REGIONAL IMBALANCES AND IMPACT OF SOIL HEALTH CARD ON FERTILIZER CONSUMPTION IN GUJARAT

A

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MAKADIA JAYANTILAL JERAJ
M.Sc. (Agri.)

DEPARTMENT OF AGRICULTURAL ECONOMICS
N. M. COLLEGE OF AGRICULTURE
NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI-396 45O
GUJARAT STATE

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Name of Student	Major Advisor
Shri J. J. Makadia	Dr. K.S.Patel

DEPARTMENT OF AGRICULTURAL ECONOMICS
N. M. COLLEGE OF AGRICULTURE
NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI-396 45O

A B S T R A C T

The present study was undertaken with a view to assess the growth in fertilizer consumption and fertilizer use pattern, to examine the gap between actual use and recommended dose of fertilizer, to study the determinants of fertilizer use, to estimate the fertilizer use efficiency and to study the impact of Soil Health Card on consumption of fertilizer in South Gujarat region. Multistage random sampling technique was used for sample selection. Total sample size comprised of 224 farmers with 50-50 per cent from with and without Soil Health Cards. The primary data were collected for the agricultural year 2010-11 by survey method.

The results of the study revealed that among all the crops in South Gujarat region, the highest area was allocated to sugarcane crop, followed by kharif paddy and summer paddy.

Among the regions, Middle Gujarat stood at top in consumption of N during all periods and Kutchh stood at the bottom. During the Period–I, IV and VI, the consumption of N fertilizer significantly increased in all the regions of Gujarat state. During Period–II and Period-III, the consumption of N increased significantly in all regions except Saurashtra region. Gujarat as a

whole, the consumption of N increased significantly during Period-IV. During Period–V, the consumption of N increased significantly in all regions along with Gujarat as a whole and the lowest instability index was found in South Gujarat region.

The consumption of P fertilizer significantly increased in all the regions along with Gujarat as a whole during Period-I. During Period–II, the consumption of P increased significantly only in North Gujarat region. The lowest instability index was found in South Gujarat region (29.07%). During Period–III, the consumption of P increased significantly in all regions except, Saurashtra region. During Period–IV, the compound growth rates were found positive but non-significant in all the regions. During Period–V, the consumption of P increased significantly in North Gujarat and Kutchh regions. For whole period, the consumption of P increased significantly in all regions. The lowest instability index was found in South Gujarat region (29.14%).

During the Period-I, the consumption of K fertilizer was not reported in any regions of Gujarat State. During Period–II, the consumption of K increased significantly in Saurashtra, North Gujarat, Kutchh and Gujarat as a whole. During Period–III, the consumption of K increased significantly only in Saurashtra region. During Period–IV, the consumption of K increased positively in all regions except Saurashtra region. During Period–V, the consumption of K increased significantly in North Gujarat and Middle Gujarat with negative growth rate in Saurashtra. Gujarat as a whole, consumption of K increased significantly. For whole period, consumption of K increased significantly in all regions except North Gujarat. Gujarat as a whole, consumption of K increased significantly.

The consumption of NPK fertilizer significantly increased in all the regions of Gujarat state along with Gujarat as a whole during Period-I. During Period–II, the consumption of NPK increased significantly in North Gujarat, South Gujarat, Kutchh and Gujarat as a whole. During Period–III, IV and V, the consumption of NPK increased significantly in all regions except, Saurashtra region. The lowest instability index was found in South Gujarat region during Period-III. During whole period, consumption of NPK increased significantly in all regions.

The compound growth rates of gap for N were found negative and significant for Period-I, III and VI for South Gujarat region. This gap was positive for the Period-IV and V but it was found statistically non-significant. In North Gujarat region, the compound growth rates of gap for N were found negative and significant in last three Periods. In Saurashtra region, the compound growth rates of gap for N were found negative and statistically significant for the last four Periods. In Middle Gujarat region, the compound growth rates of gap for N were found negative and statistically significant for all the Periods except, Period-II. In case of Kutchh region, the compound growth rates of gap for N were found negative and statistically significant for Period-I and Period-IV. The compound growth rates of gap for N were found negative and significant for all the periods, except Period-II for entire Gujarat.

The compound growth rates of gap for P were found negative and significant for Period- III and Period-VI for South Gujarat region. For rest of the Periods, it was found positive but non-significant. In North Gujarat region, the compound growth rates of gap for P were found negative and significant for all the Periods except, Period-I. In case of Saurashtra region, the compound

growth rates were found negative in all the periods except, Period-III. And it was statistically significant for Period-I, II, V and VI. In Middle Gujarat, the compound growth rates were negative in Period-I, III, V and VI and statistically significant in Period-III. In case of Kutchh region, the compound growth rates were negative and non-significant in last four Periods. For the state as a whole, the compound growth rates were found negative for all the periods but statistically significant in Period-III, V and VI.

The compound growth rate of gap for K was found negative and statistically significant only for the Period-III in South Gujarat region. In North Gujarat region, the compound growth rates were found negative and statistically significant only in Period-II. In case of Saurashtra region, the compound growth rates were found negative and statistically significant only in Period-II and found positive and statistically significant for Period-I and III. In Middle Gujarat, the compound growth rate was found negative and statistically significant only in Period-V. For Kutchh region, the compound growth rates were found negative and significant in Period-II, III and VI. For the state as a whole, the compound growth rate was negative and statistically significant for Period-II only.

The compound growth rate of gap for NPK fertilizers in the South Gujarat region was found negative and significant in Period-III and VI. In North Gujarat region, the compound growth rates were found negative and significant for Period-IV, V and VI. In Middle Gujarat, the compound growth rates of gap for NPK fertilizers were negative and significant for the Period-I, III, IV and VI. In case of Kutchh region, the compound growth rate was found negative and significant only in Period-IV. In case of Gujarat state

as a whole, the compound growth rates were negative and significant for all the periods except Period-II.

The production function analysis employed for determinants of fertilizer use indicated that annual total income of farmers, short term credit , one year lagged price and educational level were found the major influencing factors for determining the level of fertilizers use in selected crops in general, for with and without Soil Health Card farmers.

The production function analysis employed for fertilizer use efficiency indicated that there existed a variation in the production elasticities of resource inputs between the crops and groups of farmers under study. In general, area under the crop, human labours, phosphorus and other working capital were the important resource variables positively and significantly influencing the crop output in general for with and without Soil Health Card farmers. The nitrogen and manure showed the negative and significant effect on crops output when farmers used these resources excessively.

The paired ' t ' test analysis showed positive and significant impact of Soil Health Card on per hectare yield of selected crops. Generally, with Soil Health Card farmers utilized the fertilizers judiciously as per the recommendation of Soil Health Card.

The findings of the study advocates strengthening of extension and line department machineries to provide Soil Health Cards to remaining farmers and provide technical guidance to farmers. The emphasis should be given by the concern departments to wide spread the utilization of machineries for harvesting of sugarcane and paddy due to acute shortage of labours.

Dr. K.S.Patel
Professor and Head
Department of Agricultural Economics
N.M.College of Agriculture
Navsari Agricultural University,
Navsari-396 450.

CERTIFICATE

This is to certify that the thesis entitled **"REGIONAL IMBALANCES AND IMPACT OF SOIL HEALTH CARD ON FERTILIZER CONSUMPTION IN GUJARAT"** submitted by **Shri MAKADIA JAYANTILAL JERAJBHAI** in partial fulfillment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** in the subject of **AGRICULTURAL ECONOMICS** of the **NAVSARI AGRICULTURAL UNIVERSITY** is a record of bonafide research work carried out by him under my guidance and supervision and that the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Navsari **(K. S. Patel)**

Date : 30th June, 2012 Major Advisor

DECLARATION

This is to declare that the whole of the research work reported here in this thesis for the partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** in **AGRICULTURAL ECONOMICS** by the undersigned is the result of investigation carried out under the direct guidance and supervision of **Dr. K. S. Patel**, Professor and Head, Department of Agricultural Economics, N.M.College of Agriculture, Navsari Agricultural University, Navsari and that no part of the work has been submitted for any other degree so far.

Place : Navsari

Date : 30th June, 2012 **(J.J.Makadia)**

Countersigned by

(K.S.Patel)
Professor and Head
Department of Agricultural Economics
N.M.College of Agriculture
Navsari Agricultural University,
Navsari-396 450.

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Place : Navsari

Date : 30th June, 2012 **(J.J.Makadia)**

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I INTRODUCTION

1.1 General

The process of economic development and its growth in early stage of developing country is crucially dependent upon the progress of agricultural production with a larger share in national income, employment and export earnings. Thus, agriculture determines the pace of progress. In India, agricultural sector still occupies a predominant position in the country's economy, accounting for about 13.9 per cent of gross domestic product and one- fifth of foreign exchange. This sector provides employment to about 58.2 per cent (www.indiancensus, 2001) of the total labour force in the country. Furthermore, its forward and backward linkages with other sectors of the economy are well established in the literature of development economics. Therefore, to achieve an accelerated pace of economic growth, sustained development of the agriculture sector is *sine qua non.*

With the 2 per cent world's geographical area, India has the responsibility to feed 18 per cent of world population. Since independence, our country is constantly increasing foodgrains production which has reached to 244.78 million tonnes in 2010-11, more than about five times the 50.8 million tonnes in 1950-51. With the success of green, white and blue revolution, India is now in the position of self reliance in foodgrains production. It is expected that the total foodgrains demand by 2020 and 2025 is estimated to be 294 and 322 million tonnes, respectively (Kumar, 1998; Malavia, *et al.,* 2000). Thus by 2025, we need to produce about 118 million tonnes additional foodgrains per year from the same or even less area. The most challenging problem which India

faces today is the growth rate of foodgrains production which is lower than the population growth rate during last two decades. Growing population puts enormous pressure on the available natural resources and infrastructure, which become more and more fragile. The foodgrains area per person was 0.22 hectare during 1950 which declined to 0.10 hectare during 2000 and it is projected to be 0.06 hectare in 2050 (www.usda.org). Thus, in developing countries like India, reeling under population pressure, the efficient use of fertilizer must go hand-in-hand for a better tomorrow.

1.2 Meeting the challenging problem

To meet the challenge, the agricultural production can be increased either by pronging more area under cultivation or through increasing productivity. In our country, land is becoming limited and shrinking resource; the demand for land also competes for its use. The cultivated area is about 145 million hectares, and has remained constant for the last 30 years. Because of severe limitations on the increase of net area sown, it would be difficult to bring additional areas under plough to grow the extra amount of foodgrains required to feed the teeming millions. Hence, in order to realize the need based targets of agricultural production, the pattern of production enhancement will have to rest heavily on increased productivity. This essentially culls for optimizing the usage of the existing farm land by adopting new strategy for agricultural development. As a key element of the foodgrains production cycle, fertilizer usage contributed to about 50 per cent of increased foodgrains production in the world (Hegde and Sudhakarbabu, 2004; Tanwar and Bisvas, 2005). In India, fertilizer consumption is concentrated in about one- third of the cultivated

area. It is key element to increase sustainable production of agriculture (Painuly and Dev, 1998).

1.3 New strategy in agriculture

In the above context, balanced use of fertilizer is essential to stabilize crop yield and sustain high crop productivity. The new strategy of judiciously use of fertilizer with well planned integrated plant nutrient supply system(IPNS) as an approach, which adapts plants nutrition to a specific farming system and particular yield targets, the physical resource base, the available plant nutrient sources and the socio-economic back ground should be adopted to overcome the environmental problems (Dudal and Roy, 1995). The sources of plant nutrients may be mineral fertilizers and/or biological nitrogen fixation and/or organic materials depending upon particular location. This integrated plant nutrient supply system should be science based, associating agronomy, ecology and social sciences. It should use a farming system approach and not limit itself to cropping system only. It should address both increased productivity and profitability and integrate maintenance and rehabilitation of natural resources. It will thus be possible to give a technical package of management requirement for a given soil- water - plant - environment situation for realizing maximum fertilizer input use efficiency.

1.4 The role of fertilizer

It is well recognized that a cluster of social, economic, technical and institutional factors affect the level of productivity. Among these, the influence of technological factors predominates for these factors which bring structural changes in agricultural production system by affecting productivity levels. Importance of the other factors lies in as much as they make the economy

conductive to rapid adoption of technological advancement. This has been amply demonstrated by experiences of the agriculturally developed countries which have attained high level of crop productivity through application of technological inputs such as improved and high yielding varieties (HYVs) of seeds, fertilizers water management, plant protection measures and mechanization. Among these inputs, chemical fertilizers have played a vital role. The same has been experienced in Indian agriculture particularly after the mid sixties which led to substantial productivity gains in the country. The role played by fertilizers in the so-called "Green Revolution"" cannot be neglected. Hence, this revolution is also called “Seed Fertilizer Revolution".

As fertilizers are a key component in the package of practices for increasing crop production, they help to replenish essential nutrients that are lost from the soil at every harvest. Several experiments and demonstrations on fertilizers use have proved that the crop yield can be increased sustainably through proper use of fertilizers. Fertilizers, HYVs and irrigation play quite a complementary role in increasing crop yields. Although irrigation influences crop production in many ways, it does not give much higher returns without the use of fertilizers and high yielding varieties of seeds. It is difficult to assess realistically the impact of each single factor in brining about the increased agricultural production. High yielding varieties by themselves play vital role and their potential could be exploited by application of fertilizers. Thus, crop yields depend mainly on the three control variables, irrigation, high yielding variety and use of chemical fertilizers, apart from natural factors such as rainfall, plentiful sunshine and ideal temperature. The average yield per hectare of crops in India is very low due to exhausted soils which have been over cropped from

centuries without adequate replenishment for plant nutrients through fertilizers. It is not possible for the most soils to supply the needed amounts of plant nutrients removed from these soils in the past for getting continuously higher yield of crops. Such heavy removal of plant nutrients from soil leads to depletion of soil fertility, which shows up in crop yield decline and lowered factor productivity (Yadav *et at.,* 1998). Therefore, application of fertilizers is essential to prevent soil degradation, keeping agriculture land productive and economically viable.

1.5 Fertilizer consumption scenario

Among the new technology, fertilizer plays a decisive role in modern agriculture. Commercialization of agricultural sector, change in product mix and declining labour productivity and labour use are the major factors that drive the intensive use of fertilizers.

The fertilizer consumption in India has increased many folds from 65.6 thousand tonnes in 1951-52 to 281.22 lakh tonnes in 2010-11. The corresponding figures for total consumption of N_2, P_2O5 and K_2O during 2010-11 were 165.58, 80.50 and 35.14 lakh tonnes, respectively. The fertilizer consumption in India has grown considerably in the last five decades however, it is still low in comparison to other countries. The fertilizer consumption was 25.75 kg per hectare during 1970 and it increased to 75.43 kg per hectare during 1990s registering a growth rate of 3.94 per cent between 1990-91 and 2000-01 (Ramasamy, 2004). The average fertilizer consumption per hectare of cropped area in India rose from mere 0.55 kg in 1950-51 to 144.14 kg in 2010-11. It is disheartening to note that in spite of this impressive growth over

the last five decades, per hectare consumption in India is still very low as compared to that of many other countries.

A great deal of variability was observed in fertilizer consumption during 2009-10 among the states. Amongst states in the country, per hectare consumption was quite high in Punjab, Haryana and Andhra Pradesh. It was quite low in case of Rajasthan, Orissa and Madhya Pradesh. The all India average consumption of fertilizer was 135.3 kg per hectare in 2009-10. Gujarat occupied eighth position on the basis of per hectare consumption of total NPK (154.96 kg) in the country. It is still far below the levels of consumption of some of the progressive states. Hence, it is necessary to identify the factors influencing temporal and spatial variations in fertilizer use in the state of Gujarat.

The success of modern agriculture depends on the use of technological inputs, of which, chemical fertilizers happens to be quite important one, which become popular among Indian farmers after independence.

Though there are very few recent studies at the national level on growth pattern of fertilizer consumption at the end still fewer have focused specifically on study of factors influencing fertilizer consumption. The process of adoption of fertilizer technology is crop specific and region specific. Regions may differ widely in respect of soil, climatic conditions, irrigation, and adoption of HYVs, the average size of farm and so on. Analysis of region wise data on fertilizer consumption would be useful because it can reveal the degree of variation in the growth of fertilizer consumption among various regions. It will provide also an understanding of the forces behind the past growth of fertilizer consumption.

Use of fertilizers at farmer's level is a complex one. Generally it is found that farmers are not using recommended level of fertilizers for the crops under cultivation, which result into a gap in fertilizer use. It is, therefore, important from the farmers' point of view to use this input up to the level where the net income can be maximize and the gap in efficient use of fertilizer. Thus, it is clear that the studies on fertilizer consumption will be of paramount importance to the planners as well policy makers in preparing realistic future plans to create condition for rapid increase in fertilizer consumption to attain long term goals of agricultural productivity.

1.6 Soil testing services- Soil Health Card

In the context of changing policy environment, it seems likely that farmers will be under increasing pressure to pay higher prices for fertilizers. In the irrigated areas in Gujarat where the fertilizer use is widespread and has reached 1.5 times or more than the recommended rates, the issue of fertilizer use efficiency has increasingly become important (Desai, 1986). The soil testing services is closely related to fertilizer use efficiency. It identifies soil specific requirements of different nutrients. In 2005, the Government of Gujarat has launched Soil Health Card Scheme in which Soil Health Card are issued for farmers containing the information on soil type, cropping pattern, crop sequence, fertilizer dose on the basis of soil analysis etc. The farmers are advised to use chemical fertilizers on the basis of information provided in soil health card, which resulted into optimum yield response and thereby increase in net income. No systemic study to examine the impact of Soil Health Card has been conducted.

The present study entitled, " Regional imbalances and impact of soil health card on fertilizer consumption in Gujarat", was conducted with the following specific objectives.

Objectives

The specific objectives of study are spelt out below:

(I) To examine the district wise trend in consumption of fertilizers in the Gujarat state.

(II) To estimate the district wise gap between requirement and consumption of the fertilizers in the state.

(III) To study the determinants of fertilizer use in selected major crops in South Gujarat region.

(IV) To work out fertilizer use efficiency for selected major crops in South Gujarat region.

(V) To study the impact of Soil Health Card on fertilizer consumption for selected major crops in South Gujarat region.

Hypotheses

The specific hypotheses of the study are helpful for the analytical purposes. The following are the hypotheses postulated for the present study.

(i) There is outward trend in consumption of fertilizers in most of the regions of Gujarat state.

(ii) There is a wide variation in fertilizer consumption among the crops as well as regions of the state.

(iii) Farmers are not using recommended level of fertilizers for the crops under cultivation, so that it results into a gap in fertilizer use.

(iv) Irrigation, high yielding varieties, cropping intensity and size of holding are the major factors, which determines the fertilizer consumption on farm.

(v) Soil Health Card is useful to the farmers for enhancing the yield response and thereby increasing in net income.

1.7 Scope and utility of the study

The success of modern agriculture, among other things, depends largely on the use of off farm produced inputs of which chemical fertilizers happen to be quite important ones. The fertilizer technology became popular among the Indian farmers only after independence. A proper understanding of observed pattern of fertilizer consumption at district level and fertilizer use pattern at farmers' level can be emerged only after studying the behavior of individual farmer. It is important to undertake such study because it gives feedback to researchers and policy makers. The knowledge about the growth and pattern of fertilizer consumption at district level, determination of fertilizer use for selected major crops at farmers' level, in turn would be useful to shape new policies and provides guidelines for designing an appropriate institutional and technological strategy. Thus, the present study focuses attention on fertilizer consumption pattern at district level in the state of Gujarat and fertilizer use pattern, determination of fertilizer use efficiency, determinants of fertilizer use and impact of Soil Health Card on fertilizer consumption in Gujarat state in general and South Gujarat region in particular.

Limitations

(i) The finding of results depends upon the reality of the secondary data available from different sources.

(ii) Most of farmers are not maintaining the farm records. The primary data from the farm households were collected by survey method based on their memory and past experience with the help of pre-tested questionnaire. The accuracy of information depends upon farmer's memory.

(iii) The observation made and findings of the study would be applicable only study area in particular; however, it can also be useful for policy formation for the study area and also for other areas under similar condition.

II REVIEW OF LITERATURE

Research work on consumption of chemical fertilizers at micro as well macro level has been carried out in different part of the country. The available review of literature provides frame work for analytical procedure to be followed, and the strong and week points of the findings of such studies help in identifying the conceptual issues relevant to study.

Brief accounts of some of the past studies which are related to present investigation are presented in this section under the following heads

2.1 Fertilizer consumption pattern

2.2 Fertilizer use pattern on farms

2.3 Factors affecting fertilizer consumption

2.4 Fertilizer use efficiency

2.5 Impact of soil health card

2.1 Fertilizer consumption pattern

Gangadharan (1980) analyzed quantitatively the effects of fertilizer and crop output prices, farm credit and improvement in technological knowledge on the fertilizer consumption in Kerala using simple linear and double log functions. The study showed that fertilizer consumption was more elastic with respect to product price.

Anonymous (1982) has conducted a study on changing patterns of fertilizer consumption during the period 1971 to 1982. It was found that the consumption in India has increased at the compound growth rate of 9.3 per cent per annum. There was a violent fluctuation in the consumption from year to year, region to region and across the states. Fertilizer consumption increased more

rapidly in the states like Punjab, Uttar Pradesh, Haryana and West Bengal where a judicious mix of fertilizer was distributed through various channels. These states were followed by Gujarat and Bihar where only marketing federations predominated in fertilizer distribution. Balanced growth in fertilizer consumption is influenced by pricing mechanism and policies for fertilizers.

Patil and Pandey (1982) examined the demand for nitrogenous fertilizer in Indian agriculture. The rate and growth of fertilizer consumption were related to factors such as irrigation, high yielding varieties, farmers' receptiveness, price relationship between crops and fertilizer and credit rating. These gave rise to a wide range of fertilizer consumption levels within and between the states. The impact of economic and agro-climatic factors was examined in determining the consumption of N_2 at macro level and relationship of various factors was studied to gauge their relative contribution towards higher consumption of N_2 through Cobb Douglas production function. It was observed that irrigation was dominant factor, with others exhibiting varying degrees of significance in the selected study areas.

Ray and Sharma (1985) studied fertilizer consumption in different districts of India for the periods 1962-65, 1970-73 and 1978-81. The results showed that inter and intra regional disparities have widened as a result of the adoption of modern technologies. They opined that equality oriented growth is the way of distributing the benefits of modern technology more evenly.

Patel (1986) examined district-wise growth and inter-district variation in fertilizer consumption in Gujarat during the previous 20 years. The level of irrigation and extent of adoption of high value crops played an important role in the inter-district variation in per hectare fertilizer consumption. Within the irrigated

area, fertilizer consumption had relatively more high value crops like cotton, tobacco, groundnut and sugarcane.

Santra and Sarker (1989) examined market inequality in fertilizer consumption in India during 1970-71 to 1980-81. They observed that over the decades, no significant change was observed in the rank of states for fertilizer consumption. The intensity of irrigation contributed the most to variation in fertilizer use, followed by marketing outlets.

Shah (1989) conducted the study on constraints in fertilizer consumption in Gujarat and examined the economics of fertilizer use in irrigated and unirrigated crops. The main constraints reported were lack of adequate knowledge about application of fertilizer and other inputs at right time, lack of awareness about the latest technological developments and recommended packages of inputs, and above all, the farmer's belief that the use of fertilizers is risky in rainfed situations.

Kumar *et al*. (1991) studied fertilizer consumption pattern in Upper Gangetic Plain region. The total NPK consumption during 1989-90 in the region was 1349 thousand tonnes which constituted about 11.7 per cent of the total fertilizer consumption in the country and 13.8, 9.2 and 4.5 per cent of total N, P_2O_5 and K_2O in the country, respectively.

Shiyani *et al.* (1991) estimated requirement of NPK for Saurashtra region of Gujarat state for the period 1969-70 to 1988-89. The results showed significant increase in P and K, while the requirement of N remained almost static. The consumption of NPK fertilizer showed significant increasing trend suggesting that the gap between requirement and consumption decreased year after year. The analysis for districts showed large variation in fertilizer consumption.

Singh and Gupta (1991) observed that growth in fertilizer consumption in India picked up rapidly with the adoption of new high yielding varieties (HYVs) of cereal crops during 1967-68 to 1988-89. They also observed inter regional disparities in fertilizer consumption during the period.

Sharma *et al.* (1997) studied the compound growth rate of fertilizer consumption in India during the period 1970-71 to 1992-93. They concluded that the compound growth rate of phosphatic fertilizer consumption was the highest followed by Nitrogenous fertilizers. The compound growth rate of total fertilizer consumption was 8.84 per cent per annum in India.

Painuly and Dev (1998) observed that fertilizer consumption in India was concentrated in about one-third of the cultivated area in 1998 and its use has been increasing but it has been used inefficiently which needs to be considered while formulating strategies for sustainable agriculture in India.

Saran and Sethi (2000) observed that fertilizer consumption in India increased during the period 1970-71 to 1994-95, despite substantial increases in fertilizer prices. Fertilizer use was highly uneven among the states. Punjab, Haryana, Tamil Nadu and Andhra Pradesh occupied about one-third of the gross cropped area of the country and accounted for half of the fertilizer consumption. Moreover, wide variations in the growth rates of fertilizer consumption were observed among different states during different time periods.

Tiwari (2000) observed that Nitrogen continued to be the lead nutrient applied accounting for 78 per cent of the total nutrient consumed, followed by P(19%) and K(3%) in Uttar Pradesh. The NPK consumption ratio was found to be 26 : 6.3 : 1 in Uttar

Pradesh in 1997-98. The state has marked regional disparities in respect of fertilizer consumption in the study year.

Khunt *et al.* (2001) observed the high fluctuation in fertilizer consumption with high growth rate in Gujarat state during the period 1961-2000. They also noticed increasing consumption of K in rabi season and declining trend in kharif season.

Yadav and Rai (2001) revealed that the use of modern inputs especially of agro-chemicals increased manifold in Haryana state. It increased from 64 kg per hectare in 1980-81 and reached to the level of 212.34 kg per hectare in 1996-97 with the contribution of N, P and K being 172.66, 38.81 and 0.86 kg per hectare, respectively.

Sujit and Mishra (2002) observed that Indian agriculture has witnessed a massive change in fertilizer use leading to a significant demand for fertilizer in India.

Devdas and Chandrasekaran (2002) described the problems concerning fertilizer marketing in India. They suggested that fertilizer marketing policy should aim at : to increase fertilizer consumption, balanced fertilization, efficient use of fertilizers, educating farmers on the economics of fertilizer use, maintenance of soil health, provision of value added products, human resource development and farmer's prosperity.

Mukherjee (2002) analyzed the trend and pattern of fertilizer consumption in India and observed that there was a rising trend in consumption of all fertilizers, but it declined in 2000. He also observed imbalances in fertilizer use between North- Estern states and Green Revoluation states of Punjab and Haryana.

Mahmood and Shereen (2004) observed that out of the total fertilizer consumption, 35.1 per cent of fertilizer was used for paddy, 19.3 per cent for wheat, 5.9 per cent for cotton, 5.5 per cent

for sugarcane, 4.7 per cent for groundnut, 2.6 per cent for maize crop and the remaining consumption was accounted for other crops. On the whole, about 70 per cent of fertilizer was consumed in irrigated area. Another feature of fertilizer consumption in India has been that the cereal crops consumed 60 to 65 per cent.

Ramasamy (2004) studied the fertilizer consumption pattern in India. The fertilizer consumption was 25.75 kg. per hectare during 1970s and it increased to 78.43 kg. per hectare during 1990s registering a growth rate of 3.94 per cent per annum between 1990-91 and 2000-2001. There was however a notable disparity in fertilizer use among the states during 1970s and 1980s and the variation has declined marginally during 1990s. The Ginni concentration ratio was 0.46, 0.49 and 0.43 during 1970s, 1980s and 1990s, respectively.

Shipra Singh (2004) revealed that per hectare fertilizer consumption in India is less than that in other developed as well as a few developing countries, even though the consumption has been undergone a six-fold increase in the last three decades. He also noticed that 55 per cent consumption of fertilizer was concentrated in 5 states.

In the seminar on “Changing Face of Fertilizer and Agriculture” organised by Fertilizer Association of India, Shri Michel Prudhomme stated that worldwide fertilizer demand is likely to grow at about 2.1% per cent per annum during the next five years, from about 147.1 million tonnes in 2003-04 to about 2008-09. There would be a shift from low to high analysis grades. The growth would be more in P and K (2.7 % /annum) as compared to N (1.7 % /annum) (Anonymous, 2005).

Sundari and Rao (2005) revealed that in Gujarat during the period 1978-79 to 2003-04, the total consumption of fertilizers

increased at CAGR of 4.88 per cent while N, P_2O_5 and K_2O increased at CAGR of 5.9 per cent, 3.47 per cent and 2.64 per cent, respectively. They revealed that during 1996 to 2001, in India total fertilizers consumption increased at CAGR of 1.8 per cent while for Gujarat it was -1 per cent. They showed that irrigation and fertilizers prices have shown significant effect on fertilizers use (N+P+K).

Anonymous (2006) concluded that in West Bengal, the total consumption of chemical fertilizers (N, P_20_5 and K_2O) per hectare of gross cropped area increased from 13 kg per hectare in 4th Plan to 120 kg per hectare in 9th Plan period i.e. 9 times increased during this period. They also found that there was acute inter-size and inter-district variations in per hectare fertilizers use.

Kalara and Singh (2007) conducted a study in Bulandshahar district of U.P. found that the nitrogen, phosphorous and zinc sulphate consumption was 161.1, 28.9 and 6.7 kg. per hectare, respectively for fine grain and 180.0, 23.4 and 5.1 kg. per hectare, respectively for coarse grain variety of paddy.

Bhalla and Singh (2009) found more than 100 per cent growth in fertilizers consumption per hectare during 1980-83 to 1990-93. Its growth rate was just 50 per cent over the period 1990-93 to 2003-06 in India. They also propounded that over the triennium 1962-65 to 2003-06, the coefficient of variation among states declined from 531 to 118 per cent for fertilizers consumption.

Shah *et al.* (2009) reported that farmers of Gujarat have moved from a 13:7.5:1 nitrogen-phosphorous- potassium composition to 6.5:3.5:1, thereby reducing cost, optimizing production and improving net income.

Agarwal (2010) reported that though the recommended ratio of N-P-K is 4:2:1, the actual ratios in 2005-06 in Punjab and Haryana were 20:6:1 and 30:9:1, respectively.

Chand *et al.* (2011) conducted a study for input survey in India during 1991-92 and 2001-02.They showed that fertilizer use per hectare of area remained the highest in the bottom category of farm size and it declined with an increase in farm size. They also noticed that disparity in fertilizer use across size categories was much higher in unirrigated land than in irrigated land.

Khosa *et al.* (2012) conducted a study in eleven districts of Punjab State. They found that farmers were applying more fertilizers particularly nitrogen as compared to both soil test basis and target yield based fertilizer recommendation in wheat and rice crops.

2.2 Fertilizer use pattern on farms

Sen (1981) studied some aspects of fertilizer use by small farmers. He found that the farmers operating marginal holding form the largest group of fertilizer users. The second largest group of fertilizer users was that of small farmers. The marginal farmers used the highest quantity of fertilizer per unit of land and small farmers were the second highest, while the quantity in case of other farmers was the lowest. If taken singly, the share of marginal and small farmers in fertilizer consumption was the least as compared to large farmers. But by taking marginal and small farmers together their share in the total fertilizer consumption was larger than that of operators of large holdings.

Bhatia (1983) studied the pattern of fertilizer use in India. Sugarcane was one of the most important commercial crops in which rates of fertilizer use were found different in different states. Maharashtra recorded the highest application of fertilizers for

sugarcane crop (338.02 kg/ha) followed by Andhra Pradesh (270.10 kg/ha), Tamil Nadu (212.79 kg/ha), Uttar Pradesh (64.11 kg/ha) and Bihar (46.2 kg/ha). Cotton and sugarcane were the important crops which accounted for 7.14 percent and 7.12 percent, respectively of the total fertilizer consumption in the country during the year 1983.

Waghmare and Dhongade (1985) carried out an economic analysis of fertilizer application and yield rates of sugarcane in Maharashtra. They concluded that sugarcane growers had not adopted the balanced use of N, P and K fertilizers. The gaps between the recommended and observed levels of nitrogen were of the order of 10 to 15 per cent.

In a study entitled " Economics of Farm Management in Command Area of "Nagarjuna Sagar Irrigation Project" in Andhra Pradesh, it was found that the per hectare fertilizer consumption was 64.90 kg, of which, 42.50 kg was N, 16.70 kg was P_2O_5 and 5.70 kg was K_2O. The fertilizer consumption was found higher in irrigated villages while in unirrigated villages higher dose of organic manures was noticed (Anonymous, 1986).

Singh *et al.* (1989) examined the use of manures and fertilizers on different farms in Himachal Pradesh. It was found that the majority of farmers were using fertilizer in both the seasons i.e. Kharif and Rabi and it was positively related to the size of farms. It was further noticed that the use of fertilizers was below the recommended levels.

Shah *et al.* (1995) found that in Gujarat, 70 per cent of those farmers who had previously reported a reduction in fertilizer use showed the economic losses; this would occur due to their decision to reduce fertilizer use. They were willing to increase

fertilizer use. Only 7 per cent of sample farmers were unwilling to change their decision to reduce fertilizer use.

Inamke *et al.* (1996) examined the fertilizer use pattern for sugarcane in respect of three recovery zones of sugarcane in Maharashtra at different points of time. They observed that among the three recovery zones, the use of N, P_2O_5 and K_2O fertilizers was not as per the recommendation and it was very low in low recovery zone where the productivity was also very low (50 t/ha) as compared to other two zones.

Singh *et al.* (1999) revealed that impact of fertilizer use has been much less significant in rainfed farming through out the country. The average use of fertilizer remains quite low (25 kg/ha) in rainfed crops. A number of constraints limited the widespread use of fertilizer in dry lands. Uncertainty of rainfall is one of the primary risk factors influencing the farmers' decision in using this expensive input.

Velrasu and Singh (1999) revealed that most of the farmers did not follow the fertilizer use recommendations in Tamil Nadu. Besides this, there was a wide disparity in fertilizer use among various categories of farmers and crops. Fertilizer use was high on irrigated areas as compared to dry land areas. The over utilization of N and under utilization of P and K was noticed. They emphasized that all possible efforts should be made to ensure balanced fertilizer use by the farmers to make agriculture sustainable.

Singh *et al.* (2000) studied constraints in fertilizer use in arid zone of Western Rajasthan. They found that among the fertilizer users, maximum farmers had applied more nitrogenous fertilizer as compared to phosphatic fertilizer and both were applied lesser than recommended dose. The main constraints perceived by

the farmers were lack of irrigation facilities and high cost of fertilizer and lack of knowledge.

Ardeshna and Khunt (2005) in their study on fertilizer use in Saurashtra region of Gujarat found that consumption of fertilizers, in general, has increased in all the districts except K consumption, and the fertilizer consumption was mainly influenced by the gross irrigated areas. On farmers' field, the gap in use of N was observed in all the selected crops and was also not utilized efficiently in most of the selected crop.

Sananse *et.al*. (2006) concluded that in Konkan region of Maharashtra, on an average use of fertilizers per hectare (N, P_2O_5 and K_2O:74.28, 19.34, 16.36) was lower than that of recommended dose (100:50:50) for rice crop.

Naidu *et al*. (2007) reported in Nalathwad watershed in Bijapur district of Karnataka that farmers were used excess N and P than required with no use of K leading to large scale mining of soil K in sorghum, wheat and sunflower crops.

Anonymous (2008b) analyzed that total consumption of N, P_2O_5 and K_2O in Haryana grew by 8 per cent, 11.5 per cent and 6 per cent, respectively during the period 1970-71 to 2003-04,while per hectare fertilizer used increased, on an average by 6.10 and 5 per cent per annum for wheat and rice, respectively. They showed that N and P_2O_5 consumption per hectare for wheat was 150 kg. and 67 kg., respectively while for paddy, it was 167 kg. and 50 kg.

Maji and Bhakat (2010) have conducted a study in Hooghly district of West Bengal envisaged a fact that fertilizer was being used in excess of requirement (about 50.67 per cent higher over the recommended doses) .They also revealed the fact that 3.8,107.0 and 125.0 per cent of applied N,P and K, respectively could be considered as excess of requirement.

Reddy (2011) conducted a study in Darsi mandal of Prakasam district of arid region of coastal Andhra Pradesh observed that farmers across all size classes applied two and half to three times the recommended doses of nitrogen and phosphorous supplying fertilizers per acre.

Thus, the above studies have brought out the fact that the use of fertilizer is mostly common on the farms where irrigation facilities are available. It was also observed that the use of chemical fertilizers is higher in commercial crops as compared to cereals. The fertilizer use pattern also varies from region to region, crop to crop and among the varieties of the same crop. The levels of fertilizer use are not as per the recommendations.

2.3 Factors affecting fertilizer consumption

Jayaraman (1979) made an inter-district cross-sectional analysis in Gujarat for finding out the causes behind the differences in fertilizer consumption in two periods 1967-68 and 1973-74. The analysis indicated that irrigation continued to remain a significant factor in determining the use of nitrogen over the period of six year. Rainfall and cash crops emerged as significant variables influencing nitrogen use for the recent period.

Patil and Pandey (1981) using the static and dynamic models, attempted to examine the influence of economic and agronomic factors in determining the application of phosphatic fertilizer at micro level. The Cobb-Douglas type of functions was used to explore the relative contribution of such factors in enhancing phosphatic fertilizer use in different states for the period 1955-56 to 1975-76. The empirical findings of the study revealed that irrigation was the most dominating factor for increasing fertilizer consumption. The real price of fertilizer did not affect

fertilizer consumption in any significant manner in almost all the states. Improved farm technology and management practices in all the states were expected to increase future consumption of phosphatic fertilizers.

Patil and Pandey (1982) made a similar study for nitrogenous fertilizers using the time series data from 1955-56 to 1974-75. The results of the study emphasized the need for remunerative and stable prices of crops and fertilizers in most of the states apart from irrigation and trend variable indicating technological changes. In Karnataka, irrigation was the only significant factor influencing the fertilizer use over the period.

Gupta (1983) used the multiple regression analysis to capture the effect of different variables on consumption of nutrient "N" (kg) per hectare of cropped area in India (1970-79). Amongst the variables considered, area under irrigation, weather, relative price of fertilizer and the share of cropped area were found to be statistically significant while the area under HYVs and the credit factor did not turn out to be significant.

Nagraj (1983), using the correlation and regression analysis, determined the impact of factors affecting fertilizer use in different states of India. The results showed that rainfall was relatively an unimportant variable in explaining the observed variations in fertilizer use. The factors like irrigation, spread of HYVs and fertilizer intensive crops were found to have a positive and significant effect on fertilizer consumption. Use of fertilizers and relative price were inversely related in many cases but the relationship was non significant.

Singh (1983) attempted to identify factors influencing fertilizer consumption in India. The major factors found influencing

fertilizer consumption were irrigation, area under HYVs of crops and credit availability to the farmers.

Singh and Zilberman (1984) conducted a study on allocation of fertilizer among the crops under risk. They concluded that risk caused by price instability resulting in variation in income from crop affected the allocation of fertilizers among the crops. Secondly, the low risk crops associated with low levels of fertilizer use. It was suggested that appropriate prices of fertilizers and crop insurance policies should be implemented in order to stabilize the income.

Datta *et al.* (1985) observed from their study on constraints in the use of fertilizer in West Bengal that lack of irrigation facilities and inadequate extension services were the major constraints in fertilizer consumption. They suggested that the provision of adequate irrigation facilities, expansion of extension services and imparting training to the farmers in balanced use of fertilizers should be implemented in order to increase the use of fertilizers.

Flinn and Shakya (1985) studied the factors influencing the adoption and use rates of fertilizer for wheat. According to them, the factors related to fertilizer use in wheat were the area under cultivation, extent of irrigation, transport cost of fertilizer and operator's tenure status. They further viewed that the fertilizer adoption was sensitive to the cost of fertilizer procurement implying that farmers in the area were responsive to fertilizer price as reflected in procurement plus delivery cost.

Panchal and Moolchand (1985) examined the constraints in fertilizers consumption in Kanpur district of Uttar Pradesh. They reported that the reduction of fertilizer prices had no significant impact on fertilizer consumption. The price reduction combined

with extension services, expansion of area under HYV and proper propaganda about reduction of prices would lead to higher fertilizer consumption.

Desai (1986) was of the opinion that because of the constraints on lowering real prices of fertilizers, non-price policies would be more crucial in determining the pace of future growth in India's fertilizer consumption. Under the present price environment, there is great scope to accelerate growth in fertilizer consumption through non-price policies of improving the efficiency of fertilizer use, shifting the response functions upwards through use of quality seeds and removing the deficiencies in fertilizer supply and distribution system.

Thakur and Sinha (1988) concluded that area under HYVs, irrigation and rainfall significantly influenced fertilizer usage whilst fertilizer price was observed to be non significant in Bihar during the period 1968-69 to 1981-82.

John and George (1990) analysed fertilizer use in West Coast Plains and Ghat zones in India. They identified the important determinants of fertilizer use viz., credit availability, irrigation facilities, awareness of recommendation among the farmers, cost of labour and cost-benefit ratio. In certain cases, the farmers were not willing to apply fertilizers for rainfed crops due to the fear of inadequate returns.

Kute (1990) studied the factors influencing the use of fertilizers in plains and hilly regions of Gujarat. He found that weather factors such as rainfall, temperature, soil including irrigated area had direct relation with fertilizer use. The poor weather condition has resulted in the reduction in fertilizer consumption by about 20 per cent and the drought condition has reduced the fertilizer consumption by 34 per cent.

Suryawanshi *et al.* (1990) reported that the irrigation was one of the most important factors for increasing the use of fertilizer in Kukadi Command Area in Maharashtra. They found that the fertilizer use gap before introduction of irrigation in command area was about 70 to 90 per cent of the recommendation. Jowar, bajra and wheat growers did not use fertilizers due to lack of irrigation while after canal irrigation the proportion of non-users of fertilizers reduced to 35 to 40 per cent in the year 1986-87. However, for one or other reasons, the use of fertilizers for almost all crops was below the recommended levels. The farmers who did not use the fertilizers reported the major constraints viz; lack of finance (25 to 47%), costly fertilizers (18 to 27 percent), non-availability of fertilizers when needed (7 to 16 percent) and irregular irrigation turns (4 to 12 %).

Bajpai and Shrivastava (1991) identified that irrigation and high yielding varieties of seed and subsidy were the most influencing factors on fertilizer consumption in India during 1991. However, it was found that HYVs and intensity of irrigation were the most instrumental than subsidy.

John and George (1991) conducted the study on factors influencing the fertilizer application for sustainable agriculture in West Coast Plain and Ghat region of India. They found that the relatively high cost of fertilizer, low benefit-cost ratio and lack of awareness of recommended does of fertilizers for specific crops were the reasons behind the low use of fertilizers.

Kute and Haria (1991) studied nutrient balance and sustainable agriculture in plains and hills of Gujarat. They reported that ignorance and awareness of farmers about soil fertility status, deficiency of soil in major, secondary and micro nutrients, vagaries of weather and frequency of drought conditions, non-availability of

HYVs seeds, fertilizer and pesticides, saline soils, less availability of irrigation water, lack of awareness about recommended levels of fertilizers and unawareness of latest technologies were the major constraints to low fertilizers consumption in the region.

Singh and Gupta (1991) identified that irrigation facilities and availability of credit were the key determinants of fertilizer consumption in India.

Pathak *et al.* (1993) observed noticeable decline in per hectare consumption of nutrient following the fertilizer price hike in Gujarat during 1990-91 to 1991-92. The study showed that there was a shift in cropping pattern from high fertilizer consuming crops like wheat to low consuming crops like pulses.

Reddy (1993) concluded that small farmers were either restraining themselves from using higher dosage of fertilizers and this is more so in the case of HYV paddy which requires more of these inputs in Andhra Pradesh. The study also indicated that large farmers were concentrating more on HYV paddy which is more responsive to fertilizers than local varieties whereas the vice versa was true in case of small farmers.

Kayarkanni (2000) in his study in Tamil Nadu found that the relative price of fertilizer had a greater influence on fertilizer demand. He concluded that fertilizer demand for tree crop was price-inelastic. He also inferred that other things remaining constant, fertilizer use on tenant farm was more than on owner farms.

Bezbaruah and Roy (2002) studied in Barak Valley region of Assam. They found that there was no significant variation in the application of fertilizer with farm size. The application of fertilizer per hectare by the farmers has been found significantly dependent upon the availability of irrigation and access to extension service.

Sujit and Mishra (2002) observed that Indian agriculture has witnessed a massive change in fertilizer use and its demand was determined by factors like its price, subsidies, net irrigated area and area under HYVs.

Singh and Nasir (2003) observed an inadequate agricultural credit flow in Bihar. They further inferred that the agricultural credit flow had positive influence on fertilizer consumption.

Rao and Modi (2003) revealed that management initiatives were required in changing cropping pattern, rainfed farming and efficiency of fertilizer use. Availability of credit and use of information technology played a vital role in boosting fertilizer use and hence agricultural production in India.

Sundari and Rao (2005) analysed the trends in fertilizer consumption and changes in the cropping pattern in Gujarat in 2005. The causes of reduction in fertilizer consumption and changes in cropping pattern included inadequate irrigation facilities, erratic rainfall and low return in investments.

Anonymous (2008a) conducted a study in five states viz. Haryana, Tamil Nadu, Assam, Punjab and West Bengal and found that irrigation was the most important factor influencing fertilizer consumption in wheat in India with elasticity of 2.04 per cent. They also found that the impact of fertilizers consumption on the production of wheat and rice was significant and positive.

Ardeshna and Khunt (2011) in their study on fertilizer use in Saurashtra region of Gujarat found that in Kharif crops like groundnut and bajra, rainfall has great impact in determination of level of fertilizer use; whereas in crops like cotton and wheat, irrigated area, per farm gross income, lagged prices and cropping

intensity were the major factors which determine the level of use of fertilizers in these crops.

In general, agronomic factors viz.; irrigation, cropping pattern, area under HYVs and economic factors like, prices of fertilizers, certainty in level of income, capital rationing and labour cost were the important determinants of fertilizer use on the farms. It was also pointed out that the natural factors like temperature and frequency of drought were also influenced fertilizer use.

2.4 Fertilizer use efficiency

Neto *et al*. (1980) carried out an economic evaluation of fertilizer use in Central-South Region of Brazil by taking a sample of 375 farmers. They found that for most of the farms, the level of fertilizer use was in confidence interval of the optimum combination and the use of modern inputs explained most of the variation in crop productivity in the region.

Arora and Sharma (1981) studied the optimal allocation of fertilizer nutrient and its impact on cropping pattern and production levels. They concluded that in order to maximize returns to investment on fertilizers, the largest possible quantities of available fertilizers be allocated to HYVs wheat, followed in declining order to sugarcane and HYVs paddy.

Singh and Sharma (1984) revealed that in Uttar Pradesh the response to fertilization varies from region to region and from year to year which results in differential marginal physical productivities of fertilizer input in the production of particular crop. This might be due to differences in the climatic conditions, soil compositions and other factors. All these lead to differential optimal fertilizer requirement to optimize the crop output in different regions.

Seeta Prabhu (1985) studied the productivities of fertilizers along with other inputs within the Cobb-Douglas production function framework. The results indicated that the ratio of marginal value productivity of fertilizers, manures and irrigation to their unit cost were substantially higher than unity, implying thereby sub-optimal use of these inputs.

Patel (1986) made an attempt to assess the resource productivity using Cobb-Douglas production function. The ratio of marginal value productivity to marginal cost of bullock labour, irrigation, seed, manures and fertilizers indicated excessive use of these inputs.

Hossain *et al.* (1987) studied resource allocation efficiency under irrigated farming. They found that coefficients of human labour, animal power and triple super phosphate were positive which indicated a logically consistent relationship between output and these inputs. The negative signs of co-efficient of seed, manures, urea and potash revealed the excessive use of these inputs.

Reddy (1989), in his study on the efficiency of fertilizer use in groundnut indicated that efficiency of use of fertilizers on sample farms was quite low and fertilizers need to be judiciously combined with other complementary inputs such as credit, improved seed, improved implements, irrigation, insecticides and technical knowhow. The groundnut growers also need to be enlightened on proper time of application and dose of fertilizers as well as efficient methods of fertilizer application.

Singh and Srinivas (1989) examined production response of rice farmers in different locations of canal irrigation system in Andhra Pradesh. The Cobb-Douglas type of production function

was estimated. The elasticities of land and fertilizer were positive and significant which indicated their positive influence on yield.

Bali *et al.* (1990) studied the effect of nitrogen and phosphatic fertilizers on the yield of mung bean under the late sown condition in Kashmir valley. They concluded that nitrogen and phosphatic fertilization lead to increase the productivity of crop.

Sagwal and Kumar (1994) examined the effect of balanced use of fertilizers on productivity and profitability of Basmati rice. They concluded that balanced application of fertilizers ensured higher yield on long term basis. Balanced fertilization is also economical inspite of increased fertilizer prices.

Varma (1994) studied balanced fertilization for wheat in Eastern India. Fertilizer plays a key role in wheat cultivation and about 40 per cent increase in production is credited to it. Use of recommended doses of fertilizers (NPK) with FYM enhanced productivity of wheat crop. However, fertilizer use in this region is far behind the recommended level.

Shah *et al*. (1995) had carried out the study on inefficiency and efficacy of soil testing services in Gujarat state to answer the question why even after completing half a century of fertilizer use, farmers in India had not responded to soil testing services which were essential for improving fertilizer use efficiency. Three important findings of the study were; first, over–use of fertilizers was widespread and was guided by farmers perceptions about yield response rather than soil test based recommendation, second, farmers yield perceptions were shaped in a chaotic environment that was product of inefficient farm practices and fertilizer use techniques, constraints on yield response about balanced nutrient use and thirdly, unless extension system is geared to face challenge

the inefficient over-use is unlikely to cease. They indicated that easy option for productivity growth had been exhausted. Productivity could not be sustained only by applying more and more fertilizers. Efficiency of its use should not be ignored.

Raghuwanshi *et al*. (1999) in their study in Bundelkhand region of Madhya Pradesh revealed that fertilizers (N+P+K) and irrigation were found to influence the production of wheat positively and significantly with the value at 0.0172 and 0.0239, respectively.

Gaddi *et al.* (2002) conducted a study on profitability ratio in Karnataka. They found that bullock labour on small farms and human labour on large farms were optimally used and rest of the inputs differed from their optimum level. They suggested that the need for reallocation of expenditure among different inputs based on the profitability ratio.

Vagdevi *et al.* (2004) studied resource use efficiency on vegetable farms of Krishna district of Andhra Pradesh. They found that the marginal value products to opportunity cost ratios had indicated the deviation from unity revealing inefficient use of resources of different magnitudes. This offered the scope to adjust the resources so as to derive higher returns in vegetable cultivation.

Ardeshna and Khunt (2005) in their study on fertilizer use in Saurashtra region of Gujarat found that N was not utilized efficiently in most of the selected crops.

Kumar and Grover (2007) observed that in Punjab during 1965-66 to 1990-91, the productivity of crops increased on account of increasing nutrient use efficiency. It began to decline thereafter on account of imbalances in the use of N, P and K, along with the deficiencies of micro nutrients.

Maity and Chatterjee (2007) revealed that standardized regression coefficient values exhibit that among all modern inputs fertilizers(0.46) is the most important input followed by HYV (0.40),irrigated area(0.05)and pesticides(0.04) for obtaining higher food grain production in West Bengal.

Mehta (2007) revealed that CGR in total fertilizers consumption in Indian decelerated from 5.53 per cent in 1982-92 to 3.23 per cent in 1993-2005. He also concluded that fertilizers use efficiency declined from 17.1 in 1970-71 to 6.5 per cent in 2000-01.

Naidu *et al*. (2007) reported in Nalathwad watershed in Bijapur district of Karnataka that fertilizer use efficiency(N+P+K) was comparatively higher in case of marginal farmers (Rs.10.74) closely followed by small farmers (Rs.9.25) as compared to large farmers (Rs.8.46).

Singh and Kachroo (2009) studied resource use efficiency in Jammu district of Jammu and Kashmir State for maize crop. They reported that marginal value productivity of area, farmyard manure + fertilizer and machine labour was positive with its value at 117.604, 1.484 and 0.864, respectively, whereas seed and human labour showed negative sign.

Reddy (2011) conducted a study in three arid regions of Andhra Pradesh. He observed that in frontier regression analysis for paddy it could be seen that independent variables such as farm yard manure, total organic manure, nitrogen, phosphorous, human labour and bullock labour were positive and significant.

Prasad Rajendra (2012) revealed that globally the value of apparent recovery of nitrogenous fertilizer is 55 per cent, while true recovery efficiency of nitrogen (TREn) is 44 per cent whereas TREn in India in rice vary from 22-33 per cent. He also suggested that

enhancement of nitrogen use efficiency can be achieved by following the best crop management practices to achieve good yields, adopting right method and timing of fertilizer application and practicing balanced NPK application, site specific nutrient management and integrated nutrient management.

By and large, it can be concluded that fertilizer is not used optimally in most of the crops and regions of the country.

2.5 Impact of Soil Health Card

Jha and Sarin (1980) made a district level analysis on fertilizer consumption in Semi-Arid Tropical (SAT) India for the period 1969-70 to 1978-79. The study indicated that over 62 per cent of the total fertilizers (N+ P2O5+K2O) used in the SAT districts was consumed in the 78 irrigated districts which claimed only 35 per cent of the SAT cropped area. Thus fertilizer consumption was mainly concentrated in irrigated districts. The average level of fertilizer consumption per hectare of cropped area was 57 kg in the irrigated and 18 kg in the unirrigated districts. Considerable variation was noticed in fertilizer consumption between districts even within irrigated and unirrigated categories. The irrigated SAT districts showed better performance in terms of growth in total fertilizer consumption during the study period.

Krishnamacharyulu and Muralidhar (1981) estimated the growth rates of per hectare fertilizer use in 18 major states of India during 1968-69 to 1978-79. They observed that all the states except Kerala and Assam had shown significantly positive growth rates. Using the Spearman's rank correlation to examine the shift in the relative positions of the states in per hectare fertilizer use with reference to base year 1968-69, they indicated that no state had shown any significant shift in its fertilizer use status. While

computing coefficients of variation for each year to determine the inter-state disparities in fertilizer use, they found that there were large scale inter-state variation in levels of fertilizer use which did not show any tendency of narrowing down over the period.

Singh (1983) using the coefficient of variation as a measure of inequalities in fertilizer use, examined the inter-state variations in levels of fertilizer consumption in India during the period 1961-62 to 1981-82. Although the consumption levels in all the states increased over the period, the degree of variation in levels of fertilizer use among the states had continued to remain high.

Leela (1985) made a district wise study on fertilizer consumption in Andhra Pradesh for the period 1960-80. A general increase in the levels of per hectare fertilizer use in all the districts was noticed. Her study indicated reduction in the inter-district variations in levels of per hectare fertilizer use during the period, with the coefficient of variation showing a decline from 102.6 per cent in 1960-61 to 74.0 per cent in 1979-80, while there was no discerning change in the ranking order of districts.

Mohanam (1989) examined growth rates in fertilizer consumption in India and Tamil Nadu for three periods 1952-66, 1966-65 and 1969-85. Tamil Nadu recorded lower growth rates than India as a whole. He observed halving of growth rates in the initial stages of development was very low and even a small increase would show a higher growth rate. Per hectare growth rates recorded 9 per cent and 8 per cent increase between 1969-85 in India and Tamil Nadu, respectively.

Shah and Amita Shah (1992) observed that farmers have not responded soil testing services in Gujarat which are essential for improving fertilizer use efficiency. They suggested involving

qualified staff in the dissemination process to overcome the inefficient and excess use of fertilizer.

Desai *et al.* (1993) revealed that raising the level of fertilizer consumption is the key to secure future agricultural growth. A balance use of nutrient is also crucial, for which investment in soil testing is essential.

Trivedi and Patel (1994) concluded that fertilizer use efficiency (FUE) was low in India. Soil testing is a basic tool to improve FUE and to reduce adverse effect of fertilizer consumption.

Dhyan Singh (1996) revealed that soil testing is important in evaluating the fertilizer status of the soil and helps to recommend adequate and balanced plant nutrient needed for optimum crop production. He defined problematic soils and better nutrient management for higher crop productivity.

Prasad and Rao (2002) revealed that awareness should be created among the farmers regarding the importance of soil test based fertilizer recommendations. They also concluded that there was a dire need to promote Integrated Nutrient Management Concept among the farming community and thereby making savings in input cost. They observed yield improvement by 5 to 6 per cent and 20 to 30 per cent input saving as a result of improvement in soil health by extension activities done in Andhra Pradesh.

Chanda (2005) revealed that there was negative balance of nutrients in the soil in India as a result of mining of more nutrients than replenishing through fertilizer and other sources. The fertilizer crop response ratio has been declining due to lower use of fertilizer than the required amount.

Anonymous (2008a) in their study of five states viz. Haryana, Tamil Nadu, Assam, Punjab and West Bengal found that

in almost all the states, the farmers do not apply fertilizers after getting their soils tested. It ranged from 41.13 per cent in West Bengal to 2.7 per cent in Assam.

Anonymous (2008b) concluded that out of the sample farmers who got their soil tested, only 50 per cent actually followed the recommended dosage of fertilizers.

The foregoing literatures imply that there are limited in depth studies on economic analysis of fertilizer consumption, particularly in Gujarat State. This study will therefore be an attempt to address the various issues on fertilizers consumption in the state.

As a key element of food production cycle, fertilizer use contributes to resolving one of the major challenges facing developing countries: feeding their growing population. India today is not on self sufficient in grain production but also has sustainable reserve. The progress made by agriculture in the last four decades has been of the biggest success stories of free India.

The government has put emphasis on agriculture development to realize higher economic and social growth. Agriculture as a sector has a priority and the government is committed towards the public investment, credit and technology to agricultural research and extension. Irrigation and fertilizer stepped up in a significant manner. The question is should the farmers use more fertilizers. After all they are producing food for others, without which this country will have to import and incurred heavy expenses. Fertilizer can help to meet increasing food, feed and fiber demands. Therefore, the sustainable agriculture and efficient use of fertilizer must go hand-in-hand for a better tomorrow. A few studies have been carried out in recent past. The present study generates the information on fertilizer consumption

in different regions of Gujarat state which serves the purpose in the area of policy formation at state level.

III METHODOLOGY

Scientific study of any research problem requires analytical base line to arrive at reliable, unbiased conclusions. It provides an insight into the nature of the study area, sampling procedures, sources of data, methods of data collection and analytical design adopted for accomplishment of objectives under the study. The details of the methodology are discussed under following major heads.

3.1 Description of the study area

3.2 Sampling technique

3.3 Sources and method of data collection

3.4 Analytical framework

3.1 Description of the study area

3.1.1 Location

The state of Gujarat is bounded by Pakistan and the state of Rajasthan in the North and Maharashtra in South and Madhya Pradesh in East and Arabian sea in the West. The state is situated on latitude 20°01' to 24°07' North and longitude 68°04' to 74°04' East lies in the Western part of the country. It covers an area of 195,984 sq. km and accounts for six per cent of the total geographical area of the country (www.gec.gov.in). The state has 26 districts including newly formed districts in recent. Further, the geographical area of Gujarat state is sub-divided into North Gujarat, South Gujarat, Middle Gujarat, Saurashtra and Kutchh region.

The study was conducted in the south Gujarat region of Gujarat State. South Gujarat consists of seven districts viz. Bharuch, Narmada, Surat, Tapi, Navsari, Valsad and Dangs. On

the basis of rainfall, climatic conditions and the soil type, south Gujarat has been divided into two agro-climatic zones. First is South Gujarat Zone-I, which is also known as heavy rainfall area. This consists of southern part of the Dang from Ambika river, part of Valsad, Navsari, Gandevi, part of Surat district, Valod, Vyara, Uchchal, Songadh and Mahuva. The soil of this zone is clay. Whereas, second is South Gujarat Zone-II consists of some portion of Valsad and in between Ambika and Narmada river, Navsari, Gandevi, part of Surat district, Kamrej, Nizar, Palsana, Bardoli, Mangarol, part of Bharuch, Akleshwar, Valiya, Jaghadiya and Rajpipala. The soil of this zone is medium black to heavy texture.

South Gujarat has two types of agro-ecological situations *viz.,* Situation-I and Situation-III. The total geographical area of Situation-I is 5.57 lakhs hectares which is 58.00 per cent of the zone, out of which 53.00 per cent is under forest. The cultivated area is 15.29 per cent and 5.00 per cent area of this situation is under doubled crops. Further, this comes under heavy rainfall while, the total geographical area of Situation-III is 2.22 1akh hectares which is 25.21 per cent of the zone, of which 59.30 per cent is under cultivation. The cultivated area is 1.64 lakh hectares and 14.50 per cent area of it is under doubled crops. The location of the study area is shown in Figure 1.

The present study was undertaken in Surat and Navsari districts of South Gujarat region of Gujarat. Per hectare fertilizer consumption was highest in these two districts (Appendix-III). Therefore, these two districts were selected purposively for the present study.

3.1.2 Salient features of Navsari district

Navsari district lies between 20.07^0 to 21.00^0 North latitude and 72.43^0 to 73.00^0 East longitude with a geographical area of 2.20 lakh hectares and it is bound on the North by Surat district, on the West by Arabian Sea, on the South by Valsad district and on the East by Dang district and Maharashtra State. According to 2011 census, the population of the district was 13.31 lakhs with a literacy rate of 84.78 per cent. Urban and rural population of the district was 4.09 and 9.22 lakh, respectively. Average annual rainfall is 2000 mm with minimum temperate of 10^{0}C and maximum being 40^{0}C.There are 6 markets, 155 bank branches, 7 co-operative rice mills, 2 co-operative sugar factories in the district. Land holding pattern comprises of 54690 marginal holdings, 18880 of small holdings and 21207 of others holdings. The district has 25118 hectares of forest land, 15275 hectares of barren and uncultivable, 19696 hectares of land put to non-agriculture uses, 6970 hectares of culturable waste, 5346 hectares of permanent pasture and other grazing lands, 11640 hectares of current fallows, 126032 hectares of net sown area, 136318 hectares of total cropped area and 10286 hectares of area sown more than once. Net irrigated area of the district is 74945 hectares. The major soils of the district are black, heavy clay and of coastal sand. The major crops grown in the district are paddy, sugarcane, sorghum, pigeon pea and banana (Table 3.1 and Table 3.2).

Table 3.1 : General information of Navsari and Surat districts

Sr.No	Item	Unit	Navsari	Surat
1.	Area	Lakh ha	2.20	4.33
2.	Population (2011)			
	Total	lakh	13.31	60.79
	Urban	Per cent	30.74	79.68
	Rural	Per cent	69.26	20.32
3.	Literacy rate (2011)	Per cent	84.78	86.65
4.	Normal rainfall	Mm	2000	1000-1200
6.	Normal temperature	^{0}C		
	Minimum		10	9
	Maximum		40	43
7.	Major crops		Paddy	Sugarcane
			Sugarcane	Paddy
			Sorghum	Sorghum
			Pigeon pea	Pigeon pea
			Banana	Banana
8.	Regulated markets	No.	6	11
9.	Primary agricultural credit societies	No.	117	460
10.	Rice mills	No.	7	8
11.	Sugar factories	No.	2	6
12.	Land holding	No.		
	Marginal		54690	47132
	Small		18880	35615
	Others(>2.00 ha)		21207	45043
	Total		94777	127790

Source : District Statistical Information Cell, District Panchayat, Surat and Navsari (2009-10)

Table 3.2 : Land utilization pattern in Navsari and Surat Districts

(Area in hectares)

Category	Navsari	Surat
Forest land	25118	36680
Barren and uncultivable land	15275	10167
Land put to non-agriculture use	19696	38903
Culturable waste	6970	32421
Permanent pastures and other grazing lands	5346	16968
Miscellaneous tree crops not included in net area sown	--	1110
Current fallows	11640	8831
Other fallow lands	--	1946
Net area sown	126032	285671
Total geographical area	220077	432697
Total cropped area	136318	315687
Area sown more than once	10286	30016

Source : District Statistical Information Cell, District Panchayat, Surat and Navsari (2009-10)

3.1.3 Salient features of Surat district

Surat district lies between 21.00^0 to 21.23^0 North latitude and 72.38^0 to 74.23^0 East longitude. Surat district could be attributed to the presence of large number of diamond processing, textiles and chemical and petrochemical industries. It is bounded by Bharuch and Narmada in the North, Arabian Sea in the West, Navsari in the South and Tapi and Dangs district in the East. According to 2011 census, the population of the district was 60.79 lakh with a literacy rate of 86.65 per cent with a geographical area

of 4.11 lakh hectares. Urban and rural population of the Surat district was 79.68 and 20.32 per cent, respectively. Average annual rainfall is 1000-1200 mm with minimum temperate of 9^0C and maximum being 43^0C.There are 11 regulated markets, 8 rice mills and 6 sugar factories in the district. Land holding pattern comprises of 47132 marginal holdings, 35615 of small holdings and 45043 of others holdings. The district has 36680 hectares of forest land,10167 hectares of barren and uncultivable,38903 hectares of land put to non-agriculture uses,32421 hectares of culturable waste,16967 hectares of permanent pasture and other grazing lands, 1110 hectares of miscellaneous tree crops not included in net area sown,8831 hectares of current fallows,1946 hectares of other fallow lands,285671 hectares of net sown area,315687 hectares of total cropped area and 30016 hectares of area sown more than once. Net irrigated area of the district is 59,967 hectares. The major soils of the district are heavy black to medium black, heavy clay and coastal saline sodic soil. The major crops grown in the district are sugarcane, paddy, sorghum, pigeon pea, and banana. (Table 3.1 and Table 3.2).

3.2 Sampling technique

The study was conducted in the South Gujarat region of Gujarat state. A multistage sampling technique was used for the selection of sample. Two districts of South Gujarat namely Surat and Navsari were selected purposively as they rank in the use of fertilizers per hectare; and two major crops like kharif paddy and sugarcane were selected as they acquired highest area in these Districts (Appendix-II and III). At the first stage, two talukas were selected randomly from each district. In the second stage, four villages were selected from each taluka randomly and at final stage, 14 farmers (7 without soil health card + 7 with soil health card)

were selected randomly from each village for the study. Thus, total sample comprised of 224 farmers from sixteen villages. The details of sample villages and farmers are given in Table 3.3 and Figure 2, respectively.

Fig : 1 Maps showing the study area

3.3 Sources and Method of data collection

Since fertilizer being the crucial input in crop production, the growth and pattern of fertilizer consumption at district level in the state have been considered important from the policy making point of view. Therefore, the secondary data at macro level and primary data at micro level studies are required. The period of study covered at macro level is from 1960-61 to 2009-10. Districts were considered as units of reference. On the basis of 19 districts covering the whole state data on different variables considered for the study were collected from different sources. The different variables of newly formed seven districts were merged with the host districts. The secondary data were drawn from the published as well as unpublished sources. The main sources of data were the Directorate of Agriculture, Krushi Bhavan, Gandhinagar and various issues of "Fertilizer News" published by Fertilizer Association of India, New Delhi.

The primary data for the study at micro level were collected by survey method adopting personal interview of the selected respondents with the help of well structured and pre-tested questionnaire. The aim and objectives of the study were explained to respondents with a view to obtain correct responses. The fact is that kharif paddy and sugarcane growers furnished the data mostly from their memory recall and not from any written records. But care has been taken to cross check for the accuracy. The survey work was carried out for the agricultural year 2010-11. The information elicited covers the following aspects:

(i) The general information regarding the socio-economic features of the farmers;

(ii) Details of the crops grown with its expenditures and data on production during the study period;

(iii) Information on efficient use of fertilizers and manures; and

(iv) Opinions towards the use of fertilizers and the utility of soil health card.

Table 3.3 : List of selected villages

Sr.No.	District	Taluka	Village
1	Navsari	Navsari	Vejalpore
			Kadipore
			Telada
			Amari
		Jalalpore	Vedchha
			Dambhar
			Eru
			Bhutsad
2.	Surat	Bardoli	Kantali
			Orgam
			Surali
			Madhi
		Olpad	Mahmadpore
			Sarsana
			Thothab
			Kasad

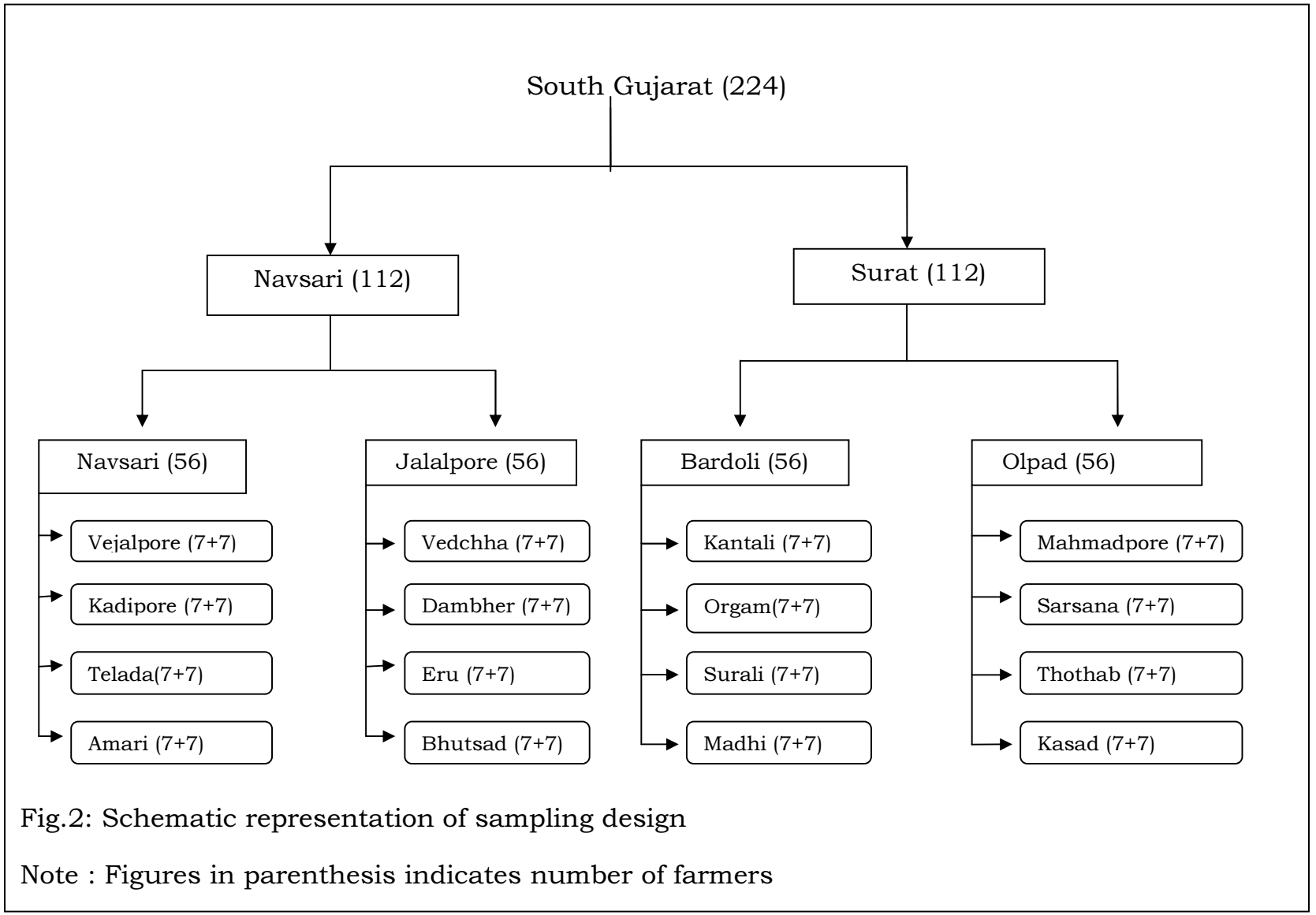

Fig.2: Schematic representation of sampling design

Note : Figures in parenthesis indicates number of farmers

3.4 Analytical Framework

The statistical analysis of the data was conducted by utilizing following techniques of analysis.

3.4.1 Trends in consumption of fertilizers

To examine the trends in consumption of fertilizers in the different regions of Gujarat state, the time series data were analyzed for the periods viz. Period-I (1960-61 to 1969-70), Period-II (1970-71 to 1979-80), Period-III (1980-81 to 1989-90), Period-IV (1990-91 to 1999-2000), Period-V (2000-01 to 2009-10), and Period-VI (1960-61 to 2009-10). The rate of growth in consumption of fertilizers in respect to N, P_2O5, K_2O and total NPK were calculated with the most frequently used exponential function of following form.

$$Y_t = ab^t u_t$$

The logarithmic form of exponential model is as under

$$\text{Log } Y_t = \log b_o + t \log b_1 + \log u_t$$

Where,

Y_t = Consumption of fertilizers in metric tonnes in year t

t = Year which takes values 1,2,……n

u_t = Disturbances term in year t

a and b are parameters to be estimated

The Compound growth rates in per cent will be computed as: (Antilog of log B_1 – 1) * 100

3.4.2 The fertilizer use gap

In order to know the gap between the requirement and consumption of fertilizer at macro level, the total requirement of fertilizer was calculated with the help of secondary data on the basis of area covered under major crops at the district level covering more than 85 per cent of the gross cropped area.

The optimum doses of the nutrient fertilizers for the different crops recommended by the Directorate of Agriculture, Gujarat state and Gujarat Agricultural Universities from time to time are considered as requirement of fertilizers for the respective crops. The quantity of fertilizers sold in different districts was considered as actual consumption of nutrient fertilizers in the district. The difference between the requirement and actual consumption of fertilizer was calculated by simple tabulation for the different regions of Gujarat state for all the six periods of time i.e. from 1960-61 to 2009-10.

The trend in respect to gap of nutrient fertilizer was estimated with the exponential function of following form

$$Y_t = ab^t u_t$$

The logarithmic form of exponential model is as under

$$\text{Log } Y_t = \log b_o + t \log b_1 + \log u_t$$

Where,

Y_t = Gap in consumption of fertilizers in metric tonnes in year t

t = Year which takes values 1,2,……n

u_t = Disturbances term in year t

a and b are parameters to be estimated

The Compound growth rates in per cent will be computed as (Antilog of log B_1 – 1) * 100

The multicollinearity was tested as per Klein, L.R. (Introduction of Econometrics, pp.64 and 101) for growth rate but not found.

3.4.3 Factors affecting fertilizer use for selected crops

The following type of multiple linear regression model was best fitted to determine the fertilizer use in selected crops under study;

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + u$$

Where,

Y = Total fertilizer (N, P, K) consumption for selected Crops (Kg/ha).

a = Intercept.

X_1 = Irrigated area under the crop in ha.

X_2 = Annual total income of the farmer in Rs.

X_3 = Cropping intensity in percentage.

X_4 = Operational holding of farmers in ha.

X_5 = Educational level of the farmers

X_6 = Short term credit per farmer in Rs.

X_7 = One year lagged average price of the crop output in Rs.per quintal of selected crop

X_8 = Manures (cartload)

X_9 = Number of irrigations

U = Error term.

b_i = Regression coefficients of the variables.

Specification of variables

Dependent variable

The total quantity of N, P_2O_5 and K_2O nutrients used per hectare of the selected crop under study was taken as dependent variable.

Independent variables

Irrigated area (X_1)

It was expected that irrigated area would have a positive association with the use of fertilizer. Irrigation water directly contributes to soil moisture. Therefore, this variable has been considered as one of the explanatory variables.

Total income of farmer (X_2)

This variable includes the income annually received from different sources of the farms along with the income other than agriculture. It was expected that higher the total income would increase the fertilizer consumption

Cropping intensity (X_3)

Area grown more than once will increase the cropping intensity which has positive effect on fertilizer use. Therefore, it has been included in set of independent variables.

Operational holding of farmer (X_4)

It is assumed that higher the operational holding of farmer, higher will be the income and results in higher use of expensive inputs like fertilizer.

Educational level of the farmer (X_5)

It has been expected that if farmers are educated then they use farm inputs judiciously. Therefore, level of education is directly related to fertilizer use on the farm. So, it is included in the analysis. For primary, secondary and above secondary education, code 1, 2 and 3 were used.

Short term credit per farmer (X_6)

It is assumed that short term credit availed in form of crop loan may affect the fertilizer use on farms. Hence, it has been taken in the set of independent variables.

Lagged price of crop (X_7)

Price of the crop output in the previous year influence the fertilizer use. Therefore to measure the effects of one year lagged average price of crop on fertilizer use, this variable has been included in the analysis.

Manure (X_8)

It is assumed that more use of farm yard manure leads to less use of chemical fertilizers. Hence, it is included in the analysis.

Number of irrigations (X_9)

Irrigation is considered as the major factor to determine the extent of fertilizer consumption. So, this variable is included in the set of independent variable. But in kharif season there was no need to apply irrigation to kharif paddy in this heavy rainfall region. Hence, number of irrigation was omitted in analysis for kharif paddy.

3.4.4 Fertilizer use efficiency

The fertilizer use efficiency for the selected crops was estimated by using production function as given below.

$$Y = a\, X_1^{b1}\, X_2^{b2}\, X_3^{b3}\, X_4^{b4}\, X_5^{b5}\, X_6^{b6}\, X_7^{b7}\, X_8^{b8}\, e^{u}$$

The Cobb-Douglas production function is the most appropriate for studying fertilizer use efficiency. In this functional form, ' Y ' is dependent variable, ' Xi' are the independent input variables, ' a ' is constant representing intercept of production function and ' bi' are the regression coefficients of the respective input variables. The regression co-efficients obtained from this function directly give the elasticities of production, which remain constant throughout the relevant range of inputs. The sum of coefficients indicates the nature of returns to scale. When the function is expressed in logarithmic term, it becomes a linear function of the following type.

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7 + b_8 \log X_8 + u \log e$$

Where,

Y = Output of crop in qtl/ha.
a = Intercept
X_1 = Area under crop in hectares.
X_2 = Human labour in man days/ha.
X_3 = Bullock labour in pair days/ha.
X_4 = Manures in cartloads/ha.
X_5 = Nitrogen in kg/ha.
X_6 = Phosphorus in kg/ha.
X_7 = Potash in kg/ha.
X_8 = Other working capital in rupees.
b = Regression coefficients of inputs
e = Error term

Specification of variables

Dependent variable

Crop output in quintals (Y)

Per hectare output of selected crop (main produce) has been decided as dependent variable.

Independent variables

Area under crop (X_1)

The area under the crop in hectares per farm has been taken as and independent variable as it influences crop output.

Human labour (X_2)

This input has been expressed in terms of man days of eight hours each. It included all human labour including hired labour and family labour utilized for performing crop production activities right from preparation of land to threshing. For the convenience, family labours were charged at the rate of hired labour charges prevailing in the villages.

Bullock labour (X_3)

Bullock labour used for different farm operations has been considered as a separate variable and it has been measured in pair days. Here one pair day means eight hours of work by one pair of bullocks. The value of own bullock labour was taken on the basis of hire rate prevailing in the villages.

Manures (X_4)

Manure has been considered as a separate explanatory variable. This variable is measured in physical units expressed in cartloads. Here one cartload means the quantity of manure in one bullock cart. The purchased manures were valued at the actual price paid by the farmers.

Nitrogen (X_5)

Per farm quantity of nitrogen used in kilograms for raising the crop concerned has been taken as an independent variable.

Phosphorus (X_6)

Per farm quantity of phosphatic fertilizer used in kilogram was taken as an independent variable.

Potash (X_7)

Per farm quantity of potash fertilizer used in kilograms for a crop was considered as an independent variable in present analysis.

Other working capital (X_8)

The expenditure on seed, irrigation, pesticides, fungicides, repairs and maintenance of implements and machinery is also important in the production process. But inclusion of all these inputs as separate variables would greatly reduce the degree of

freedom in the analysis. In analysis, owned and hired charges of tractor were included. The owned tractor charges were calculated at market value. Therefore, other working capital has been included in the set of explanatory variables.

3.4.5 Impact of Soil Health Card on fertilizers consumption

Since 2005, the Government of Gujarat has launched Soil Health Card scheme. The farmers are advised to use chemical fertilizers on the basis of information provided in soil health cards. Simple tabular analysis with cost concept is used to examine the impact of Soil Health Card on fertilizer consumption in the study area.

For the selected crops viz; sugarcane and kharif paddy the difference between with and without Soil Health Card farming in respect of yield per hectare was tested by using paired ' t ' test.

Formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S} \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$$

Where,

$\overline{X_1}$ and $\overline{X_2}$ are the means of yield per hectare of with and without Soil Health Card farmers, respectively, n_1 and n_2 are the number of observations in the two samples and S is the standard deviation of the difference between two samples.

IV RESULTS AND DISCUSSION

Among all the modern inputs, fertilizer plays a key role in modern agriculture. Fertilizer has been universally accepted as an integral part of package of practice for raising the agriculture to a higher technological plank. Balanced use of fertilizer is essential to stabilize crop yields and sustain crop productivity. Efforts have been made in this study to determine the growth of fertilizer consumption, gap in fertilizer use, factors determining the fertilizer consumption, fertilizer use efficiency, and the impact of soil health card on fertilizer consumption. The results presented in this chapter have been discussed under the following heads:

4.1 General features of sample farmers
4.2 Trends in fertilizer consumption
4.3 Analysis of gap in consumption of fertilizer
4.4 Determinants of fertilizer consumption
4.5 Fertilizer use efficiency
4.6 Impact of Soil Health Cards on the use of fertilizer

4.1 General features of the sample farmers

An understanding of general characteristics of sample farmers is expected to provide birds' eye view of the general features prevailing in the study area. Therefore, an attempt has been made in the study to analyze some of the important characteristics of the sample farmers. Important aspects like family size, educational status, land use pattern and cropping pattern are discussed in this section to understand the distinct economic features of the selected total 224 sample farmers.

4.1.1 Socio-economic characteristics of sample farmers

The information on socio-economic characteristics of sample farmers is presented in Table 4.1. The average age of the

selected farmers was 53.16 and 53.44 years in Navsari and Surat districts, respectively. The literacy level was slightly higher (9.00 std.) in Surat district as compared to Navsari district (8.00 std.). The percentage of educated farmers was 100. It is healthy sign of literacy. The average size of family ranged from 5.25 persons in Surat district to 5.26 persons in Navsari district indicating that there was no much difference in family size between the districts.

Table 4.1 Socio-economic characteristics of sample farmers

Particulars	Navsari	Surat	South Gujarat
Age (Year)	53.16	53.44	53.43
Education (Std.)	8.00	9.00	8.50
Size of family (No.)	5.26	5.25	5.25

4.1.2 Land use pattern of sample farmers

The study of land use pattern is of great importance because land is the main limiting factor in agricultural production. Land utilization pattern indicate how farmers utilize land for increasing crop production. Land use pattern of the sample farmers is furnished in Table 4.2. The size of holding was found higher (2.04 ha) in Surat as compared to Navsari district (1.48 ha). The overall size of holding in South Gujarat was 1.76 hectares. The cultivated area per farmer was high (2.04 ha) in Surat as compared to Navsari district (1.48 ha). In South Gujarat as a whole, the average cultivated area of sample farmers was 1.76 hectares. The highest irrigated area was observed in Surat district (2.04 ha). The gross cropped area per farmer was higher in Surat (2.45 ha) as compared to Navsari district (1.90 ha). The cropping intensity of Navsari and Surat district was 128.21 and 120.07 per cent,

respectively. The overall cropping intensity in South Gujarat region was 123.87 per cent of the sample farmers.

Table 4.2 Land use pattern of sample farmers (Area in ha.)

Particulars	Navsari	Surat	South Gujarat
Size of holding	1.48	2.04	1.76
Cultivated area	1.48	2.04	1.76
Uncultivated area	0.00	0.00	0.00
Irrigated area	1.45	2.04	1.75
Unirrigated area	0.03	0.00	0.01
Gross cropped area	1.90	2.45	2.18
Cropping intensity (%)	128.81	120.07	123.87

4.1.3 Cropping pattern of sample farmers

The cropping pattern indicates the proportion of gross cropped area allotted by the farmers to different crops. Farmers decide their cropping pattern by considering the availability of resources like climate, type of soil, rainfall, availability of irrigation facilities etc. The cropping pattern of selected farmers is presented in Table 4.3.

From the Table 4.3, it is seen that sugarcane (61.28 %) and kharif paddy (36.52 %) shared the highest of the total cropped area in Surat and Navsari districts, respectively. The kharif paddy (22.25 %) and sugarcane (32.20 %) occupied the top second rank in Surat and Navsari districts, respectively. Next to these two crops, summer paddy occupied the third position (14.58 %), followed by vegetables (0.80 %), cotton (0.73 %) and kharif jowar (0.36 %) in Surat district. Whereas, in Navsari district, summer paddy (18.28 %), fruit crops (11.19 %), vegetables (0.98 %) and banana (0.83 %) occupied the top successive rank. Overall in South Gujarat,

sugarcane gained the highest share (48.56 %) followed by kharif paddy (28.49 %), summer paddy (16.20 %), fruit crops (4.89 %), vegetables (0.88 %), cotton (0.41 %), banana (0.36%) and kharif jowar (0.21%), respectively. It indicated that about fifty per cent area of gross cropped area was under sugarcane cultivation. The kharif paddy occupied the top second rank in this region. That's why the highest per hectare fertilizer consumption and area under these two crops were noticed in these two districts (Appe.-II and III).

Table 4.3 Cropping pattern of sample farmers (Area in ha.)

Sr.No.	Crops	Navsari	Surat	South Gujarat
1.	Sugarcane	68.6659 (32.20)	168.0660 (61.28)	118.3659 (48.56)
2.	Kharif Paddy	77.8948 (36.52)	61.0209 (22.25)	69.4579 (28.49)
3.	Kharif jowar	-	1.0000 (0.36)	0.5000 (0.21)
4.	Summer paddy	38.9862 (18.28)	39.9789 (14.58)	39.4826 (16.20)
5.	Cotton	-	2.0000 (0.73)	1.0000 (0.41)
6.	Banana	1.7705 (0.83)	-	0.8852 (0.36)
7.	Vegetables	2.0908 (0.98)	2.1895 (0.80)	2.1402 (0.88)
8.	Fruits	23.8626 (11.19)	-	11.9313 (4.89)
	Gross cropped area	213.2708 (100)	274.2553 (100)	243.7631 (100)

Note: Figures in parentheses indicates percentage to total

4.2 Trends in fertilizer consumption

In this study, an effort has been made to know the trends in N, P, K and total nutrient fertilizers in different regions of Gujarat State. Using time series data in logarithmic form of exponential model, the compound growth rates for six periods viz.,

Period-I (1960-61 to 1969-70), Period-II (1970-71 to1979-80), Period-III (1980-81 to 1989-90), Period-IV (1990-91 to 1999-2000), Period-V (2000-2001 to 2009-10) and Period-VI (1960-61 to 2009-10) have been worked out. The results of zone wise consumption of N, P, K and total nutrient fertilizers are presented in Table 4.4 to 4.7, respectively.

4.2.1 Trends in N fertilizer consumption

The period wise estimated compound growth rates and instability indices for N during different regions of Gujarat state are presented in Table 4.4 and depicted in Figure 3 as well as Figure 5. The average consumption of N fertilizer for the Period-I was the highest in Middle Gujarat (14755 ton/yr) and the lowest in case of Kutchh (184 ton/yr) with the state average of 34061 tonnes per annum. The compound growth rates were found to be statistically highly significant for all the regions during the first period. The rate of annual increase in the consumption of nitrogen fertilizer during this period was found highest in case of Saurashtra region (48.57%), followed by Kutchh (48.24 %), North Gujarat (33.51%), South Gujarat (24.04 %) and Middle Gujarat (22.97 %). Relatively, lower growth of nitrogen consumption in case of Middle Gujarat could be attributed mainly to the fact that Middle Gujarat enjoyed the benefits of higher level of consumption from the base year itself. It is interesting to note that instability indices were also found the lowest in Middle Gujarat (17.94). The high growth with low instability indices is desirable situation as it implies a steady increase in fertilizer consumption. In general, it can be concluded that there existed high growth with high regional disparity in the consumption of nitrogen in Gujarat. However, it was more pronounced particularly in the regions of Kutchh, Saurashtra and North Gujarat.

During the Period-II, the average annual consumption of N varied from 2084 tonnes in Kutchh to 49336 tonnes in Middle Gujarat. The compound growth rates were found positive and significant in all the regions, except Saurashtra region. It was found the highest (14.19 %) in case of North Gujarat, followed by Kutchh (8.46 %), South Gujarat (8.03 %) and Saurashtra (6.93 %). The value of instability index was found highest (34.51) in Saurashtra region, followed by Kutchh (22.55), Middle Gujarat (19.18), North Gujarat (17.42) and South Gujarat (8.74). The consumption of N at the state level increased at the rate of 7.91 per cent per annum.

For the Period-III, the average consumption of N was found the highest (96587 ton/yr) in Middle Gujarat and the lowest (4771 ton/yr) in case of Kutchh region with 304557 tonnes per year for the state as a whole. The results revealed that positive and statistically significant compound growth rates of N consumption were registered for all the regions of the state, except Saurashtra region. It was the highest (13.86%) in case of Kutchh region, followed by South Gujarat (9.91 %), Middle Gujarat (8.00 %) and North Gujarat (7.85 %). The value of instability index for N consumption was found lowest (10.47) in South Gujarat and the highest (24.01) in case of Saurashtra region.

During the Period-IV, the average consumption of N was found the lowest in Kutchh region (15813 ton/yr) and the highest was found in Middle Gujarat (171051 ton/yr) with the state average of 547555 tonnes. Though, the compound rate of growth was found positive and significant in all the regions, its magnitude varied across the regions. The value of instability indices ranged from 6.84 in case of North Gujarat to 19.98 in case of Saurashtra region.

The average annual consumption of N for the Period-V was the highest in the Middle Gujarat (175206 ton/yr) and the lowest (18189 ton/yr) in Kutchh region. It was as high as 568565 tonnes for the state as a whole. The compound growth rates were found significant in all the regions. It was found the highest (7.47 %) in Kutchh region, followed by Saurashtra (3.40 %), North Gujarat (2.40 %), South Gujarat (2.38 %) and Middle Gujarat (2.01 %). The value of instability index was found lowest in South Gujarat (7.73) and the highest in Saurashtra region (24.70). One common conclusion can be drawn from the results that though there was significant increase in the consumption of N across the regions in different periods, the rate of increase has declined over the period of time. Similarly, a decline in instability was also noticed.

The average consumption of N for the entire period as a whole i.e. from 1961-10 was the highest in Middle Gujarat (94108 ton/yr), followed by Saurashtra (86523 ton/yr), North Gujarat (63585 ton/yr), South Gujarat (43714 ton/yr) and Kutchh region (7624 ton/yr). The compound growth rates were found positive and highly significant in all the regions and for the state as a whole. Kutchh district registered the highest growth in nitrogen consumption (15.62 %), followed by North Gujarat (11.87 %), Saurashtra (9.93 %), South Gujarat (8.69 %) and the lowest in case of Middle Gujarat (7.92 %).

It may be concluded that high compound growth rates accompanied with high instability indices were observed over the period across different regions. However, it is pertinent to note that it has declined considerably during the last decade. It might be due to increased awareness of farmers towards package of practices of crops in response of krushimela, krushi sibir, khedut din etc.

Table 4.4 : Period wise compound growth rates of nitrogen fertilizer consumption in Gujarat State by region

Region	Period	Period-I	Period-II	Period-III	Period-IV	Period-V	Period-VI
South Gujarat	C.G.R.(%)	24.04**	8.03**	9.91**	3.67**	2.38**	8.69**
	Std. error	3.89	1.10	1.26	0.96	0.52	0.46
	R^2	0.85	0.88	0.89	0.66	0.62	0.90
	Instability Index	21.37	8.74	10.47	7.39	7.73	23.95
	Mean(ton/yr)	5800	19389	45773	80114	83840	43714
North Gujarat	C.G.R.(%)	33.51**	14.19**	7.85**	5.28**	2.40**	11.87**
	Std. error	5.55	2.20	2.09	0.85	0.75	0.78
	R^2	0.86	0.86	0.66	0.84	0.45	0.86
	Instability Index	30.27	17.42	15.95	6.84	11.56	31.31
	Mean(ton/yr)	3464	25340	63946	125863	128920	63585
Saurashtra	C.G.R.(%)	48.57**	6.93	3.79	5.55*	3.40*	9.93**
	Std. error	4.17	4.23	2.79	2.34	1.52	0.84
	R^2	0.96	0.26	0.19	0.42	0.28	0.78
	Instability Index	18.14	34.51	24.01	19.98	24.70	37.04
	Mean(ton/yr)	9858	42387	93481	154715	162420	86523
Middle Gujarat	C.G.R.(%)	22.97**	6.34*	8.00**	3.55*	2.01*	7.92**
	Std. error	2.85	2.53	1.59	1.42	0.82	0.46
	R^2	0.91	0.46	0.77	0.45	0.32	0.88
	Instability Index	17.94	19.18	12.78	11.66	12.88	24.84
	Mean(ton/yr)	14755	49336	96587	171051	175206	94108
Kutchh	C.G.R.(%)	48.24**	8.46*	13.86**	11.66**	7.47**	15.62**
	Std. error	10.02	3.20	2.65	1.16	0.90	1.00
	R^2	0.81	0.49	0.80	0.93	0.85	0.87
	Instability Index	51.46	22.55	21.60	9.16	12.26	39.88
	Mean(ton/yr)	184	2084	4771	15813	18189	7624
Gujarat	C.G.R.(%)	29.42**	7.91**	6.99**	4.79**	2.73**	9.21**
	Std. error	2.70	2.37	1.75	1.16	0.82	0.56
	R^2	0.95	0.60	0.68	0.69	0.47	0.87
	Instability Index	15.44	19.94	14.52	9.68	13.01	27.72
	Mean(ton/yr)	34061	138527	304557	547555	568565	295554

* Significant at 5 per cent level, ** Significant at 1 per cent level

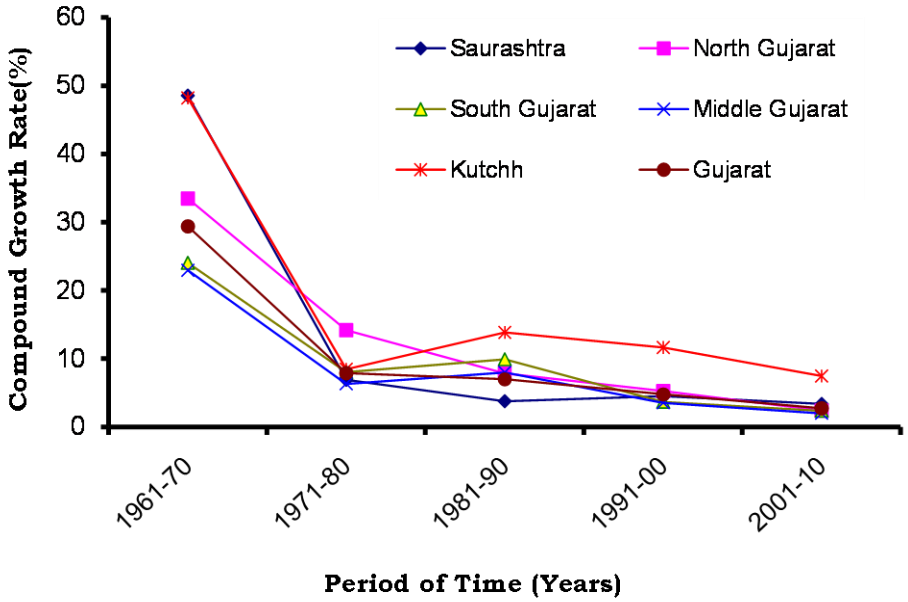

Fig. 3: Compound growth rates of N consumption in different regions of Gujarat state

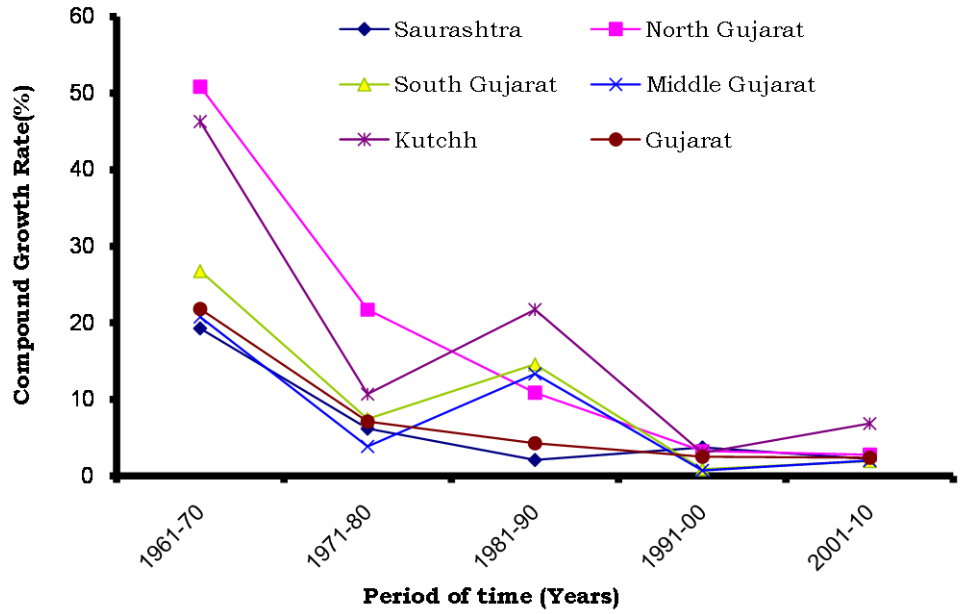

Fig. 4: Compound growth rates of P_2O_5 consumption in different regions of Gujarat state

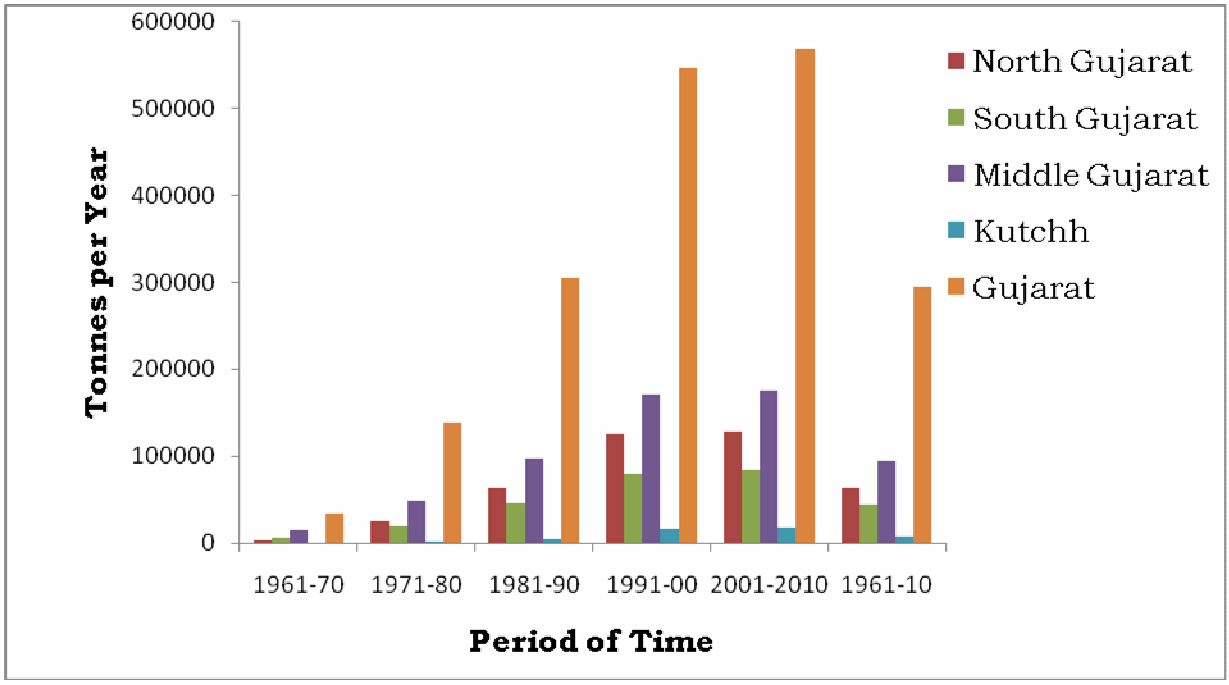

Fig.5 : Average consumption of N fertilizer in different regions of Gujarat state during 1960-61 to 2009-10

organized by agricultural universities and Krushi Mahotsav organized by the Government of Gujarat. Reduction in instability in the consumption of nitrogen fertilizer is a desirable situation. High growth with low instability helps fertilizers industries in optimum allocation of fertilizers in the respective regions.

The results indicated high compound growth rate with high instability indices over the period across different regions may be due to adoption of high value crops and irrigation facilities. These results confirms with the findings of Patel (1986), Shiyani *et al* (1991), Sujit and Mishra (2002), Ramasamy (2004) and Ardeshna *et al*. (2011).

4.2.2 Trends in P fertilizer consumption

The results of compound growth rates and instability indices for P consumption in different regions of Gujarat State are presented in Table 4.5 and Figure 4 as well as Figure 8.

The results revealed that the average consumption of P fertilizer varied from 51 tonnes per year in Kutchh region to 8807 tonnes per year in case of Saurashtra region for the Period-I. The compound growth rates were noticed positive and statistically highly significant for all the regions. The highest compound growth rate was found in North Gujarat (50.87 %) followed by Kutchh (46.30 %), South Gujarat (26.76 %), Middle Gujarat (20.79 %) and Saurashtra region (19.26%). The value of instability index for P consumption was found lowest in Saurashtra region (16.45) and the highest in the Kutchh region (72.27).

The average consumption of P in the Period-II was found highest in Saurashtra region (42865 ton/yr) and the lowest in Kutchh region (458 ton/yr). The consumption growth rate was registered statistically significant and the highest in North Gujarat (21.71 %) and the lowest in Middle Gujarat (3.85 %), which was statistically non-significant. The results for the instability index in South Gujarat were found the lowest (29.07) and the highest in the Saurashtra region (37.91).This might be due to the fact that South Gujarat region lies in medium to heavy rainfall area accompanied with assured irrigation facilities. Whereas, Saurashtra region frequently suffered by drought and uneven rainfall.

During the Period-III, the average consumption of P was observed highest in Saurashtra (72761 ton/yr) and the lowest in Kutchh region (2034 ton/yr). The compound growth rates were found positive and significant in North Gujarat, South Gujarat, Middle Gujarat and Kutchh region, while it was found negative in Saurashtra region. This might be due to occurrence of severe drought in the later years of the decade. The instability index value for P consumption ranged from 7.82 in Kutchh region to 27.14 in Saurashtra region.

Table 4.5 : Period wise compound growth rates of phosphorus fertilizer consumption in Gujarat State by region

Region	Period	Period-I	Period-II	Period-III	Period-IV	Period-V	Period-VI
South Gujarat	C.G.R.(%)	26.76**	7.43	14.58**	0.88	1.94	10.71**
	Std. error	4.33	2.03	1.66	1.85	0.94	0.63
	R^{2}♣	0.86	0.36	0.92	0.03	0.25	0.88
	Instability Index	38.12	29.07	13.51	15.08	14.23	29.14
	Mean(ton/yr)	1451	6534	20108	33843	36090	18273
North Gujarat	C.G.R.(%)	50.87**	21.71**	10.08**	3.25	2.75**	14.42**
	Std. error	7.62	4.60	1.52	1.82	0.81	1.09
	R^{2}	0.89	0.77	0.86	0.29	0.48	0.82
	Instability Index	35.46	31.05	11.27	14.96	7.29	36.42
	Mean(ton/yr)	705	7183	23393	40398	42900	21251
Saurashtra	C.G.R.(%)	19.26**	6.18	-2.08	3.71	2.21	7.20**
	Std. error	2.78	4.73	3.49	2.72	1.46	0.64
	R^{2}	0.88	0.18	0.05	0.19	0.15	0.76
	Instability Index	16.45	37.91	27.14	23.03	23.27	32.26
	Mean(ton/yr)	8807	42865	72761	78751	101012	61323
Middle Gujarat	C.G.R.(%)	20.79**	3.85	13.34**	0.71	2.01	9.33**
	Std. error	6.19	4.72	1.78	2.50	1.26	0.57
	R^{2}	0.63	0.08	0.89	0.01	0.17	0.87
	Instability Index	45.57	36.73	13.09	19.83	18.68	29.49
	Mean(ton/yr)	1941	6353	17885	30398	32563	16672
Kutchh	C.G.R.(%)	46.30**	10.68	21.72**	3.01	6.85**	17.21**
	Std. error	9.43	5.17	1.22	3.22	1.62	1.04
	R^{2}	0.81	0.37	0.98	0.10	0.60	0.88
	Instability Index	72.27	34.91	7.82	28.85	23.62	38.71
	Mean(ton/yr)	51	458	2034	4527	5744	2480
Gujarat	C.G.R.(%)	21.81**	7.12	4.26	2.52	2.39*	8.73**
	Std. error	2.38	4.15	2.18	2.14	1.02	0.59
	R^{2}	0.93	0.28	0.33	0.15	0.30	0.85
	Instability Index	14.77	33.99	20.01	17.82	15.90	28.14
	Mean(ton/yr)	12954	63394	136181	207817	218309	119998

* Significant at 5 per cent level, ** Significant at 1 per cent level

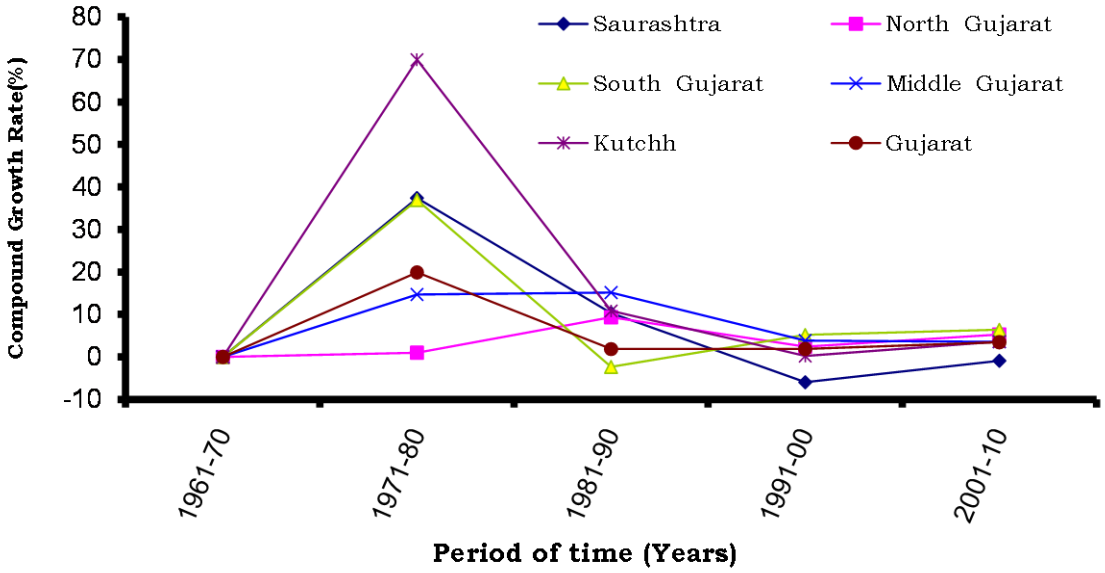

Fig. 6: Compound growth rates of K_2O consumption in different regions of Gujarat state

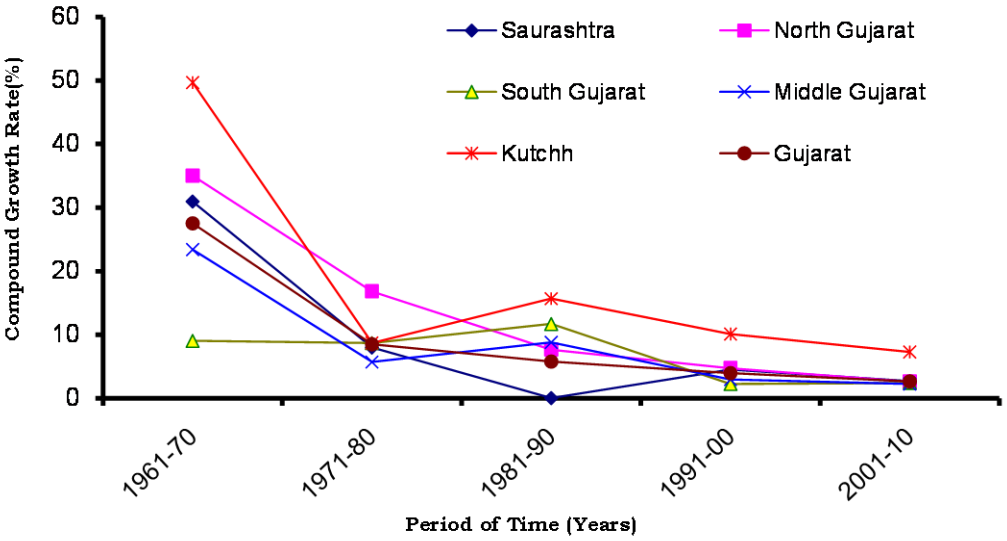

Fig. 7: Compound growth rates of NPK consumption in different regions of Gujarat state

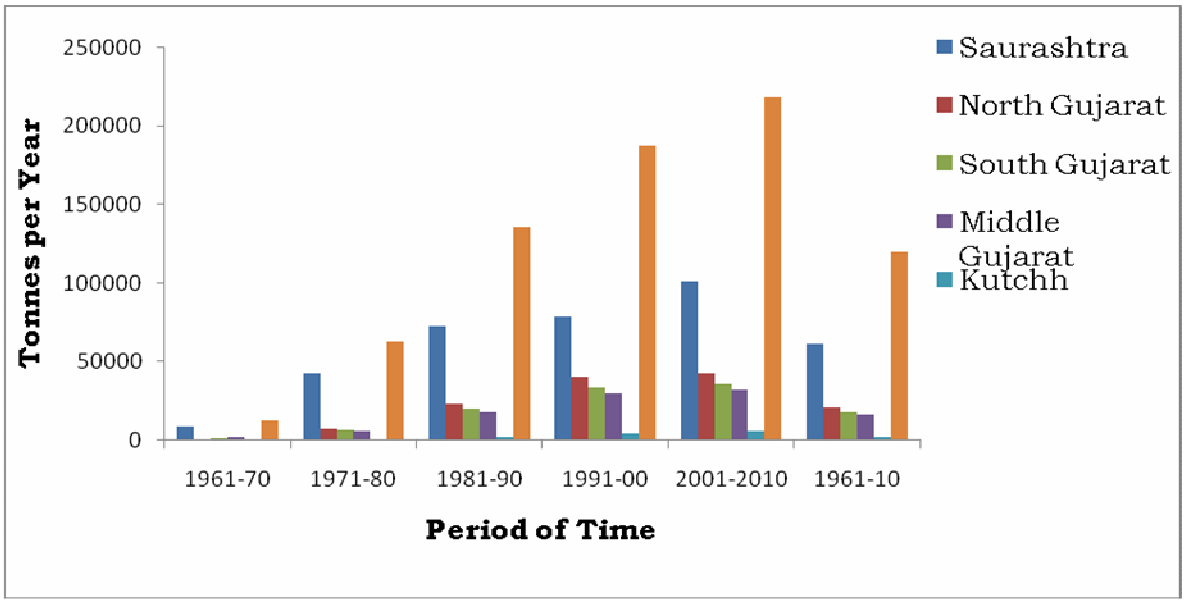

Fig.8 : Average consumption of P fertilizer in different regions of Gujarat state during 1960-61 to 2009-10

During the Period-IV, the average consumption of P was found the highest in Saurashtra region (78751 ton/yr) and the lowest in Kutchh region (4527 ton/yr). The compound growth rates were found positive and statistically non-significant for all the regions. The compound growth rate was found highest in Saurashtra region (3.71 %) and the lowest in Middle Gujarat region (0.71 %). The value of instability index was found lowest in North Gujarat (14.96) and the highest in Kutchh region (28.85).

During the Period-V, the average consumption was highest in Saurashtra region (101012 ton/yr) and the lowest in Kutchh region (5744 ton/yr). The compound growth rate was found significant and the highest in Kutchh region (6.85 %) and the lowest in Middle Gujarat region (2.01 %). The instability indices varied from 7.29 in North Gujarat region to 23.62 in Kutchh region.

Analysis of average consumption of P for the Period-VI showed that the highest consumption was observed in Saurashtra

region (61323 ton/yr) and the lowest in Kutchh region (2480 ton/yr). The compound growth rates were positive and highly significant for in all the regions. It was found highest in Kutchh region (17.21 %), followed by North Gujarat (14.42 %), South Gujarat (10.71 %), Middle Gujarat (9.33 %) and Saurashtra region (7.20 %). The value of instability index was lowest in South Gujarat (29.14) and the highest in Kutchh region (38.71).

The overall analysis showed that P consumption in different regions and the state during all the period did not found uniform trend. It may be concluded that high compound growth rates accompanied with high instability indices in different regions across the Period-I. This might be due to lower consumption of P in the initial years and higher consumption in the later years during the decade. Therefore, the use of P consumption was found unstable. In rest of periods, low growth rates with high instability indices were observed for all the regions. These results showed inter and intra regional disparities existed in the state. The extent of adoption of new technologies, irrigation facilities, changing cropping pattern and rainfall have widened the inter and intra regional disparities in the state. These results corroborate the findings of Patel (1986), Singh and Gupta (1991), Shiyani *et al* (1991) and Mukharjee (2002).

4.2.3 Trends in K fertilizer consumption

The analysis of region wise K consumption in Gujarat State in respect to average consumption, compound growth rates and instability indices are presented in Table 4.6 and depicted in Figure 6 as well as Figure 9.

The result for the average consumption of K fertilizer was found the highest in Saurashtra region (5914 ton/yr) and the

lowest in Kutchh region (137 ton/yr) for the Period-II. The compound growth rate was found highly significant and highest in Kutchh region (69.93 %), followed by Saurashtra region (37.36%), North Gujarat (36.93 %), South Gujarat (14.68 %) and Middle Gujarat (1.01 %). value of instability indices varied from 69.73 in Saurashtra region to 25.88 in South Gujarat region. The high growth and high instability was observed in Saurashtra, Kutchh and North Gujarat region and low growth rate and high variability was observed in Middle Gujarat region.

During the Period-III, the result for average consumption of K was observed the highest in Saurashtra region (13281 ton/yr) and the lowest in Kutchh region (219 ton/yr). The compound growth rate was registered positive and the highest in South Gujarat (15.15 %) and negative and the lowest in North Gujarat region (-2.33 %). In Saurashtra region, the compound growth rate was found positive and statistically highly significant (10.33 %). The value of instability indices varied from 18.39 in North Gujarat to 47.25 in Kutchh region. The South Gujarat region has observed high growth rate in K consumption as compared to other regions of the state. It might be due to increased irrigated area and changing cropping pattern during this period.

The results for the Period-IV observed that the average consumption of K was found the highest in South Gujarat (29408 ton/yr) and the lowest in Kutchh region (385 ton/yr). The compound growth rate was found positive and the highest in North Gujarat (5.17 %) and negative in Saurashtra region (-5.97 %). The value of instability index was found the lowest in Middle Gujarat

Table 4.6 : Period wise compound growth rates of potash fertilizer consumption in Gujarat state by region

Region	Period	Period-I	Period-II	Period-III	Period-IV	Period-V	Period-VI
South Gujarat	C.G.R.(%)	-----	14.68	15.15	3.84	3.58	9.03**
	Std. error	-----	4.11	2.77	5.45	4.44	0.67
	R^2	-----	0.65	0.81	0.06	0.07	0.08
	Instability Index	-----	25.88	20.87	63.01	59.29	84.05
	Mean(ton/yr)		4249	12571	29408	29494	18197
North Gujarat	C.G.R.(%)	-----	36.93**	-2.33	5.17	6.39**	6.05
	Std. error	-----	7.07	2.13	2.61	1.17	1.03
	R^2	-----	0.82	0.13	0.34	0.71	0.52
	Instability Index	-----	41.99	18.39	20.57	16.81	34.44
	Mean(ton/yr)		2908	6128	5920	7113	5630
Saurashtra	C.G.R.(%)	-----	37.36*	10.33**	-5.97	-0.91	4.07**
	Std. error	-----	11.37	2.02	2.80	2.28	1.40
	R^2	-----	0.65	0.75	0.35	0.01	0.21
	Instability Index	-----	69.73	18.49	26.16	37.21	52.62
	Mean(ton/yr)		5914	13281	9633	9742	9660
Middle Gujarat	C.G.R.(%)	-----	1.01	9.32	2.44	5.26**	5.84**
	Std. error	-----	6.73	4.39	1.80	1.07	0.72
	R^2	-----	0.00	0.38	0.19	0.66	0.68
	Instability Index	-----	50.54	37.50	14.35	18.08	36.36
	Mean(ton/yr)		4494	5322	11871	14100	8847
Kutchh	C.G.R.(%)	-----	69.93**	10.82	0.23	3.58	10.87**
	Std. error	-----	10.19	6.43	3.51	2.39	1.61
	R^2	-----	0.91	0.28	0.01	0.15	0.61
	Instability Index	-----	47.91	47.25	29.13	48.85	51.53
	Mean(ton/yr)		137	219	385	442	291
Gujarat	C.G.R.(%)	-----	19.88**	1.86	1.89	3.48*	6.30**
	Std. error	-----	5.86	1.91	3.40	1.57	0.68
	R^2	-----	0.63	0.11	0.04	0.28	0.73
	Instability Index	-----	42.30	15.15	32.38	25.39	28.89
	Mean(ton/yr)	-----	17702	37521	57216	62644	42625

* Significant at 5 per cent level, ** Significant at 1 per cent level

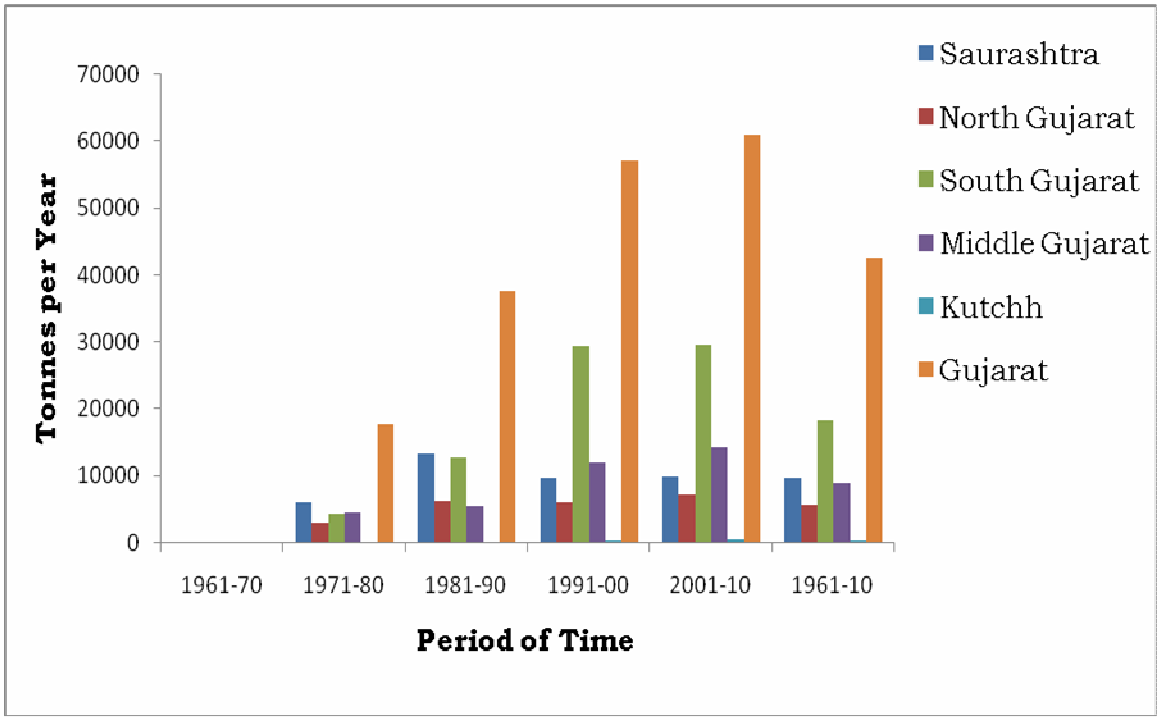

Fig. 9 : Average consumption of K fertilizer in different regions of Gujarat state during 1960-61 to 2009-10

(14.35) and the highest in South Gujarat (63.01). It was found that there was negative growth rate in Saurashtra region. It might be due to increasing area of horticultural, vegetables and sugarcane crops which consume more potassic fertilizer in South Gujarat region.

The result of average consumption of K was observed highest in South Gujarat (29494 ton/yr) and the lowest in Kutchh region (442 ton/yr) during the Period-V. The compound growth rate was noticed positive and highest in North Gujarat (6.39 %), which was statistically highly significant, whereas it was lowest in the Saurashtra region (-0.91). The value of instability indices varied from 16.81 in North Gujarat to 59.29 in South Gujarat. The low growth rate and high instability was found in South Gujarat, Saurashtra and Kutchh region.

The analysis for the Period-VI showed that the average consumption of K was found lowest in Kutchh region (291 ton/yr) and the highest in the South Gujarat region (18197 ton/yr). The compound growth rates were found positive and highly significant for all the regions except North Gujarat region, which was statistically non-significant. It was found highest in Kutchh region (10.87 %), followed by South Gujarat (9.03 %), North Gujarat (6.05 %), Middle Gujarat (5.84 %) and Saurashtra region (4.07 %). The result of instability indices value found lowest in North Gujarat (34.44) and the highest in South Gujarat (84.5). The low compound growth rates and high instability indices value were observed for all the regions and the Gujarat State as a whole.

The overall analysis of compound growth rate and instability indices values showed that there were low compound growth rates and high value of instability indices found in all the regions and periods under study. The consumption of K declined in Saurashtra region (-5.97 %) for the Period-IV and increased at the rate of 69.93 per cent per annum in Kutchh region for the Period-II. This indicated that there were inter regional disparities exists in consumption of K in different regions of the state over different period of time. This might be due to changing cropping pattern, increasing irrigation facilities, extent of adoption of new technologies and weather conditions. This is in commensurate with the findings of Patil and Pandey (1982), Ray and Sharma (1985), Shiyani *et al.* (1991), Yadav and Rai (2001) and Ardeshna et al. (2011).

4.2.4 Trends in total fertilizer consumption

The results of average consumption, compound growth rate and instability indices of total fertilizer during different periods

for regions of Gujarat State are presented in Table 4.7 and depicted in Figure 7 as well as 10.

The average consumption of total fertilizer for the Period-I was found the highest in Saurashtra region (18665 ton/yr) and the lowest in Kutchh region (235 ton/yr). The compound growth rates were found positive and highly significant for all the regions of the state. It was registered the highest in Kutchh region (49.68 %), followed by North Gujarat (35.01 %), Saurashtra region (30.95 %), South Gujarat (25.11 %) and Middle Gujarat (23.42 %). The value of instability indices varied from 13.82 in Saurashtra region to 34.78 in Kutchh region. Results of compound growth rates and instability indices revealed that there were high growth rates and instability indices were found for all the regions across the period.

During the Period-II, the average consumption of total fertilizer was found the highest in Saurashtra region (91609 ton/yr) and the lowest in Kutchh region (2579 ton/yr). The compound growth rate was registered positive and highly significant in North Gujarat region (16.82 %), followed by Kutchh (8.69 %) and South Gujarat (8.68 %). The compound growth rate in Saurashtra and Middle Gujarat was found positive and non-significant. The value of instability indices was found highest in Saurashtra (37.18) and the lowest in South Gujarat (13.71).

The average consumption of total fertilizer for the Period-III was found highest in the Saurashtra region (177992 ton/yr) and the lowest in Kutchh region (7024 ton/yr). The compound growth rates were found positive and statistically highly significant in all the regions of the state except Saurashtra region, where compound growth rate was found negative (-0.03 %). The highest growth rate was registered in Kutchh region (15.67 %), followed by South

Table 4.7 : Period wise compound growth rates of total fertilizer consumption in Gujarat State by region

Region	Period	Period-I	Period-II	Period-III	Period-IV	Period-V	Period-VI
South Gujarat	C.G.R.(%)	25.11**	8.68**	11.68**	2.25*	2.42**	9.73**
	Std. error	2.91	1.78	1.20	0.96	0.51	0.51
	R^2	0.92	0.76	0.93	0.41	0.64	0.90
	Instability Index	16.70	13.71	9.75	8.07	8.11	25.40
	Mean(ton/yr)	7250	30426	77762	138596	147998	74986
North Gujarat	C.G.R.(%)	35.01**	16.82**	7.67**	4.74**	2.62**	7.53**
	Std. error	4.75	2.77	1.79	0.89	0.63	0.49
	R^2	0.90	0.84	0.71	0.79	0.58	0.88
	Instability Index	26.18	21.73	13.74	7.40	9.81	20.13
	Mean(ton/yr)	4176	35428	93363	172179	178931	113482
Saurashtra	C.G.R.(%)	30.95**	7.98	-0.03	4.53	2.68	8.57**
	Std. error	2.40	4.61	2.91	2.06	1.39	0.70
	R^2	0.96	0.29	0.01	0.39	0.23	0.79
	Instability Index	13.82	37.18	23.73	17.78	22.67	32.90
	Mean(ton/yr)	18665	91609	177992	265523	274791	155656
Middle Gujarat	C.G.R.(%)	23.42**	5.72	8.82**	2.94*	2.25**	8.23**
	Std. error	2.34	2.58	1.53	1.11	0.67	0.47
	R^2	0.94	0.39	0.82	0.47	0.47	0.89
	Instability Index	14.32	20.61	12.22	9.57	10.97	24.28
	Mean(ton/yr)	16665	60184	119804	212220	221204	117435
Kutchh	C.G.R.(%)	49.68**	8.69*	15.67**	10.10**	7.26**	15.92**
	Std. error	7.22	3.63	2.01	1.42	0.80	0.97
	R^2	0.90	0.44	0.90	0.88	0.87	0.88
	Instability Index	34.78	25.79	15.60	11.11	11.29	38.07
	Mean(ton/yr)	235	2579	7024	21125	24631	10397
Gujarat	C.G.R.(%)	27.51**	8.48*	5.76**	3.94**	2.63**	9.24**
	Std. error	1.77	2.93	1.71	1.08	0.72	0.58
	R^2	0.97	0.53	0.60	0.64	0.51	0.87
	Instability Index	11.32	24.97	14.80	9.17	11.79	27.13
	Mean(ton/yr)	47484	219622	478259	812588	849518	448809

* Significant at 5 per cent level, ** Significant at 1 per cent level

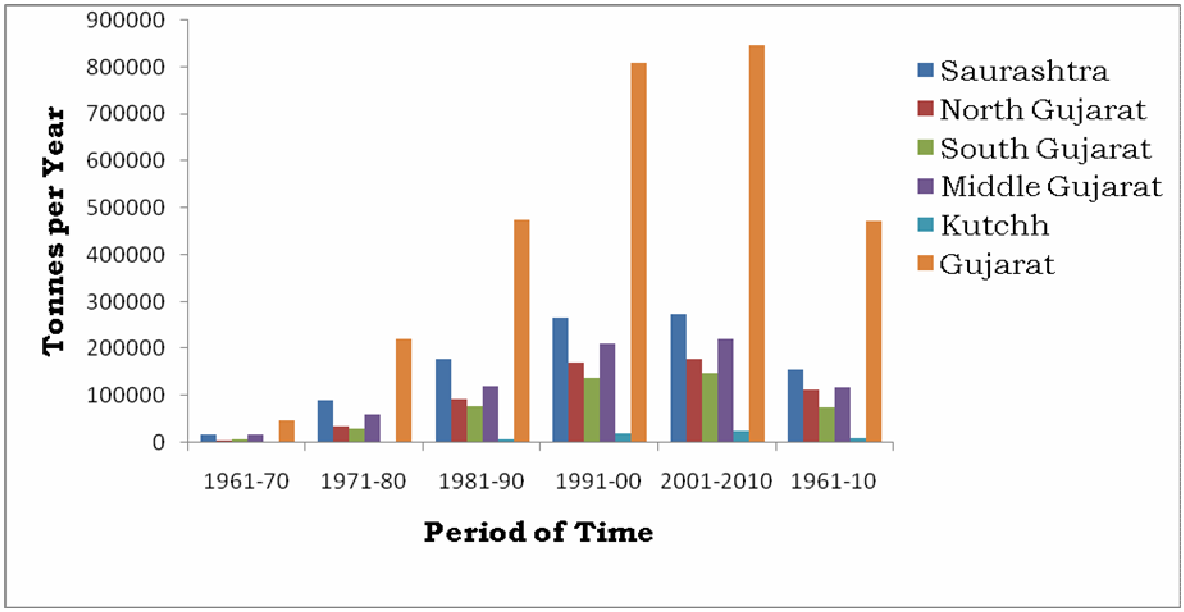

Fig. 10 : Average consumption of total fertilizer in different regions of Gujarat state during 1960-61 to 2009-10

Gujarat (11.68 %), Middle Gujarat (8.82 %) and North Gujarat (7.67 %). The value of instability index was found lowest in South Gujarat (9.75) and the highest in Saurashtra region (23.73).

The results obtained for the Period-IV, average consumption of total fertilizer was found highest in Saurashtra region (265523 ton/yr) and the lowest in Kutchh region (21125 ton/yr). The compound growth rates were found statistically significant except Saurashtra region. The highest compound growth rate was registered in Kutchh region (10.10 %) and the lowest in South Gujarat region (2.25 %). The value of instability indices varied from 7.40 in North Gujarat to 17.78 in Saurashtra region.

During the Period-V, the average consumption of total fertilizer was found highest in Saurashtra region (274791 ton/yr) and the lowest in Kutchh region (24631 ton/yr). The compound growth rates were found positive and highly significant for all the regions except, Saurashtra region. It was noticed the highest in Kutchh region (7.26 %), followed by North Gujarat (2.62 %), South

Gujarat (2.42 %) and Middle Gujarat (2.25 %). The value of instability index was found lowest in case of South Gujarat (8.11) and the highest in Saurashtra region (22.67).

The average consumption of total fertilizer for the Period-VI was observed highest in Saurashtra region (155656 ton/yr) and the lowest in Kutchh region (10397 ton/yr). The compound growth rates were found positive and statistically highly significant for all the region and Gujarat State as a whole. It was noticed the highest in Kutchh region (15.92 %), followed by South Gujarat (9.73 %), Saurashtra region (8.57 %), Middle Gujarat (8.23 %) and North Gujarat (7.53 %). The consumption of total fertilizer increased as the compound growth rate at 9.24 per cent per annum for the Gujarat State. This supports our hypothesis that there is upward trend in consumption of fertilizers in the most of the regions of the Gujarat State. The value of instability indices varied from 20.13 in case of North Gujarat to 38.07 in Kutchh region.

The overall analysis of the compound growth rates were found positive except, Saurashtra region for the Period-III, where declining trend was observed. There was higher rates of growth were observed for all the regions for the Period-I. There was wide variation in compound growth rate noticed from region to region and over decades. The results showed high inter and intra regional disparities which might be due to adoption of new technologies change in cropping pattern over time, irrigation facilities, farmers' responsiveness, credit rating and agro-climatic factors. These results corroborate the findings of Patil and Pandey (1982), Ray and Sharma (1985), Santra and Sanker (1989), Khunt *et al.* (2002) and Shah et al. (2009).

4.3 Analysis of gap in consumption of fertilizers

To stabilize the crop yields and sustained the crop productivity in different regions, balance use of fertilizer is quite important. Efforts have been made in this study to estimate the gap between requirement and actual consumption of fertilizers in different regions of Gujarat State. Imbalance use of fertilizers in various crops in a region resulted into low productivity and yield gaps. Therefore, the application of recommended dose of fertilizer is essential in stabilizing the yield. The gap in fertilizer use was estimated by calculating the requirement of fertilizers in different crops with respect to recommended dozes and area under the crops in different regions of the state. The difference between actual use and the requirement of fertilizer is considered as a gap in fertilizer consumption for the period of 1960-61 to 2009-10. Using this time series data in the logarithmic form of exponential model, period wise growth rate of N, P_2O_5, K_2O and total fertilizer in different regions have been worked out and presented in Table 4.8 to 4.11 and depicted in Figure 11 to 18, respectively.

4.3.1 Trends in gap of nitrogenous fertilizer consumption

The period wise compound growth rates, instability index and average gap in N consumption in different regions are presented in Table 4.8 and depicted in Figure 11 as well as Figure 13. The average gap in consumption of N was found the highest in Period-I (54538 tonnes/yr) and the lowest in the Period-IV (12989 tonnes/yr) in case of South Gujarat region. This is due to continuous increase in fertilizer consumption in this region. The compound growth rates were found negative in case of Period-I to Period-III and positive for the Period-IV and Period-V but it was found statistically non-significant. The instability indices ranged from 3.86 in Period-I to 46.33 in case of Period-V. It indicates that

the instability has increased across the region over the period of time. The gap of nitrogen consumption reduced over period of time might be due to increased irrigation facilities, increased awareness of farmers and increased supply of agricultural credit.

In North Gujarat region, the average gap in N consumption was found the highest during the Period-I (128245 tonnes/yr) and decrease up to 77043 tonnes/yr in Period-V. The compound growth rates were found negative for all the periods except Period-II and the rate of decline has increased over the period of time with an average decline at the rate of 1.80 per cent per annum. The value of instability indices ranged from 8.50 in Period-I to 20.79 in case of Period-III.

The average gap in consumption of N fertilizer for the Saurashtra region was observed declining at faster rate over the period from 1960-61 to 2009-10. The highest gap in consumption was found in Period-II (177146 tonnes/yr) and declined up to 66342 tonnes in the period-V. The compound growth rates were found positive but statistically non-significant for the Period-I and Period-II but for the rest of the period, it was found negative and significant. For the overall period, compound growth rate was declined at the rate of 6.23 per cent per annum. The instability index was observed the lowest in the Period-I (5.45) and the highest in Period-V (43.66). High declining trend as well as instability was found in the Period-V indicating the instability in consumption.

In Middle Gujarat region, the average gap in N consumption found declining from 156848 tonnes/yr in Period-I to 31205 tonnes/yr in Period-V. The compound growth rates were negative across the period of time and maximum rate of decline was in Period-V (-33.45 %). The instability indices ranged from 3.86 in Period-I to 56.37 in Period-V.

Table 4.8 : Period wise compound growth rates of gap in nitrogen fertilizer consumption in Gujarat State by region

Region	Period	Period-I	Period-II	Period-III	Period-IV	Period-V	Period-VI
South Gujarat	C.G.R.(%)	-1.33*	-1.47	-14.34**	4.40	11.78	-5.72**
	Std. error	0.43	0.84	3.11	36.95	16.96	1.62
	R^2	0.51	0.28	0.69	0.02	0.04	0.21
	Instability Index	3.86	6.99	24.09	55.14	46.33	47.93
	Mean(ton/yr)	54538	43935	27489	12989	13976	32650
North Gujarat	C.G.R.(%)	-2.14	0.36	-6.00	-4.89*	-5.43**	-1.80**
	Std. error	0.97	1.16	3.10	1.77	1.32	0.26
	R^2	0.37	0.01	0.31	0.50	0.55	0.52
	Instability Index	8.50	10.38	20.79	14.83	20.29	18.81
	Mean(ton/yr)	128245	105211	105549	84770	77043	101015
Saurashtra	C.G.R.(%)	0.19	0.61	-6.50*	-9.45	-26.97*	-6.23**
	Std. error	0.62	1.10	2.37	4.67	11.51	1.76
	R^2	0.01	0.04	0.47	0.32	0.23	0.22
	Instability Index	5.45	9.46	17.94	32.03	43.66	36.90
	Mean(ton/yr)	168305	177146	129922	70958	66342	127752
Middle Gujarat	C.G.R.(%)	-1.65**	-0.87	-9.63**	-13.05	-33.45**	-9.10**
	Std. error	0.45	0.91	1.19	6.99	9.61	1.69
	R^2	0.63	0.10	0.88	0.27	0.38	0.38
	Instability Index	3.86	7.73	10.62	50.46	56.37	45.06
	Mean(ton/yr)	156848	120241	88344	36969	31205	91609
Kutchh	C.G.R.(%)	-5.83*	7.67	-27.47	-30.92*	-5.58	-3.03
	Std. error	2.44	5.38	26.53	12.01	8.92	1.96
	R^2	0.40	0.21	0.09	0.36	0.03	0.05
	Instability Index	21.80	32.82	36.53	40.41	44.00	39.81
	Mean(ton/yr)	34440	24879	28715	19421	20502	26397
Gujarat	C.G.R.(%)	-1.64*	0.43	-9.79*	-13.1*	-30.45*	-7.61**
	Std. error	0.67	1.07	3.14	5.26	11.30	1.82
	R^2	0.43	0.02	0.52	0.40	0.28	0.27
	Instability Index	5.73	9.32	22.66	33.95	48.60	42.71
	Mean(ton/yr)	459429	388464	297072	142160	126121	296477

* Significant at 5 per cent level, ** Significant at 1 per cent level

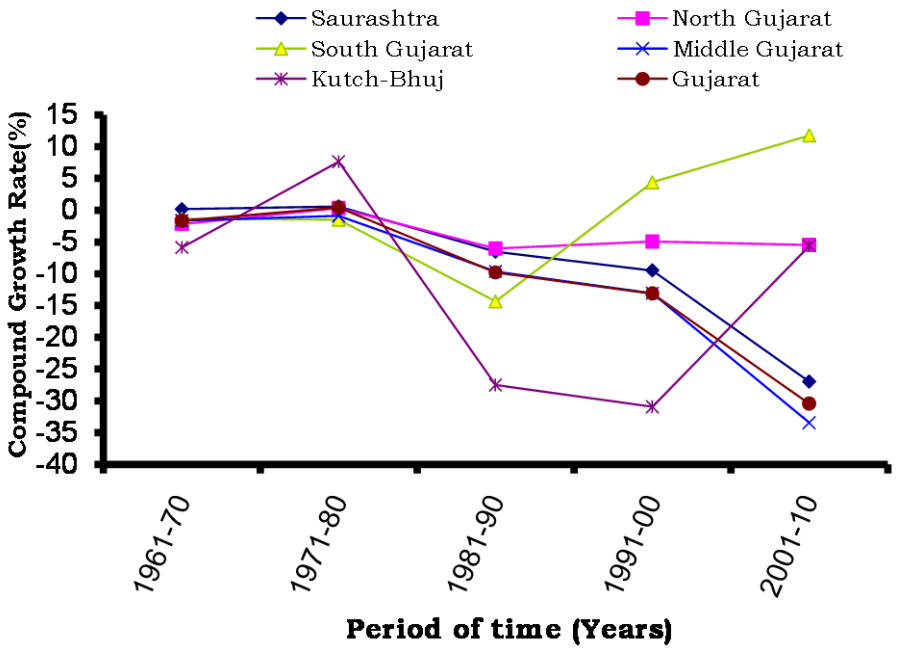

Fig. 11: Compound growth rates of gap in N consumption in different regions of Gujarat state

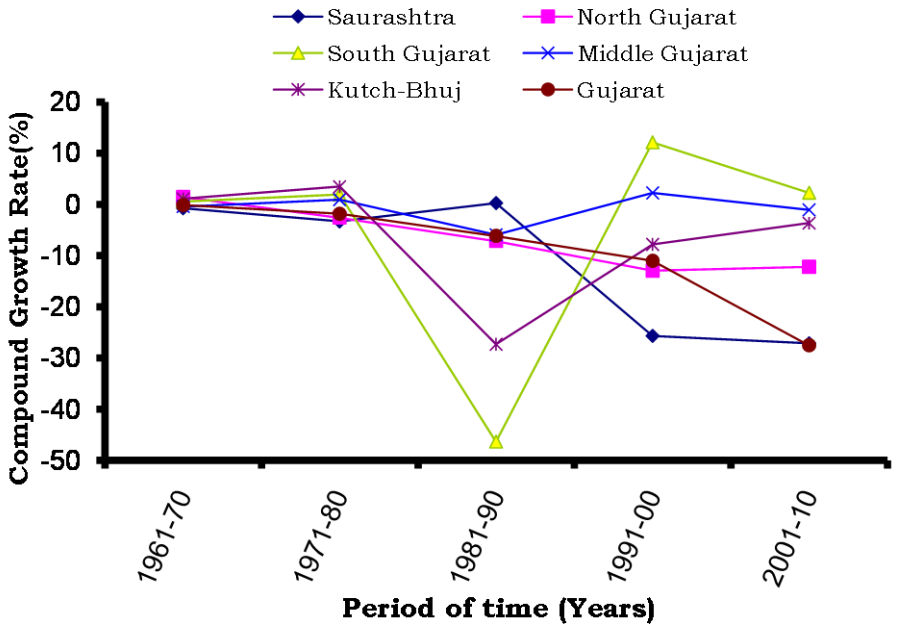

Fig. 12: Compound growth rates of gap in P_2O_5 consumption in different regions of Gujarat state

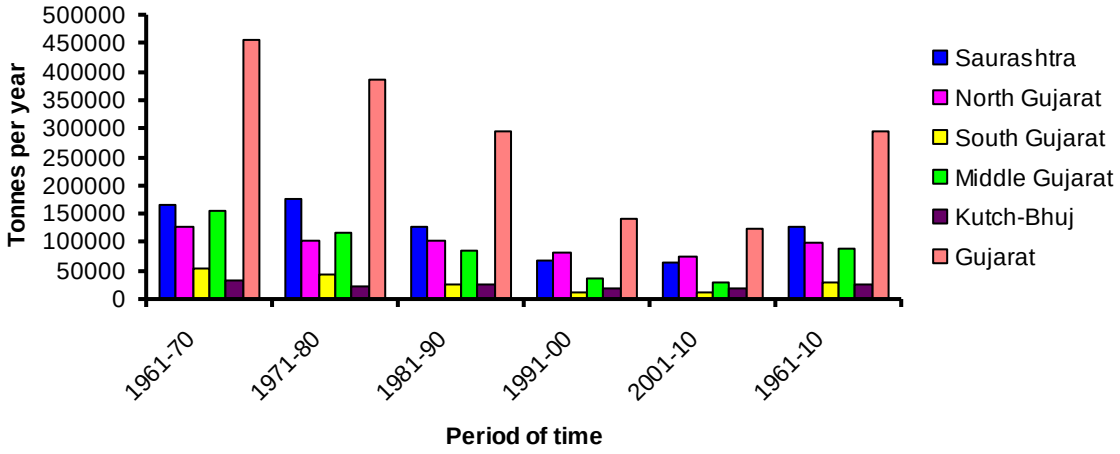

Fig. 13 : Average gap of N fertilizer in different regions of Gujarat state during 1960-61 to 2009-10

In case of Kutchh region, the gap in N consumption was the highest in Period-I (34440 tonnes/yr) and the lowest in the Period-IV (19421 tonnes/yr). The compound growth rates were found negative in all the periods except Period-II. The rate of decline was found the highest in Period-IV (-30.92 %) and the positive rate of increase in Period-II (7.67 %). This might be due to change in cropping pattern and severe drought in the respective period of time. The instability indices ranged from 21.80 in Period-I to 44.00 in case of Period-V.

The average gap in consumption of N fertilizer was found the highest in Period-I (459429 tonnes/yr) and the lowest in Period-V (126121 tonnes/yr) for the state as a whole. The compound growth rates were negative and significant for all the periods except Period-II. The gap in N consumption declined with maximum rate in Period-V (-30.45 %). The value of instability index was the lowest in Period-I (5.73) and the highest in Period-V (48.60).

It may be concluded that the high rate of decline in gap of N consumption accompanied with high instability indices were found over the period of time.

On the basis of overall result, it can be concluded that the significant decline in the gap of N consumption across the region in different periods and the rate of decline has increased over the period of time. The instability indices were increased over period of time. These might be due to increased irrigation facilities, changing cropping pattern and increasing perception of farmers towards package of practices of crops. This supports our hypothesis that there exists wide variation in consumption of fertilizers in different regions of the state. These results are in conformity with the results of Shiyani (1991), Sundari and Rao (2005) and Ardeshna and Khunt (2011).

4.3.2 Trends in gap of phosphetic fertilizer consumption

The period wise compound growth rates, instability index and average gap in P consumption to different regions are presented in Table 4.9 and depicted in Figure 12 as well as Figure 14. The average gap in consumption of P fertilizer for the South Gujarat region was observed declining at faster rate over the period from 1960-61 to 2009-10. The highest gap in consumption was found in Period-I (21781 tonnes/yr) and declined up to 9802 tonnes in the period-V. The compound growth rates were found negative and statistically significant for the Period-III and Period-VI but for the rest of the period, it were found positive but non significant. For the overall period, compound growth rate was declined at the rate of 3.80 per cent per annum. The instability index was observed the lowest in the Period-I (5.43) and the highest in Period-V (53.50). High declining trend as well as instability was found in the Period-III and Period-V, respectively. This might be due to changing cropping pattern, increased irrigation facilities and agronomic practices.

In North Gujarat region the average gap in P consumption was found the highest during the Period-I (49407 tonnes/yr) and decreased up to 14540 tonnes/yr in Period-V. The compound growth rates were found negative for all the periods except Period-I and the rate of decline has increased over the period of time with an average decline at the rate of 4.79 per cent per annum. The value of instability indices increased over decadal periods ranged from 2.27 in Period-I to 37.69 in case of Period-V.

The average gap in consumption of P was found the highest in Period-II (177146 tonnes/yr) and the lowest in the Period-V (66342 tonnes/yr) in case of Saurashtra region. The compound growth

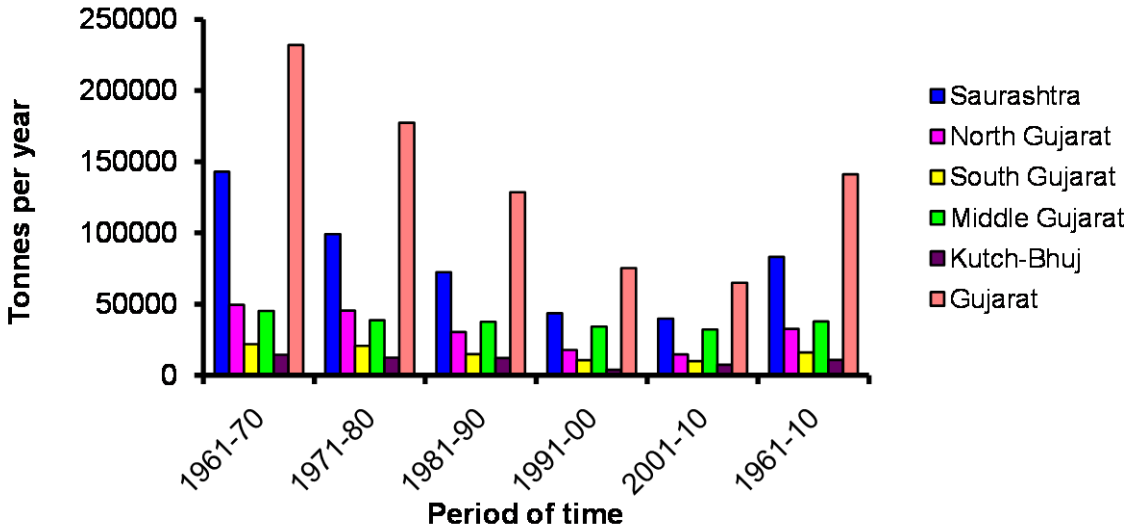

Fig. 14 : Average gap of P_2O_5 fertilizer in different regions of Gujarat state during 1960-61 to2009-10

Table 4.9 : Period wise compound growth rate of gap in phosphorus fertilizer consumption in Gujarat State by region

Region	Period	Period-I	Period-II	Period-III	Period-IV	Period-V	Period-VI
South Gujarat	C.G.R.(%)	0.56	1.92	-46.37*	12.12	2.27	-3.80*
	Std. error	0.65	1.70	15.21	9.90	4.65	1.64
	R^2	0.09	0.14	0.38	0.17	0.02	0.11
	Instability Index	5.43	13.67	39.65	47.56	53.50	41.10
	Mean(ton/yr)	21781	20742	14854	10614	9802	16018
North Gujarat	C.G.R.(%)	1.42**	-2.61*	-7.17**	-12.94*	-12.19**	-4.79**
	Std. error	0.28	0.91	1.85	4.16	2.89	0.46
	R^2	0.77	0.50	0.64	0.51	0.56	0.70
	Instability Index	2.27	7.75	14.96	31.75	37.69	26.67
	Mean(ton/yr)	49407	45338	30414	17763	14540	32660
Saurashtra	C.G.R.(%)	0.19	0.61	-6.50*	-9.45	-26.97*	-6.23**
	Std. error	0.62	1.10	2.37	4.67	11.51	1.76
	R^2	0.01	0.04	0.47	0.32	0.23	0.22
	Instability Index	5.45	9.46	17.94	32.03	43.66	36.90
	Mean(ton/yr)	168305	177146	129922	70958	66342	127752
Middle Gujarat	C.G.R.(%)	-0.44	0.93	-5.98**	2.24	-1.08	-1.04**
	Std. error	0.86	1.11	1.68	1.70	0.93	0.17
	R^2	0.03	0.08	0.60	0.18	0.09	0.47
	Instability Index	7.30	9.19	14.22	14.30	15.84	13.90
	Mean(ton/yr)	45202	38634	37563	34270	32260	37731
Kutchh	C.G.R.(%)	1.06	3.46	-27.34	-7.82	-3.64	-2.28
	Std. error	1.39	4.87	24.15	5.99	3.42	1.61
	R^2	0.07	0.06	0.10	0.16	0.08	0.04
	Instability Index	11.45	27.72	36.61	33.49	36.34	35.69
	Mean(ton/yr)	14463	12393	12072	3739	7511	10788
Gujarat	C.G.R.(%)	-0.15	-1.85	-6.18*	-11.04	-27.55*	-7.10**
	Std. error	0.40	1.16	2.36	5.72	11.28	1.71
	R^2	0.02	0.24	0.45	0.29	0.25	0.27
	Instability Index	3.40	10.10	18.19	44.90	51.25	42.61
	Mean(ton/yr)	231937	177439	128520	75219	65028	141208

* Significant at 5 per cent level, ** Significant at 1 per cent level

rates were found negative in all the periods except, Period-III and it was statistically significant for Period-1, Period-II, Period-V and Period-VI. The instability indices increased over decadal periods ranged from 2.62 in Period-I to 58.36 in case of Period-V. It indicated that the instability has increased across the period of time in all the regions.

In Middle Gujarat region, the average gap in P consumption found declining from 45202 tonnes/yr in Period-I to 32260 tonnes/yr in Period-V. The compound growth rates were negative in Period-I, Period-III Period-V and Period-VI. It was statistically significant in Period-III. The maximum rate of decline was found in Period-III (-5.98 %). The instability indices increased over periods ranged from 7.30 in Period-I to 15.84 in Period-V.

In case of Kutchh region, the gap in P consumption was the highest in Period-I (14463 tonnes/yr) and the lowest in the Period-IV (3739 tonnes/yr). The compound growth rates were found negative in all the periods except, Period-I and Period-II. The rate of decline was found the highest in Period-III (-27.34 %) and the positive rate of increase in Period-I (1.06 %) and Period-II (3.46 %). The instability indices ranged from 11.45 in Period-I to 36.61 in case of Period-III.

The average gap in consumption of P fertilizer was found the highest in Period-I (231937 tonnes/yr) and the lowest in Period-V (65028 tonnes/yr) for the state as a whole. The compound growth rates were negative for all the periods but statistically significant in Period-III, Period-V and Period-VI. The gap in P consumption decline at maximum rate in Period-V (-27.55 %). The value of instability index was the lowest in Period-I (3.40) and the highest in Period-V (51.25).

It may be concluded that the high rate of decline in gap of P consumption accompanied with high instability indices were found over the period of time.

On the basis of overall result, it can be concluded that the significant decline in the gap of P consumption across the region in different periods and the rate of decline has increased over the period of time. The instability indices also increased over period of time. These results might be due to changing cropping pattern, increased in irrigated areas, river linking, khet talavadi jyotigram yojana, adoption of new technologies and rainfall in the state. These results are in collaborating with the results of Rao (1982), Shiyani *et al.* (1991), Sharma *et al.* (1997) and Ardeshna and Khunt (2011).

4.3.3 Trends in gap of potassic fertilizer consumption

The period wise compound growth rates, instability index and average gap in K consumption to different regions are presented in Table 4.10 and depicted in Figure 15 as well as Figure 17. The average gap in consumption of K fertilizer for the South Gujarat region was observed some extent constant across different periods of time. The highest gap in consumption was found in Period-III (58929 tonnes/yr) and the lowest in Period-IV (52519 tonnes/yr). The compound growth rates of gap were found negative for Period-III, Period-IV and Period-VI but found statistically significant for the Period-III only. It were found positive and non significant for Period-I, Period-II and Period-V. For the overall period, compound growth rate was declined at the rate of 1.95 per cent per annum. The instability index was observed the lowest in the Period-I (0.39) and the highest in Period-IV (36.39). High declining trend as well as instability was found in the Period-IV. These results might be due

to increasing area of vegetable and horticultural crops which requires high dose of potassic fertilizer.

In North Gujarat region the average gap in K consumption was found the highest during the Period-I (7789 tonnes/yr) and the lowest in Period-III (3582 tonnes/yr). The compound growth rates were found negative for the periods-II and Period-IV but it was statistically significant only in Period-II. The compound growth rates were positive for the Period-I, Period-III, Period-IV and Period-VI but found statistically significant only in Period-III. The average decline in the gap of K consumption was 0.04 per cent per annum. The value of instability indices were hovering between 1.38 (Period-I) to 47.39 (Period-II) with an average of 39.49.

The average gap in consumption of K was found the highest in Period-I (19186 tonnes/yr) and the lowest in the Period-III (6931 tonnes/yr) in case of Saurashtra region. The compound growth rates were found negative in Period-II, Period-V and Period-VI but it was statistically significant only in Period-II. The compound growth rates were found positive during Period-I, Period-III and Period-IV but it was statistically significant for Period-I and Period-III. The average gap in consumption of K fertilizer declined at the rate of 2.57 per cent. The instability indices were the lowest (3.45) in Period-I and the highest (39.56) in Period-V with 51.51 per cent for overall period.

In Middle Gujarat region, the average gap in K consumption found irregular with the lowest and the highest during Period-II (4857 tonnes/yr) and Period-III (16170 tonnes/yr), respectively. The compound growth rates were negative in Period-I and Period-V but statistically significant in Period-V. The maximum rate of decline was found in Period-V (-6.31 %). The average gap in K consumption for whole period was increased at the rate of 2.34 per cent.

Table 4.10 : Period wise compound growth rate of gap in potash fertilizer consumption in Gujarat State by region

Region	Period	Period-I	Period-II	Period-III	Period-IV	Period-V	Period-VI
South Gujarat	C.G.R.(%)	0.15	0.09	-1.42*	-5.36	7.55	-1.95
	Std. error	0.07	0.33	0.61	32.31	18.72	1.84
	R^2	0.39	0.01	0.40	0.00	0.01	0.03
	Instability Index	0.39	2.73	5.22	36.39	29.14	16.32
	Mean(ton/yr)	58197	56140	58929	52519	52774	56082
North Gujarat	C.G.R.(%)	0.08	-46.08*	11.81**	1.44	-2.55	0.04
	Std. Error	0.16	14.90	2.98	1.52	1.20	1.75
	R^2	0.03	0.38	0.69	0.10	0.25	0.00
	Instability Index	1.38	47.39	23.71	12.77	17.87	39.49
	Mean(ton/yr)	7789	4789	3582	7111	6560	5778
Saurashtra	C.G.R.(%)	1.05*	-45.93*	31.34*	8.52	-4.37	-2.57
	Std. Error	0.40	15.29	10.11	3.72	4.42	1.78
	R^2	0.46	0.37	0.61	0.42	0.07	0.05
	Instability Index	3.45	38.65	34.09	24.43	39.56	51.51
	Mean(ton/yr)	19186	13768	6931	9115	8591	11727
Middle Gujarat	C.G.R.(%)	-3.78	14.43	3.44	1.23	-6.31**	2.34
	Std. Error	2.13	35.93	4.71	1.45	2.04	1.70
	R^2	0.26	0.02	0.06	0.08	0.41	0.04
	Instability Index	14.47	47.78	27.14	11.38	23.24	47.14
	Mean(ton/yr)	8687	4857	16170	14332	12342	10717
Kutchh	C.G.R.(%)	0.15	-5.45*	-2.18*	-0.23	-15.80	-3.09*
	Std. Error	0.11	1.99	0.93	1.51	8.16	1.09
	R^2	0.18	0.47	0.40	0.00	0.20	0.15
	Instability Index	0.99	14.32	7.94	12.83	27.30	15.18
	Mean(ton/yr)	1232	1104	1017	846	785	1007
Gujarat	C.G.R.(%)	0.07	-6.74**	1.96	-3.45	5.13	-2.42
	Std. Error	0.25	1.92	2.02	38.80	18.14	1.81
	R^2	0.01	0.59	0.11	0.00	0.01	0.04
	Instability Index	2.21	15.45	15.25	40.22	37.96	25.50
	Mean(ton/yr)	59322	44890	50861	48155	45243	49542

* Significant at 5 per cent level, ** Significant at 1 per cent level

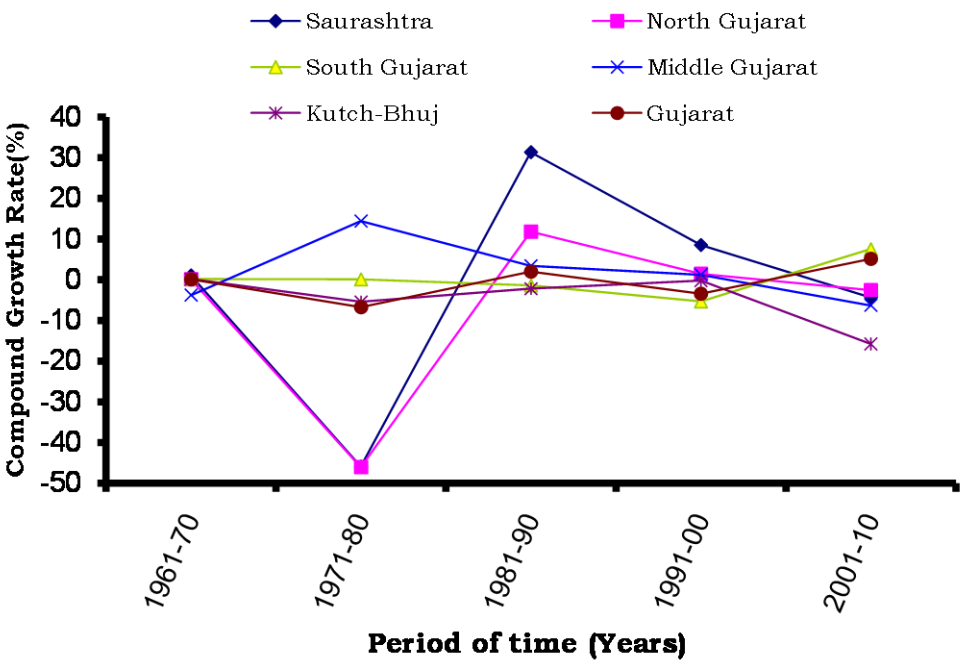

Fig. 15: Compound growth rates of gap in K_2O consumption in different regions of Gujarat state

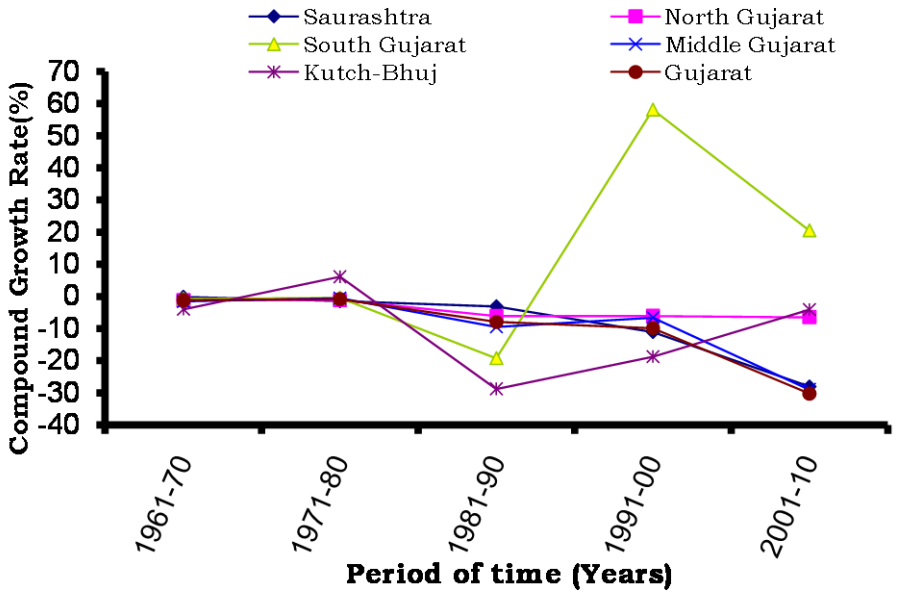

Fig. 16: Compound growth rates of gap in NPK consumption in different regions of Gujarat state

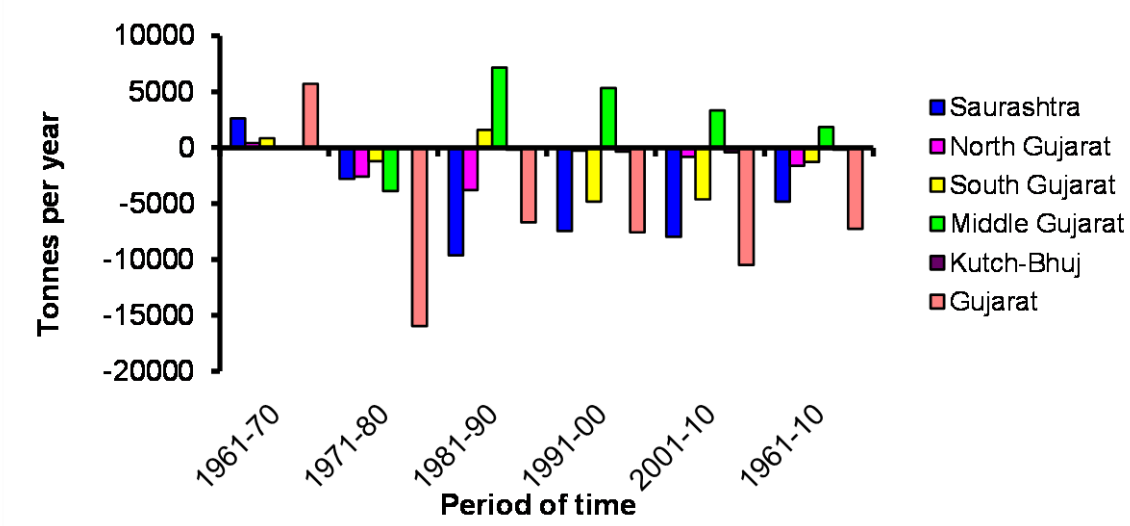

Fig. 17 : Average gap of K_2O fertilizer in different regions of Gujarat state during 1960-61 to 2009-10

There was irregular trend in instability indices with the lowest and the highest in Period-IV (11.38 %) and Period-II (47.78 %), respectively.

In case of Kutchh region, the gap in K consumption was the highest in Period-I (1232 tonnes/yr) and the lowest in the Period-V (785 tonnes/yr). The compound growth rates were found negative in all the periods except Period-I and it was significant in Period-II, Period-III and Period-VI with an average declined at the rate of 3.09 per cent. The instability indices ranged from 0.99 in Period-I to 27.30 in case of Period-V.

The average gap in consumption of K fertilizer was found the highest in Period-I (59322 tonnes/yr) and the lowest in Period-II (44890 tonnes/yr) for the state as a whole. The compound growth rates were negative for Period-II, Period-IV and Period-VI but statistically significant for Period-II only. The gap in K consumption declined with maximum rate in Period-II (-6.74 %). The value of instability index was the lowest in Period-I (2.21) and the highest in Period-IV (40.22).

It may be concluded that the high rate of decline in gap of K consumption accompanied with high instability indices were found over the period of time.

On the basis of overall result, it can be concluded that the significant decline in the gap of K consumption across the periods in all the regions and the rate of decline has increased over the period of time. The instability indices were also increased over period of time. This indicates the instability in the use of K fertilizers in different regions which resulted in to gap in fertilizer use. This supports our hypothesis that there exists wide variation in the different regions of the state. This might be due to changing cropping pattern, adoption of new technologies and rainfall. The similar results have also been obtained by Shiyani *et al.* (1991), Sharma *et al.* (1997) and Ardeshna and Khunt (2011).

4.2.4 Trends in gap of total fertilizer consumption

The period wise compound growth rates, instability index and average gap in NPK consumption to different regions are presented in Table 4.11 and depicted in Figure 16 as well as Figure 18. The average gap in consumption of NPK fertilizer for the South Gujarat region was declined at faster rate from Period-I (74563 tonnes/yr) to Period-V(19339 tonnes/yr). The compound growth rates were found negative for initial three periods and Period-VI but significant in Period-III. It was found positive and non significant for Period-IV and Period-V. For the overall period, compound growth rate was declined at the rate of 5.69 per cent per annum. The instability index was increased over decadal periods and it was the lowest and the highest in Period-I (3.20 %) and Period-V (59.87%), respectively. The gap of NPK consumption was decreased at the rate of 5.69 per cent for whole period. High declining trend was found in the

Period-III. It might be due to changing cropping pattern in this region.

In North Gujarat region the average gap in NPK consumption was found the highest during the Period-II (147951 tonnes/yr) and the lowest in Period-V (90753 tonnes/yr). The compound growth rates were found negative for all the periods but found significant for Period-IV, Period-V and Period-VI. The average decline in the gap of NPK consumption was 2.40 per cent per annum. The value of instability indices ranged from 6.67 per cent in Period-I to 20.26 per cent in Period-V with an average of 18.03.

The average gap in consumption of NPK was found the highest in Period-I (329771 tonnes/yr) and the lowest in the Period-V (112427 tonnes/yr) in case of Saurashtra region. The compound growth rates were found negative in all the periods but found significant in Period-V and Period-VI. The average gap in consumption of NPK fertilizer declined at the rate of 6.68 per cent. The instability indices increased with the successive decadal periods with an average of 38.17 per cent.

In Middle Gujarat region, the average gap in NPK consumption was decreased with period of time with the lowest and the highest during Period-V (48692 tonnes/yr) and Period-I (183451 tonnes/yr). The compound growth rates were negative in all the periods and significant for the Period-I, Period-III, Period-IV and Period-VI. The maximum rate of decline was found in Period-V (-28.98 %). The average gap in NPK consumption for whole period was decreased at the rate of 7.22 per cent. The instability indices increased across the periods of time.

In case of Kutchh region, the gap in NPK consumption was the highest in Period-I (46251 tonnes/yr) and the lowest in the Period-IV (26722 tonnes/yr). The compound growth rates were

Table 4.11 : Period wise compound growth rate of gap in total fertilizer consumption in Gujarat state by region

Region	Period	Period-I	Period-II	Period-III	Period-IV	Period-V	Period-VI
South Gujarat	C.G.R.(%)	-0.69	-0.36	-19.21**	58.18	20.57	-5.69**
	Std. error	0.37	1.33	3.55	53.09	18.54	1.73
	R^2	0.30	0.01	0.75	0.19	0.10	0.19
	Instability Index	3.20	11.08	25.22	57.04	59.87	48.95
	Mean(ton/yr)	74563	60601	42011	20935	19339	45952
North Gujarat	C.G.R.(%)	-1.13	-1.15	-6.08	-6.04*	-6.46**	-2.40**
	Std. Error	0.76	1.17	2.81	1.99	1.31	0.25
	R^2	0.21	0.11	0.36	0.52	0.64	0.67
	Instability Index	6.67	10.31	19.35	17.00	20.26	18.03
	Mean(ton/yr)	13348	147951	132258	102256	90753	132085
Saurashtra	C.G.R.(%)	-0.15	-1.48	-3.10	-11.05	-28.00*	-6.68**
	Std. error	0.27	1.10	1.86	5.07	11.88	1.82
	R^2	0.04	0.18	0.25	0.35	0.23	0.23
	Instability Index	2.26	9.32	15.19	33.85	44.74	38.17
	Mean(ton/yr)	329771	288996	210196	120681	112427	221690
Middle Gujarat	C.G.R.(%)	-1.54*	-0.50	-9.44**	-6.57	-28.98*	-7.22**
	Std. error	0.52	1.25	1.62	4.08	10.49	1.67
	R2	0.52	0.02	0.79	0.23	0.29	0.29
	Instability Index	4.53	10.60	14.18	31.30	44.59	42.32
	Mean(ton/yr)	183451	135950	114285	58787	48692	112606
Kutch	C.G.R.(%)	-3.99	6.18	-28.79	-18.73*	-4.05	-2.59
	Std. Error	2.09	5.10	26.87	7.35	4.97	1.85
	R^2	0.30	0.16	0.09	0.40	0.05	0.04
	Instability Index	18.52	30.45	35.81	34.90	40.49	37.17
	Mean(ton/yr)	46251	37592	40920	26722	27646	36941
Gujarat	C.G.R.(%)	-1.07*	-0.77	-7.90*	-9.81*	-30.20*	-7.24**
	Std. Error	0.46	1.14	2.63	4.05	11.98	1.89
	R^2	0.40	0.05	0.51	0.40	0.25	0.24
	Instability Index	3.97	10.04	19.54	28.32	42.57	41.24
	Mean(ton/yr)	729621	589726	455385	244467	215325	466160

* Significant at 5 per cent level, ** Significant at 1 per cent level

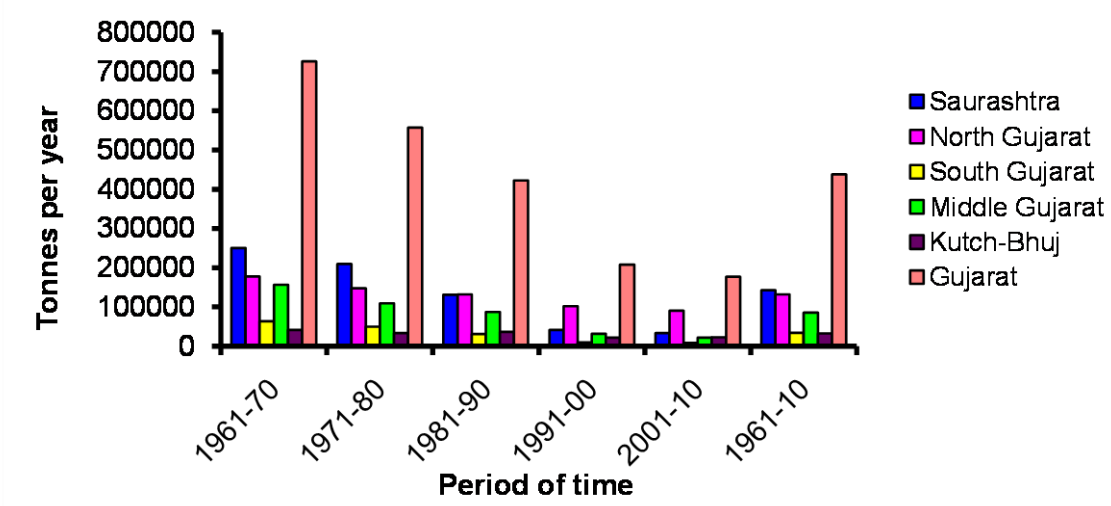

Fig. 18 : Average gap of total fertilizer in different regions of Gujarat state during 1960-61 to 2009-10

found negative in all the periods except Period-II and it was significant only in Period-IV with an average decline rate of 2.59 per cent. The instability indices increased over period of time ranged from 18.52 in Period-I to 40.49 in Period-V.

The average gap in consumption of NPK fertilizer was found the highest in Period-I (729621 tonnes/yr) and the lowest in Period-V (215325 tonnes/yr) for the state as a whole. The compound growth rates were negative for all the periods and significant except Period-II. The gap in NPK consumption declined at maximum rate in Period-V (-30.20 %). The value of instability indices increased over decadal periods with the lowest in Period-I (3.97) and the highest in Period-V (42.57).

It may be concluded that the high rate of decline in gap of NPK consumption accompanied with high instability indices were found across the periods of time.

On the basis of overall result, it can be concluded that the significant decline in the gap of NPK consumption across the regions in different periods and the rate of decline has increased over the period of time. This might be due to changing cropping

pattern, increased irrigated area and increased supply of agricultural credit. The instability indices were also increased over period of time. This indicates the instability in the use of NPK fertilizers in different regions which resulted in to gap in fertilizer use. This supports our hypothesis that there exists wide variation in consumption of fertilizers in the different regions of the state.

4.4 Determinants of fertilizer consumption

Factors determining the consumption of fertilizer in sugarcane and kharif paddy crops in the study area for the year 2010-11 have been discussed as under.

4.4.1 Determination of fertilizer use in sugarcane crop

Factor determining the fertilizer use was studied using the information of sample farmers for selected crops from two districts of South Gujarat region for the year 2010-11. Multiple linear regression type of function was best fitted to determine the relative importance and significance of different factors in explaining the fertilizer consumption. The explanatory variables viz., irrigated area under the crop, annual total income of farmers, cropping intensity, amount of credit, operational holding, education level, short- term credit, one year lagged price, manure and number of irrigations were included in function.

The determinants of fertilizer use for sugarcane crop are presented in Table 4.12. The value of R^2 was found 36.40 per cent and 61.20 per cent for without Soil Health Card in Surat and Navsari districts, respectively. It is revealed from the table that for with Soil Health Card farmers in Navsari district, all the variables except, operational holding and manure were positive but non significant. The operational holding (X_4) and manure (X_8) showed negative sign but non-significant. It indicated that farmers of this district judiciously used the fertilizers when they used more manures with their limited financial resources. Whereas, educational level (X_5) was found positive and significant at 1 per cent for Soil Health Card holders. In Navsari district educational

level showed the positive and statistically significant effect on consumption of fertilizers. For without Soil Health Card farmers of Navsari district, all variables except manure were found positive but statistically non significant. Manure (X_8) showed the similar trend in with Soil Health Card and without Soil Health Card farmers.

It is seen from the Table 4.12 that in Surat district, for with Soil Health Card farmers, operational holding (X_4) and manure (X_8) were found negative but statistically non- significant. For manure, the similar trend was also observed in Surat district. It indicated that this is the general tendency of the farmers of this region. The short term credit (X_6) means crop loan showed the positive significant effect at one per cent level. It indicated that one per cent increased in short term credit increased the consumption of fertilizer by 0.01 Kg per hectare. This result is in conformity with the results obtained by Singh (1983), Singh and Gupta (1991) and Singh and Nasir (2003). All other variables were found positive but non significant. For without Soil Health Card farmers of Surat district, all variables except, manure (X_8) were found positive but non significant. The manure reflected the similar trend as per with Soil Health Card farmers.

For South Gujarat as a whole, all variables except, operational holding and manure were found positive but non- significant for with and without Soil Health Card farmers. The operational holding (X_4) and manure (X_8) were found negative but non-significant. Only one variable one year lagged price (X_7) was found statistically significant at one per cent for without soil health card farmers. The similar results were obtained by Ardeshna and Khunt (2011). The number of irrigations (X_9) did not show the significant positive effect on fertilizer consumption in this region

might be due to highly assured canal irrigation facilities and tendency of farmers to grow cash crop like sugarcane.

Table 4.12 Determinants of fertilizers use in sugarcane Crop

Particulars	Navsari		Surat		South Gujarat	
	With SHC	Without SHC	With SHC	Without SHC	With SHC	Without SHC
Constant	60.80	644.75	1329.35	583.59	314.37	457.97
Irrigated area under the crop (X_1) (ha)	38.7244 (26.79)	0.0510 (0.0411)	0.0137 (0.1085)	0.0371 (0.9412)	59.0447 (54.6490)	0.5610 (0.4108)
Annual total income Per farmer (X_2) (Rs.)	0.0011 (0.001)	0.2630 (0.3632)	0.1997 (0.2931)	0.1610 (0.1923)	0.3274 (0.3912)	0.2527 (0.3542)
Cropping intensity (X_3) (%)	0.0525 (0.3215)	0.0076 (0.4680)	0.2963 (0.9319)	0.1642 (0.2556)	0.0918 (0.4472)	0.1499 (0.2631)
Operational holding (X_4) (Ha.)	-31.3222 (27.0064)	1.6863 (35.4201)	-11.78 (24.0740)	5.0372 (10.3531)	-55.5784 (54.5362)	-12.2242 (10.4431)
Educational level (X_5)	6.3416** (2.4530)	0.4731 (19.0653)	2.2212 (26.7560)	7.7351 (10.3561)	6.6275 (14.5698)	18.1052 (11.5364)
Short term credit (X_6) (Rs.)	0.0003 (2.4530)	0.0012 (0.0008)	0.0127* (0.0057)	0.0115 (0.0112)	0.1617 (0.0178)	0.0012 (0.0002)
One year lagged average price (X_7) (Rs/tonne)	0.1434 (0.1128)	0.0378 (0.0223)	0.0256 (0.0212)	0.0276 (0.0844)	0.0599 (0.0898)	0.0532** (0.0179)
Manure (X_8) (No. of cartload)	-0.2759 (0.5915)	-1.8842 (1.7960)	-0.2192 (0.3906)	-0.1685 (0.1590)	-0.0782 (0.2176)	-0.2881 (0.2162)
Number of irrigation (X_9)	4.0130 (4.0881)	16.3807 (13.0385)	13.9207 (14.9290)	4.2487 (5.9773)	2.6360 (6.3217)	5.4559 (6.4678)
R^2	54.71	61.20	60.00	36.40	40.86	49.83

Figures in parentheses are the standard errors

* Indicates 5 per cent level of significance

** Indicates 1 per cent level of significance

4.4.2 Determination of fertilizer use in kharif paddy

The determinants of fertilizer use for kharif paddy crop are presented in Table 4.13. The value of R^2 was found 40.29 per cent and 79.41 per cent in case of with Soil Health Card in Navsari and Surat districts, respectively. It is revealed from the table that for with Soil Health Card farmers in Navsari district, all the variables were found positive but non significant. The annual total income of the farmers (X_2) was only the variable showed significant positive effect at five per cent level. It indicated that one per cent increased in total annual income of the farmers leads to increase fertilizer consumption by 0.50 Kg per hectare. For without Soil Health Card farmers of Navsari district, all variables except, manure were found positive but statistically non- significant. The manure (X_8) was found negative and non-significant. The short term credit (X_6) and one year lagged price (X_7) exhibited the positive and statistically significant effect at one per cent level. These results are in conformity with the results obtained by Ardeshna and Khunt (2011). The negative sign of farm yard manure showed that farmers used lesser quantity of fertilizers when they used higher quantity of manures due to their financial limitations.

A look to Surat district with Soil Health Card farmers revealed that operational holding (X_4) and manure (X_8) were found negative but statistically non -significant. For manure, the similar trend was also observed in Surat district as per Navsari district. It indicated that this is the general tendency of the farmers of this region. The short- term credit (X_6) showed the positive and significant effect at one per cent level. It indicated that one per cent increased in short term credit increased the consumption of fertilizer by 0.10 Kg per hectare. This result is in conformity with the results obtained by

Singh (1983), Singh and Gupta (1991) and Singh and Nasir (2003). The rest of the variables were found positive but non- significant. For without Soil Health Card farmers of Surat district, all variables were found positive but non- significant.

For south Gujarat as a whole for with Soil Health Card farmers all the variables except, operational holding and manure were found positive but statistically non significant. The operational holding (X_4) and manure (X_8) were found negative but non-significant. The similar trend was also observed in without Soil Health Card farmers.

An overview of production function analysis applied to determine the factors responsible for fertilizer use for sugarcane and kharif paddy revealed that annual total income of the farmers, one year lagged price, short term credit and educational level were found the major factors for fertilizer use in this region.

Table 4.13 Determinants of fertilizers use in kharif paddy Crop

Particulars	Navsari		Surat		South Gujarat	
	With SHC	Without SHC	With SHC	Without SHC	With SHC	Without SHC
Constant	63.64	817.99	647.31	134.63	45.85	134.63
Irrigated area under the crop (X_1) (ha)	0.1821 (0.2630)	3.4535 (447.33)	0.2845 (0.3441)	0.1142 (0.1048)	0.2731 (0.3715)	0.1710 (0.3762)
Annual total income Per farmer (X_2) (Rs.)	0.5047* (0.2452)	0.1273 (0.0976)	0.3841 (0.1440)	0.0914 (0.0826)	0.0249 (0.0223)	0.1315 (0.2336)
Cropping intensity (X_3) (%)	0.3091 (0.8042)	0.1459 (0.4601)	0.2021 (0.5053)	0.0411 (0.0437)	0.0287 (0.1945)	0.0411 (0.0437)
Operational holding (X_4) (Ha.)	2.0930 (2.6409)	4.4618 (6.6407)	-7.8773 (32.8933)	0.8553 (1.7139)	-5.9151 (7.1812)	-0.8535 (1.7140)
Educational level(X_5)	5.4214) (6.53.62)	0.6079 (0.2056)	1.8773 (32.8933)	1.3919 (1.8639)	8.0762 (11.9317)	1.3923 (1.8634)
Short term credit (X_6) (Rs.)	0.0341 (0.0424)	0.1864** (0.0719)	0.1030** (0.0447)	0.0814 (0.0723)	0.0286 (0.1820)	0.1010 (0.2115)
One year lagged average price (X_7) (Rs/qtl.)	0.2994 (0.5857)	2.7542** (1.662)	2.4306 (2.8056)	0.0316 (0.1908)	0.4492 (0.7504)	0.0031 (0.1901)
Manure (No. of cartload) (X_8)	0.0103 (0.2754)	-1.2154 (5.8114)	-1.3288 (0.6037)	0.0175 (0.1143)	-0.3204 (0.2994)	-0.0175 (0.1143)
R^2	40.29	59.71	79.41	45.83	42.67	45.83

Figures in parentheses are the standard errors

* Indicates 5 per cent level of significance

** Indicates 1 per cent level of significance

4.5 Fertilizer use efficiency

The input-output functional relationship can be studied by number of forms such as Cobb-Douglas power function, Spill man function, Transcendental function, Quadratic polynomial forms, etc. The empirical evidences from the previous studies suggest that the Cobb-Douglas Production function has been usually used in agriculture for studying relationship between crop output and input variables. This Cobb-Douglas production function was best fitted to measure fertilizer use efficiency for selected crops are discussed as under.

4.5.1 Fertilizer use efficiency for with and without Soil Health Card for sugarcane crop

The data on regression coefficients, standard errors and coefficients of multiple determinations are presented in Table 4.14. It is revealed from the table that value of coefficients of multiple determinations was found 48.18 per cent and 65.53 per cent in case of with Soil Health Card in Surat and Navsari district, respectively. In Navsari district for with Soil Health Card farmers, the regression coefficients of the entire resource variables were found positive and non-significant except, nitrogen (X_5). The nitrogen (X_5) was found statistically significant at 1 per cent. The highly significant regression coefficient observed in case of nitrogen indicated that the one per cent change in its use level would increase the output of sugarcane by 0.25 per cent keeping the use levels of the other variable constant. It is due to the fact that with Soil Health Card farmers of Navsari district applied the nitrogen as per recommended dose of Soil Health Card. These results collaborated the results obtained by Singh and Srinivas (1989). For without Soil Health Card farmers of Navsari district, the entire

resource variables were found positive and non-significant except nitrogen and manure. The manure reflected negative effect on sugarcane yield due to excess utilization of the said variable. But it was non-significant. The nitrogen (X_5) was found negative and significant at 5 per cent level. It is clearly indicated that over utilization of nitrogen would decrease the sugarcane yield and also decrease its fertilizer use efficiency. It might be due to the fact that without Soil Health Card farmer of Navsari district applied 8 per cent higher dose of nitrogen then recommended dose. These results are in conformity with results obtained by Hossain *et al.*(1987).

Table 4.14 Fertilizer use efficiency for sugarcane

Particulars	Navsari		Surat		South Gujarat	
	With SHC	Without SHC	With SHC	Without SHC	With SHC	Without SHC
Constant	2.4552	4.0357	5.8992	7.4516	2.5521	3.7640
Area under crop (X_1) (ha)	0.0561 (0.0679)	0.0912 (0.0814)	0.2719 (0.2224)	0.2628* (0.1216)	0.1714 (0.2426)	0.0815 (0.0296)
Human labour (X_2) (man day/ha)	0.0598 (0.0366)	0.0611 (0.0435)	0.1044 (0.0780)	0.2087** (0.0684)	0.0321 (0.0422)	0.0033 (0.0482)
Bullock labour(X_3) (Pair day/ha)	0.0378 (0.0205)	0.0083 (0.0069)	0.0035 (0.0039)	0.0019 (0.0038)	0.0426 (0.0417)	0.0014 (0.0041)
Manures (X_4) (Cartload/ha)	0.1014 (0.4995)	-0.0038 (0.0032)	-0.0050 (0.0048)	0.0017 (0.0039)	-0.0045 (0.0036)	-0.0012 (0.0032)
Nitrogen (X_5) (Kg./ha)	0.2535** (0.0701)	-0.1165* (0.0523)	0.0357 (0.2427)	-0.4410** (0.1128)	0.3591** (0.1041)	0.0432 (0.0683)
Phosphorus (X_6) (Kg./ha)	0.0011 (0.0702)	0.0979 (0.0937)	0.0188 (0.0416)	0.1356 (0.1664)	0.0328 (0.0366)	0.0309 (0.1154)
Potash (X_7) (Kg./ha)	0.0288 (0.0395)	0.0149 (0.0646)	0.1007 (0.0612)	0.1175 (0.2393)	0.0735 (0.0434)	0.0813 (0.0951)
Other working Capital (X_8) (Rs.)	0.0486 (0.0322)	0.0047 (0.0340)	0.0296 (0.0770)	0.1411 (0.0881)	0.0651 (0.0387)	0.0293 (0.0502)
R^2	65.53	55.40	48.18	58.71	53.62	42.56

Figures in parentheses are the standard errors

* Indicates 5 per cent level of significance

** Indicates 1 per cent level of significance

In Surat district for with Soil Health Card farmers, all the included resource variables were found positive and non-significant except, manure (X_4). The manure (X_4) was found negative but non-significant. It indicated the over utilization of manure by the farmers. The resource variables like area under the crop (X_1) and human labour (X_2) were found statistically significant at 5 per cent and 1 per cent level, respectively for without Soil Health Card farmers. The nitrogen (X_5) was found negative and significant at 1 per cent indicating over utilization of the said variable in the production process. It might be due to 12 per cent excess application of nitrogenous fertilizer by without Soil Health Card farmers in Surat district (Table 4.16, pp.113) These results collaborate the results obtained by Shah et al. (1995).

In south Gujarat as a whole for with Soil Health Card farmers, the only one resource variable nitrogen (X_5) was found positive and significant at 1 per cent. The manure (X_4) exhibited negative effect but non-significant. The rest of the variables were found positive but non-significant. It indicated that with Soil Health Card farmers applied the nitrogenous fertilizer in sugarcane crop near about same quantity recommended by Soil Health Card. These results are in conformity with the results obtained by Sagwal and Kumar (1994). For without Soil Health Card farmers, all the resource variables were found positive but non-significant except, manure (X4). The manure (X4) was found negative but non-significant.

An over view of production function analysis of sugarcane crop, nitrogen (X_5) was over utilized by the without Soil Health Card farmers in both the districts. The with Soil Health Card farmers used nitrogen judiciously as per recommendation of Soil Health Card resulted into better fertilizer use efficiency.

4.5.2 Fertilizer use efficiency for with and without soil Health card for kharif paddy crop

The data on regression coefficients, standard errors and coefficients of multiple determinations are given in Table 4.15. It is observed from the table that value of coefficients of multiple determinations was found 49.93 per cent and 61.69 per cent for with Soil Health Card farmers in Surat and Navsari district, respectively. In Navsari district for with Soil Health Card farmers, the regression coefficients of all the resource variables except, manure (X_4) were found positive but non-significant. The only variable found statistically significant at 5 per cent was area under the crop (X_1).The resource variable manure (X_4) showed the negative and non-significant effect on crop output. It indicated the excess use of the said variable in production process. The resource variables like human labour (X_2) and phosphorus (X_6) were found positive and statistically significant at 1 per cent and 5 per cent, respectively for without Soil Health Card farmers in Navsari district. The positive significant effect of phosphorus (X_6) might be due to lower dose of phosphorus applied by the without Soil Health Card farmers as compared to recommended dose. The resource variables like manure (X_4) and nitrogen (X_5) were found negative but non-significant. It indicated the over utilization of the said variables in the production process. The without Soil Health Card farmers of Navsari district used 10 per cent more nitrogen as compared to recommended dose resulted into negative effect on crop yield (Table 4.17, pp.115). The higher dose of nitrogen enhanced vegetative growth and the problem of lodging would occur. These results are in conformity with the results obtained by Kumar and Grower (2007).

In Surat district for with Soil Health Card farmers, all the resource variables exhibited positive effect but non-significant except, area under the crop (X_1) and phosphorus (X_6). The area under the crop (X_1) showed positive significant effect at 5 per cent, while phosphorus (X_6) exhibited positive significant effect at 1 per cent. It might be due to the fact that with Soil Health Card farmers of Surat district utilized near about quantity of phosphorus as recommended by Soil Health card (Table 4.17, pp.115).

Table 4.15 Fertilizer use efficiency for kharif paddy

Particulars	Navsari		Surat		South Gujarat	
	With SHC	Without SHC	With SHC	Without SHC	With SHC	Without SHC
Constant	4.9875	5.7032	8.8192	-0.5643	7.3674	6.6312
Area under crop (X_1) (ha)	0.2024* (0.1015)	0.1241 (0.1517)	0.1917* (0.0827)	0.1415 (0.1720)	0.0781 (0.1047)	0.1247* (0.0611)
Human labour (X_2) (man day/ha)	0.0542 (0.1492)	0.6185** (0.0963)	0.2578 (0.8455)	0.1984* (0.1033)	0.0690 (0.0911)	0.3573 (0.0651)
Bullock labour (X_3) (Pair day/ha)	0.0202 (0.0162)	0.0054 (0.0071)	0.0632 (0.0512)	0.0133 (0.0113)	0.0082 (0.0074)	0.0069 (0.0064)
Manures (X_4) (Cartload/ha)	-0.0128 (0.0136)	-0.0040 (0.0037)	0.0195 (0.0416)	-0.0489** (0.0179)	0.0040 (0.0052)	-0.0124 (0.0058)
Nitrogen (X_5) (Kg./ha)	0.2172 (0.3127)	-0.1752 (0.0597)	0.1432 (0.1843)	0.6482 (1.0146)	0.2298 (0.1995)	-0.2369 (0.1032)
Phosphorus (X_6) (Kg./ha)	0.2032 (0.1863)	0.1013* (0.0444)	0.1961** (0.0410)	0.1188 (0.4916)	0.0389 (0.0839)	0.1350 (0.0896)
Potash (X_7) (Kg./ha)	0.1054 (0.0445)	0.0001 (0.0147)	0.0351 (0.0385)	0.1558 (0.1750)	0.0704 (0.0711)	0.0368 (0.0228)
Other working Capital (X_8) (Rs.)	0.2418 (0.1651)	0.0219 (0.0403)	0.0309 (0.0307)	0.3948* (0.1878)	0.0006 (0.0433)	0.1005 (0.0696)
R^2	61.69	83.78	49.93	81.98	50.47	69.73

Figures in parentheses are the standard errors
* Indicates 5 per cent level of significance
** Indicates 1 per cent level of significance

For without Soil Health Card farmers in Surat district, human labour (X_2) and other working capital (X_8) were found positive and significant at 5 per cent and 1 per cent, respectively. The manure (X_4) was found negative and significant at 5 per cent indicating over utilization of this input. These results are in conformity with the results obtained by Patel (1986) and Hossain *et al*. (1987).

In South Gujarat as a whole for with Soil Health Card farmers, all the resource variables were found positive but non-significant. For without Soil Health Card farmers, area under the crop (X_1) was found statistically significant at 5 per cent. The manure (X_4) and nitrogen (X_5) were found negative but non-significant.

On the examination of the production function analysis of kharif paddy crop, manure (X_4) and nitrogen (X_5) were over utilized by the without Soil Health Card farmers in this region. These two variables should be judiciously used for bringing out the positive change in the kharif paddy output.

4.6 Impact of Soil Health Card on consumption of fertilizers

Since 2005, the Government of Gujarat has launched Soil Health Card scheme. The farmers are advised to use chemical fertilizers on the basis of information provided in Soil Health Cards. To study the impact of Soil Health Card on fertilizer consumption and yield obtained by the farmers, this objective has been incorporated in the study. The two major crops of this region viz; sugarcane and kharif paddy were taken for the study. Simple tabular analysis with cost concept and "t" test is used to examine the impact of Soil Health Card on fertilizer consumption in the study area.

4.6.1 Fertilizer consumption for with and without Soil Health Card in sugarcane crop. (Kg/ha)

The crop wise and zone wise information on actual fertilizer use level, recommended dose of fertilizer, recommended dose as per Soil Health Card and extent of gap for the selected crops have been discussed in this section. The extent of gap in fertilizer use in sugarcane has been given in Table 4.16. In Navsari and Surat districts little more over utilization of N was observed for Soil Health Card farmers. The magnitude of over utilization ranged from 0.38 per cent in Navsari to 3.08 per cent in Surat district. While, the extent of over utilization was higher for without Soil Health Card farmers. It ranged from 8 per cent in Navsari to 12 per cent in Surat districts. The magnitude of over utilization of N in south Gujarat region for with Soil Health Card farmers and without Soil Health Card farmers was observed to the tune of 4.02 per cent and 13.20 per cent, respectively. It clearly indicated that there is an impact of Soil Health Card on consumption of fertilizers.

As far as P is concern, the gap observed was negative for all farmers. It indicated that there was under utilization of P in sugarcane crop. But the extent of gap was smaller for with Soil Health Card farmers as compared to without Soil Health Card farmers. This gap ranged from 4.03 per cent in Navsari to 4.72 per cent in Surat district for with Soil Health Card farmers. This gap was wide for without Soil Health Card farmers. It ranged from 25.60 per cent in Navsari to 11.20 per cent in Surat district. For south Gujarat as a whole, the extent of gap was 6.15 per cent for with Soil Health Card farmers to 12 per cent for without Soil Health Card farmers.

The extent of gap in respect of K in both the districts was observed. This gap ranged from 9.09 per cent in Navsari district to 10.98 per cent in Surat district for with Soil Health Card farmers. This gap was wider for without Soil Health Card farmers. It ranged from 36.80 per cent in Navsari district to 24.80 per cent in Surat district. The overall gap in South Gujarat was just 1 per cent for with Soil Health Card farmers and 24.80 per cent for without Soil Health Card farmers. It indicated that extent of gap was small for with Soil Health Card farmers as compared to without Soil Health Card farmers. These results are in conformity with the results obtained by Trivedi and Patel (1994), Dhyan Singh (1996) and Prasad and Rao (2002).

Table 4.16 Fertilizer consumption for with and without Soil Health Card in sugarcane crop. (kg/ha)

District	Particular		N	P	K
Navsari	With Soil Health card	As per Soil Health Card doze	260	124	99
		Actual use	261	119	90
		Gap	+1 (0.38)	-5 (4.03)	-9 (9.09)
	Without Soil Health card	Recommended doze	250	125	125
		Actual use	270	93	79
		Gap	+20 (8.00)	-32 (25.60)	-46 (36.80)
Surat	With Soil Health card	As per Soil Health Card doze	227	127	82
		Actual use	234	121	73
		Gap	+7 (3.08)	-6 (4.72)	-9 (10.98)
	Without Soil Health card	Recommended doze	250	125	125
		Actual use	280	111	94
		Gap	+30 (12.00)	-14 (11.20)	31 (24.80)
South Gujarat	With Soil Health card	As per Soil Health Card doze	238	130	88
		Actual use	248	122	87
		Gap	+10 (4.02)	-8 (6.15)	-1 (1.14)
	Without Soil Health card	Recommended doze	250	125	125
		Actual use	283	110	94
		Gap	+33 (13.20)	-15 (12.00)	-31 (24.80)

(Figures in parentheses indicate per cent of gap)

Note : + and – sign indicate over and under utilization of fertilizers, respectively.

4.6.2 Fertilizer consumption for with and without Soil Health in kharif paddy crop. (Kg/ha)

The extent of gap in fertilizer use in kharif paddy has been given in Table 4.17. In Navsari and Surat districts less over utilization of N was observed for Soil Health Card farmers. The

magnitude of over utilization ranged from 1 per cent in Navsari to 5.77 per cent in Surat district. While, the extent of over utilization was higher for without Soil Health Card farmers. It ranged from 10 per cent in Navsari district to 23 per cent in Surat districts. The magnitude of over utilization of N in south Gujarat region for with Soil Health Card farmers and without Soil Health Card farmers was observed to the tune of 2.94 per cent and 15.00 per cent, respectively. It clearly indicated that there is some impact of Soil Health Card on consumption of fertilizers.

As far as P is concern, the gap observed was negative for all farmers. It indicated that there was under utilization of P in kharif paddy crop. But the extent of gap was smaller for with Soil Health Card farmers as compared to without Soil Health Card farmers. This gap ranged from 3.57 per cent in Surat district to 9.68 per cent in Navsari district for with Soil Health Card farmers. This gap was wide for without Soil Health Card farmers. It ranged from 6.67 per cent in Surat district to 13.33 per cent in Navsari district. For south Gujarat as a whole, the extent of gap was found to 6.66 per cent for with Soil Health Card farmers and 10 per cent for without Soil Health Card farmers. It indicated that the gap was smaller for with Soil Health Card farmers as compared to without Soil Health Card farmers.

These results are in conformity with the results obtained by Dhyan Singh (1996) and Prasad and Rao (2002).

Table 4.17 Fertilizer consumption for with and without Soil Health Card in kharif paddy crop. (kg./ha.)

District	Particular		N	P	K
Navsari	With Soil Health card	As per Soil Health Card doze	101	31	0
		Actual use	102	28	0
		Gap	+1 (0.99)	-3 (9.68)	0
	Without Soil Health card	Recommended doze	100	30	0
		Actual use	110	26	0
		Gap	+10 (10.00)	-4 (13.33)	0
Surat	With Soil Health card	As per Soil Health Card doze	104	28	0
		Actual use	110	27	0
		Gap	+6 (5.77)	-1 (3.57)	0
	Without Soil Health card	Recommended doze	100	30	0
		Actual use	123	28	0
		Gap	+23 (23.00)	-2 (6.67)	0
South Gujarat	With Soil Health card	As per Soil Health Card doze	102	30	0
		Actual use	105	28	0
		Gap	+3 (2.94)	-2 (6.66)	0
	Without Soil Health card	Recommended doze	100	30	0
		Actual use	115	27	0
		Gap	+15 (15.00)	-3 (10.00)	0

(Figures in parentheses indicate per cent of gap)

4.6.3 Per hectare cost structure for selected crops

The profitability of farm business can be deducted from the relationship between costs incurred and returns obtained from it. The cost structure depends upon the type of resource employed, the resource mix and the extent of their employment. The ultimate aim of farmer is to get high net return per unit area. Hence, cost concept is discussed as under.

4.6.3.1 Per hectare cost of cultivation for with and without Soil Health Card in sugarcane crop (Rs./ha)

The increase or decrease in the cost structure depends upon the changes in the use of different resources and substitution of one form of resource for another. Item wise detail of per hectare cost of cultivation of sugarcane crop for with and without Soil Health Card farmers have been worked out at different cost levels and presented in Table 4.18. The data enclosed in table revealed that the per hectare cost of cultivation for sugarcane crop for with Soil Health Card farmers in Navsari district was worked out to Rs. 88,148, Rs. 1,21,413, Rs. 1,23,954 and Rs. 1,36,350 at cost ' A ', cost ' B ', cost ' C1 ' and cost ' C2 ', respectively. The expenditure incurred for without Soil Health Card farmers in Navsari district was worked out to Rs. 82,432, Rs. 1,11,990, Rs. 1,15,669 and Rs. 1,27,236 at cost ' A ', cost ' B ', cost ' C_1 ' and cost ' C_2 ', respectively. The net return per hectare over cost-C_2 found higher for with Soil Health Card farmers (Rs.65, 870) as compared to without Soil Health Card farmers (Rs.60, 165). This might be due to the fact that balanced use of fertilizer lead to higher crop yield. The similar type of results were also obtained by Dhyan Singh (1996).

In Surat district per hectare cost of cultivation for with Soil Health Card farmers was worked out to Rs. 94,883, Rs. 1,30,013, Rs. 1,32,087 and Rs. 1,45,296 at cost ' A ', cost ' B ', cost 'C_1 ' and cost ' C_2 ', respectively. This cost for without Soil Health Card farmers was worked out to Rs. 94,043, Rs. 1,28,422, Rs. 1,30,132 and Rs. 1,43,146 at cost 'A ', cost ' B ', cost ' C_1 ' and cost ' C_2 ', respectively. The net return per hectare over cost-C_2 found higher for with Soil Health Card farmers (Rs.82, 475) as compared to without Soil Health Card farmers (Rs.68,533) of Surat district.

Table 4.18 Cost of cultivation per hectare for with and without Soil health Card in sugarcane crop

(Rs./ha.)

Sr. No.	Particular	Navsari				Surat				South Gujarat			
		With Soil Health Card		Without Soil Health Card		With Soil Health Card		Without Soil Health Card		With Soil Health Card		Without Soil Health Card	
		Physical unit	Value	Physical unit	Value	Physical unit	Value	Physical unit	Value	Physical unit	Value	Physical unit	Value
1	A. Family labour (Man days)	28.31	2541	40.50	3678	22.06	2074	18.13	1710	24.37	2247	22.76	2117
	B. Hired labour (Man days)	361.82	32645	341.65	307.46	346.26	32107	341.69	32094	352.01	32306	341.68	31815
2	Bullock labour (days)	8.99	3594	8.42	3212	6.12	3794	5.52	2606	7.18	3720	6.12	2731
3	Seed (tonnes)	12	25255	11	21501	13	23792	12	266642	13	24332	12	25578
4	Manures (cartloads)	19	3221	18	3462	39	9340	34	7028	31	7080	31	6290
5	Chemical fertilizer(kgs.) N	261	5826	270	5605	234	6054	280	6337	248	5970	283	6186
	P	119		93		121		111		122		110	
	K	90		79		73		94		87		94	
6	Irrigation	-	4068	-	4613	-	5076	-	3973	-	4704	-	4106
7	Insec/pest. cost	-	0	-	0	-	223	-	264	-	140	-	209
8	Miscellaneous. Cost including tractor charges	-	3664	-	3694	-	3921	-	4656	-	3826	-	4457
9	Depreciation	-	431	-	759	-	411	-	367	-	418	-	448

contd...

10	Int. on working capital	-	9441	-	831	-	10166	-	10076	-	9900	-	9818
11	Rent	-	-	-	-	-	-	-	-	-	-	-	-
12	Rental value of own land	-	33041	-	29193	-	34873	-	34190	-	34197	-	33156
13	Int. on own fixed capital	-	223	-	372	-	257	-	189	-	245	-	22714
14	Managerial charge	-	12395	-	11567	-	13209	-	13013	-	12908	-	12713
15	Cost-A	-	88148	-	82432	-	94883	-	94043	-	92396	-	91639
16	Cost-B	-	121413	-	111990	-	130013	-	128422	-	126837	-	125022
17	Cost-C_1	-	123954	-	115669	-	132087	-	130132	-	129083	-	127139
18	Cost-C_2	-	136350	-	127236	-	145296	-	143146	-	141992	-	139853
	Yield (tonnes/ha.)	93	202220	89	187401	99	227771	92	211679	97	222175	92	206655
	Return over Cost-C_2 (Rs./ha.)		65870		60165		82475		68533		80183		66802

The cost of cultivation for South Gujarat as a whole for with Soil Health Card farmers was worked out to Rs. 92,396, Rs. 1,26,837, Rs. 1,29,083 and Rs. 1,41,992 at cost ' A ', cost ' B ', cost 'C_1 ' and cost ' C_2 ', respectively. This cost for without Soil Health Card farmers was worked out to Rs. 91,639, Rs. 1,25,022, Rs. 1,27,139 and Rs. 1,39,853 at cost ' A ', cost ' B ', cost ' C_1 ' and cost ' C_2 ', respectively. The net return per hectare over cost-C_2 found higher for with Soil Health Card farmers (Rs.80, 183) as compared to without Soil Health Card farmers (Rs.66,802). It clearly indicated that with Soil Health Card farmers gained more net return per hectare as compared to without Soil Health Card farmers. The per hectare yield difference in both the districts might be due to agronomic practices, soil fertility level, awareness of farmers, etc.

4.6.3.2 Per hectare cost of cultivation for with and without Soil Health Card in kharif paddy crop (Rs./ha)

Item wise detail of per hectare cost of cultivation of kharif paddy crop for with and without Soil Health Card farmers have been worked out at different cost levels and presented in Table 4.19. The data exhibited in table revealed that the per hectare cost of cultivation for kharif paddy crop for with Soil Health Card farmers in Navsari district was worked out to Rs. 20,057, Rs. 30,784, Rs. 32,976 and Rs. 36,273 at cost ' A ', cost ' B ', cost ' C1 ' and cost ' C2 ', respectively. The similar cost for without Soil Health Card farmers in Navsari district was worked out to Rs. 18,281, Rs. 31,894, Rs. 34,166 and Rs. 37,583 at cost ' A ', cost ' B ', cost ' C_1 ' and cost ' C_2 ', respectively. The net return per hectare over cost-C_2 found higher for with Soil Health Card farmers (Rs.33,818) as compared to without Soil Health Card farmers (Rs.30, 097).

In Surat district per hectare cost of cultivation for with Soil Health Card farmers was worked out to Rs. 22,986 Rs. 37,657, Rs. 39,422 and Rs. 43,364 at cost ' A ', cost ' B ', cost 'C_1 ' and cost ' C_2 ', respectively. This cost for without Soil Health Card farmers was worked out to Rs. 18,457, Rs. 35,163, Rs. 36,684 and Rs. 40,352 at cost ' A ', cost ' B ', cost 'C_1 ' and cost ' C_2 ', respectively. The net return per hectare over cost-C_2 found higher for with Soil Health Card farmers (Rs.29,185) as compared to without Soil Health Card farmers (Rs.25,017).

The cost of cultivation for South Gujarat as a whole for with Soil Health Card farmers was worked out to Rs. 22,744, Rs. 35,085 Rs. 37,102 and Rs. 40,813 at cost ' A ', cost ' B ', cost 'C_1 ' and cost ' C_2 ', respectively. This cost for without Soil Health Card farmers was worked out to Rs. 18,361, Rs. 33,380, Rs. 35,311 and Rs. 38,842 at cost ' A ', cost ' B ', cost ' C_1 ' and cost ' C_2 ', respectively. The net return per hectare over cost-C_2 found higher for with Soil Health Card farmers (Rs.31,355) as compared to without Soil Health Card farmers (Rs.26,697). It clearly indicated that with Soil Health Card farmers gained more net return per hectare as compared to without Soil Health Card farmers. These results support our hypotheses that Soil Health Card is beneficial for farmers. The similar type of results were also obtained by Trivedi and Patel (1994) and Prasad and Rao (2002).

Table 4.19 Cost of cultivation per hectare for with and without Soil health Card in kharif paddy crop

(Rs./ha.)

Sr.No.	Particular	Navsari				Surat				South Gujarat			
		With Soil Health Card		Without Soil Health Card		With Soil Health Card		Without Soil Health Card		With Soil Health Card		Without Soil Health Card	
		Physical unit	Value	Physical unit	Value	Physical unit	Value	Physical unit	Value	Physical unit	Value	Physical unit	Value
1	A. Family labour (Man days)	24.05	2192	25.12	2272	18.54	1765	16.20	1521	21.80	2017	21.06	1931
	B. Hired labour (Man days)	119.84	10974	109	9872	146.81	13951	115.33	10809	130.88	12193	111.88	10298
2	Bullock labour (days)	1.62	628	1.55	611	0.52	209	1.28	968	1.17	456	1.43	773
3	Seed (kgs.)	67	1441	66	1618	61	1513	64	1594	65	2958	65	1607
4	Manures (cartloads)	10	1709	9	1531	8	1839	2	434	9	1762	6	1032
5	Chemical fertilizer(kgs.) N	102	2055	110	1652	110	1875	123	1870	106	1981	103	1751
	P	28		26		27		28		28		27	
	K	-		-		-		-		-		-	
6	Irrigation	-	-	-	-	-	-	-	-	-	-	-	-
7	Insec/pest. cost	-	-	-	-	-	-	-	-	-	-	-	-
8	Miscellaneous. Cost including tractor charges	-	1840	-	1650	-	2207	-	1725	-	1990	-	1684

contd...

9	Depreciation	-	640	-	644	-	368	-	346	-	528	-	508
10	Int. on working capital	-	771	-	703	-	1024	-	710	-	875	-	706
11	Rent	-	-	-	-	-	-	-	-	-	-	-	-
12	Rental value of own land	-	10479	-	13295	-	14485	-	16535	-	12119	-	14768
13	Int. on own fixed capital	-	248	-	318	-	186	-	171	-	223	-	251
14	Managerial charge	-	3298	-	3417	-	3942	-	3668	-	3710	-	3531
15	Cost-A	-	20057	-	18281	-	22986	-	18457	-	22744	-	18361
16	Cost-B	-	30784	-	31894	-	37657	-	35163	-	35085	-	33380
17	Cost-C_1	-	32976	-	34166	-	39422	-	36684	-	37102	-	35311
18	Cost-C_2	-	36273	-	37583	-	43364	-	40352	-	40813	-	38842
	Yield (kgs./ha.)	4522	70091	4200	67680	5136	72549	4556	65369	4773	72168	4308	65539
	Return over Cost-C_2 (Rs./ha)		33818		30097		29185		25017		31355		26697

4.6.4 Comparison of crop yield between farmers for with and Without Soil Health Card in South Gujarat.

The yield obtained per unit area is one of the crucial parameters for economic gain for farmers. An attempt has been made to quantify the effect of Soil Health Card on yield of selected crops in the study area. The paired ' t ' test is used to find out the effect of Soil Health Card on yield obtained by with and without Soil Health Card farmers.

The different parameters related to ' t ' test were presented in Table 4.20. The data revealed that for sugarcane crop, the mean yield was found higher for with Soil Health Card farmers (101.10 tonnes/ha.) as compared to without Soil Health Card farmers (95.70 tonnes/ha.) in Surat district. While, for Navsari district it was 92.18 tonnes per hectare and 85.92 tonnes per hectare, respectively. In both the districts, the yield differences for with and without Soil Health card farmers were found statistically significant at 1 per cent level of significance. The similar trend was also observed in South Gujarat region as a whole. In case of kharif paddy, the mean yield was found higher for with Soil Health Card farmers (4934.50 kgs/ha.) as compared to without Soil Health Card farmers (4641.88 kgs/ha.) in Surat district. While, for Navsari district it was 5317.23 kgs per hectare and 4804.69 kgs per hectare, respectively. In both the districts, the yield differences for with and without Soil Health card farmers were found statistically significant at 5 per cent level of significance. For South Gujarat region, it was found significant at 1 per cent. Thus, our hypothesis was supported by these results that Soil Health Card is beneficial for farmers. This might be due to balanced fertilizer use by with Soil Health card farmers. The similar type of results was also obtained by Desai *et al.* (1993).

Table 4.20 Comparison of crop yield between farmers for with and without soil health card in South Gujarat

Crop	District	Parameters	With SHC	Without SHC	't' test	Probability
Sugarcane	Surat	Mean	101.10	95.70	3.3019**	0.0014
		S.D.	59.74	64.40		
		No. of observation	46	47		
	Navsari	Mean	92.18	85.92	6.3129**	0.00003
		S.D.	15.71	14.7624		
		No. of observation	33	29		
	South Gujarat	Mean	97.37	91.97	4.1956**	0.00004
		S.D.	60.49	67.91		
		No. of observation	79	76		
Paddy	Surat	Mean	4934.50	4641.88	2.0905*	0.0464
		S.D.	48183.38	351886.44		
		No. of observation	17	21		
	Navsari	Mean	5317.23	4804.69	2.6401*	0.0119
		S.D.	976741.64	189765.94		
		No. of observation	30	37		
	South Gujarat	Mean	5178.79	4745.74	3.1841**	0.0021
		S.D.	667085.04	249550.77		
		No. of observation	47	58		

* Indicates 5 per cent level of significance
** Indicates 1 per cent level of significance

On the examination of paired ' t ' test applied to quantify the effect of Soil Health Card on per hectare yield obtained by with and without Soil Health Card farmers for sugarcane and kharif paddy crops reflected positive and significant effect of Soil Health Card on selected crop yields in South Gujarat region.

V SUMMARY AND CONCLUSIONS

In India, agriculture occupies predominant position in the economy. The pattern of production enhancement will have to rest heavily on increased yield. Fertilizer is key element to stabilize crop yields and sustain high crop productivity. It is estimated that the combination of fertilizers in association with water could increase the output as high as 70 per cent. The fertilizer consumption in India has increased by many folds. However, the pattern of fertilizer consumption and its utilization efficiency is not uniform in the country; it varies among the crops as well as across the regions. The factors affecting fertilizer use for different crops and the impact of Soil Health Card on fertilizer use ultimately play sine qua none role for betterment of farming society. Considering these aspects, the study entitled "Regional Imbalances and Impact of Soil Health Card on Fertilizer Consumption in Gujarat" was conducted with the following objectives.

1. To examine the district wise trend in consumption of fertilizers in the Gujarat state.
2. To estimate the district wise gap between requirement and consumption of the fertilizers in the state.
3. To study the determinants of fertilizer use in selected major crops in South Gujarat region.
4. To work out fertilizer use efficiency for selected major crops in South Gujarat region.
5. To study the impact of Soil Health Card on fertilizer consumption for selected major crops in South Gujarat region.

The study area comprised two districts of South Gujarat region viz; Navsari and Surat. These districts were selected purposively as they occupied highest rank in fertilizer consumption per hectare. A multistage random sampling technique was used for the selection of sample. Two major crops like kharif paddy and sugarcane were selected as they acquired highest area in this region. At the first stage, two talukas were selected randomly from each district. In the second stage, four villages were selected from each taluka randomly and at final stage, 14 farmers (7 without soil health card + 7 with soil health card) were selected randomly from each village for the study. Thus, total sample comprised of 224 farmers from sixteen villages.

The secondary data on disrictwise fertilizer consumption, gross cropped area and crop area were drawn from the published sources and primary data on various resources and output were collected from the sample farmers through pretested questionnaire for the year 2010-11. Regarding the analytical tools, compound growth rate was estimated by using exponential function; multiple linear regression technique was applied to identify the determinants of fertilizer use at the farm level. Cobb-Douglas production function was used to find out the functional relationship between input and output. Simple tabular analysis with cost concept and paired ‘ t ’ test are used to examine the impact of Soil Health Card on fertilizer consumption in the study area.

5.1 Summary and findings

5.1.1 General features of sample farmers

1. The average age of all selected farmers was about 53 years. The literacy level was 8.50 standard. The average size of family was about 5.25 persons.

2. The average size of holding of the sample farmers under study was 1.7592 hectares. The average cropping intensity was 123.87. Mostly all the area under study was irrigated. The proportionate share of area under sugarcane, kharif paddy and summer paddy were 48.56 per cent, 28.49 per cent and 16.20 per cent, respectively.

5.1.2 Trends in fertilizer consumption

1. Among the regions, Middle Gujarat stood at top in mean consumption of N during all periods and Kutchh stood at the bottom. The consumption of N fertilizer significantly increased in South Gujarat, North Gujarat, Saurashtra, Middle Gujarat and Kutchh, regions during the Period –I. In all periods, the consumption of N was increased significantly in all the regions except Period-II and Period-III of Saurashtra region.

2. During Period–II, the consumption of N increased significantly in all regions except Saurashtra region. The lowest instability index was found in South Gujarat region (8.74%). Overall in Gujarat, the consumption of N is increased at the rate of 7.91 per cent during Period-II.

3. During Period–III, the consumption of N increased significantly in all regions except Saurashtra region. The lowest instability index was found in South Gujarat region (10.47%). Gujarat as a whole, consumption of N increased significantly at the rate of 6.99 per cent.

4. During Period–IV, the consumption of N increased significantly in all regions. For entire Gujarat, the consumption of N is increased significantly at the rate of 4.79 per cent.

5. During Period–V, the consumption of N increased significantly in all region with the highest rate in Kutchh (7.47%). The

lowest instability index was found in South Gujarat region (7.73%). Gujarat as a whole, consumption of N increased significantly at the rate of 2.73 per cent with instability index of 13.01.

6. During Period-VI, consumption of N increased significantly in all regions with the highest rate in Kutchh (15.62%) and the lowest rate in Middle Gujarat region (7.92%).The lowest instability was found in South Gujarat region (23.95%).

7. In all regions, Saurashtra stood at top in mean consumption of P during all periods and Kutchh stood at the bottom. The consumption of P fertilizer significantly increased in all the regions of Gujarat State along with Gujarat as a whole during Period-I. The lowest instability index was found in Saurashtra region (16.45%). Gujarat as a whole, the consumption of P was increased significantly at the rate of 21.81 per cent.

8. During Period–II, the consumption of P increased significantly only in North Gujarat region The lowest instability index was found South Gujarat region (29.07%).

9. During Period–III, the consumption of P increased significantly in all regions except Saurashtra region with the highest and the lowest rate in Kutchh (21.72%) and the lowest in Saurashtra region (-2.08%). The highest and the lowest instability indices were found in Saurashtra (27.14%) and Kutchh region (7.82%), respectively.

10. During Period–IV, the consumption of P increased in all regions but found non-significant. The highest and the lowest instability indices were found in kutchh (28.85%) and North Gujarat region (14.96%), respectively.

11. During Period–V, the consumption of P increased significantly in North Gujarat and Kutchh regions. The lowest rate of P consumption was found in South Gujarat region (1.94%). The highest and the lowest instability indices were found in Kutchh (23.62%) and North Gujarat region (7.29%), respectively.

12. For entire period, consumption of P increased significantly in all regions with the highest rate in Kutchh (17.21%) and the lowest rate in Saurashtra region (7.20%).The instability index was found lowest in South Gujarat region(29.14%).

13. During the Period-I, the consumption of K fertilizer was not reported in any regions of Gujarat State.

14. During Period–II, among the regions, Saurashtra stood at top in mean consumption of K and Kutchh stood at the bottom in all periods. The consumption of K increased significantly in Saurashtra, North Gujarat and Kutchh regions. The lowest instability index was found in South Gujarat region (25.88%). Overall in Gujarat, the consumption of K increased significantly at the rate of 19.88 per cent.

15. During Period–III, the consumption of K increased significantly only in Saurashtra region with the highest rate in South Gujarat (15.15%).

16. During Period–IV, the consumption of K increased positively in all regions except Saurashtra region with the highest and the lowest rate in North Gujarat (5.17%) and Saurashtra region (-5.97%), respectively.

17. During Period–V, the consumption of K increased significantly in North Gujarat and Middle Gujarat with negative growth

rate in Saurashtra region. Gujarat as a whole, consumption of K increased significantly at the rate of 3.48 per cent with instability index of 25.39.

18. For entire period, consumption of K increased significantly in all regions except North Gujarat with the highest rate in Kutchh (10.87%) and the lowest rate in Saurashtra region (4.07%).The instability index was found highest in South Gujarat region (84.05%) and the lowest in North Gujarat region (34.44%).

19. Among the regions, Saurashtra stood at top in mean consumption of NPK during all periods and Kutchh stood at the bottom. The consumption of NPK fertilizer significantly increased in all the regions of Gujarat State along with Gujarat as a whole during Period-I. Overall in Gujarat, the consumption of NPK increased significantly at the rate of 27.51 per cent during Period-I.

20. During Period–II, the consumption of NPK increased significantly in North Gujarat, South Gujarat and Kutchh regions. The highest and the lowest instability indices were found in Saurashtra (37.18%) and South Gujarat region (13.71%), respectively. Overall in Gujarat, the consumption of NPK increased significantly at the rate of 8.48 per cent.

21. During Period–III, the consumption of NPK increased significantly in all regions except Saurashtra region. lowest instability index was found in South Gujarat region (9.75%.). Gujarat as a whole, consumption of NPK increased significantly at the rate of 5.76 per cent per annum.

22. During Period–IV, the consumption of NPK increased significantly in all regions except Saurashtra region. The highest and the lowest instability indices were found in Saurashtra (17.78%) and North Gujarat region (7.40%), respectively. Overall in Gujarat, the consumption of NPK increased significantly at the rate of 3.94 per cent.

23. During Period–V, the consumption of NPK increased significantly in all regions of Gujarat State except Saurashtra region. The highest and the lowest rate of consumption were found in Kutchh (7.26%) and Middle Gujarat region (2.25%), respectively. The highest and the lowest instability indices were found in Saurashtra (22.67%) and South Gujarat region (8.11%), respectively. Gujarat as a whole, consumption of NPK increased significantly at the rate of 2.63 per cent with instability index of 11.79.

24. During whole period, consumption of NPK increased significantly in all regions with the highest rate in Kutchh (15.92%) and the lowest rate in North Gujarat region (7.53%).The instability index was found highest in Kutchh region (38.07%) and the lowest in North Gujarat region (20.13%).

5.1.3 Analysis of gap in consumption of fertilizer

1. The compound growth rates of gap of N were found negative in case of Period-I to Period-III and positive for the Period-IV and Period-V but it was found statistically non-significant in South Gujarat region.

2. In North Gujarat region, the compound growth rates of gap of N were found negative for all the periods except Period-II. And it was significant in last three periods.

3. In Saurashtra region, the compound growth rates of gap of N were found negative and statistically significant for the last four periods except Period-IV. The instability index was observed the lowest in the Period-I (5.45) and the highest in Period-V (43.66).

4. In Middle Gujarat region, the compound growth rates of gap of N were found negative and statistically significant for all the periods except perod-II.

5. In case of Kutchh region, the compound growth rates of gap of N were found negative and significant in period-I and Period-IV. The instability index was found minimum in Period-I.

6. The compound growth rates of gap of N were negative and significant for all the periods except Period-II for entire Gujarat. The value of instability index was the lowest in Period-I (5.73) and the highest in Period-V (48.60).

7. In case of South Gujarat region, the compound growth rates of gap of P were found negative and statistically significant for the Period-III and Period-VI but for the rest of the period, it was found positive but non- significant.

8. In North Gujarat region, the compound growth rates of gap of P were negative and significant for all the periods except period-I. In period-I, it was positive with minimum instability.

9. In case of Saurashtra region, the compound growth rates of gap of P were found negative in last four period and it was statistically significant for Period-III, Period-V and Period-VI. The minimum instability was observed in Period-I.

10. In Middle Gujarat region, the irregular trend of compound growth rates of gap of P was found in different periods. But it was found negative and significant in Period-III and Period-VI.

11. In case of Kutchh region, the compound growth rates of gap of P were found negative and non-significant in last four periods. The minimum instability was found in Period-I.

12. For the state as a whole, the compound growth rates of gap of P were negative for all the periods but statistically significant in Period-III, Period-V and Period-VI. The value of instability index was the lowest in Period-I (3.40).

13. In South Gujarat region, the compound growth rates of gap of K were found negative and statistically significant for the Period-III only. The instability index was observed the lowest in the Period-I (0.39).

14. In North Gujarat region, the compound growth rate of gap of K was found negative and statistically significant only in Period-II. The value of instability index was found minimum in Period-I with an average of 39.49.

15. The compound growth rate of gap of K was found negative and statistically significant only in Period-II. The compound growth rates were found positive and statistically significant for Period-I and Period-III. The instability indices were the lowest (3.45) in Period-I and the highest (39.56) in Period-V with 51.51 per cent for overall period.

16. In Middle Gujarat region, the compound growth rate of gap of K was found negative and statistically significant in Period-V only. There was irregular trend in instability indices over periods of time.

17. The compound growth rates of gap of K were found negative and significant in Period-II, Period-III and Period-VI with an average declined at the rate of 3.09 per cent in Kutchh region. The minimum instability was observed in Period-I.

18. In Gujarat state, the compound growth rate of gap of K was negative and statistically significant for Period-II only. The value of instability index was the lowest in Period-I (2.21).

19. The compound growth rates of gap of NPK were found negative and significant in Period-III and Period-VI with the lowest instability (3.20) in Period-I in South Gujarat region.

20. In North Gujarat region, the compound growth rates of gap of NPK were found negative and significant for Period-IV, Period-V and Period-VI.

21. In case of Saurashtra region, the compound growth rates of gap of NPK were found negative and significant in Period-V and Period-VI.

22 The compound growth rates of gap of NPK were found negative and significant for the Period-I, Period-III, Period-V and Period-VI in Middle Gujarat region. The instability indices increased across the periods of time.

23. In Kutchh region, the compound growth rate of gap of NPK was found negative and significant only in Period-IV with an average decline rate of 2.59 per cent.

24. The compound growth rates of gap of NPK were found negative for all the periods and significant except Period-II. The value of instability indices increased over decadal periods with the lowest in Period-I (3.97) and the highest in Period-V (42.57) for entire Gujarat state.

5.1.4 Determinants of fertilizer use

1. The only variable educational level (X_5) was found positive and significant for Soil Health Card farmers in Navsari district for sugarcane crop.

2. In Surat district, the short term credit (X_6) showed the positive and significant effect on fertilizer consumption in sugarcane crop for with Soil Health Card farmers.
3. The only variable one year lagged price (X_7) was found positive and statistically significant in sugarcane crop for without Soil Health Card farmers in South Gujarat.
4. The annual total income of the farmers (X_2) was only the variable showed significant positive effect on fertilizer consumption in kharif paddy crop for with Soil Health Card farmers in Navsari district.
5. The short term credit (X_6) and one year lagged price (X_7) exhibited the positive and statistically significant effect on fertilizer consumption in kharif paddy crop for without Soil Health Card farmers in Navsari district.
6. The only variable short term credit (X_6) found positive and significant to determine the level of fertilizer consumption in paddy crop for Soil Health Card farmers in Surat district.

5.1.5 Fertilizer use efficiency

1. The production elasticity of sugarcane crop for with Soil Health Card farmers of Navsari district was found positive and significant for nitrogen (X_5). The resource variable nitrogen (X_5) was found negative and significant for without Soil Health Card farmers of Navsari district adversely affected the yield of sugarcane crop.
2. The production elasticities of area under the crop (X_1) and human labour (X_2) were found positive and significant in sugarcane crop for without Soil Health Card farmers of Surat district.

3. The production elasticities of nitrogen (X_5) was found positive and significant in sugarcane crop for with Soil Health Card in South Gujarat.

4. The production elasticities of area under the crop (X_1) was found positive and significant in kharif paddy crop for with Soil Health Card farmers of Navsari district. For without Soil Health Card farmers of Navsari district, the production elasiticities of human labour (X_2) and phosphorus (X_6) were found positive and significant.

5. The production elasticities of area under the crop (X_1) and phosphorus (X_6) was found positive and significant in kharif paddy crop for with Soil Health Card farmers of Surat district. The production elasticities of human labour (X_2) and other working capital were found positive and significant in kharif paddy crop for without Soil Health Card farmers of Surat district. The resource variable manure (X_4) was found negative and significant for without Soil Health Card farmers of Surat district adversely affected the yield of kharif paddy crop.

6. For without Soil Health Card farmers of South Gujarat, the production elasticities of area under the crop (X_1) positively and significantly affected kharif paddy yield.

5.1.6 Impact of Soil Health Card

1. In general, with Soil Health Card farmers utilized N near about the same quantity as per the recommendation of Soil Health Card. Whereas, the extent of over utilization of N was found higher for without Soil Health Card farmers in sugarcane crop.

2. The extent of gap of P fertilizer was found less for with Soil Health Card farmers as compared to without Soil Health Card farmers in sugarcane crop in general.

3. The extent of gap in respect of K in both the districts was observed but it was smaller for with Soil Health Card farmers as compared to without Soil Health Card farmers in sugarcane crop in general.

4. The with Soil Health Card farmers of Navsari district judiciously used N fertilizer in kharif paddy as compared to with Soil Health Card farmers of Surat district.

5. As far as P is concern, the gap observed was negative for all the farmers. But the extent of gap was smaller for with Soil Health Card farmers as compared to without Soil Health Card farmers for kharif paddy in general.

6. The net return per hectare over cost-C_2 for sugarcane crop in Navsari district was found higher for with Soil Health Card farmers (Rs.65, 870) as compared to without Soil Health Card farmers (Rs.60, 165).

7. The net return per hectare over cost-C_2 for sugarcane crop in Surat district was found higher for with Soil Health Card farmers (Rs.82, 475) as compared to without Soil Health Card farmers (Rs.68,533).

8. The net return per hectare over cost-C_2 for sugarcane crop in South Gujarat region was found higher for with Soil Health Card farmers (Rs.80, 183) as compared to without Soil Health Card farmers (Rs.66,802).

9. The net return per hectare over cost-C_2 for kharif paddy crop in Navsari district was found higher for with Soil Health Card farmers (Rs.33,818) as compared to without Soil Health Card farmers (Rs.30, 097).

10. The net return per hectare over cost-C_2 for kharif paddy crop in Surat district was found higher for with Soil Health Card farmers (Rs.29,185) as compared to without Soil Health Card farmers (Rs.25,017).

11. The net return per hectare over cost-C_2 for kharif paddy in South Gujarat region was found higher for with Soil Health Card farmers (Rs.31,355) as compared to without Soil Health Card farmers (Rs.26,697).

12. The paired ' t ' test reflected positive and significant effect of Soil Health Card on sugarcane and kharif paddy yield in South Gujarat region.

5.2 Conclusions

The following conclusions can be drawn from the findings of the study.

1. In South Gujarat region, sugarcane and kharif paddy occupied the highest share in total gross cropped area.

2. Among the regions, Middle Gujarat stood first in mean consumption of N during all the periods and Kutchh stood at the bottom.

3. The consumption of N, P, K and NPK fertilizers increased significantly in all the regions for entire period of time.

4. In all regions, Saurashtra stood at top in mean consumption of P during all periods and Kutchh stood at the bottom.

5. The compound growth rates of gap of N, P and NPK decreased significantly in all the regions except Kutchh region for whole period.

6. The compound growth rates of gap of K decreased significantly only in Kutchh region for entire period.

7. The instability indices of gap of N, P, K and NPK were increased in all the regions over period of time.
8. The short term credit, one year lagged price, educational level, total annual income of the farmers were found major determinants responsible for fertilizer consumption.
9. There existed a great variation in the production elasticities of the different inputs in sugarcane and kharif paddy crops for with and without Soil Health Card farmers. In general, area under the crop, human labour, nitrogen, phosphorus and other working capital were the major resource inputs influencing sugarcane and kharif paddy crops yield.
10. In general, with Soil Health Card farmers of Navsari and Surat districts used the fertilizers judiciously as per recommendation of Soil Health Card as compared to without Soil Health Card farmers.
11. The net returns obtained from sugarcane and kharif paddy crops in Navsari and Surat districts were relatively higher for with Soil Health Card farmers as compared to without Soil Health Card farmers.
12. The Soil Health Card found beneficial for farmers to obtain optimum economic crop yield.

5.3 Policy implications

The following policy implications emerged out on the basis of the conclusion of the study.

1. The fertilizer companies should consider the gross irrigated area while fixing the districtwise target of fertilizer consumption at distribution network.

2. There exists gap in use of P and K fertilizers in selected crops in South Gujarat region as a whole. This calls for the need of extension efforts to use of these fertilizers optimally.
3. The Soil Health Card should be provided to all the farmers for all pieces of land.
4. The extension and line department should be strengthen to provide technical information to farmers.
5. The emphasis should be made to use sugarcane cutting machine and paddy harvester because of acute shortage of labour.
6. The efforts should be made to supply credit at lower rate of interest to farmers because credit emerged as the key factor in deciding fertilizer use.

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* Original not seen.

APPENDIX – I

Topic of Research: "Regional imbalances and impact of Soil Health Card on fertilizer consumption in Gujarat"

Questionnaire

1. Information of farmers:

(i) Name of farmer: _____ (ii) Age : _____

(iii) Village : _____ (iv) Taluka : _____ (v) District : _____

(vi) Education : _____ (vii) Occupation : a. Main _____

b. Subsidiary _____

c. Subsidiary income ____

2. Land holding :

Sr. No.	Particular	Area (ha)	Leased out (ha)	Leased in (Ha)	Rent paid or received (Rs)	Land revenue(Rs)
1.						
2.						
3.						

3. Land utilization (ha) :

Sr. No.	Items	Total land	Cultivated land		Grazing Land	Fallow land	Any other
			Irrigated	Unirrigated			

4. Cropping pattern and yield :

Sr. No.	Season and crop		Crop (Ha)					Main yield (qtl.)	Price (Rs./qtl.)	Previous Year price (Rs./qtl.)	Byproduct Yield (qtl.)	Price (Rs./qtl.)
A.	*Kharif*	Area (Ha)	Food grain	Vegetables	Orchard	Cash crop	Others					
1.												
2.												
3.												
B.	*Rabi*											
1.												
2.												
3.												
C.	*Sum -mer*											
1.												
2.												
3.												

5. Implements and machinery :

Sr. No.	Item	No	Year of purchase	Price (Rs.)	Present Value (Rs.)	Repairing During year	Remaining life (year)
A.	Implements						
1.	Wooden plough						
2.	Iron plough						
3.	Seed drill						
4.	Harrow						
5.	Hoe						
6.	Bullock cart						
7.	Others						
B.	Machinery						
1.	Electric motor						
2.	Oil engine						
3.	Tractor						
4.	Sprayer/Duster						
5.	Trailer						
6.	Cultivator						
7.	Plough						
8.	Pipi line						
9.	Thresher						
C.	Others						
1.	Sickle						
2.	Kudali						
3.	Spade						
4.	Others						

6. Livstock :

Sr. No.	Type	No	Age	Purchased/Home breeded		Present value (Rs.)
1.	Bullock					
2.	Local cow					
3.	Cross breed cow					
4.	Buffaloes					
5.	Heifers					
6.	Sheep					
7.	Goat					
8.	Poultry birds					
9.	Others					

7. (a) Cost of cultivation :

Variety : Area : Source of irrigation :

Sr. No.	Particulars	Labour required (Days)						Labour expenditure (Rs.)					
		Labour				Bullock		Labour				Bullock	
		Own		Hired		Own	Hired	Own		Hired		Own	Hired
		M	F	M	F			M	F	M	F		

(b) Input expenditure :

Sr. No.	Type of expenditure	Particulars	Quantity (kgs.)	Price (Rs.)	Remark
1.	Seed/ Seedling				
2.	Manures				
	(i) F.Y.M. (cartload)				
	(ii) Castor cake				
3.	Chemical fertilizers				
	N				
	P				
	K				
4.	Irrigation				
	(i)				
	(ii)				
	(iii)				
	(iv)				
5.	Plant protection/ Weedicide				
6.	Tractor or other machinery cost				
7.	Hired implement expenditure cost.				
8.	Land rent/ Revenue				
9.	Market expenditure				
10.	Others				

APPENDIX-II

Area of major crops grown in South Gujarat region

('00 hectares)

Crop/Year	2005-06	2006-07	2007-08	2008-09	2009-10	Average
Kharif paddy	1899	1995	3894	2384	2452	2524.8
Kharif Jowar	578	406	488	558	620	530.0
Kharif Tur	935	987	1035	1184	1218	1071.8
Rabi Jowar	326	362	288	606	259	368.2
Summer paddy	112	136	160	177	90	135.0
Sugarcane	1991	1965	1934	1987	1732	1921.8
Cotton	1945	2031	1807	1829	1565	1835.4

Source : Yearwise 'Margdarshika' on Distictwise area, production and yield of important food & non-food crops in Gujarat State, published by Directorate of Agriculture, Krishi Bhavan, Gandhinagar, Gujarat

APPENDIX-III

Districtwise fertilizer consumption per hectare in South Gujarat region

(Kilograms)

District/Year	2005-06	2006-07	2007-08	2008-09	2009-10
Bharuch	103.72	110.46	90.36	119.56	161.15
Narmada	82.13	90.73	89.48	117.88	150.79
Surat	294.25	311.85	368.98	418.77	486.05
Navsari	208.89	213.83	235.24	360.24	334.27
Tapi	__	__	__	101.25	147.43
Valsad	170.74	151.49	141.51	169.12	182.22
Dangs	0.89	0.95	1.09	1.03	1.39

Source : Yearwise ' Fertilizer and agriculture statistics, Western region' published by the Fertilizer Association of India, Western region, Mumbai

CERTIFICATE

This is to certify that I have no objection for supplying to any scientist or worker a copy of thesis or any part of it for rendering reference service either in a library or documentation centre.

Place : Navsari

Date : 30th June, 2012 **(J.J.Makadia)**