertilizer produced in the United States is made with processes developed by Tennessee Valley Authority (TVA).

Major fertilizers and fertilizer intermediates introduced by Tennessee Valley Authority (TVA) include ammonium nitrate, high-analysis phosphates, Di-ammonium phosphate, nitric phosphates, ammonium polyphosphate, urea ammonium phosphates, 11-16-0 and other liquid base solutions, super phosphoric acid, wet-process super phosphoric acid, suspensions, granular urea, and S-coated urea. These have had major impact upon the production of mixed fertilizers, bulk blending, and the fluid fertilizer industry. Future fertilizers not only must be technologically feasible, economical, and agronomical suitable as have been past fertilizers but also must meet various air and water pollution standards during production and have reduced total energy requirements (Darrell and Gerald, 1977).

1.4 Entry of chemical Fertilizers to Indian market

The industry had a very humble beginning in 1906, when the first manufacturing unit of Single Super Phosphate (SSP) was set up in Ranipet near Chennai with an annual capacity of 6000 MT. The Fertilizer & Chemicals Travancore of India Ltd. (FACT) at Cochin in Kerala and the Fertilizers Corporation of India (FCI) in Sindri in Bihar were the first large sized fertilizer plants set up. The installed capacity as on 30.01.2003 has reached a level of 121.10 lakh MT of nitrogen (inclusive of an installed capacity of 208.42 lakh MT of urea after reassessment of capacity) and 53.60 lakh MT of phosphatic nutrient, making India the 3rd largest fertilizer producer in the world. The rapid build-up of fertilizer production capacity in the country has been achieved as a result of a favourable policy environment facilitating large investments in the public, co-operative and private sectors (Anon, 2015).

1.5 Global scenario of fertilizers

The fertilizer market was valued at USD 155.80 billion in 2019, and it is estimated to register a CAGR of 3.8 per cent, during the forecast period (2020-2025). In 2019, Asia-Pacific was the largest geographical segment of the market studied and accounted for a share of around 60 per cent of the overall market. The fertilizer industry was heavily challenged in 2016. It was confronted with uneven global nutrient demand, soft economic prospects, depressing crop prices, rising market competition, and volatile energy prices. This combination created high uncertainty in the fertilizer market throughout the year.

Since 2015, a sustained downturn in the world consumption of fertilizer market, coupled with decreasing crop prices, mainly in the United States and Asia - Pacific, has made it difficult to maintain consistent growth. The major technological innovations in the industry, along with growing demand for bio-based and micronutrient fertilizer are expected to drive the market. However, regulatory and environmental constraints and high production costs are likely to act as drawbacks in the industry (Anon, 2018).

1.6 Indian Scenario of fertilizers

The Indian fertilizer market was worth INR 6,258 Billion in 2019. Fertilizers have played a key role in the success of India's green revolution and subsequent self-reliance in food-grain production. After china, India is the second largest consumer of fertilizer in the world with an annual consumption of more than 55 million metric tons. Among the various type of fertilizers used in India, Urea is one of the highest consumed fertilizers in the country as a source of Nitrogen. The consumption of urea in the country in 2019 was 29 million tons. DAP is the second major consumed fertilizer in country. Looking forward, the Indian fertilizer market is projected to reach INR 11,116 billion by 2024, growing at CAGR of 12.3 per cent during 2019-2024. The Indian fertilizers market is expected to witness a CAGR of 11.9 per cent during the forecast period 2020-2024. The Indian fertilizer market was worth INR 6,258 Billion in the year 2019. Fertilizer consumption recorded a modest growth in 2018-19. Total estimated nutrient consumption ($N+P_2O_5+K_2O$) was 27.29 million MT in 2018-19 as against 26.59 million MT in the previous year showing a growth of 2.6 per cent. The increase in fertilizer consumption has contributed significantly to sustainable production of food grains in the country. As a result, the demand of fertilizers has witnessed double-digit growth rates over the past several years.

According to Department of Fertilizers, the total production of Urea in India was 20.7 million metric tons in 2017 and DAP was 14.6 million metric tons in 2017, which was 1.36 per cent higher compared to the previous year.

Urea is the major consumed fertilizer in India followed by DAP. According to Department of fertilizer of India, the production of DAP and Complex fertilizers are increasing in the country. The production of DAP reached 4.3 million metric ton and the production of complex fertilizers reached 7.9 million metric ton in 2017, which was estimated to reach 5.03 million metric ton and 9.03 million metric ton in 2018. The production of DAP has increased in the period of 2017-2018 when the global prices for phosphate raw materials fallen. This boosted the production of DAP in the country owing to the higher demand for the fertilizer (Anon, 2019).

1.7 Production of fertilizers in India

India is the second populated country in the world and 60 to 70 per cent of these people depend on agriculture activities. Increasing the population may affect the requirement of food grains. The demand for fertilizer has grown along with the increasing demand of food grains. At present in India 30 large size Urea units are manufacturing urea, 21 units produce DAP and complex fertilizer and 2 units manufacture ammonium sulphate product.1 Asia was the largest geographic market in the fertilizer market in 2015, accounting for $20 billion or 20 per cent of the global market. Asia is the largest market because of the presence of a large farming community in China and India using fertilizers. The Americas was the second largest geographic market. Europe was the third largest geographic market of the global market. India is the third largest consumer and producer of fertilizer product. Indian manufacturer is not fulfilling the demand of domestic consumption of fertilizer since Indian Government importing the fertilizer for requirement of farming sector.

Indigenous production of fertilizer nutrients slipped marginally over the previous year. Fertilizer production at 17.93 million MT nutrients ($N+P_2O_5$) during 2018-19 was 1.2 per cent lower than the previous year. Production of nitrogen (N) at 13.34 million MT in 2018-19 was 0.6 per cent lower than the level of 2017-18. However, phosphate (P_2O_5) production at 4.59 million MT declined by 2.8 per cent over the previous year.

In terms of products, production of urea at 23.90 million MT in 2018-19 fell marginally by 0.5 per cent over the previous year. Whereas, the production of DAP at 3.90 million MT registered a sharp decline of 16.2 per cent during the period. In contrast, production of complex fertilizers at 8.98 million MT recorded a steep increase of 9 per cent. Production of SSP at 4.08 million MT also showed growth of 4.2 per cent during the period (Anon, 2019).

1.8 Utilization/application of fertilizers in India

In India, major fertilizer consuming zones and states helps to understand consumption pattern in our country. During the period 2007-11, it was observed that west zone was consuming 31,116.73 kilo tonnes of fertilizers which was the highest among the four zones and was also having highest total annual compound growth rate percentage of 9.68. Among major fertilizer, consuming states of India

Uttar Pradesh was found to be consuming maximum fertilizers that is 16,621.29-kilo tonnes. Rice and wheat are the major crops, which are consuming 37 per cent and 24 per cent of the total fertilizers consumed in India among various crops. Climatic factors, like rainfall pattern have a very crucial role in the consumption of fertilizers as their demand increase with an increase in irrigated areas. Agro-ecological zone no.7 was consuming 177.1 kg/ha, of fertilizer which was the highest among the different agro ecological zones of India.

Fertilizers should be used in a balanced manner through integrated management of nutrient involving the use of chemical fertilizers, bio fertilizers, compost and vermicomposting. Balanced use of fertilizers will reduce harmful effects of chemical fertilizers on the environment and will help in making our agriculture sustainable. It also increases water and nutrients use efficiency, improve grain quality, soil health and give better economic returns to farmers and helps in sustainability (Mohammad and Monowar, 2018).

1.9 Company Profile:

Gujarat Narmada Valley Fertilizers & Chemicals (GNFC) is an Indian manufacturer of fertilizers and Chemicals. GNFC was founded in 1976 and it is listed on Bombay Stock Exchange. The company was jointly promoted by the Gujarat and the Gujarat State Fertilizers and Chemicals (GSFC). Located at Bharuch in a prosperous industrial belt, GNFC draws on the resources of the natural wealth of the land as well as the industrially rich reserves of the area.

Name of company	: Gujarat Narmada Valley Fertilizers & Chemicals Ltd.
Date of Establishment	: 1976
Corporate Address	: Post office Narmadanagar, Bharuch, Gujarat, 392 015, India.
Company Website	: www.gnfc.in
Managing Director	: Shri Pankaj Joshi
General Manager	: Shri A C Shah

1.9.1 Mission:

To be the leading provider of chemicals and agricultural inputs through adoption of state of the art technologies and business processes.

1.9.2 Vision:

To be a technology driven, environmentally responsible joint sector company manufacturing fertilizers, commodity and specialty chemicals maintaining highest standards of operational excellence and innovation for creating sustainable value for all stakeholders.

1.9.3 Product Portfolio of Company:

Table 1.1 Product Portfolio of Company's fertilizers

Di-Ammonium Phosphate (DAP)	Muriate of Potash (MOP)
Ammonium Sulphate	Single Super Phosphate (SSP)

The present study helps to find out the growth of fertilizer, crop productivity and production, Problem of soil and alkalinity. This study is also useful to understand the demand and supply of fertilizer distribution in India. The result of the study would help to understand the fertilizer imbalance respective to Saurashtra region.

1.10 Objectives of Study:

1. To study the fertilizer scenario in India.
2. To analyse the demand and supply of fertilizer distribution in India.
3. To analyse the fertilizer imbalance respective to Saurashtra region.
4. To compare and contrast the production of fertilizers and food grains in India.

1.11 Limitations of the Study

The study is based on secondary data. The secondary data was collected from Fertilizer statistics of Fertilizer association of India. The study area was limited to Saurashtra districts and the findings may not be appropriate to other markets, as vast difference exists. Hence, the findings of the study are limited to these constraints.

CHAPTER II

REVIEW OF LITERATURE

Literature review aims to portray the critical points of current and collected knowledge on the problem under study. It seeks to describe, summarize, evaluate, clarify and integrate the content of primary reports. Moreover, it forms the basis for the justification for future research in the area. As such, review of literature has become an inevitable part of any scientific investigation. Hence, a brief review of available literature, related to the study is presented under following heads.

2.1 To study the fertilizer scenario in India.
2.2 To analyse the demand and supply of fertilizer distribution in India
2.3 To analyse the fertilizer imbalance respective to Saurashtra region.
2.4 To compare and contrast the production of fertilizer and food grains in India.

2.1 Fertilizer scenario in India.

Sharma and Thaker (2011*)* analyzed that the fertilizer consumption trends and then identifies important determinants of fertiliser demand and develops projects demand scenarios for fertilizers in India in 2020-21. India is the second largest consumer of fertilizers in the world after China, consuming about 26.5 million tonnes. However, average intensity of fertiliser use in India remains much lower than most countries in the world but is highly skewed, with wide inter-regional, inter-state, and inter-district variations. The results show that non-price factors such as irrigation, high yielding varieties, were more important than price factors in influencing demand for fertilizers. Of the two price policy instruments, affordable fertiliser prices and higher agricultural commodity prices, the former is more powerful in influencing fertiliser demand. It suggests that in order to ensure self-sufficiency in agricultural production in the country, availability of fertilizers at affordable prices should be prioritized over higher output prices. By 2020, fertiliser demand in the country is projected to increase to about 41.6 million tones and is expected to grow at a faster rate in eastern and southern region compared with north and west. To meet the increasing fertiliser requirements of the country, a conducive and stable policy environment, availability of raw materials, capital resources, and price incentives will play a critical role.

Mala (2013) analyzed that India made impressive gains in the field of agricultural production and harvested a record in food grains production of 230 million tonnes during 2007-2008. Introduction of HYV"s and hybrid varieties brought optimism about fertilizer response superiority of modern varieties. The total nutrient consumption (N+P_2O_5 +K_2O) touched level of 264lakh million tonnes during 2009-10, the highest so far. Since the rain fed areas, which constitute 70 per cent of the cultivated areas, consume only 20 per cent of the total fertilizers, the government has been taking steps in recent years to increase the consumption of fertilizers in these areas. Even though India is the third largest fertilizer user, average rate of nutrient application is only 85 kg/ha. The use of fertilizers is affected by a number of factors like irrigation, high yielding variety seeds, size of the farm credit etc. Increased area under high yielding varieties led to increased food grains production. With effect from 1 April 2003, the Government implemented the "New Fertilizer Policy", which allowed urea manufacturers to market initially 25 per cent and subsequently 50 per cent of their production outside the purview of distribution control. The efficiency of fertilizer use could be improved through fertilization practices that include an application of macronutrients and micronutrients according to crop requirements. An adequate supply of credit for farmers and distributors is necessary to ensure the availability of fertilizers when and where they are required.

Pathak *et al.* (2014) studied that India is the second largest producer of the firms output where majority of population depends on the agricultural activities for their livelihood. Growth of Industries and openings of MNCs have not yet declined the importance of agriculture in India. Economic development is not a sole function of Industrial development; it also includes development of agriculture. Sustainable development is the need of the time and it can only be achieved through balanced growth of both agriculture and Industrial sector. There is a popular saying "Countries are known for their greenery, and India is one of those country. Growth of agriculture and growth of fertilizer Industry supplement each other. Both go hand in hand. The article attempts to present a broad view of fertilizer Industry in Indian perspective. Through the use of secondary data, attempts have been made to study issues like demand and supply position, consumption trends, growth factor of fertilizer in India.

Sharma (2014) studied that the role of chemical fertilizers for increased agricultural production, particularly in developing countries such as India, is well established. Some argue that fertilizer was as important as seed in the Green Revolution contributing as much as 50 per cent to the yield growth in Asia Others have found that one-third of worldwide cereal production is due to the use of fertilizer and related factors of production for the past four decades, India has relied on increasing crop yields to supply an ever-increasing demand for food. According to Ministry of Agriculture data, total food grains production rose from about 102 million tons in the triennium ending (TE) 1973–1974 to about 253 million tons in TE2012–2013, a 148 per cent increase (GoI 2013). Meanwhile, the total area under food grains, which accounted for nearly three-fourths of the total cropped area in early 1970s, declined to 63.6 per cent in TE2011–2012 and total area under food grains declined from 125 million hectares (ha) in the 1970s to 122 million ha in the 2000s. This dramatic increase in food grains production was the result of a 133 per cent increase in crop yields between TE1973–1974 and TE2011–2012. During the past two decades, India has lost 2 to 3 million ha of net sown area to non-agriculture purposes. Food security has been and will continue to be one of the major challenges confronting the world, including India, as the country faces the challenge and pressure to feed more than 1 billion people today. The agricultural policy has focused on increasing productivity and modern inputs, such as high-yielding variety (HYV) seed, chemical fertilizers, and irrigation, and subsidies that supported intensive farming played an important role during the 1970s and 1980s. Trends in fertilizer consumption and cereal production in India, clearly indicate that the increased consumption of fertilizer has been a dominant factor underlying increases in crop production in the country. However, the association between fertilizer use and cereals production has weakened over time; for example, the correlation coefficient between fertilizer consumption and cereals production increased from 0.88 during the first phase of the Green Revolution (1965–1966 to 1970–1971) to 0.95 in the second phase (1980s) but declined during the 1990s (0.86) and 2000s (0.83).

Srivastava (2015) studied that the domestic production of chemical fertilizers is not keeping pace with increasing demand leading to increased dependency on imports. In view of current scenario of limited availability of gas and lack of domestic availability of fertilizer raw materials, the country should focus more on setting up joint ventures (JV) plants abroad in resource rich countries for production facilities with buy back arrangements. The imbalanced use of fertilizer nutrients experienced in recent years is a cause of concern. There is great potential to increase the agricultural productivity through integrated nutrient management systems comprising of chemical and organic fertilizers. The usage of city compost as organic fertilizers would also help in cleaning the city and fully complements the "SWACHH BHARAT ABHIYAN" campaign of Government of India.

Chanda and Sati studied (2018) that the scenario of a modest increase in indigenous production, stable rupee, normal weather, followed by rise in sale of fertilizers. There was better performance of DAP and NP/NPKs as against fall in urea production. Fertilizer industry continued to suffer from shortfall in availability of natural gas from domestic sources. Shortfall was made up from high cost imported LNG. Some of the plants faced technical & equipment problems besides limitations in availability of phosphoric acid experienced by a few DAP/NP/NPK plants. Indian fertilizer industry continued to remain hard pressed with liquidity problem due to limitations in availability of feedstock. There was large opening inventory of fertilizers at the beginning of the year. Sale of most of the fertilizers has shown increase with the exception of SSP. The paper presents a detailed review of development in fertilizer capacity, production, despatches sale and stock of fertilizers during 2017.18.

Chanda and Sati studied (2019) that the mixed scenario of comfortable inventory, subdued production, high imports and increased sale of fertilizers. Fertilizer industry continued to suffer due to inadequate availability of natural gas from domestic sources. Gap in availability of natural gas was fulfilled through high cost imported LNG. Fertilizer production suffered due to closure of two urea plants in major part of the year, extended shutdown in some plants, etc. Total rainfall was nine per cent below Long Period Average (LPA) during South-west monsoon. Twenty four sub divisions received normal to excess rains during the period. Fertilizer consumption increased in most of the states where rainfall was normal to excess. Overall fertilizer sale /consumption recorded a modest growth during the year. Indian fertilizer industry continued to remain hard pressed with liquidity problem due to delay in payment of subsidy. The paper presents a detailed review of development in fertilizer capacity, Production, despatches, sale and stock of fertilizers along with policy developments during 2018-19.

Bishnoi *et al.* (2020) studied that India is using 165.85 Kg of fertilizer per hectare of arable land. China stands at 1st rank and India ranks 2nd and in nitrogenous and phosphatic fertilizer consumption. The Indian fertilizer market was worth INR

5,437 billion in 2018. Looking forward, the market is projected to reach INR 11,116 billion by 2024, growing at a CAGR of 12.3per cent during 2019-2024. In case of Urea, India has achieved 80-85per cent of self-sufficiency, and rest is imported from our joint ventures in abroad. To meet the demand of urea by indigenous production and to reduce the imports, Government of India, is investing an amount of Rs. 37971 Crore Rupees for revival of five fertilizer plants in India. Since FY 2016-17, the food grain production is increasing with the fertilizer consumption in India, because use of fertilizer is an important factor which impacts the food grain production in India. Unfortunately, the, heavy use of urea is misbalancing the ideal fertilizer application ratio. To improve this ratio farmers has to move from straight fertilizers towards NPKS complex fertilizers for supplying the essential nutrients required by the plants for growth.

2.2 Demand and supply of fertilizer distribution in India.

Jasbir (2013) analyzed those chemical fertilizers are key element of modern technology and have played an important role in agricultural production growth in India. However, the demand-supply gap of fertilizer in India has increased in recent times due to dependency on imports. Indian imports, which were about 2 million tons in early part of 2000, has increased to 10.2 million tonnes consumption of fertilizers in 2008-09. In view of importance of fertilizers in agriculture growth and the possibility of an emerging demand-supply gap, there is a need to forecast future demand. The paper begins with an overview of fertilizer consumption trends and then identifies important determinants of fertilizer demand and develops projects demand scenarios for fertilizers in India in 2020-21. India is the second largest consumer of fertilizers in the world after China, consuming about 26.5 million tonnes. However, average intensity of fertilizer use in India remains much lower than mostly countries in the world but is highly skewed, with wide inter-regional, inter-state, and inter-district variations. In present study we want to find that how we can fulfil increasing gap between fertilizer consumption demand and supply. We would like to analysis that what is the estimated growth rate of fertilizer consumption in 1915-16 to 2020-21. The paper suggests that in order to ensure self-sufficiency in agricultural production in the country, availability of fertilizers at affordable prices should be prioritized over higher output prices. By 2020, fertilizer demand in the country is projected to increase to about 41.6 million tones and is expected to grow at a faster rate in eastern and southern region compared with north and west.

Singh (2013) in his research paper highlighted the role of Chemical fertilizers in making the country self-reliant in food grain production. Attempts have been made to study issues like demand and supply position, consumption trends, growth factor of fertilizer in India. The author mentioned that there are various determinants like price factor and non-price factor (better seeds, irrigation, and credit) which influence the demand of fertilizers. The study revealed that non-price factor (better seed, irrigation, credit) plays more important role in increasing demand of fertilizers as compared to price factor.

Pathak *et al.* (2014) studied that three fundamental or basic needs of humanity are food, cloth and shelter. Indian constitution provides for all these three basic need for human beings. Unfortunately, after 68 years of Independence, the problem of food remains unsolved. It has created much more future demand for the food Industry. Although rapid farming and improved techniques have made possible to increase the crop yield, but has corroded the soil fertility. Use of fertilizers in these regards have been a practical solution to preserve the nutrient content in the soil and increase the increase the soil fertility. Fertilizer Industries are doing a commendable job in helping the farmers to increase the productivity at large. The present paper presents a review on the previous work done in fertilizer marketing in India and abroad.

Roy (2014) studied the importance of market research in fertilizer Industry. Market research helps to understand fertilizer market, need of farmers, demand and supply of fertilizer, problem and opportunity of fertilizer market, which help to make appropriate marketing strategy and actions to make growth of fertilizer industries as well agriculture development.

Suryawanshi (2015) studied those Plants nutrients supply from the chemical fertiliser is the key to increasing agriculture production by improving the land productivity. However, the demand and supply gap of fertilizers in India has increased in recent times, thereby leading to increased dependency on imports. India imports which were about 2 million tonnes in early parts of 2000 increased to 10.2 million tonnes of fertilizers in 2008-09. However, the demand supply gap of fertilizers in India has increased in recent times due to dependency on imports. Consumption of chemical fertilizers have led to import of its. The increase in rate of subsidy of chemical fertilizers combined with increase in consumption of fertilizers has led to a substantial increase in requirement of subsidy.

Chakravarthy (2016) studied that non-price factors are more important than the price of fertilizer in determining fertilizer demand. Study recommended that to increase agricultural output, government subsidy policies need to be geared toward the use of balanced nutrients for improving soil conditions, at the same time, provide an incentive to fertilizer manufacturing firms to develop new environmentally-sustainable products for agriculture.

Gaurav *et al.* (2018) studied that fertilizer supply chain in India is well established but there is a huge gap between the demand and supply of fertilizers to the farmers. This gap is due to less concentration of dealers near the farmers. The case analyzes the reach of fertilizers to the farmers in major crops (cereals, pulses, oilseeds major commercial crops) available through dealers/retailers and focuses on the potential for the dealers in the current fertilizer supply chain. It also highlights the features of the Indian fertilizer market, the government policies, and the operational issues. This case provides an account of how a person could assess the potential of the sector and make a business decision to enter a sector.

Shalini *et al.* (2020) studied that Agriculture has most demanding and advancement factor in marketing. Fertilizers contain one or more of these essential plant nutrients. Nitrogen, Phosphate, and Potassium are the major nutrients supplied by chemical fertilizers. Nitrogen promotes plant growth and development. Plants look green and the growth will be pushful. It helps increasing crop yields. At higher levels nitrogen causes a loss of certain plant species, depletion of soil nutrients, death of fish and aquatic organisms, and contamination of drinking water. The supply and demand for nitrogen is discussed relative importance of fertilizer and fixed nitrogen

2.3 Imbalance of fertilizer use.

Mishra *et al.* (2005) studied that agriculture is the backbone of the Indian economy and fertilizer play a key role in agricultural prosperity. As the population increased rapidly and since the possibilities of increasing the net sown area were nearly exhausted, the incremental output from agriculture had to come from a higher yield per unit area. Hence the green revolution saw an increase consumption of chemical fertilizers namely nitrogenous (N), phosphorus (P) and potash (K). One of the reasons for problems of soil salinity and alkalinity in agricultural regions of India is the indiscriminate and faulty use of fertilizers. There is a recommended level of fertilizer for each crop and soil, which is known as the optimum level. Fertilizer use above or below this level creates imbalance. which in turn causes environmental problems. In this paper an empirical analysis has been carried out to see the imbalance in fertilizer use. Thus, this study becomes very vital for the growth of the Indian economy, which is based upon Indian agriculture.

Ramesh and Pandey (2008) studied that the role of fertiliser in increasing agricultural productivity and production during the last five and half decades has been well documented. A very close association is observed between growth of fertiliser and crop productivity in almost all the states of the country. No input in agriculture has seen as much growth as witnessed in the use of fertiliser in the recent history of agriculture. Fertiliser consumption was around 67 thousand tonnes in early 1950s and it picked up very fast during mid-1950s. By early 1960s consumption of NPK crossed 400 thousand tons and at the time of onset of green revolution consumption of fertiliser approached 1 million tons. On per hectare basis, fertiliser consumption in India increased from 0.5 kg in early 1950s to 7 kg at the time of onset of green revolution in 1966-67. It is worth mentioning that in the pre green revolution post-Independence period fertiliser consumption remained quite low but its growth rate was higher than that of crop production. Average growth rate in crop production (index) during 1950-51 to 1966-67 was 2.48 per cent whereas average growth rate in fertiliser consumption in the same period was 19.41 per cent. This shows that even in the pre green revolution period fertiliser was used as an important input for raising agricultural production.

Prasad (2012) studied that fertilizer has been the key input in augmenting food production in India. However, fertilizer use in India is skewed, high in a few states having adequate irrigation and dismally low in the NE states. There is also imbalanced use of N, P and K. Deficiency of secondary nutrient sulphur, micronutrient zinc is widespread in the country, and boron deficiency is reported from the eastern states. While attempts are being made to increase the fertilizer use in states where levels of application are low, the focus is on developing and promoting secondary and micronutrient fortified/ customized fertilizers. A serious thought needs to be given for increasing the use efficiency of nitrogen, which is very low, especially in rice. Therefore, more efficient nitrogen fertilizers using low-cost nitrification inhibitors and coating materials need to be developed and produced. Production and promotion of organic manures also needs due attention.

Sharma *et al.* (2014) studied that the long-term effects of continuous use of chemical fertilizers and manure on soil fertility and productivity of a maize–wheat system were investigated in the ongoing long-term fertilizer experiment, during *rabi* (2007–2008) and *kharif* (2008) seasons at the research farm of Chaudhary Sarwan Kumar Himachal Pradesh Agricultural University–Hill Agricultural Research and Extension Centre, Dhaulakuan. After 16 cropping cycles, bulk density decreased in plots where farmyard manure (FYM) was applied, whereas pH decreased in all the treatments. The organic carbon content of the soil increased in all the treatments except 100per cent nitrogen (N). Cation exchange capacity (CEC) increased in all the treatments over the initial status of the soil. Available N showed buildup over the initial status in most of the treatments. Available phosphorus (P) declined from initial status in treatments where only N was applied alone or with FYM. There was reduction in available potassium (K) status in all the treatments except 100per cent NPK. Continuous addition of FYM with balanced application of inorganic fertilizers improved content of exchangeable calcium (Ca) and magnesium (Mg) over initial status compared to imbalanced application of fertilizers. Continuous use of imbalanced inorganic fertilizers resulted in lesser crop yields and nutrient uptake compared to that with the application of balanced dose of inorganic fertilizers with FYM.

Patra *et al.* (2016) studied that changing farming practices, particularly with increasing use of chemical fertilizers, this study attempts to statistically model the implications of such input intensification for growth of agricultural production and yield and crop diversification in Hooghly district of the Indian state of West Bengal. Understanding the issue is very important for sustainable growth of the sector in the long-run. The study uses secondary data collected from the Bureau of Applied Economics and Statistics of the Government of West Bengal for the period 1989–2010. The study shows that greater use of chemical fertilizers has no strong correlation with growth of agricultural production and yield. It is also found that agricultural production has fluctuated during this period possibly due to improper use of N–P–K over the years exceeding the assimilative capacity of soil. Further, excessive use of chemical fertilizers has also resulted in over extraction of ground water in the area. It is, therefore, suggested that efforts should be made towards deeper understanding of inherent potentials as well as limitations of soil and designing the farming strategies accordingly. In addition, formation of farming groups and promotion of organic farming should be explored to facilitate sustainable growth of the sector. Decentralized participatory planning can play a crucial role in this regard.

Jadeja *et al.* (2019) conducted field experiment at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during rabi season of 2014-15 to evaluate soil application of potassium and sulphur on nutrient content, uptake, quality and yield parameter of chickpea (Cicer arietinum L.) under south Saurashtra region of Gujarat. The experiment comprising of four levels of potassium viz., 0, 40, 60 and 80 kg K2O ha-1 and sulphur viz., 0, 20, 40, 60 kg S ha-1 and experiment was laid out in Factorial Randomized Block Design and replicated thrice. The results revealed that the various levels of potassium and sulphur significantly influenced the content and uptake nutrient, yield of chickpea. The application of potassium 60 and 80 kg K2O ha-1 and sulphur 40 and 60 kg S ha-1 significantly increased the content, uptake, quality and yield of chickpea.

Bhatt *et al.* (2020) studied that the imbalanced use of chemical fertilizers under intensive cultivation practices over a period of years leads to various soil-associated problems particularly nutrient availability. Thus, to examine the effect of long-term application of balanced and imbalanced inorganic fertilizer and farmyard manure (FYM) application on the chemical fraction of DTPA-extractable micronutrients under rice–wheat cropping system after 29 years, the observations were recorded from the ongoing field experiment at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, India. An application of balanced inorganic fertilizer with FYM in rice, while without FYM in wheat significantly improved the DTPA-extractable Zn, Fe, Mn and Cu after rice and wheat crops in both the surface and sub-surface soil layers. Lowest DTPA-extractable Zn, Fe, Mn and Cu were recorded, in surface and sub-surface soil under rice and wheat crops in control. The highest DTPA-extractable Zn, in both surface and sub-surface layers of rice (3.31, 1.62 mg kg^{-1}, respectively) and wheat (2.96, 0.99 mg kg^{-1}, respectively) was recorded because of application of N_{180}+P_{80}+K_{40}+Zn(F) + FYM in rice and N_{180}+P_{80}+K_{40}+Zn(F) in wheat. However, the DTPA-extractable Fe, Mn and Cu were highest in rice and wheat because of N_{120}+P_{40}+K_{40}+FYM and N_{120}+P_{40}+K_{40} application, respectively. The balanced use of inorganic fertilizer with FYM (N_{180}+P_{80}+K_{40}+Zn(F) + FYM) in rice and without

FYM [N_{180}+P_{80}+K_{40}+Zn(F)] in wheat supported the highest rice (6.74 t ha^{-1}) and wheat (3.50 t ha^{-1}) grain yields, while lowest in control. Based on the study results, long-term application of FYM at 5 tonnes ha^{-1} in rice crop sustained the availability of DTPA-extractable cationic micronutrients to rice and wheat in Mollisols.

Mathukia *et al.* (2020) studied that the effect of integration of chemical fertilizers, enriched compost and bio fertilizers on growth and yield of coriander (Coriandrum sativum L.). The experimental results revealed that significantly higher values of growth parameters viz., plant height, number of branches per plant, and dry matter production, and yield attributes viz., number of umbels per plant, number of umbellets per umbel, number of seeds per umbellate, and test weight along with higher stover yield (1688 kg/ha) were recorded with application of enriched compost + recommended dose of fertilizers (RDF) + vesicular-arbuscular mycorrhizae (VAM). Whereas, significantly higher seed yield (14.93 q/ha), nutrient uptake by plant, available N, P, K in soil after harvest along with higher net return (₹ 69434/ha) and B:C ratio (2.81) were realized with the application of RDF + VAM + Azotobacter+ phosphate solubilizing bacteria (PSB) + potash mobilizing bacteria (KMB).Based on the results, it could be concluded that higher production and net returns from coriander can be obtained by the application of RDF (60-60-40 N-P2O5K2O kg/ha) + soil application of Azotobacter + PSB + KMB each @ 3 L/ha + VAM @ 0.25 kg/ha.

2.4 Production of fertilizers and food grains in India.

Verma *et al.* (2007) studied that agricultural diversification in India is steadily accelerating towards high value crops and livestock activities to augment farm income. Some of the factors that influence the nature and pace of agricultural diversification from staple food to high value crops are technological change in crop production, improved rural infrastructure and diversification in food demand. The nature of agricultural diversification differs across regions due to wide heterogeneity in agro-climatic and socio-economic conditions. Generally, the pattern of agricultural diversification shows a shift from crop production to livestock production during the 1980s to 1990s. The livestock sub-sector across different regions has grown as a result of the mounting demand for livestock products, namely, milk, meat, eggs, etc. Diversification in favour of horticulture and livestock commodities is more pronounced in rainfed areas. The focus of this study relates to diversification of food production and consumption in both rural and urban areas of India. With rising incomes, the patterns of diet normally change from a basic cereal-based diet to non-cereal items. Several recent studies have found evidence of this in India. Analyses of expenditure patterns of Indian households in urban and rural areas based on National Sample Survey data provide evidence that the income elasticity of demand for cereals is very low or zero for the population as whole, even though households at low income levels may still have a positive income elasticity of demand for cereals. A varied diet is likely to include protein, fats and other non-cereal items such as fruits and vegetables.

Kinekar (2011) studied that the relationship between fertilizer use and food grain production is weakening year after year. Stagnation in food grain production and productivity is a matter of great concern in addition to number of other factors, imbalanced and inefficient use of fertilizers is one of the major factors for stagnation in food grain. Between the years of 2004-05 and 2009-10, the total consumption of fertilizer has increased by 43 per cent while food grain production has increased by 10 per cent only. K consumption has maintained pace of growth and has touched a record of 3.33 million tons in 2009-10. Consumption of potash increased by merely 15 kg/ha during last 27 years from less than 2 kg in 1971-72 to 17.1 kg in 2008-09.

Venkatesh *et al.* (2016) revealed that per capita consumption has decreased in cereals and is stagnant in pulses, and has doubled in edible oils, vegetables, eggs, fish and meat during 1993-94 to 2011-12. It has reflected the nutritional intake wherein calorie and protein intake has declined; fat intake has increased during this period. Simultaneously, a significant growth has been observed in per-capita income and availability of food commodities along with rapid urbanization. The multivariate regression analysis of 28 states has suggested that dietary diversity significantly increases with production diversity and per-capita income and is significantly higher in other states vis-a-vis north-eastern states. A significant non-linear relationship has been observed between dietary diversity and literacy. The study has highlighted a significant impact of local production diversity on consumption pattern and therefore, policies should target the diversification of agricultural production, particularly in the north-eastern states to bring out dietary diversity and desired nutritional outcome.

Kumar and Indira (2017) studied that Introduction of green revolution, modernization of agriculture, encouragement to research and extension in agriculture are some of the factors contributed for this growth. However, this is accompanied by considerable increase in the usage of chemical fertilizers starting with the introduction of green revolution in 1960s leading to unsustainable agriculture. The Green Revolution was a technology package and it contains technical component of improved high yielding varieties of two staple cereals (rice and wheat), irrigation and use of fertilizers, pesticides, and better management practices. The high yielding varieties demanded more usage of fertilizers and it is supported by the subsidy policy on fertilizers. In the early 1980s, India introduced New Economic Policy (NEP) which has opened up the economy to privatization and globalization. In the globalized economy agricultural sector became more commercial and production is oriented to export market. This also led to increase in fertilizer consumption. The main objective is to analyse the trends in the consumption of chemical fertilizers and food grain production in India and to identify the relationship between these two. The study is based on the secondary data and Co-integration Technique and CAGR are used to analyse the trends. The analysis revealed long run relationship between these two variables in India. Encouraged by the increased production, farmers have increased fertilizer consumption without considering the environmental consequences and sustainability of agriculture.

Gupta *et al.* (2018) analyzed that India is second most populous country after China, which houses 15 per cent of global population (census 2011) within 2.42 per cent of geographical land area of world. The ever-growing population and improving economic condition pressurize to produce and supply higher quantity of food grains. However, the country's agriculture production is not increasing but somewhere stagnated, this increasing demand for food grain production. Agriculture sector therefore needs much attention to decrease this gap between increasing demand and production. Wheat, the staple cereal crop in world, is grown in 220.38 million hectares contributing 27.21 per cent of total cereal grain production. In India, wheat is grown in an area of about 29.06 million hectares with a production of 86.87 million ton (FAO, 2011). The yield of wheat increased after sixties and early seventies bringing the green revolution in India. In recent years, production of wheat crop in response to the increasing application rates of the input resources is experiencing a declining trend. The decline in yield is mainly due to shortening of growth period, decrease in photosynthesis ability and increase in respiration demanding more irrigation water supply. Crop simulation models can provide an alternative, less time-consuming and inexpensive means of determining the optimum management option (Nitrogen and irrigation requirements) under varied soil and climatic conditions. Crop growth modelling has emerged as a powerful tool for optimizing crop yield and identifying critical factors, contributing to yield under varying climate change. In this context, dynamic mechanistic models CERES (Crop Environment Resource Synthesis)-Wheat available in Decision Support System for Agro technology Transfer (DSSAT) can be used for predicting growth and yield of wheat (Tritium aestivum L.) under different nitrogen and water management conditions. Our present study focuses the performance evaluation of CERES wheat model and use of the model for analysis of climate change impact on wheat yield. Keeping these in view, the present study was formulated with the objectives of Calibration and validation of CERES-wheat model.

Casey (2020) studied that Agriculture has played an important role in the economic development of agrarian India with ~17 per cent of the gross value added (GVA) and more than 50 per cent of the population depending on it. In the last 17 years, the all-India food grain production increased at a compound annual growth rate (CAGR) of ~3 per cent from 175 million t in 2002 – 2003 to 296 million t in 2019 – 2020. With only a marginal increase in acreage, the increase in the productivity levels plays a vital role in the growth of the agriculture industry, as fertilizers account for at least half of the crop yield. However, while India has the largest area of arable and permanently cropped land in the world, it ranks third in the world in overall food grain production after China and the US, primarily due to low crop productivity. With limited arable land and rising food needs, the long-term potential for increase in fertilizer usage is moderately high in India. On the other hand, with the increase in acreage from 16.3 million ha. In FY2002 – 2003 to 25.49 million ha. In FY2018 – 2019 and improved productivity from 8.9 t/ha. To 12.3 t/ha. During the same period, all-India horticulture production increased at a CAGR of ~5 per cent from 144.4 to 313.85 t during the 17-year period.

Maurya *et al.* (2020) studied that India is facing various challenges in agriculture sector for sustaining soil fertility and food grains production, besides environmental degradation and food security of the country in the event of ever-increasing demands of food grains production with limited cultivable land. Cultivable land and maintaining its soil fertility are one of the major tasks which supports about 17.6 per cent of its population and leads to fact that, our natural resources are under considerable strain. Food grains are a major source of energy and are thus are vital for food and nutritional security. Besides, technological advances and use of machinery for crop harvesting leave behind large quantities of crop residues, which is burnt by farmers as cheap and easiest method with misconception that, burning of crop residues enhances soil fertility and helps in control weeds, insects and pests. From various studies, it is concluded that burning of crop residues result in heavy loss of organic carbon as well as soil nutrients, emits large amount of submicron aerosols and trace gases like Carbon dioxide (CO2), Sculpture dioxide (SO2), Carbon mono-oxide (CO) and smoke, thereby posing problem to environment and human health hazards.

Reddy *et al.* (2020) studied that the treatments consisted of various fertilizer practices including recommended fertilizer practice compared with site-specific nutrient management and leaf colour chart based N management. The results revealed that farmers practice with high fertilizer dose of 330:158:100 kg N, P2O5 & K2O/ha recorded significantly higher mean grain yield of 69.91q/ha as compared to Nutrient expert based application of 125:37:57 kg N, P2O5 & K2O/ha with a mean grain yield of 58.73q/ha. However Nutrient expert based NPK compares well with recommended fertilizer practice (62.0q/ha) and remained on par with it in all the years as well as in the mean yields. Nutrient expert based NPK resulted in 37, 63 and 43 per cent saving in N, P and K against recommended practice.

CHAPTER III

METHODOLOGY

This chapter deals with the methodology adopted for evaluation of the objectives under the present study. In the process of achieving the objectives of the research study, it is very imperative to follow a systematic and scientific approach to present and interpret the result of the study or investigation conducted. This chapter on methodology gives a detailed description of the research approach, sampling procedure, nature and sources of data, the analytical tools and techniques employed and other relevant information.

3.1 Location and Study Area

3.2 Sampling Technique

3.3 Sources of Data

3.4 Statistical Analysis

3.1 Location and Study Area

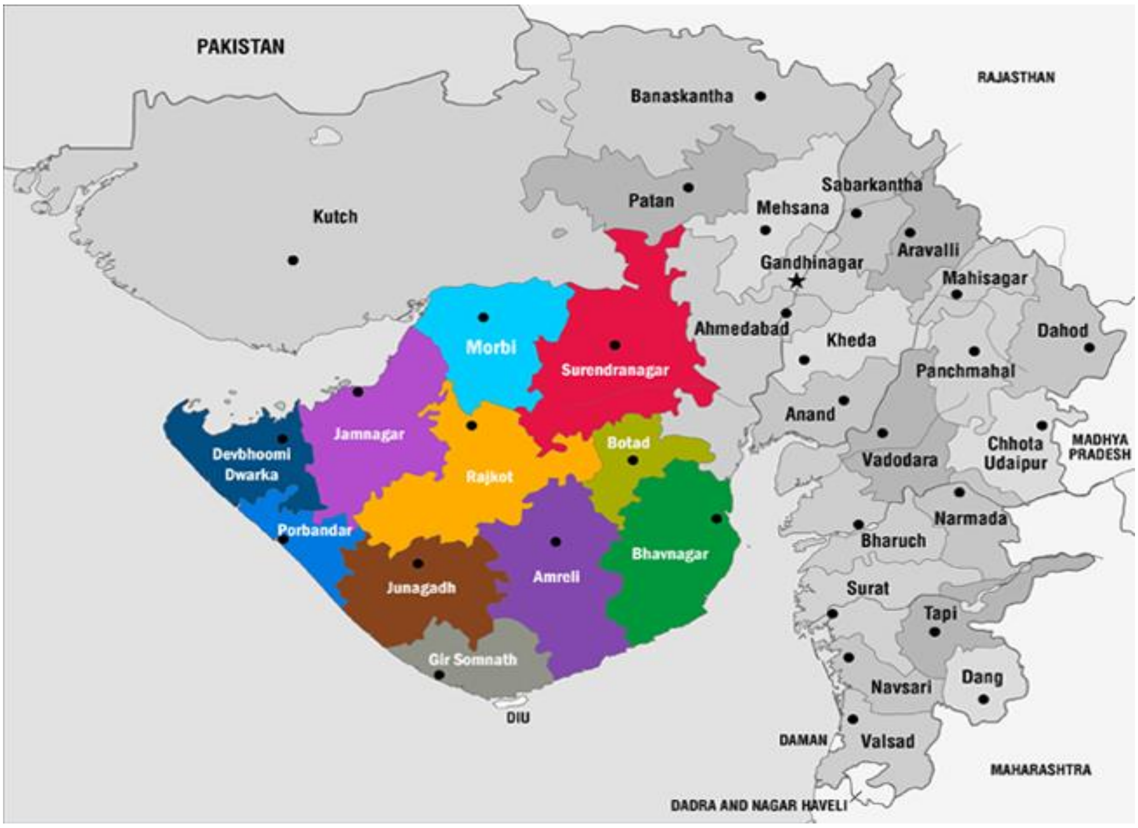

Figure 3.1 Map of Saurashtra

Saurashtra, and some part of it also known as Sorath or Kathiawar, is a peninsular region of Gujarat, India, located on the Arabian Sea coast. It covers about a third of Gujarat state, notably 11 districts of Gujarat. Hence, the present study was confined to the Devbhumi Dwarka, Jamnagar, Morbi, Rajkot, Porbandar, Junagadh, Gir Somnath, Amreli, Bhavnagar, Botad, Surendranagar districts of Saurashtra. The study was carried out during the year 2020. Saurashtra was formerly a state of India before it merged with Bombay state. In 1961, it separated from Bombay and joined Gujarat. Saurashtra peninsula is bound on the south and south-west by the Arabian Sea, on the north-west by the Gulf of Kutch and on the east by the Gulf of Khambhat. From the apex of these two gulfs, the Little Ran of Kutch and Khambhat, waste tracts half salt morass half sandy desert, stretch inland towards each other and complete the isolation of Kathiawar, except one narrow neck which connects it on the north-east with the mainland of Gujarat. It lies between 22° 30" North latitude and 70° 78" East longitude. The main crops grown in Kharif season are Great Millet, Bajra, Maize, Paddy, and Groundnut. In Rabi season, these are Cotton, Wheat, Mustard, Cumin and Vegetables. It has an area of 66,000 km^2 and has a population of 15,300,000. The population density of Saurashtra is 230 km^2.This location was only used for the secondary data collection for studying imbalance use of Fertilizer.

The secondary data related to the fertilizer was used for studying production, consumption, import, export, capacity and capacity utilization of fertilizer for the year 2000-2019.

3.2 SAMPLING TECHNIQUE

For this study, Saurashtra region was selected purposively. Eleven district were selected from region. For each district, Fertilizer’s consumption of 19 year were selected. Saurashtra region was selected due to the imbalance use of fertilizer.

3.3 SOURCES OF DATA

The data was collected from secondary sources.

3.3.1 Secondary data

Secondary data regarding company’s information and consumption of fertilizer over a period of 19 year in the Saurashtra region were collected from Fertilizer statistics of Fertilizer association of India, Government reports and other internet sources.

3.4 STATISTICAL ANALYSIS

3.4.1 Fertilizer scenario

To study the fertilizer scenario in India, simple analysis based on the available literature was used. The study uses secondary data from published and unpublished sources. The parameters, which were included for the study of the fertilizer scenario of India, is given below:

a) Production of N & P (In thousand tonnes)
b) Fertilizer consumption (In lakh tonnes)
c) Fertilizer Import (In lakh tonnes)
d) Export of N P K (in lakh tonnes)
e) Capacity and Capacity utilization (In thousand tonnes)

3.4.2 Demand and supply of fertilizer distribution

Fertilizer analysis

This study uses causal model because time series data on fertilizer consumption as well as variables influencing fertilizer use are available.

This study estimated fertilizer demand model using annual time series data, from 2000-01 to 20018-2019 using simple linear regression model using ordinary least squares (OLS) method (Sharma and Thaker, 2011**)**. The demand for fertilizer is a function of prices (specifically price of fertilizers and food grains), subsidy, as well as non-price factors such as irrigated area, coverage of high yielding varieties, area under food grains and non-food grains, cropping intensity, rainfall, capital availability. The empirical model for the fertilizer use is specified as follows:

$$\mathbf{F_{it} = b_0 + b_1\ HYV_t + b_2\ GIA_t + b_3\ CI_t + b_4\ Pfert_{it} + b_5\ Pr{+}w_t + b_6\ Credit_t + U_t}$$

Where, Fit is fertilizer consumption; i denotes three nutrients N, P and K and total (N+P+K) fertilizer consumption in thousand tonnes; t denotes year

The following independent variables were hypothesized to influence the consumption Positively (+), negatively (-), or either negatively or positively (+/-):

HYV = Per centage of area under HYV to gross cropped area (+)

GIA = Per centage of gross irrigated area to gross cropped area (+)

CI = Cropping intensity (per cent) (+)

P_{fert} = Prices of fertilizers are represented by price of N through Urea, average price of P Through DAP and SSP, price of K through MOP and N+P+K price is the price of N, P and K and weighted by their consumption shares (-)

P_{r+w} = Output price is represented by procurement price of rice and wheat (main users of Fertilizers) and weighted by the share of their production (+)

3.4.3 Fertilizer imbalance

This prompted us to estimate exact nature of imbalance in fertiliser use against norm of balance use of N, P and k that is recommended to be in the ratio of 4:2:1. This was estimated by using an indicator of imbalance adopted in earlier studies (Chand and Pandey, 2008) as under:

$$I = \sqrt{\{(Na- Nn)2+(Pa- Pn)2+(ka- kn)2\}/3}$$

Where, I is the measure of deviation in proportion of actual use of N, P and k from the norm and subscript `a' indicates actual and subscript `n'.

3.4.4 Compare and contrast the production of fertilizer and food grains

The study is based on secondary information. The data is collected from various sources such as planning Commission report, economic survey, annual reports of agriculture and other reports published by the Government of India. Compound Annual Growth Rate (CAGR) has been calculated to analyse the trends in fertilizer consumption and food grain production in India. The study has used Co-integration and Granger Causality techniques to identify the relationship between chemical fertilizer consumption and food grains production.

3.4.4.1 Co integration and Granger Causality Techniques

Co-integration between fertilizer consumption and food grain production from 2000-01 to 2018-19 was estimated by Co-integration and analysis. The Granger Causality test has been used to identify the causality between these two variables.

In the time series analysis, first and foremost step is to check whether the data under consideration is stationary or not. To check the level and stationarity of variables, ADF test is used.

3.4.4.2 Augmented Dickey- Fuller (ADF) Test

$$\Delta yt = \alpha + \beta t + \gamma yt - 1 + \delta 1 \Delta yt - 1 + \cdots + \delta p - 1 \Delta yt - p + 1 + \varepsilon t,$$

Where Ɛt is a pure white noise error term and where ΔYt-1 = (Yt-1 – Yt-2), ΔYt-2 = (Yt-2 – Yt-3) etc. "The number of lagged difference terms to include is often determined empirically. In ADF we test whether δ=0 and ADF test follows the same asymptotic distribution as the DF statistics, so the same critical values can be used" (Gujarati and Porter, 2009).

3.4.4.3 : Johansen Juselius Co-integration Test

VAR-based co-integration tests using the Johansen methodology (Hjalmarsson and Österholm, 2007) performed using a Group object or an estimated VAR object. Consider a VAR of order:

$$y_t = \mu + A_1 Y_{t-1} + \ldots + A_p y_{t-p} + \varepsilon_t,$$

Where y_t *is a* k -vector of non-stationary I (1) variables, x_t is a d -vector of deterministic variables, and ε_t is a vector of innovations. We may rewrite this VAR as,

$$\Delta yt = \prod yt - 1 + \sum_{i=1}^{p-1} \Gamma \ i\Delta yt - i + \epsilon t$$

Where:

$$\prod = \sum_{i=1}^{p} Ai - I, \qquad \Gamma i = -\sum_{i=i+1}^{p} Ai$$

Granger's representation theorem asserts that if the coefficient matrix ∏ has reduced rank *r<k*, then there exist *kxr* matrices *α* and *β* each with rank *r* such that ∏= α β' and *β'*y_t is I (0). *r* is the number of co-integrating relations (the co-integrating rank) and each column of β is the co-integrating vector. As explained below, the elements of α are known as the adjustment parameters in the VEC model. Johansen's

method is to estimate the $\prod$ matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of $\prod$.

3.4.4.4 : Granger Causality Test

The Granger approach (Sarker and khan, 2020) to the question of whether *x* causes *y* is to see how much of the current *y* can be explained by past values *y* of and then to see whether adding lagged values of *x* can improve the explanation. *y* is said to be Granger-caused by *x* if *x* helps in the prediction of *y,* or equivalently if the coefficients on the lagged *x's* are statistically significant. Note that two-way causation is frequently the case; *x* Granger causes *y* and *y* Granger causes *x*.

It is important to note that the statement "*x* Granger causes *y*" does not imply that *y* is the effect or the result of *x.* Granger causality measures precedence and information content does not itself indicate causality in the more common use of the term.

Bivariate regressions of the form:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} + \beta_1 X_{t-1} + \ldots + \beta_p X_{t-p} + \nu 1,\ t,$$
$$X_t = \alpha_0 + \alpha_1 X_{t-1} + \ldots + \alpha_p X_{t-p} + B_1 Y_{t-1} + \ldots + B_p Y_{t-p} + \nu 2,\ t,$$

For all possible pairs of (*x, y*) series in the group. The reported *F*-statistics are the Wald statistics for the joint hypothesis:

H_0: $\beta_1 = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\beta_p = 0$ and indicates X does not Granger cause Y.

H_0: $\beta_1 = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\beta_p = 0$ and indicates Y does not Granger cause X.

For each equation. The null hypothesis is that *x* does not Granger-cause *y* in the first regression and that *y* does not Granger-cause *x* in the second regression.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter is devoted to presentation and interpretation of the result obtained through the analysis of the data. In this chapter, the data collected from the sample population were critically analyzed using different analytical tools and the observations were presented under the following heads:

4.1 Fertilizer scenario in India.

4.2 Demand and supply of fertilizer distribution in India.

4.3 Fertilizer imbalance respective to Saurashtra region.

4.4 Compare and contrast the production of fertilizers and food grains in India.

4.1 FERTILIZER SCENARIO IN INDIA

A number of factors like production, consumption, import and export, capacity and capacity utilization affects the use of fertilizers. These are mainly selected for the study and discussed below. It was not possible to include all the characteristics, which influence the fertilizer scenario. However, important characteristics were selected and findings have been presented as under.

4.1.1 Production of Nitrogen and phosphorus

Table 4.1 shows that the total production of nitrogen and phosphorus in each year from 2000-01 to 2018-19. It was observed that, during the year 2015-16 had highest production of nitrogen (13475.90 thousand tons) and during the year 2002-03 had recorded lowest nitrogen production (10,507.60 thousand tons) in the entire study period. It also shows that highest production of phosphorus (4724.4 thousand tons) was recorded in the year 2017-18 and lowest production of phosphorus (3417.3 thousand tons) was observed in the year 2008-09. The given table shows an overall increase in the fertilizer production in most of the study period.

Table 4.1 Production of Nitrogen and phosphorus (In Thousand Tones)

Year	**N**	P
	Production	**Production**
2000-01	10,942.80	3734.2
2001-02	10,689.50	3835.3
2002-03	10,507.60	3907.7
2003-04	10,556.80	3626.6
2004-05	11,304.90	4038.4
2005-06	11,332.90	4202.6
2006-07	11,524.90	4440
2007-08	10,902.80	3714.3
2008-09	10,900.20	3417.3
2009-10	11,924.00	4374.3
2010-11	12,178.60	4371.2
2011-12	12,288.10	4363.7
2012-13	12,237.30	3826
2013-14	12,408.60	3972
2014-15	12,433.70	4118.9
2015-16	13,475.90	4425.8
2016-17	13,376.80	4552.7
2017-18	13,422.60	4724.4
2018-19	13,336.80	4590.5

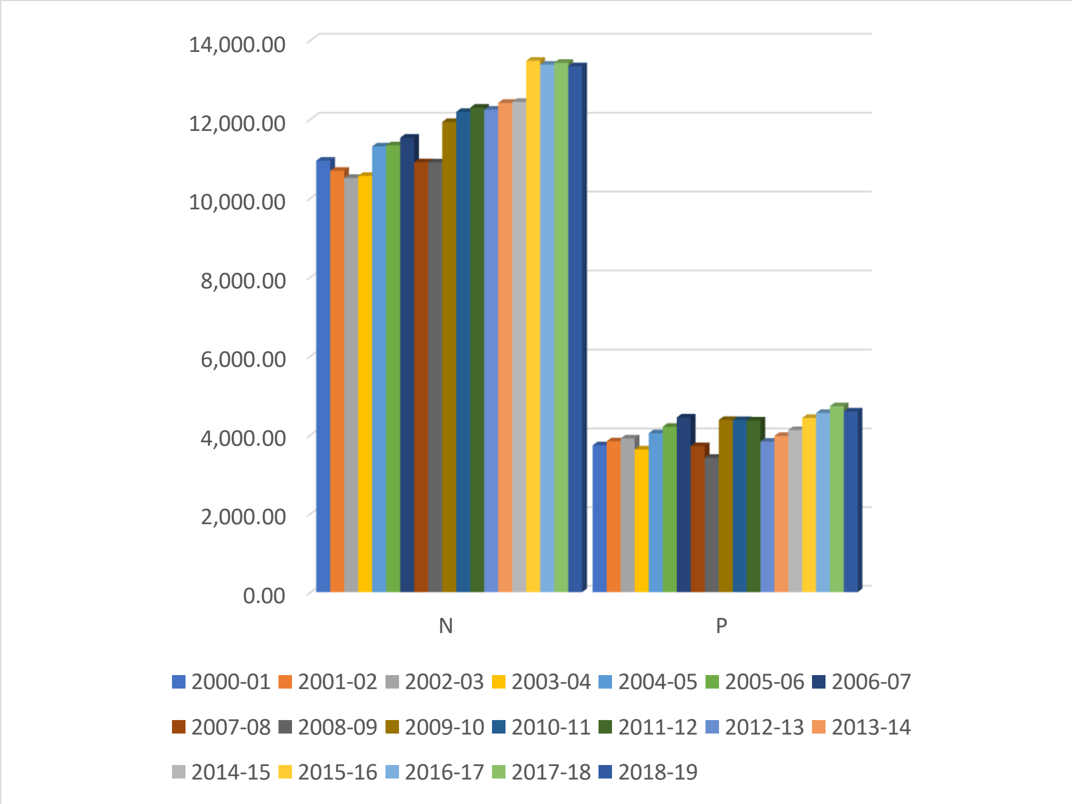

Figure 4.1 Production of Nitrogen and phosphorus (In Thousand Tones)

4.1.2 Fertilizer Consumption

Table 4.2 shows that the total Consumption of nitrogen, phosphorus and potassium in each year from 2000-01 to 2018-19. It was observed that, during the year 2010-11 had highest consumption of fertilizer (281.22 lakh tons) and during the year 2002-03 had recorded lowest fertilizer consumption (160.94 lakh tons) in the entire study period. The given table shows an overall increase in the fertilizer consumption in most of the study period.

Table 4.2 Fertilizer consumption (In Lakh Tonnes)

Year	N	P	K	Total
2000-01	109.2	42.15	15.68	167.02
2001-02	113.1	43.82	16.67	173.6
2002-03	104.74	40.19	16.01	160.94
2003-04	110.77	41.24	15.98	167.99
2004-05	117.14	46.24	20.61	183.98
2005-06	127.23	52.04	24.14	203.41
2006-07	137.73	55.43	23.35	216.51
2007-08	144.19	55.15	26.36	225.7
2008-09	150.91	65.06	33.13	249.09
2009-10	155.8	72.74	36.32	264.86
2010-11	165.58	80.5	35.14	281.22
2011-12	173	79.14	25.75	277.9
2012-13	168.21	66.53	20.62	255.36
2013-14	167.5	56.33	20.99	244.82
2014-15	169.45	60.98	25.32	255.76
2015-16	173.72	69.79	24.02	267.53
2016-17	167.35	67.05	25.08	259.49
2017-18	169.58	68.54	27.79	265.91
2018-19	176.28	69.68	27.79	273.75

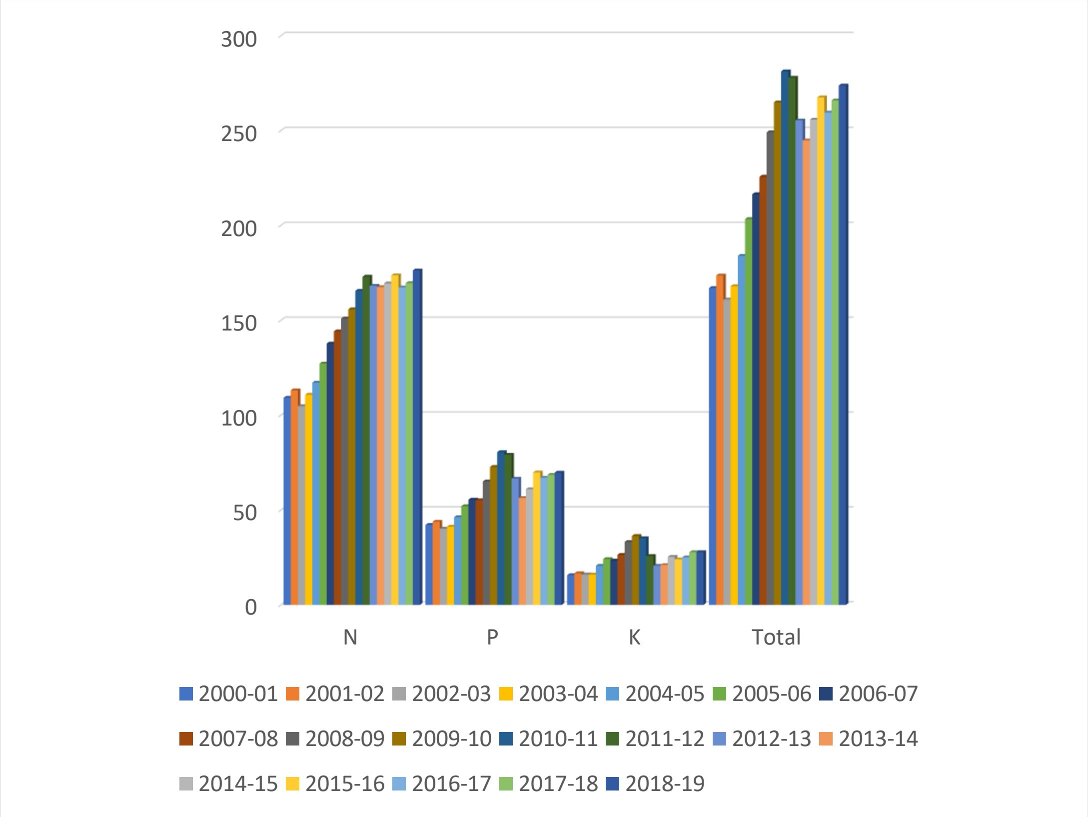

Figure 4.2 Fertilizer consumption (In Lakh Tonnes)

4.1.3 Fertilizer import

Table 4.3 shows that the total import of nitrogen, phosphorus and potassium in each year from 2000-01 to 2018-19. It was observed that, during the year 2011-12 had highest import of nitrogen (5240 lakh tons) and during the year 2002-03 had recorded lowest nitrogen import (67 lakh tons) in the entire study period. It also shows that highest import of phosphorus (4427 lakh tons) was recorded in the year 2011-12 and lowest import of phosphorus (170 lakh tons) was observed in the year 2002-03. It also shows that highest import of potassium (4069 lakh tons) was recorded in the year 2010-11 and lowest import of potassium (1230 lakh tons) was observed in the year 2012-13. The given table shows an overall increase in the fertilizer import in most of the study period.

Table 4.3 Fertilizer Import (In Lakh Tonnes)

Year	N	P	K	Total
2000-01	154	396	1541	2091
2001-02	269	429	1701	2399
2002-03	67	170	1520	1757
2003-04	132	338	1548	2018
2004-05	411	296	2045	2752
2005-06	1385	1121	2747	5253
2006-07	2688	1323	2069	6080
2007-08	3677	1253	2653	7583
2008-09	3844	2927	3380	10151
2009-10	3447	2756	2944	9147
2010-11	4492	3802	4069	12363
2011-12	5240	4427	3335	13002
2012-13	4690	2778	1230	8698
2013-14	3808	1590	1333	6731
2014-15	4766	1832	2537	9135
2015-16	5068	2888	2053	10009
2016-17	3385	2130	2325	7840
2017-18	3588	2047	2895	8530
2018-19	4701	3167	2629	10497

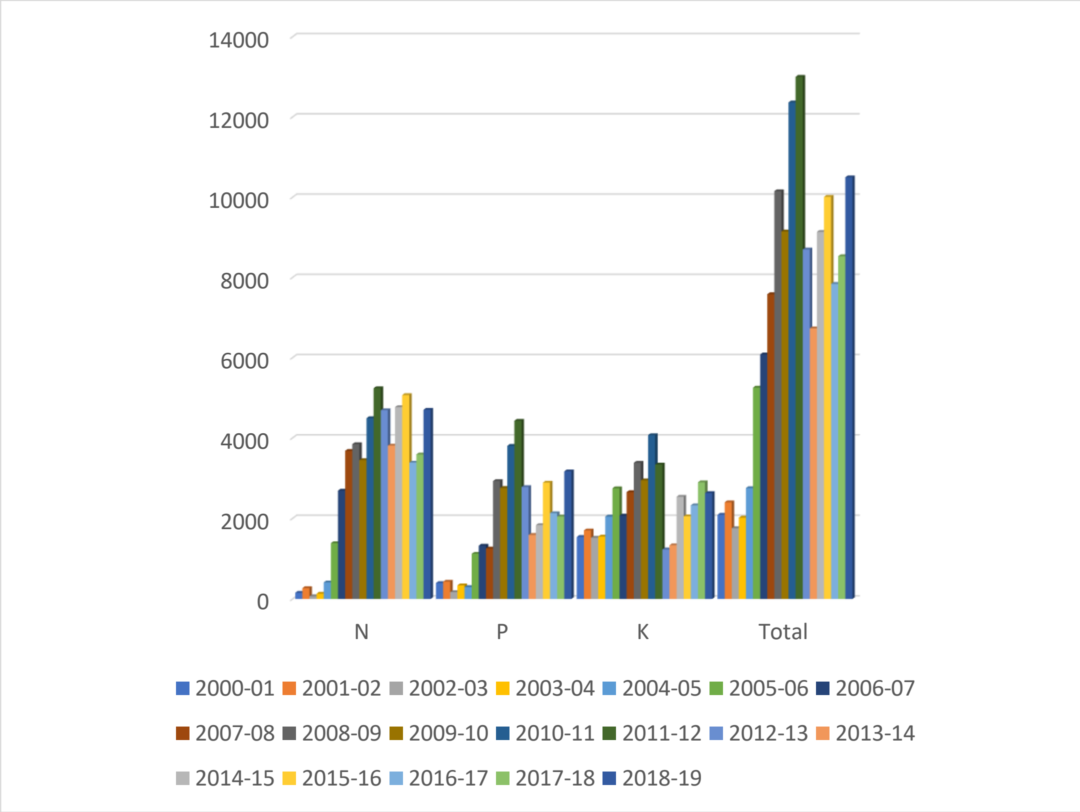

Figure 4.3 Fertilizer Import (In Lakh Tonnes)

4.1.4 Fertilizer export

Table 4.4 shows that the total export of fertilizer in each year from 2000-01 to 2018-19. It was observed that, during the year 2010-11 had highest export of fertilizer (25 lakh tons) and during the year 2001-02 had recorded lowest fertilizer export (0.07 lakh tons) in the entire study period. The given table shows an overall increase in the fertilizer export in most of the study period.

Table 4.4 Fertilizer Export (In Lakh Tonnes)

Year	Export
2000-01	0.34
2001-02	0.07
2002-03	0.09
2003-04	0.4
2004-05	0.23
2005-06	0.21
2006-07	0.26
2007-08	0.35
2008-09	0.36
2009-10	0.38
2010-11	25
2011-12	7
2012-13	6
2013-14	0.51
2014-15	0.39
2015-16	0.98
2016-17	1.05
2017-18	1.14
2018-19	1.74

4.1.5 Capacity and Capacity Utilization of Fertilizer

Table 4.5 shows that the capacity and capacity utilization of nitrogen and phosphorus in each year from 2000-01 to 2018-19. It was observed that, during the year 2017-18 had highest capacity of nitrogen (14317.50 thousand tons) and during the year 2003-04 had recorded lowest capacity of nitrogen (11563.60 thousand tons) in the entire study period. It also shows that highest capacity of phosphorus (7340.1 thousand tons) was recorded in the year 2018-19 and lowest of phosphorus (4987.7 thousand tons) was observed in the year 2000-01. It also shows that highest capacity utilization of nitrogen (99.55 thousand tons) was recorded in the year 2006-07 and lowest capacity utilization of nitrogen (89.43 thousand tons) was observed in the year 2001-02. It also shows that highest capacity utilization of phosphorus (77.4 thousand tons) was recorded in the year 2006-07 and lowest capacity utilization of phosphorus (58.36 thousand tons) was observed in the year 2008-09. The given table shows an overall increase in the fertilizer capacity and capacity utilization in most of the study period. It is clear from the table that more capacity utilization was observed in case of nitrogen than phosphorous.

Table 4.5 Fertilizer Capacity and Capacity Utilization (In Thousand Tonnes)

Year	**Capacity**	**Capacity**	**Capacity Utilisation per cent**	
	N	**P**	**N**	**P**
2000-01	11,987.70	4987.7	91.28	74.87
2001-02	11,953.00	5112.4	89.43	75.02
2002-03	11,684.10	5333	89.93	73.27
2003-04	11,563.60	5401.6	91.29	67.14
2004-05	11,604.60	5480.4	97.42	73.69
2005-06	11,634.90	5459.6	97.4	76.98
2006-07	11,576.90	5736.3	99.55	77.4
2007-08	11,606.90	5874.6	93.93	63.23
2008-09	11,898.30	5855.3	91.61	58.36
2009-10	12,567.60	6202.1	94.88	70.53
2010-11	12,567.60	6198.3	96.9	70.52
2011-12	12,572.80	6221.3	97.74	70.14
2012-13	13,078.90	6373.8	93.57	60.03
2013-14	13,533.30	6719.2	91.69	59.11
2014-15	13,533.30	6889.9	91.87	59.78
2015-16	13,574.10	7032.8	99.28	62.93
2016-17	13,712.40	7220.9	97.55	63.05
2017-18	14,317.50	7293.9	93.75	64.77
2018-19	14,299.10	7340.1	93.27	62.54

4.2 DEMAND AND SUPPLY OF FERTILIZER DISTRIBUTION IN INDIA

The regression estimates for total fertilizer consumption equation are reported in Table 4.6 the high R_2 value (0.99) indicates that explanatory variables in the model have accounted for over 99 per cent variation in fertilizer use and the model best fits when predicting fertilizer demand. The model was significant at 1 per cent level. Price of fertilize and percentage of HYV to GCA was negatively related with demand and supply of fertilizer while percentage of GIA to GCA, cropping intensity and output price had a positive relationship with fertilizers demand and supply.

The results show that non-price factors were more important determinants of fertilizer use. Among the non-price factors, irrigation was the most important factor influencing fertilizer demand, followed by cropping intensity. The price of fertilizers was the third important determinant of fertilizer use in the country. Price of output is less important compared with input price. The results clearly indicate that increase in area under irrigation, and cropping intensity will accelerate fertilizer consumption in the country. In case of pricing policy instruments, increase in prices of fertilizers would lead to reduction in fertilizer use while output price had a positive impact on fertilizer consumption but was less powerful than input prices. Therefore, it is necessary to prioritize input price policy mechanism over higher output prices as high output price benefits a small proportion of farmers while low input price will increase fertilizer consumption on millions of marginal and small farmers.

Table 4.6 Estimated regression equation for total fertilizer use in India

Cropping Intensity	**Coefficients**	**Standard Error**	**t Stat**
Intercept	-160.326	298.7718	-0.53662
Percentage of HYV to GCA	-0.6012	5.509793	-0.10912
Percentage of GIA to GCA	8.725691	3.884014	2.246565
Cropping Intensity	0.257	1.744563	0.147315
Output Price	0.119846	0.034578	3.465974
Weighted Price	-6.3749	1.534842	-4.15345
R Square	0.912063	-	-
Adjusted R Square	0.878241	-	-
F	26.96671	-	-

*** Significant at one per cent; ** Significant at 5 per cent; * Significant at 10 per cent; @ Significant at 15 per cent

4.3 FERTILIZER IMBALANCE RESPECTIVE TO SAURASHTRA REGION

Table 4.7 shows that, In Amreli, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2011-12 onward some hike in imbalanced were observed. After, policy intervention by the government in price control, same negative trend was reflect in use of fertilizer in Amreli district. Although, in term of norm used of fertilizer with compare of actual use of fertilizer, there is wide gap have found from the study. For the optimum use of fertilizer in this district, government should play important role for minimizing the overuse of chemical fertilizer for the maintain of soil harness.

Table 4.7 District wise Fertilizer Imbalance of Amreli

Amreli				
Year	N	P_2O_5	K_2O	I
2000-01	31.11	25.18	1	20.59
2001-02	26.48	17.08	1	15.63
2002-03	26.33	18.05	1	15.87
2003-04	22.23	13.95	1	12.58
2004-05	18.74	11.74	1	10.20
2005-06	11.64	6.88	1	5.23
2006-07	11.77	6.47	1	5.17
2007-08	10.38	6.03	1	4.36
2008-09	9.47	5.69	1	3.81
2009-10	7.24	5.31	1	2.67
2010-11	8.09	4.97	1	2.92
2011-12	15.25	8.21	1	7.42
2012-13	18.71	8.49	1	9.28
2013-14	23.40	8.55	1	11.82
2014-15	17.32	8.00	1	8.43
2015-16	13.19	6.07	1	5.80
2016-17	18.83	8.46	1	9.34
2017-18	16.85	8.63	1	8.35
2018-19	13.46	6.97	1	6.17

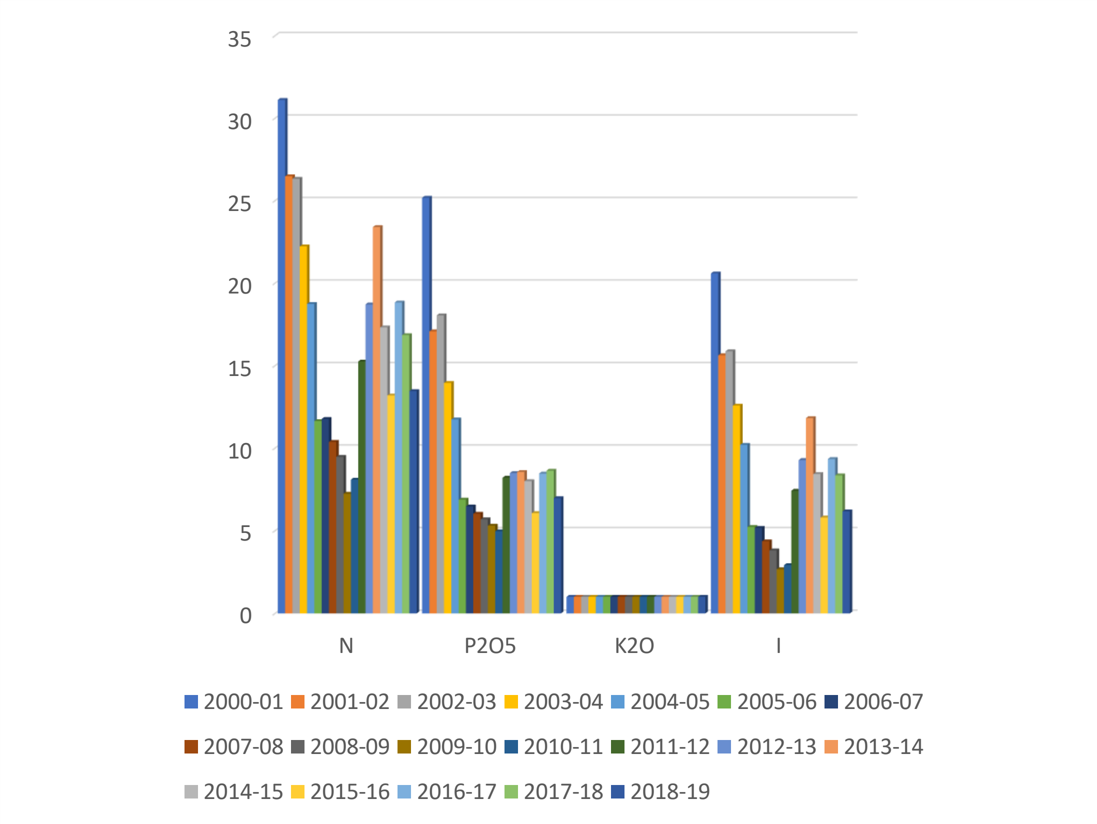

Figure 4.4 District wise Fertilizer Imbalance of Amreli

Table 4.8 shows that, In Bhavnagar, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2011-12 onward some hike in imbalanced were observed. Although, in term of norm used of fertilizer with compare of actual use of fertilizer, there is wide gap have found from the study. For the optimum use of fertilizer in this district, government should play important role for minimizing the overuse of chemical fertilizer for the maintain of soil harness.

Table 4.8 District wise Fertilizer Imbalance of Bhavnagar

Bhavnagar				
Year	N	P_2O_5	K_2O	I
2000-01	63.9	40.08	1	40.98
2001-02	46.53	23.95	1	27.63
2002-03	30.62	14.65	1	17.02
2003-04	36.75	17.31	1	20.87
2004-05	24.79	12.61	1	13.47
2005-06	15.65	7.86	1	7.53
2006-07	16.74	7.99	1	8.12
2007-08	12.81	6.61	1	5.74
2008-09	9.70	5.25	1	3.79
2009-10	9.26	6.06	1	3.84
2010-11	9.63	5.36	1	3.78
2011-12	12.46	6.48	1	5.53
2012-13	13.47	6.26	1	5.99
2013-14	18.04	6.86	1	8.58
2014-15	15.14	6.94	1	7.04
2015-16	12.86	5.68	1	5.54
2016-17	12.32	5.61	1	5.24
2017-18	10.45	4.67	1	4.03
2018-19	9.79	4.65	1	3.68

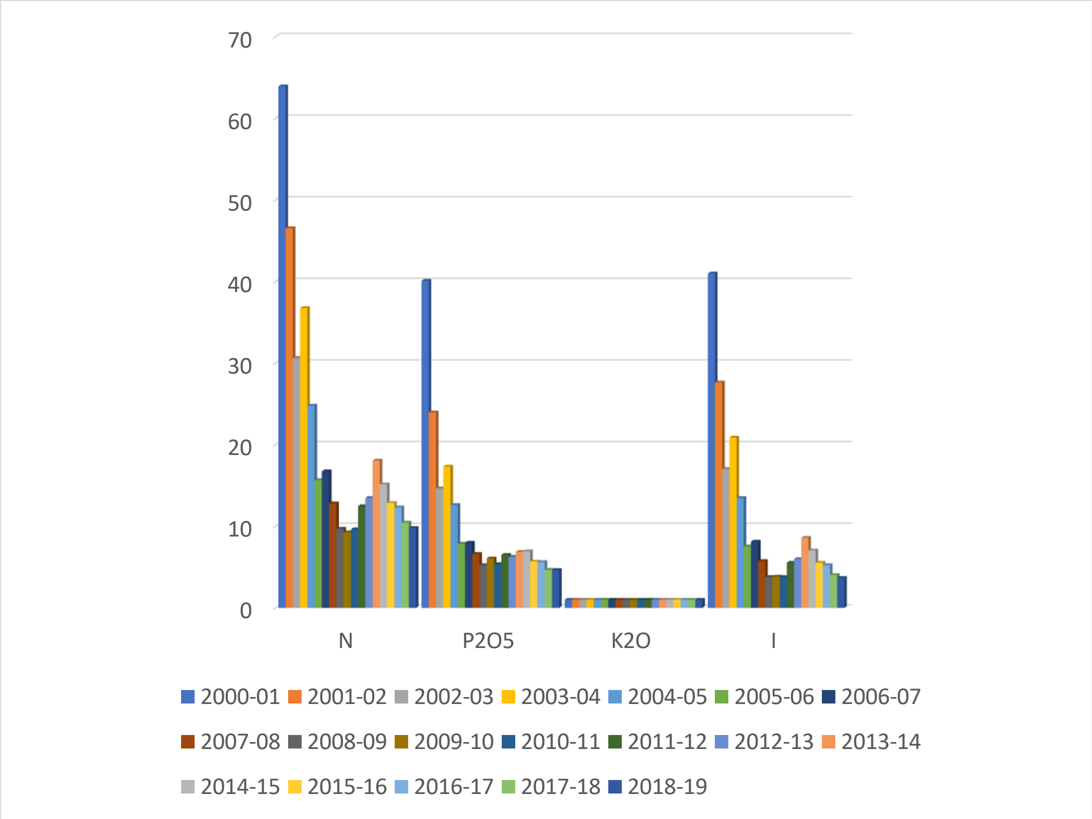

Figure 4.5 District wise Fertilizer Imbalance of Bhavnagar

Table 4.9 shows that, In Jamnagar, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2003-04 there was a positive hike after that up to 2010-11 negative slop observed. From 2011-12 to 2013-14 observed positive hike and from 2014-15 to 2018-19 alternate fluctuation observed.

Table 4.9 District wise Fertilizer Imbalance of Jamnagar

Jamnagar				
Year	N	P_2O_5	K_2O	I
2000-01	25.11	23.16	1	17.26
2001-02	21.57	19.40	1	14.28
2002-03	12.97	11.18	1	7.41
2003-04	17.22	12.49	1	9.74
2004-05	13.42	9.56	1	6.97
2005-06	11.46	6.80	1	5.12
2006-07	10.12	5.73	1	4.14
2007-08	9.66	6.04	1	4.01
2008-09	7.43	5.16	1	2.69
2009-10	8.90	6.24	1	3.74
2010-11	7.82	4.70	1	2.70
2011-12	11.42	6.35	1	4.96
2012-13	15.90	7.95	1	7.68
2013-14	15.00	7.72	1	7.16
2014-15	10.76	5.85	1	4.49
2015-16	12.13	5.38	1	5.08
2016-17	10.39	6.42	1	4.49
2017-18	9.72	5.86	1	3.98
2018-19	9.81	6.29	1	4.17

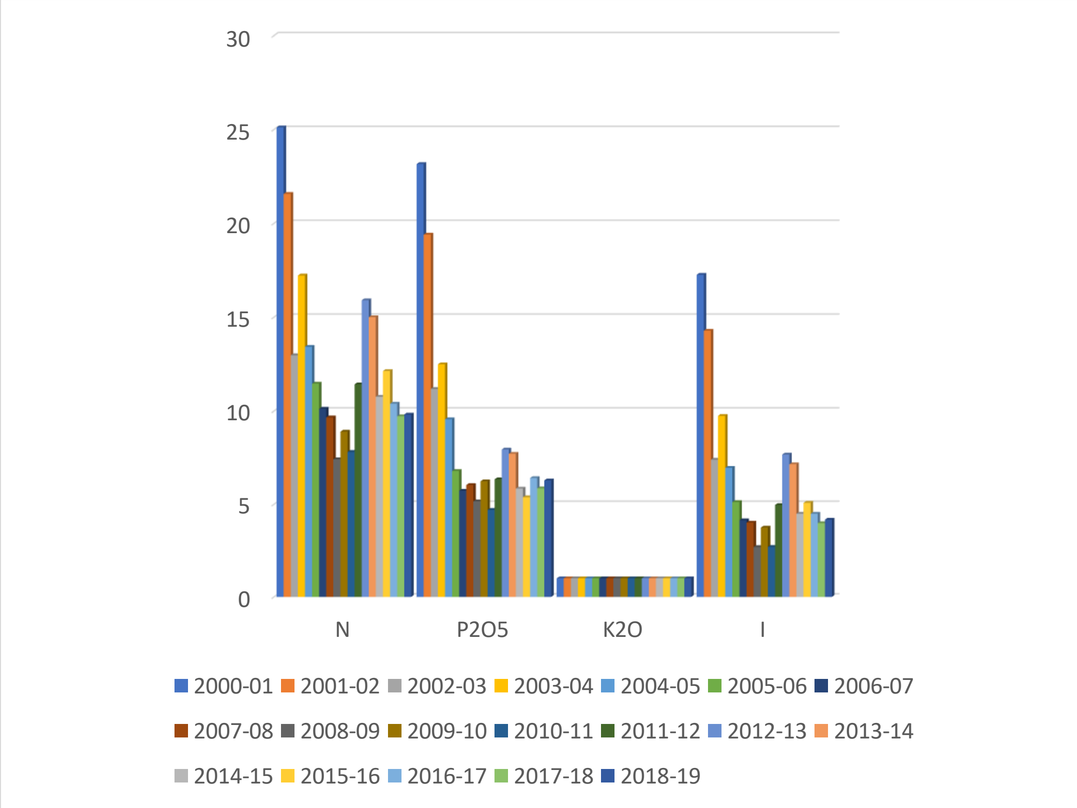

Figure 4.6 District wise Fertilizer Imbalance of Jamnagar

Table 4.10 shows that, In Junagadh, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2003-04 there was a positive hike after that up to 2009-10 negative slop observed. From 2010-11 to 2011-12 observed positive hike and from 2012-13 to 2018-19 alternate fluctuation observed.

Table 4.10 District wise Fertilizer Imbalance of Junagadh

Junagadh				
Year	N	P_2O_5	K_2O	I
2000-01	14.22	9.18	1	7.21
2001-02	13.29	9.19	1	6.78
2002-03	10.84	8.48	1	5.44
2003-04	14.48	9.34	1	7.39
2004-05	9.97	6.65	1	4.37
2005-06	9.32	6.09	1	3.87
2006-07	9.13	5.68	1	3.64
2007-08	8.76	5.52	1	3.42
2008-09	7.38	4.84	1	2.55
2009-10	5.81	4.02	1	1.56
2010-11	8.92	5.25	1	3.41
2011-12	11.80	6.24	1	5.13
2012-13	18.70	7.15	1	8.99
2013-14	14.28	6.17	1	6.40
2014-15	11.64	5.46	1	4.84
2015-16	11.60	5.74	1	4.89
2016-17	9.31	4.74	1	3.45
2017-18	9.29	5.20	1	3.57
2018-19	7.84	5.00	1	2.81

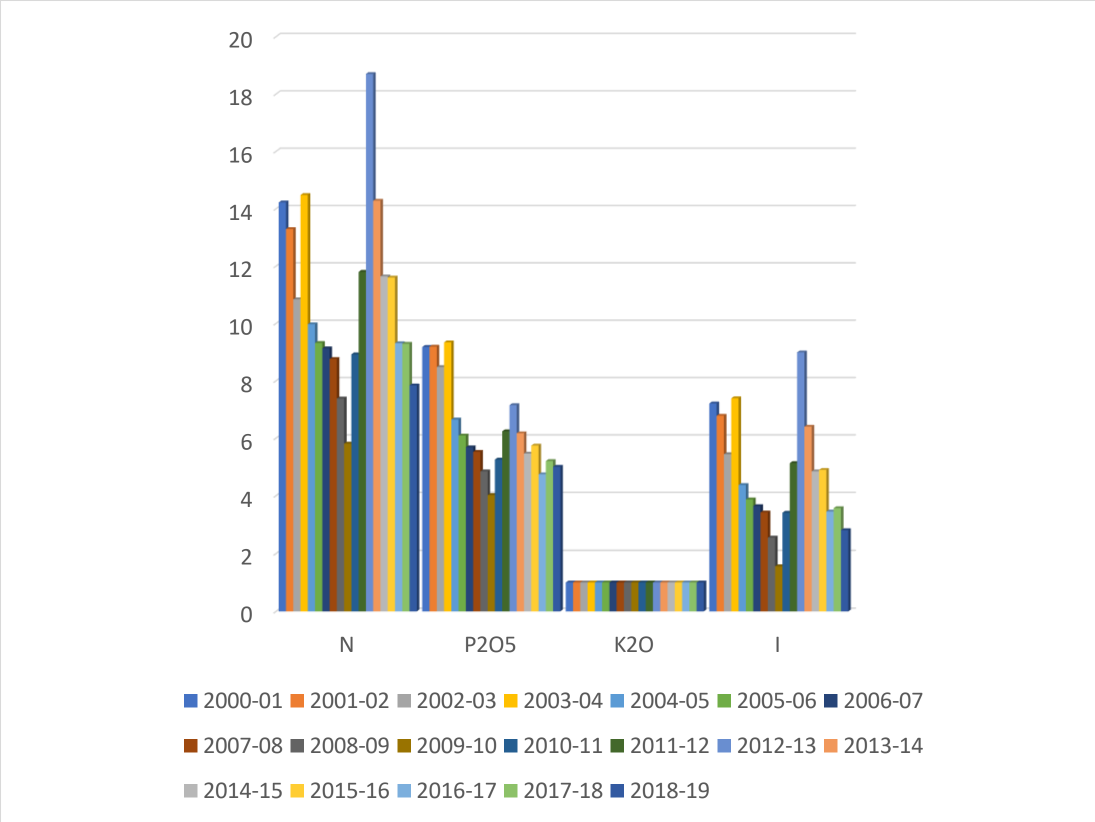

Figure 4.7 District wise Fertilizer Imbalance of Junagadh

Table 4.11 shows that, In Porbandar, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2008-09 there was a positive hike after that up to 2010-11 negative slop observed. From 2011-12 to 2013-14 observed positive hike and from 2014-15 to 2018-19 alternate fluctuation observed.

Table 4.11 District wise Fertilizer Imbalance of Porbandar

Porbandar				
Year	N	P_2O_5	K_2O	I
2000-01	31.28	57.74	1	35.83
2001-02	26.85	17.35	1	15.89
2002-03	24.72	22.26	1	16.73
2003-04	11.78	9.25	1	6.14
2004-05	10.57	7.42	1	4.92
2005-06	8.43	6.18	1	3.52
2006-07	11.57	7.17	1	5.29
2007-08	11.74	7.69	1	5.55
2008-09	13.51	9.97	1	7.16
2009-10	12.22	10.08	1	6.65
2010-11	9.07	5.93	1	3.70
2011-12	10.71	7.88	1	5.15
2012-13	20.62	13.99	1	11.83
2013-14	22.16	15.66	1	13.12
2014-15	14.78	7.75	1	7.05
2015-16	18.93	11.13	1	10.10
2016-17	8.45	4.71	1	3.01
2017-18	12.77	7.88	1	6.09
2018-19	12.48	7.80	1	5.93

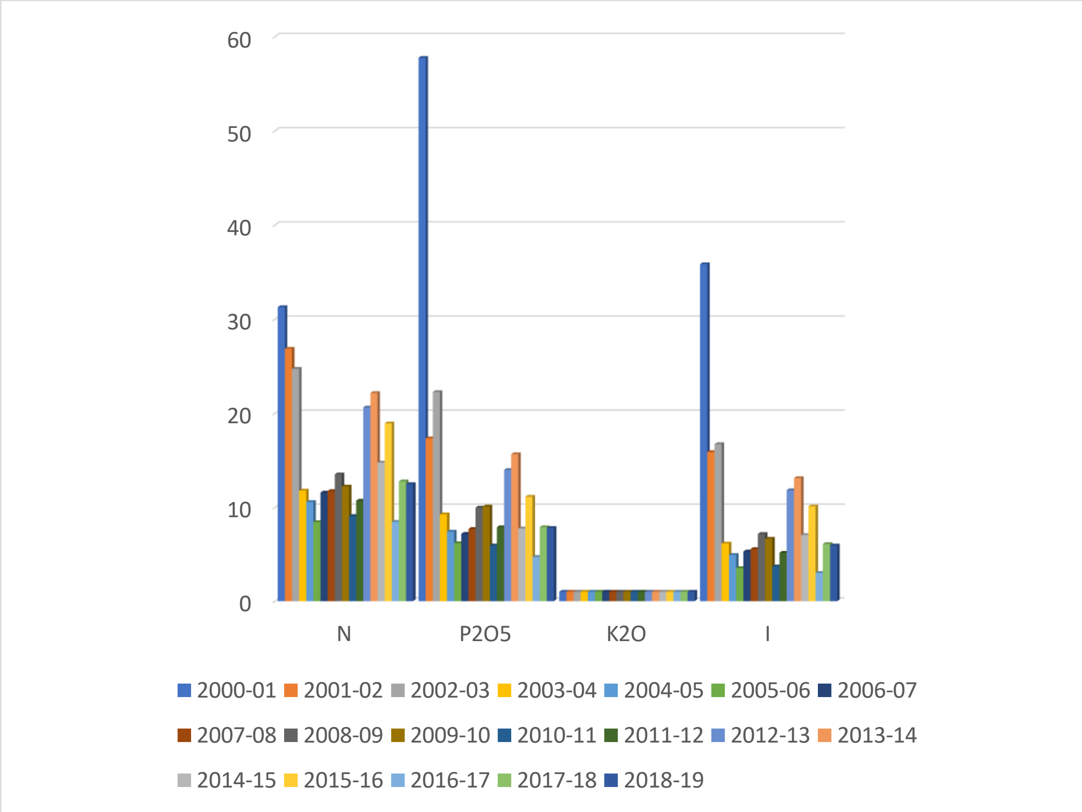

Figure 4.8 District wise Fertilizer Imbalance of Porbandar

Table 4.12 shows that, In Rajkot, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2003-04 there was a positive hike after that up to 2008-09 negative slop observed. From 2009-10 to 2013-14 observed positive hike and from 2014-15 to 2018-19 alternate fluctuation observed.

Table 4.12 District wise Fertilizer Imbalance of Rajkot

Rajkot				
Year	N	P_2O_5	K_2O	I
2000-01	13.59	7.92	1	6.50
2001-02	11.10	7.12	1	5.05
2002-03	8.80	6.67	1	3.87
2003-04	11.23	6.40	1	4.89
2004-05	10.27	6.04	1	4.31
2005-06	8.31	4.20	1	2.79
2006-07	7.62	3.80	1	2.33
2007-08	6.59	3.46	1	1.72
2008-09	5.22	3.14	1	0.97
2009-10	5.11	3.29	1	0.98
2010-11	5.90	3.28	1	1.32
2011-12	9.24	4.37	1	3.32
2012-13	9.96	4.65	1	3.76
2013-14	11.61	4.47	1	4.62
2014-15	10.74	4.11	1	4.08
2015-16	9.68	4.08	1	3.49
2016-17	7.06	3.49	1	1.96
2017-18	7.46	4.01	1	2.31
2018-19	6.72	3.61	1	1.82

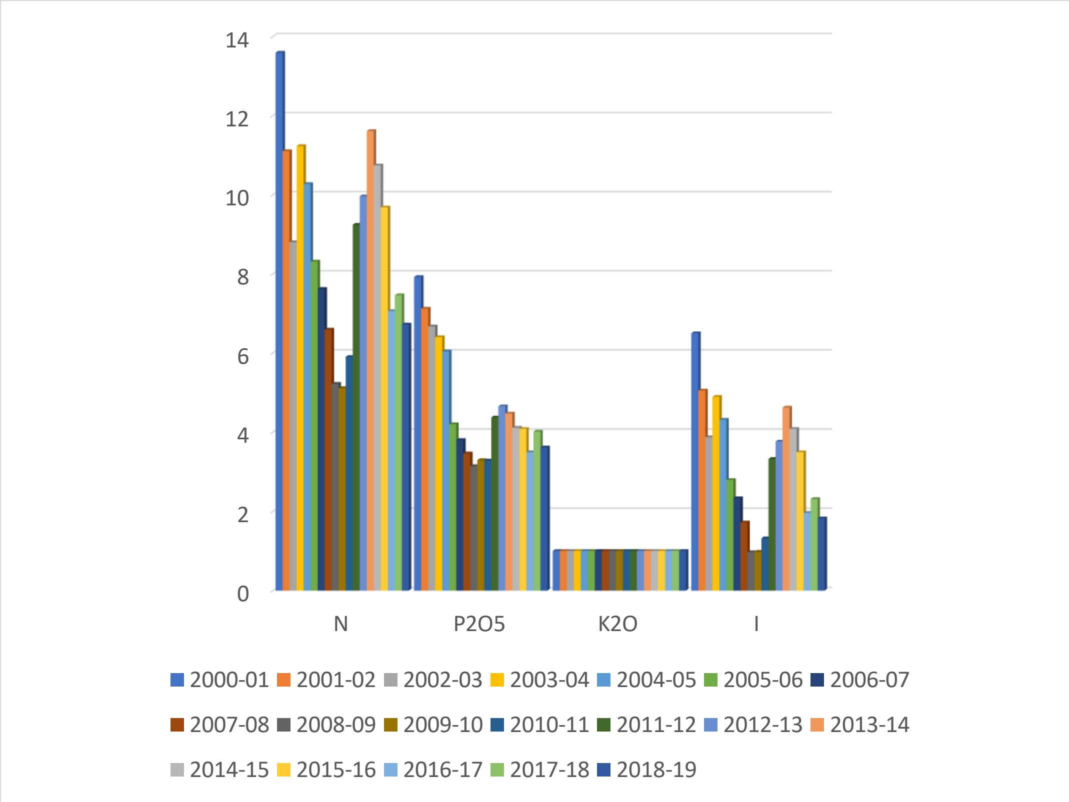

Figure 4.9 District wise Fertilizer Imbalance of Rajkot

Table 4.13 shows that, In Surendranagar, highest imbalance used of fertilizer were observed in the year of 2012-13, followed by 2002-03 and 2000-01. The trend of imbalance in use of fertilizer was fully fluctuated during the period of study.

Table 4.13 District wise Fertilizer Imbalance of Surendranagar

Surendranagar				
Year	N	P_2O_5	K_2O	I
2000-01	76.23	38.23	1	46.65
2001-02	65.98	29.45	1	39.14
2002-03	81.64	40.82	1	50.12
2003-04	64.46	22.76	1	36.91
2004-05	61.69	20.77	1	35.02
2005-06	11.12	4.21	1	4.30
2006-07	23.16	8.33	1	11.65
2007-08	21.26	8.22	1	10.59
2008-09	16.89	6.75	1	7.93
2009-10	12.69	5.76	1	5.47
2010-11	26.07	10.76	1	13.71
2011-12	39.54	12.93	1	21.47
2012-13	100.51	36.58	1	59.19
2013-14	47.81	15.19	1	26.41
2014-15	29.99	9.21	1	15.57
2015-16	51.77	14.14	1	28.46
2016-17	28.07	10.14	1	14.67
2017-18	41.60	15.52	1	23.07
2018-19	25.69	11.36	1	13.64

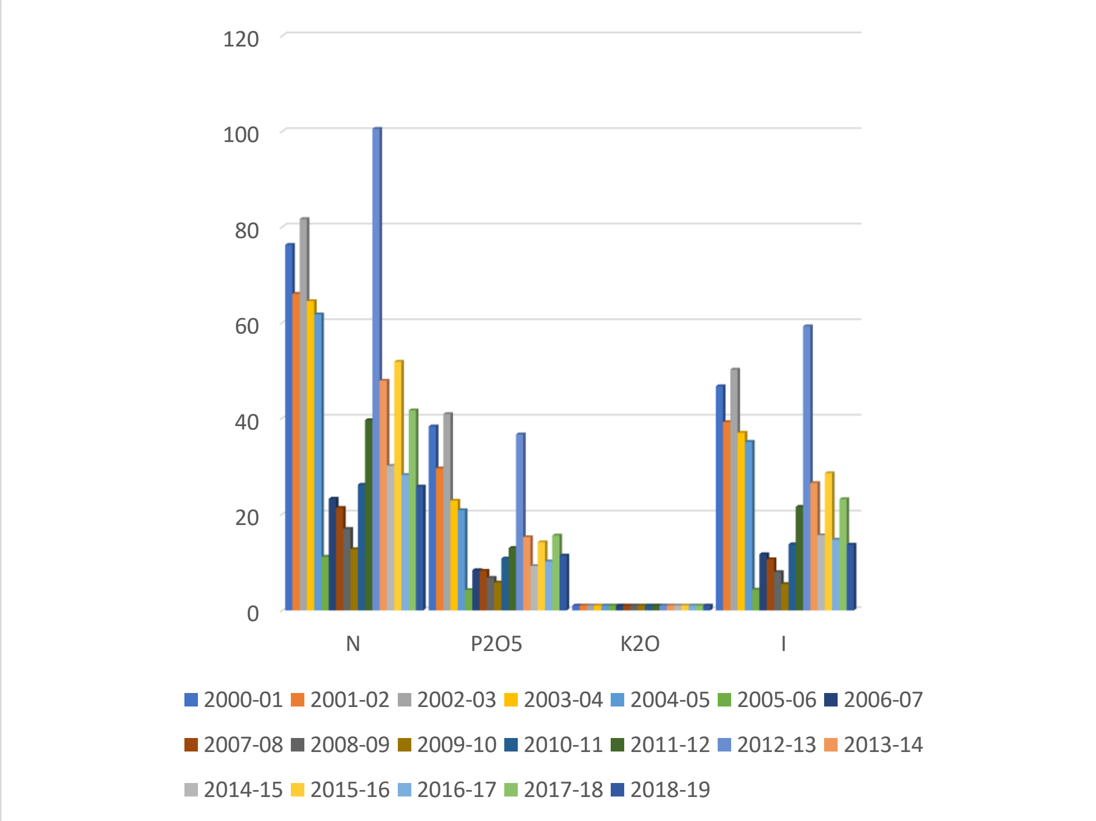

Figure 4.10 District wise Fertilizer Imbalance of Surendranagar

4.4 COMPARE AND CONTRAST THE PRODUCTION OF FERTILIZERS AND FOOD GRAINS IN INDIA

Table 4.14 presents results for the causality test. To perform the test, we focus on the food grain production and fertilizer consumption as part compare and contrast production of fertilizers and food grains in India. Granger Causality is attempted to understand the two-way relationship between consumption of chemical fertilizers and food grain production. Consumption of chemical fertilizers and food grain production are expected to be influencing each other. While increased fertilizer consumption leads to increased output, increased out is likely to influence the fertilizer consumption as increased return on agriculture increases affordability to purchase fertilizers.

Table 4.14 Granger Causality Test

Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
NPK does not Granger Cause FGP	48	2.44062	0.0991
FGP does not Granger Cause NPK		3.45662	0.0405

The null hypothesis of "no Granger causality" is rejected highly significantly for the relationship between the food grain production and the fertilizer consumption with a *p* value of 9.91 per cent. However, the causality test reveals causality from the food grain production and the fertilizer consumption with a lower significance level of 4.05 per cent. Thus, test results document bidirectional causality of Granger type between the fertilizer consumption and the food grain production. The pairwise granger causality test (Table 4.14) has identified the causation of fertilizer consumption on food grains production at lag 2. This shows that the fertilizer consumption has a significant influence on food grain production. On the other hand, food grain production does not seem to influence fertilizer consumption through its influence on incomes of the farmers.

Table 4.15 Augmented Dickey- Fuller (ADF) Test

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
FGP (-1)	6.303394	3.208652	1.964499	0.0554
C	-970.4696	610.4449	-1.589774	0.1186

The ADF test result of first difference and intercept of the log form indicate that stationarity can be achieved at first difference. It implies the first order integration of fertilizer consumption and food grain production. Based on the integration at first order the Johnsen and Juselius co-integration was run. The results of the test are presented in Table 4.16.

Table 4.16 Johansen Juselius Co-integration Test results

Unrestricted Co-integration Rank Test (Trace)

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.326648	22.40281	15.49471	0.0039
At most 1	0.068759	3.419404	3.841466	0.0644

The test indicates 1 co integratingeqn(s) at the 0.05 level * indicated that rejection of the hypothesis at the 0.05 level.

Table 4.17 Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.326648	18.98341	14.2646	0.0083
At most 1	0.068759	3.419404	3.841466	0.0644

Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 4.16 and 4.17 shows that in both the tests the null hypotheses of no co-integrating vectors have been rejected against one co-integrating vectors. But we cannot reject null hypothesis of at most one co-integration vectors in the both the cases. (Because P value in trace test statistics and max-eigen value is greater than 5per cent) Both the test results indicated the existence of at least one cointegrating vectors in the model at 1per cent of significance. The one co-integration vector implies that the fertilizer consumption and food grain production are related in the long run.

CHAPTER V

SUMMARY AND CONCLUSION

Agriculture is the backbone of the Indian economy and fertilizer play a key role in agricultural prosperity. The population of India is 1.3 billion. 60 per cent of the population of India depends on agriculture to eke out their livelihood. Since independence, Indian agriculture has been significantly progressing; it grew at the rate of one percent per annum for sixty years during pre-independence era 1860-1920. Further, it springs up at the rate of about 2.6 per cent per annum in the post-independence era 1951-56.

The industry had a very humble beginning in 1906, when the first manufacturing unit of Single Super Phosphate (SSP) was set up in Ranipet near Chennai with an annual capacity of 6000 MT. The Fertilizer & Chemicals Travancore of India Ltd. (FACT) at Cochin in Kerala and the Fertilizers Corporation of India (FCI) in Sindri in Bihar were the first large sized fertilizer plants set up. The installed capacity as on 30.01.2003 has reached a level of 121.10 lakh MT of nitrogen (inclusive of an installed capacity of 208.42 lakh MT of urea after reassessment of capacity) and 53.60 lakh MT of phosphatic nutrient, making India the 3rd largest fertilizer producer in the world. The rapid build-up of fertilizer production capacity in the country has been achieved as a result of a favourable policy environment facilitating large investments in the public, co-operative and private sectors.

The Indian fertilizer market was worth INR 6,258 billion in 2019. Fertilizers have played a key role in the success of India's green revolution and subsequent self-reliance in food-grain production. After China, India is the second largest consumer of fertilizer in the world with an annual consumption of more than 55 million metric tons.

Climatic factors, like rainfall pattern have a very crucial role in the consumption of fertilizers as their demand increase with an increase in irrigated areas. Agro-ecological zone no.7 was consuming 177.1 kg/ha, of fertilizer which was the highest among the different Agro- ecological zones of India. Fertilizers should be used in a balanced manner through integrated management of nutrient involving the use of chemical fertilizers, bio fertilizers, compost and vermicomposting. Balanced use of fertilizers will reduce harmful effects of chemical fertilizers on the environment and will help in making our agriculture sustainable. It also increases water and nutrients use efficiency, improve grain quality, soil health and give better economic returns to farmers and helps in sustainability.

Specifically, the project work was done to achieve the following objectives:

1. To study the fertilizer scenario in India.
2. To analyse the demand and supply of fertilizer distribution in India.
3. To analyse the fertilizer imbalance respective to Saurashtra region.
4. To compare and contrast the production of fertilizers and food grains in India.

The study was carried out during the year 2020. For this study, Saurashtra region was selected purposively. Eleven districts were selected from region. For each district, Fertilizer's consumption of 19 year were selected. Saurashtra region was selected due to the imbalance use of fertilizer.

The data was collected from secondary sources. Secondary data regarding company's information and consumption of fertilizer over a period of 19 year in the Saurashtra region were collected from Fertilizer statistics of Fertilizer association of India, Government reports and other internet sources.

For study the fertilizer scenario in India, simple analysis based on the available literature was used. The study uses secondary data from published and unpublished sources. The demand and supply of fertilizer distribution in India was estimated fertilizer demand model using annual time series data, from 2000-01 to 20018-2019 using simple linear regression model using ordinary least squares (OLS) method. Fertilizer imbalance was estimated by using an indicator of imbalance adopted in earlier studies. To compare and contrast the production of fertilizers and food grains in India has used Co-integration and Granger Causality techniques to identify the relationship between chemical fertilizer consumption and food grains production.

5.1 THE MAJOR FINDINGS OF THE STUDY WERE SUMMARIZED AS UNDER

5.1.1 FERTILIZER SCENARIO IN INDIA

- It was found that, during the year 2015-16 had highest production of nitrogen (13475.90 thousand tons) and during the year 2002-03 had recorded lowest nitrogen production (10,507.60 thousand tons) in the entire study period. It also shows that highest production of phosphorus (4724.4 thousand tons) was recorded in the year 2017-18 and lowest production of phosphorus (3417.3 thousand tons) was observed in the year 2008-09.

- It was found that, during the year 2010-11 had highest consumption of fertilizer (281.22 lakh tons) and during the year 2002-03 had recorded lowest fertilizer consumption (160.94 lakh tons) in the entire study period.
- It was found that, during the year 2011-12 had highest import of nitrogen (5240 lakh tons) and during the year 2002-03 had recorded lowest nitrogen import (67 lakh tons) in the entire study period. It also shows that highest import of phosphorus (4427 lakh tons) was recorded in the year 2011-12 and lowest import of phosphorus (170 lakh tons) was observed in the year 2002-03. It also shows that highest import of potassium (4069 lakh tons) was recorded in the year 2010-11 and lowest import of potassium (1230 lakh tons) was observed in the year 2012-13.
- It was found that, during the year 2010-11 had highest export of fertilizer (25 lakh tons) and during the year 2001-02 had recorded lowest fertilizer export (0.07 lakh tons) in the entire study period.
- It was found that, during the year 2017-18 had highest capacity of nitrogen (14317.50 thousand tons) and during the year 2003-04 had recorded lowest capacity of nitrogen (11563.60 thousand tons) in the entire study period. It also shows that highest capacity of phosphorus (7340.1 thousand tons) was recorded in the year 2018-19 and lowest of phosphorus (4987.7 thousand tons) was observed in the year 2000-01. It also shows that highest capacity utilization of nitrogen (99.55 thousand tons) was recorded in the year 2006-07 and lowest capacity utilization of nitrogen (89.43 thousand tons) was observed in the year 2001-02. It also shows that highest capacity utilization of phosphorus (77.4 thousand tons) was recorded in the year 2006-07 and lowest capacity utilization of phosphorus (58.36 thousand tons) was observed in the year 2008-09.

5.1.2 DEMAND AND SUPPLY OF FERTILIZER DISTRIBUTION IN INDIA

- It was found that the high R_2 value (0.99) indicates that explanatory variables in the model have accounted for over 99 per cent variation in fertilizer use and the model best fits when predicting fertilizer demand. The model was significant at 1 per cent level. Price of fertilize and percentage of HYV to GCA was negatively related with demand and supply of fertilizer while percentage of GIA to GCA, cropping intensity and output price had a positive relationship with fertilizers demand and supply. The results show that non-price factors were more important determinants of fertilizer use. Among the non-price factors, irrigation was the most important factor influencing fertilizer demand, followed by cropping intensity. The price of fertilizers was the third important determinant of fertilizer use in the country. Price of output is less important compared with input price. The results clearly indicate that increase in area under irrigation, and cropping intensity will accelerate fertilizer consumption in the country. In case of pricing policy instruments, increase in prices of fertilizers would lead to reduction in fertilizer use while output price had a positive impact on fertilizer consumption but was less powerful than input prices.

5.1.3 FERTILIZER IMBALANCE RESPECTIVE TO SAURASHTRA REGION

- It was found that, In Amreli, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2011-12 onward some hike in imbalanced were observed. After, policy intervention by the government in price control, same negative trend was reflect in use of fertilizer in Amreli district. Although, in term of norm used of fertilizer with compare of actual use of fertilizer, there is wide gap have found from the study.
- It was found that, In Bhavnagar, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2011-12 onward some hike in imbalanced were observed. Although, in term of norm used of fertilizer with compare of actual use of fertilizer, there is wide gap have found from the study.
- It was found that, In Jamnagar, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2003-04 there was a positive hike after that up to 2010-11 negative slop observed. From 2011-12 to 2013-14 observed positive hike and from 2014-15 to 2018-19 alternate fluctuation observed.
- It was found that, In Junagadh, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2003-04 there was a

positive hike after that up to 2009-10 negative slop observed. From 2010-11 to 2011-12 observed positive hike and from 2012-13 to 2018-19 alternate fluctuation observed.

- It was found that, In Porbandar, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2008-09 there was a positive hike after that up to 2010-11 negative slop observed. From 2011-12 to 2013-14 observed positive hike and from 2014-15 to 2018-19 alternate fluctuation observed.
- It was found that, In Rajkot, highest imbalance used of fertilizer were observed in the year of 2000-01, followed by 2001-02 and 2002-03. The trend of imbalance in use of fertilizer was negative slope was observed, but in 2003-04 there was a positive hike after that up to 2008-09 negative slop observed. From 2009-10 to 2013-14 observed positive hike and from 2014-15 to 2018-19 alternate fluctuation observed.
- It was found that, In Surendranagar, highest imbalance used of fertilizer were observed in the year of 2012-13, followed by 2002-03 and 2000-01. The trend of imbalance in use of fertilizer was fully fluctuated during the period of study.

5.1.4 COMPARE AND CONTRAST THE PRODUCTION OF FERTILIZERS AND FOOD GRAINS IN INDIA

- It was found that the null hypothesis of "no Granger causality" is rejected highly significantly for the relationship between the food grain production and the fertilizer consumption with a *p* value of 9.91 per cent. However, the causality test reveals causality from the food grain production and the fertilizer consumption with a lower significance level of 4.05 per cent. Thus, test results document bidirectional causality of Granger type between the fertilizer consumption and the food grain production. The pairwise granger causality test has identified the causation of fertilizer consumption on food grains production at lag 2. This shows that the fertilizer consumption has a significant influence on food grain production. On the other hand, food grain production does not seem to influence fertilizer consumption through its influence on incomes of the farmers.

- It was found that The ADF test result of first difference and intercept of the log form indicate that stationarity can be achieved at first difference. It implies the first order integration of fertilizer consumption and food grain production. Based on the integration at first order the Johnsen and Juselius co-integration was run. The results of the test are presented.
- It was found that in both the tests the null hypotheses of no co-integrating vectors have been rejected against one co-integrating vectors. But we cannot reject null hypothesis of at most one co-integration vectors in the both the cases. (Because P value in trace test statistics and max-eigen value is greater than 5per cent) Both the test results indicated the existence of at least one cointegrating vectors in the model at 1per cent of significance. The one co-integration vector implies that the fertilizer consumption and food grain production are related in the long run.

5.2 SUGGESTIONS

Based on findings of the study, the following suggestions implications are drawn:

- Fertilizer scenario revealed production, consumption, import-export and capacity, capacity utilization of fertilizer. It was fully fluctuated during the period of study. It was not possible to include all the characteristics, which influence the fertilizer scenario. However, important characteristics were selected. It should have selected more characteristics, which influence fertilizer scenario.
- It is necessary to prioritize input price policy mechanism over higher output prices as high output price benefits a small proportion of farmers while low input price will increase fertilizer consumption on millions of marginal and small farmers.
- The optimum use of fertilizer in this district, government should play important role for minimizing the overuse of chemical fertilizer for maintain of soil harness.
- The trend of imbalance use of fertilizer was negative slope was observed in between the year and again it was recorded high for particular year. This trend is fluctuated over the years. Because, Total consumption of N P K does not cause the Food grain Production. Therefore, it should not increase food grain production in spite of negative slop was observed in between the year.

5.3 CONCLUSION

It can be concluded that Fertilizer scenario revealed production, consumption, import-export and capacity, capacity utilization of fertilizer and these characteristics highly influenced the fertilizer scenario.

Non-price factors were more important determinants of fertilizer use. Among the non-price factors, irrigation was the most important factor influencing fertilizer demand, followed by cropping intensity. The price of fertilizers was the third important determinant of fertilizer use in the country. Price of output is less important compared with input price. The results clearly indicate that increase in area under irrigation, and cropping intensity will accelerate fertilizer consumption in the country. Therefore, it can be concluded that In case of pricing policy instruments, increase in prices of fertilizers would lead to reduction in fertilizer use while output price had a positive impact on fertilizer consumption but was less powerful than input prices.

It can be concluded that the trend of imbalance in use of fertilizer was negative slope was observed. After, policy intervention by the government in price control, same negative trend was reflect in use of fertilizer in districts. Although, in term of norm used of fertilizer with compare of actual use of fertilizer, there is wide gap have found from the study.

It has been found that the trend of imbalance use of fertilizer was negative slope was observed in between the year and again it was recorded high for particular year. This trend is fluctuated over the years. Because, Total consumption of N P K does not cause the Food grain Production.

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