SUSTAINABLE AGRICULTURE DEVELOPMENT IN HARYANA: A STUDY OF NCR REGION

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DECLARATION

I, hereby declared that the presented work in the thesis entitled "**Sustainable Agriculture Development In Haryana: A Study Of NCR Region"** in fulfilment of degree of **Doctor of Philosophy (Ph. D.)** is outcome of research work carried out by me under the supervision of **Dr. Sajad Nabi Dar,** working as **Assistant Professor, in the Geography Department** of Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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<u>CERTIFICATE</u>

This is to certify that the work reported in the Ph. D. thesis entitled "**Sustainable Agriculture Development In Haryana: A Study Of NCR Region"** submitted in fulfillment of the requirement for the award of degree of **Doctor of Philosophy (Ph.D.)** in the **Geography Department**, is a research work carried out by **Sanju Bala, 41800407**, is bonafide record of her original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

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ABSTRACT

The present research entitled with “sustainable agriculture development in Haryana: A study of NCR Region” is mainly focused on the NCR part of the Haryana state. This part of Haryana state is undergone huge LULC and cropping pattern changes due to the nearness of Delhi NCR. The National Capital Region (NCR) of Haryana stands at the forefront of rapid urbanization and population growth, leading to unprecedented changes in land use and cropping patterns. This dynamic region, which plays a pivotal role in the economic and agricultural landscape of Northern India, has been witnessing transformative shifts that pose significant challenges to the sustainability of agriculture. Surprisingly, despite the urgency and magnitude of these changes, a dedicated study that comprehensively examines the evolving land use and cropping patterns while focusing on the sustainability of agriculture in NCR Haryana has been conspicuously absent. The pace at which these changes are occurring underscores the need for a thorough investigation to understand the implications on the socio-economic fabric and the long-term viability of agriculture in the region. The absence of a dedicated study focused on these critical aspects leaves a significant gap in our understanding of the challenges faced by the agrarian community in adapting to these rapid transformations. So, the present study is the sound effort to fulfil this research gap with the help of the following objectives: -

1. To examine the land use changes in the NCR region of Haryana.

2. To evaluate the changing cropping pattern of the NCR region of Haryana.

3. To examine the socio-economic conditions of the farmers and their perspective about agriculture sustainability

4. To suggest the appropriate measures to attain the sustainable development of agriculture.

With the help of the above said objectives, following research questions have been been framed for the detailed research investigation: -

1. What is the status of changes in the land use and land cover pattern in the study area?

2. Why are the changes occurred in the cropping pattern in the study area?

3. what are the socio-economic conditions of the farmers?

4. What are the crucial factors that determine to attain of sustainable agriculture in the area?

Hypothesis

1. Increasing irrigation intensity have increased the cropping intensity
2. Irrigation intensity have positive impact on the area of the crops like rice, wheat, cotton and negative on bajra, gram, barley.

The choice of Haryana NCR as the research area is grounded in the critical socio-economic and environmental implications of the observed transformations. The substantial reduction in agricultural land raises concerns about food security, resource sustainability, and the overall resilience of the region's agricultural system. This comprehensive study delves into the dynamic landscape of land use changes and shifting cropping patterns in the National Capital Region (NCR) of Haryana from 1991 to 2022. Utilizing Landsat satellite imagery, the research uncovers significant transformations in agricultural and built-up areas, leading to implications for socio-economic conditions and agricultural sustainability. In first objective, the focus is on land use changes, particularly the drastic decrease in agricultural land (-7.8%) and the corresponding increase in built-up (10%) areas. Population growth and urbanization emerge as primary drivers, emphasizing the urgency for sustainable land-use planning. Population growth (11.1 million to 16.5 million from 1991 to 2011) and urbanization (30.3 to 36.2 from 1991 to 2011) are the major causes for the dreastic change in built-up area. the corelation betwwen built-up and population growth and resulted that both are positively corelated with each other and this corelation is very strong in 2022 (r-0.91) due to rapid population growth. Coefficient of Determination (R^{2-}0.83) is also positve as population is the major cause for these drastic change in built-up expansion. All the LULC classes showing decreasing trend except built-up section from 1991 to 2022 which is a matter of great concern for the sustainable growth of the region.

Second objective is evaluating the changing cropping pattern in Haryana NCR, revealing shifts in major crops, cropping intensity, and irrigation intensity. There has been major shifting of cropping system from mixed to mono culture which led negative impacts on the soil and water conditions of the study area. Irrigation intensity within the study area has been increased from 150.7% in 1991-94 to 173% in 2019-22. Irrigation intensity plays a vital role in the agriculture development in Haryana NCR. Cropping intensity has increased from 149 percent during 1991-94 to 184 percent during 2019-2022 and the reason behind that are the development of irrigation facilities, HYV seeds, mechanization, fertilizers etc. Crop diversification is also decreasing in North East tehsil namely districts Karnal, Panipat, Sonipat, Safidon tehsil and Bawal tehsil and the crop diversification index is above 30 in this area as all of them follow mono-culture. The crop diversification index is positive in tehsils with poor soil and fewer irrigation facilities as they grow 4 to 5 crops during a single cropping year. Karl Pearson correlation applied on irrigation intensity and cropping intensity with area under different crops. It resulted in that area under rice, wheat, sugarcane and cotton positively correlated with irrigation intensity and cropping intensity. It is significant with 0.01 and 0.05 levels. Irrigation intensity is negatively correlated with bajra, barley, gram and mustard as due to expansion in irrigation facilities, farmers started to grow other crops like rice, and cotton in place of bajra. Gram and barley were replaced by mustard as it is also a very important cash crop but mustard is also negatively correlated with irrigation intensity as it is sown as a prime crop in southern Haryana. Irrigation intensity and cropping intensity are also positively correlated and significant at the level of 0.01 and 0.05. The study underscores the impact of crop choices on groundwater dynamics and fertilizer application, emphasizing the need for sustainable agricultural practices. Objective-3 explores the socio-economic implications of cropping patterns, presenting findings from a survey of 390 respondents. The study identifies demographic concerns, gender disparities, social group dynamics, educational challenges, and landholding issues. The survey unveils income distribution patterns, housing structures, family dynamics, education choices, and agricultural work patterns among respondents. Furthermore, the study investigates awareness about agricultural sustainability, revealing a significant lack of awareness among farmers. Education is identified as a crucial factor in spreading awareness. The survey indicates diverse cropping patterns among respondents, with a significant proportion adopting mono-culture, posing challenges for agricultural sustainability. The study emphasizes the interconnectedness of cropping choices with resource management, socio-economic characteristics, and perceptions of groundwater level changes. A substantial portion of respondents expresses health concerns, attributing them to the overuse of chemical fertilizers and pesticides. Opinions on income sufficiency from agriculture are divided, with socio-economic factors influencing respondents' views. Changes in agricultural land holdings are explored, with family bifurcation identified as a significant reason for holding size changes. The survey concludes with an assessment of major agricultural problems, highlighting varying degrees of concern among farmers. Lastly farmers were asked to give rank to the present major agricultural problems and it resulted that majority of the respondents give first rank to ground water depletion, second rank to decreasing holding size, 3rd rank to higher use of fertilizers, 4th rank to soil depletion and 5th rank to stagnation of productivity. Then applied Friedman Rank test which is significant at the level of 0.05 which indicates that significant difference is found between the mean ranks of the major agricultural problems faced by the respondents.

In conclusion, this study provides a comprehensive understanding of the intricate interplay between land use changes, cropping patterns, and socio-economic conditions in NCR Haryana. The findings underscore the need for sustainable agricultural practices, awareness campaigns, and targeted interventions to ensure the region's long-term agricultural and socio-economic sustainability. This research stands as a pioneering effort to fill the void in our understanding of the profound changes occurring in NCR Haryana. By focusing on land use changes, cropping patterns, and the sustainability of agriculture, this study aims to contribute valuable insights that can inform policies, foster awareness, and pave the way for sustainable agricultural practices in this critical region.

The study, through its comprehensive assessment of major agricultural problems, illuminates the multifaceted challenges faced by farmers. Groundwater depletion, decreasing holding sizes, and higher fertilizer usage emerge as primary concerns. This calls for policy measures that address the complex web of challenges faced by the agricultural community in Haryana NCR. In conclusion, achieving sustainable agriculture in region requires a multifaceted approach. Policies should focus on sustainable land-use planning, incorporating urbanization needs without compromising agricultural resources. Education and awareness campaigns should target farmers, empowering them with the knowledge to make informed choices that promote resource conservation. Initiatives promoting diversified cropping patterns, judicious use of irrigation, and reduced reliance on chemical inputs are imperative for long-term agricultural sustainability. Moreover, interventions must consider the socio-economic realities, bridging demographic gaps and empowering farmers with the tools for sustainable practices. This research, by unravelling the complexities of NCR region of Haryana's agricultural landscape, lays the foundation for informed decision-making. It is a clarion call for collaborative efforts from policymakers, researchers, and the farming community to implement sustainable practices that ensure the resilience and longevity of agriculture in this vital region.

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Chapter-1

1 INTRODUCTION

Sustainable word was used for the first time in 1713 in a forestry handbook of the German language which stated that never cut forests beyond their regeneration power. However, the Sustainable development phrase was used for the first time in the Cocoyo Declaration on Environment and Development in 1970. The word sustainable became famous during the publication of the Brundtland Commission report in English. According to the Brundtland Commission, Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED,1987). Sustainable development ensures improvement in the quality of human life while living within the regenerating capacity of the supporting ecosystem (Shrikumar Chattopadhyay). So, the objectives of Sustainable development are to take maximum benefit of the three factors of our environment-economic, social and biophysical. Sustainable development advocates a development process that is biophysically permissible, economically viable, and socially acceptable. Sustainable development is a multilateral approach that involves a triangle of natural resources management- communal balance, economic capability, and environmental safety (Vasudeva,2010).

M.S. Swaminathan,father of the green revolution in India, was also considered the father of the second green revolution in India because he used terms such as sustainable development, environment-friendly sustainable development, food security, and conservation of biodiversity in India which he called ‘evergreen revolution’

In the pursuit of a sustainable future, agriculture stands as a cornerstone, playing a pivotal role in addressing the complex challenges that humanity faces. As we navigate the 21st century with an ever-growing global population, dwindling natural resources, and escalating environmental concerns, the significance of agriculture in sustainability has never been more pronounced. Agriculture not only provides the nourishment essential for human survival but also holds the key to mitigating climate change, preserving biodiversity, and fostering economic resilience. So, there is a utter need to make agriculture sustainable.

1.1 Sustainable Agriculture

Sustainable agriculture is a method of cultivating how present requirements are fulfilled without harming the needs of future generations. It includes such practices which are economically viable, socially permissible and within environmental boundaries. It is based on the concept of equal man and environment cooperation. It favors the cropping pattern which is economically beneficial for the farmers as well as safe for the environment. (Department of Agriculture and Cooperation, (2010). Agriculture sustainability is a broad concept that includes three important parameters for human growth as well as nature's health. Duanski, K. et al. (1998) mainly focused on the future of sustainable agriculture and the need for organic farming with the help of major indicators of sustainable farming. There are three major indicators of assessing sustainable agriculture viz. environmentally friendly (describe Land Quality Indicators (LQI) like land diversification, intensity of land use, land safety by cover crops etc.), economically viable and socially acceptable. Assessment of these indicators was done through Framework for Evaluating Sustainable Land Management (FESLM). Some key indicators that were identified by the researcher based on primary survey like productivity (yield, growth of crops), risk management (dry spell repetition, income from animals) and conservation (total top layer degradation, intensity of crops). Sustainable agriculture includes three major goals- decent quality of habitat, fine economic reward and communal balance and emphasizes that there is an utter need for long-term management of the available resources and unified policies for better agricultural development (Brodt et. al. (2011).

The agriculture sector faces many problems like unexpected economic loss, decreasing land holding size causes decreasing interest of the farmers and no desired growth in India. So, agriculture sustainability is the best solution for all because it gives environment-friendly cultivation method that is helpful for collective growth viz.

economic, social and environmental and uses the agriculture sustainability index based on some key variables of sustainability- economic profitability, environment safety and social equality (Kareemulla, K. and Venkattakumar, R. (2017). Sustainable agriculture is based on three collective elements- environmental safety, farmer's economic development and collective community liabilities. It is a method to adopt ways of farming those are good for environment and a business approach that is different from other profit approaches as it is concerned about the environment (Ontario Ministry of Agriculture2019).

According to the report of National Centre for Appropriate Technology (NCAT), (2005) agriculture sustainability is based on the three major parameter's:

-1. Guardianship of the environment: sustainable agriculture promotes agricultural practices that are beneficial for the farmers as well as for the natural environment like crop rotation, covering crops etc.

2- Ensured economic benefit of the Farmers: economic viability is the pre-necessary condition before adopting any new technologies. If it is economically sufficient and helps in their livelihood development, then it is acceptable.

3- Social awareness/acceptability/ social equality: before adopting any new phenomenon, it is necessary to spread awareness regarding this. Social acceptability is the very first condition for the application of any concept.

Zhen, L. & Routray, J.K.(2003) conclude major indicators under three headings namely ecological which includes quantity of the fertilizers & pesticides, underground water level, water management, soil nutrition value; economic which includes productivity of the crops, actual or net farm income, expenditure-profit ratio, per head food grain production; social indicator which includes self-reliance, equity in income, consciousness and understanding about the sustainability and natural resources. So, it is very important to select indicators very carefully according to the region and time requirements.

1.2 Agriculture Scenario- India

In India, agriculture is a very important part of the Indian economy because it provides 17-18 percent (**Annual Report 2019-20**) of GDP (Gross Domestic Product) and employment to 54.6 percent of the country's population. It also provides raw materials to agro-based industries and provides demand for different industries like fertilizer, pesticides, machinery, and seeds. India stands 1st in the world in the highest net cropped area. India has the largest agriculture research system in the world with 27500 agriculture research scientists and 1 lakh helping staff. However, it still faces many agricultural and environmental problems and stagnation of productivity (Borthakur, A. & Singh, P. (2012) Today, the share of agriculture in the GDP of India is declining although it plays a great role in the overall development of the country. India is in 10th place in the largest arable land resources. India is the largest exporter of agro-based products in the world. Green Revolution helped to move India out of the food crisis in 1960 but it promoted only a few crops and generated economic disparity among farmers. This package technology promotes wheat and rice mainly which affects crop diversification within the country and generates many agricultural and environmental problems (Singh, S. (2020). At present Indian agriculture sector is facing many problems like low productivity, poor infrastructure, improper food storage, low GDP share, fewer irrigation facilities, etc. which affect the growth of Indian agriculture. India exports most of its products to developing and underdeveloped countries.

Hinz, R. et al (2020) concluded that to fulfil future food needs, agricultural land should be expanded, and the intensity of the present land has been increased but both the processes increased carbon level and biodiversity loss. Govt. should make policies to increase the intensity of the present farms and decrease the bio-diversity loss in India. Jibran, S. and Mufti, A. (2019) have researched regarding problems related to Indian agriculture and concluded that it has undergone many challenges like overuse of chemical fertilizers, decreasing holding sizes, uneven rainfall, no proper storage, increasing population and also changes in LULC and all these problems are causing hindrances in the way of food security and sustainability. The possible solutions to these problems are spreading awareness regarding modern technologies and giving financial support to adopt new agricultural practices.

In the 21st century, India is facing three biggest challenges namely concern regarding nutrition and food security, viable use of available resources and adjustment to the changing climate. If we talk about other sectors like manufacturing, IT, telecom etc., these are growing continuously with govt. efforts, but the agriculture sector is not growing as compared to others. There is no doubt that the agriculture sector has developed a lot as compared to 1960 but after the 1990s, there has been no significant change in the development of agriculture as compared to growth in other sectors (Chand, R. (2019). The economic share of the agriculture in Indian economy is decreasing but still, it plays a vital role in the economic development of the country. There is a need to address problems like stagnation of productivity, food security, nutrition value, overuse of chemical fertilizers and rural economic development. Narayan (2012) states that India has set self-sufficiency because of the green revolution in food grain production but enhanced the need for sustainability and organic farming. The Green Revolution raised many problems in the field of agriculture nutrition value, soil fertility, water level etc. Kamble & and Chavan (2018) state that the present conditions of Indian agriculture indicate the need for sustainable development to fulfil the food requirements of the rapidly growing population of India.

1.3 Agriculture Scenario- Haryana

Haryana is known as the main beneficiary of green revolution among Indian states and a major foodgrain supplier of the country as it produces more foodgrains than its consumption. Hence, it is called the bread basket of India. It is a major supplier of foodgrains distributed through the public distribution system. Agriculture growth was divided into five stages :

from 1951 to 1966- the stage of increasing population pressure and extensive mode of cultivation, the second (1966-71)- that was called the phase of green revolution expansion, third (1971-1981)- beginning of monoculture and robbery of groundwater, fourth (1981-91)- phase of in-depth cultivation and degradation of resources fifth (1991-97)- the phase of stagnant production and yield (Vashishtha, P.S. et al(2001)).

In Haryana during the last twenty years, history presents a clear picture of huge changes in this field like changes in cropping, land ownership, farm practices, productivity, cropping intensity, groundwater level, soil fertility etc. Farmers are very limited in crop selection because they are bound by market prices and value of the different crops which changed the cropping pattern as well as the institutional, infrastructural & and technological environment of society. (Haryana Kisan Ayog) Haryana is a leading state (2^{nd} position) in food grain production as 86% geographical area within the state comes under cultivation and provides 17.6% of food grains (2009-10) to our country. The green revolution played a very important role in agriculture growth in Haryana as it boosted the production of food grains from 2.6 million tons in 1966-67 to 16.6 million tons in 2010-11. The production of wheat increased eleven times and rice sixteen times, which was a miracle in the field of agriculture. For great performance in wheat production, the Indian government gave the Krishi Karman Award to Haryana with 11.6 million tons of production (4624 kg/hac productivity). The green revolution also raises many problems like soil degradation, overuse of fresh water, overuse of fertilizer, decreasing human wellness, change in land use etc.

Haryana is blessed with good soil and irrigation facilities with nearness to domestic and global market facilities due to the NCR region contiguity. The state is divided into three agriculture zones based on soil and water conditions and almost 84 percent area is under cultivation. The state is in second position in its share of food grains in the central pool of India and expert in basmati rice in terms of production and export. (Working Group Report- HKA, 2013).

Singh, J. et all(2015) explained that the economy of Haryana state is going through commendable changes from agriculture and allied sector to manufacturing and services and the share of this sector in the GDP of the state also declined from 60 % (1969-70) to 28% (2001-2002) because of better growth of manufacturing and service sector.

Haryana is a leading state in food grain production and almost 80% area is under crop production and a major food grain exporter in India (exporting 1.2 billion in 2017-18) and continues to increase in the production of food grains. Haryana has a more average yield of rice and wheat crops in comparison to the country which was 4841 kg in Haryana and 3172 kg in India for wheat in 2016-17 and it adds 15% to the central pool of India in food grains and is also known as breadbasket for our country (4th agriculture summit-2019).

Agriculture is a very important activity in the state of Haryana as it has very fertile land with better irrigation facilities. In the GDP of Haryana, agriculture has a very important share which is 14.5% and it also provides work for almost 51 % of the population and about 75 % of the area within the state has good irrigation facilities like tubewell and canal irrigation. Excess use of fertilizer and HYV seeds have caused many problems in the agriculture of Haryana affecting soil erosion, groundwater depletion negatively, and have decreased nutrition value (Godara, R. and Krishan, B. 2020).

ICFA (Indian Council of Food and Agriculture) report on agriculture in Haryana pointed out that Haryana belongs to the top 10 states in India in total food grain production, 4th place in wheat production and 10th position in rice production. As per the census 2011, Haryana has 44.96% population engaged in agriculture and has 15th rank among all the states. Agriculture in Haryana faces many problems like soil degradation, overuse of underground water, stagnated production, pest management, improper cold storage facilities etc.

1.2 Review of Literature

In navigating the expansive landscape of sustainability, the present study undertakes a comprehensive exploration, artfully delineated into three discerning categories. This strategic approach not only enhances the depth of our understanding but also orchestrates a symphony of knowledge, harmonizing the multifaceted facets of sustainability into a nuanced and compelling narrative. Through this meticulously curated literature survey, we embark on a journey through the intricacies of environmental, social, and economic sustainability, unraveling the interconnected threads that weave the tapestry of a sustainable future.

1.2.1 Issues in Agriculture and the Need of Sustainability

Dumanski, J.D.,Coote G.L. And Lok C. (1986) stated that sustainability is closely related to the quality of environment and soil. In the modern system of agriculture, farmers use high machinery, fertilizers, pesticides, and improper farm practices which affect the soil fertility, and nutrition value of crops as well as the environment.

The Green Revolution helped the state achieve food self-sufficiency and become a major food producer & supplier in the country. On the other hand, it also generates many ecological problems in the field of agriculture as well as for the environment. Hashmi, S.N. (1994) in his present research paper entitled "Impact of New Agricultural Technology on the Agricultural Development in Haryana'' focuses on the impact of modern innovations on agricultural production in Haryana and its positive as well as negative impact on agriculture. It helps to increase agricultural production but on the other hand, it disturbs hydrological balance and decreases soil fertility.

(Singh, R.B. (2000) in their present research mainly focused on the results of the green revolution on the agriculture of Haryana and found that no doubt the green revolution helped Indian agriculture to achieve self-sufficiency in food grain production, but it also led to many negative effects on soil quality, food quality, water resources, environment etc. More than 50% area within the state faced water logging, salinity and alkalinity which is a big problem for food security in the state of Haryana. Almost 80% area of the state was under cultivation and if want to enhance production, we have to use large amounts of energy which is also a threat to the environment, soil, nutrition value etc.

Brahmanand et al. (2000) in their research article entitled "Agronomic Strategies for Forever Green Revolution'' focus on the conditions of agriculture in three north Indian states Uttar Pradesh, Haryana and Punjab and try to show the result of the green revolution. The study infers that among all three states, the impact of the green revolution was very positive, and production was increased at a very fast level.

Bonny, B.P. et al (2001) conducted a study on rice grower farmers in Kerela and used an index of sustainability to measure the level of their acceptance of sustainable agriculture techniques. The researcher concluded that all the farmers in the study area used chemical fertilizer because of the lack of availability of organic fertilizer.

Yadav, D.B. and Rai, K.N. (2001) researched the anticipation and outlook of agriculture sustainability in the state of Haryana and found that most of the agriculture area concentrated under four major crops viz. rice, cotton, sugarcane and wheat and all these crops were also a robber of underground water. If talk about fertilizer consumption, nitrogen is the highly consumable fertilizer in the state which generates so many problems like soil degradation, groundwater pollution, increasing nitrate concentration in underground water, lower nutritional value, loss of living species in soil etc. Haryana is in second place in food grain production in India after Punjab and it also improved its per capita income.

Kumar, M.D. (2003) observed that the present water conditions in India reflected a worse future for food security because there is no planning for water saving. Farmers should use modern technologies to save water as well as enhance production like treadle pumps in water-rich areas. There should be proper management of water supply and irrigation demand. There should be a proper volumetric price system for canal water and also for electricity bills which enable the rich and poor farmers to achieve their goals of production equally.

Hussain, M. (2004) mainly focused on the food grain production in eastern India and analyzed the fact that all the Northeast states faced food shortages due to less cultivable land and uneven distribution of land holdings. The number of landless farmers is continuously increasing in the North-East states.

Conventional farming would be more sustainable by adopting some old biological methods because conventional farming requires more fertilizer, water and pesticides which affects the soil fertility, water loss and nutritional benefits of the foodgrains. A comparison was made by the researchers between conventional farming, livestock-based organic farming and legume-based biological farming and showed that animal-based and legume-based farming consumes less water and energy sources and increases soil fertility than conventional farming (Pimentel, D et. al2005).

Krishnaraj, M. (2006) mainly focused on the problem of crop selection by the farmers as the government supported only wheat and rice by hybrid seeds and higher technology which ignored the main cereal crops and also the nutritional value of crops. The researcher also focused on the problem of low income of the farmers and suggested some measures to cure that problem.

Majumdar, N.A. (2006) observed that agriculture played a wider role in the economy of our country because almost 60 to 65 percent of people of India are engaged in agriculture and allied activities. So, it deserved a principal place in the Indian economy as it provided food, employment, and self-sufficiency in food production and also the base of many industries.

Shergill, H.S. (2007), focused on the security of wheat and rice production in Punjab state as many experts said that the groundwater table of the state has gone below the danger mark. The researcher has analyzed that it has not yet gone below the danger line and neither the wheat nor rice cultivation is responsible for it. Marketing of the production was also in a good position and no need to worry.

Chand, R. (2007) observed that production of food grain was not increasing as per as its demand whereas the prices of food grains were increasing continuously in 2006. The condition was worst for the other crops like cereals and pulses which affected the protein as well as nutritional value for human beings. In the year 2000-2005, the growth of cereals was 7 % lower than last five-year production which is a very serious issue for the food security of our country.

Dubhas, K.N. (2007) researched problems related to groundwater depletion due to water-intensive crops like rice in India. The researcher concluded that after 1991, due to more electricity supply and fewer bills, water wastage increased at a very fast speed for both houses as well as farm level which is causing a water crisis for future generations. Many blocks had gone under dark zones due to over-exploitation of water resources.

Pretty, J. (2008) in the present research, focused mainly on the concept of sustainability and the need for sustainability to secure the future of mankind. There is a very urgent need for sustainable agriculture practices to save the environment, health, nutrition, water and soil health. There is no doubt that agriculture has progressed a lot in the last few decades, but it also has many negative consequences owing to excess use of fertilizer, water, machines and pesticides.

Land use/ land cover changes vastly in the NCR region due to migration, population growth and infrastructural activities which affects the agriculture development and also the ecology of the region (Suzanchi, K. & Kaur, R. (2011). Mousavi, S.R. & Eskandari, H. (2011) described intercropping as a powerful tool for achieving sustainability in the field of agriculture. Old farm techniques and one cropping system have damaged the Indian agriculture system together and if we want better production, protection from weeds, better soil health, yield, and more effective use of available resources then we have to adopt the intercropping system. This system will help us get out of all these problems.

Narayan, S.S. (2012), in their present research mainly focused on the utter need for sustainability and organic farming in Indian agriculture. Almost 65% of the population of our country is engaged in agriculture and its related activities. Therefore, it becomes important that we pay attention to the field of agriculture, how we can bring sustainability, and use more organic methods in farms. There are many methods like vermicomposting, nitrogen fixation, organic manure, crop rotation, intercropping, and integrated pest management to attain the goal of sustainability in agriculture.

Savci, S. (2012) tried to focus on the harmful effects of fertilizer on human health and the environment. In the race to feed the rapidly growing population, humans forgot about soil fertility, nutritional value, environmental issues, and human health. We must focus on the soil structure and soil requirements, then we should provide appropriate fertilizers and pesticides. Farmers should take soil tests from time to time.

Scanlon B.R. and et. al. (2012) observed that the continuous depletion in groundwater in the United States is a matter of concern because 35% of southern plains will not be able to support agriculture in upcoming years. So, there is a great need for sustainable water use in the U.S.A. for better agricultural development.

Kumar, V. (2014) in his present study entitled “Economic Benefits and Ecological Cost of Green Revolution: A Case Study of Haryana, India’’ observed that agriculture production increased in Haryana because of the green revolution. On the other hand, it damages the environment in the form of soil degradation, water, and vegetation damage. The Green Revolution brought intensive cropping systems among the states and used access water, pesticides, and fertilizers which affected the environment in different forms. During the Green Revolution, the main focus was laid on only two crops, wheat and paddy which highly affected the fertility of soil.

Reytar, K. & others (2014) tried to find out the most favorable conditions for the farmers to adopt sustainability actually and not only in papers. The researchers set six stages and each stage has fixed indicators and goals. It was helpful to minimize the pollution and enable the farmers and policymakers to recognize the present situation, flow of thought, results of production, etc.

Alam A. (2014) in his present study tried to explain the problem of soil degradation at worldwide which occurs due to improper farm techniques like the eviction of green cover at large scale, improper irrigation techniques, plough method and salinity. The researcher also gave some suggestions to prevent soil erosion like better farm practices, preventing water erosion, crop rotation, contour ploughing and growing plants in barren land.

Patel, N., and others (2014), in their present paper, observed that biofertilizer is a very important agent in achieving the goals of sustainability in the field of agriculture. Chemical fertilizer enhanced production but on the other hand, it affected the soil quality and lowers human health as well. The use of biofertilizer is a healthy option that helps the soil to maintain moisture and good health. It will be possible by regular soil testing which is helpful for the farmers to understand the needs of soil and fertilizer.

Devi, S.A.K. (2015) observed in their research that most of the cropland within the study area was changed into a plantation which is a very bad signal for agriculture. Due to mismanagement of underground water and less rain negatively affects productivity. Higher labour costs were also a big reason for decreasing agriculture within the study area and the growth of plantations. The researcher also throws light on the negative effect of Juli flora on soil and its moisture conditions.

Chahal (2015) in their present article entitled "Sustainable Development and Agriculture Sector Issue and Challenges'' stated that Indian agriculture faces many problems due to the green revolution. Govt. gave more attention to other sectors of the Indian economy and less attention to the agriculture sector.

Sudhakar B. (2016) observed that sustainability would be the future for Indian agriculture because it helps to mitigate food needs, problems like soil degradation, decreasing water levels, nutrition value of crops and crop productivity. He also focused on challenges and issues in the way of sustainability in India like enhancement in urban areas and secondary activities.

Barman, M. & others (2017) tried to study the future of biofertilizers in sustainable agriculture in India and explained the negative effects of chemical fertilizers on the environment as well as human health. There were many obstacles in the way of biofertilizers like improper distribution facilities and the absence of knowledge about the use of proper limit of biofertilizers. If we want to attain food security and better human health, govt. should generate better technologies and a better command of quality for marketing biofertilizers.

Singh A. and Singh J. (2017) in their study entitled "Agricultural Scenario and Issues: A Study of Punjab and Haryana'' observe and discuss about current scenario and issues related to the development and growth of the agriculture sector in Punjab and Haryana from 1980 to 2015. Haryana shows a very fast growth rate as compared to Punjab. The effect of the green revolution on crop production in Punjab has run out. Haryana and Punjab showed negative growth in the agricultural sector from 2011 to 2016. So, it is essential to improve crop production because it plays a vital role in the GSDP of the state. On the other hand, the livestock sector showed positive growth in both states. So, it is a prerequisite for government to take steps for the improvement and growth of the agriculture sector.

Itelima J. al. (2018) studied the research paper related to the use of bio-fertilizer as a main ingredient to increase the soil health and production of crops and reviewed that access use of chemical fertilizer has degraded the quality of soil and poorer the nutritional value also. The use of micro-organism fertilizer is a very healthy path to get more production and more nutrients in the food. Biofertilizers also enhance the life of soil by nitrogen fixation, phosphorus soluble etc.

Basalingappa, K.M., Nataraj, R. And Thangaraj, G. (2018) observed that chemical fertilizers have caused great damage to agriculture as well as soil and human health. It acts as a fast food for the crops to help them grow fast but causes many health issues to human health. So, bio fertilizers are a very healthy replacement of chemical fertilizers by nitrogen fixation, provide soluble phosphorus and directly affect plant's growth.

Sivagnanam K.J. (2019) observed that the use of fertilizer in agriculture is increasing day by day which affects soil health, human health as well as environmental quality adversely. Farmers must be educated to use an adequate quantity of fertilizer which boosts soil health and nutrition value.

Godara, R. and Krishna, B. (2020) conducted research on the movement and stage of production in agriculture in Haryana. Agriculture is the backbone of our country, but the importance of agriculture & and allied sectors is decreasing with time and decreasing land holding size is responsible for that. Due to the decreasing size of land holdings, the interest of future generations is decreasing and moving towards other sectors like service, industries etc. The writer also discussed the factors that negatively affect productivity like soil degradation, and water crises and suggestions, on how to improve productivity, proper use of high-yielding seeds, prevent crops from diseases and promote crops that meet the changing demands of society like horticulture.

Gupta, N. et al(2021) in their present article, mainly focused on the current level of sustainability in Indian agriculture and revealed that no doubt the green revolution helped India to achieve food self-sufficiency but it led to many negative effects on the environment, soil, nutrition, groundwater, biodiversity etc. sustainable agriculture practices are far away from the present agriculture practices as only 4% farmers adopt some practices in their farms and at the research level, there is a shortage of research for long term assessment of sustainable agriculture practices and short period (0.5 to 3years) impact assessment are available only for few practices like conservation agriculture. The government must allocate more funds to sustainable agriculture practices and awareness programs to enhance the knowledge of the farmers.

Soil health is a very important element for plant growth and production, but due to excessive use of fertilizer, the health and capacity are decreasing day by day and conventional farming is the main reason for that. For better growth of agriculture and environmental safety, conservation farming methods should be applied so that the goal of worldwide sustainability can be achieved (Rodriguez, B.C., et al. 2022).

Dhanda, S. et al (2022) found that agriculture and environmental conditions in the North-West region of India have undergone huge soil degradation, pollution, groundwater depletion, and biodiversity changes due to water-intensive crop production as they demand high water.

There is an utter need for sustainability in the field of agriculture because due to the race to earn money, a human being has forgotten about nature, the environment, and also his health. During the 19^{th} century, a miracle was needed in the field of agriculture to feed the rapidly growing population and that miracle was the green revolution. After the green revolution, production was increased but the quality of food kept falling due to using more chemical fertilizer. Therefore, the Green Revolution gave rise to many problems in the field of agriculture decreasing water table, decreasing food quality, decreasing soil fertility, increasing pollution, decreasing environment quality, agricultural unemployment, decreasing health level, increasing diseases, etc.

Because of all these problems, little attention of the people is now going towards sustainable agriculture because it is based on long-term crops and livestock development to attain the present requirements of the people without compromising the needs of future generations and environmental conditions. It promotes the growth of a healthy ecosystem by using natural methods of crop growing, decreasing the use of chemical fertilizers and conserving water resources.

1.2.2 Land use/ Land cover change and need for sustainability.

Vashishtha, P.S. et al (2001) investigated the dynamics of land use change in Haryana state, revealing a nuanced interplay of social, economic, and physical factors. The collaborative influence of these factors has notably intensified cropping practices, higher chemical inputs, the adoption of high-yielding variety (HYV) seeds, minimum support prices (MSP) for wheat and rice, improved irrigation, and infrastructure development. Central to these changes is the visible impact of population pressure, serving as a key indicator driving alterations in land use. This is evident in the substantial decline of permanent pasture and fallow land sections, which have converted into agricultural land or built-up areas, leading to a positive surge in built-up and infrastructure segments.

Choudhary, B.S. et al (2008) delved into Human-Induced Land Use/Land Cover transformations in the northern part of Gurgaon District. Their research illuminated a continuous decrease in agricultural land, positive trend in built-up due to urban expansion, National Capital Region (NCR) sprawl, and industrial development. Utilizing LISS data, the researchers discerned an increase in closed forest cover attributed to governmental efforts, contrasted by a rapid reduction in wasteland as it converted into residential and other purposes.

Meenakshi, R. et al (2009) concluded from their study in Tamil Nadu that the state's land use/land cover pattern is undergoing transformation propelled by human needs and development activities. The twin forces of a increasing population, industrial and urban expansion emerged as major catalysts for changes in land use/land cover, detrimentally impacting agricultural land.

Suzanchi, K. & Kaur, R. (2011) investigated the National Capital Region (NCR), revealing a rapid transformation in land use/land cover patterns due to population pressure, infrastructural development, and high rates of migration towards Delhi spanning the years 1989 to 2006. Utilizing remote sensing and GIS techniques, the researchers found that various land sections experienced a shift towards built-up areas owing to human-induced activities. Kumar et al (2012) discerned contrasting trends in land use in Solan District, with a negative trend in pulses but positive trends in the area under vegetables, wheat, paddy, and cash crops. Meanwhile, there was a decreasing trend in the area under maize and barley.

Sangwan, S. et al (2014) focused on the analysis of urban land use changes in Sonipat City, Haryana. Their study highlighted a substantial increase in unplanned built-up areas, growing from 20 percent to 35 percent. This transformation stemmed from the conversion of agricultural land, posing a critical challenge to sustainable agriculture.

Saroj et al (2014) explored land use/land cover changes in Sonipat District, noting a rapid transformation accelerated by its proximity to Delhi and its status as part of the NCR region. Agricultural land was significantly affected, transitioning into built-up areas. Barren/waste land also decreased, transforming into built-up and agricultural areas due to population pressure and the emergence of planned and unplanned colonies.

Seema et al (2015) delved into land use/land cover and urban expansion in Sonipat City, revealing an expanding area under settlements at the expense of valuable agricultural land. During the periods 1991 to 2001 and 2001 to 2011, substantial hectares were transformed into built-up areas along the major transport routes of the city, as determined through Arc GIS and ERDAS IMAGINE software.

Singh, J. et al (2015) underscored the substantial changes in land use/land cover patterns in Haryana, attributing them to population pressure and the green revolution, particularly impacting crops like wheat and rice. The conversion of valuable agricultural land into built-up areas emerged as a critical concern. Rejula K. and Singh R. (2015) observed changes in land use and cropping patterns in Kerala from 2001 to 2012, noting a negative growth in the total cropped area and a preference for monocropping.

Hassan et al (2016) scrutinized the dynamic of land use and land cover in Islamabad, Pakistan, over four decades. Using remote sensing and GIS techniques, they attributed changes to population explosion, economic development, urbanization, and climatic conditions.

Vijayalakshmi, T. (2017) conducted research on land use and cropping patterns in Moovanallur village, Tamil Nadu, highlighting the dependence of land use on topography, soil conditions, water availability, rainfall, and government policies. While land resource utilization increased, it adversely affected agricultural land.

Rajesh (2018) employed LISS satellite imageries and GIS techniques to examine land use/land cover in Hisar District, Haryana. The study revealed a continuous increase in built-up areas, accompanied by challenges such as saline underground water and waterlogging. The Bhakhara canal system, however, positively impacted cropping intensity.

Goyal, A. et al (2019) focused on Gurugram District, detecting significant changes in built-up and barren areas, along with a decline in agriculture, green cover, and water areas. Rapid urbanization and construction emerged as key factors influencing these changes.

Rani, P. (2019) conducted a spatial-temporal study on changing land use patterns in Haryana from 1966 to 2013. The research, based on secondary data and utilizing Arc GIS techniques, revealed a sharp decline in net sown area and a growth trend in non-agricultural uses due to population growth, urban expansion, and industrial development.

Naikoo, M.W., et al (2020) researched LULC changes in the National Capital Region, attributing built-up changes to agriculture, vegetation, and barren land transformations. The study emphasized the importance of remote sensing and GIS tools in assessing global LULC changes.

Sarkar, A. et al (2020) explored LULC changes and their impact on groundwater quality in Rohtak and Sonipat districts within the NCR region. The study concluded that both states experienced significant LULC changes due to population growth and infrastructural activities, negatively impacting agricultural areas and stressing water resources.

Wang, S.W. et al (2020) investigated LULC changes in Bhutan's capital, Thimphu, using GIS and remote sensing techniques. The study revealed that increasing migration from rural to urban areas drove the growth of built-up areas, while forest and agriculture sections witnessed a concerning negative trend.

Kumar, J. (2022) observed LULC changes in NH-48 in the National Capital Region over the last two decades, highlighting substantial changes driven by fast urban sprawl, land conversion, and industrial growth. Built-up areas exhibited continuous growth, while agriculture land, vegetation, and bare land faced persistent decline, intensify by in-migration from rural to urban areas.

A comprehensive study on Islamabad city in Pakistan, analysing Landsat imagery from the years 2000, 2010, and 2020. Over the past two decades, rapid urbanization has significantly altered the city's land use and land cover (LULC), with the built-up area expanding from 3.58% to 35.17%. The study also noted a decrease in the groundwater table attributed to excessive freshwater pumping. Interestingly, the study found a decrease in land surface temperature (LST) due to an increase in the Normalized Difference Vegetation Index (NDVI) over the study period. An investigation in Babuzai, Pakistan, covering the years 1998, 2003, 2010, 2013, 2017, and 2022, utilizing modern remote sensing and GIS techniques was done. Their findings indicated a rising urban heat island effect in the area, with higher LST observed in urban centers compared to the surrounding regions. They also observed a positive correlation between LST and the Normalized Difference Built-Up Index (NDBI), while NDVI showed a negative correlation with LST due to surface thermal reflectance. (Sohail et al. 2023; Fahad et al. 2023).

Bala, S. and Dar, S.N. (2024), conducted research on the Faridabad district of Haryana state in India, revealing significant changes in Land Use and Land Cover (LULC) patterns. Their findings indicated a notable increase in land surface temperature, facilitated by remote sensing and Geographic Information System (GIS) techniques. These ongoing LULC transformations pose a considerable threat to the environment and the sustainability of agriculture. Furthermore, the study suggests that these changes are likely to persist in the future, exacerbating environmental concerns and agricultural challenges.

1.2.3 Cropping Pattern Changes and Need of Sustainability

Sangwan S.(1985) researched that green revolution had played a vital role in reforming the cropping pattern in state Haryana and factore like irrigation, price, fertilizer, machinary, HYV seed etc were the key causes behind the change of cropping pattern.

Kaur (1991) did a research on change in agriculture pattern in Punjab and stated that it is a very active part of the agriculture and differ from one time to another and also this change would be the result of many factors like water availability, value of crops, technologies, fertilizers etc. Green revolution played a vital role in crop pattern change in Punjab which replaced low value crops by high value crops and decreased the crop diversification.

Behura D. and Naik D. (1994) observed the cropping pattern in Orissa from 1966 to 1991 and revealed that area under rice crop decreased continuously from 1966 to 1991 because farmers started to grow other crops. The area under paddy crops decreased from 58% to 38 in 1991.

Malik, R.P.S. (1995) stated that crop patterns in Haryana and Punjab had shifted from less water consumable crops to more water consumable crops like wheat and rice which created a big threat for underground water resources within the states. Cropping pattern had shifted due to the green revolution as it preferred mainly rice and wheat growth which was a big reason for the decreasing diversification rate in both Haryana & Punjab.

Haryana is clearly divided into two zones-arid and semi arid and both the region are significantly different from each other in cropping pattern as both have different soil conditions and water availability, rainfall etc. in north east semi arid zone, green revolution reformed the cropping pattern and oocupied mainly two crops- wheat and rice.

In arid zone of the state, bajra, oil seeds, gram, cotton were the major crops. Haryana cropping pattern and agriculture growth clearly passes through five different stages from 1951 to 1997 from extensive agriculture to mechanised farming which changed the crop pattern from diversification to mono-culture which is a big threat for environment (Vashishtha, P.S. et al(2001)).

Taneja, N.K. et al (2007) concluded that rice and wheat are the major food crops in India and with the time, the productivity of these crops reduced or pleatue stage. It is a matter of concern for Indian Government as it become a threat for the food security of the country. The total factor productivity of these crops declined due to other commercial crops.

Tingre et. al. (2008) studied how many changes occur in cropping pattern and diversification of crops in Akola district of Vidarbha. The study resulted that most of cereals crops reflect decreasing trend in growth rate and soyabean affect the cropping pattern highly.

Meenakshi, R. and Indumathy. R. (2009) observed that what is the current situation of land use and pattern of crops in Tamil Nadu and the study resulted that cultivated area in the state was continuously falling as it influenced the production from the agriculture due to increasing population and other non-agricultural activities.

Bhupender and Nandal, s. (2010) tried to describe the agriculture diversification in state Haryana and revealed that farmers of Haryana state facing so many problems like up-down in prices, un-education, poor economic condition, poor water facilities etc. This study was based on primary data which was collected from three districts of Haryana state and found that people choose cereals or other crops because they had minimum support price but crops like vegetables, fruits and pluses had no MSP. People also think about the risk factors involved in high value crops like fruits, vegetables, pluses and oilseeds so they choose low risk crops like cereals. There are no proper market facilities for flowers which is also a barrier in crop diversification.

Crop pattern of Haryana state faced huge fluctuation due to emergence of green revolution in the agriculture field of India .It affected the production and growth of few crops namely wheat and rice which recorded the growthratefrom 10 to 14 % but the area under maize, barley and gram decreased continuously from 1966-67 to 2009-10 (Ramphul(2012)).

Malik J. (2012) in his present paper tried to analyze the differences that occur in pattern of crops in Haryana from 1995 to 2005. Area under agriculture declined and it increased in non- agriculture sectors during study period and reasons for that were spread of urban area, manufacturing activities and other planning works like construction of railways, roads, new townships etc. During last two decades cropping pattern of the state faces many changes due to positive attitude of the farmers towards commercial crops.

Uma.H.R, et al(2013) stated that changing pattern of crops negatively affects the food production within India due to less interest of the people in agricultural activities, higher wages in other sectors, higher attention to commercial crops and better facilities in other sectors. This would be a big danger for the food security in the upcoming days so that government should make better policies in the field of agriculture to encourage farmers to grow different crops.

Green revolution is a miracle in the field of agriculture and helped Haryana state to get food self-sufficiency and become a big producer and exporter of foodgrains. On the other hand, it also affected the crop diversification within the state and enhanced the monoculture in many districts like Karnal, Panipat, Sonipat, Ambala etc. and due to higher MSP of wheat and rice, area under bajra, jawar, gram, sugarcane was continuously decreasing. Bajra was the main crop in kharif during 1966-67 with 54 percent area under it and it was drastically replaced by rice which occupied 49 percent area during 2011-12 and during rabi season, gram was principal crop with 48 percent area(2011-12) and it was replaced by wheat with 66 percent(2011-12) (Working Group Report- HKA, 2013).

Rani, P. (2014) conducted research on the theme on farmland use changes in terms of inter-specific crop diversity in Panipat district and resulted that cropping pattern within the state has been changed sharply from more crops to mono culture which has impacted crop diversification and environment quality loss. So, govt. should make plans to motivate the farmers for sowing multiple crops in their farms as monoculture is responsible for the water table depletion, loss of soil fertility, increasing weed problems, health issue etc.

Singh, J. & et al(2015) agriculture of Haryana had experienced huge changes in their structural formation of ecconomy from primary activities to tertiary activities. In Haryana, wheat and rice had the highest profitability value and this value played a crucial role in cropping pattern change in haryana. Although sugarcane has the highest gross value outcome but there are many restrictions which stop farmer to choose sugarcane. As a result of green revolution, fixed highest MSP and low rate of risk, wheat and rice replaced the other crops like gram, mustard in rabi season and bajra, sugarcane etc in kharif season.

Sangral,C.(2015) in his present article entitled "Changing in Cropping Pattern and Crop Diversification in Jammu and Kashmir' observes that the old system of agriculture in Jammu and Kashmir was based on customary system only for livelihood. But after the green revolution, the cropping pattern of the state totally changed. Now people sow more commercial crops for more earnings. So, the researchers tried to find out the difference which occurs in the cropping pattern of Jammu and Kashmir and used secondary data for result and discussions.

Sunita, et all (2017) in their present article entitled "Changing Pattern of Area, Production and Productivity of Principal Crops in Haryana, India" observe that cropping pattern of the state faced considerable changes from 1993 to 2013 and result shows a positive growth in food grain production and negative for pulse production.

Vijayalakshmi,T.(2017) in his study entitled "Land use and Cropping Pattern'' observes that factors like irrigation facilities, conditions of soil, land form and regional factors are the basic factors for adopting a suitable cropping pattern within a region which positively enhanced intensity of cropping and net sown area positively. In the study area, the maximum use of land increased day by day but irrigation trend changed from higher use of water to less use. Cropping pattern was also changed within the state from paddy crops to black gram production.

Ali, H. (2018) in his present study entitled "Changing Cropping Pattern and Irrigation Intensity: A study of Murshidabad District, West Bengal, India'' observes that intensity of some particular crops was increasing in Murshidabad district and irrigation facilities affected the intensity of cropping positively. The researcher observes that during the study period, many variations took place in cropping pattern due to variation in irrigation facilities and almost 80% people depended on agriculture in Murshidabad district and the writer concludes the paper with that remarks increase in the irrigated area made a great contribution in agriculture growth of the district.

Ansari A.N. (2018) stated that Indian agriculture underwent so many changes like changing cropping pattern, highly diversified crops, intensive agriculture, and adoption of innovative technologies. The share of agriculture in GDP of India is declining although it plays a vital role in Indian economy because almost 70% population depends on agriculture. Horticulture was more diversified than food crops and gross cropped area increased towards food crops to non-food crops.

Andrabi J.A. (2018) in his present paper tried to examine the space and time related differences occur in cropping pattern and intensity in agriculture of Jammu & Kashmir for the time period of 1965-66 to 2010-2011 and results shows that maize & wheat were the highly cultivating crops within the state. Intensity of crops was increasing and Samba was the highest intensive cultivated district in J&K and it reached on plateau stage and government would take more steps towards pulses cultivation as they recorded negative growth.

Laxhmi K.V. and Nagpure S.C. (2018) conducted a comprehensive investigation in their recent research paper, delving into the evolving landscape of crop patterns, diversification, production, and area growth spanning the years 1970 to 2014. Their study of the Akola district revealed significant spatial and temporal transformations, witnessing a shift from subsistence agriculture to commercial practices. Notably, the study highlighted a decline in the cultivation of jowar and cotton, accompanied by a rise in pulse cultivation. The observed crop diversification during the study period was notably extensive, underscoring the dynamic nature of agricultural practices.

Sarkar, R. (2018) centered his study, titled "Agricultural Land Use and Cropping Pattern of Uttar Dinajpur District," on the crucial aspect of cropping patterns within the study area. Recognizing its pivotal role in agriculture, Sarkar emphasized the fluctuations in cropping patterns over time and space. The findings indicated an expansion in agricultural land and a reduction in non-agricultural uses, barren land, etc. Noteworthy was the decrease in the cultivation of oilseeds and pulses. Sarkar utilized secondary data sources and statistical tools to derive insights, shedding light on the persistence of traditional farming methods due to factors such as small land holdings, high population dependence on agriculture, and prevalent poverty.

Gautam, R. & Sangwan, B. (2021) undertook a research endeavour focused on the evolution of crop patterns in Haryana from 1980 to 2015. Their investigation revealed that the state's cropping pattern was predominantly influenced by wheat and rice, a consequence of the green revolution technology. This trend, while boosting wheat and rice production, adversely impacted the groundwater table. The diminishing cultivation of crops such as bajra, gram, mustard, pulses, and sugarcane were attributed to the greater Minimum Support Prices (MSP), demand, lower risk, and simplified harvesting associated with wheat and rice.

Dhanda, S. et al. (2022) concluded, through their research, that the cropping pattern in North-West India underwent a transformation due to the advent of green revolution technology. While this technological shift increased the cultivation of rice and wheat, it also gave rise to a myriad of issues including soil degradation, pollution, loss of biodiversity, groundwater depletion, and labour scarcity. The study emphasized the dual impact of increased production and emerging challenges, highlighting the complex repercussions of adopting new farming technologies in the region.

In summary, the literature survey provides a nuanced understanding of the complex interplay between the Green Revolution, socio-economic factors, and changing cropping patterns across various states in India. The studies collectively underscore the need for balanced agricultural policies to ensure sustainable farming practices, environmental conservation, and food security.

On the basis of the literature survey, following research gap has been analyzed: -

1.3 Research Gap

Many studies were conducted on land use and cropping patterns in Haryana and there is no agriculture study conducted that focused on Haryana NCR as this part is adjoining to Delhi and faces huge land use/ land cover changes. So, the present study tries to fill this research gap and also provides the latest land use/ land cover changes as well as cropping pattern changes. The present study is a sound effort to examine the past and present scenarios of agriculture in Haryana NCR as this region is more vulnerable as compared to other districts of the Haryana state. Much research has been done on Haryana NCR, but they are related to education, population etc. At present, the agriculture section is more vulnerable in Haryana NCR as it has undergone drastic changes in its cropping pattern and LULC which impacts agriculture sustainability. In this research, the focus has tried to analyze the impact of the present cropping pattern on the socio-economic condition of the farmers and their perspective about sustainability and present agricultural problems arising in the region.

1.4 Scope of the Study

Every person needs three basic things viz. food, clothes & housing in their life and agriculture support to achieve all three necessities. Land resources are limited but the population is increasing day by day, which increases the demand for food. Factors like broken families, improper farming practices, higher use of fertilizers, the small size of land holdings, decreasing water level etc negatively affect agriculture production. So, there is a need for planned development in the field of agriculture which is possible only by the way of sustainability. So, the present research mainly focused on the drastic LULC and cropping pattern changes in Haryana NCR. Due to high growth in built-up section, the valuable agriculture land is continuously decreasing. Also analyses the present socio-economic conditions of the farmers as they are sustainable or not. It is a sound effort to analyses the increasing built-up area so, it would be helpful for policy makers for better urban sprawl planning. Decreasing crop diversification and increasing crop specialization is also analyses through the research.

1.5 Statement of the Problem

Haryana is a leading state in production in the field of agriculture and manufacturing but the state faces so many problems in agriculture like changing cropping patterns, LULC, higher use of chemical fertilizers, and pesticides, decreasing nutrition value of crops, pollution, decreasing soil fertility, decreasing groundwater level, over-irrigation by canals, improper irrigation system, emergence of dark zones etc. In proximity to Delhi NCR, many district of Haryana have undergone huge changes in their LULC pattern. Delhi NCR region takes over fourteen districts out of total twenty-two districts of the Haryana state and there is dire need to make regional and functional plans for these districts. Haryana NCR part faces drastic change in its built-up section due to the nearness to Delhi which is harming overall ecological sustainability of the region. So, only through planning sustainable agriculture development in the NCR region this problem can be addressed in Haryana. Suzanchi, K. & Kaur, R.(2011) did research on Delhi NCR from 1986 to 2006 and concluded that the valuable agricultural land is continuously decreasing in this region due to rapid urbanization and population growth. Sangwan, S. et al (2014) in their research on the Sonipat district resulted that due to the nearness of India's capital Delhi, the LULC pattern within the district changed drastically which is a big threat to agriculture sustainability. India is a developing country and infrastructural growth is necessary at this time but in the race of development, we should not forget about the food security and the future of the coming generation. So, the NCR part of Haryana is facing more acute changes in their LULC and cropping patten. Therefore, there is a need for research in this part so that the changing situation can be analyse with the help of the following objectives.

1.5.1 Objectives of The Study

1. To examine the land use changes in the NCR region of Haryana.

2. To evaluate the changing cropping pattern of the NCR region of Haryana.

3. To examine the socio-economic conditions of the farmers and their perspective on agriculture sustainability

4. To suggest the appropriate measures to attain the sustainable development of agriculture.

1.5.2 Research Questions

1. What is the status of changes in the land use and land cover pattern in the study area?

2. Why do the changes occur in the cropping pattern in the study area?

3. what are the socio-economic conditions of the farmers?

4. What are the crucial factors that determine the attainment of sustainable agriculture in the area?

1.5.3 Hypothesis

1. Increasing irrigation intensity has increased the cropping intensity.
2. Irrigation intensity has a positive impact on the area of the crops like rice, wheat, cotton and negative on bajra, gram, barley.

1.6 Data Base and Methodology

The present study is based primary as well as secondary data collected from different sources viz. District Statistical Handbook, Census Handbook, Directorate of Economics and statistics, Statistical Abstract of Haryana, Central Statistical Newspaper, Books, Journals, Internet etc.

- Department of Agriculture and Farmers Welfare, Haryana- Panchkula•
- Directorate of Economics and Statistics, Ministry of Agriculture, New Delhi
- Economic Survey, Ministry of Finance
- Central Statistical Organization, Ministry of Statistics and Program Implementation.

1.6.1 Indicators

1. Land use/ Land cover: Agriculture and Non- Agriculture

2. Cropping Pattern: Rabi Crops and; Kharif Crops

3. Socio-Economic Condition: Economic and Social

1.6.2 Methodology

In the present study, both analytical and descriptive approaches have been used which are based on primary as well as secondary data sources. Both approaches represent the overall picture of land use/land cover and cropping pattern in the study area and also their socio-economic implication on the farmer's life and also draw a clear-cut picture of the level of sustainability in the agriculture of NCR Region of Haryana state. There are some key issues related to the boundaries of the tehsils are as follow: -

- The number of the tehsil has changed during the study period as there were 31 tehsils in NCR Haryana in 1990, while in 2021, there were 52 tehsils in NCR Haryana and no efforts were made by the government to make separate data series for the newly constructed tehsil/district for past years.

- So, to evaluate the changes and growth in certain parameters, you may create essential data for these blocks/tehsils/districts for previous years or join together both the block new and old (Bhalla and Singh-2001, Meenakshi, R. and Indumathy. R. 2009).

- This is not possible to create new data series for previous years. So, in the present research, newly formed tehsils have been merged with old tehsils.

1.6.2.1 Objective Wise Methodology- Land use/land cover Changes in Haryana NCR

The selection of the satellite was based on two rules: -

- Satellite must have less than 10% cloud cover.
- The selected satellite series should be obtainable for long time series.

To show land use / Land cover changes from 1991 to 2022 with the land use/ land cover map based on satellite imageries of the different years. For the present study, Landsat 5 data has been used for the preparation of LULC maps for the years 1991 and 2006 and Lansat(OLI) 8 for the year 2022. Satellite imageries were downloaded from the USGS site. Arc GIS 2010 and ERDAS IMAGINE 2014 software have been used for the preparation of the maps and change detection. Both the sensors (OLI & TM) are mainly used for the LULC, forest, vegetation and water body monitoring and mapping. Landsat imageries were downloaded from the USGS portal (http://earthexplorer.usgs.gov/). The details of the satellites are as follows: -

- Land use/ land cover map of 1991- Landsat (5TM)
- Land use/land cover map of 2006- Landsat (5TM)
- Land use/ land cover map of 2022- Landsat (OLI)

Table: - 1-details of satellites

Sr. no.	Sattelite	Sensor	Cloud Cover	Month/year of the used imagery	Resolution	Bands
1	Landsat 5	Thematic Mapper (TM)	4.15%	March 1991	30 m	7
2	Landsat 5	Thematic Mapper (TM)	4.15%	March 2006	30 m	7
3	Landsat 8	Operational Land Imager (OLI)	3.5%	March 2022	30m	9

Fig. 1- Methodology, workflow, and Interpretation

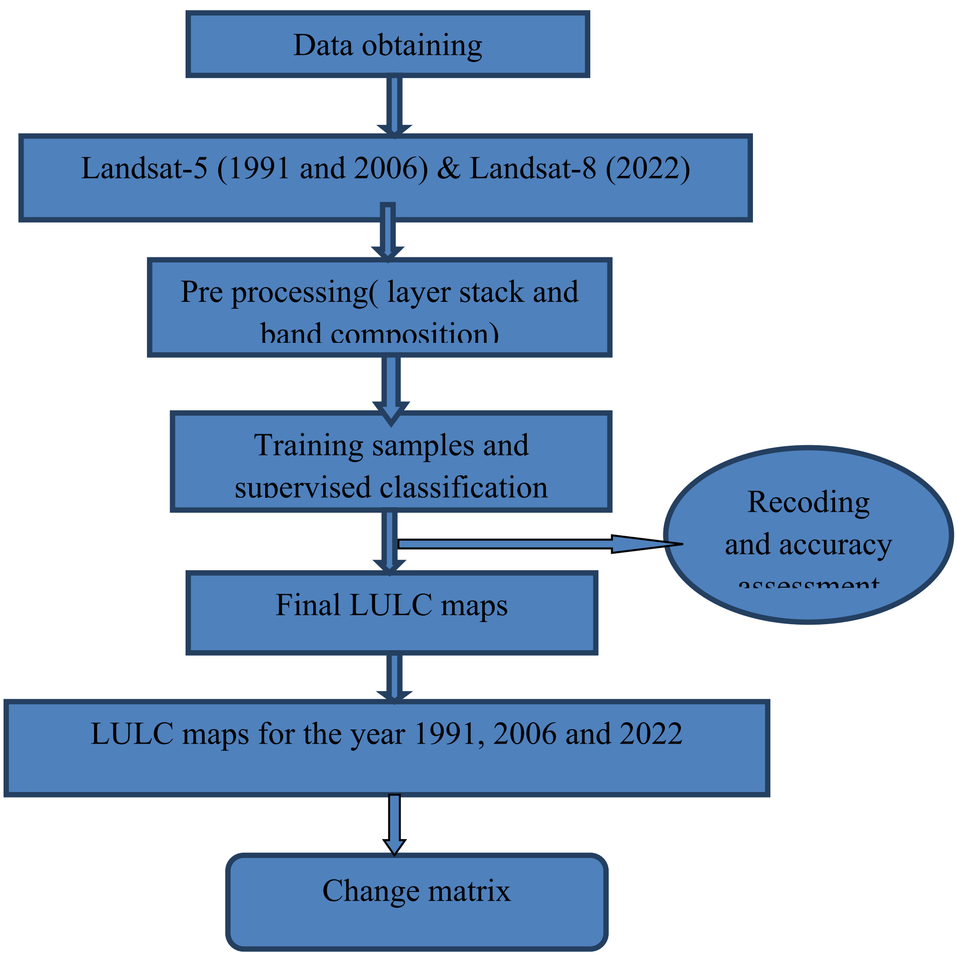


Table: -2 Land Use/ Land cover classification scheme

Sr. no.	Land use/Land cover classes	Details of the classes
1	Waterbody	Rivers, Canals, Ponds/Lakes, Reservoir
2	Vegetation	All-natural vegetation, plantations
3	Agriculture land	Cropland
4	Settlements	Residential-urban/rural, industrial, roads, railways, playgrounds, institutions, etc.
5	Barren land	Barren rocky, Sandy area, scrubland, salt affected

1.6.2.2 Objective 2- To evaluate the changing cropping pattern of the NCR region of Haryana.

To examine the cropping pattern change, secondary data is collected from different sources and framed different tables for the average of three years 1991-1992, 1992-1993, 1993-1994 and 2018-2019, 2019-2020, 2020-2021. To show the spatial and temporal changes in cropping pattern in NCR Haryana, two spatial units are used- changes at overall NCR Haryana and at the tehsil level for the years 1991-94 to 2018-2021. The objective is defined under the following headings-

1. Cropping pattern change in major crops
2. Cropping intensity
3. Crop rank
4. Crop diversification index
5. Irrigation intensity
6. Hypothesis testing

Crop Diversification Index- Jasbir Singh (1976) used this formula to understand the spatial pattern of crop diversification in Haryana and all the crops which occupied 5% or more of the total cropped area, were included.

Crop Diversification Index- Percent of total cropped area under N crops/ Number of N crop

Cropping intensity- Gross cropped area/ Net sown area*100

Irrigation Intensity- Gross irrigated area/ Net irrigated area *100

Correlation: -

Correlation has been used for analysing the relationship between different socio-economic variables. Correlation Coefficient (r) has been computed by Karl Pearson's method.

Formula: $\frac{\sum(X-\bar{X})(Y-\bar{Y})}{\sqrt{(X-\bar{X})^2\sum(Y-\bar{Y})^2}}$

It is represented by the letter r, which varies from -1 to +1. A zero correlation indicates that there is no correlation between the variables. The correlation is considered to be very low if the coefficient has a value under 0.20 and is considered as low if the value ranges between 0.21 and 0.40. A coefficient value of above 0.70 is considering high correlation.

Cartographic Techniques

Cartographic techniques including bar diagraph, and choropleth using GIS map, have been used to show the regional pattern of land use/land cover, cropping pattern and socioeconomic conditions of different sections of the society.

1.6.2.3 Objective-3 To examine the socio-economic conditions and their perspective about agriculture sustainability

A primary survey has been conducted to know the ground level conditions of the farmers. To fulfil the 3rd objective, a detailed questionnaire has been prepared which includes both farmers socio-economic conditions as well as their perspective about agriculture sustainability. On the local level, factors affecting crop selection like water conditions, market facilities, social factors and also the present problems which the farmers face at time like decreasing water table, soil degradation, health issues and their reasons, low production, over use of fertilizers etc. To fulfil the objective, stratified random sampling method is applied for selection of the village for primary survey. Accurate sample has been calculated with the help of the following formula: -

Taro Yamnee:- $n=N/(1+N(e)^2)$

N=number of total cultivators

(e) = sampling error (0.05)

Table 3- List of Selected Block and Villages for the Primary Survey

Sr.no	District	Block	villages	No. of cultivaters	Sample size
1	Karnal	Indri	Jundla	543	20
			Bahlolpur	217	8
			Gularpur	580	20
2	Panipat	Panipat	Sewah	912	32
			Rajakheri	403	14
			Palheri	118	5
3	Panipat	Smalakha	Raksehra	371	13
			Kiwana	566	20
			Haldana	257	9
4	Bhiwani	Tohsham	Sandwa	1940	68
			Nigana	236	8
			Khawa	387	10
5	Jhajjar	Beri	Majra	1462	53
			Malikpur	268	10
			Palra	288	10
6	Mahendergarh	Nagal Choudry	Sirohi	569	20
			Morund	241	8
			Amarpura	148	5
7	Nuh	Nuh	Ujina	442	16
			Rehna	287	10
			Chhapera	133	5
8	Rewari	Bawal	Sulkha	288	10

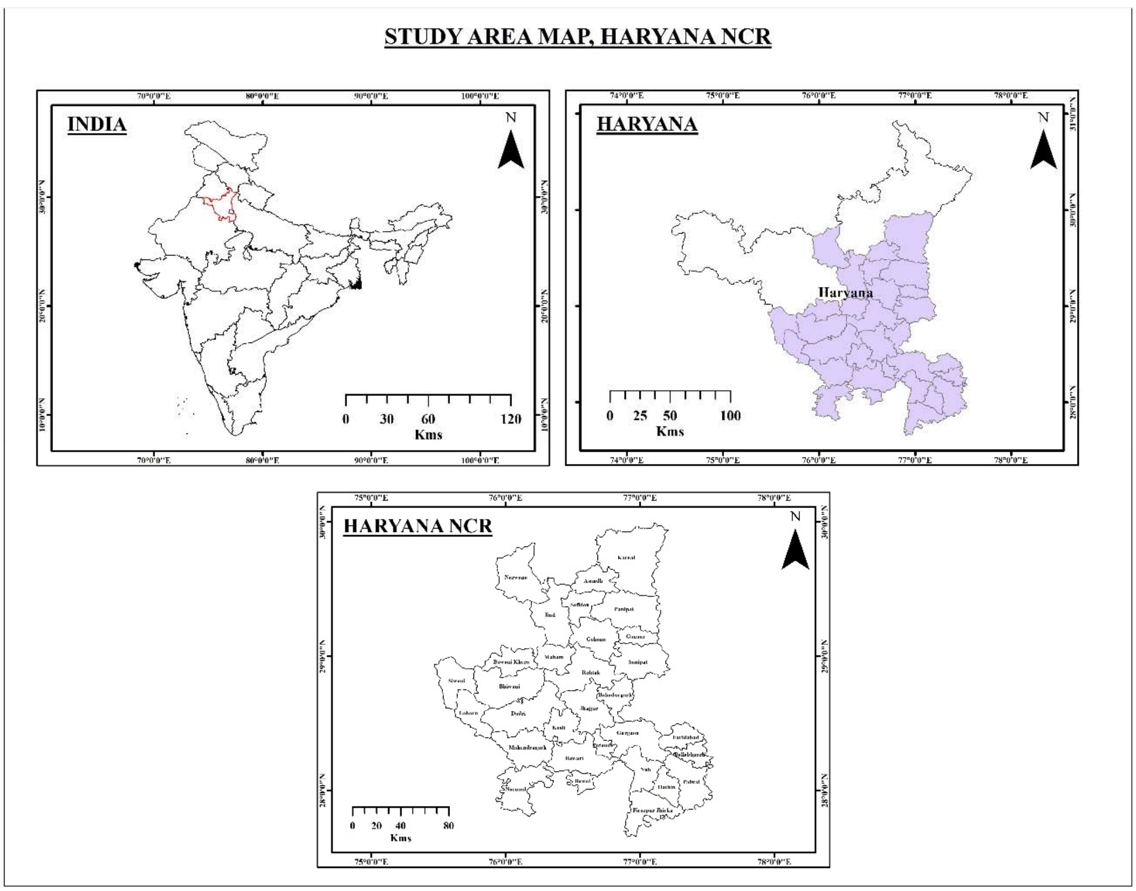
			Rasiawas	230	8
			teekla	212	8
Total	7	8	24	11098	390

Sampling has been done in three stages. In the first stage, all the districts have been divided into three classes based on net sown area namely high, medium & low net sown area and selected seven districts with the help of systematic random sampling technique. In the second stage, all the blocks of the seven districts were classified into three categories based on net sown area and then selected the eight blocks with a systematic random sampling method. In the third stage, all the villages of each block have been divided into three classes and chose very first village from each class. After the list of the village-wise cultivators has been downloaded from the census and then calculated the 3.5% of the total cultivators. After this, the number of cultivators was divided into three groups based on their social category. in Haryana, 40% of the total population belongs to the General category, 40% belongs to the Backward category (BC) 20% to the Schedule class(SC). There are 11098 cultivators in all the selected villages, according to the formula, 390 is the accurate sample number and it covered almost 3.5 percent of the total cultivators.

1.7 Study Area

The National Capital Region is a central planning region that was developed by the National Capital Planning Region Board in 1985. It covers the area of Delhi and some other adjoining states- Uttar Pradesh, Haryana and Rajasthan. The National Capital Region Planning Board (NCRPB) is the planning body for the entire NCR. Haryana state has the highest area under NCR and it covers 14 districts of the state with an area of 25327 km^2 which covers 57 percent of the entire state and the population is 1.64 crore. It covered 54.97% area of the total NCR area. Bhiwani is the largest district which covers 3432 km sq. area of Haryana in the NCR region and Charkha Dadri is the smallest district in Haryana NCR covering 575 km^2 Area (fig. 2).

Fig. 2- Location Map of Haryana NCR



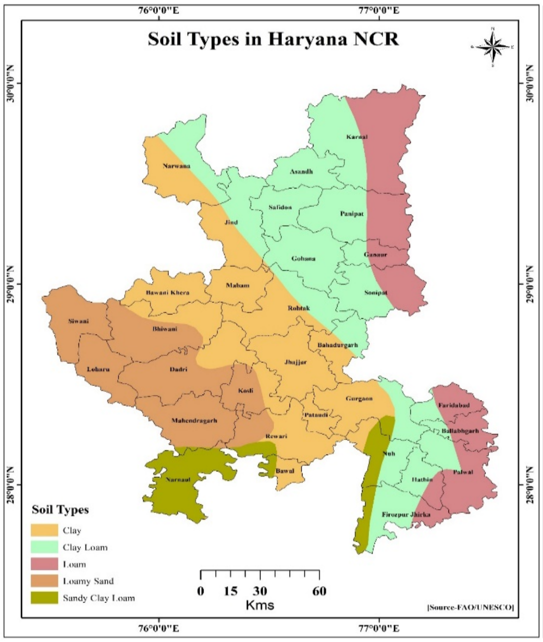
1.7.1 Physical Division of Haryana NCR

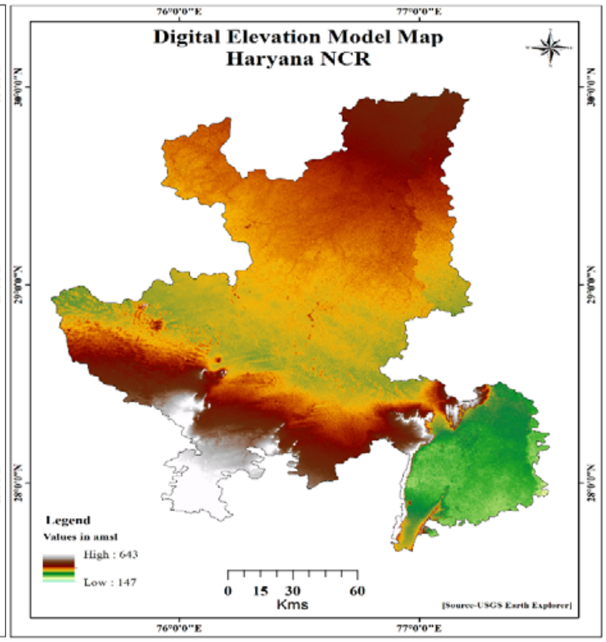
Agricultural pattern of any region is totally the by-product of its relief structure and also led direct impact on the soil structure, usability of the modern techniques and also LULC pattern. Agricultural development is also flourished in low elevated areas as here, farming is very easy due to best use agricultural machines. Now a days, digital elevation model (DEM) is best suited for showing topographic surface of any area. It is free of cost available and USGS DEM is commonly used to fulfill the requirements. Most of the area of Haryana NCR is below 300 meters as it is the part of Indo-Gangetic plains. So, the agriculture pattern of the Haryana NCR is not highly affected by its relief structure. If we talk about slope, it is North-east to southwest for most of the area but for Bhiwani, Mahendergarh, Loharu, Rewari, Kosli, Bawal and Gurgaon, the slope is south towards North. Overall, we can say that the slope is gentle for most of the area except Bhiwani, Mahendergarh, Narnoul, Rewari and Gurgaon. Agricultural growth is also different in North-East and South-West tehsils due to flat surface and rocky structure in both the areas (fig. 4).

1.7.2 Types of Soils in the NCR region of Haryana

Soil is a very important factor for plant growth as it determines the crop selection, production, intensity. For plant growth and germination is not possible without soil. So, soil structure, parent material, formation process, climate etc. are the helping factors of the development in the soil fertility. In NCR region of Haryana, different types of soils are found due to difference of physiography and climatic conditions namely clay, clay loam, loam, loamy sand and sandy clay loam (fig. 3).

Fig. 3- Types of the Soil and Fig. 4- Relief Structure of Haryana NCR





1- Loam: - it includes the soil which is made from sand, clay and silt. It is very fertile and is also spread in major parts of the following tehsils namely Karnal, Panipat, Ganour, Sonipat, Faridabad, Ballabgarh, Palwal and Hathin. It is found in north-eastern part of the study region and also called khaddar. It is very fertile in nature and also rich in nutritional factors.

2- Clay Loam: - it is a composite mixture of clay and silt which covers a major part of the following tehsils namely Karnal, Assandh, Gohana, Panipat, Ganour, Sonipat, Safidon, Jind, Narwana, Gurgaon, Nuh, Palwal, Firojpur Zirkha, Faridabad. It is also very fertile in nature and supports so many crops to grow within it.

3- Clay soil:- soil which includes finest particles of soil are called clay type soil. It is found in the following tehsils; Bawani Khera, Maham, Rohtak, Jhajjar, Bhiwani, Rewari, Bawal etc.

4- Loamy Sand: - it is a good if irrigation facilities are available and spread in following tehsils mainly Siwani, Loharu, Bhiwani, Mahendergarh and Kosli. All these tehsils are connected to Rajasthan boarder. Here, sprinkle irrigation method is best suited for crop cultivation.

5- Sandy Clay Loam: - it is also less fertile and low in nutrition value for crop production. It has more sandy structure and found mainly tehsils Narnoul, some parts of Rewari, Bawal, Nuh and Firojpur Zirkha.

1.7.3 River and Canal System in Haryana NCR-

There are a few rivers which are flowing through the NCR region of Haryana like Sahibi(which is called Najafgarh drain), Dohan (originates in Jhunjhun and disappears in Mahendergarh), Krishnawati (also disappears in Mahendergarh) and Indori(originate in Sikkar and flows in Rewari). There is only one dam in Haryana NCR which is known as Anagpur dam in Faridabad on the Hakra river. Some lakes are also present in south Haryana like Badkhal and Surajkund in Faridabad, Damdama in Gurgaon and Karnal lake in Karnal. Dhosi hill is a very beautiful example of an extinct volcano and a beautiful tourist place in Mahendergarh with 345 to 470 m height from the nearby land and 740m from sea level.

1.7.4 Demography in Haryana NCR

Population is the most important agent for driving changes in every sector of the world as everything is revolving around them. Humans are making a lot of changes in nature to fulfill the requirements of the growing population. The population of the Haryana NCR is growing very fast as it was 9.8 million in 1991, 13.4 million in 2001 and reached 16.4 million in 2011. Urban population is also increasing very fast as it was 3.3 million in 1991, 5.4 million in 2006 and 6.5 million in 2011. Urbanization level of Haryana NCR has remained higher as compared to all over Haryana urbanization level. Haryana NCR urbanization is 30.3% in 1991, 33.7% in 2001 and 36.2% in 2011 whereas, urbanization level of all over Haryana state was 24.6% in 1991, 28.9% in 2001 and 34.9% in 2011 (Census of India). So, it is clearly depicted that both population growth and urbanization level are high in Haryana NCR which affect it LULC pattern highly as compared to all over Haryana (Fig. 5)

Fig. 5- Growth of Total Population and Urban Population

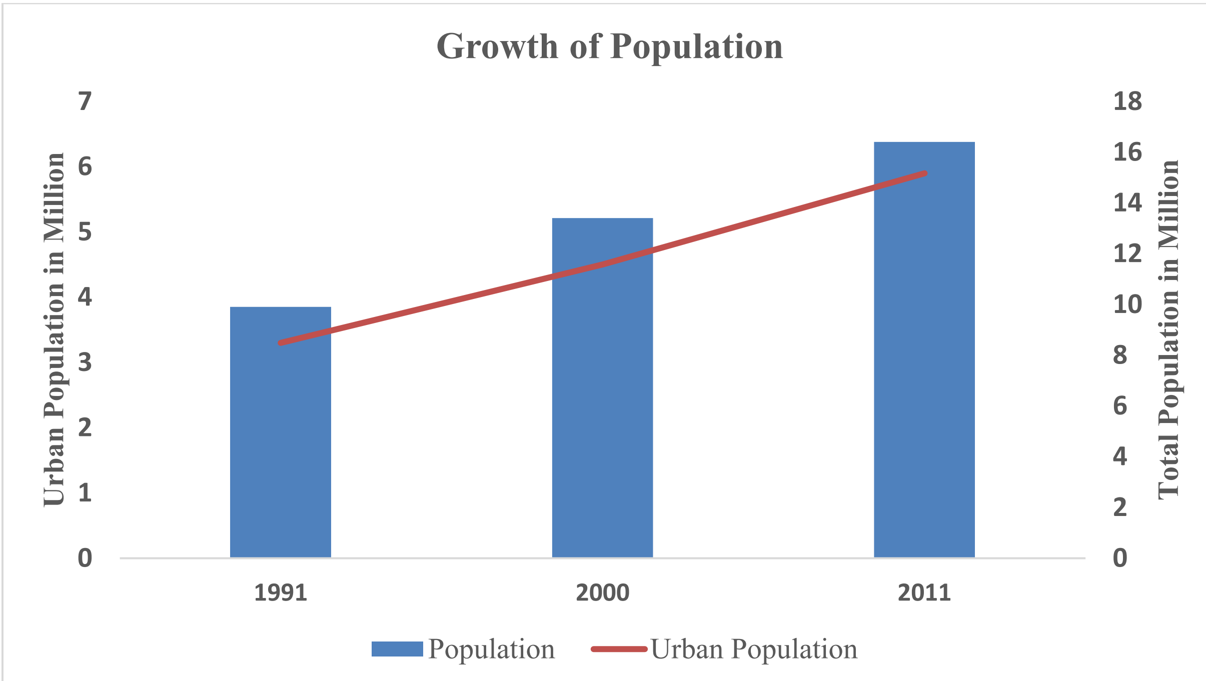


Fig. 6- Population Growth- Tehsil wise

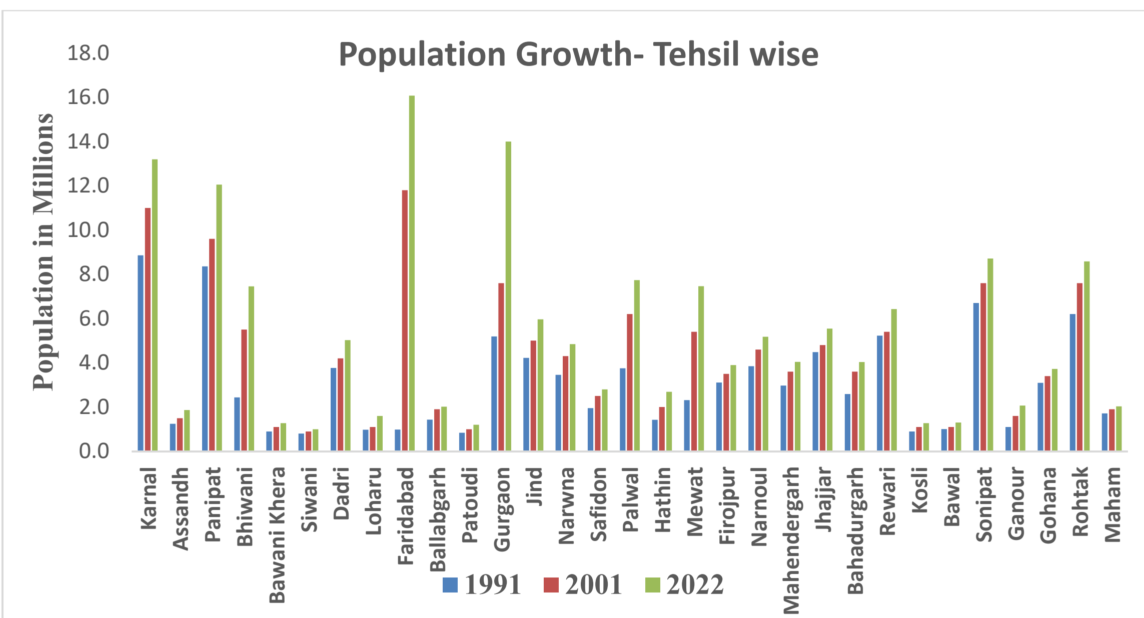
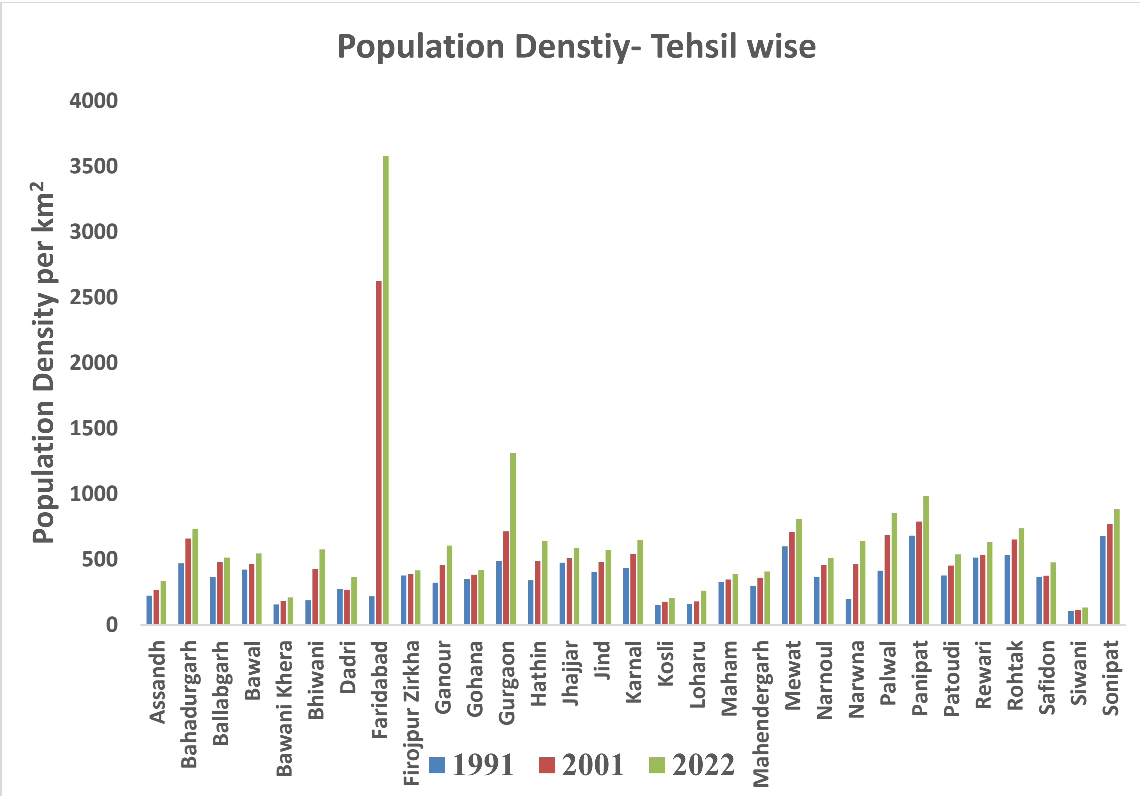


Fig. 7- Changes in Population Density- Tehsil wise



Population Growth: - As fig. 6 and 7 are showing the changes in population growth and density and reflected that there is a continous growth in population and density among all the tehsils of the Haryana NCR. The total population in millions for the years 1991, 2001 and 2011 among all the tehsils is respectively 8.9, 11, 13.2 in Karnal; 1.2, 1.5 and 1.9 in Assandh; 8.4, 9.6 and 12.1 million in Panipat; 2.4, 5.5 and 7.5 million in Bhiwani; 0.8, 0.9 and 1.0 million in Siwani; 3.8, 4.2 and 5.0 million in Dadri; 1.0, 1.1 and 1.6 million in Loharu; 1.0, 11.8 and 16.1 million in Faridabad; 1.4, 1.9 and 2.0 million in Ballabgarh; 0.8, 1.0 and 1.2 million in Patoudi; 5.2, 7.6 and 14.0 million in Gurgaon; 4.2, 5 and 6.0 million in Jind; 3.5, 4.3 and 4.8 million in Narwana; 2.0, 2.5 and 2.8 million in Safidon; 3.8, 6.2 and 7.7 million in Palwal; 1.4, 2 and 2.7 million in Hathin; 2.3, 5.4 and 7.5 million in Mewat; 3.1, 3.5 and 3.9 million in Firojpur Zirkha; 3.8, 4.6 and 5.2 million in Narnoul; 3, 3.6 and 4.0 million in Mahendergarh; 4.5, 4.8 and 5.5 million in Jhajjar; 2.6, 3.6 and 4.0 million in Bahadurgarhj; 5.2, 5.4 and 6.4 million in Rewari; 0.9, 1.1 and 1.3 million in Kosli; 1, 1.1 and 1,3 million in Bawal; 6.7, 7.6 and 8.7 million in Sonipat; 1.1, 1.6 and 2.1 million in Ganour; 3.1, 3.4 and 3.7 million in Gohana; 6.2, 7.6 and 8.6 million in Rohtak and 1.7, 1.9 and 2.0 million in Maham.

Population Density: - Population density also increased in all the tehsils from 1991 to 2011 and it increased in all the study years namely 1991, 2006 and 2022 by 224, 269 and 335 persons/ km^2 in Assandh; 471, 659 and 734 in Bahadurgarh; 366, 479 and 515 in Ballabgarh; 423, 464 and 546 in Bawal; 157, 181 and 210 in Bawani Khera; 189, 426 and 577 in Bhiwani; 274, 269 and 365 in Dadri; 219, 2625 and 3581 in Faridabad; 377, 388 and 416 in Firojpur Zirkha; 322, 457 and 606 in Ganour; 349, 383 and 420 in Gohana; 488, 714 and 1310 in Gurgaon; 340, 486 and 642 in Hathin; 475, 509 and 588 in Jhajjar; 405, 480 and 572 in Jind; 437, 542 and 650 in Karnal; 153, 177 and 205 in Kosli; 160, 180 and 262 in Loharu; 328, 347 and 388 in Maham; 299, 360 and 408 in Mahendergarh; 600, 709 and 807 in Mewat; 366, 455 and 513 in Narnoul; 200, 463 and 643 in Narwana; 414, 686 and 854 in Palwal; 682, 789 and 984 in Panipat; 377, 453 and 539 in Patoudi; 514, 535 and 633 in Rewari; 533, 652 and 738 in Rohtak; 367, 376 and 477 in Safidon; 107, 113 and 134 in Siwani and 679, 770 and 883 in Sonipat respectively. The highest population density is in Faridabad tehsil followed by Gurgaon tehsil and both of them are attached with territory of Delhi.

So, in NCR region of Haryana, population growth and urbanization level are much higher than all over Haryana. LULC changes are more frequent in this part of Haryana state. It is an urgent requirement to do more research on this part as it is highly dynamic in nature due to the nearness of Delhi proximity.

1.8 Chapterisation Scheme: -

The present research is bifurcated in following Chapters: -

Chapter 1: - it is entitled with 'Introduction' which give a brief introduction of the research. It also gives detailed review of literature, research gap, scope of the research, statement of the problem, objectives, methodologies, sampling procedure and physiography and demographic profile of the study area.

Chapter 2: - it deals with first objective i,e ‘To examine the land use changes in the NCR region of Haryana’. It deals with LULC changes in Haryana NCR from 1991 to 2022 with the help of imageries.

Chapter 3: - It deals with second objective ie ‘To evaluate the changing cropping pattern of the NCR region of Haryana’. It is showing the changes in cropping pattern, cropping intensity, crop-rank, crop diversification, irrigation intensity and their correlation and hypothesis testing.

Chapter 4: - third objective ‘To examine the the socio-economic conditions and perspective about agriculture sustainability’ has been divided in to two parts. First part is showing the socio-economic conditions and their relationship with some important socio-economic indicator with the help of Chi-square test at the 0.05 level of significance.

Chapter 5: - it deals with the second part of the third objective ‘Farmers perspective about agriculture sustainability’ and it deals with farmer’s awareness regarding sustainability concept, major agricultural problems, economic sustainability.

Chapter 6: - this chapter presents the major results and finding of the research, conclusion and also give appropriate suggestions to attain the sustainable agriculture development.

Chapter-2

LAND USE / LAND COVER (LULC) DYNAMICS OF HARYANA NCR

2. Introduction

The term land use means the use of available land in different ways like area under forest, tree crops, fallow land etc. It is a difficult phenomenon that highly depends on different variables like climatic as well as socio-economic factors. Technological factors also affect land use from time to time. The conversion in the environment of the earth started in the late Pleistocene and the same conversion became faster due to agricultural and other development activities (Stephens et al., 2019). The prime indicator for showing man-environment association is LULC change (Gregorio, 2016). we observe a sharp shift of land use from agriculture to non-agriculture and how this shift affected the area percentage in negative in different sections of land use like tree crops area and cultivable wasteland. (Gairhe S. et al., 2011). Worldwide conversion in LULC is the result of growing human needs, starting from basic to endless aspirations (Foley et al., 2005). LULC is playing the role of a catalyst for universal environment conversion ie. natural terrain, ecosystem diversity, air quality, and decreasing mankind welfare (Lambin, et al., 2000, MEA, 2005). During last two or three decades, the LULC has faced huge transformations due to many reasons natural as well as man-made (Hassan et al., 2016). All the developing countries have undergone huge LULC changes as they had population pressure, growing urban expansion, infrastructural development etc. (Sangwan, S. et al 2014, Saroj et al ,2014).

The environment of the earth had gone through many changes due to man-generated LULC changes like highly polluted cities, negative impacts on biodiversity, water cycle, water purity, air standards, etc.(Bailey, McCleery, Binford, & Zweig, 2016, Sun et al., 2016, Das & Das, 2019) A research in the southern Haryana shows that the agriculture land has decreased a lot. So, present land use/land cover changes are very harmful to the mankind and ecosystem (Chaudhary B.S. & Sinha, A.K. 2003). As the land is being used for other activities, the temperature of the earth's surface is also increasing which is a big threat to mankind (Dutta et al. (2019), and the environment is also affected highly by changes in LULC (Talukdar et al. (2020). There has been a lot of research published about LULC changes throughout the world concerning itself with the side effects of LULC changes on the natural environment. This research also has suggested ways for the management and better plans for the use of natural resources (Lai, 2020, Fenta, et al., 2017). Urban sprawl would be the most effective factor for the change in LULC pattern which included both planned and unplanned settlements (Seema et al, 2015). Most of the urban expansion was faster along with main transportation routes of the cities (Kumar, J., 2022). Most of LULC changes occurred in the built-up section due to increasing population, urban sprawl, and industrial and infrastructural growth in the NCR region of Delhi (Suzanchi, K. & Kaur, R. (2011), Naikoo, M.W. et al(2020)). Population pressure planned and Unplanned sprawl of urban areas, and infrastructural and industrial growth are the major reasons behind the LULC change in the Sonipat district of Haryana state (Saroj et al ,2014, Seema, et al 2015). Underground water is also decreasing due to heavy changes in LULC patterns in Sonipat & Rohtak district and due to the nearness to New Delhi. Both the cities have seen the fastest growth in built up area (Sarkar, A. et al. 2020).

Remote sensing and GIS techniques are the most powerful assets for LULC change detection because it presents the exact picture of any area(Chaudhary B.S. et al, 2003, Wang, S.W. et al(2020) There have been many studies conducted on the detection of LULC changes through remote sensing and GIS techniques and different methodologies like indices based index, cellular automata, Markov chain, expert system classification approach, supervised, unsupervised, and maximum likelihood (Wang et al(2020), Hassan et al., 2016). Supervised and unsupervised classification are the highly used techniques for mapping LULC changes (Lang et al., 2008). Some of the research focused on the problem of LULC changes that occurred due to migration as it also enhanced the pressure on cities and degraded their LULC pattern (Chen, R. et al., (2014), Naikoo, M.W(2020).

Many studies have been done about the LULC changes in Haryana state as well as Delhi NCR region, but NCR Haryana needs attention separately as compared to Haryana state because this region has undergone crucial changes in LULC due to nearness to the capital of India. It covered 57% of the Haryana and 54.9% area of the NCR region(fig.no.1.1). So, Delhi NCR covered the highest area of the Haryana state as compared to other states.

Though Haryana is a leading state in foodgrain production in India due to these LULC changes, its agricultural land is continuously decreasing. The population density of NCR Haryana was 440 persons per square kilometre in 1991(census, 1991) which reached 651 persons/sq. km in 2011(census, 2011), and the population density of Delhi was 6352 p/sq. km in 1991 which reached 11,297 in the 2011 census. The present study is focused on Haryana NCR separately because it faced huge changes due to rapid population growth and urbanization. Urban expansion is much higher in NCR Haryana as compared to the rest of Haryana. The population of NCR Haryana was 11.1 million in 1991 which reached on 16.5 million in 2011. In 1991, 24.6% of people in Haryana and 30.3% of people in NCR Haryana were living in urban areas and according to the 2011 census, 34.9% in Haryana and 36.9% in NCR Haryana were living in urban areas. Population growth and urbanization are playing a key role in LULC change in Haryana as well as NCR Haryana.

In the present research, land use/land cover interpretation is shown by two areal units for spatial-temporal analysis-

1. Land use/ Land cover changes in Haryana NCR
2. Land use/ Land cover changes- Tehsil wise.

2.1 Data Base and Methodology

Satellite imagery data, which was downloaded from USGS Earth Explorer with login credentials was used for the map preparations. All the LULC maps have been prepared in Erdas Emagine software (2014 version) with a signature table and supervised classification approach. The final layout of LULC maps of NCR Haryana and all the tehsils are created with the help of Arc GIS (2010 version) software. Landsat 5 (TM) has been used for LULC mapping for the years 1991 and 2006 and Landsat8(OLI) for the year 2022. All the satellite imageries are freely available.

2.1.1 Pre-processing-

First, we downloaded the satellite imageries for the years 1991, 2006 and 2022, then by going to arc GIS, layer stacking was done. For Landsat 5 TM, all seven bands were composed together with the help of the band composite tool. After band composition, with the help of the shape file of the study region, the imagery for the desired region was clipped. Five major land use/land cover classes were identified from the study region namely agriculture, built-up, vegetation, barren land, and water body. Haryana is blessed with good soil and topographic conditions, that's why, only five classes are identified, and the classification scheme is given below: -

Table: - 2.1 Land Use/ Land cover classification scheme

Sr. no.	Land use/Land cover classes	Details of the classes
1	Waterbody	Rivers, Canals, Ponds/Lakes, Reservoir
2	Vegetation	All-natural vegetation, plantations
3	Agriculture land	Cropland
4	Settlements	Residential-urban/rural, industrial, roads, railways, playgrounds, institutions, etc.
5	Barren land	Barren rocky, Sandy area, scrubland, salt affected

Source- National Remote Sensing Centre (NRSC) ISRO

2.1.2 post-processing: -

After the pre-processing, with the help of Erdas Imagine 2014 software, a signature editor table was made and the AOI (Area of Interest) was selected. Further, it was added to the particular class and after that more and more signatures from all the LULC classes from the imagery were selected. Then after going to the raster, the supervised classification tool was selected, and the signature table was added to it. Thus, the initial map of LULC was prepared. The recoding tool can also be used to change the desired field with the help of AOI if any error is found in mapping.

2.1.3 Accuracy Assessment

Evaluation of the accuracy of any classification is a necessary pre-condition for LULC mapping and is used to test the accuracy level of the LULC maps (Mishra, Rai, & Rai (2019). It is performed by the results of the image processing using an error matrix and Kappa coefficient method (Naikoo et al, 2020, Wang 2020, Manandhar et al 2009). Accuracy evaluation has increased the quality of the research and provides better results which are also helpful for policymakers, but the assessment results should be more than 80 per cent (Keshtkar, et al., 2017). For the present study, the kappa co-efficient and error matrix has been prepared for accuracy assessment. Table 1.1 shows the accuracy assessment of the LULC mapping process and for the outcome, 3000 stratified random points were selected for the years 1991,2006 and 2022. All the selected points are cross-checked by ocular elucidation of reference imageries, field tours, Google Earth and also LULC data available on the Bhuvan portal.

Table 2.2- Accuracy Assessment

Year	Accuracy Assessment	Water Body	Vegetation	Agriculture	Built-Up	Barren Land
1991	User Accuracy	0.86	0.98	0.96	0.93	0.92
	Producer Accuracy	0.70	0.56	0.99	0.92	0.62
2006	User Accuracy	0.96	0.98	0.98	0.96	0.95
	Producer Accuracy	0.82	0.88	0.99	0.94	0.76
2022	User Accuracy	0.91	0.92	0.99	0.94	0.98
	Producer Accuracy	0.91	0.85	0.99	0.99	0.82

Source: - Calculated by the Researcher with ARC GIS

Table 2.2 shows the results of the accuracy assessment for the concerned years. Accuracy of the user, producer, omission error, and commission error has been calculated for all the LULC classes for the years 1991, 2006, and 2022. Kappa coefficient values are 0.8 for the years 1991 and 0.9 for the years 2006 & 2022 and Overall accuracy values are 95%, 98%, and 98% for the years 1991, 2006 & 2022 respectively. User accuracy values range between 86% to 98% in 1991; 95% to 98% in 2006, and 91% to 99% in 2022 and producer's accuracy remains betwixt 56% to 92% in 1991, 76% to 99% in 2006, and 82% to 99% in 2023. Due to spectral similarities between vegetation & agriculture land and water body and agriculture land, some misclassification errors have occurred and may be the cause of low accuracy in these classes.

2.2 Results and Discussion

In the current chapter, we meticulously delve into the intricate dynamics of Land Use and Land Cover (LULC) in Haryana's NCR spanning the temporal expanse from 1991 to 2022. This exploration is facilitated by the meticulous analysis of Landsat data for pivotal years – 1991 (Landsat 5 TM), 2006 (Landsat 5 TM), and 2022 (Landsat 8 OLI). The year 1991 acts as a temporal anchor, setting the baseline for our investigation. As we traverse through time to 2006, pivotal transformations begin to emerge, marking the initial phases of shifts in land utilization and coverage. The culmination of our study in 2022 brings to light the contemporary state of LULC dynamics in Haryana's NCR, allowing for a comprehensive evaluation of the long-term trends and emergent patterns. This chapter serves as a visual and analytical journey through the altering facets of Haryana NCR's land use and cover, employing robust satellite data to peel back the layers of temporal change. The ensuing discussion not only unravels the empirical evidence but also engages with the implications and significance of these transformations, laying the groundwork for a comprehensive evolving dynamic in Haryana's NCR.

2.2.1 LULC Changes in Haryana NCR

With the help of satellite imageries, LULC maps have been prepared for the years 1991, 2006 and 2022 which resulted as follows: -

Fig. 2.1 shows the real-time image of the Haryana NCR which clearly shows the highest positive change in built-up. Fig. 2.2 shows the LULC changes and reflects that in the year 1991, agriculture had the preponderance all over the region as it covered almost 88.7 per cent of the study area and area under all the LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively 22463.3km^2 (88.7%), 1218.3km^2(4.8%), 936.4km^2(3.7%), 218.1km^2(0.9%) and 477.7km^2(1.9%) in 1991whereas in 2006, it is 22412.7km^2 (88.5%), 1024.4km^2(4.0%), 1322.7km^2(5.2%), 123.3km^2(0.5%) and 430.2km^2(1.7%) respectively. In 2022, the area under all the LULC categories is 20487.3km^2 (80.9%), 865.1km^2(3.4%), 3469.5km^2(13.7%), 100.4km^2(0.4%)

and 391km^2(1.5%) respectively. LULC maps have been prepared for the years 1991, 2006 and 2022 which showed that land use/ land cover has had the most negative impact on agricultural land which was 22463.3km^2 ^{in} the year 1991 and decreased by 1925.5 km^2

(-7.6%) (Table 2.3 (a).

Fig. 2.1- Landsat Imageries of Haryana NCR for the year 1991, 2006 and 2022

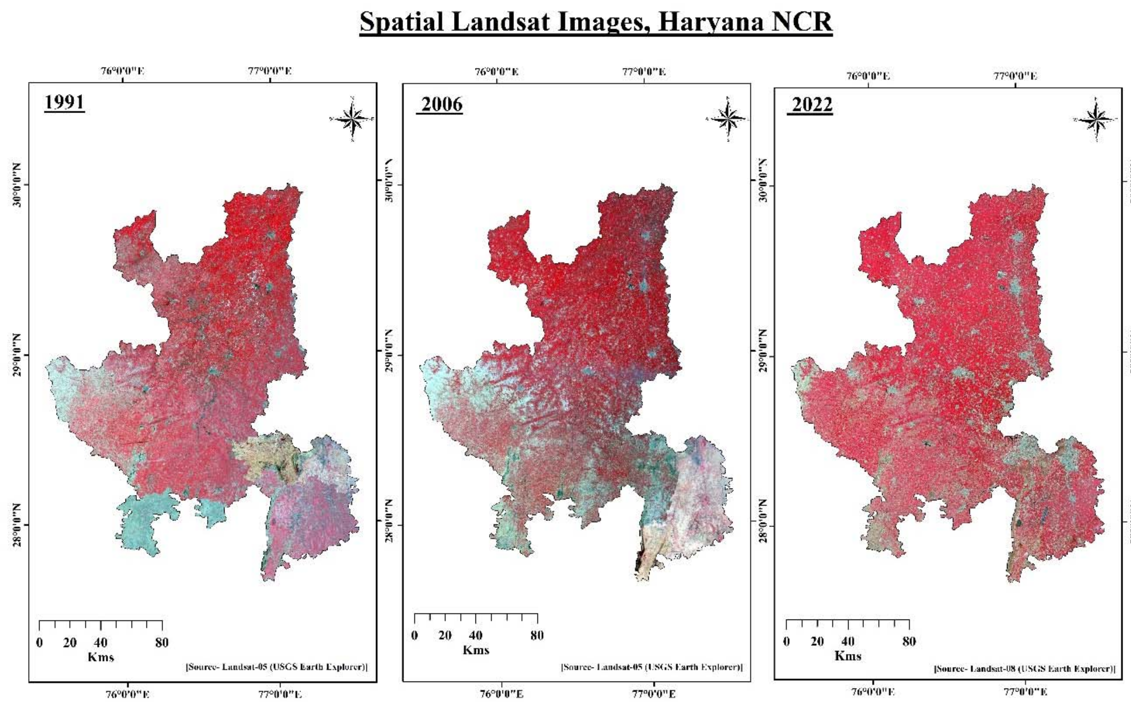


Fig. 2.2-LULC Cover Changes in Haryana NCR for the year 1991, 2006 and 2022

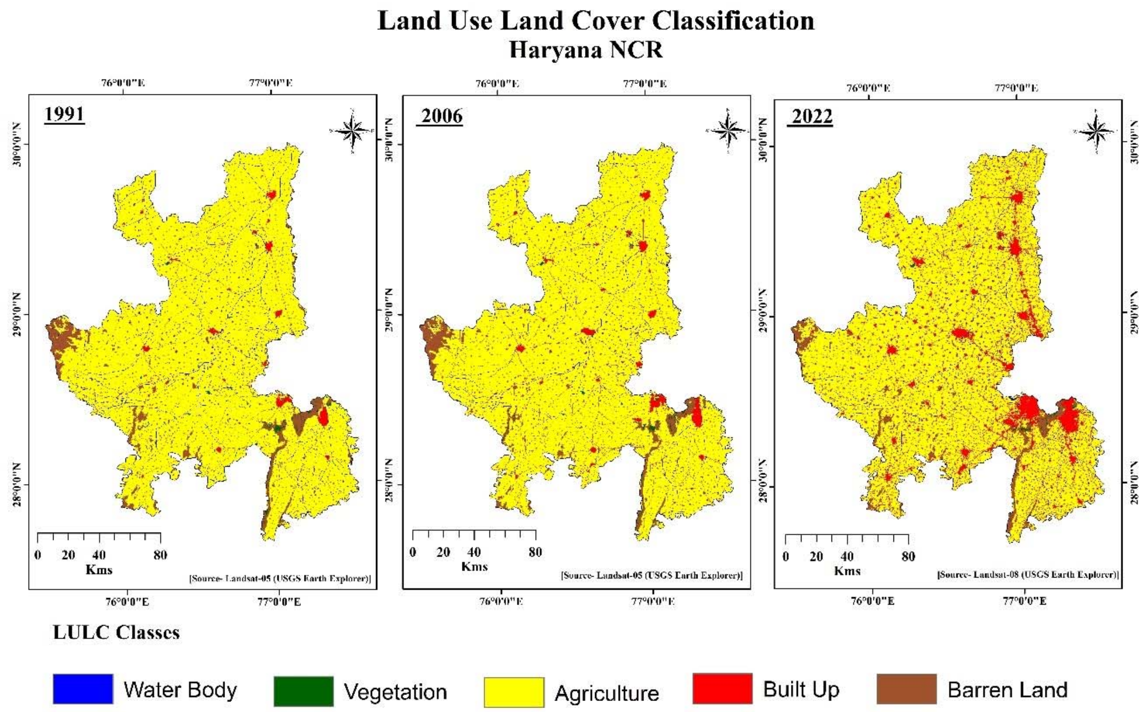


Table 2.3:- (a) LULC in Haryana NCR- Since 1991 to 2022

LULC Classes	1991		2006		2022	
	Area in km^2	Area in %	Area in km^2	Area in %	Area in km^2	Area in %
Agriculture	22463.3	88.7	22412.7	88.5	20487.3	80.9
Barren land	1218.3	4.8	1024.4	4.0	865.1	3.4
Built Up	936.4	3.7	1322.7	5.2	3469.5	13.7
Vegetation	218.1	0.9	123.3	0.5	100.4	0.4
Water Body	477.7	1.9	430.2	1.7	391.0	1.5
Total	25313.7	100.0	25313.3	100.0	25313.3	100.0

Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher

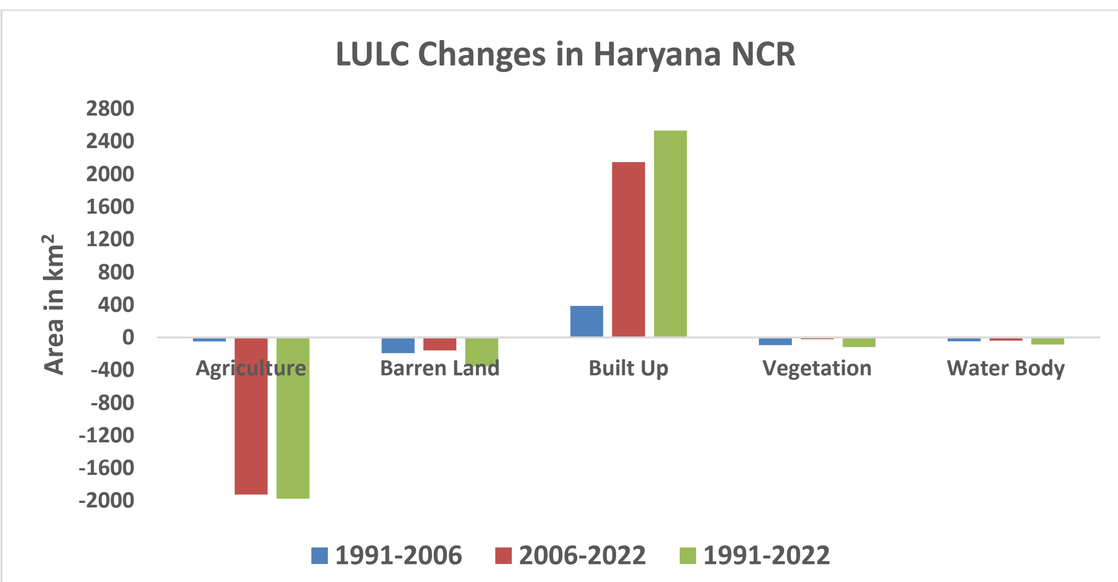
Table 2.3:- (b) LULC changes in Haryana NCR- Since 1991 to 2022

LULC Classes	1991-2006		2006-2022		1991-2022	
	Area in km^2	Area in %	Area in km^2	Area in %	Area in km^2	Area in %
Agriculture	-50.5	-0.2	-1925.5	-7.6	-1976.0	-7.8
Barren land	-193.9	-0.8	-159.3	-0.6	-353.2	-1.4
Built Up	386.3	1.5	2146.8	8.5	2533.1	10.0
Vegetation	-94.8	-0.4	-22.9	-0.1	-117.7	-0.5
Water Body	-47.5	-0.2	-39.2	-0.2	-86.7	-0.3

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Barren land is in second position which was 4.8% in the year 1991 and reached at 3.4% in the year 2022. Mostly both agriculture and barren land were transformed into Built-up areas due to population pressure and other growth activities. Vegetation also showed a negative fall in the area which was 0.9% in 1991 and reached 0.4% in 2022. The water body area has decreased from 1991 to 2022 from 1.9% to 1.5%. Only the built-up section shows the highest growth from 3.7% to 13.7% in 2022(table 2.3 (b).

Fig. 2.3- Graphical Representation of LULC changes in Haryana NCR



(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

So the growth under built-up was remarkable due to population growth, urban expansion, and other infrastructural development activities. Population growth and urbanization are major factors responsible for this unbeatable growth in the built-up section. The highest changes in LULC pattern of the Haryana NCR occurred from 2006 to 2022 by 8.5% due to rapid urbanization and infrastructural development within the region. Development is necessary for the growth of any region or country, but the valuable agricultural land should also not be ignored. Haryana is a leading food producer in India and the way agricultural land is being used in Haryana is a threat to sustainable agriculture development and food security (fig. 2.3).

Table 2.4(a, b, c): - LULC Change Matrix in Haryana NCR - 1991 and 2022 (%)

LULC Classes (a)		**2006**					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	86.7	0.2	1.5	0.1	0.2	88.7
	Barren Land	0.9	3.7	0.1	0.1	0.0	4.8
	Built Up	0.1	0.0	3.6	0.0	0.0	3.7
	Vegetation	0.4	0.2	0.0	0.3	0.0	0.9
	Water Body	0.4	0.0	0.1	0.0	1.4	1.9
	Total	88.5	4.0	5.2	0.5	1.7	100.0

LULC Classes (b)		**2022**					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
2006	Agriculture	79.1	0.5	8.5	0.1	0.3	88.5
	Barren Land	1.0	2.7	0.2	0.1	0.0	4.0
	Built Up	0.5	0.0	4.7	0.0	0.0	5.2
	Vegetation	0.1	0.2	0.1	0.1	0.0	0.5
	Water Body	0.3	0.0	0.2	0.0	1.2	1.7
	Total	80.9	3.4	13.7	0.4	1.5	100.0

LULC Classes (c)		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	78.6	0.3	9.5	0.1	0.3	88.7
	Barren Land	1.4	2.9	0.4	0.1	0.0	4.8
	Built Up	0.3	0.0	3.4	0.0	0.0	3.7
	Vegetation	0.3	0.2	0.2	0.2	0.0	0.9
	Water Body	0.4	0.0	0.3	0.0	1.2	1.9
	Total	80.9	3.4	13.7	0.4	1.5	100.0

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Table 2.4 (a,b,c) shows the LULC transition between different LULC classes from 1991 to 2006, 2006 to 2022 and 1991 to 2022. Between 1991 to 2006, very slight changes occurred in all the classes. Agriculture land had converted into built-up, barren land, vegetation and water bodies by 1.5%, 0.2%, 0.1% and 0.2% respectively. From 2006 to 2022, agricultural land had been converted into built-up, barren land, vegetation and water bodies by 8.5% , 0.5% ' 0.1% and 0.3% respectively, whereas barren land converted into agriculture, built-up and vegetation by 1.0% , 0.2% and 0.1% respectively. From 1991 to 2022, the highest changes and conversion occurred between agriculture and built-up section by 9.5%. The table shows that there has been a drastic positive change in the built-up section due to population growth, increasing urban population, urban expansion and other development activities. The highest negative changes occurred in agriculture which is a threat to agriculture sustainability and food security.

2.2.2 Tehsil Wise LULC Changes in NCR Haryana

If we talk about the Haryana NCR level, the highest changes occurred in the agriculture section and the built-up section whereas, at the tehsil level, the same two classes have changed drastically. Highest LULC change occurred in those tehsils which are attached to Delhi territory namely Sonipat, Ballabgarh, Faridabad, Bahadurgarh and Gurgaon and along with NH-44 which includes all the tehsils of Panipat and Karnal districts. In the proximity of Delhi, the land conversion rate is very high due to rapid urbanization and indusrial development. Migration towards cities is also a big cause of urban expansion in Haryana NCR.

Karnal Tehsil

It is located in the North East of the study area with 2028.8 km^2 total geographical area. Yamuna river frows its eastern side and it has a western Yamuna canal system as a major irrigation source. Karnal is a very fertile tehsil and it is located on NH-44 which plays a vital role in the change of LULC pattern within the tehsils. Major built-up expansions have been developed along with this major transportation route. Growing population, urbanization and industrial factors are also the major reasons behind these drastic changes in the LULC pattern.

Fig. 2.4- LULC Change Map of Karnal Tehsil since 1991, 2006 to 2022

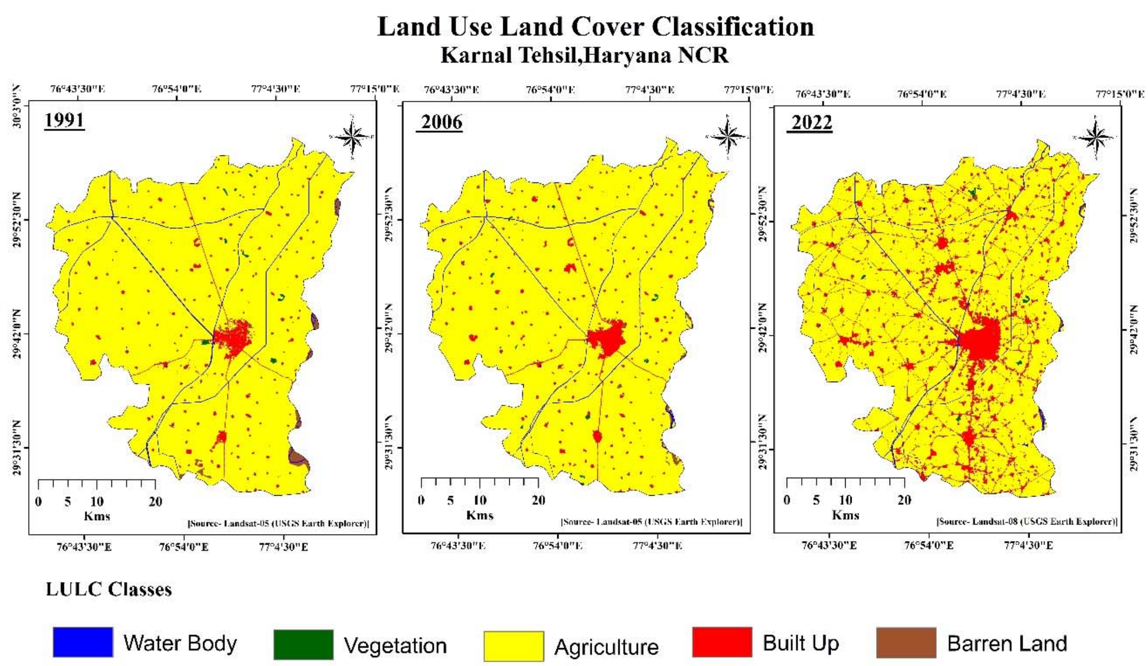


Table 2.5 :- LULC Change in Karnal Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	1915.0	94.4	1913.4	94.3	1750.3	86.3	-164.7	-8.1
Barren Land	16.3	0.8	6.7	0.3	2.8	0.1	-13.5	-0.7
Built up	62.9	3.1	77.2	3.8	243.7	12.0	180.7	8.9
Vegetation	3.9	0.2	3.3	0.2	4.2	0.2	0.3	0.0
Water Body	30.6	1.5	28.2	1.4	27.8	1.4	-2.8	-0.1
Total	2028.8	100.0	2028.8	100.0	2028.8	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

In Karnal tehsil(fig. 2.4), the most drastic changes occurred in the built-up section as the population is increasing and other infrastructural activities are also in the growing stage. The agriculture section is continuously decreasing due to expansion in the residential section. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 1915km^2, 16.3km^2, 62.9km^2, 3.9km^2 and 30.6km^2 in 1991; 1913.5km^2, 6.7km^2, 77.2km^2, 3.3km^2 and 28.2km^2 in 2006; 1750.3km^2, 2.8km^2, 243.7km^2, 4.2km^2 and 27.8km^2 in 2022. The agricultural land has decreased by 8.1% and built-up area has increased by 8.9%(table 2.5). It indicates that most of the agricultural land has been converted into built-up 181.9 km^2, barren land by 0.7 km^2, water body by 5.8 km^2 and vegetation by 2.6 km^2. Barren land is also converted into agriculture, built-up, vegetation and water bodies by 11.7 km^2, 1.3 km^2, 0.1 km^2 and 1.5 km^2 respectively. The built-up area had also undergone some change and transformed into agriculture by 4.2 km^2. Vegetation cover has also transformed into agriculture(2 km^2), barren land (0.01 km^2) and built-up (0.5 km^2) respectively. Water bodies had changed into agriculture and built up by 8.4 km^2 and 1.5 km^2 respectively. (Annexure-1 table no.1.2).

Assandh Tehsil: - Asandh tehsil (fig. 2.5)is a part of Karnal district, blessed with fertile soil and good irrigation facilities in the form of good canal and underground water facilities. The tehsil is experiencing some changes in its LULC pattern due to rural and urban expansion. Population growth is playing a vital role in LULC modification within the Tehsil. The total geographical area is 556.8 km^2 and around 92% area is under agriculture.

Fig. 2.5- LULC Change Map of Asandh Tehsil for 1991, 2006 to 2022

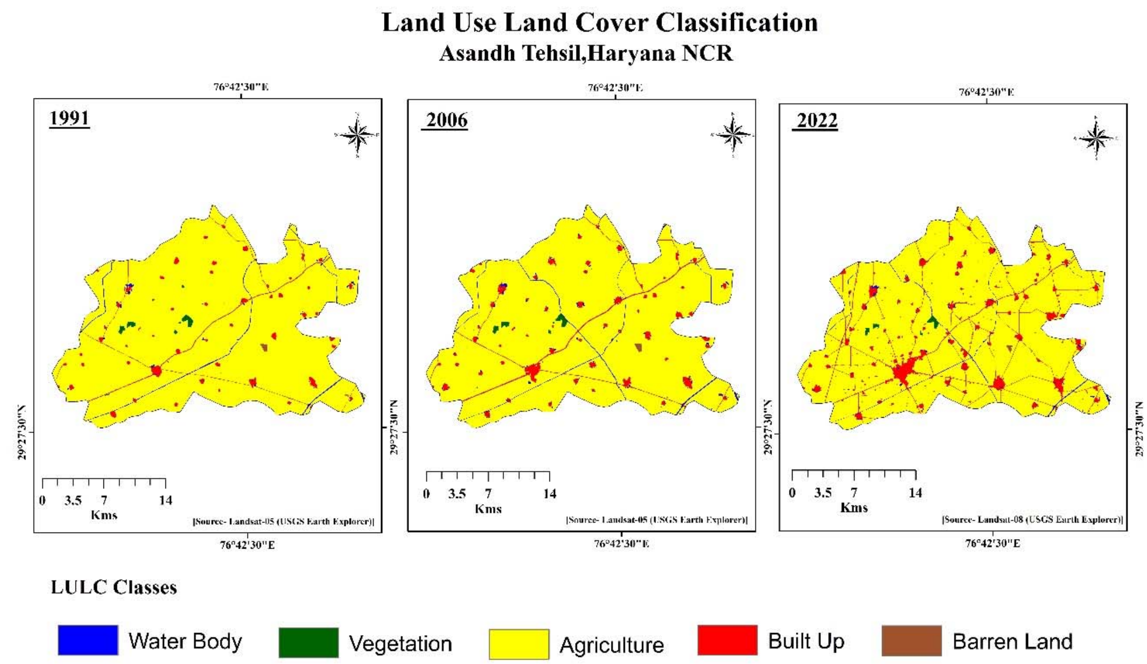


Table 2.6:- LULC Change in Asandh Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	534.4	96.0	526.5	94.6	510.1	91.6	-24.3	-4.4
Barren Land	0.6	0.1	0.7	0.1	0.4	0.1	-0.3	-0.1
Built up	14.6	2.6	20.7	3.7	38.8	7.0	24.2	4.3
Vegetation	2.2	0.4	2.0	0.4	1.6	0.3	-0.6	-0.1
Water Body	5.1	0.9	7.0	1.3	6.0	1.1	0.9	0.2
Total	556.8	100	556.8	100	556.8	100		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

The highest change occurred in agriculture and built-up sections within the tehsil which is an alarming threat for future food security. The change matrix table shows that agricultural land within the tehsil changed drastically due to population pressure and other development works. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are 534.4km^2, o.6km^2, 14.6km^2, 2.2km^2 and 5.1km^2 respectively in 1991; 526.5km^2, 0.7km^2, 20.7km^2, 2km^2 and 7km^2 respectively in 2006; 510.1km^2, 0.4km^2, 38.8km^2, 1.6km^2 and 6km^2 respectively in 2022. The agricultural land has decreased by 4.4% and built-up area has increased by 4.3%(table 2.6). It indicated clearly that most of the agricultural land has been converted into built-up. Agricultural area had changed into built-up (25 km^2), barren land (0.1 km^2), water body (2.5 km^2) and vegetation (0.1 km^2) respectively. Barren land is also converted into agriculture and water bodies by 0.3 km^2 and 0.1 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.1 km^2. Vegetation cover also transformed into agriculture(0.6 km^2) and water bodies had changed into agriculture and built up by 1.5 km^2 and 0.4 km^2. respectively (Annexure-1 table no.1.1).

Panipat Tehsil: - Panipat tehsil, the LULC pattern is showing huge changes due to population pressure, urbanization and rural & urban expansion. NH-44 is passing through the tehsil which is playing a great role in its LULC modifications. Panipat is the hub of handloom industry which is also in continously growing and causing changes in LULC pattern. Panipat (fig. 2.6) is the hub of the handloom industry and also a great manufacturer and exporter of handloom articles. Panipat Tehsil passes through heavy changes in its LULC pattern due to many reasons like population pressure, migration, urban expansion and other development works. The agricultural area is the most vulnerable section within the tehsil as it transformed fastly and converted into a built-up, water body, barren and vegetation. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 1115.4km^2, 24.8km^2, 51.1km^2, 5.9km^2 and 28.1km^2 in 1991; 1106.3km^2, 16.7km^2, 69.5km^2, 4.4km^2 and 28.5km^2 in 2006; 996.9km^2, 13.6km^2, 188.2km^2, 3.5km^2 and 23.3km^2 in 2022.

Fig. 2.6- LULC Change Map of Panipat Tehsil for 1991, 2006 to 2022

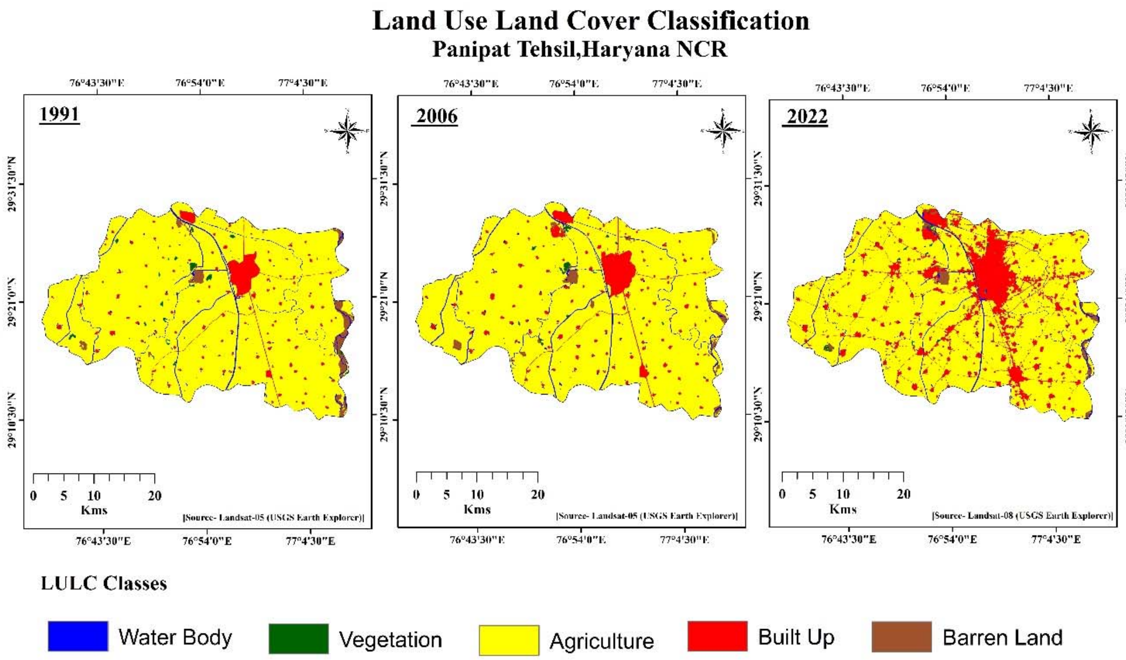


Table 2.7: - LULC Change in Panipat Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	1115.4	91.0	1106.3	90.3	996.9	81.4	-118.5	-9.7
Barren Land	24.8	2.0	16.7	1.4	13.6	1.1	-11.3	-0.9
Built up	51.1	4.2	69.5	5.7	188.2	15.4	137.0	11.2
Vegetation	5.9	0.5	4.4	0.4	3.5	0.3	-2.3	-0.2
Water Body	28.1	2.3	28.5	2.3	23.3	1.9	-4.8	-0.4
Total	1225.3	100.0	1225.4	100.0	1225.4	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

The highest change occurred in the built-up section by 11.2% and most of the area comes from the agriculture section which is a matter of great concern for agriculture sustainability within the region(table 2.7). The agricultural area had changed into built-up (135km^2), barren land (2.8km^2), water bodies (1.5 km^2) and vegetation (2.6 km^2). Barren land is also converted into agriculture, built-up, vegetation and water body by 12.4km^2, 0.7 km^2, 0.6 km^2 and 1.8 km^2.respectively. The built-up area had also undergone some changes and transformed into agriculture by 0.8 km^2. Vegetation cover also transformed into agriculture(4.3km^2), barren land (0.3 km^2) and built-up (0.9 km^2). water body had changed into agriculture and built up by 5.8 km^2 and 2 km^2. respectively. (Annexure-1 table no.1.3).

Ganour Tehsil:- Ganour is the part of Sonipat district with 341.4 km^2 of geographical area. it is also situated in the Northeast side of the study area and is blessed with good soil and water facilities as the Yamuna river flows eastern side of the tehsil. NH-44 is also passing through it which is the major centre of LULC change within the tehsil.

Fig. 2.7- LULC Change Map of Ganour Tehsil for 1991, 2006 to 2022

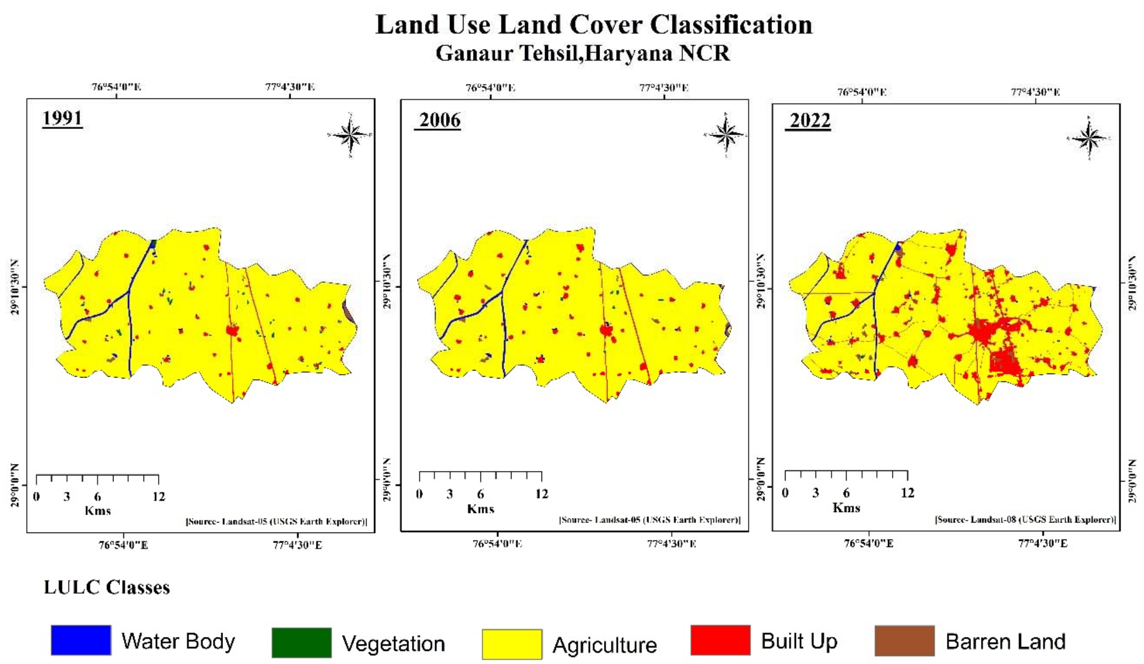


Table 2.8:- LULC Change in Ganour Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	324.6	95.1	323.7	94.8	293.0	85.8	-31.6	-9.3
Barren Land	1.3	0.4	1.4	0.4	3.2	0.9	1.9	0.6
Built up	8.2	2.4	10.1	2.9	39.8	11.7	31.6	9.3
Vegetation	1.8	0.5	0.5	0.1	0.4	0.1	-1.4	-0.4
Water Body	5.6	1.6	5.9	1.7	5.0	1.5	-0.5	-0.2
Total	341.5	100.0	341.5	100.0	341.4	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Ganour (fig.2.7) tehsil is a part of Sonipat district and has also undergone huge LULC changes due to the nearness to NCR core region. In the tehsil, The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 324.6km^2, 1.3km^2, 8.2km^2, 1.8km^2 and 5.6km^2 in 1991; 323.7km^2, 1.4km^2, 10.1km^2, 0.5km^2 and 5.9km^2 in 2006; 293km^2, 3.2km^2, 39.8km^2, 0.4km^2 and 5km^2 in 2022. The agricultural land has been reduced by 9.3% from 1991 to 2022 and built-up increased by 9.3%(table 2.8). The agricultural area had changed into built-up (31.3km^2), barren land (2.4 km^2), water bodies (1 km^2) and vegetation (0.3 km^2). Barren land was also converted into agriculture and built up by 1 km^2, and 0.1 km2. The built-up area had also undergone some change and transformed into agriculture by 0.6 km^2. Vegetation cover has also transformed into agriculture(0.7 km^2), barren land (0.4 km^2) and built-up (0.5 km^2). water body had changed into agriculture and built up by 1.1 km^2 and 0.3 km^2. (Annexure-1 table no.1.4).

So, urbanization, rural-urban expansion, huge industrial development and growing population are the major causes of drastic LULC Changes within the tehsil.

Gohana Tehsil

It is also the part of Sonipat tehsil with 886.9 km^2 geographical area. Gohana has very good agricultural land due to better soil and irrigation facilities. It also experienced some changes in its LULC pattern from 1991 to 2022. But these LULC changes are not so severe like

Sonipat and Ganour tehsils as it is located far away from NH-44. almost 90% area within the tehsil comes under cultivation and it is the major economic activity of the tehsil. Rural-urban expansion and growing population are the major causes of change in LULC pattern within the tehsil.

Fig. 2.8- LULC Change Map of Gohana Tehsil for 1991, 2006 and 2022

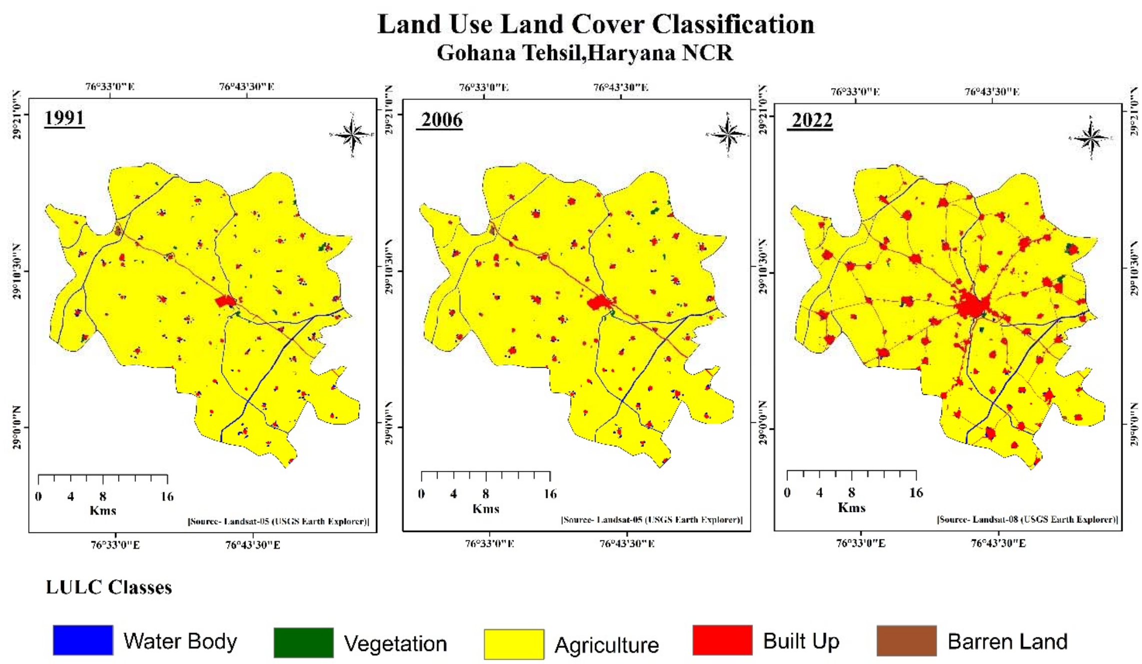


Table 2.9:- LULC Change in Gohana Tehsil- 1991 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	847.2	95.5	842.0	94.9	795.2	89.7	-52.1	-5.9
Barren Land	0.9	0.1	0.8	0.1	0.5	0.1	-0.4	0.0
Built up	15.6	1.8	25.0	2.8	73.0	8.2	57.4	6.5
Vegetation	2.6	0.3	1.7	0.2	2.2	0.2	-0.4	0.0
Water Body	20.7	2.3	17.4	2.0	16.0	1.8	-4.6	-0.5
Total	886.9	100.0	886.9	100.0	886.9	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water bodies are respectively; 847.2 km^2, 0.9 km^2, 15.6 km^2, 2.6 km^2 and 20.7 km^2 in 1991; 842 km^2, 0.8 km^2, 25 km^2, 1.7 km^2 and 17.4 km^2 in 2006; 795.2 km^2, 0.5 km^2, 73 km^2, 2.2 km^2 and 16 km^2 in 2022. All the LULC classes show a decreasing trend except the built-up section which has increased by 6.5% from 1991 to 2022(table 2.9). The agricultural area had changed into built-up (53 km^2), barren land (0.4 km^2), water body (3.9 km^2) and vegetation (1.6 km^2) respectively. Barren land was also converted into agriculture by 0.8 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.1 km^2. Vegetation cover also transformed into agriculture(1.4 km^2), barren land (0.1 km^2) and built-up (0.6 km^2). water body had changed into agriculture and built up by 3.5 km^2 and 5 km^2. (Annexure-1 table no.1.5).

Sonipat Tehsil

It is located in the Northeast side of the study region with 986.5km^2 geographical area. Sonipat is sharing its boundary line with Delhi and also NH-44 is passing through it. These two factors are mainly responsible for huge LULC modification within the tehsil. There are mainly residential projects going on due to the expansion of Delhi surroundings which highly affected the Sonipat LULC pattern. So, those tehsils that are sharing its boundary line with Delhi, have undergone drastic changes in their LULC patterns. In Sonipat tehsil (fig. 2.9), the agriculture area is decreasing extremely fast due to human growth activities and nearness of the Delhi. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water bodies respectively; 917.9km^2, 10.7 km^2, 35.7 km^2, 4 km^2 and 18.3 km^2 in 1991; 907.3 km^2, 3.5 km^2, 57.2 km^2, 1.1 km^2 and 17.4 km^2 in 2006; 790.6 km^2, 1.8 km^2, 174 km^2, 2.3 km^2 and 17.8 km^2 in 2022. built-up area was 35.7 km^2 in 1991 and reached at 174 km^2 in 2022 due to residential and industrial growth within the region (table 2.10). It is a big threat and a question of agriculture sustainability within the region as Sonipat is closely associated with Delhi.

Fig. 2.9- LULC Change Map of Sonipat Tehsil for 1991, 2006 and 2022

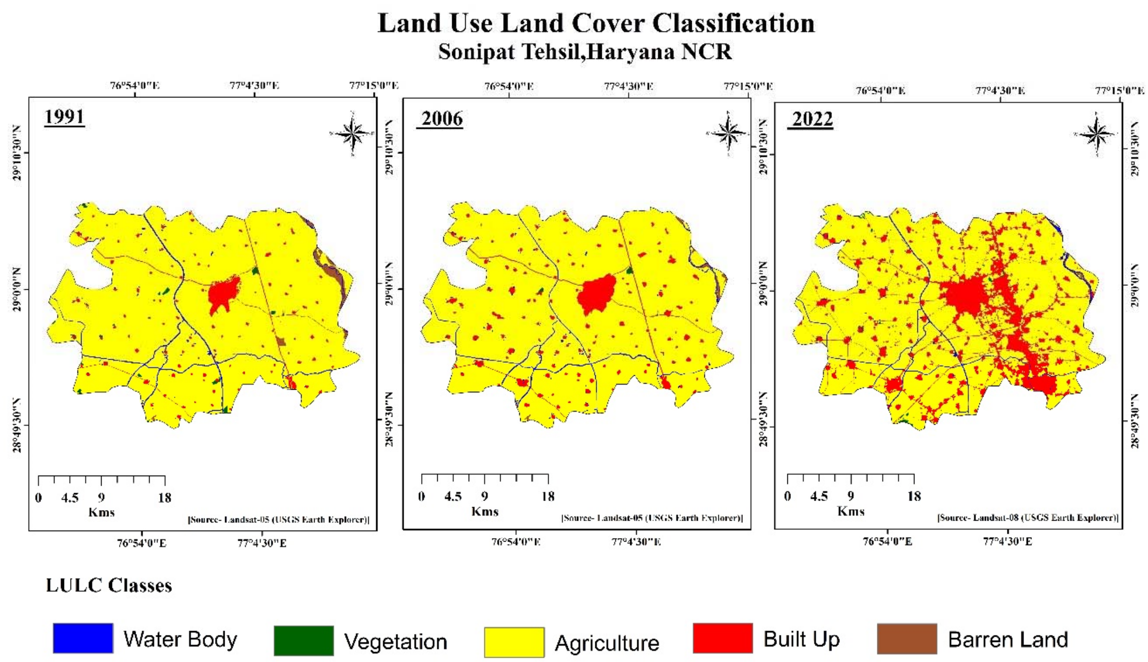


Table 2.10:- LULC change in Sonipat tehsil for the years- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	917.9	93.0	907.3	92.0	790.6	80.1	-127.3	-12.9
Barren Land	10.7	1.1	3.5	0.4	1.8	0.2	-8.9	-0.9
Built up	35.7	3.6	57.2	5.8	174.0	17.6	138.3	14.0
Vegetation	4.0	0.4	1.1	0.1	2.3	0.2	-1.7	-0.2
Water Body	18.3	1.9	17.4	1.8	17.8	1.8	-0.5	-0.1
Total	986.6	100.0	986.5	100.0	986.5	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

The agricultural area had changed into built-up (135.7km^2), barren land (0.5 km^2), water body (2.6 km^2) and vegetation (2.0 km^2). Barren land has also been converted into agriculture, built-up, vegetation and water body by 5.9 km^2, 1.3 km^2, 0.1 km^2 and 2.2

respectively. The built-up area had also undergone some change and transformed into agriculture by 1.3 km^2. Vegetation cover also transformed into agriculture(2.2 km^2), and built up (1.6 km^2). Water bodies had changed into agriculture and built-up by 4.3 km^2 and 1.1 km^2. (Annexure-1 table no.1.6).

Jind Tehsil, Safidon and Narwana Tehsils

All these tehsils are part of the Jind district of Haryana NCR with a geographical area of 1041 km^2, 531.5 km^2 and 1160.1 km^2 respectively. All of them have good & average types of soils and irrigation facilities. almost 90% area of Jind & Safidon and 92% of Narwana tehsil is under cultivation. Rural and urban expansion and population growth are major causes of LULC change in these tehsils.

Fig. 2.10- LULC Change Map of Jind Tehsil for 1991, 2006 and 2022

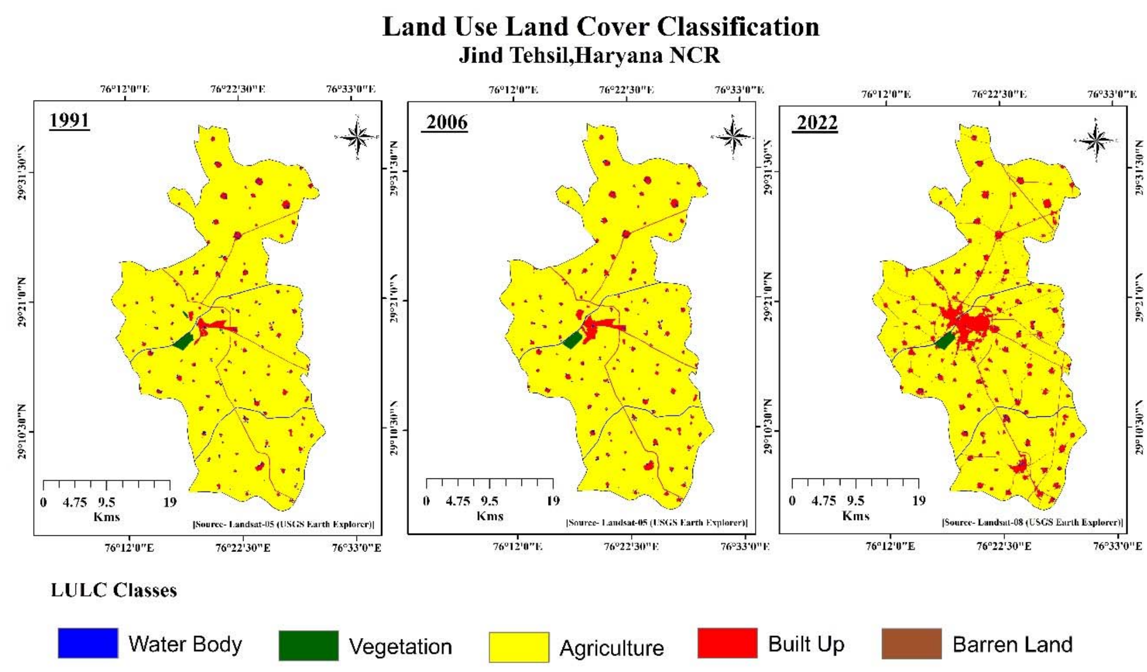


Table 2.11:- LULC Change in Jind Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	987.5	94.9	978.7	94.0	932.0	89.5	-55.5	-5.3
Barren Land	0.2	0.0	0.3	0.0	0.2	0.0	0.0	0.0
Built up	36.9	3.5	46.5	4.5	93.2	9.0	56.3	5.4
Vegetation	5.1	0.5	4.0	0.4	4.6	0.4	-0.6	-0.1
Water Body	11.4	1.1	11.5	1.1	11.0	1.1	-0.4	0.0
Total	1041.1	100.0	1041.0	100.0	1041.0	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Jind (fig. 2.10) is an agriculturally sound district within the state and blessed with fertile soil and good irrigation facilities. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 987.5 km^2, 0.2 km^2, 36.9 km^2, 5.1 km^2 and 11.4 km^2 in 1991; 978.7 km^2, 0.3 km^2, 46.5 km^2, 4 km^2 and 11.5 km^2 in 2006; 932 km^2, 0.2 km^2, 93.2 km^2, 4.6 km^2 and 11 km^2 in 2022(table 2.11). All the tehsils in Jind district show a decrease in trend in agriculture area from 1991 to 2022 due to human development activities.

Agricultural area had changed into built-up (57.1 km^2), barren land (0.2 km^2), water bodies (0.7 km^2) and vegetation (0.5 km^2). Barren land has also been converted into agriculture, and built up by 0.1 km^2 and 0.2 km^2. The built-up area had also undergone some change and transformed into agriculture by 2.6 km^2. Vegetation cover also transformed into agriculture(0.5 km^2) and built up (0.7 km^2). water body had changed into built up by 1.2 km^2. (Annexure-1 table no.1.7).

Fig. 2.11- LULC Change Map of Safidon Tehsil for 1991, 2006 and 2022

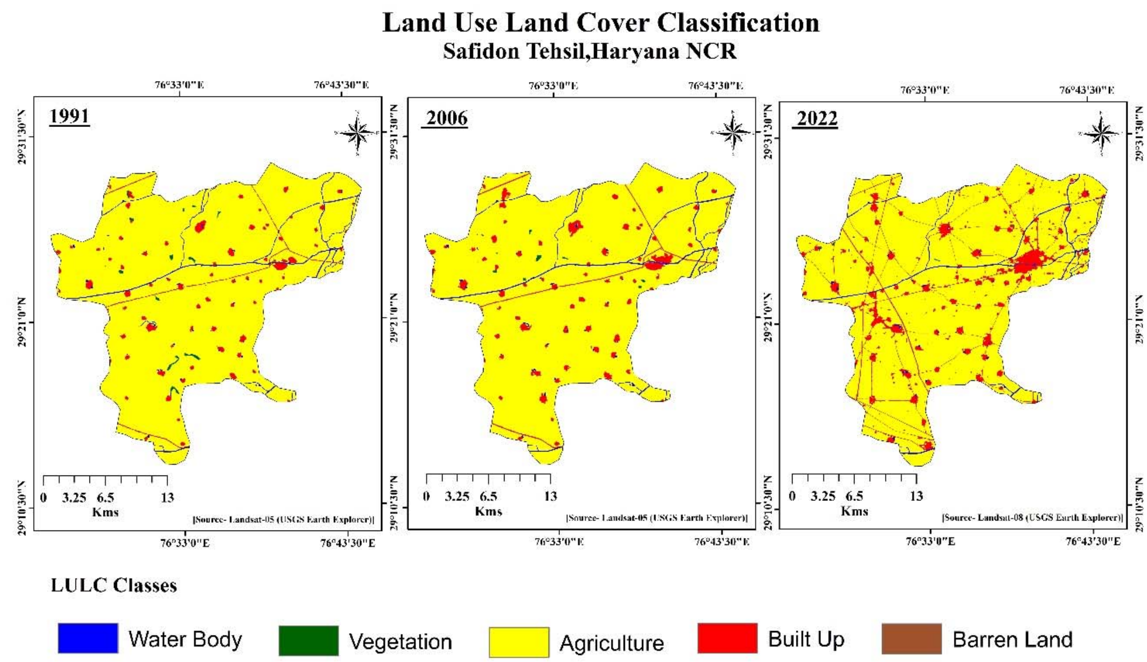


Table 2.12:- LULC Change in Safidon Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	503.4	94.7	497.8	93.6	474.8	89.3	-28.5	-5.4
Barren Land	0.2	0.0	0.2	0.0	0.1	0.0	-0.1	0.0
Built up	16.8	3.2	22.8	4.3	46.8	8.8	29.9	5.6
Vegetation	2.0	0.4	0.8	0.2	0.3	0.1	-1.7	-0.3
Water Body	9.2	1.7	10.0	1.9	9.5	1.8	0.3	0.1
Total	531.6	100.0	531.5	100.0	531.5	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

As fig. 2.11 shows the LULC changes within different land use classes from 1991 to 2022 in Safidon tehsil of Jind district. Most of the changes occurred in the agriculture area and built-up section and most of the agriculture area was converted into a built-up up due to the expansion of the residential area. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body respectively; 503.4 km^2, 0.2

km^2, 16.8 km^2, 2 km^2 and 9.2 km^2 in 1991; 497.8 km^2, 0.2 km^2, 22.8 km^2, 0.8 km^2 and 10 km^2 in 2006; 474.8 km^2, 0.1 km^2, 46.8 km^2, 0.3 km^2 and 9.5 km^2 in 2022(table 2.12).

Agricultural area had changed into built-up (31.4 km^2), barren land (0.1 km^2), water bodies (1.5km^2) and vegetation (0.3 km^2). Barren land was also converted into built-up by 0.2 km^2. The built-up area had also undergone some change and transformed into agriculture by 2.1 km^2. Vegetation cover also transformed into agriculture(1.7 km^2) and built up (0.2 km^2). water body had changed into agriculture and built up by 1 km^2 and 0.3 km^2(Annexure-1 table no.1.8).

Fig. 2.12- LULC Change Map of Narwana Tehsil for 1991, 2006 and 2022

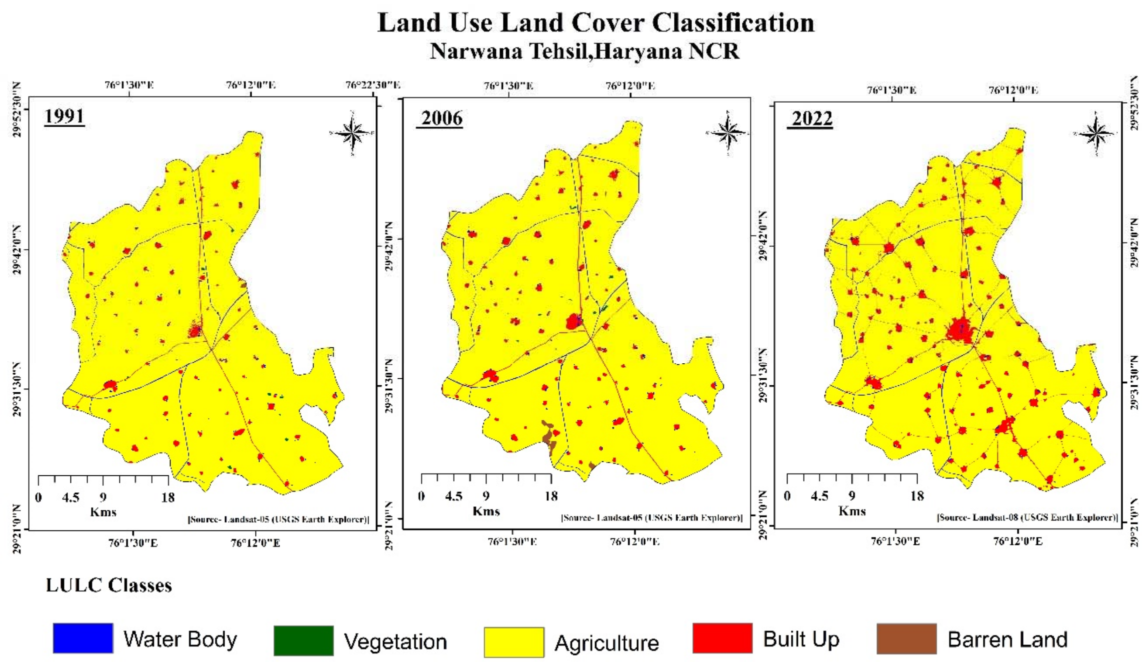


Table 2.13:- LULC Change in Narwana Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	1107.6	95.5	1100.7	94.9	1070.7	92.3	-37.0	-3.2
Barren Land	0.5	0.0	4.4	0.4	0.3	0.0	-0.2	0.0
Built up	29.1	2.5	39.3	3.4	74.7	6.4	45.6	3.9
Vegetation	1.1	0.1	1.4	0.1	0.2	0.0	-0.9	-0.1
Water Body	21.9	1.9	14.4	1.2	14.3	1.2	-7.6	-0.7
Total	1160.3	100	1160.2	100	1160.1	100		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Fig. 2.12 shows LULC changes in Narwana tehsil from 1991 to 2022. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water bodies respectively; 1107.6 km^2, 0.5 km^2, 29.1 km^2, 1.1 km^2 and 21.9 km^2 in 1991; 1100.7 km^2, 4.4 km^2, 39.3 km^2, 1.4 km^2 and 14.4 km^2 in 2006; 1070.7 km^2, 0.3 km^2, 74.7 km^2, 0.2 km^2 and 14.3 km^2 in 2022. Agriculture land is showing a decreasing trend of 3.2% and built-up showing an increasing trend of 3.9%)(table 2.13). The agricultural area had changed into built-up (47.4 km^2), barren land (0.2 km^2), and water bodies (2.2 km^2). Barren land was also converted into agriculture by 0.4 km^2. The built-up area had also undergone some change and transformed into agriculture by 2.4 km^2. Vegetation cover also transformed into agriculture(0.9 km^2) and built up (0.2 km^2). water body had changed into agriculture and built up by 9.1 km^2 and 0.6 km^2(Annexure-1 table no.1.9).

Rohtak and Maham Tehsils

Rohtak and Maham are the part of Rohtak district and both are facing huge LULC transformations during the study period. The geographical area of both the tehsils are 1163.3 km^2 and 522.9 km^2. Rohtak is facing more severe changes in their LULC pattern as compared to Maham tehsil as Rohtak is the major city which expanding at high pace and NH-71A is also playing a vital role in LULC changes in Rohtak tehsil.

Fig. 2.13- LULC Change Map of Rohtak Tehsil – 1991, 2006 and 2022

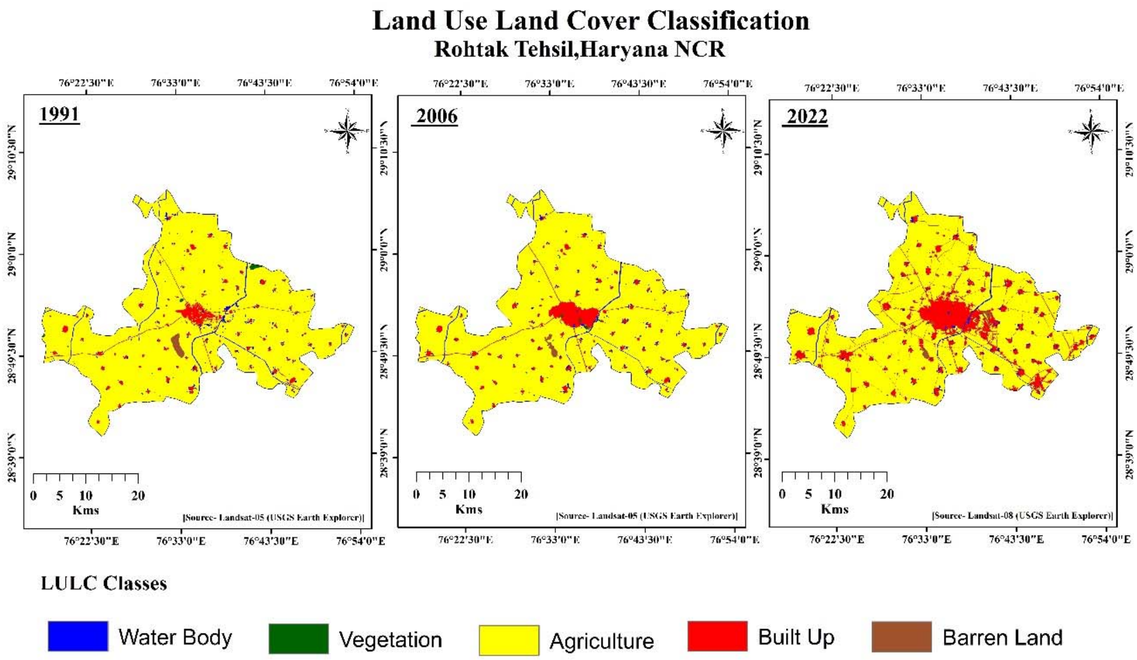


Table 2.14:- LULC Change in Rohtak Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	1082.1	93.0	1069.6	91.9	979.0	84.2	-103.2	-8.9
Barren Land	7.3	0.6	4.9	0.4	5.1	0.4	-2.2	-0.2
Built up	45.3	3.9	63.1	5.4	156.1	13.4	110.7	9.5
Vegetation	2.6	0.2	1.7	0.1	0.4	0.0	-2.2	-0.2
Water Body	26.0	2.2	24.0	2.1	22.7	2.0	-3.3	-0.3
Total	1163.3	100.0	1163.3	100.0	1163.3	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Fig. 2.13 shows the LULC in Rohtak tehsil between 1991 to 2022 and resulted that The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body respectively; 1082.1 km^2, 7.3 km^2, 45.3 km^2, 2.6 km^2 and 26 km^2 in 1991; 1069.6 km^2, 4.9 km^2, 63.1 km^2, 1.7 km^2 and 24 km^2 in 2006; 979 km^2, 5.1 km^2, 156.1 km^2, 0.4 km^2 and 22.7 km^2 in 2022.. Agriculture area is decreasing and it is reduced due to human-induced activities by 8.9% whereas the area under settlements have increased by 9.5% from 1991 to 2022 (table 2.14). Agricultural areas had changed into built-up (109.3 km^2), barren land (2.9 km^2), water bodies (3.8 km^2) and vegetation (0.3 km^2). Barren land is also converted into agriculture, built-up, vegetation and water bodies by 3.1 km^2, 2 km^2, 0.1 km^2 and 0.1 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.9 km^2. Vegetation cover also transformed into agriculture(2.3 km^2) and built up (0.3 km^2). The water body had changed into agriculture and built-up by 6 km^2 and 1.6 km^2. (Annexure-1 table no.1.10).

Fig. 2.14- LULC Change Map of Maham Tehsil for 1991, 2006 to 2022

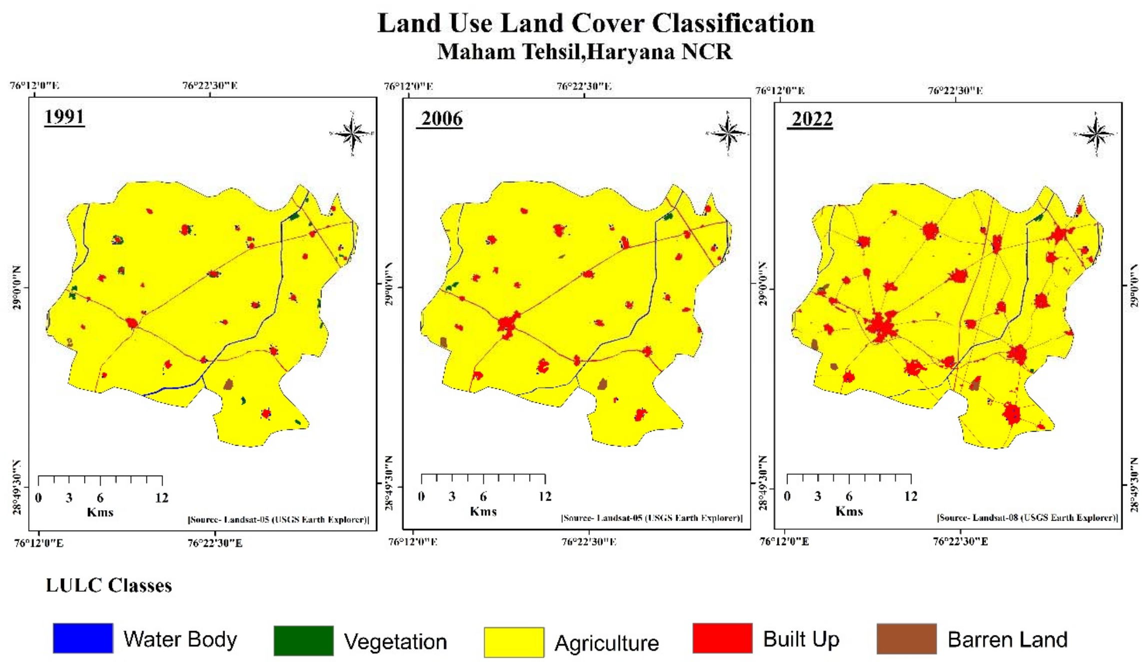


Table 2.15:- LULC Change in Maham Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	502.3	96.1	497.3	95.1	472.8	90.4	-29.5	-5.6
Barren Land	1.1	0.2	1.7	0.3	2.2	0.4	1.1	0.2
Built up	10.5	2.0	18.4	3.5	43.2	8.3	32.6	6.2
Vegetation	2.9	0.6	0.8	0.2	0.5	0.1	-2.5	-0.5
Water Body	6.1	1.2	4.7	0.9	4.3	0.8	-1.8	-0.4
Total	523.0	100.0	522.9	100.0	522.9	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Maham (Fig. 2.14) is a part of the Rohtak district and is also blessed with good agricultural conditions. Table 2.15 shows the LULC changes in Maham tehsil during the last 30 years and shows that the agriculture area had decreased and area under built-up had increased and most of the agricultural land had converted into built-up. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water bodies respectively; 502.3 km^2, 1.1 km^2, 10.5 km^2, 2.9 km^2 and 6.1 km^2 in 1991; 497.3 km^2, 1.7 km^2, 18.4 km^2, 0.8 km^2 and 4.7 km^2 in 2006; 472.8 km^2, 2.2 km^2, 43.2 km^2, 0.5 km^2 and 4.3 km^2 in 2022. The agricultural area had changed into built-up (109.3km^2), barren land (2.9 km^2), water bodies (3.8 km^2) and vegetation (0.3 km^2). Barren land is also converted into agriculture, built-up, vegetation and water bodies by 3.1 km^2, 2 km^2, 0.1 km^2 and 0.1 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.9 km^2. Vegetation cover also transformed into agriculture(2.3 km^2) and built up (km^2). water body had changed into agriculture and built up by 6 km^2 and 1.6 km^2. (Annexure-1 table no.1.11).

Jhajjar Tehsil: - It is also showing LULC modification due to rural-urban expansion, passing of NH-71 and growing population. The geographical area of Jhajjar is 942.9 km^2 and 88.7% area is under cultivation.

Fig. 2.15- LULC Change Maps of Jhajjar Tehsil for the years- 1991, 2006and 2022

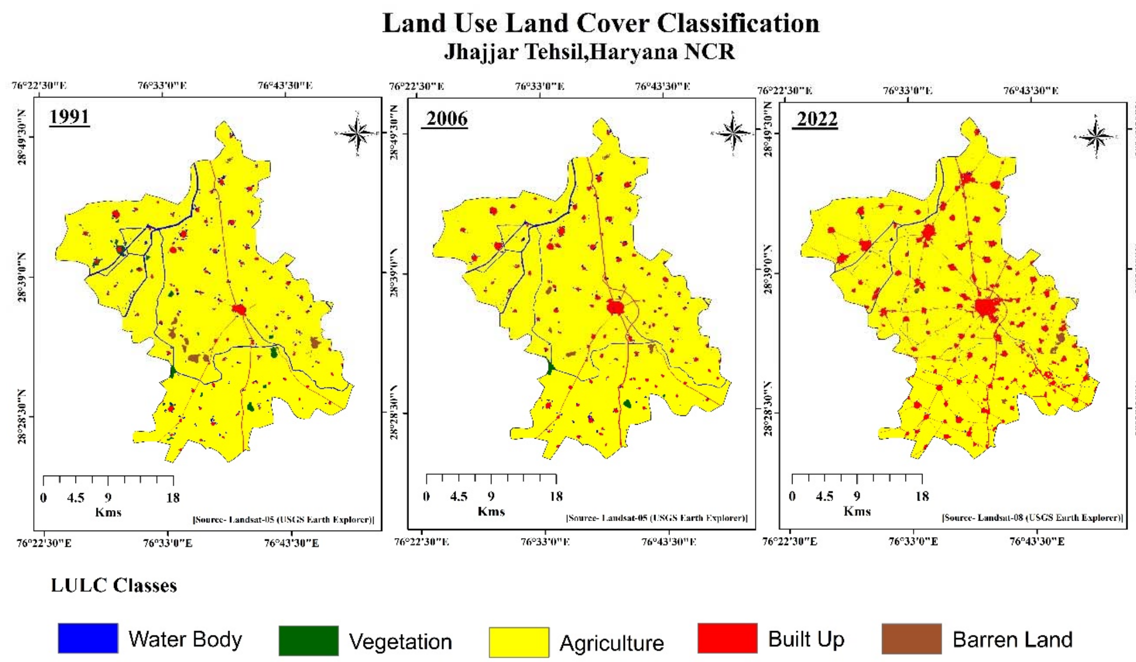


Table 2.16:- LULC Change in Jhajjar Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	881.7	93.5	883.9	93.7	836.7	88.7	-45.0	-4.8
Barren Land	7.0	0.7	3.0	0.3	3.4	0.4	-3.6	-0.4
Built up	21.5	2.3	33.8	3.6	84.5	9.0	63.0	6.7
Vegetation	7.2	0.8	2.4	0.3	0.6	0.1	-6.6	-0.7
Water Body	25.7	2.7	19.8	2.1	17.7	1.9	-7.9	-0.8
Total	942.9	100.0	942.9	100.0	942.9	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Table 2.16 and fig. 2.15 shows the LULC changes in the Jhajjar tehsil of Jhajjar district. Due to the closeness to India's capital New Delhi, the tehsil had experienced huge changes in the agriculture and built-up section. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water bodies respectively; 881.7 km^2, 7 km^2, 21.5 km^2, 7.2 km^2 and 25.7 km^2 in 1991; 883.9 km^2, 3 km^2, 33.8 km^2, 2.4 km^2 and 19.8 km^2 in 2006; 836.7 km^2, 3.4 km^2, 84.5 km^2, 0.6 km^2 and 17.7 km^2 in 2022. The agricultural area had changed into built-up (58.4 km^2), barren land (1.7 km^2), water bodies (8.3 km^2) and vegetation (0.3 km^2). Barren land also converted into agriculture and built up by 5.4 km^2, and 0.1 km^2. The built-up area had also undergone some change and transformed into agriculture by 2.5 km^2. Vegetation cover also transformed into agriculture(4.7 km^2), barren land (0.2 km^2) and built-up (1.9 km^2). water body had changed into agriculture and built up by 11.2 km^2 and 5.1 km^2. (Annexure-1 table no.1.12).

Bahadurgarh Tehsil: - Bahadurgarh is part of the Jhajjar district of Haryana state which is also sharing its boundary line with Delhi. This is also a very good tehsil for agriculture as it has flat land with good water and soil conditions. However, due to the nearness of India's Capital, New Delhi, it is undergoing huge LULC dynamics from 1991 to 2022. In 1991, agriculture is the major LULC class and very few changes occurred in this class from 1991 to 2006. But from 2006 to 2022, drastic changes occurred in agriculture as well as built-up sections due to population growth, the nearness of Delhi and other infrastructural activities. Many projects have been initiated in Bahadurgarh which occupied the nearby valuable agricultural land. Bahadurgarh tehsil (fig. 2.16) is a part of the Jhajjar district and it is closely connected with NCR core region. The nearness to the capital of India has brought huge changes in the LULC pattern in this tehsil. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water bodies respectively; 506.5 km^2, 0.7 km^2, 24.5 km^2, 4.1 km^2 and 13.7 km^2 in 1991; 499.1 km^2, 0.6 km^2, 35.4 km^2, 0.6 km^2 and 13.7 km^2 in 2006; 449.4 km^2, 0.3 km^2, 85.2 km^2, 0.7 km^2 and 13.9 km^2 in 2022. Bahadurgarh is an agriculturally sound state with good soil and water conditions with less barren land.

Fig. 2.16- LULC Change Maps of Bahadurgarh for the Years- 1991, 2006 and 2022

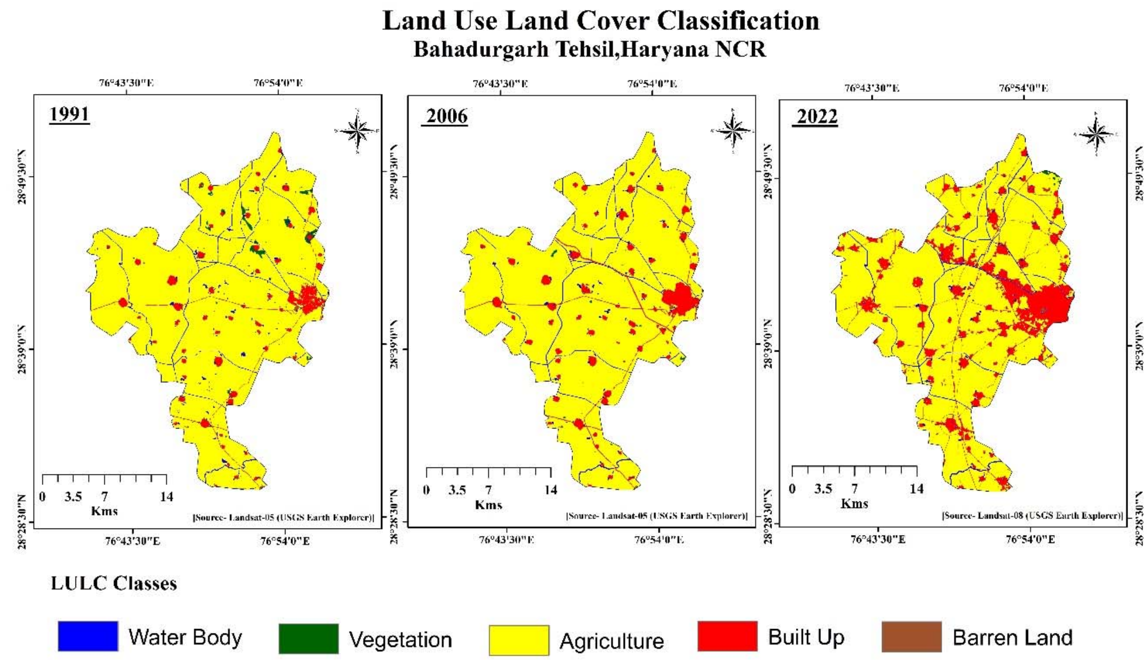


Table 2.17:- LULC Change in Bahadurgarh Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	506.5	92.2	499.1	90.8	449.4	81.8	-57.1	-10.4
Barren Land	0.7	0.1	0.6	0.1	0.3	0.0	-0.4	-0.1
Built up	24.5	4.5	35.4	6.5	85.2	15.5	60.7	11.0
Vegetation	4.1	0.7	0.6	0.1	0.7	0.1	-3.5	-0.6
Water Body	13.7	2.5	13.7	2.5	13.9	2.5	0.2	0.0
Total	549.5	100.0	549.4	100.0	549.4	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

So, most of the changes occurred in the agriculture and built-up section(table 2.17). The agricultural area had changed into built-up (58.4 km^2), barren land (0.1km^2), water bodies (2.7 km^2) and vegetation (0.6 km^2). Barren land also converted into agriculture and built up by 0.3 km^2, 0.3 km^2. The built-up area had also undergone some change and transformed into agriculture by 24.5 km^2. Vegetation cover also transformed into agriculture(4.1 km^2) and built up (2.3 km^2). water body had changed into agriculture and built up by 1.6 km^2 and 1 km^2. (Annexure-1 table no.1.13).

Faridabad Tehsil

It is the part of Faridabad district of Haryana and is also closely attached to Delhi. It has undergone huge LULC changes due to population growth, urbanization, and migration. Apart from this, shelter needs, rapid migration, industrialization and development of new township projects (Omaxe world homes, Godrej Retreat Phase-2, BPTP Project, Adore smart city, etc.) are also playing a vital role in LULC modification within the study area. This phenomenal modification in LULC causes a big threat to agriculture sustainability as very essential productive land is continuously decreasing due to the rapid expansion of built-up sections. NCR core region is surrounded by Faridabad, Gurgaon, Jhajjar and Sonipat district of the Haryana state and almost three sides of Delhi are covered by Haryana. So, these districts have undergone huge LULC pattern change due to population pressure, migration, industrial growth and other development works. It lost almost the second most agricultural land from 1991 to 2022 which is almost 21% after Gurgaon tehsil.

Fig. 2.17- LULC Change Map of Faridabad Tehsil for 1991, 2006 and 2022

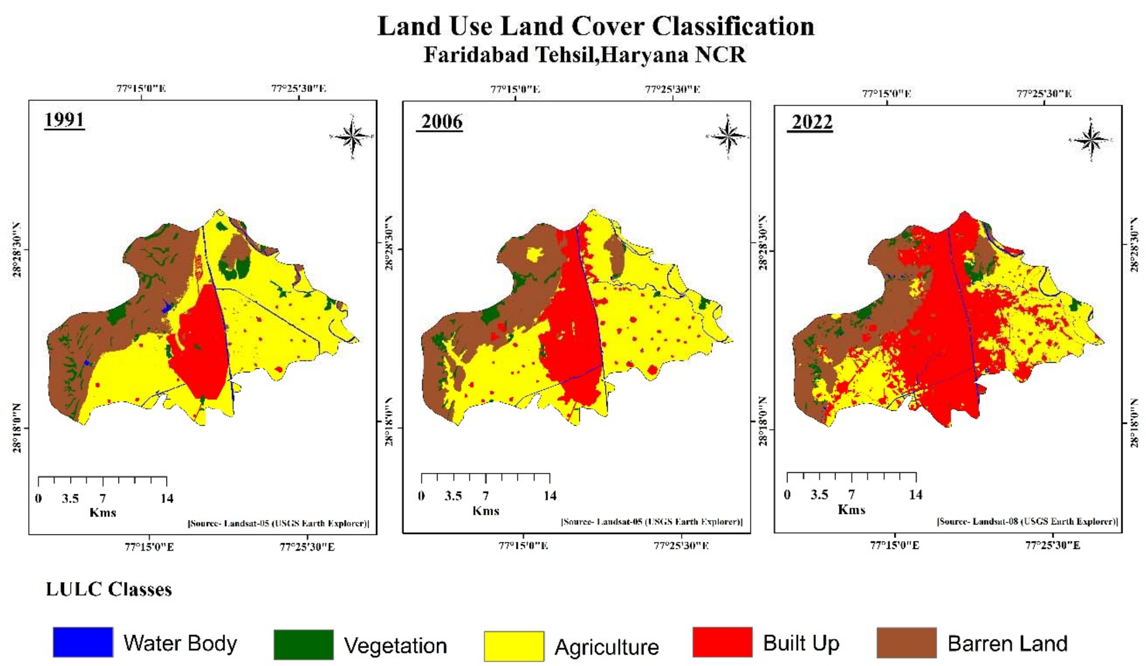


Table 2.18:- LULC Change in Faridabad Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	228.3	50.9	228.8	51.0	129.9	29.0	-98.4	-21.9
Barren Land	130.7	29.1	107.9	24.1	101.8	22.7	-28.9	-6.4
Built up	57.4	12.8	91.7	20.4	195.0	43.5	137.6	30.7
Vegetation	24.3	5.4	13.6	3.0	15.0	3.4	-9.3	-2.1
Water Body	7.9	1.8	6.6	1.5	6.8	1.5	-1.1	-0.2
Total	448.7	100.0	448.5	100.0	448.5	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Table 2.18 shows the results of LULC change in Faridabad tehsil from 1991 to 2022 and the result that agricultural land had shrunk and converted into built-up, water bodies, barren land and vegetation. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body respectively; 228.3 km^2, 130.7 km^2, 57.4 km^2, 24.3 km^2 and 7.9 km^2 in 1991; 228.8 km^2, 107.9 km^2, 91.7 km^2, 13.6 km^2 and 6.6 km^2 in 2006; 129.9 km^2, 101.8 km^2, 195 km^2, 15 km^2 and 6.8 km^2 in 2022(fig. 2.17).
agriculture area had changed into built-up (109.2 km^2), barren land (1.6 km^2), water body (2.1km^2) and vegetation (0.7 km^2). Barren land is also converted into agriculture, built up and vegetation by 10.5 km^2, 23.5 km^2 , 5.9km^2. Vegetation cover also transformed into agriculture(2.1 km^2), barren land (9.5 km^2) and built-up (4.1 km^2). water body had changed into agriculture and built up by 2.4 km^2 and 1.5 km^2. (Annexure-1 table 1.14).

Ballabgarh Tehsil:-

It is also showing drastic LULC transformation due to the nearness of Delhi as it has lost around 14% of its agriculture area from 1991 to 2022 which is a matter of concern for agriculture growth within the region. The geographical area of the tehsil is 391.4 km^2 and the Yamuna river passes through it which makes it more fertile.

Fig. 2.18- LULC Change Maps of Ballabgarh Tehsil- 1991, 2006 and 2022

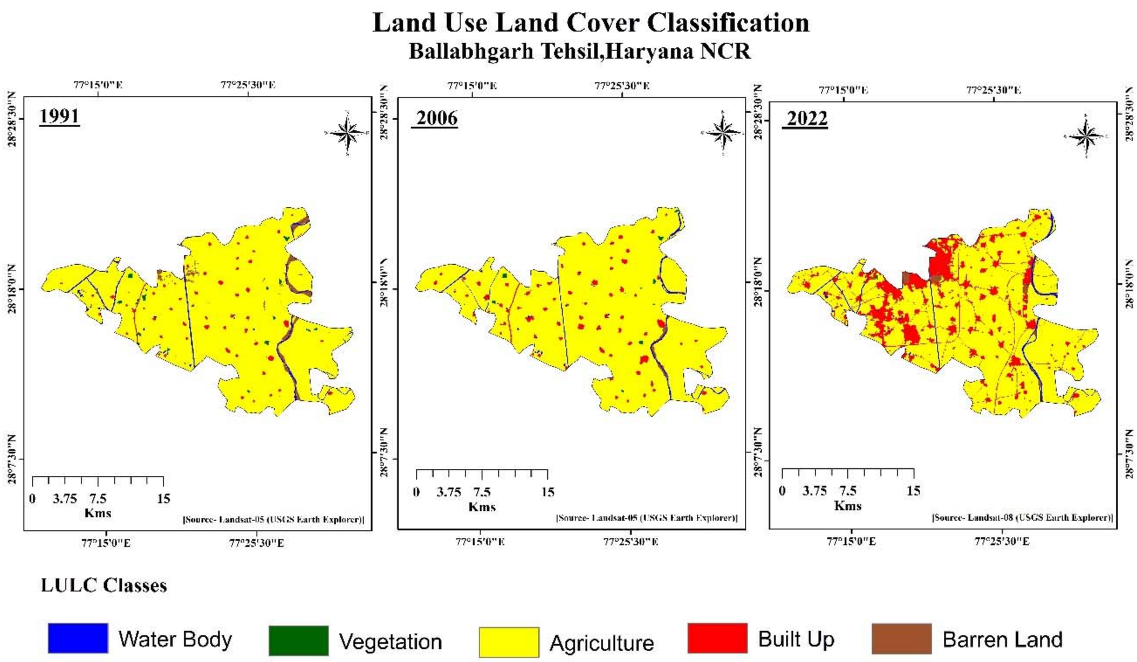


Table 2.19:- LULC Change in Ballabgarh Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	367.5	93.9	370.0	94.5	315.4	80.6	-52.0	-13.3
Barren Land	8.0	2.0	1.6	0.4	3.8	1.0	-4.2	-1.1
Built up	6.4	1.6	11.4	2.9	64.4	16.5	58.0	14.8
Vegetation	2.3	0.6	1.2	0.3	0.4	0.1	-1.9	-0.5
Water Body	7.3	1.9	7.1	1.8	7.3	1.9	0.0	0.0
Total	391.5	100.0	391.4	100.0	391.4	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Ballabgarh is part of Faridabad district which is highly affected by the Delhi proximity, The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 367.5 km^2, 8 km^2, 6.4 km^2, 2.3 km^2 and 7.3 km^2 in 1991; 370 km^2, 1.6 km^2, 11.4 km^2, 1.2 km^2 and 7.1 km^2 in 2006; 315.4 km^2, 3.8

km^2, 64.4 km^2, 0.4 km^2 and 7.3 km^2 in 2022. Within the tehsil, the agricultural land decreased by 13.3% and built-up increased by 14.8%. barren land and vegetation cover have also decreased by 1.1% & 0.5%(fig. 2.18 & table 2.19) Agriculture area had changed into built up (56 km^2), barren land (1.9 km^2), water body (1.2 km^2) and vegetation (0.2 km^2). Barren land is also converted into agriculture and water bodies by 3.6 km^2, 0.6 km^2. The built-up area had also undergone some change and transformed into agriculture by 0.1 km^2. Vegetation cover also transformed into agriculture(1.5 km^2) and built up (0.4 km^2). water body had changed into agriculture and built up by 2.2 km^2 and 0.3 km^2. (Annexure-1 table no.1.15).

Gurgaon Tehsil

Gurgaon tehsil is the part of Gurgaon district of Haryana state, and it also shares the longest boundary line with New Delhi among the four Tehsils of Haryana state which share their boundary with Delhi. Due to the proximity of Delhi, the highest changes in the LULC pattern of Gurgaon tehsils have been recorded during the study period from 1991 to 2022. Due to the growing population, urbanization, in-migration, and thousands of innovative projects, the LULC pattern within the tehsils has undergone drastic up and down among all the LULC classes. Agriculture is the highest negatively affected during the study period as it has been decreasing continuously.

Fig. 2.19- LULC Change Maps of Gurgaon Tehsil- 1991, 2006 and 2022

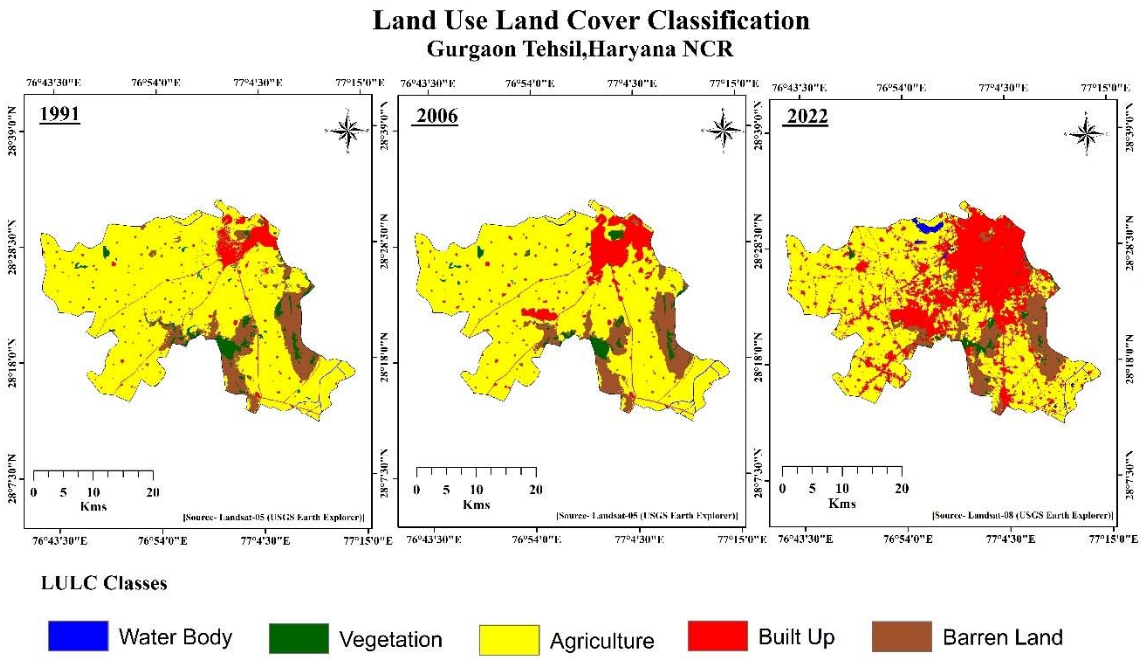


Table 2.20:- LULC Change in Gurgaon Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	843.9	79.3	825.0	77.6	590.8	55.5	-253.2	-23.8
Barren Land	119.2	11.2	105.6	9.9	102.2	9.6	-17.0	-1.6
Built up	60.3	5.7	102.3	9.6	343.7	32.3	283.4	26.6
Vegetation	37.7	3.5	27.1	2.5	16.7	1.6	-21.0	-2.0
Water Body	2.8	0.3	3.9	0.4	10.4	1.0	7.6	0.7
Total	1063.8	100.0	1063.8	100.0	1063.7	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Table 2.20 shows the LULC transformation in the Gurgaon tehsil of Gurgaon district and the resulted that the tehsil is facing huge changes in the field of land use/ land cover. The agricultural land is shrinking and the area under built up is expanding and this is a matter of great concern for the policymakers as the area needs a better land use plan for sustainable growth. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 843.9 km^2, 119.2 km^2, 60.3 km^2, 37.7 km^2 and 2.8 km^2 in 1991; 825 km^2, 105.6 km^2, 102.3 km^2, 27.1 km^2 and 3.9 km^2 in 2006; 590 km^2, 102.2 km^2, 343.7 km^2, 16.7 km^2 and 10.4 km^2 in 2022(fig. 2.19). Agricultural area had changed into built-up (264.6 km^2), barren land (6.1 km^2), water bodies (8 km^2) and vegetation (0.01 km^2). Barren land was also converted into agriculture and built up by 18.5 km^2, 13.2 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.0 km^2. Vegetation cover also transformed into agriculture(5.5 km^2), barren land (8.8km^2) and built-up (6.6 km^2). water body had changed into agriculture and built up by 0.6 km^2 and 0.1 km^2. (Annexure-1 table no.1.16).

Pataudi Tehsil:-

Pataudi is the part of Gurgaon District and is also near to Delhi with 222.7 km^2 geographical area. almost 87.8% area within the tehsil is under cultivation. Due to the nearness of Delhi, it has undergone huge LULC modification and lost almost 7.5% agricultural area from 1991 to 2022. Apart from these, it faces rural and urban expansion which occupies its precious agricultural land. Pataudi is the tehsil of the Gurgaon district and table 2.21 & fig. 2.20 shows the LULC changes within the tehsil during 1991 to 2022. Pataudi faces huge LULC changes, especially in the field of agriculture and built-up. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water bodies respectively; 212.2 km^2, 0.2 km^2, 7.3 km^2, 1.5 km^2 and 1.6 km^2 in 1991; 210.4 km^2, 0.3 km^2, 10.2 km^2, 0.5 km^2 and 1.2 km^2 in 2006; 195.5 km^2, 0.2 km^2, 25.7 km^2, 0.4 km^2 and 0.9 km^2 in 2022.

Fig. 2.20- LULC Maps of Pataudi Tehsil- 1991, 2006 and 2022

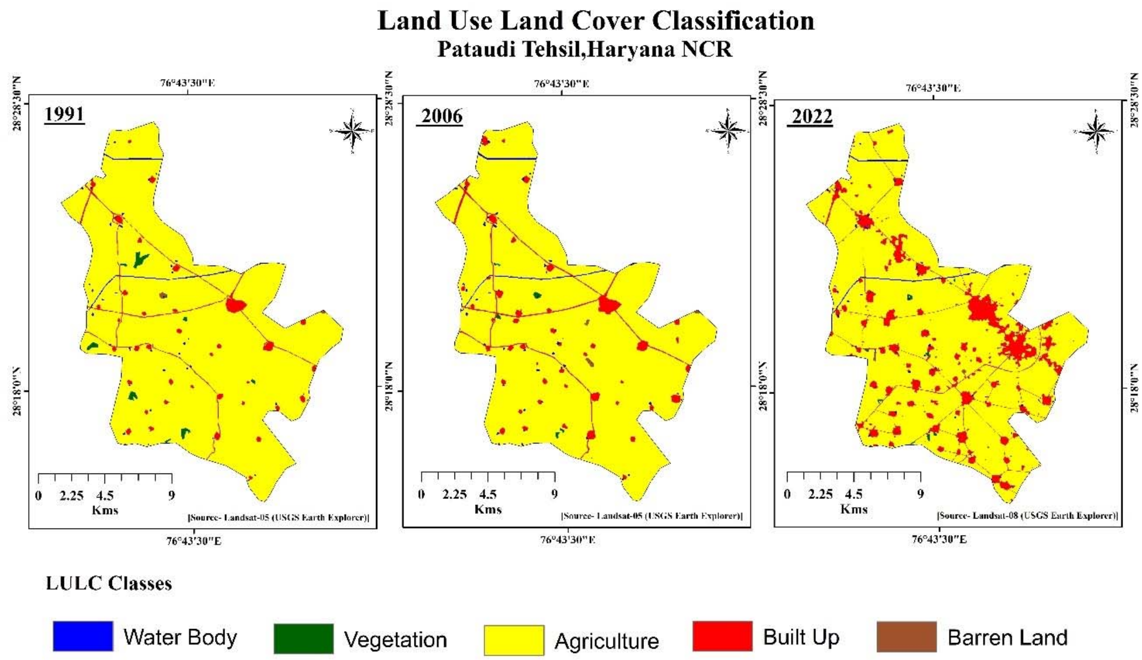


Table 2.21:- LULC Change in Patoudi Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	212.2	95.3	210.4	94.5	195.5	87.8	-16.7	-7.5
Barren Land	0.2	0.1	0.3	0.1	0.2	0.1	0.0	0.0
Built up	7.3	3.3	10.2	4.6	25.7	11.5	18.4	8.3
Vegetation	1.5	0.7	0.5	0.2	0.4	0.2	-1.1	-0.5
Water Body	1.6	0.7	1.2	0.6	0.9	0.4	-0.7	-0.3
Total	222.7	100.0	222.7	100.0	222.7	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

If we talk about transition, the Agriculture area had changed into built-up (19.3 km^2), barren land (0.2km^2), water body (0.1 km^2) and vegetation (0.2 km^2). Barren land is also converted into agriculture and vegetation by 0.1 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.1 km^2. Vegetation cover also tranformed into agriculture(1.2 km^2) and built up (0.1 km^2). water body had changed into agriculture and built up by 0.7 km^2 and 0.1 km^2. (Annexure-1 table no.1.17).

Nuh Tehsil

It is the part of Nuh district of Haryana NCR and does not so much good soil and irrigation facilities. Almost 74.9% area of the tehsil is under cultivation with 12% waste/Barren land in the form of Arawali hills. The geographical area is 641.1 km^2 and has undergone some LULC modification which affects its agriculture area which has decreased by -5.9% from 1991 to 2022.

Fig. 2.21- LULC Change Map of Nuh Tehsil for 1991, 2006 to 2022

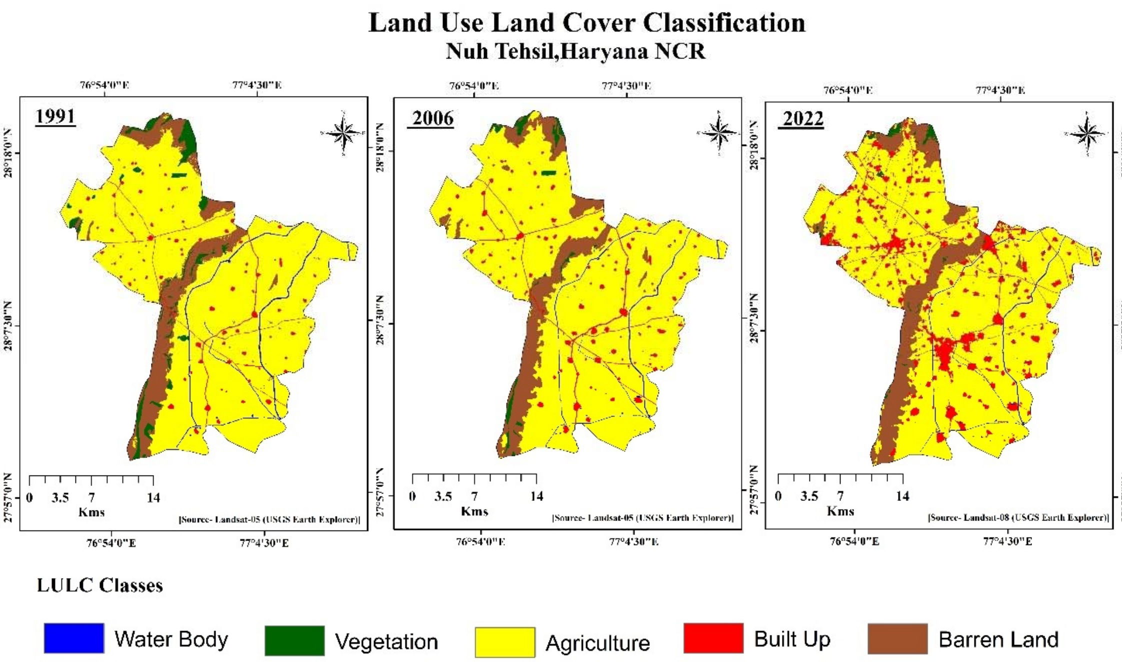


Table 2.22:- LULC Change in Nuh Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	517.8	80.8	524.0	81.7	480.0	74.9	-37.8	-5.9
Barren Land	77.6	12.1	76.5	11.9	78.7	12.3	1.1	0.2
Built up	16.3	2.5	25.0	3.9	71.2	11.1	54.8	8.6
Vegetation	21.2	3.3	8.7	1.4	4.8	0.7	-16.4	-2.6
Water Body	8.3	1.3	7.0	1.1	6.5	1.0	-1.9	-0.3
Total	641.2	100.0	641.1	100.0	641.1	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Table 2.22 and Fig. 2.21 show LULC changes in Nuh tehsil from 1991 to 2022. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water bodies respectively; 517.8 km^2, 77.6 km^2, 16.3 km^2, 21.2 km^2 and 8.3 km^2 in 1991; 524 km^2, 76.5 km^2, 25 km^2, 8.7 km^2 and 7 km^2 in 2006; 480 km^2, 78.7 km^2, 71.2 km^2, 4.8 km^2 and 6.5 km^2 in 2022. The area under agriculture from 1991 to 2006 increased but after that, it decreased from 2006 to 2022 and it decreased by 5.9% from 1991 to 2022 whereas built-up increased by 8.6%. Agricultural area had changed into built-up (53 km^2), barren land (2.1 km^2), water body (0.7 km^2) and vegetation (0.2 km^2). Barren land was also converted into agriculture, and vegetation and built up by 10.9 km^2, 1.3 km^2, 2.7 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.9 km^2. Vegetation cover also transformed into agriculture(3.2 km^2) and built up (1.2 km^2). water body had changed into agriculture and built up by 2.4 km^2 and 0.3 km^2. (Annexure-1 table no.1.30).

Firojpur Zirkha Tehsil

It is the part of Nuh tehsil with 825.4 km^2 geographical area. Firojpur Zirkha is blessed with good soil and moisture conditions. During the last 30 to 32 years, firojpur Zirkha has faced huge LULC changes mainly in the field of agriculture. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 687.2 km^2, 102 km^2, 18.1 km^2, 12.2 km^2 and 6 km^2 in 1991; 687.6 km^2, 95.4 km^2, 27.1 km^2, 8.8 km^2 and 6.5 km^2 in 2006; 637.7 km^2, 100.5 km^2, 80.4 km^2, 1.3 km^2 and 5.5 km^2 in 2022. Except built-up area, all the classes have lost area from 1991 to 2022 and the highest amount of area decreased in two LULC categories namely agriculture and vegetation by 6% and 1.3%. area under built-up is continuously increasing (fig. 2.22, table no. 2.23).

Fig. 2.22- LULC Change Map of Firojpur Jhirkha for the Years- 1991, 2006 and 2022

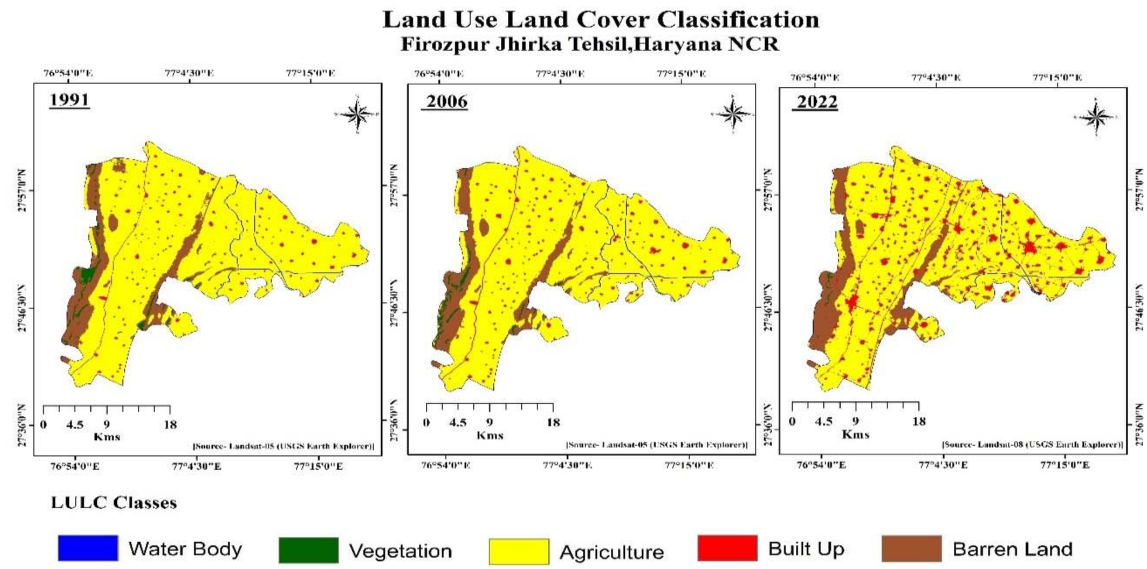


Table 2.23:- LULC Change in Firojpur Zirkha Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	687.2	83.3	687.6	83.3	637.7	77.3	-49.5	-6.0
Barren Land	102.0	12.4	95.4	11.6	100.5	12.2	-1.5	-0.2
Built up	18.1	2.2	27.2	3.3	80.4	9.7	62.3	7.5
Vegetation	12.2	1.5	8.8	1.1	1.3	0.2	-10.9	-1.3
Water Body	6.0	0.7	6.5	0.8	5.5	0.7	-0.5	-0.1
Total	825.5	100	825.4	100	825.4	100		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

If we talk about the transition between all the LULC classes, the Agriculture area had changed into built-up (59.4 km^2), barren land (6.2 km^2) and water body (1.1 km^2). Barren land was also converted into agriculture and built up by 14.7 km^2, 3.3 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.0 km^2. Vegetation cover also transformed into agriculture(0.4 km^2) and built up (10.5 km^2). water body had changed into agriculture and built up by 1.2 km^2 and 0.3 km^2. (Annexure-1 table no.1.31).

Palwal Tehsil

It is part of Palwal district with 905.5 km^2 geographical area. almost 84.8% area is under cultivation with good soil and irrigation facilities. In Palwal tehsil, table 2.24 shows the LULC changes that occurred within the tehsil from 1991 to 2022. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 844.9 km^2, 9.9 km^2, 29 km^2, 6 km^2 and 15.7 km^2 in 1991; 841.6 km^2, 1.4 km^2, 43.8 km^2, 2.3 km^2 and 16.3 km^2 in 2006; 767.8 km^2, 2.4 km^2, 114.8 km^2, 2.1 km^2 and 18.4 km^2 in 2022. Except for built-up areas and water bodies, all the classes have lost area from 1991 to 2022 and the highest amount of area decreased in two LULC categories namely agriculture and barren land by 8.5% and 0.8%. area under built-up is continuously increasing and the built-up area has increased by 9.5% (fig. 2.23).

Fig. 2.23- LULC Maps of Palwal Tehsil- 1991, 2006 and 2022

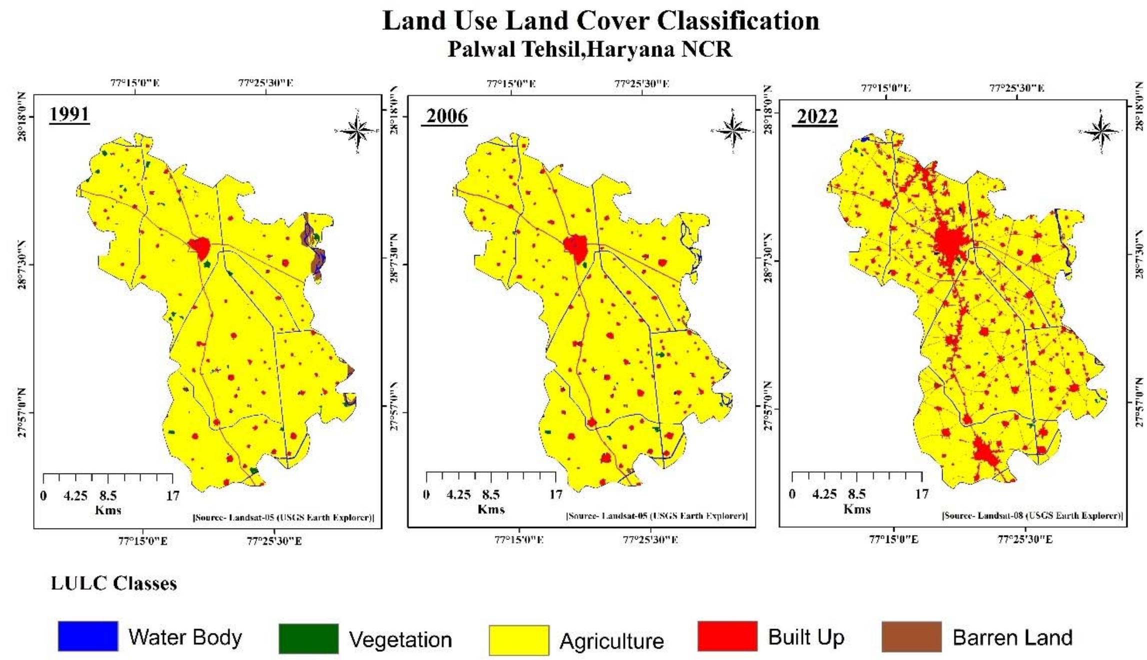


Table 2.24:- LULC Change in Palwal Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	844.9	93.3	841.6	93.0	767.8	84.8	-77.1	-8.5
Barren Land	9.9	1.1	1.4	0.2	2.4	0.3	-7.5	-0.8
Built up	29.0	3.2	43.8	4.8	114.8	12.7	85.8	9.5
Vegetation	6.0	0.7	2.3	0.3	2.1	0.2	-3.9	-0.4
Water Body	15.7	1.7	16.3	1.8	18.4	2.0	2.6	0.3
Total	905.5	100.0	905.5	100.0	905.5	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Agricultural area had changed into built-up (85.5 km^2), barren land (1.5 km^2), water bodies (5.5 km^2) and vegetation (0.8 km^2). Barren land is also converted into agriculture, water bodies and built up by 7.6 km^2, 1.2 km^2, 0.3 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.1 km^2. Vegetation cover also transformed into agriculture(4.4 km^2) and built up (0.4 km^2). water body had changed into agriculture and built up by 3.1 km^2 and 0.9 km^2. (Annexure-1 table no.1.18).

Hathin Tehsil

Hathin Tehsil is the part of Palwal district with 419.1 km^2 geographical area. Almost 87.1% of the total area is under cultivation and blessed with good soil and water facilities. Table 2.25 and fig. 2.24 shows the LULC changes in Hathin tehsil of Palwal district from 1991 to 2022. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body were respectively; 387.2 km^2, 2.6 km^2, 17.4 km^2, 2 km^2 and 10 km^2 in 1991; 386.3 km^2, 0.9 km^2, 21.7 km^2, 0.8 km^2 and 9.4 km^2 in 2006; 365.2 km^2, 1.8 km^2, 42.9 km^2, 0.3 km^2 and 8.9 km^2 in 2022.

Fig. 2.24- LULC Map of Hathin Tehsil- 1991, 2006 and 2022

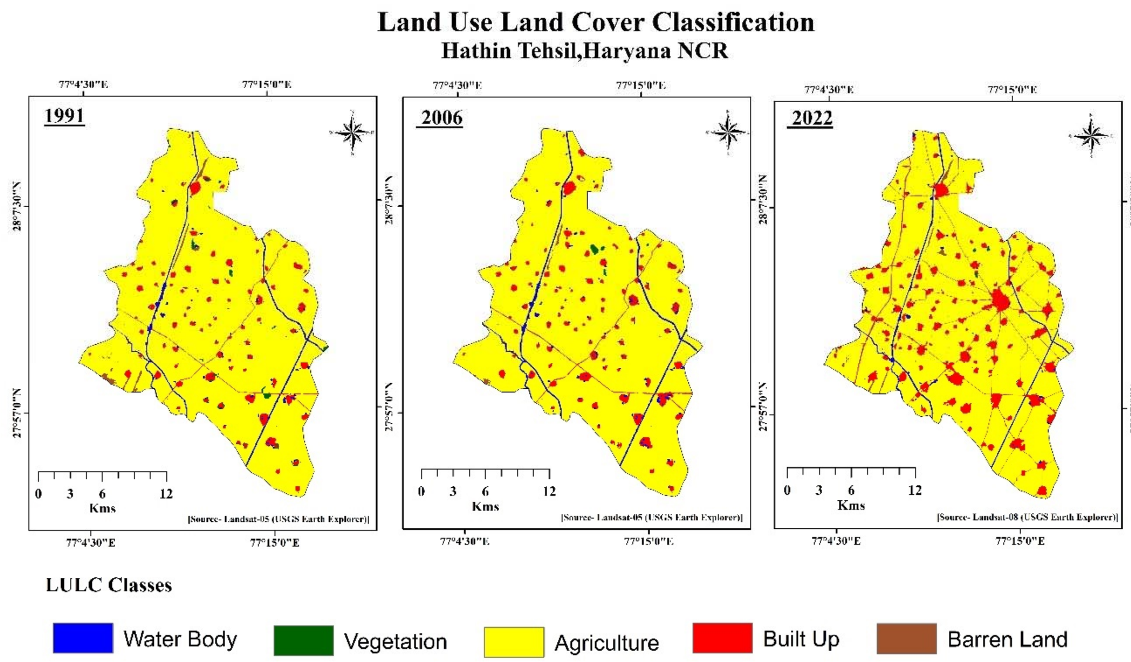


Table 2.25:- LULC Change in Hathin Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	387.2	92.4	386.3	92.2	365.2	87.1	-22.0	-5.2
Barren Land	2.6	0.6	0.9	0.2	1.8	0.4	-0.7	-0.2
Built up	17.4	4.1	21.7	5.2	42.9	10.2	25.5	6.1
Vegetation	2.0	0.5	0.8	0.2	0.3	0.1	-1.7	-0.4
Water Body	10.0	2.4	9.4	2.2	8.9	2.1	-1.2	-0.3
Total	419.2	100.0	419.1	100.0	419.1	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Except built-up area, all the classes have lost area from 1991 to 2022 and the highest amount of area decreased in two LULC categories namely agriculture and vegetation by 5.2% and 0.4%. between 1991 to 2022, agricultural land was converted into built-up, water body, barren land, and vegetation by 25.4km^2, 1.7km^2, 0.8km^2 and 0.2km^2. barren land had changed into agriculture by 1.4 km^2. (Annexure-1 table no.1.19).

Kosli Tehsil

Fig. 2.25 and Table 2.26 show the LULC changes in the Kosli tehsil of Rewari district and resulted that agricultre land undergoing a huge negative trend due to expansion in other LULC classes. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 585.6 km^2, 8.5 km^2, 11.4 km^2, 9.2 km^2 and 6.4 km^2 in 1991; 583.7 km^2, 7.3 km^2, 18.6 km^2, 6 km^2 and 5.3 km^2 in 2006; 541 km^2, 15.4 km^2, 54.2 km^2, 4.7 km^2 and 5.7 km^2 in 2022. Expansion of rural-urban areas and growing population are the major causes of LULC changes within the tehsil.

Fig. 2.25- LULC Map of Kosli Tehsil- 1991, 2006 and 2022

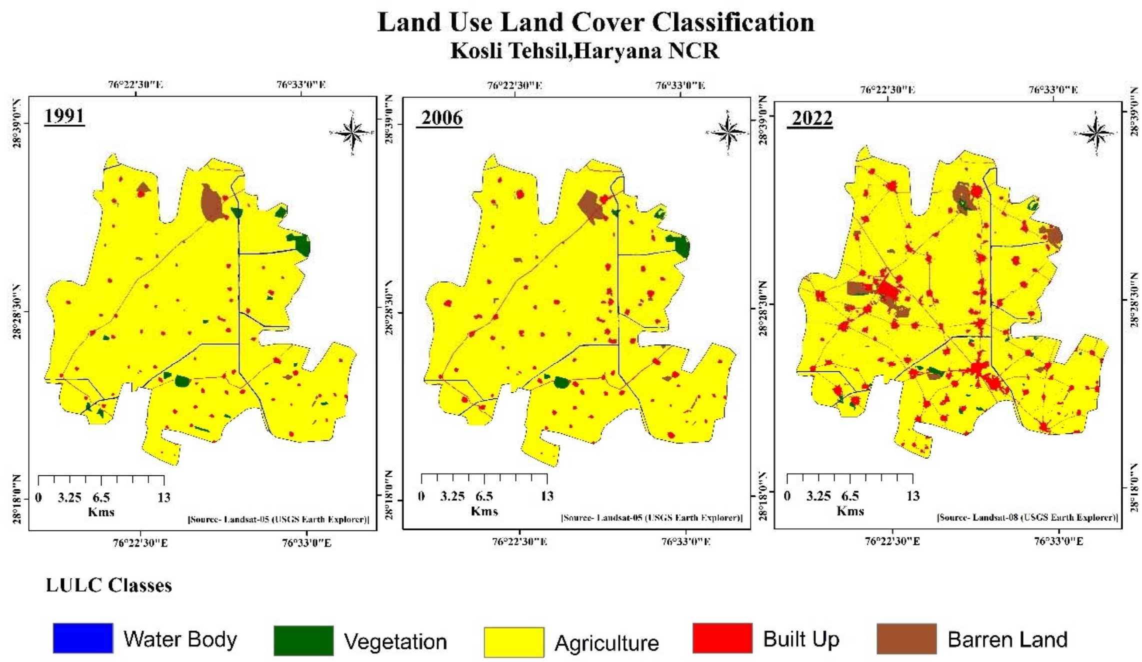


Table 2.26: - LULC Change in Kosli Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	585.6	94.3	583.7	94.0	541.0	87.1	-44.7	-7.2
Barren Land	8.5	1.4	7.3	1.2	15.4	2.5	6.8	1.1
Built up	11.4	1.8	18.6	3.0	54.2	8.7	42.8	6.9
Vegetation	9.2	1.5	6.0	1.0	4.7	0.8	-4.5	-0.7
Water Body	6.4	1.0	5.3	0.8	5.7	0.9	-0.7	-0.1
Total	621.1	100.0	620.9	100.0	620.9	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Except built-up area, all the classes have lost area from 1991 to 2022 and highest amount of area decreased in two LULC categories namely agriculture and barren land by 7.2% and 1.1%. The area under built-up is continuously increasing. Agriculture land had changed into built-up (42.6 km^2), barren land (6.9km^2), water bodies (0.7km^2) and vegetation (1.8 km^2). Barren land had changed into agriculture (2.2 km^2), vegetation(0.8km^2) and built-up (0.7km^2). vegetation cover had decreased and transformed into barren land (3.6 km^2), agriculture(3.3km^2) and built-up (0.2km^2). area under the water body had converted into agriculture and built up by 1.2 km^2 and 0.2 km^2. built-up area had also shown conversion into agriculture by 0.9km^2. (Annexure-1 table no.1.28).

Rewari Tehsil

Table 2.27 and fig. 2.26 shows the LULC changes in Rewari tehsil and resulted that The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 926.4 km^2, 46.2 km^2, 31.8 km^2, 8.1 km^2 and 3.2 km^2 in 1991; 926.8 km^2, 34.7 km^2, 47.2 km^2, 2.9 km^2 and 3.9 km^2 in 2006; 853.8 km^2, 33.7 km^2, 122.2 km^2, 0.9 km^2 and 4.8 km^2 in 2022. Except built-up area, all the classes have lost area from 1991 to 2022 and the highest amount of area decreased in two LULC categories namely agriculture and barren land by 7.2% and 1.2%. area under built-up is continuously increasing.

Fig. 2.26- LULC Maps of Rewari Tehsil for 1991, 2006 to 2022

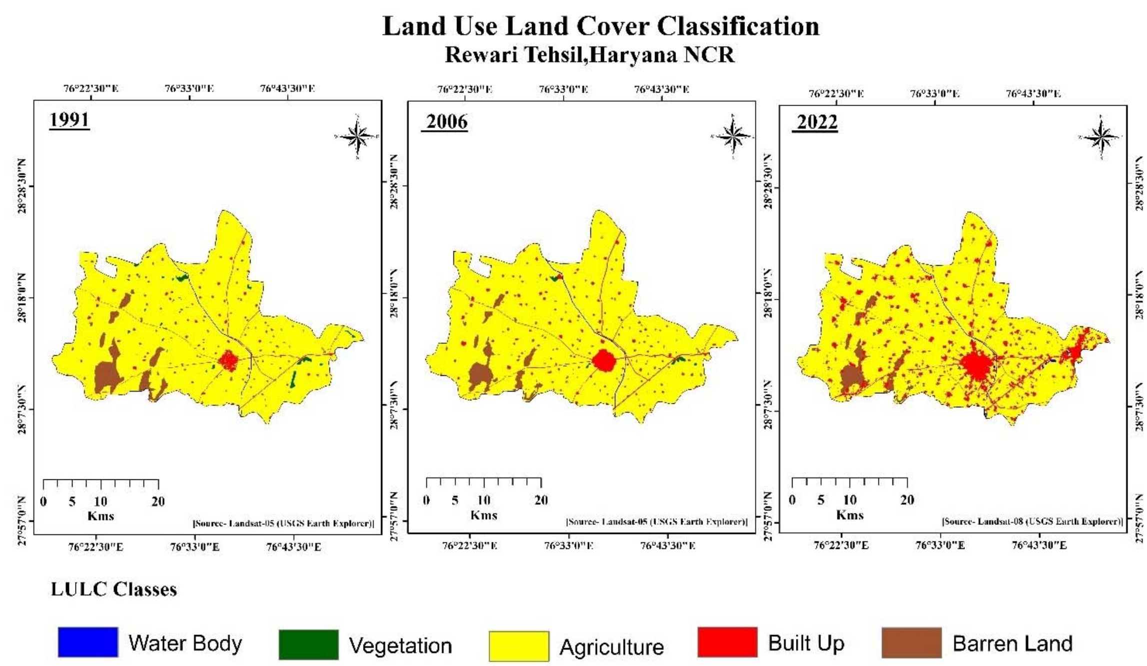


Table 2.27:- LULC Change in Rewari Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	926.4	91.2	926.8	91.3	853.8	84.1	-72.6	-7.2
Barren Land	46.2	4.5	34.7	3.4	33.7	3.3	-12.4	-1.2
Built up	31.8	3.1	47.2	4.6	122.2	12.0	90.4	8.9
Vegetation	8.1	0.8	2.9	0.3	0.9	0.1	-7.2	-0.7
Water Body	3.2	0.3	3.9	0.4	4.8	0.5	1.6	0.2
Total	1015.6	100.0	1015.4	100.0	1015.4	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Agriculture is converting into built-up, barren land, water bodies and vegetation by 84.7 km^2, 2.5 km^2, 1 km^2 and 0.4 km^2. Barren land had converted into agriculture (8.5 km2), built up (6.3 km^2) and vegetation (0.2 km^2) and vegetation area had converted into agriculture (5.3 km^2), built up (1.5 km^2) and water body (0.9 km^2). Built-up is the most profitable class among all the LULC classes and most of the area gains from the agriculture section. Some of the areas under built-up had converted into agriculture by 2.1 km^2. The water body area had converted into agriculture (0.2 km^2) and built up (0.1 km^2) (Annexure-1 table no.1.27).

Bawal Tehsil

It is part of Rewari district with a 238.1 km^2 geographical area. almost 78.9% of the area is under cultivation and it has lost around 12.9% agricultural area due to built-up expansion from 1991 to 2022. Table 2.28 is showing the LULC changes in the Bawal tehsil of Rewari district. From 1991 to 2022, The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water bodies respectively; 218.7 km^2, 7.4 km^2, 4.6 km^2, 3.9 km^2 and 3.5 km^2 in 1991; 209.5 km^2, 6.6 km^2, 16.4 km^2, 3.3 km^2 and 2.5 km^2 in 2006; 187.9 km^2, 8.5 km^2, 36.6 km^2, 2.9 km^2 and 2.2 km^2 in 2022.

Fig. 2.27- LULC Maps of Bawal Tehsil for 1991, 2006 to 2022

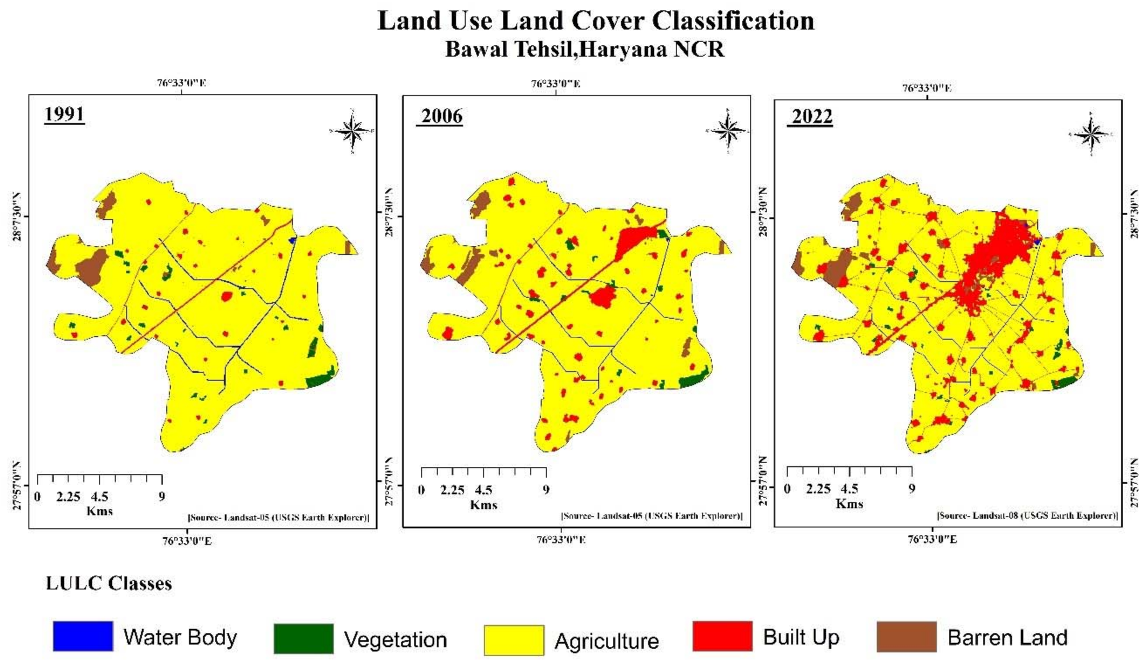


Table 2.28:- LULC Change in Bawal Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	218.7	91.8	209.5	88.0	187.9	78.9	-30.7	-12.9
Barren Land	7.4	3.1	6.6	2.8	8.5	3.6	1.1	0.5
Built up	4.6	1.9	16.4	6.9	36.6	15.3	31.9	13.4
Vegetation	3.9	1.7	3.3	1.4	2.9	1.2	-1.1	-0.5
Water Body	3.5	1.5	2.5	1.0	2.2	0.9	-1.3	-0.5
Total	238.2	100.0	238.1	100.0	238.1	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Except built-up area, all the classes have lost area from 1991 to 2022 and the highest amount of area decreased in two LULC categories namely agriculture and vegetation by 12.9% and 0.5%. area under built-up is continuously increasing (fig. 2.27). The agriculture transforms into built-up, barren land, and water bodies by 30.9 km^2, 2.4 km2, 0.2 km^2 and

1.4 km^2. The agriculture section underwent a huge loss of area and the built-up section gained the highest area during the study period. Barren land had changed into built-up, agriculture by 1.1 km^2, 0.6 km^2. Vegetation cover had changed into agriculture, barren land and built up by 0.7 km^2, 0.4 km^2 and 0.1 km^2. Some of the areas of the water body had changed into agriculture (1.2 km^2) during 1991 to 2022**.** (Annexure-1 table no.1.29).

Siwani Tehsil

Siwani is a tehsil of Bhiwani district with a lot of sandy area. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body respectively; 377.9 km^2, 349.6 km^2, 15.2 km^2, 0.6 km^2 and 6.5 km^2 in 1991; 398.3 km^2, 324.1 km^2, 22 km^2, 0.1 km^2 and 0.9 km^2 in 2006; 551.5 km^2, 156 km^2, 35.2 km^2, 1.8 km^2 and 5.3 km^2 in 2022 (Table 2.29 & fig. 2.28). Siwani is the only tehsil which showed positive change in their agriculture area from 1991 to 2022.

Fig. 2.28- LULC Maps of Siwani Tehsil for the year 1991, 2006 and 2022

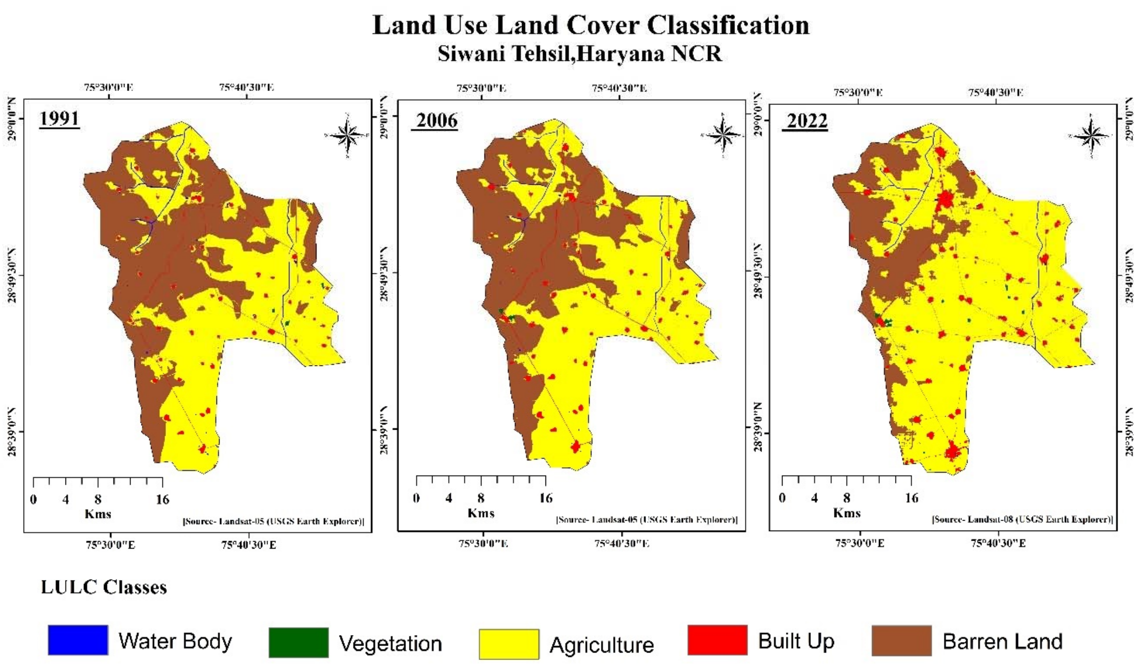


Table 2.29:- LULC Change in Siwani Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	377.9	50.4	398.3	53.1	551.5	73.6	173.6	23.2
Barren Land	349.6	46.6	324.1	43.2	156.0	20.8	-193.6	-25.8
Built up	15.2	2.0	22.0	2.9	35.2	4.7	19.9	2.7
Vegetation	0.6	0.1	0.8	0.1	1.8	0.2	1.2	0.2
Water Body	6.5	0.9	4.6	0.6	5.3	0.7	-1.2	-0.2
Total	749.8	100.0	749.7	100.0	749.7	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

In Siwani, the LULC transition is as follows- The agriculture area converted into barren land, built up, vegetation and water body by 1.7 km^2, 16.8 km^2, 1 km^2 and 0.1 km^2. Barren land had converted into agriculture, built-up, and vegetation by 189.9 km^2, 5.6 km^2, 0.9km^2 and 0.7 km^2 and built-up area also increased and most of add up came from the cultivable area and barren land by 17.6 km^2 ans 5.3 km^2. Water bodies also changed into agriculture by 1.2 km^2 and vegetation into agriculture by 0.4 km2. this is the only tehsil of NCR Haryana which is showing positive growth in the agriculture area due to expansion in irrigation facilities within the tehsil. (Annexure-1 table no.1.24).

Bhawani Khera Tehsil

It is part of the Bhiwani district with 605.8 km^2 geographical and the tehsil has undergone huge changes in LULC pattern from 1991 to 2022. The results show that the area under cultivation, vegetation and water bodies had decreased and the area under built-up and barren land had increased. Many factors like increasing population, growth activities etc. are playing a vital role in LULC change within the tehsil(fig. 2.29).

Fig. 2.29- LULC change Map of Bhawani Khera for the years 1991, 2006 and 2022

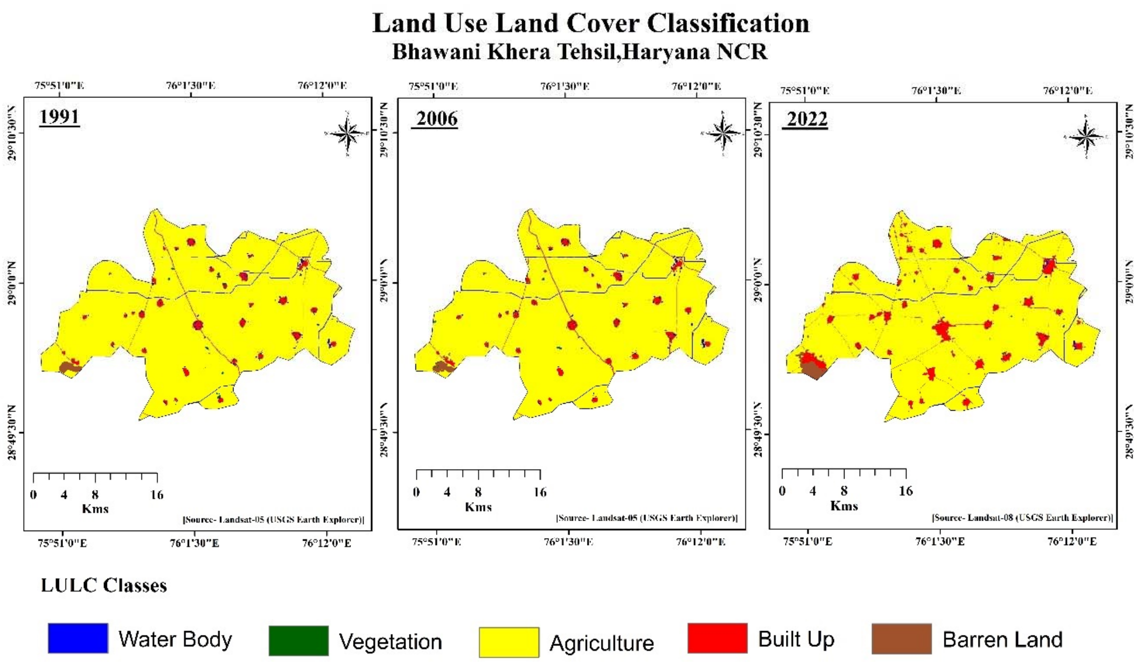


Table 2.30:- LULC Change in Bhawani Khera Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	576.5	95.2	574.2	94.8	555.0	91.6	-21.5	-3.6
Barren Land	3.0	0.5	3.1	0.5	5.9	1.0	3.0	0.5
Built up	15.8	2.6	17.9	3.0	36.0	5.9	20.2	3.3
Vegetation	1.0	0.2	0.4	0.1	0.4	0.1	-0.6	-0.1
Water Body	9.6	1.6	10.2	1.7	8.5	1.4	-1.1	-0.2
Total	605.8		605.8		605.8			

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 576.5 km^2, 3 km^2, 15.8 km^2, 1 km^2 and 9.6

km^2 in 1991; 574.2 km^2, 3.1 km^2, 17.9 km^2, 0.4 km^2 and 10.2 km^2 in 2006; 555 km^2, 5.9 km^2,36 km^2, 0.4 km^2 and 8.5 km^2 in 2022. Except built-up area, all the classes have lost area from 1991 to 2022 and the highest amount of area decreased in two LULC categories namely agriculture and vegetation by 3.6% and 0.1%. area under built-up is continuously increasing (table 2.30). Agriculture land had converted into built-up, barren, vegetation and water body by 20.1 km^2, 3.3 km^2, 0.2 km^2 and 0.9 km^2. all the tehsils of Bhiwani district have passed through great changes in their LULC pattern during the last 30 years. (Annexure-1 table 1.21).

Bhiwani Tehsil

Bhiwani tehsil has undergone huge LULC changes due to human-induced activities like increasing population, industrial development and other infrastructural activities(fig. 2.30). Total geographical area is 1291.7 km^2 with 90% cultivable area. The tehsil is also showing some LULC changes in the form of rural-urban expansion due to urbanization and population growth.

Fig. 2.30- LULC change Map of Bhiwani Tehsil for 1991, 2006 and 2022

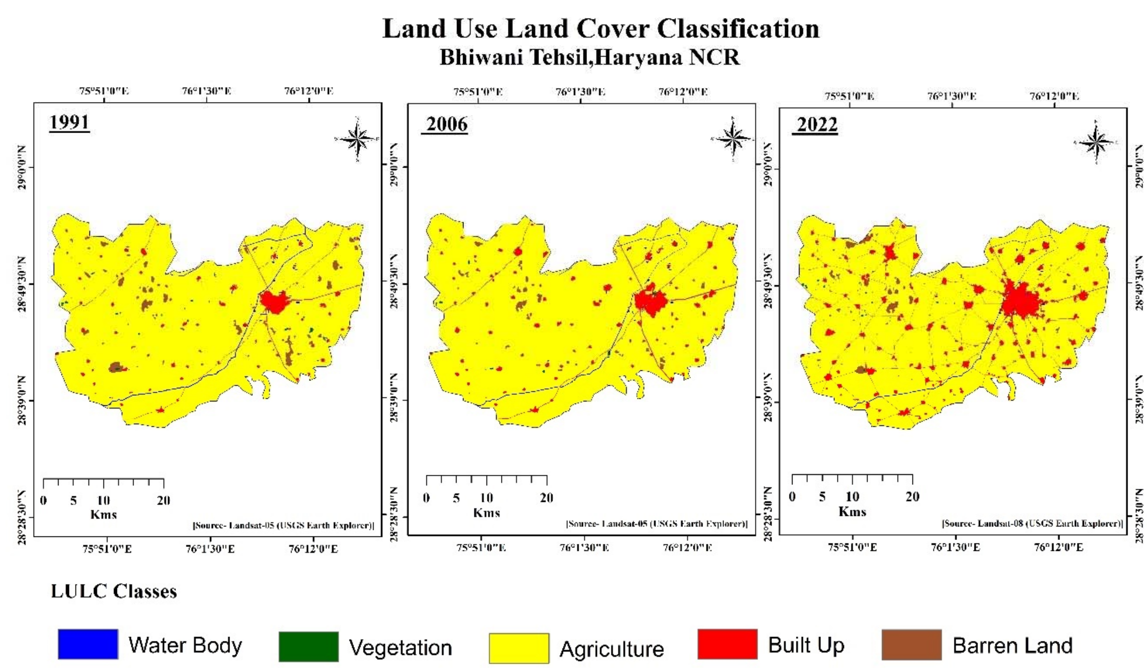


Table 2.31:- LULC Change in Bhiwani Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	1218.6	94.3	1219.3	94.4	1162.5	90.0	-56.1	-4.3
Barren Land	23.2	1.8	10.3	0.8	14.8	1.1	-8.4	-0.6
Built up	37.0	2.9	53.0	4.1	105.9	8.2	68.8	5.3
Vegetation	2.5	0.2	1.3	0.1	1.6	0.1	-0.9	-0.1
Water Body	10.5	0.8	7.8	0.6	6.9	0.5	-3.6	-0.3
Total	1291.8	100.0	1291.7	100.0	1291.7	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body respectively; 1218.6 km^2, 23.2 km^2, 37 km^2, 2.5 km^2 and 10.5 km^2 in 1991; 1219.3 km^2, 10.3 km^2, 53 km^2, 1.3 km^2 and 7.8 km^2 in 2006; 1162.5 km^2, 14.8 km^2, 105.9 km^2, 1.6 km^2 and 6.9 km^2 in 2022. Except for the built-up area, all the classes have lost area from 1991 to 2022 and the highest amount of area decreased in two LULC categories namely agriculture and barren land by 4.3% and 0.6%. and the area under built-up is continuously increasing (table 2.31). Agriculture land converted into barren land, built up, vegetation and water bodies by 5.7 km^2, 69 km^2, 1 km^2. most of the agricultural land transformed into built-up sections. Barren land had transformed into agriculture(12.8 km^2), built up (2 km^2) and vegetation (0.2 km^2). (Annexure-1 table no.1.20).

Dadri Tehsil

The total geographical area of Dadri tehsil is 1376 km^2 and it is now a separate district. Almost 88.7% area is under cultivation in Dadri and it has decreased by -2.6% during the study period. Dadri is also showing some LULC change in the form of rural-urban expansion.

Fig. 2.31- LULC Change Map of Dadri Tehsil for 1991, 2006 and 2022

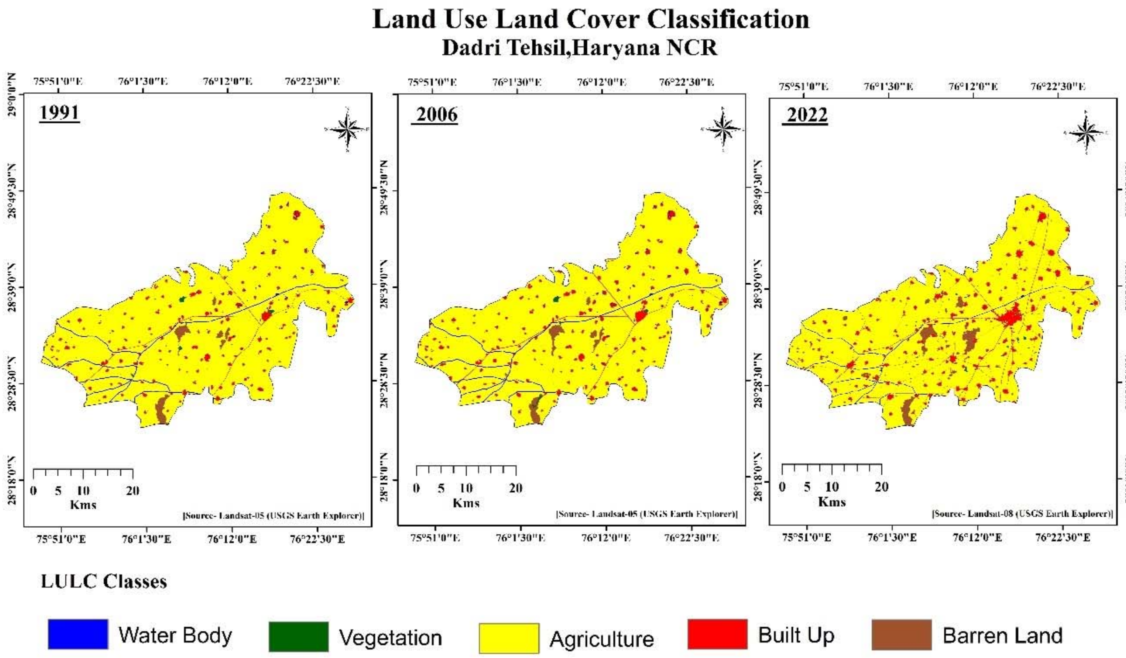


Table 2.32: - LULC Change in Dadri Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	1257.8	91.4	1261.0	91.6	1221.5	88.7	-36.3	-2.6
Barren Land	27.9	2.0	21.3	1.5	36.5	2.7	8.6	0.6
Built up	57.6	4.2	66.3	4.8	97.9	7.1	40.2	2.9
Vegetation	7.6	0.6	3.0	0.2	2.1	0.2	-5.5	-0.4
Water Body	25.7	1.9	25.0	1.8	18.5	1.3	-7.2	-0.5
Total	1376.7		1376.5		1376.5			

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Table 2.32 and Fig. 2.31 show the LULC change in Dadri tehsil and results that The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 1257.8 km^2, 27.9 km^2, 57.6 km^2, 7.6 km^2 and 25.7 km^2 in

1991; 1261 km^2, 21.3 km^2, 66.3 km^2, 3 km^2 and 25 km^2 in 2006; 1221.5 km^2, 36.5 km^2, 97.9 km^2, 2.1 km^2 and 18.5 km^2 in 2022.

Except built-up area, all the classes have lost area from 1991 to 2022 and the highest amount of area decreased in two LULC categories namely agriculture and vegetation by 2.6% and 0.4%.and the area under built-up is continuously increasing. The area under cultivation had converted into built-up, barren land and vegetation by 48.2 km2, 8.2 km^2, and 1.6 km^2. Barren land had changed into agriculture, built up and vegetation by 3.2km^2, 0.7km^2 and 0.1km^2. built-up section also showed conversion into agriculture, barren land and water bodies by 10.4km^2, 1.1km^2 and 0.5km^2. vegetation cover had decreased and converted into agriculture(2.7km^2), barren land(3km^2), built up(1.6km^2) and water body(0.1km^2). water body had changed into agriculture(6.1km^2) and built up(1.6 km^2). (Annexure-1 table no.1.22).

Loharu Tehsil

Loharu is part of the Bhiwani district with a 610.8 km^2 geographical area. It is located far away from the core NCR region as it is not so much affected by the LULC changes of peripheral areas. All the LULC changes which have occurred within the tehsil due to the rural-urban expansion and population growth.

Fig. 2.32- LULC Change Map of Loharu Tehsil for- 1991, 2006 and 2022

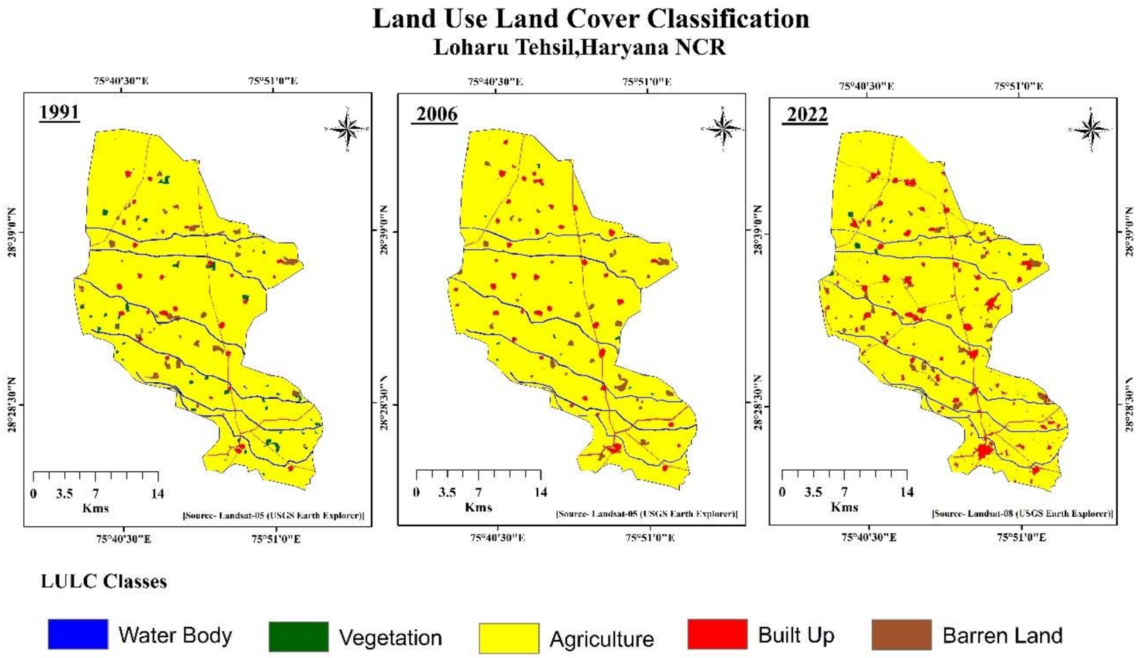


Table 2.33:- LULC Change in Loharu Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	565.3	92.5	568.9	93.1	557.3	91.2	-7.9	-1.3
Barren Land	9.8	1.6	8.0	1.3	11.2	1.8	1.4	0.2
Built up	11.3	1.8	17.3	2.8	27.5	4.5	16.2	2.6
Vegetation	7.0	1.1	0.8	0.1	1.5	0.2	-5.5	-0.9
Water Body	17.6	2.9	15.7	2.6	13.2	2.2	-4.3	-0.7
Total	610.9	100.0	610.8	100.0	610.8	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Loharu Tehsil is a part of the Bhiwani district and has arid climatic conditions with lots of sandy soil. Table 2.33 and Fig. 2.32 shows the LULC changes within the Loharu tehsil from 1991 to 2022 and resulted that The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 565.3 km^2, 9.8 km^2, 11.3 km^2, 7 km^2 and 17.6 km^2 in 1991; 568.9 km^2, 8 km^2, 17.3 km^2, 0.8 km^2 and 15.7 km^2 in 2006; 557.3 km^2, 11.2 km^2, 27.5 km^2, 1.5 km^2 and 13.2 km^2 in 2022. The highest area has decreased in agriculture due to the expansion of built-up.. Agricultural land had converted into built-up (15.7 km2) and barren land(3.5 km^2). The barren area also reflected some transformation into agriculture(2.6 km^2) and built-up (0.8 km^2). built up area also chnaged into agriculture(1.8 km^2), barren land(0.3km^2) and water body(0.1km^2). vegetation cover had changed into agriculture, and barren land and was built up by 3.2 km2, 1.5 km^2 and 1.6 km^2. (Annexure-1 table no.1.23).

Mahendergarh Tehsil

It is located in the Southwest of the study area with 991.8 km^2 geographical area. There are some parts of the Arawali hills. Here, soil and water availability is not so much good. From 1991 to 2022, tehsil underwent some LULC changes mainly in agriculture and built-up sections due to rural-urban expansion and other development activities. As table no. 2.34 and fig. 2.33 shows the LULC changes in Mahendrgarh and resulted that The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively;850.8 km^2, 94 km^2, 26.8 km^2, 14.1 km^2 and 6.3 km^2 in 1991; 865.6 km^2, 79.3 km^2, 34.4 km^2, 4.6 km^2 and 7.9 km^2 in 2006; 819 km^2, 80.2 km^2, 80.7 km^2, 6.5 km^2 and 5.4 km^2 in 2022. The highest area has decreased in agriculture due to the expansion of built-up.

Fig. 2.33- LULC Maps of Mahendergarh Tehsil for the year- 1991, 2006 and 2022

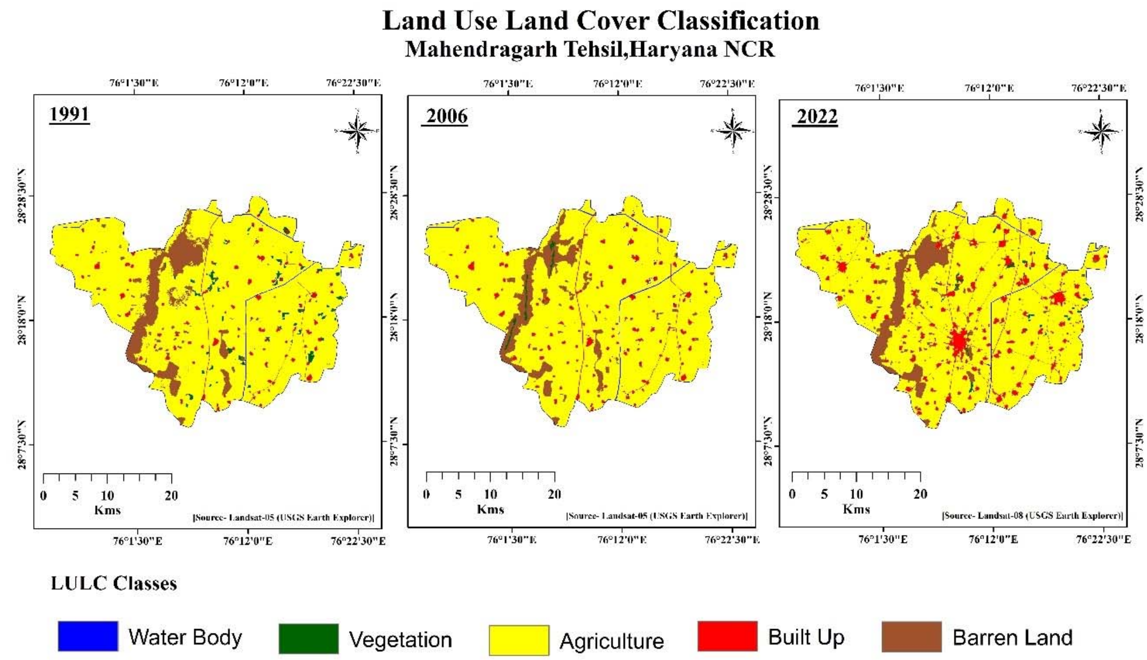


Table 2.34:- LULC Change in Mahendergarh Tehsil- 1991, 2006 and 2022

LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	850.8	85.8	865.6	87.3	819.0	82.6	-31.9	-3.2
Barren Land	94.0	9.5	79.3	8.0	80.2	8.1	-13.7	-1.4
Built up	26.8	2.7	34.4	3.5	80.7	8.1	53.9	5.4
Vegetation	14.1	1.4	4.6	0.5	6.5	0.7	-7.6	-0.8
Water Body	6.3	0.6	7.9	0.8	5.4	0.5	-0.8	-0.1
Total	992.0	100.0	991.8	100.0	991.8	100.0		

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

the agriculture within the tehsil Mahendergarh had changed into built-up, barren land, water body and vegetation by 52.7 km2, 5.2 km^2, 0.7 km^2 and 1.8 km^2 from 1991 to 2022. Barren land had also decreased and changed into agriculture, built up and vegetation by 16.5 km^2, 3.1 km^2 and 1.3 km^2. The built-up area had also converted into agriculture and barren land by 4.6 km^2 and 0.4 km^2. vegetation cover within the tehsil had also decreased and converted into agriculture(6.8 km^2), built up(2.4 km^2) and barren land (1.5 km^2). The area under water bodies had changed into agriculture (0.8 km^2), built-up (0.8 km^2) and vegetation (0.1 km^2). (Annexure-1 table no.1.25).

Narnoul Tehsil

It is part of Mahendergarh district with a 944 km^2 geographical area. it is also located far away from the core region of Delhi NCR. Narnoul is also experiencing some changes in its LULC pattern, especially in agriculture and built-up sections due to the expansion of settlements to fulfil the growing population's shelter needs.

Fig. 2.34- LULC Change Map of Narnoul Tehsil for 1991, 2006 to 2022

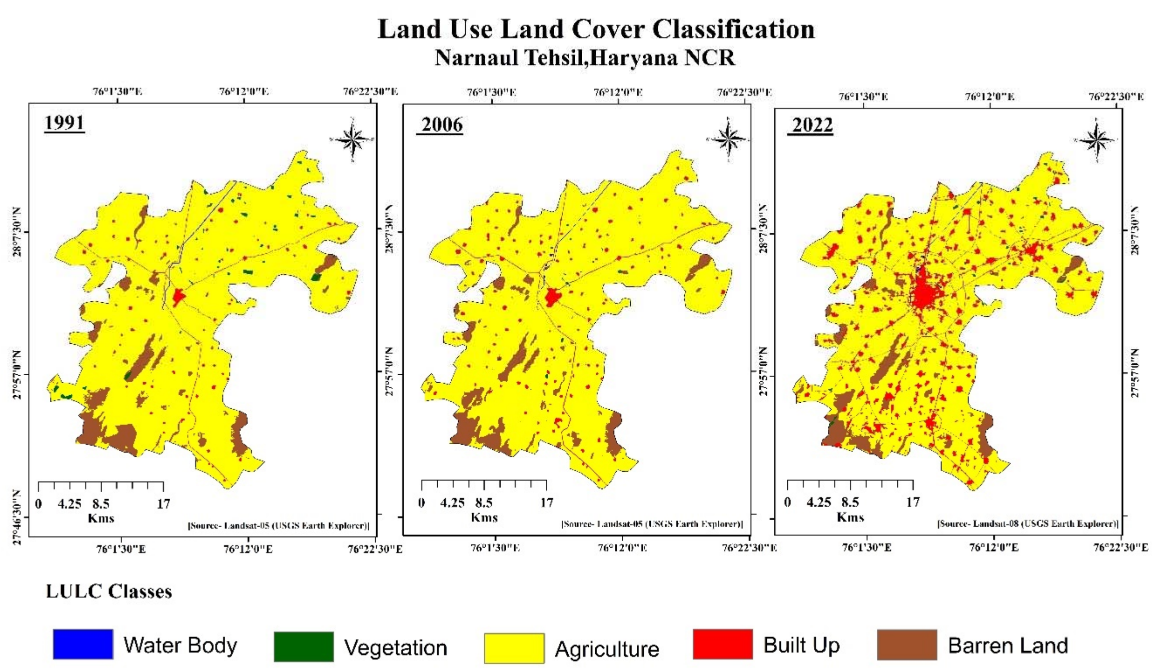


Table 2.35:- LULC Change in Narnoul Tehsil- 1991, 2006 and 2022

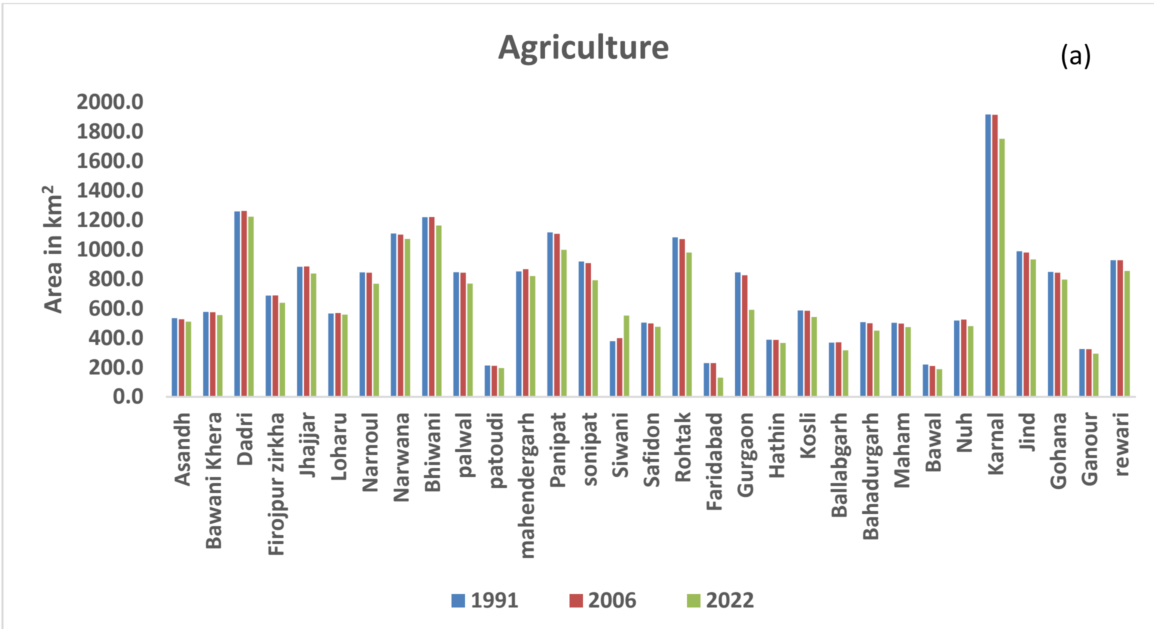
LULC Classes	1991		2006		2022		Change in Area 1991-2022	
	Km2	%	Km2	%	Km2	%	Km2	%
Agriculture	844.4	89.4	841.6	89.1	767.5	81.3	-76.9	-8.1
Barren Land	73.2	7.8	69.8	7.4	63.5	6.7	-9.8	-1.0
Built up	17.4	1.8	29.7	3.1	108.3	11.5	90.9	9.6
Vegetation	7.1	0.8	1.2	0.1	3.1	0.3	-4.0	-0.4
Water Body	2.0	0.2	1.8	0.2	1.7	0.2	-0.3	0.0
Total	944.1	100.0	944.0	100.0	944.0	100.0	-0.1	0.0

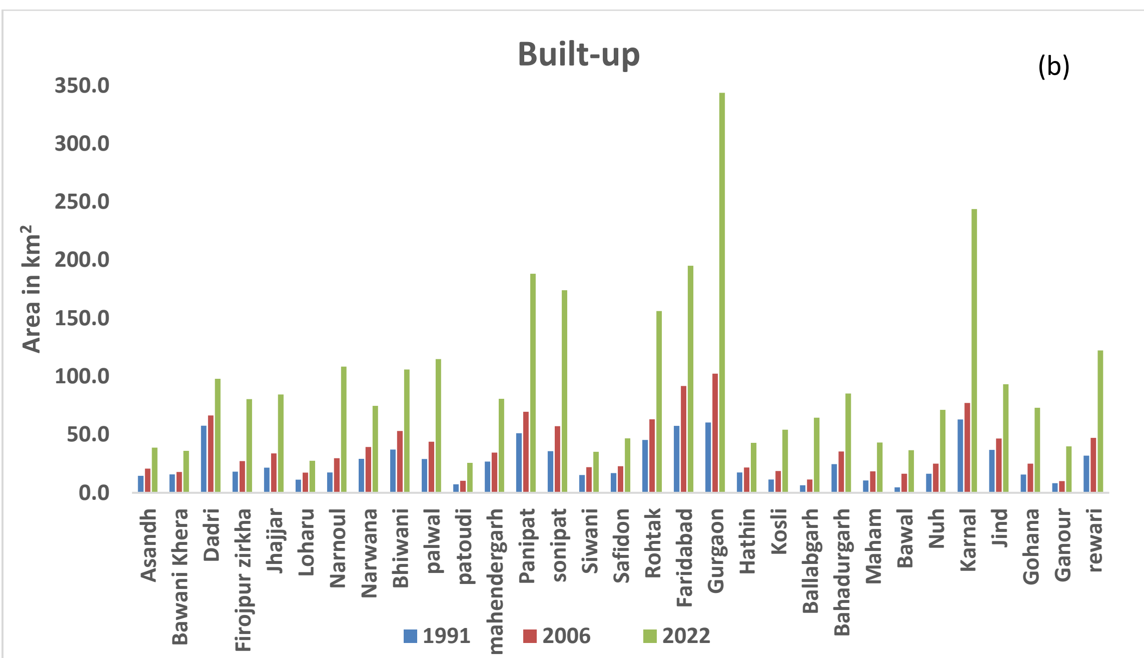
(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

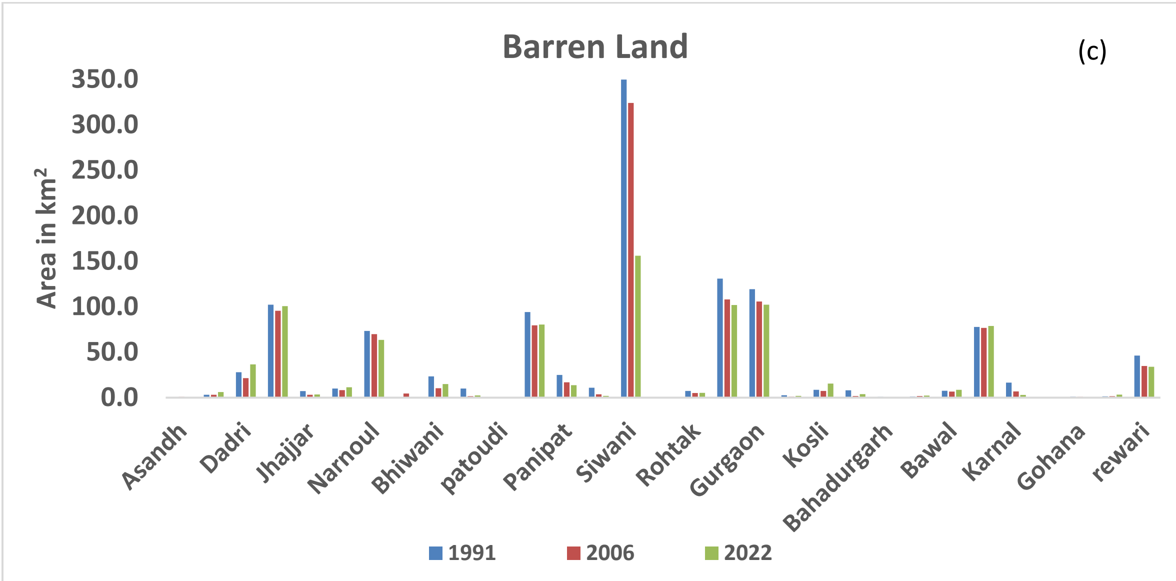
Narnoul is a tehsil of Mahendergarh district and adjoining with Rajasthan border with pure arid climatic conditions. The area under different LULC classes namely agriculture, barren land, built-up, vegetation and water body are respectively; 844.4 km^2, 73.2 km^2, 17.4 km^2, 7.1 km^2 and 2 km^2 in 1991; 841.6 km^2, 69.8 km^2, 29.7 km^2, 1.2 km^2 and 1.8 km^2 in 2006; 767.5 km^2, 63.5 km^2, 108.3 km^2, 3.1 km^2 and 1.7 km^2 in 2022. The highest area has decreased in agriculture by 8.1% due to the expansion of built-up (Table 2.35 and fig. 2.34). Agriculture area had changed into built-up (87.2 km^2), barren land (6.9 km^2), water body (0.6 km^2) and vegetation (0.1 km^2). Barren land is also converted into agriculture, built-up, vegetation and water body by 13.7 km^2, 4.4 km^2, 0.1 km^2 and 0.5 km^2. The built-up area had also undergone some change and transformed into agriculture by 1.3 km^2. Vegetation cover also transformed into agriculture(2.1 km^2), barren land (2 km^2) and built-up (0.5 km^2). water body had changed into agriculture and built up by 0.8 km^2 and 0.2 km^2. (Annexure-1 table no.1.26).

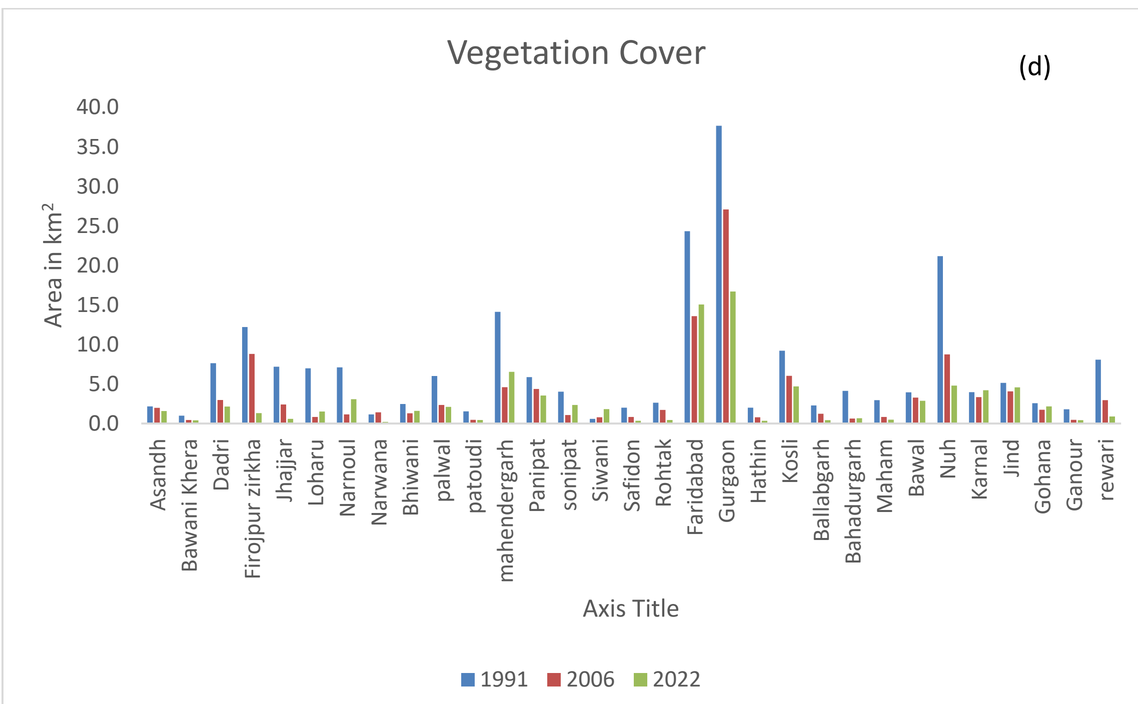
Fig. 2.35- Tehsil wise changes in area under Agriculture(a), Built-up(b), Barren land(c), Vegetation(d) and Water body(e)

(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)






Barren Land
(c)
Area in km²
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Asandh
Dadri
Jhajjar
Narnoul
Bhiwani
patoudi
Panipat
Siwani
Rohtak
Gurgaon
Kosli
Bahadurgarh
Bawal
Karnal
Gohana
rewari
1991
2006
2022


Vegetation Cover
(d)
Area in km²
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Asandh
Bawani Khera
Dadri
Firojpur zirkha
Jhajjar
Loharu
Narnoul
Narwana
Bhiwani
palwal
patoudi
mahendergarh
Panipat
sonipat
Siwani
Safidon
Rohtak
Faridabad
Gurgaon
Hathin
Kosli
Ballabgarh
Bahadurgarh
Maham
Bawal
Nuh
Karnal
Jind
Gohana
Ganour
rewari
Axis Title
1991
2006
2022

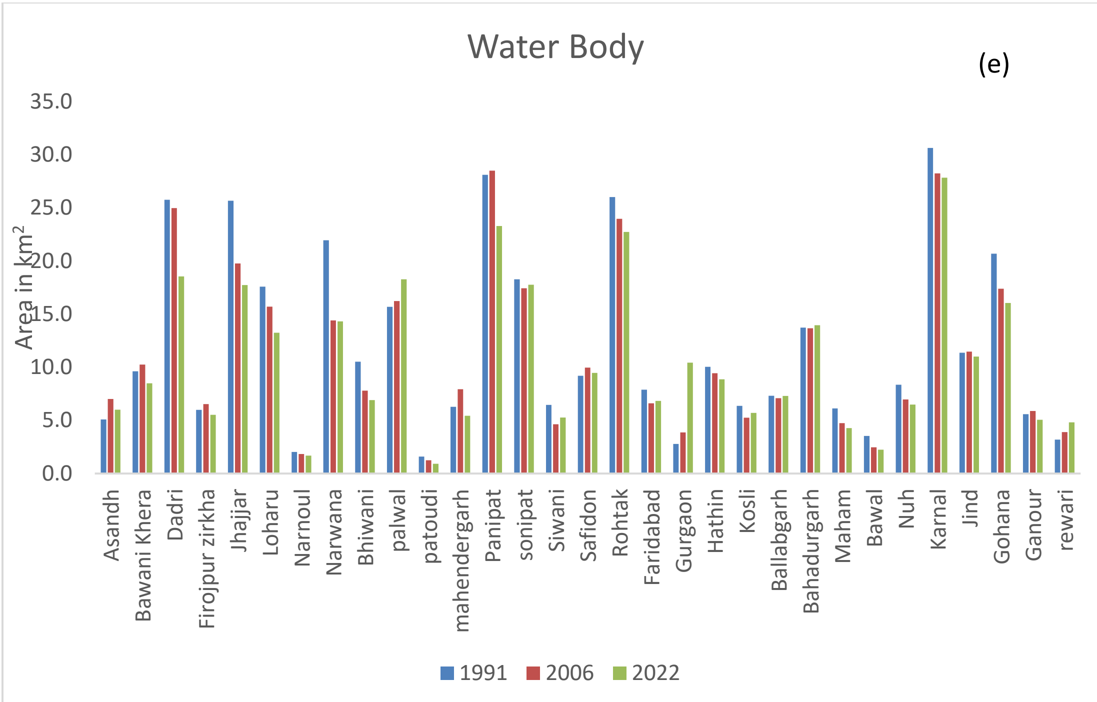
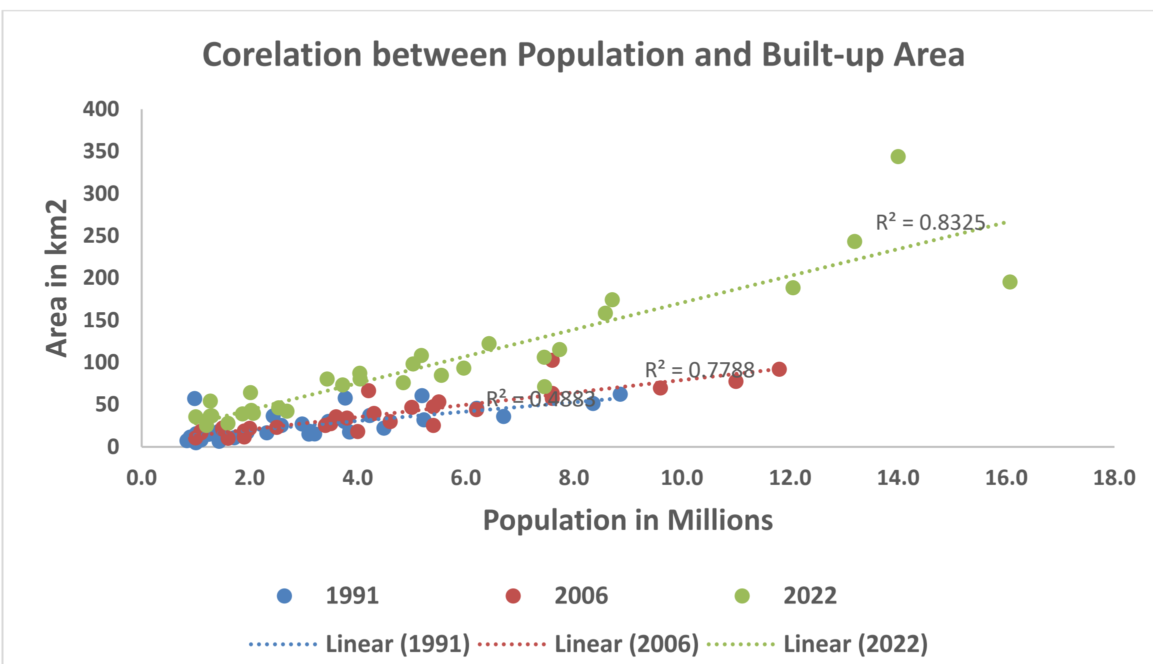


Fig. 2.36-Corelation between Population and built-up area for the years 1991, 2006 and 2022



(Source- Landsat Imageries (1991, 2006, 2002) and data calculated by the Researcher)

Fig.2.35(a, b, c, d, e) shows the changes in all the LULC classes at the tehsil level and it can be concluded that the most precious agricultural land is continuously decreasing in all the tehsils except Siwani because there has been highest area under barren land in Siwani during 1991 but due to expansion of irrigation facilities within the tehsils, barren land have been converted into arable land. Gurgaon and Faridabad had lost the highest agriculture area due to urban expansion and proximity to Delhi (fig.2.35-a). built-up section is showing the highest positive growth in all the tehsils from 1991 to 2022 and population pressure and urbanization are the prime causes for that change. The highest growth in the built-up section has been recorded in Gurgaon, Faridabad, Karnal, Panipat and Sonipat. The highest growth in the built-up section has appeared in the proximity of Delhi and along with main transportation routes in NCR Haryana (fig.2.35-b). Barren land had decreased almost in all the tehsils except Bhiwani, Dadri, Nuh and Kosli and most of the barren land has been converted into agriculture due to expansion in irrigation facilities. Those tehsils which have shown increasing trend in barren land, have some part of Arawali hills and due to development in construction activities, stone-breaking work is being done at a faster pace which has converted nearby agricultural land into barren land in these tehsils (fig. 2.35-c). area under water bodies has decreased among all the tehsils from 1991 to 2022 due to the drying up of many ponds and small canals(fig. 2.35-e). if we talk about green cover in all the tehsils, the area has decreased drastically during the study period. The highest area of vegetation cover has been converted into agriculture and after that into barren land(fig. 2.35-d). Many trees have been cleared for agricultural purposes without thinking about environmental sustainability. So, the overall pattern of LULC change reflected that due to the growing population and urbanization, land use is modified with more speed which causes a big threat to sustainability of the agriculture. To fulfil the residential requirement of the growing people, the most valuable arable land has been converted into a built-up area. Fig. 2.36 shows the positive correlation between population and built-up area for the years 1991(r-0.70), 2006(r-0.88) and 2022 (0.9). the correlation became stronger in 2006(r-0.88) and in 2022(r-0.91) as compared to 1991 due to rapid growth of the population. The coefficient of determination is also very strong in 2006 (R^2- 0.78), and 2022 (R^2- 0.83) which was 0.48 in 1991 shows that population is the major factor for the expansion of built-up within the study area.

2.3 Final Results

In this chapter Land use/Land cover changes have been identified with the help of Remote sensing and GIS techniques from 1991 to 2022 tehsil wise. Following are the conclusions that came from the above analysis-

- For present study, landsat satellite 5(TM) for the year 1991,2006 and Landsat 8(OLI) imageries have been used for LULC map preparations.
- In Haryana NCR, agricultural land is decreasing very fast from 22463.3 km^2 (88.7%) in 1991 to 20487.3 km^2 (80.9%) in 2022. The reason behind this negative change in agricultural areas is the growing population and urbanization. Most of the agricultural area has been converted into built-up for fulfilling the people's residential requirements.
- In NCR Haryana, the built-up area is increasing very fast due to the increasing population from 936.4 km^2 in 1991 and 3469.5 km^2 in 2022. To fulfil the shelter-related requirements of the people and also other infrastructural and industrial needs, the very precious agricultural land is changing into built up which is a matter of great concern for the resources of the region. Some built-up area also changed into agriculture, water body, vegetation and barren land due to classification error as most of the agricultural fallow land appeared the same in colour as built-up in imageries.
- Population growth (11.1 million to 16.5 million from 1991 to 2011) and urbanization (30.3 to 36.2 from 1991 to 2011) are the major causes for the drastic change in a built-up area
- Barren land which included ridges, sand dunes, river sand etc. is decreased significantly during the study period which was 1218.3 km^2 in 1991 and decreased by 353.2 km^2 till 2022 and reached at 865.1 km^2. most of the barren land had changed into agriculture and built up.

- Vegetation cover has also decreased from 218.1 km^2 in 1991 to 100.4 km^2 in 2022 and it has changed into agriculture, barren and built up.
- Area under water bodies has decreased by 0.3% from 1991 to 2022. This huge change is due to the drying up of many ponds and also small canals.
- Fig. no 2.35-a shows the tehsil-wise changes in agriculture area and the result that the area is continuously decreasing from 1991 to 2022 and most of the agricultural land in converted into built-up due to population growth and other infrastructural activities. Some tehsils showed some positive growth in the agricultural area from 1991 to 2006 but in the overall view, the area has decreased.
- Fig. 2.35-b shows that Tehsil wise most drastic changes occurred in the built-up section. All the tehsil showing the increasing trend in built up since 1991 to 2022 as the population is increasing and other development activities are also in a growing stage.
- Fig 2.35-c shows tehsil-wise changes in barren land and shows that the area under barren land in most of the tehsils is decreasing excluding Bawani Khera, Dadri, Loharu and Kosli. Those tehsils that have shown an increasing trend in barren land, have some part of Arawali hills and due to development in construction activities, stone-breaking work is being done on a faster pace which has converted nearby agricultural land into barren land in these tehsils as most of the barren land area increased from agriculture and vegetation section. Some forest areas also vanished and converted into barren land due to human-induced activities.
- Fig. 2.35-e shows the tehsil-wise changes in the water bodies area and shows that all the tehsils witnessed negative growth and most of the water bodies converted into agriculture and built up.
- Fig. 2.35-d shows the vegetation cover changes and results that all the tehsils are showing a decreasing trend in area under vegetation and most of the area is converted into agriculture and built up.

- Fig.2.36 shows the correlation between built-up and population growth and results that both are positively correlated with each other and this correlation is very strong in 2022 (r-0.91) due to rapid population growth.
- Coefficient of Determination ($R^{2-}0.83$) is also positive as the population is the major cause for these drastic changes in built-up expansion.

Chapter-3

CROPPING PATTERN DYNAMICS IN HARYANA NCR

3. Introduction

The proportion of area under different crops at a particular point of time is called a cropping pattern. A cropping pattern change is defined as the change in percentage area under different crops between two time periods(Rahman, 2020). The cropping pattern of an area is based on different factors like natural (climate, soil, temperature, rainfall) socio-economic factors(social environment, prices, sizes of land holdings, income etc) technology, and government policies. One important point of the cropping pattern of Haryana NCR is the increasing share of cereals from 1991 to 2022.

So many factors are responsible for cropping pattern change in any area like physical, social, and economic and the result would also be different for every region. In Haryana, huge changes in cropping patterns took place after the Green Revolution as it introduced HYV seeds, new farm technology, high use of fertilizer, and high water consumption. These factors affected the production of some crops highly like wheat and rice. So, this innovation played a vital role in cropping pattern change (Vashishtha, P.S. et al(2001)).

Haryana is blessed with two agro-climatic zones namely arid, semi-arid & humid. Agriculture plays a vital role in the economy of the state as 51 percent population depends directly or indirectly on agriculture. The GDP of the state contributes almost 15 percent. There are three cropping seasons in Haryana namely rabi, kharif, and zaid (Kumar, S. (2019). Irrigation intensity and cropping intensity are growing positively which leads to a positive impact on the growth of rice and wheat within the study region.

In his insightful work, Malik, R.P.S. (1995) delineated a significant transformation in the agricultural landscape of Haryana and Punjab, where the traditional tapestry of crops underwent a profound evolution. The shift, as connected by Malik, was characterized by a transition from crops with modest water requirements to those with an uncontrolled thirst, notably exemplified by the cultivation of wheat and rice. This noteworthy transition, instigated by the influential wave of the Green Revolution, not only elevated the prominence of these staple grains but also cast a formidable shadow over the precious underground water resources within both states.

Singh, J. et al. (2015) underscored the profound metamorphosis that Haryana's agricultural sector underwent, transitioning significantly in its economic structural composition from primary to tertiary activities. This seismic shift was particularly evident in the realm of cropping patterns, where the attractiveness of profitability became a pivotal force in reshaping the agricultural landscape. Within the context of Haryana's agrarian economy, wheat and rice emerged as the flag bearers of prosperity, boasting the highest profitability values. This, in turn, prompted a discernible displacement of traditional crops like gram and mustard during the rabi season and bajra and sugarcane in the kharif season, as wheat and rice assumed precedence. While sugarcane boasted the highest gross value outcome, its adoption faced formidable constraints. Various restrictions impeded farmers from opting for sugarcane cultivation, creating a dichotomy between economic desirability and practical feasibility. The Green Revolution's strategic interventions, such as the establishment of a fixed MSP and a mitigated risk profile, not only elevated the appeal of wheat and rice but also ushered in a transformative era marked by the marginalization of erstwhile staple crops.

The study area boasts favourable conditions across various dimensions, including soil quality, water resources, and both economic and physical parameters. Haryana's contribution to the central pool of India is noteworthy, standing at almost 15%. Additionally, the state exhibits a commendable agricultural prowess, evidenced by its superior average yields of wheat and rice compared to the national average, a fact highlighted during the 4th Agriculture Summit in 2019.

In the current research endeavour, our focus is directed towards the segments of Haryana falling within the ambit of the National Capital Region (NCR), a geographic area that has undergone substantial Land Use and Land Cover (LULC) transformations and witnessed pronounced shifts in cropping patterns. The proximity to Delhi has proven to be a catalytic force in instigating these changes. Notably, Haryana NCR shares a contiguous boundary with Delhi, and decisions pertaining to the region's growth plans are managed by the National Capital Region Planning Board (NCRPB).

3.1 Data Base and Methodology

As previous chapter is focused on the LULC changes in Haryana NCR and the present chapter deals with cropping pattern changes. Data used for this chapter have been collected from the District Statistical Abstract, and State Statistical Abstract. In the present chapter, cropping pattern changes have been analyzed for Haryana NCR as a whole and tehsil-wise. For Haryana NCR and tehsils wise changes, the triennium average has been calculated for the years 1991-94, 2005-2008, and 2019-22. All the changes have been discussed under the following heading:-

- Crop-wise area for Haryana NCR
- 1st Rank Crop in Haryana NCR- Rabi and Kharif Season
- Changes in area under major crops
- Crop diversification
- Cropping intensity
- Irrigation Intensity
- Correlation of irrigation intensity with cropping intensity and area of major crops

Crop Diversification Index- Jasbir Singh (1976) used this formula to understand the spatial pattern of crop diversification in Haryana and all the crops which occupied 5% or more of the total cropped area, were included.

Crop Diversification Index- Percent of total cropped area under N crops/ Number of N crop

Cropping intensity- Gross cropped area/ Net sown area*100

Irrigation Intensity- Gross irrigated area/ Net irrigated area *100

Correlation:-

Correlation has been used for analysing the relationship between different socio-economic variables. Correlation Coefficient (r) has been computed by Karl Pearson's method.

Formula: $\frac{\sum(\boldsymbol{X}-\overline{\boldsymbol{X}})(\boldsymbol{Y}-\overline{\mathbf{Y}})}{\sqrt{(\boldsymbol{X}-\overline{\mathbf{X}})^{2}\sum(\boldsymbol{Y}-\overline{\mathbf{Y}})^{2}}}$

The intensity of the cropping pattern depends on the irrigation facilities. So, irrigation is the most powerful weapon for shaping the agriculture pattern and increasing the cropping intensity.

Hypothesis testing- The following hypothesis testing has been analyzed-

1. Irrigation facilities help in the growth of rice, wheat, and cotton and replace crops like gram, barley, maize, and jowar.
2. As irrigation facilities developed, it also helped in the development of cropping intensity

Hypothesis testing has been done through the Karl-Pearson correlation method with a significant level of 0.01 and 0.05.

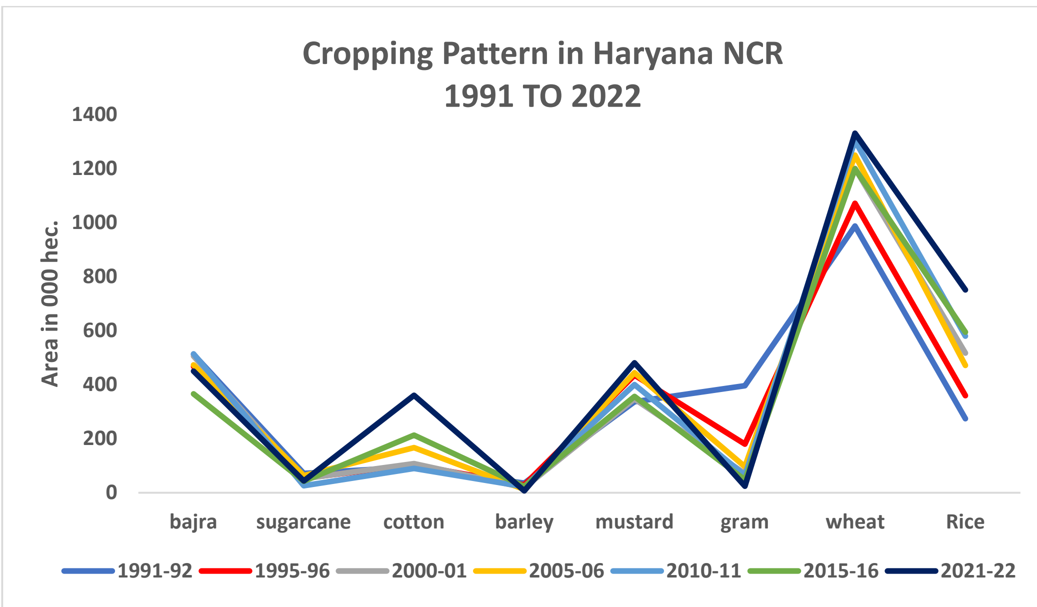
3.2 Results and Discussion

Haryana, particularly in the NCR region, stands as a testament to the collaboration of good soil and water conditions, as well as favourable economic and physical environments. The region's significance in bolstering the nation's agricultural output is not only substantial but also characterized by a remarkable proficiency in the cultivation of key staples. The agricultural calendar in Haryana NCR unfolds in two principal growing seasons: Kharif, spanning from June to the end of October, and the Rabi season, sown from November to December and harvested from March to April. As we delve into the intricacies of this study, the dynamic interplay of geographical nuances, urban proximity, and the stewardship of the NCRPB over growth plans emerge as critical components shaping the agricultural landscape in the selected areas of Haryana. The confluence of favourable conditions and strategic decision-making positions this region as a crucial focal point for understanding the broader implications of land use, cropping patterns, and agricultural sustainability in the context of urban-rural dynamics.

3.2.1- Crop-wise area for Haryana NCR

Fig 3.1 shows the temporal pattern of the area under different crops in Haryana NCR and indicates that rice, wheat, cotton, and oil seeds area have increased from 1991-92 to 2021-22 due to increases in irrigation facilities, package technology, MSP, and market facilities. The area under other crops namely bajra, sugarcane, gram, barley, maize, and jowar has been falling from 1991-92 to 2021-22 because of the high remuneration of other crops. Wheat and rice are the major food crops as most people use them as food but if we talk about bajra, it is a less demanding crop as it is not suitable to eat throughout the year. The area under sugarcane cultivation has decreased and many factors are responsible for this negative trend like sugarcane requires high labor which is not fully available at the time of harvesting and also labour cost is high, lack of govt. support and delayed payments to the farmers, and long queues at the time of harvesting in front of mills.

Fig. 3.1- Spatial-Temporal Changes in Area under Different Crops



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Table 3.1- NCR Haryana- crop wise Average area during 1991-1994 and 2019-2022

Crops	Area in 000 hec. 1991-94	Area in percent 1991-94	2005-2008	Area in Percent 2005-2008	Area in 000 hec. 2018-2021	2019-22
Rice	260.31	8.50	521.7	13.94	703.9	19.73
Bajra	531.8	17.37	512.2	13.7	398.75	11.18
Maize	14.081	0.46	1.1	0.03	1.85	0.0517
Cotton	60.1	1.96	142.1	3.8	269.2	7.54
Sugarcane	64.85	2.12	59.5	1.6	53.21	1.49

Wheat	1010.3	32.99	1238.9	33.1	1323.63	37.1
Gram	304.6	9.95	95.2	2.5	83.18	2.33
Barley	62.71	2.05	14.8	0.4	9.33	1.4
Mustard	195.6	6.39	534	14.3	470.1	10.64
Others	448.2	14.64	623.8	16.7	345	9.67
Total cropped area	3062.3	100	3743.3	100	3567.9	100
Net sown area	1979		1983.6		1887.6	

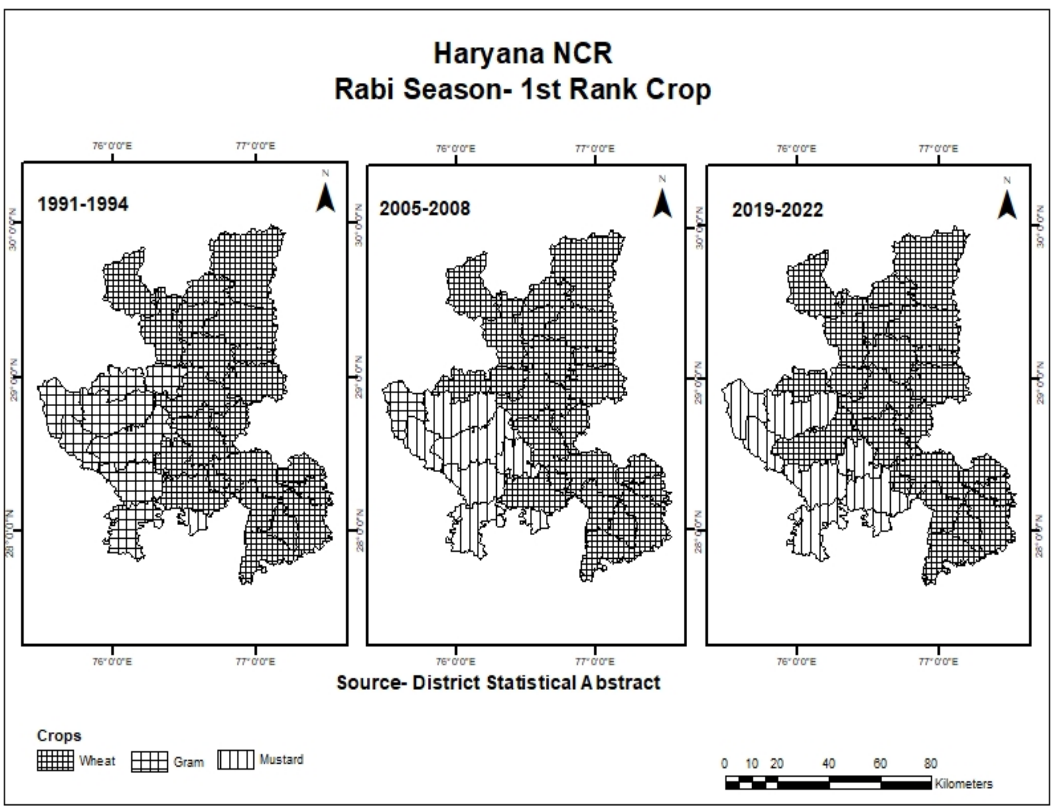
(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

In 1991-94, the main crops grown in NCR Haryana were wheat 32.99%, Rice 8.50%, Bajra 17.37%, Cotton 1.96%, Sugarcane 2.12%, Oil seed 6.39, Maize 0,46%, Gram 9.95%, Barley 2.05% and other crops 14.64% of the total cropped area. The main crop of the region was wheat which occupied 1010.3 thousand hectares of land and Karnal was in first position with 134.6^{000} hectares area under wheat followed by Panipat, Narwana, Jind, etc. bajra was the 2nd main crop grown in NCR Haryana with 531.8^{000} hectares and major tehsils were Bhiwani, Mahendergarh, Narnoul and Loharu. gram was in 3rd place with 304.6^{000} hectares and Dadri was in 1st position with the highest net sown area under gram in NCR Haryana. During 2005-2008, the percentage of the area under major crops in Haryana NCR were respectively 13.9% under rice, 13.7% under bajra, 0.03% under maize, 3.8% under cotton, 1.6%0 under sugarcane, 33.1% under wheat, 2.5% under gram, 0.4% under barley, 14.3% under oil seeds and 16.7% occupied by other crops. In 2019-22, these were the main crops grown in NCR Haryana - wheat 37.1%, rice 19.73, cotton 7.54%, oilseeds 10.64%, bajra 11.18%, sugarcane 1.49%, gram 2.33%, barley 1.4%, maize 0.05% and other crops (pulses, fodder, vegetables, etc.) 8.57% of the gross cropped area. Wheat and rice were the major crops grown in NCR Haryana as they comprised almost 60 % area of the region (table 3.1).

3.2.2- 1st Rank Crop in Haryana NCR- Rabi Season

As fig. 3.2 shows that During 1991-1994, all the area was devoted to three crops namely wheat, gram, and oil seeds. All the North East tehsil had grown wheat and called the wheat basket of Haryana. Wheat is grown on 1010.3^{000} hectares (32.99%) area within the NCR Haryana. In Karnal, Panipat, Asandh, Safidon, Jind, Narwana, Ganour, Sonipat, Rohtak, Maham, Jhajjar, Bahadurgarh, Kosli, Rewari, Patoudi, Gurgaon, Faridabad, Ballabgarh, Nuh, Firojpur Zirkha, Palwal, Hathin wheat had the 1st rank crop during rabi season. Gram was on 1st rank in Siwani, Bawani Khera, Bhiwani, Loharu, Dadri, Mahendergarh, and Narnoul as these tehsils have undulating surfaces with weak soil and fewer irrigation facilities. Mustard was on 1st rak crop grown in Bawal tehsil and from 2005 to 2008, the area under wheat cultivation increased and several tehsils also grew wheat as the first rank crop, tehsil under gram cultivation decreased and the number of tehsils under mustard cultivation increased. In 2019 to 2022, the picture was different from 1991-94 due to the expansion of irrigation facilities and most of the tehsils shifted towards wheat cultivation during rabi season and only a few tehsils are growing mustard.

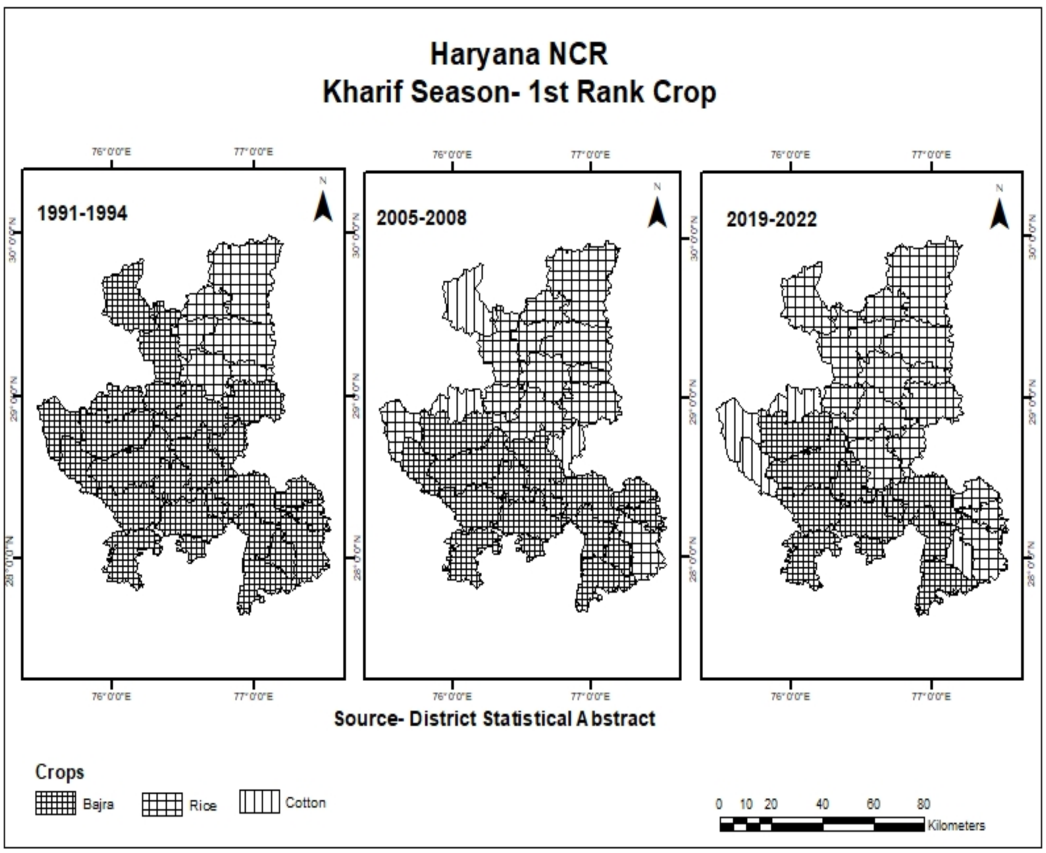
Fig. 3.2- Rabi Season- First Rank Crop



3.2.3- Kharif Season- 1st Rank Crop (Tehsil Wise)

As fig. 3.3 shows that Kharif is a very important cropping season within the region and seedling is in June-July and harvesting is in October-November. Important kharif crops are rice, bajra, cotton, jowar, maize, and sugarcane (one-year crop). The main kharif crops grown in NCR Haryana during 1991-1994 were rice and bajra. The rice crop was the 1st rank crop grown in seven tehsils namely Karnal, Asandh, Panipat, Safidon, Ganour, Gohana, and Sonipat which were located in the North-East This region has good alluvial soil, underground water, flat surface, and semi-arid climatic conditions which favoured the growth of rice in this area. Almost 8.5 percent area is covered by rice crops and 17.4 percent area is covered with bajra. So, bajra is a prime crop within the region during 1991-1994.

Fig. 3.3- Kharif season- First Rank Crop



During 2005-2008, the number of tehsils under bajra cultivation has decreased by nine whereas the number of tehsils under rice cultivation has increased. Now area under cotton cultivation has increased and in some tehsils, it occupies the first position in the Kharif season. The reason for this shift is an expansion of irrigation facilities. From 2019 to 2022, the area under rice cultivation has increased and it occupies first position in the following tehsils are respectively Karnal, Assandh, Panipat, Ganour, Gohana, Jhajjar, Rohtak, Maham, Bahadurgarh, Jind, Safidon, Narwana, Faridabad, Ballabgarh, Palwal(fig.2.3).

3.2.4- Changes in area under major crops

Changes in area under all the major eight crops of Haryana NCR have been calculated and depicted here. All the maps have been prepared with the help of the choropleth method which shows the changes very efficiently.

3.2.4.1. Rice cultivation in Haryana NCR

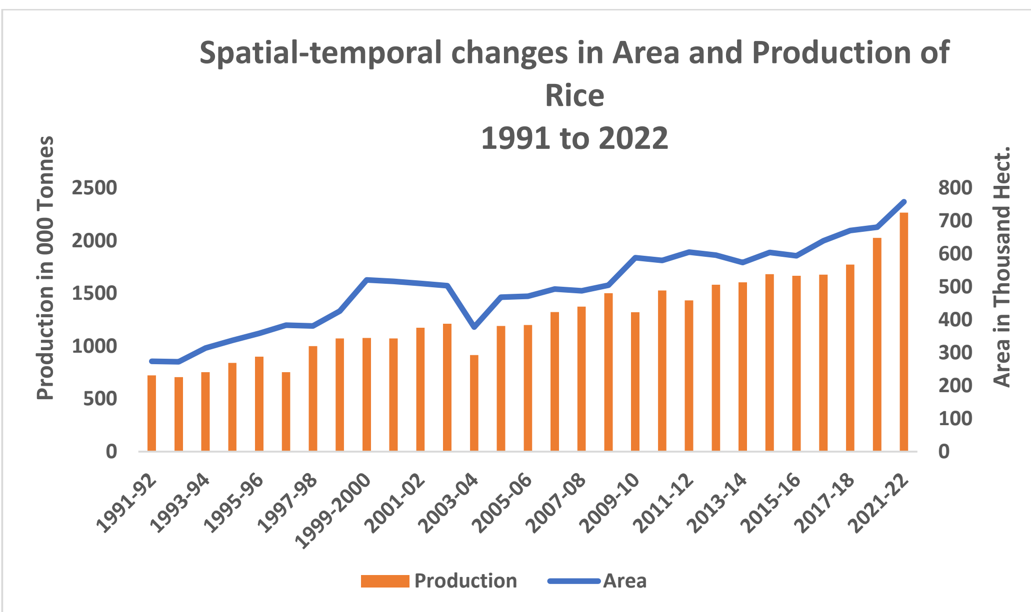
In Haryana NCR, rice is the principal crop among all the Kharif crops and if we talk about the area it was 260^{000} hectares in 1991-92 and reached 758.5^{000} hectares in 2021-22. The production of rice was 723 thousand tonnes in 1991-92 and reached 2266 thousand tonnes in 2021-22 (fig. 3.4). It is a very important crop in all the Kharif crops of NCR Haryana. Rice areas are divided into three categories: -

1 Rice cultivation- high

2 Medium

3 Low

Fig. 3.4- Spatial-Temporal Changes in Area and Production of Rice: 1991 to 2022



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Fig. 3.5- Rice Cropped Area- Haryana NCR

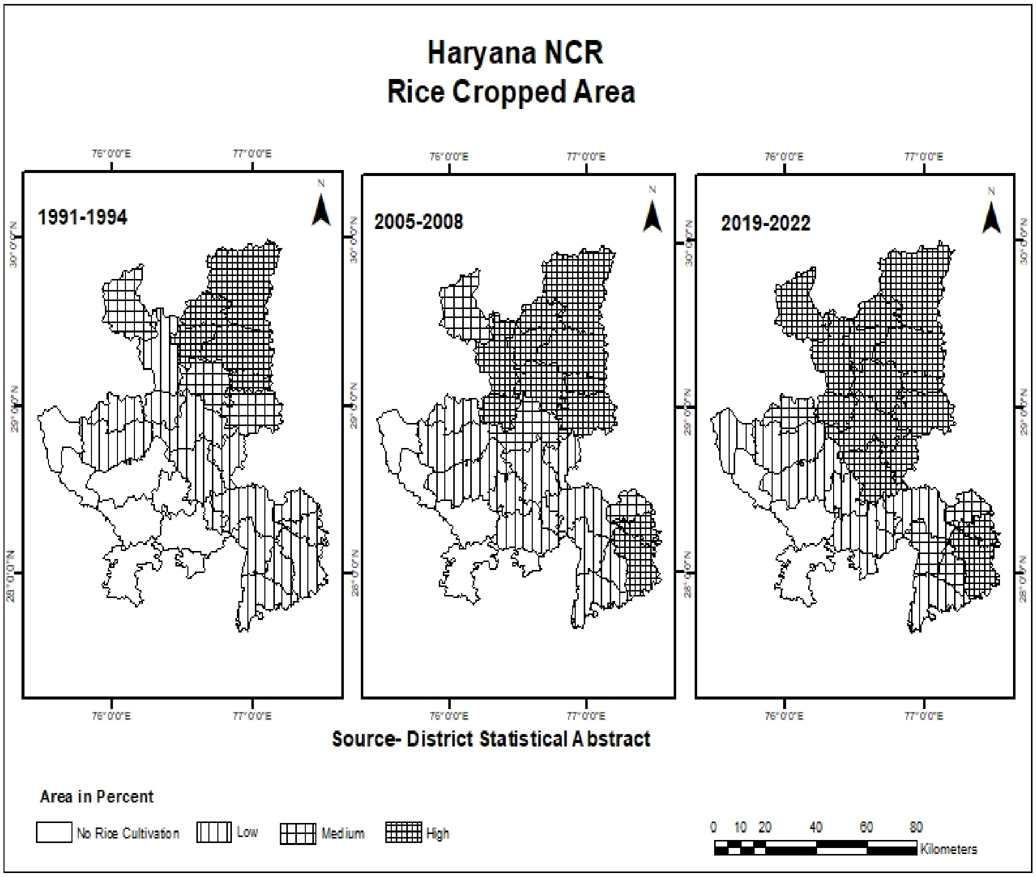


Table 3.2- Haryana NCR rice cultivation tehsil wise

Category	1991-1994		2005-2008		2019-2022	
	Tahsils	Total		Total	Tehsils	Total
High (above 14%)	Karnal, Panipat, Assandh, Ganour, Safidon	5	Karnal, Panipat, Assandh, Ganour, Safidon, Sonipat, Maham, Jind, Gohana, Palwal Ballabgarh,	11	Jind, Narwna, Safidon, Karnal, Assandh, Panipat, Ballabgarh, Sonipat, Ganour, Gohana, Jhajjar, Maham Bahadurgarh, Rohtak, Palwal	15
Medium (7-14%)	Sonipat, Gohana, Narwana	3	Narwana, Rohtak Faridabad	3	Bhawani Khera, Mewat, Faridabad, Hathin	4

Low (below 14%)	faridabad, ballabgarh, palwal, hathin, rohtak, jhajjar, bahadurgarh, maham, jind, gurgaon, Patoudi, Nuh, Firojpur Zhirka, Bhiwani, Bhawani khera	15	Bawani Khera, Bhiwani, Dadri, Rewari, Kosli, Patoudi, Jhajjar, Mewat, Gurgaon, Bahadurgarh Firojpur Zirkha, Kosli,	12	Siwani, Dadri, Rewari, Bawal, Kosli, Firojpur Zirkha, Gurgaon, Patoudi, Bhiwani	9
No rice cultivation	mahendergarh, rewari, kosli, narnoul, bawal, loharu, siwani, dadri	8	Mahendergarh, Narnoul, Loharu, Siwani, Bawal	5	Loharu, Narnoul, Mahendergarh	3
Total		31		31		31

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Rice cultivation- High

Haryana is a land of diversity concerning soil, cropping patterns, languages, agriculture development, etc. Today rice and wheat crops are the major crops growing in Haryana as well as NCR Haryana. The eastern belt of Haryana is mainly well suited for Rice cultivation as this area has good alluvial soil and better irrigation conditions. In the northeast belt of the NCR Haryana is famous for rice cultivation in which Karnal(36.86%), Panipat(24.77%), Assandh(32.25%), Ganour(17.25%) and Safidon(20.60%) tehsils stands on 1st category of high rice cultivation. These five tehsils almost cover 75% area of the total rice-cropped area. All these tehsils have better irrigation facilities and also have many big mandies which is also a big support for rice cultivation. During 2005 to 08, there were eleven tehsils in high rice cultivation category due to expansion of irrigation facilities namely Karnal(43.9%), Panipat(41.1%), Assandh(45%), Ganour(46%), Safidon(59.9%) Sonipat(18.4%), Maham(18.3%), Jind(23.6%), Gohana(26.1%), Palwal(16.7%) and Ballabgarh(14.7%). From 2019 to 2022, the percentage of the area under rice crops in different tehsils increased remarkably in the north, northeast, and central parts of the NCR Haryana. It covered almost 20 percent of the total cultivated area of the region. Karnal was in 1st place with the highest percentage of area under rice which was 45.5% and Tohsham had the lowest proportion of area which was 0.11%. Tosham has very dry conditions, low rainfall and sandy surface which are not in favour of rice crop cultivation. On the other hand, Karnal has good alluvial soil, a canal system and also easy fetching of underground water which is helpful in rice cultivation well.

Most of the tehsils in North East part of the NCR Haryana had a high proportion of rice cultivation area and fourteen tehsils came in the high rice cultivation category namely Jind(30.05%), Narwna(23.18), Safidon(43.51%, Karnal(45.51%), Assandh(45.01%), Panipat(43.80%), Ballabgarh(25.42%), Sonipat(35.25%), Ganour(40.97%), Gohana(35.21%), Jhajjar(17.36%), Bahadurgarh(23.66%), Rohtak(27.32%), Palwal(22.46%) due to good soil and irrigation facilities. These districts have very good big-size mandies for rice marketing. These tehsils almost covered 89 percent of the total rice cultivation area in NCR Haryana (table 3.2 & fig. 3.5).

Rice cultivation- Medium

In 1991-94, There were three tehsils in the medium rice cultivation area category which covered almost 15.17 percent area of the total rice area Sonipat(7.74 %), Gohana(10.79%) and Safidon(9.25%). In these tehsils, there are sound irrigation facilities with easy fetching of groundwater and also a good canal system which is very helpful for rice production. From 2005 to 2008, Narwana, Rohtak and Faridabad tehsils existed in the medium rice cultivation category with 8.7%, 13.5% and 7.1%. In 2019-22, The number of tehsils also increased from three to six tehsils and covered almost 6.5 percent of the total rice cultivation area in NCR Haryana. These tehsil were Bhiwani(10.39%), Bhawani Khera(13.58%), Mewat(9.01%), Faridabad(12.35%), Maham(9.50%), Hathin(7.72%). All these tehsils showed remarkable growth in rice cultivation and jumped from low rice cultivation to medium rice cultivation due to the expansion of irrigation facilities (table 3.2 & fig. 3.5).

Rice cultivation- Low

In 1991-94, There were fifteen tehsils came under the low rice cultivated area section which covered only 10 percent of the total rice cultivated area. Faridabad(5.58%), Ballabgarh(1.91%), Palwal(5.29), Hathin(1.77%), Rohtak(1.72%), Jhajjar(0.36%), Bahadurgarh(0.68%), Maham(1.14%), Jind(6.03%), Gurgaon(0.18%), Patoudi(0.51%), Nuh(0.64%), Firojpur Zhirka(0.36%), Bhiwani(0.25%), Bhawani Khera(0.14%). Tehsils of the south, centre and southwest come under low rice cultivated area sections as they have fewer irrigation facilities, low rainfall and dry conditions. From 2005 to 2008, these twelve tehsils come under low rice cultivation category namely Bawani Khera, Bhiwani, Dadri, Rewari, Kosli, Patoudi, Jhajjar, Mewat, Gurgaon, Bahadurgarh Firojpur Zirkha, Kosli, In 2019 to 2022, these had the lowest area under rice cultivation namely Siwani(0.59%), Tosham(0.11%), Dadri(4.15%), Rewari(1.61%), Bawal(0.14%), Kosli(0.41%), Firojpur Zirkha(2.81%), Gurgaon(5.59%), Patoudi(4.18%). Nine tehsils came under this category from thirty-two tehsils. The main reasons behind the low rice cultivation are dry conditions, low irrigation facilities and less chance of fetching underground water.

Following tehsils had no rice cultivation in 1991-94, Mahendergarh, Rewari, Kosli, Narnoul, Bawal, Loharu, Siwani, Dadri whereas in 2005 to 2008, Mahendergarh, Narnoul, Loharu, Siwani, Bawal have no rice cultivation and Loharu, Narnoul, Mahendergarh, in 2019 to 2022. there was no rice cultivation because of dry conditions, less rainfall, sandy soil and fewer irrigation facilities (table 3.2 & fig. 3.5).

Changes in Rice Cultivation

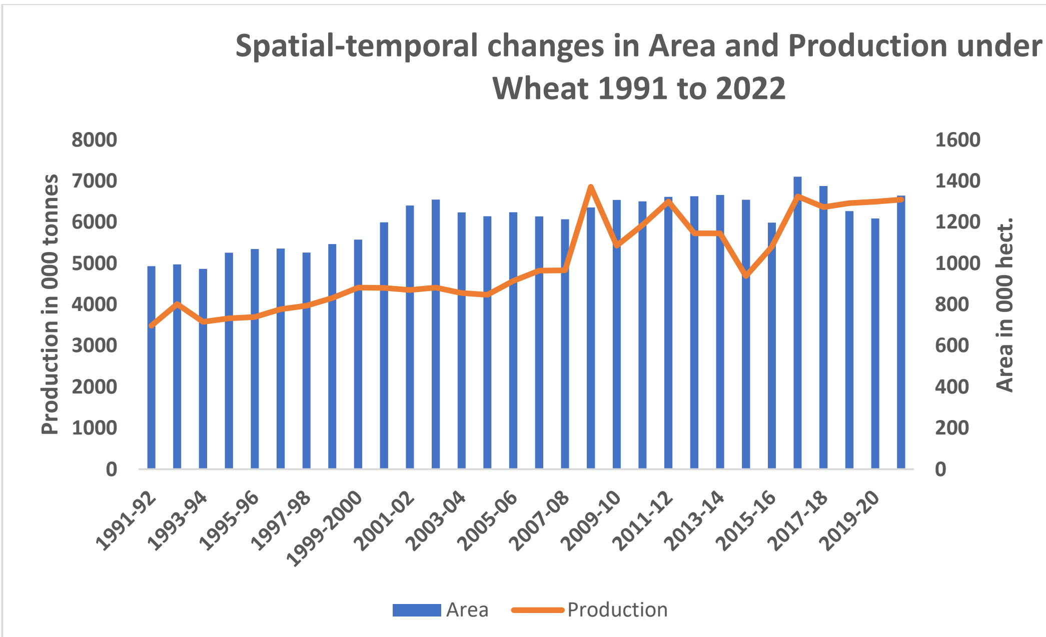
Due to expansion in irrigation facilities, the area under rice cultivation has increased drastically in the North and North East tehsils of the study area. During 1991-94, almost 8.5% of the covered by rice, 13.9% during 2005-08 and 19.7% during 2019-22. There were many factors responsible for the growth in rice cultivation like HYV seeds, better market facilities, mechanization and increasing irrigation facilities. Rice is the most demanding food and also a profitable crop that’s why farmers prefer to grow rice than less profitable crops like bajra, and jowar.

3.2.4.2. Wheat Cultivation in Haryana NCR

Wheat is a very eminent crop within the region and grows in all the tehsils of the study area. Haryana has favourable climatic conditions for wheat as it requires temperature between 15 to 20 degrees at growing time and 25 to 28 degrees at harvesting time and rainfall of 45 to 75 centimetres and all these conditions are available in Haryana from November to April. The region is also blessed with the best alluvial soil and also better irrigation facilities. On the basis of the area under wheat cultivation, the region was divided into three groups

1. High wheat growing tehsils- above 40%
2. Medium wheat growing tehsils- 20-40 %
3. Low wheat growing tehsils- below 20 %

Fig. 3.6- Spatial-temporal changes in Area and Production under Wheat: 1991 to 2022



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Wheat Farming

In 1991-92, Wheat covered the highest area among all the crops which were grown in NCR Haryana 1010.3 thousand hectares (32 percent) of the total cropped area and reached at 37% during 2021-22 and production was 348 thousand tonnes to 655 thousand tonnes from 1991 to 2022 (fig. 3.6). It was sown in October and November and cut down in the month of march and April. The lowest percent of the area under wheat was found in Siwani tehsil (4.4 percent) and the highest area was in Gohana tehsil (53%) because of climatic, soil, irrigation facilities etc. Green revolution was also greatly responsible for the wheat growth as it affected the growth of wheat and rice.

High Wheat Sowing Tehsils- 1991-94

In 1991-94, In the north, northeast, south and central parts of the region, the growing high proportion of the wheat crop covered almost 75 percent of the total cropped area. Eleven tehsils out of 31 tehsils came under this group of high cultivation because of fresh water supply, better rainfall, good alluvial soil etc. Sonipat(50.43%), Gohana(53.47%), Ganour(45.75%), Faridabad(48.93%), Palwal(43.47%), Hathin(50.77%), Karnal(44.28%), Panipat(47.17%), Assandh(50.31%), Bahadurgarh(49.16%), safidon(49.17%). During 2005-08, nineteen tehsils out of 31 come highest wheat sowing category namely Sonipat, Gohana, Ganour, Faridabad, Palwal, Hathin, Karnal, Panipat, Assandh, Bahadurgarh, safidon, Narwana, Jind, Maham, Gurgaon,Mewat, Patoudi, Ballabgarh, Firojpur Zirkha by 45.2%, 45.6%, 53.3%, 60.5%, 59.2%, 67.1%, 44.5%, 46.6%, 43.2%, 40.2%, 46.6%, 45.3%, 45.6%, 42.3%, 44.2%, 62.1%, 48.1 respectively.

In 2019-22, Seventeen tehsils out of 32 tehsils come under this section of high wheat cultivation area and covered almost 74 percent of the total cropped area within the region namely Firojpur Zirkha(53.72%), Jind(44.26%), Narwana(45.87%), Rohtak(48.90%), Jhajjar(40.86%), Ballabgarh(51.96%), Sonipat(48.8%), Gohana(48.14%), Ganour(45.81%), Faridabad(48.51%), Palwal(48.95%), Hathin(51.84%), Karnal(45.68%), Panipat(48.11%), Assandh(46.11%), Bahadurgarh(53.88%), safidon(45.31%). Most of the tehsils are located in the north, northeast, south-east and central parts of the region and this part was blessed with rich soil conditions, underground water facilities, and better markets. These conditions help in crop production in both seasons of rabi and kharif. So the high wheat cultivation in these tehsils is directly linked with good soil conditions, better irrigation, flat surface, better mandies and also the social and economic level of the farmers (table 3.3 & fig. 3.7).

Fig. 3.7- Wheat Cropped Area- Haryana NCR

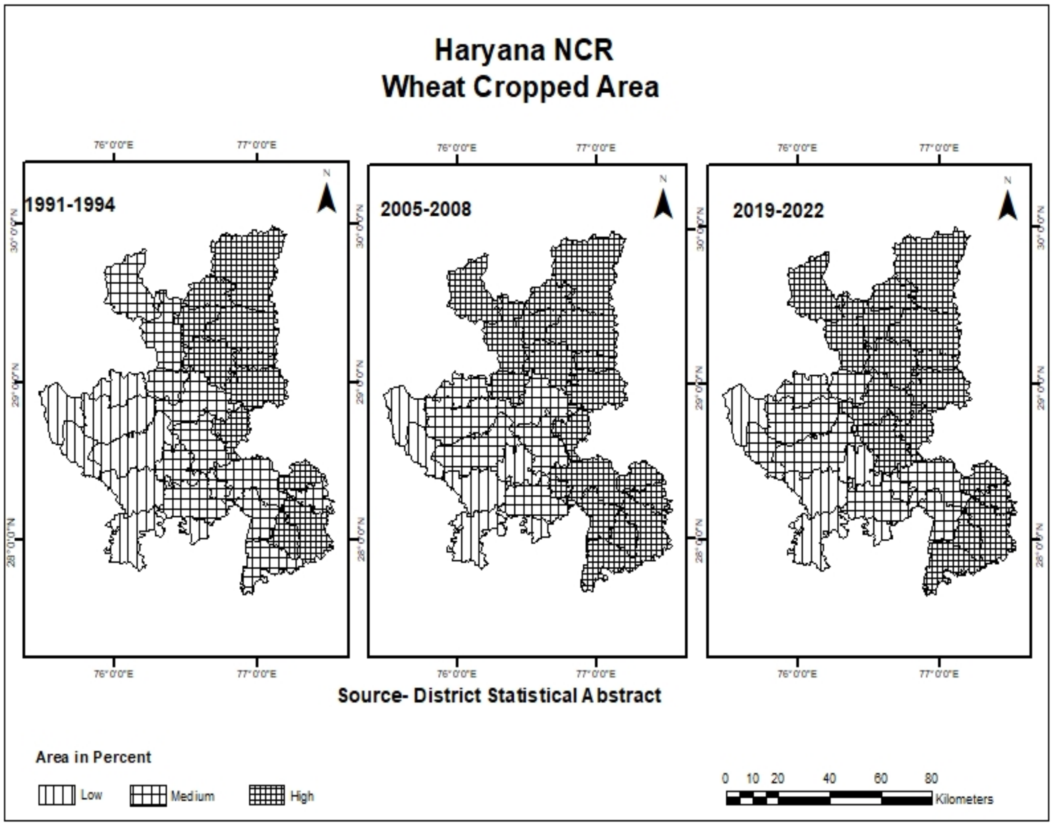


Table no. 3.3- Haryana NCR- Wheat cultivation tehsil wise

Category	1991-94		2005-2008		2019-22	
	Tahsils	Total	Tehsil	Total	Tehsils	Total
High (above 40%)	Sonipat, Gohana, Ganour, Faridabad, Palwal, Hathin, Karnal, Panipat, Assandh, Bahadurgarh, safidon	11	Sonipat, Gohana, Ganour, Faridabad, Palwal, Hathin, Karnal, Panipat, Assandh, Bahadurgarh, safidon, Narwana, Jind, Maham, Gurgaon,Mewat, Patoudi, Ballabgarh, Firojpur Zirkha	19	Firojpur Zirkha, Jind, Narwana, Rohtak, Jhajjar, Ballabgarh, Sonipat, Gohana, Ganour, Faridabad, Palwal, Hathin, Karnal, Panipat, Assandh, Bahadurgarh, safidon	17
Medium (20-40%)	Ballabgarh, Rewari, Rohtak, Jhajjar, Maham, Kosli, Jind,	12	Bawani Khera, Bhiwani, Rohtak, Dadri, Jhajjar, Rewari	6	Rewari, Maham, Gurgaon, Patoudi, Mewat, Bhiwani,	9

	Narwana, Gurgaon, Patoudi, Nuh, Firojpur Zirkha				Bhwani khera, Dadri, Loharu	
Low (below 20%)	Narnoul, Mahendergarh, Bawal, Bhiwani, Bhwani khera, Dadri, Loharu, Siwani	8	Siwani, Loharu, Mahendergarh, Narnoul, Kosli, Bawal	6	Narnoul, Mahendergarh, kosli, Siwani, Bawal	5
Total		31		31		31

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Medium Wheat Sowing Tehsils-

In 1991-94, In this category, twelve tehsils out of thirty-one tehsils came namely Ballabgarh(39.57%), Rewari(25.03%), Rohtak(38.04%), Jhajjar(33.68%), Maham(24.78%), Kosli(25.07%), Jind(36.13%), Narwana(35.67%), Gurgaon(36.11%), Patoudi(38.89%), Nuh(30.40%), Firojpur Zirkha(37.18%). 20 to 40 percent of the total cropped area comes under wheat cultivation in all the tehsils and has good soil cover, flat surface and better irrigation.

From 2005 to 2008, Bawani Khera, Bhiwani, Rohtak, Dadri, Jhajjar and Rewari tehsils come under the medium wheat cultivation category by 36.1%, 21.7%, 33.8%, 22.1%, 30.5% and 25% respectively. In 2019-22, Ten tehsils out of thirty-two tehsils come in this section of medium wheat cultivation namely Rewari(23.5%), Maham(24.34%), Gurgaon(30.45%), Patoudi(27.15%), Nuh(36.07%), Bawal(22.16%), Bhiwani(29.01%), Bhwani khera(32.96%), Dadri(24.07%), Loharu(22.30%). Most of these tehsils are located in the south, southwest part of the NCR Haryana. All of the tehsils covered 20 to 40 percent area under wheat cultivation and it is positively related to the good irrigation facilities and large size of land holdings (table 3.3 & fig. 3.7).

Low Wheat Sowing Tehsils-

In 1991-94, Eight tehsils come under this category of low wheat cultivation areas namely Narnoul(14.07%), Mahendergarh(11.85%), Bawal(16.58%), Bhiwani(9.8%), Bhwani khera(15.03%), Dadri(13.57%), Loharu(6.88%), Siwani(4.43%) and almost covered 9% of the total cropped area under wheat crop within the region. The major reasons behind the low wheat cultivation in these tehsils are less rainfall, sandy soil in the south-west part, undulating topography etc.

In 2005 to 2008, the picture was slightly different from 1991 as all the districts including this category showed positive growth in the area under wheat by Siwan(10.2%)i, Loharu(13.3%), Mahendergarh(15.1%), Narnoul(14.7%), Kosli(15.8%), Bawal(16.7%).

In 2019-22, Only five tehsils come under this category namely Narnoul(11.1%), Mahendergarh(19.45%), kosli(17.16%), Tosham (18.53%) and Siwani(10.59%). Due to the expansion of irrigation facilities, the area under wheat cultivation increased and three tehsils jumped into the next category. Dry conditions and the expansion of sandy soil affect the wheat growth in these tehsils as their soil conditions are more suitable for mustard and gram production.

Wheat is the only crop growing in all the tehsils of the region and almost covered 37.1 percent of the total cropped area during 2019-22 and it was a 4.2 percent increase since 1991-94. It requires two watering from sowing to harvesting and requires less water, that's why, it was grown in all the tehsils. The reasons behind this growth of wheat cultivation are green revolution innovations, HYV seeds, chemical fertilizers, machines, extending markets etc. area under wheat cultivation varies from 10.9 percent in Siwani tehsil of Bhiwani district and 53.88 percent in Bahadurgarh in Rohtak district (table 2.3 & fig. 2.7).

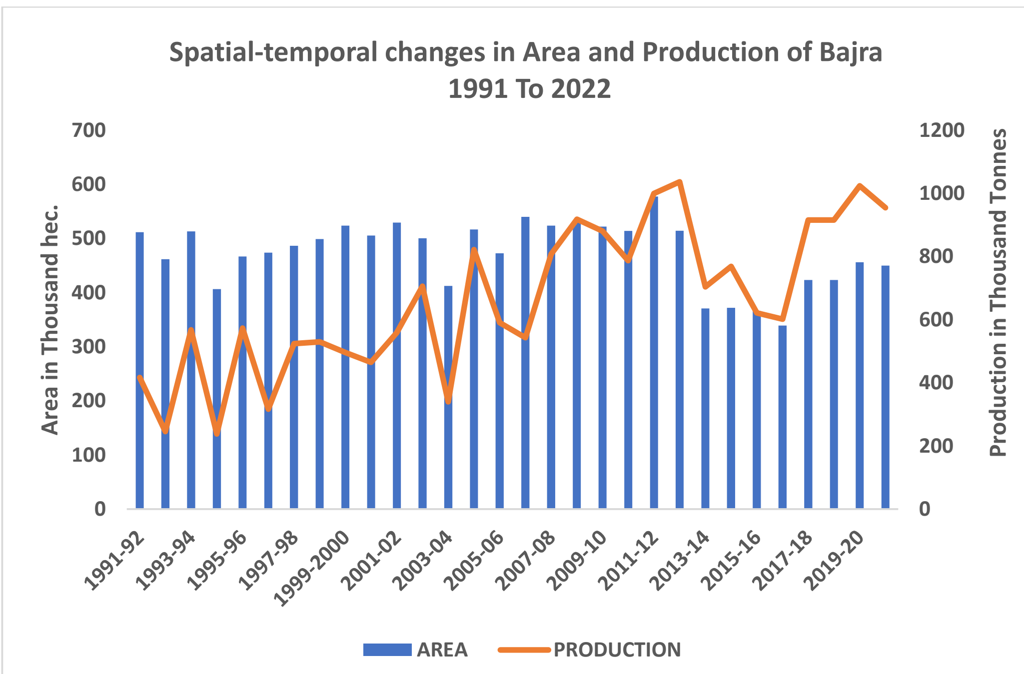
Changes in area under Wheat Cultivation

The highest changes have occurred in the area under wheat cultivation in Haryana NCR as it is also a major food crop. Green revolution mainly focused on wheat and rice cultivation. So, this package technology highly affects the wheat production within the study area. From 1991 to 94, it covered 32.9% of the gross cropped area, 33.1% from 2005 to 08 and 37.1% of the gross cropped area. Factors like increasing irrigation facilities, market facilities, mechanization and more demand are responsible for this growth. Most of the wheat-growing tehsils have good ground water facilities which affects the growth of the crop positively.

3.2.4.3. Bajra cultivation in NCR Haryana

Bajra is a very important kharif crop among all the crops as it comprised the highest area which was 738 thousand hectares in 1991-94, but it decreased by 456 thousand hectares in 2017-2020. it is growing in all the tehsils of the NCR Haryana but mainly grows in the south and south-west part of the region as it requires less water and sandy loam soil and all these characteristics available in the south and western side of the region. Area under bajra decreased but production increased from 417 thousand tonnes to 955 thousand tonnes because of HVY seeds and chemical fertilizers (fig. 3.8).

Fig. 3.8- Spatial-Temporal Changes in Area and Production under Bajra: 1991 to 2022



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Area of high bajra cultivation

Six tehsils had the highest proportion area under bajra namely Narnoul(42.7%), Mahendergarh(43.8%), Bhiwani(38.5%), Dadri(39.49%), Loharu(55.7%), Siwani(45.23%) in 1991-94 whereas in 2005 to 2008, number of tehsils in the first category have been increased namely Kosli(31.6%), Rewari(31.5%), Bawal(30%), Mahendergarh(39.6%), Narnoul(34.9%), Patoudi(30.8%), Siwani(36.9%), Loharu(36.3%), Dadri(31.9%). but the picture was different in 2017-2020 as the number of tehsils in the first two categories decreased due to the expansion of irrigation facilities. Now Narnoul(40.94%), Mahendergarh(31.3%), Rewari(31.94%), Bawal(38.6%), Kosli(36.7%) had the highest proportion under bajra cultivation. All the high bajra cultivation tehsils are located in south and southwest areas of NCR Haryana as they have dry conditions and sandy soil. The Bajra crop demands less water and it flourishes in sandy soil, these conditions are available in the south and southwest tehsils of the study area (table 3.4 & fig. 3.9).

Fig. 3.9- Bajra Cropped Area- Haryana NCR

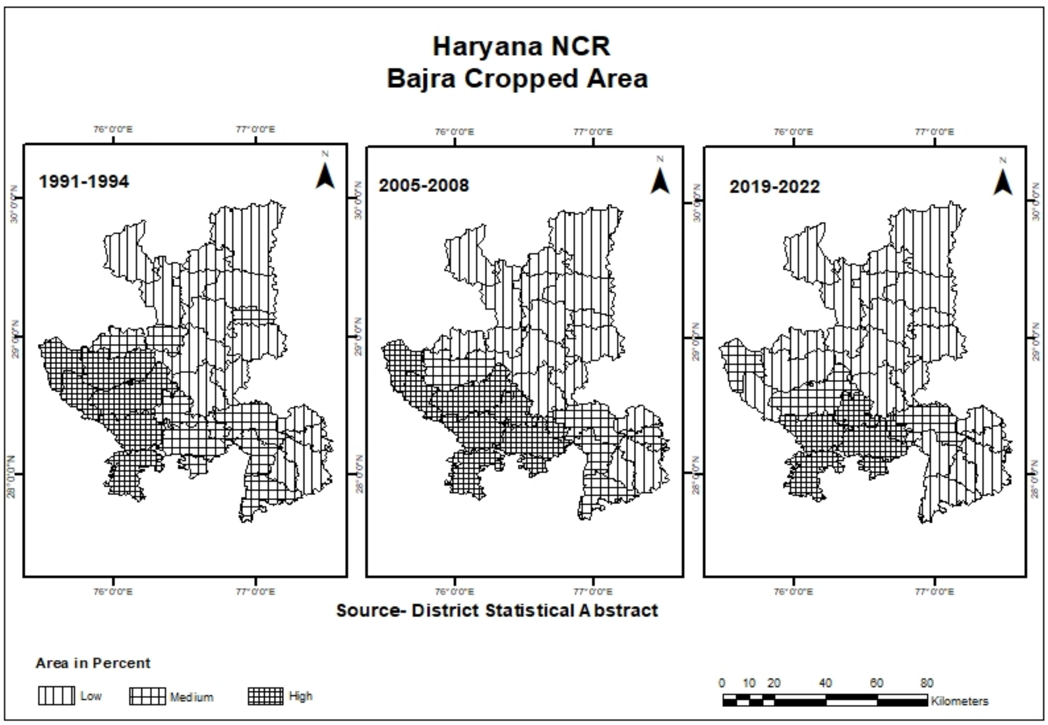


Table no. 3.4- Haryana NCR- Bajra cultivation tehsil wise

Category	1991-94 Bajra		2005-08		2019-2022	
	Tahsils	Total		Total	Tehsils	Total
High (>30%)	Narnoul, Mahendergarh, Bhiwani, Dadri, Loharu, Siwani,	6	Kosli, Rewari, Bawal, Mahendergarh, Narnoul, Patoudi, Siwani, Loharu, Dadri	9	Narnoul, Mahendergarh, Rewari, Bawal, Kosli	5

Medium (15-30%)	Ganour, Rewari, Bawal, Maham, Kosli, Bhiwani Khera, Gurgaon, Patoudi, Nuh, Firojpur jirkha	10	Bhiwani, Gurgaon, Mewat, Ballabgarh, Firojpur Zirkha	5	Gurgaon, Patoudi, Dadri, Siwani	4
Low (<15%)	sonipat, Gohana, Faridabad, Ballabgarh, Palwal, Hathin, Karnal, Panipat, Assandh, Rohtak, Jhajjar, Bahadurgarh , Jind, Narwan, Safidon	15	sonipat, Gohana, Ganour Faridabad, Palwal, Hathin, Karnal, Panipat, Assandh, Rohtak, Jhajjar, Bahadurgarh , Maham, Jind, Narwana, Safidon, Maham, Bhawni Khera,	17	sonipat, Gohana, Ganour Faridabad, Ballabgarh, Palwal, Hathin, Karnal, Panipat, Assandh, Rohtak, Jhajjar, Bahadurgarh , Maham, Nuh, Firojpur Jirkha, Jind, Narwan, Safidon, bhiwani, Bhawni Khera, Loharu, Tohsham	23
Total		31				32

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Tehsils wise Area of Bajra cultivation in Haryana NCR- Medium

In 1991-94, ten tehsils came under this category namely Ganour(15%), Rewari(25%), Bawal(25.03%), Maham(15.6%), Kosli(20.84%), Bhiwani Khera(18.5%), Gurgaon(19.2%), Patoudi(17.3%), Nuh(15.87%), Firojpur jirkha(15.07%). From 2005 to 2008, five tehsils have been coming in this category namely Bhiwani(18%), Gurgaon(28.6%), Mewat(18.3%), Ballabgarh(17.6%), Firojpur Zirkha(21.2%). but in 2017-2020, only four tehsils came in this section namely Gurgaon(21.3%), Patoudi(35.9%), Dadri(17.9%), Siwani(18.24%). All these tehsils are located in the south and south-west part of the region. Bajra crop flourishes in low water conditions and poor soil quality and all these are available in the south and southwest part of the study region area (table 3.4 & fig. 3.9).

Tehsil-wise area of bajra in Haryana NCR- lowest

In1991-94, fifteen tehsils came in this section namely Sonipat(3.5%), Gohana(0.99%), Faridabad(13.8%), Ballabgarh(6.4%), Palwal(6.2%), Hathin(11.04%), Karnal(0.19%), Panipat(1.22), Assandh(1.5%), Rohtak(9.44%), Jhajjar(14.14%), Bahadurgarh(8.39%) , Jind(14.2%), Narwan(13.5%), Safidon(3.8%). During 2005 to 2008, tehsils namely Sonipat(3.3%), Gohana(3.5%), Ganour(4.8%) Faridabad(9.5%), Palwal(3.3%), Hathin(9.3%), Karnal(0.1%), Panipat(0.01%), Assandh(0.8%), Rohtak(6.8%), Jhajjar(12.8%), Bahadurgarh(3%) , Maham(11.3%), Jind(8.3%), Narwana(14.9%), Safidon(2.5%), Maham(11.3%), Bhawni Khera(8.9%) have lowest area under bajra cultivation. If we looked bajra cultivation in 2017-20, twenty-three tehsils came under this section namely Sonipat(2.2%), Gohana(1.6%), Ganour(1.1%) Faridabad(6.8%), Ballabgarh(6.7%), Palwal(3.4%), Hathin(5.4%), Karnal(0.1%), Panipat(0.02%), Assandh(0.2%), Rohtak(4.1%), Jhajjar(13.9%), Bahadurgarh(8.8%), Maham(6%), Nuh(15%), Firojpur Jirkha(14.8%), Jind(3.5%), Narwan(2.2%), Safidon(1.1%), bhiwani(12.5%), Bhawni Khera(2.6%), Loharu(9%). The area under bajra cultivation had decreased sharply due to expansion in irrigation techniques and was replaced by other more valuable crop areas (table 3.4 & fig. 3.9).

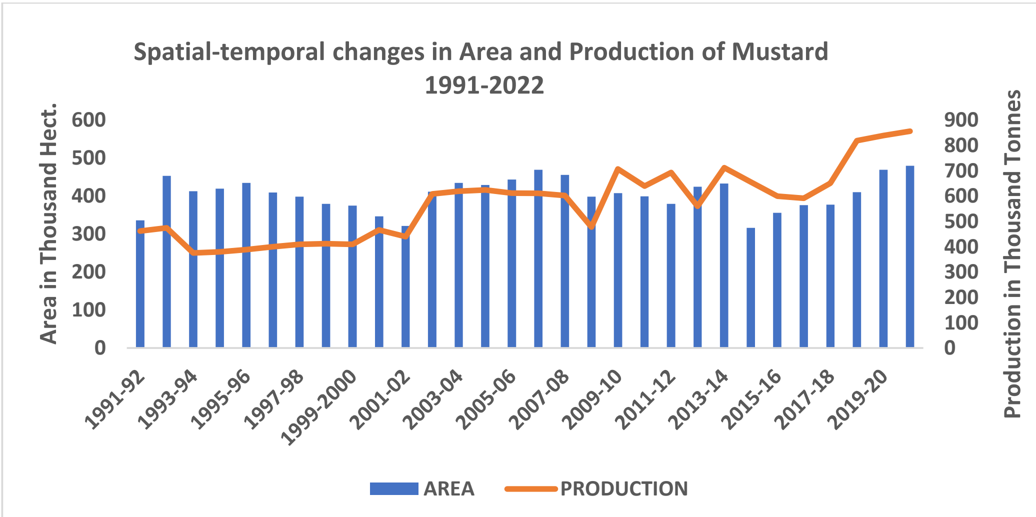
Changes in Area under Bajra Cultivation from 1991 to 2022

Bajra cultivation has been negatively affected by irrigation facilities within the study area. Due to the expansion of irrigation facilities, farmers have started to grow other crops like cotton and rice. During 1991-94, the area under bajra cultivation was 17.4%, 13.7% during 2005-08 and 11.2% during 2019-22. It has been grown in less rainfall areas but due to expansion in groundwater irrigation, bajra have been replaced by other crops.

3.2.4.4. Mustard cultivation in Haryana NCR

Mustard was grown by two methods – one is an independent method in which only one crop was grown and the second is inter cropping method in which two crops were grown in the same field. Mustard requires no heavy soil and less water consumption. So, these were grown separately in the south and southwest part of the study area and with others like wheat, gram and barsem in semi-dry tehsils in the winter season and with cotton and maize in Kharif season. In the rabi season, they are grown in October and November and harvested in March with other rabi crops. In 1991-94, the area under mustard cultivation was 336.7 thousand hectares and reached up to 480.3 thousand hectares in 2019-2022. Production under mustard was 463 thousand tonnes in 1991-94 and reached at 856.9 thousand tonnes in 2019-22 as a result of HYV seeds, fertilizers and mechanization (fig. 3.10).

Fig. 3.10- Spatial-Temporal Changes in Area and Production under Mustard: 1991 to 2022



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Tehsils with high areas under mustard cultivation

Mustard flourished well in dry and hot conditions and all these conditions were found in south and southwest Haryana. This was the reason behind the high oil seeds cultivation in these tehsils namely Narnoul(14.98%), Mahendergarh(11.5%), Rewari(17.4%), Bawal(23.9%), Kosli(18.6%), Firojpur Jirkha(13.3%), gurgaon(10.1%), Patoudi(28.09%), Mewat(19.2%), Jhajjar(17.5%) in 1991-94 whereas in 2005 to 2008, Narnoul(38%), Mahendergarh(32.4%), Rewari(16.1), Bawal(50%), Kosli(38.5%), Bhiwani(24.8%), Loharu(26.5%), Dadri(26.5%), Firojpur Jirkha(17.3%), Bhawani khera(13.1%), Siwani(17%), Gurgaon(10.8%), Mewat(19.2%), Jhajjar(17.5%), Bahadurgarh(12.5%) and during 2019 to 2022, Narnoul(31.3%), Mahendergarh(29.9%), Rewari(30.8%), Bawal(40.9%), Kosli(33.4%), Bhiwani(24.6%), Loharu(26%), Dadri(23.4%), Firojpur Jirkha(24.4%), Bhawani khera(18.7%), Siwani(16.1%), Gurgaon(10.5%), Patoudi(18.3%) . Due to the presence of a hilly surface, sandy soil, and sandy loam, less irrigation facilities are the reason for high oil seed cultivation in these tehsils (table 3.5 and fig. 3.11).

Fig. 3.11- Mustard Cropped Area- Haryana NCR

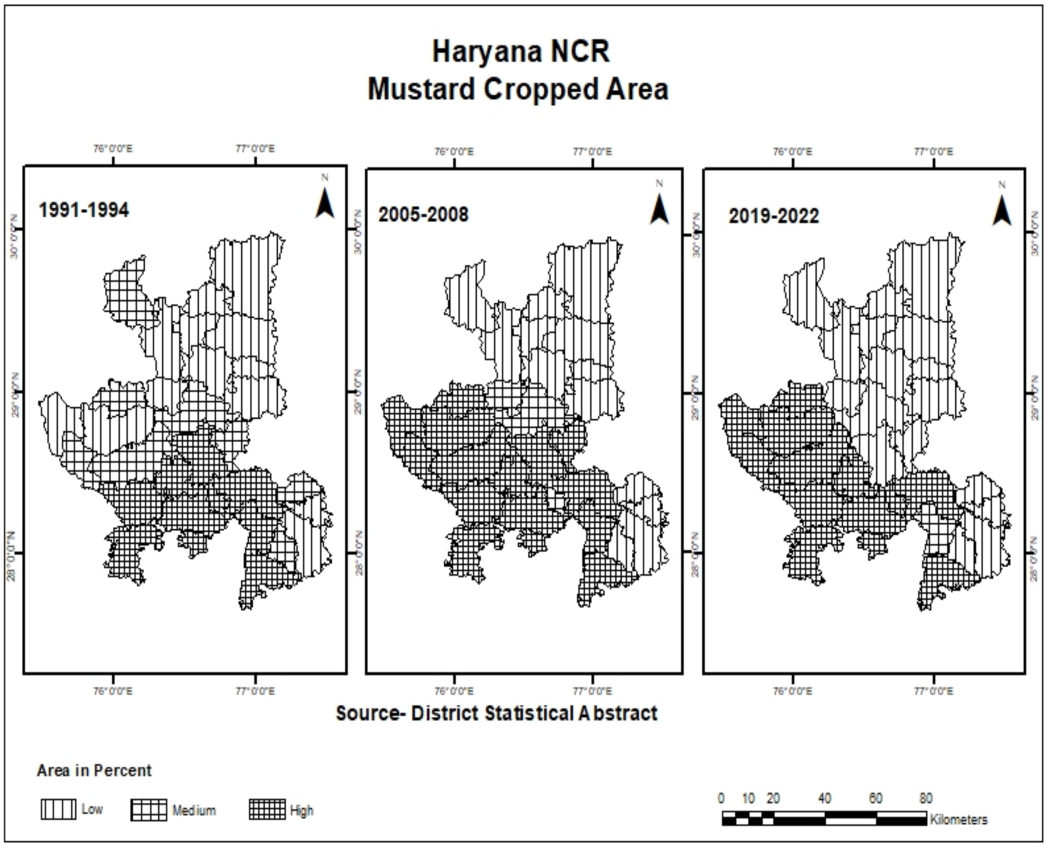


Table no. 3.5- Haryana NCR- Mustard cultivation tehsil wise

Category	1991-94 Mustard		2005-2008		2019-2022	
	Tahsils	Total	Tehsils	Total	Tehsils	Total
High (>10%)	Narnoul, Mahendergarh, Rewari, Bawal, Kosli, Firojpur Jirkha, gurgaon, Patoudi, Nuh, Jhajjar	10	Narnoul, Mahendergarh, Rewari, Bawal, Kosli, Bhiwani, Loharu, Dadri, Firojpur Jirkha, Bhawani khera, Siwani, Gurgaon, Mewat, Jhajjar, Bahadurgarh	16	Narnoul, Mahendergarh, Rewari, Bawal, Kosli, Bhiwani, Loharu, Dadri, Firojpur Jirkha, Bhawani khera, Siwani, Gurgaon, Patoudi	13
Medium (5-10%)	Faridabad, Hathin, Rohtak, Bahadurgarh, Bhawani khera, Dadri, Loharu, Narwna	8	Maham, Rohtak, Patoudi	3	Mewat	1
Low (5%)	Jind, Safidon, Karnal, Assandh,	13	Karnal, Assandh, Safidon, Narwana, Jind,	13	Jind, Narwna, Safidon, Karnal, Assandh, Panipat, Sonipat,	17

	Panipat, Sonipat, Gohana, Ganour, Ballabgarh, Maham, Palwal. Bhiwani, Siwani		Panipat, Sonipat, Ganour, Gohana, Faridabad, Ballabgarh, Palwal, Hathin		Gohana, Ganour, Faridabad, Ballabgarh, Jhajjar, Bahadurgarh, Rohtak, Maham, Palwal, Hathin	
Total		31				31

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Tehsils with medium area under mustard cultivation

Eight tehsils come under this section of medium mustard cultivation namely Faridabad(6.01%), Hathin(8.61%), Rohtak(5.09%), Bahadurgarh(7.65%), Bhawani Khera (5.5%), Dadri(7.49%), Loharu(5.95%), Narwna(5.29%) during 1991-94, whereas in 2005 to 2008, Maham(8.5%), Rohtak(9.5%), Patoudi(8.3%) but during 2019-22, only one tehsil remain in this category was Mewat(6.8%). These tehsils are also located in south and south-west zone with dry conditions, lower irrigation facilities and less rainfall (table 3.5 and fig. 3.11).

Tehsils with lowest area under mustard cultivation

In 1991-94, thirteen tehsils namely Jind(3.2%), Safidon(2.64%), Karnal(0.31%), Assandh(0.83%), Panipat(1.1%), Sonipat(3.04%), Gohana(2.7%), Ganour(1.3%), Ballabgarh(3.6%), Maham(3.97%), Palwal(4.98%), Bhiwani(2.63%), Siwani(4.3%) had the lowest area under oil seeds cultivation and Karnal(0.31%) had lowest area under oil seeds cultivation. During 2005 to 2008, Karnal(0.2%), Assandh(0.4%), Safidon(0.01%), Narwana(0.7%), Jind(1.7%), Panipat(0.4%), Sonipat(1.1%), Ganour(0.5%), Gohana(1%), Faridabad(4.3%), Ballabgarh(4.4%), Palwal(3.5%), Hathin(4.1%) have the liwest area under mustard cultivation. During 2019-22, seventeen tehsils namely Jind(1.7%), Narwna(0.9%), Safidon(0.9%), Karnal(0.4%), Assandh(0.6%), Panipat(0.34%), Sonipat(0.4%), Gohana(0.5%), Ganour(0.33%), Faridabad(0.43%), Ballabgarh(0.002%), Jhajjar(0.6%), Bahadurgarh(0.35%), Rohtak(0.54%), Maham(0.23%), Palwal(0.9%), Hathin(2.03%) had the lowest area under oil seeds cultivation in NCR Haryana and Ballabgarh(0.002%) had the lowest area under mustard cultivation. All these tehsils had good irrigation facilities, rich soil conditions and also received a good amount of rainfall. So, most of the area was covered by wheat and rice cultivation (table 3.5 and fig. 3.11).

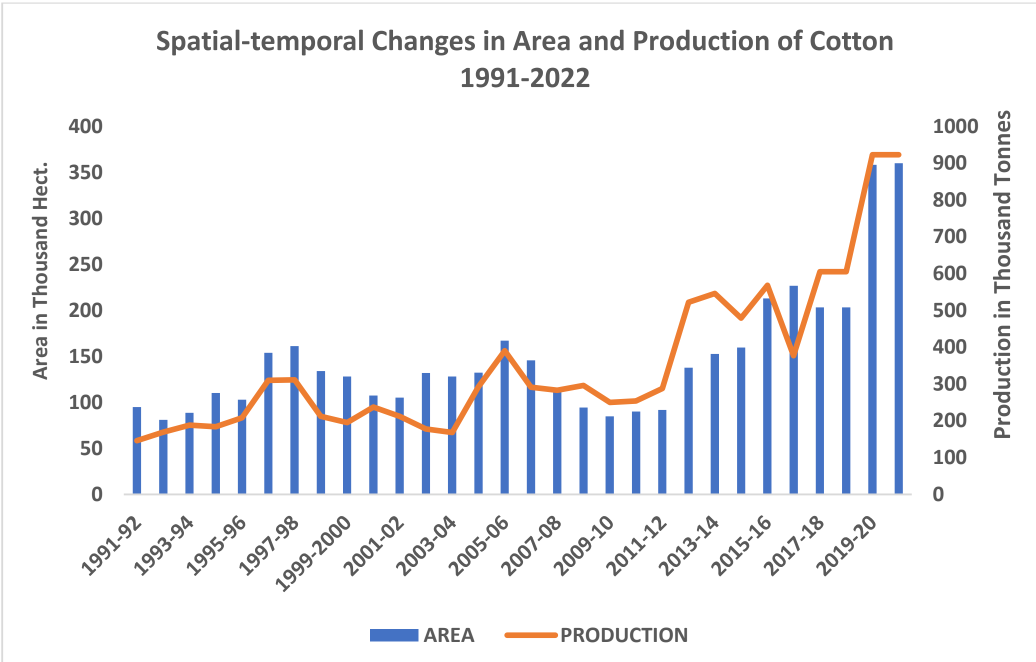
Changes in Area under Mustard Cultivation from 1991 to 2022

Mustard has flourished well in dry and sandy soil which fully exists in south western part of Haryana. The area under mustard has increased from 6.4% during 1991-94, 10.6% during 2005-08 and 14.3% during 2019-2022. Due to irrigation through sprinkle, the area has been shifted from gram & barley to mustard cultivation. Technological development, sprinkle systems and price factors are responsible for the positive growth in areas under mustard cultivation. Mustard is a very useful product for home as well as commercial purposes which affected the growth of mustard positively. The area and production of cotton has been increased continuously from 1991 to 2022 (fig. 3.12).

3.2.4.5. Cotton cultivation in NCR Haryana

Cotton is a kharif season crop and also a very important cash crop in the NCR Haryana. In 1991-92, the area under cotton cultivation was 94.9 thousand hectares which reached at 360 thousand hectares in 2021-22. If we talk about production, it was 923 thousand tonnes in 1991-92 and reached at 146 thousand tonnes in 2021-22. Both area and production were increased since 1991 to 22 (fig. 3.12). Semi-Arid climatic conditions are best suited for cotton cultivation and these conditions are available in the south and south western side of the study area. The temperature should be 20 to 35 degrees Celsius during the growing period and cool temperature, clear and dry weather conditions at the harvesting time. It requires good irrigation but very little as compared to rice. During 1991-94, the area under cotton cultivation was 60 thousand hectares which increased to 269 thousand hectares during 2019-22. During 1991-94, Faridabad, Ballabgarh, Narnoul, Mahendergarh, Bawal, Rohtak, Jhajjar, Bahadurgarh, maham, Kosli tehsils had no cotton cultivation but during 2019-22, only three tehsils had no cotton cultivation namely Karnal, Assandh and Panipat.

Fig. 3.12- Spatial-Temporal Changes in Area and Production under Cotton: 1991 to 2022



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Tehsils with high areas under cotton cultivation

During 1991-94, only one tehsil had the highest proportion area under cotton cultivation which was Bhawani Khera(18.2%) whereas from 2005 to 2008, Narwna(20.5%), Jind(10.4%), Bawani Khera(23.8%) but during 2019-22, eight more tehsils were included in this category namely Jind(11%), Narwana(19.8%), Bhiwani(12.7%), Bhawani Khera (29.5%), Loharu(30.1%), Siwani(19.8%), Dadri(12.2%), Mahendergarh(14.3%), Hathin(10.1%). All these tehsils had best-suited climatic conditions for cotton cultivation like hot, dry weather, good soil and availability of good canal irrigation system (table 3.6 and fig. 3.13).

Fig. 3.13- Cotton Cropped Area- Haryana NCR

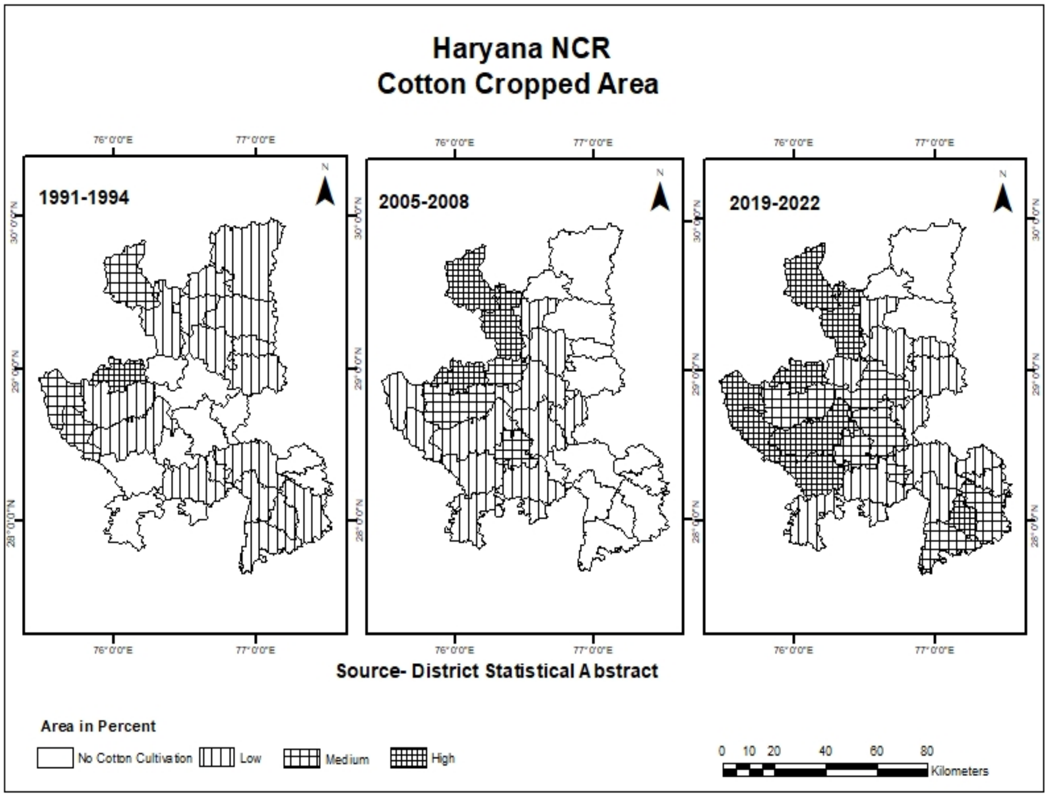


Table no. 3.6- Haryana NCR- Cotton cultivation tehsil wise

Category	1991-94 cotton		2005-08		2019-2022	
	Tahsils	Total	Tehsils	Total	Tehsils	Total
High (>10%)	Bhawani Khera	1	Narwna, Jind, Bawani Khera	3	Jind, Narwana, Bhiwani, Bhawani khera, Loharu, Siwani, Dadri, Mahendergarh, Hathin	9
Medium (5-10%)	Loharu, Siwani, Narwana	3	Bhiwani, Maham, Kosli	3	Jhajjar, Bawal, Kosli, Firojpur Zirka, Rohtak, Patoudi, Palwal	7
Low (<5%)	Sonipat, Gohana, Ganour, Palwal, Hathin, Rewari, Jind, Safidon, Karnal, Assandh, Panipat, Bhiwani, Dadri, Gurgaon, Patoudi, Nuh, Firojpur Zirkha	17	Siwani, Loharu, Dadri, Mahendergarh, Narnoul, Rewari, Bawal, Jhajjar, Bahadurgarh, Rohtak, Gohana, Safidon	12	Safidon, Narnoul, Rewari, Mewat, Sonipat, Gohana, Ganour, Faridabad, Ballabgarh, Bahadurgarh, Maham, Gurgaon	12

No cotton Cultivation	Faridabad, Ballabgarh, Narnoul, Mahendergarh, Bawal, rohtak, jhajjar, bahadurgarh, maham, Kosli	10	Karnal, Assandh, Panipat, Ganour, Sonipat, Patoudi, Gurgaon, Mewat, Firojpur Zirkha, Hathin, Palwal, Faridabad, Ballabgarh	13	Karnal, Assandh, Panipat	3
Total		31				31

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Tehsils with medium areas under cotton cultivation

During 1991-94, only three tehsils namely Loharu(5.03%), Siwani(5.13%), and Narwana(8.94%) had medium cotton cultivation whereas from 2005 to 2008, Bhiwani(9.3%), Maham(7.9%), Kosli(7.9%). During 2017-2020, the number of tehsils would be increased from three to seven tehsils namely Jhajjar(5.1%), Bawal(4.9%), Kosli(9.2%), Firojpur Zirka(5%), Rohtak(7.1%), Patoudi(5.3%), Palwal(7.8%) as the area under cotton cultivation was increased since 1991 to 2022 All these tehsils were located nearby high area cotton cultivation tehsils and spread in the central, south and south-west part of the study area. Reasons behind the cotton cultivation are better irrigation facilities, big hand holdings and also cotton requires less water compared to other paddy crops. In western tehsils of the study region, canal irrigation facilities were developed which highly affects cotton cultivation (table 3.6 and fig. 3.13).

Tehsils with low areas under cotton cultivation

There were seventeen tehsils namely Sonipat(0.7%), Gohana(1.5%), Ganour(1.25%), Palwal(0.16%), Hathin(0.44%), Rewari(0.08%), Jind(4.49%), Safidon(1.39%), Karnal(0.25%), Assandh(0.95%), Panipat(0.6%), Bhiwani(3.96%), Dadri(0.76%), Gurgaon(0.01%), Patoudi(0.01%), Nuh(0.02%), Firojpur Zirkha)0.03%) had the lowest proportion under cotton cultivation during 1991-94 whereas during 2005 to 2008, Siwani(1.4%), Loharu(1%), Dadri(4.9%), Mahendergarh(1.4%), Narnoul(1.6%), Rewari(3.2%), Bawal(3.3%), Jhajjar(1.1%), Bahadurgarh(1.25%), Rohtak(0.9%), Gohana(0.8%), Safidon(4.4%). But the number of tehsils decreased from seventeen to twelve from 1991 to 2022. Safidon(1%), Narnoul(2.6%), Rewari(3.9%), Mewat(1.6%), Sonipat(1.1%), Gohana(1.8%), Ganour(0.3%), Faridabad(0.4%), Ballabgarh(0.3%), Bahadurgarh(1.7%), Maham(1%), Gurgaon0.4%) had the lowest area under cotton cultivation during 2019-22. Reasons behind the lower area under cotton cultivation are the availability of good irrigation facilities, better soil health, better market etc. and that's why most of the areas in these tehsils were devoted to rice cultivation during kharif season. During 2019-22, Ballabgarh(0.28%) had the lowest proportion of cotton cultivation and Loharu (30%) had the highest proportion of cotton cultivation (table 3.6 and fig. 3.13).

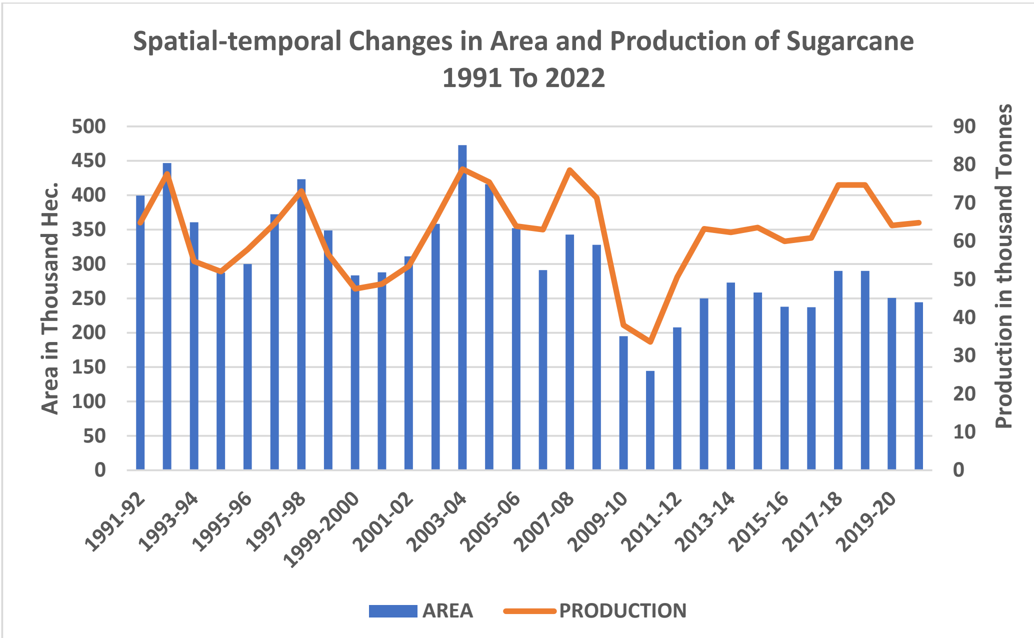
Changes in Area of Cotton Cultivation

Cotton is a very important cash crop and the area under cotton cultivation has positively increased from 1991 to 2022. During 1991-94, 1.96% area was under cotton cultivation, 3.8% during 2005-08 and 7.54% during 2019-22. The cotton area has increased and it replaced the bajra and jowar area. Best climatic conditions are available in the south and southwest part of Haryana NCR like hot and arid climatic conditions with good irrigation facilities.

3.2.4.6. Sugarcane cultivation in NCR Haryana

Sugarcane is a crop of hot and humid climate with 21-degree to 27-degree temperatures and 70 to 75 cm rainfall. If rainfall is less than 75cm then it will be cultivated with the help of irrigation. It is a major cash crop in NCR Haryana as it produces sugar, Gur and Khand which are an important part of the food. It is a major Kharif crop in NCR Haryana and is sown between March to April and harvested between December to March. During 1991-92, the area under sugarcane cultivation was 64 thousand hectares which decreased and reached at 53 thousand hectares during 2021-22 (fig. 3.14). Although area decreased under sugarcane, the production was as it is from 360 thousand tonnes in 1991-92 to 359.9 thousand tonnes in 2021-22. The cultivated area under sugarcane was decreasing continuously as a result of shifting in climatic conditions, fluctuation in price, no proper availability of sugar mills, labour shortage at season and also not proper clearance by the mill during harvesting time. During 1991-94, Faridabad, Narnoul, Mahendergarh, Rewari, Bawal, Kosli, Bhiwani, Bhawani khera, Loharu, Siwani, Dadri tehsils had no sugarcane cultivation and during 2019-22, Narnoul, Mahendergarh, Rewari, Bawal, Kosli, Loharu, Siwani, Faridabad had no sugarcane cultivation.

Fig. 3.14- Spatial-Temporal Changes in Area and Production under Sugarcane: 1991- 2022



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

The area under sugarcane cultivation- Tehsil Wise

During 1991-94, Mahem(9.7%) and Rohtak tehsil had the highest percentage of area under sugarcane cultivation and Patoudi(0.1 %) tehsil had the lowest proportion. Sonipat(3.5%), Gohana(5.25%), Ganour(5.5%), Palwal(3.1%), Panipat(4.5%), Jind(4.4%) had come in medium category of sugarcane cultivation and Ballabgarh, Hathin, Karnal, Jhajjar, Assandh, Bahadurgarh, Narwana, Safidon, Gurgaon, Patoudi, Nuh, Firojpur Jirkha had lowest area under sugarcane cultivation (fig.3.15 & table 3.7).

In 2005 to 2008, Ganour(4.6%), Gohana(4.4%), Rohtak(4.7%), Hathin(3.4%) had themedium proportionate under sugarcane cultivation and Karnal(2.6%), Assandh(0.5%), Panipat(1.8%), Narwana(0.1%), Jind(0.7%), Safidon(1.5%), Maham(2.8%), Bawani Khera(0.3%), Bhiwani(1%), Dadri(0.3%), Jhajjar(0.8%), Bahadurgarh(0.5%), Sonipat(2.7%), Ballabgarh(2.6%), Palwal(2.5%) had the lowest area under sugarcane cultivation (fig.3.15 & table 3.7.

Fig. 3.15- Sugarcane Cropped Area- Haryana NCR

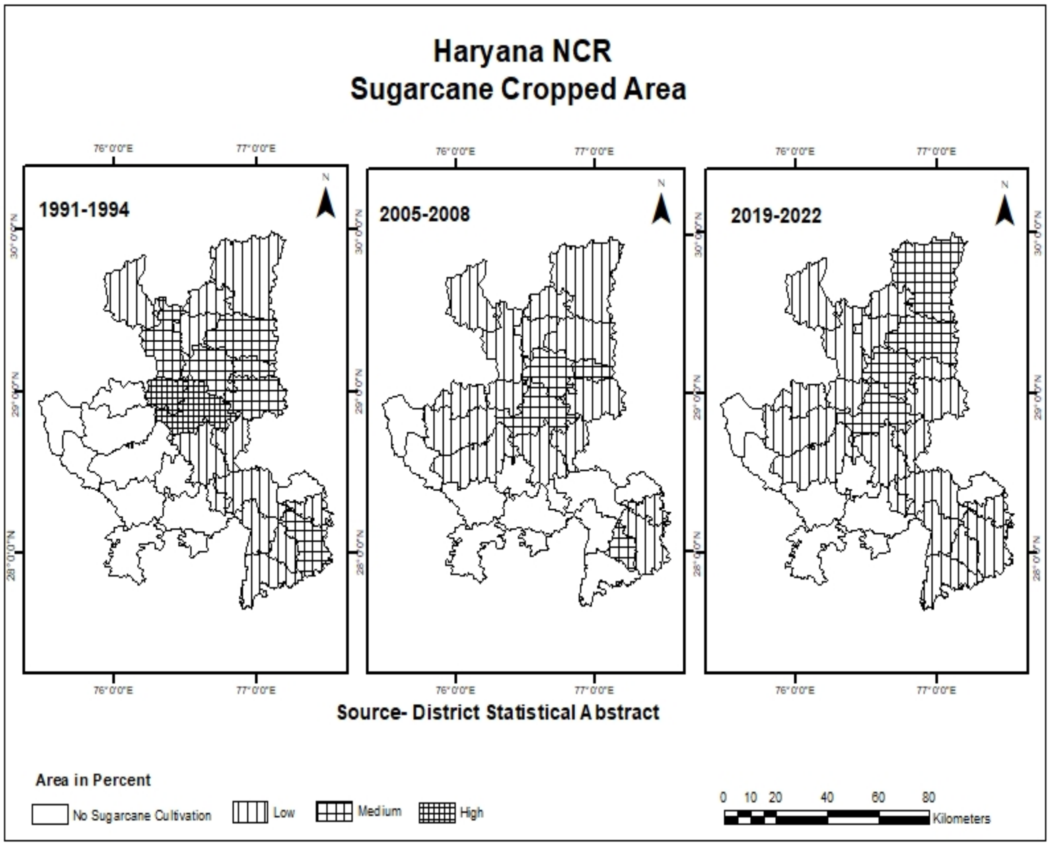


Table no. 3.7- Haryana NCR- Sugarcane cultivation tehsil wise

Category	1991-94		2005-2008		2019-2022	
	Tahsils	Total	Tehsils	Total	Tehsils	Total
High (>6%)	Rohtak, Maham	2		0		
Medium (3 to 6%)	Sonipat, Gohana, Ganour, Palwal, Panipat, Jind	6	Ganour, Gohana, Rohtak, Hathin	4	Karnal, Panipat, Rohtak, Gohana	4
Low (<3 %)	Ballabgarh, Hathin, Karnal, Jhajjar, Assandh, Bahadurgarh, Narwana, Safidon, Gurgaon, Patoudi, Nuh, Firojpur Jirkha	23	Karnal, Assandh, Panipat, Narwana, Jind, Safidon, Maham, Bawani Khera, Bhiwani, Dadri, Jhajjar, Bahadurgarh, Sonipat, Ballabgarh, Palwal	15	Jind, Narwana, Safidon, Assandh, Bhiwani, Bawani Khera, Dadri, Firojpur Zirkha, Ballabgarh, Sonipat, Ganour, Jhajjar, Bahadurgarh, Maham, Gurgaon	19

					Patoudi, Palwal, Hathin, Nuh	
No Sugarcane	Faridabad, Narnoul, Mahendergarh, Rewari, Bawal, Kosli, Bhiwani, Bhawani khera, Loharu, Siwani, Dadri	11	Siwani, Laharu, Mhaendergarh, Narnoul, Kosli, Rewari, Bawal, Gurgaon, Mewat, Firojpur Zirkha, Patoudi, Faridabad	12	Narnoul, Mahendergarh, Rewari, Bawal, Kosli, Loharu, Siwani, Faridabad	8
Total		31		31		31

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

From 2019 to 2022, nineteen tehsils out of thirty-one tehsils gathered in the lowest area under sugarcane cultivation namely Jind, Narwana, Safidon, Assandh, Bhiwani, Bawani Khera, Dadri, Firojpur Zirkha, Ballabgarh, Sonipat, Ganour, Jhajjar, Bahadurgarh, Maham, Gurgaon Patoudi, Palwal, Hathin, Nuh and only four tehsils have existed in medium category namely Karnal, Panipat, Rohtak, Gohana (fig.3.15 & table 3.7).

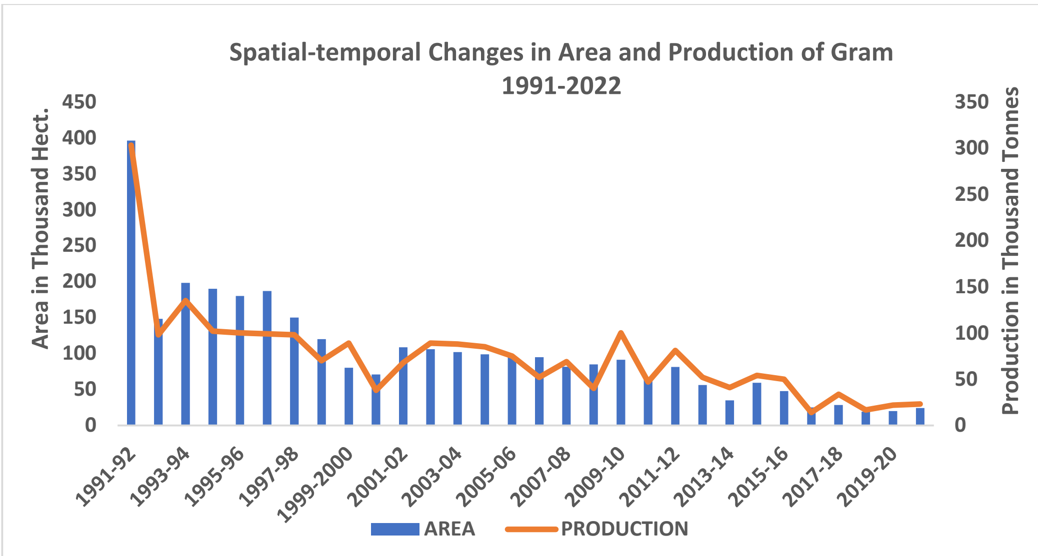
Changes in area under sugarcane cultivation

The area under sugarcane cultivation was 64 thousand hectares in 1991-94 and reached at 53 thousand hectares in 2019-22. It decreased by 11 thousand hectares due to competition with rice & wheat, lack of labour facilities and lack of sugar mills. Sugarcane takes one year to harvest which seems like a long time and also it depends on labour for sowing and harvesting works which is not easily available. Government policies are mainly responsible for the negative growth of sugarcane cultivation as the Green Revolution mainly focused on wheat and rice cultivation.

3.2.4.7. Gram cultivation in NCR Haryana

Gram is a rabi crop and also requires the same climatic conditions as wheat. It demands less water and grows well in poor soil conditions. Sandy and clay loam soils are best suited for its production. This crop also increased soil fertility and was helpful for the next kharif crop cultivation. It was in 2nd place in area after wheat during 1991-94 but it shifted to 3rd place during 2019-2022 as improvement in irrigation facilities in gram-cropped tehsils. Siwani(31%) had the highest proportion area under gram cultivation and Karnal had the lowest proportion area during 1991-94. Five tehsils namely Palwal, Hathin, Gohana, Faridabad, and Ballabgarh had no gram cultivation during 2019-22. The area under gram cultivation was 396 thousand hectares during 1991-94 reached at 24.1 thousand hectares in 2021-22 (fig. 3.16)

Fig. 3.16- Spatial-temporal changes in Area and Production under Gram: 1991 to 2022



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Highest area under gram cultivation-Tehsil Wise

Twelve tehsils namely Jhajjar(14.7%), Maham(14.7%), Kosli(17.3%), Bhiwani(25.4%), Bawani Khera(18%), Dadri(27%), Loharu(19.5%) Siwani(31.4%), Narnoul(15.6%), Mahendergarh(24%), Rewari(12.7%), Bawal(18%) had the highest proportion area under gram cultivation during 1991-94. Most of the tehsils were located in the south and southwest zone of the study area as all the favourable conditions required for gram cultivation were present in these tehsils. From 2005 to 2008, only one tehsil Swani(25%) had the highest area under gram cultivation and the picture was different from 2019 to 2022, no one had left in the category as the area under gram sharply declined due to the expansion of irrigation facilities among all the tehsils (fig. 3.17 and table 3.8).

Fig. 3.17- Gram Cropped Area- Haryana NCR

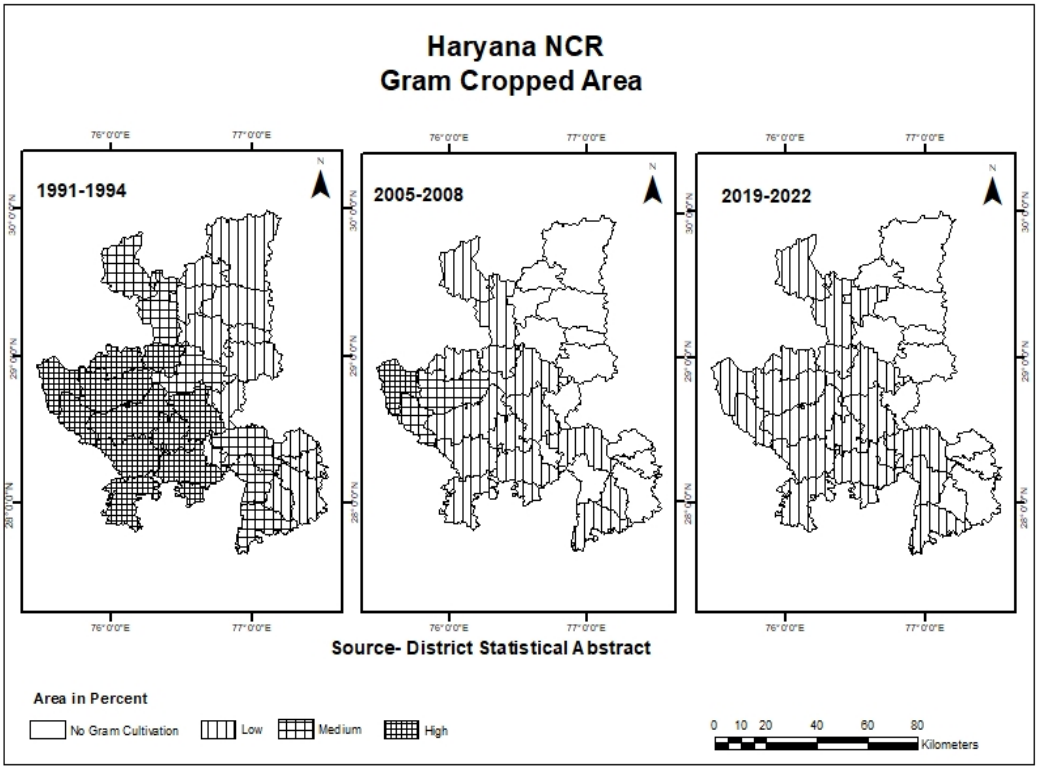


Table 3.8- Gram cropped area during 1991-94 and 2018-2021

Category	1991-94		2005-2008		2019-2022	
	Tahsils	Total	Tehsils	Total	Tehsils	Total
High (>12%)	Jhajjar, Maham, Kosli, Bhiwani, Bawani Khera, Dadri, Loharu Siwani, Narnoul, Mahendergarh, Rewari, Bawal	12	Siwani	1		0
Medium (6-12%)	Jind, Narwana, Gurgaon, Nuh, Firojpur Jirkha, Rohtak	6	Bhiwani, Loharu	2		0
Low (6%)	Safidon, Patoudi, Sonipat, Ganour, Gohana, Ballabgarh, Palwal, Hathin, faridabad,	13	Narwana, Jind, Bawani Khera, Maham, Rohtak, Dadri, Jhajjar, Kosli, Mahendergarh, Narnoul, Rewari, Bawal,	15	Safidon, Patoudi, Jind, Narwana, Gurgaon, Nuh, Firojpur Jirkha, Rohtak, Jhajjar, Maham, Kosli, Bhiwani, Bawani Khera, Dadri,	20

	Karnal, Assandh, Panipat, Bahadurgarh		Gurgaon, Hathin, Firojpur Zitkha		Loharu Siwani, Narnoul, Mahendergarh, Rewari, Bawal	
No gram			Safidon, Patoudi, Sonipat, Ganour, Gohana, Ballabgarh, Palwal, faridabad, Karnal, Assandh, Panipat, Bahadurgarh, Mewat	13	Palwal, Hathin, Gohana, Faridabad, Ballabgarh, Sonipat, Ganour, Panipat, Karnal, Assandh, Bahadurgarh	11
Total		31				31

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Medium area under gram cultivation- tehsil-wise

During 1991-94, six tehsils had the medium proportion area under gram cultivation namely Jind(6.5%), Narwana(6.6%), Gurgaon(7.1%), Nuh(8.5%), Firojpur Jirkha(7.3%), Rohtak(8.2%) which was 6 to 12 percent whereas during 2005 to 2008, only two tehsils namely Bhiwani(11.8%), Loharu(6.2%) had come in this category. The picture was different during 2019-2022 and no one was left in this category and the reason was the same- expansion in irrigation facilities (fig. 3.17 and table 3.8).

The lowest area under gram cultivation- tehsil-wise

During 1991-94, thirteen tehsils namely Safidon, Patoudi, Sonipat, Ganour, Gohana, Ballabgarh, Palwal, Hathin, faridabad, Karnal, Assandh, Panipat, Bahadurgarh had the lowest proportion area under gram cultivation which was below 6 percent of the gross cropped area whereas during 2005 to 2008, fifteen tehsils have a lowest proportionate area under gram cultivation namely Narwana, Jind, Bawani Khera, Maham, Rohtak, Dadri, Jhajjar, Kosli, Mahendergarh, Narnoul, Rewari, Bawal, Gurgaon, Hathin, Firojpur Zitkha During 2019-2022,twenty tehsils namely Safidon, Patoudi, Jind, Narwana, Gurgaon, Nuh, Firojpur Jirkha, Rohtak, Jhajjar, Maham, Kosli, Bhiwani, Bawani Khera, Dadri, Loharu Siwani, Narnoul, Mahendergarh, Rewari, Bawal had the lowest proportion area due to expansion in irrigation facilities, most of the tehsils prefer wheat and oil seed cultivation during rabi season (fig. 3.17 and table 3.8).

Changes in the area under Gram Cultivation

Due to the expansion of irrigation intensity, the area under gram cultivation has been negatively affected. It has decreased by 7% from 1991-94 to 2019-22 and it was replaced mainly by wheat and mustard. Gram required less amount of moisture but due to expansion in irrigation intensity, farmers started growing other crops. The area under gram cultivation was 304 thousand hectares during 1991-94 reached at 83.2 thousand hectares in 2019-22. Rohtak and Bhiwani were the major districts to grow gram but due to package technology and irrigation expansion, farmers prefer other crops.

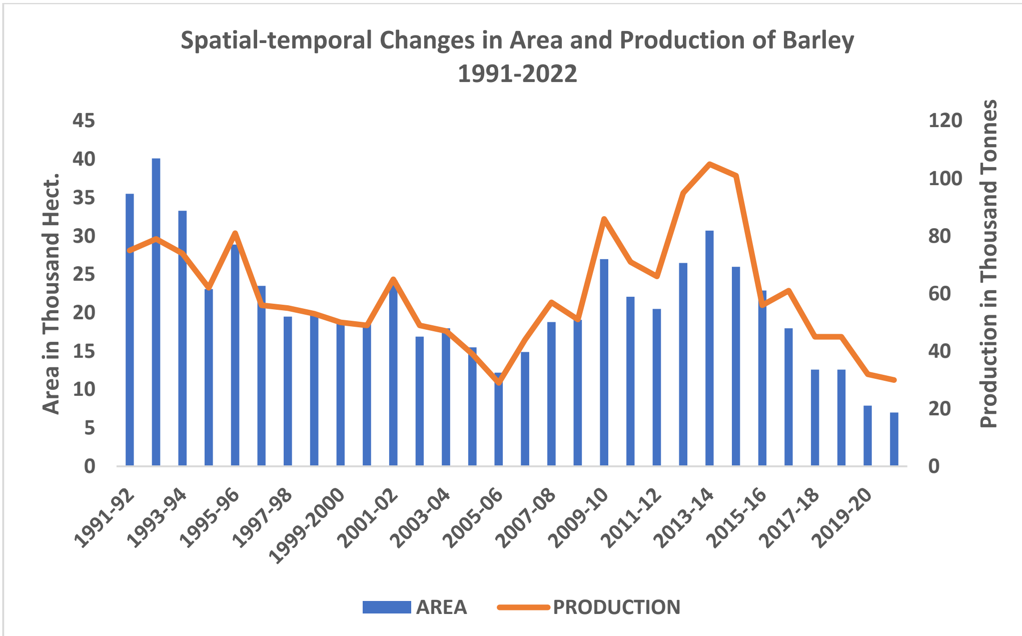
3.2.4.8. Barley cultivation in Haryana NCR

Barley is a rabi season crop and is sown after most of the time bajra in October, and November. It was mostly grown in dry areas of the south and southwest side of NCR Haryana as it requires less water and is almost neglected by the farmers of the northeast region. Due to expansion in irrigation facilities, the proportion area was decreased from 35.5 thousand hectares during 1991-92 to 7 thousand hectares during 2021-22. Production was 75 thousand tonnes in 1991-92 and reached at 30 thousand tonnes in 2021-22 (fig. 3.18)

Tehsil-wise barley cultivation

During 1991-94, Kosli, Rewari, Bawal, Gurgaon, Patoudi, Nuh, Firojpur Jirkha, Faridabad, Ballabgarh, Palwal, and Hathin had the highest proportion area under barley cultivation and all these tehsils were located in south and south-west zone of the region. Due to dry conditions, less fertile soil and less irrigation facilities, these tehsils were preferred for barley cultivation. Narnoul and Jhajjar had the medium proportion area under barley cultivation which was 2 to 4 percent. Eighteen tehsils namely Mahendergarh, Karnal, Panipat, Assandh, Rohtak, Badurgarh, Maham, Bhiwani, Bawani Khera, Loharu, Dadri, Siwani, Jind, Narwana, Safidon, Sonipat, Gohana, Ganour had the lowest proportion area under barley due to better irrigation facilities (fig. 3.19 and table 3.9).

Fig. 3.18- Spatial-Temporal Changes in Area and Production under Barley: 1991 to 2022



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Fig. 3.19- Barley Cropped Area- Haryana NCR

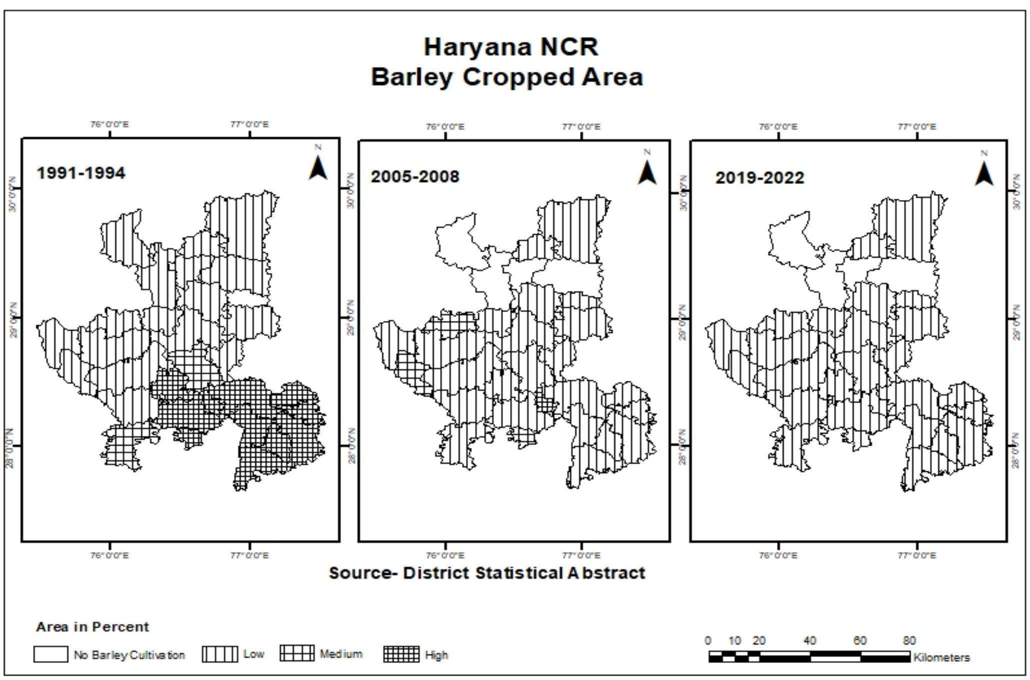


Table no. 3.9- Haryana NCR- Barley cultivation tehsil wise

Category	1991-94		2005-2008		2019-2022	
	Tahsils	Total	Tehsil	Total	Tehsils	Total
High (> 4%)	Kosli, Rewari, Bawal, Gurgaon, Patoudi, Nuh, Firojpur Jirkha, Faridabad, Ballabgarh, Palwal, Hathin	11	Patoudi	1		0
Medium (2-4 %)	Narnoul, Jhajjar,	2	Bawani Khera, Loharu, Bawal	3		0
Low (< 2%)	Mahendergarh, Karnal, Panipat, Assandh, Rohtak, Badurgarh, Maham, Bhiwani, Bawani Khera, Loharu, Dadri, Siwani, Jind, Narwana, Safidon, Sonipat, Gohana,	18	Siwani, Bhiwani, Maham, Rohtak, Dadri, Mahendergarh, Narnoul Karnal, Assandh, Ganour, Gohana, Sonipat, Faridabad, Ballabgarh, Palwal, Hathin, Firojpur Zirkha	23	Kosli, Rewari, Bawal, Gurgaon, Patoudi, Nuh, Firojpur Jirkha, Faridabad, Ballabgarh, Palwal, Hathin, Narnoul, Jhajjar, Mahendergarh, Karnal, Panipat, Assandh, Rohtak, Badurgarh, Maham, Bhiwani, Bawani Khera, Loharu, Dadri, Siwani, Jind, Narwana, Safidon, Sonipat, Gohana, Ganour	27
No Barley	Ganour	0	Narwana, Jind, safidon, Panipat	4	Jind, Narwan, Safidon, Panipat,	4
Total		31				31

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

From 2005 to 2008, no one tehsil left in the first category and only three tehsils had medium areas under barley cultivation namely Bawani Khera, Loharu and Bawal whereas most tehsils had lowest areas under barley cultivation due to the expansion of irrigation facilities. During 2019-2022, all the tehsils had shifted in the category of low-proportion area under barley and Jind, Narwan, Safidon, and Panipat had no barley cultivation at all. All these tehsils have better irrigation facilities and good soil conditions. So, the statement that irrigation facilities and green technology help in the growth of crops like rice and wheat but on the other hand, it hurts the area of crops like jower, bajra, gram, barley etc (fig. 3.19 and table 3.9).

Changes in Barley Cultivation

Barley is grown for fodder purposes in Haryana NCR and the area under this has also decreased from 1991-94 to 2019-22. The area under barley cultivation was 62.7 thousand hectares and it reached at 9.3 thousand hectares in 2019-22. It decreased by 52 thousand hectares during the last 32 years and it was replaced by wheat and mustard. All the tehsils with high Barley cultivation have been shifted to the low barley cultivation category due to the green revolution, HYV seeds and irrigation expansion.

3.2.5. Crop Diversification in Haryana NCR

Crop diversification means how many crops are growing in a particular year from the same piece of land. After the green revolution in Haryana, the crop diversification index has decreased as it facilitates only wheat and rice which has led to many negative impacts on the agriculture of Haryana like groundwater depletion, decreasing soil fertility, increasing the problem of weeds, environmental pollution and also stagnation of productivity.

During 1991-1994, highest crop diversification was in fourteen districts namely Loharu(18.6), Bawani Khera (15.3), Narwna(13.2), Jind(15.7), Maham(16.2), Rohtak(13.7), Jhajjar(18.4), Rewari(17.3), Gurgaon(15.5), Nuh(14.5), Firojpur Zirkha(15.9), Faridabad(16.6), Palwal(18.3) and Bawal(17.9). This tehsil grows five crops in an agricultural year on their farms. Medium crop diversification index was in thirteen tehsils namely Siwani(27.3), Bhiwani(24.6), Dadri(21.9), Mahendergarh(22.8), Narnoul(21.8), Kosli(20.4), Patoudi(23.3), Hathin(20.1), Ballabgarh(22.9), Ganour(20.9), Gohana(23.2) and Sonipat(29.1). Crop specialization was found in four tehsils namely Karnal(40.6), Asandh(41.3), Panipat(35.9) and safidon(34.9). Tehsils with fertile soil, moisture conditions, better underground water and better economic conditions have adopted crop specialization and tehsils with poor soil and water conditions have adopted crop diversification. Tehsil under crop specialisation has been growing only two crops in their farms namely wheat and rice (fig. 3.20 and table 3.10).

Fig. 3.20- Crop Diversification Index- Haryana NCR

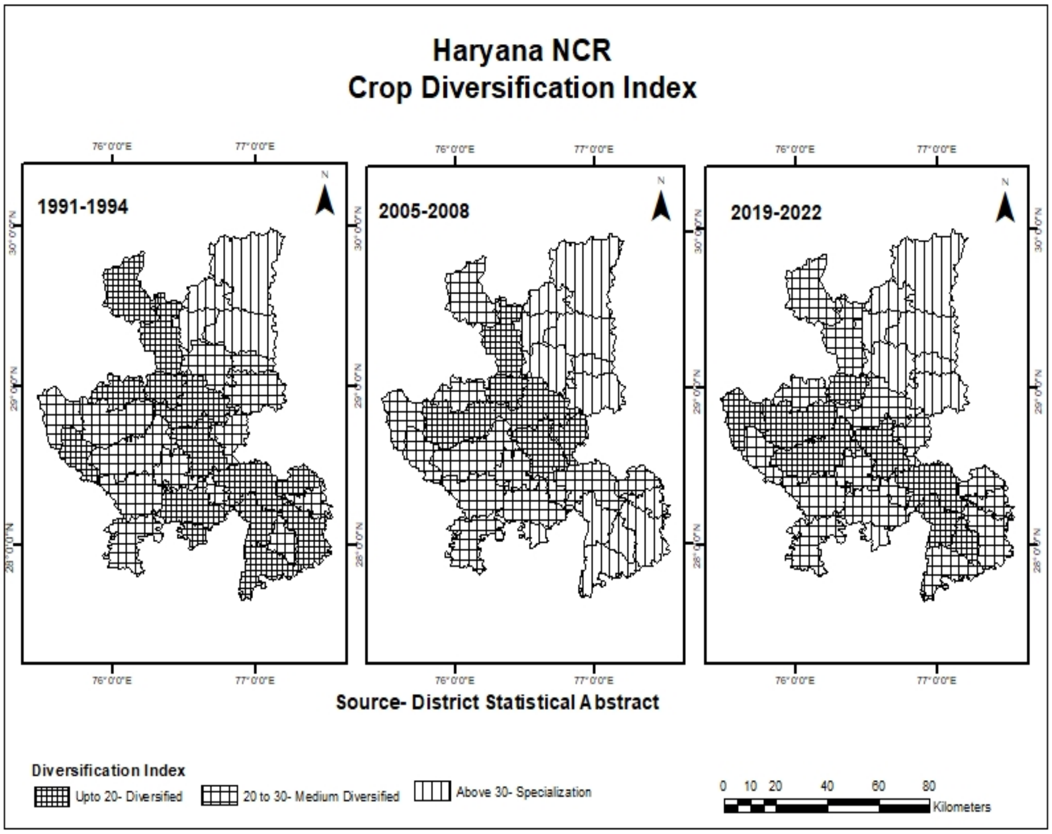


Table 3.10- Crop Diversification Index- Tehsil Wise

Category	1991-94		2005-08		2018-2021	
	Tahsils	Total	Tehsils	Total	Tehsils	Total
High >20	Loharu, Bawani khera, Narwna, Jind, Maham, Rohtak, Jhajjar, Rewari, Gurgaon, Nuh, Firojpur Zirkha, Faridabad, Palwal and Bawal	14	Jind, Maham, Bhiwani, Rohtak, Jhajjar, Bahadurgarh	6	Siwani, Bhiwani, Dadri, Maham, Jhajjar, Gurgaon, Nuh and Hathin	8
Medium 20-30	Siwani, Bhiwani, Dadri, Mahendergarh, Narnoul, Kosli, Patoudi, Hathin, Ballabgarh, Ganour, Gohana and Sonipat	13	Narwana, Bawani Khera, Siwani, Loharu, Dadri, Kosli, Narnoul, Mahendergarh, Rewari, Patoudi, Gurgaon, Faridabad	12	Narwana, Jind, Bawani Khera, Rohtak, Bahadurgarh, Loharu, Mahendergarh, Narnoul, Kosli, Rewari, Patoudi, Faridabad, Ballabgarh, Palwal	16

		31			and Firojpur Zirkha, Bawal	
Low <30	Karnal, Asandh, Panipat and safidon	4	Karnal, Asandh, Panipat, safidon, Ganour, Gohana, Sonipat, Nuh, Firojpur Zirkha, Palwal, Hathin, Ballabgarh, Bawal	13	Karnal, Asandh, Panipat, safidon, Ganour, Gohana and Sonipat	7
Total		31		31		31

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

During 2005-2008, six tehsils existed in highly diversified categories namely Jind(19.9), Maham(17.6), Bhiwani(17.8), Rohtak(15.9), Jhajjar(16.8) Bahadurgarh(18). Following tehsils namely Narwana(22.4), Bawani Khera(20.5), Siwanai(22.3), Loharu(20.6), Dadri(21.5), Kosli(23.7), Mahendergarh(29), Narnoul(29.2), Rewari(24.2), Patoudi(22.4), Gurgaon(27.2), Faridabad(25.7) have medium diversified. Twelve tehsils have shifted towards specialization namely Karnal(44.2), Assndh(44.1), Safidon(53.2), Panipat(43.8), Ganour(49.7), Gohana(35.8), Sonipat(31.8), Ballabgarh(31.5), Mewat(31.4), Firojpur Zirkha(30.8), Hathin(38.2), Palwal(37.9) (fig. 3.20 and table 3.10).

During 2019-2022, only eight tehsils are left in the highest crop diversification class namely Siwani(13.9), Bhiwani(15.4), Dadri(19.4), Maham(13.3), Jhajjar(19.3), Gurgaon(16.9), Nuh(16.7) and Hathin(18.8). Tehsils namely Narwana(29.6), Jind(28.4), Bawani Khera(23.7), Rohtak(27.8), Bahadurgarh(28.8), Loharu(21.6), Mahendergarh(23.8), Narnoul(27.8), Kosli(24.1), Rewari(28.7), Patoudi(22.7), Faridabad(22.6), Ballabgarh(28), Palwal(26.4) and Firojpur Zirkha(24.5) are in the medium crop diversification class. Four more tehsil are added in the crop specialization category namely Ganour(43.4), Gohana(41.7), Sonipat(42), Bawal(31), Karnal(45.6), Panipat(45.9), Assandh(45.5) and Safidon(44.4%) (fig. 3.20 and table 3.10).

Changes in Crop Diversification in Haryana NCR from 1991-94 to 2019-22

Diversification of the cropping pattern is good for the soil as well as environmental health conditions. However, due to the green revolution which affects the production of some particular crops, especially wheat and rice, farmers started to grow wheat and rice which has negative impacts on soil, environment, groundwater level and human health. During 1991-94, the diversification of the study area was in good conditions in all the tehsils except Karnal, Panipat, Safidon and Assandh but due to the expansion of irrigation facilities, HVY seeds of wheat and rice, more demands and good soil conditions, farmers of north and northeastern side tehsils have been following mono-culture.

3.2.6. Cropping Intensity in Haryana NCR

The intensity of the cropping pattern is defined as the ratio of the total cropped area during a year to the net sown area. How intensively the area has been cropped? Or how many crops, a farmer grows in a whole year from the same piece of land. The cropping intensity has increased from 149.8 percent in 1991-94 to 184 percent during 2019-22. So, the growth is very significant in the context of cropping intensity and factors like development in irrigation facilities and HYV seeds played a vital role in this positive growth.

Based on cropping intensity, NCR Haryana is divided into three parts namely

1. Tehsils with High Intensity of cropping
2. Tehsils with Medium Intensity of Cropping
3. Tehsils with Low Intensity of cropping

Fig. 3.21- Cropping Intensity- Haryana NCR

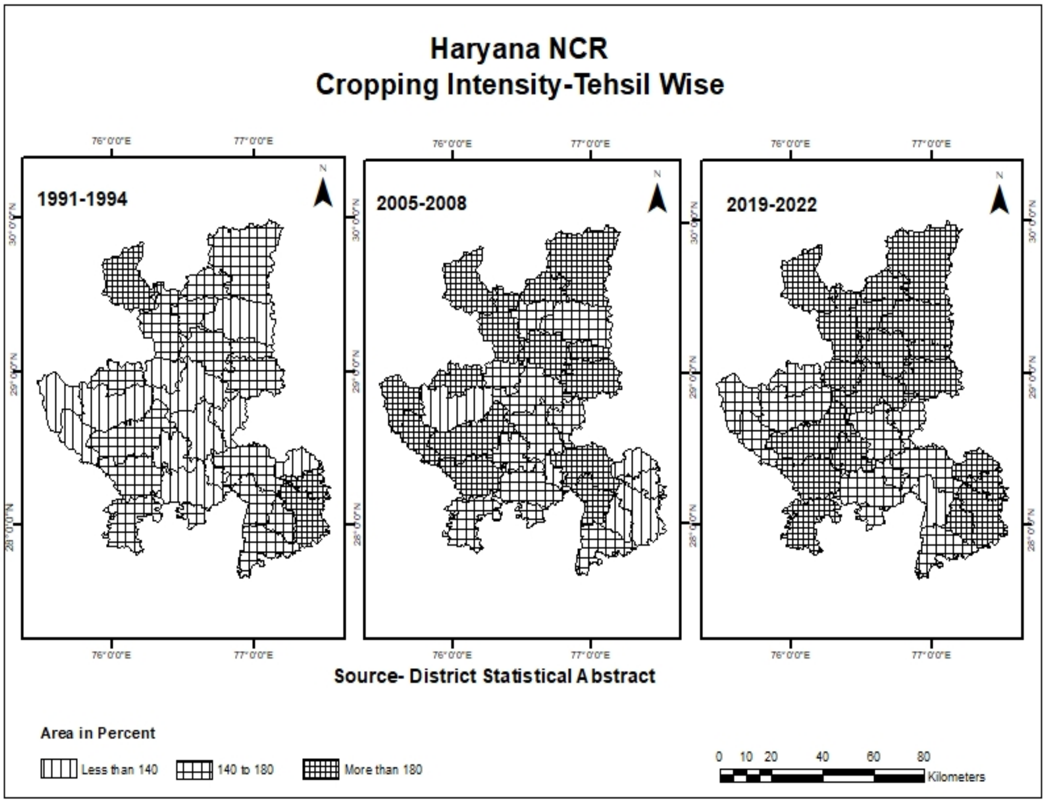


Table 3.11- Cropping Intensity- Tehsil Wise

Category	1991-94		2005-08		2018-2021	
	Tahsils	Total		Total	Tehsils	Total
High >180	Palwal, Narwana, Ballabgarh	3	Karnal, Assandh, Narwana, Jind, Gohana, Ganour, Sonipat, Gurgaon, Mewat, Bawani Khera, Siwani, Loharu, Bhiwani, Mahendergarh	14	Karnal, Asandh, Jind, Safidon, Ganour, Gohana, Sonipat, Hathin, Dadri, Mahendergarh, Narnoul, Rohtak, Maham, Faridabad, Ballabgarh, Palwal, Hathin, Narwana, Panipat	19
Medium 140-180	Karnal, Asandh, Jind, Safidon, Ganour, Gohana, Sonipat, Gurgaon, Hathin, Firojpur Zirkha, Bawani Khera, Dadri, Mahendergarh, Narnoul, Bawal	15	Safidon, Panipat, Maham, Rohtak, Jhajjar, Bahadurgarh, Kosli, Rewari, Bawal, Narnoul, Firojpur Zirkha		Siwani, Bhiwani, Loharu Jhajjar, Bahadurgarh, Bawal Rewari, Patoudi, Gurgaon, Bawani khera, Firojpur Zirkha	11

Low <140	Siwani, Bhiwani, Loharu, Maham, Rohtak, Jhajjar, Bahadurgarh, Kosli, Rewari, Patoudi, Faidabad, Nuh, Panipat	13			Nuh	1
Total		31				31

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Table 3.11 shows the cropping intensity in NCR Haryana during 1991-94, 2005-08 and 2019-22 tehsil-wise. During 1991-1994, the highest cropping intensity was in Palwal, Narwana and Ballabgarh;, medium in Karnal, Asandh, Jind, Safidon, Ganour, Gohana, Sonipat, Gurgaon, Hathin, Firojpur Zirkha, Bawani Khera, Dadri, Mahendergarh, Narnoul & Bawal and lowest intensity was in Siwani, Bhiwani, Loharu, Maham, Rohtak, Jhajjar, Bahadurgarh, Kosli, Rewari, Patoudi, Faidabad, Nuh, Panipat (fig. 3.21).

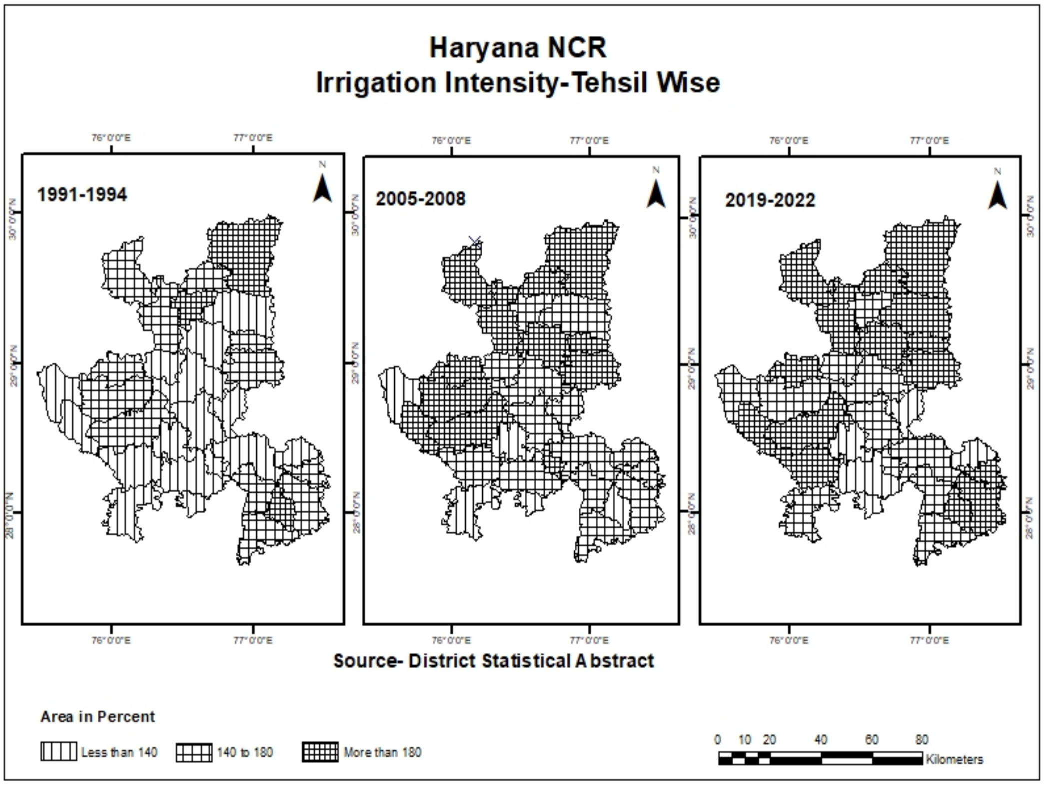
From 2005 to 2008, the highest cropping intensity was in Karnal, Assandh, Narwnan, Jind, Gohana, Ganour, Sonipat, Bawani Khera, Siwani, Loharu, Dadri, Mahendergarh, Gurgaon, Nuh. Medium cropping intensity in Safidon, Panipat, Maham, Jhajjar, Rohtak, Bahadurgarh, Kosli, Rewari, Bawal, Firojpur, Narnoul and low cropping intensity in Bhiwani, Faridabad, Ballabgarh, Palwal, Hathin (fig. 3.21).

During 2019-22, highest cropping intensity is in Karnal, Asandh, Jind, Safidon, Ganour, Gohana, Sonipat, Hathin, Dadri, Mahendergarh, Narnoul, Rohtak, Maham, Faridabad, Ballabgarh, Palwal, Hathin, Narwana, Panipat and most of these tehsil belong to semi arid climatic conditions and good soil, irrigation facilities. Medium cropping intensity is in Siwani, Bhiwani, Loharu Jhajjar, Bahadurgarh, Bawal Rewari, Patoudi, Gurgaon, Bawani khera, Firojpur Zirkha. Only Nuh is in the lowest cropping intensity class (fig. 3.21).

3.2.7. Irrigation Intensity in Haryana NCR

Irrigation facility is a pre-condition for the growth of the crops in any agriculture field and it is defined as the ratio of the total irrigated area during a year to the net irrigated area. Irrigation intensity within the study area has been increased from 150.7% in 1991-94 to 173% in 2019-22. Irrigation intensity plays a vital role in the agriculture development in Haryana NCR as it enables the farmers to grow water-intensive crops like rice. Both irrigation intensity and the green revolution made the region self-sufficient in food grain production.

Fig. 3.22- Irrigation Intensity- Haryana NCR



As fig. 3.22 shows the changes in irrigation intensity in Haryana NCR for the years 1991-94, 2005-08 and 2019-22. During 1991-94, the irrigation intensity was low as most of the tehsils were collected in medium and low irrigation intensity categories and only three tehsils had the highest irrigation intensity namely Karnal, Safidon and Hathin. During 2005-08 and 2019-22, the number of tehsils has increased in the high irrigation intensity category due to expansion in irrigation intensity.

3.2.8. Correlation of Irrigation Intensity with Cropping Intensity and area under major crops

As irrigation is the most powerful tool for change in pattern change and cropping intensity. So, it correlation have been calculated with area under different crops and cropping intensity and results are as follow:-

Table 3.12:- Testing of Hypothesis

Major Crops	Irrigation intensity	Cropping intensity	Irrigation intensity	Cropping intensity	Irrigation intensity	Cropping intensity
	1991-94		2005-2008		2019-2022	
Rice	0.30	0.38*	0.49**	0.23	0.50**	0.47**
Bajra	-0.21	-0.28	-0.41*	-0.04	-0.49**	-0.19
Sugarcane	-0.18	0.06	0.23	0.03	0.31*	0.27
Cotton	0.18	0.04	0.23	0.23	0.20	-0.38**
Wheat	0.17	0.21*	0.26	-0.34*	0.28	0.14
Gram	-0.15	-0.31	-0.27	0.19	-0.01	-0.32
Oil seeds	-0.48*	-0.30	-0.50	0.03	-0.39**	-0.18
Barley	-0.15	-0.19*	0.07	-0.20	-0.34	-0.31
Cropping Intensity	0.56**	1.0	0.30*	1.0	0.37*	1.0

(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Correlation significant at 0.01 level (**), 0.05 (*) two-tailed

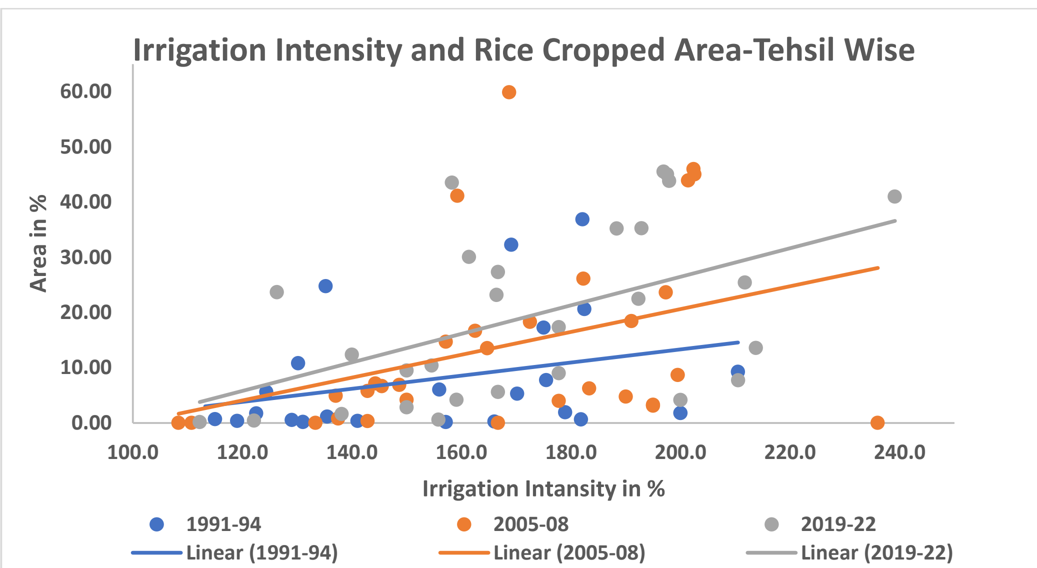
The hypothesis was proved that more profitable crops like rice, wheat, cotton, and oil seeds replaced the less profitable crops like bajra, barley and gram due to expansion in irrigation facilities. During 1991-1994, the irrigation intensity was positively correlated with rice (r 0.30), cotton (r 0.18), and wheat (r 0.17) and negatively correlated with bajra (r -0.21), sugarcane (r -0.18), oil seeds (r -0.48), gram (r -0.15) and barley (r -0.15). The development of irrigation facilities is the major reason for cropping pattern change within the study area as reflected by the results. The intensity of cropping was also positively correlated with rice (r 0.38) moderate, low but positive with wheat (r 0.21), sugarcane (r 0.06), cotton (r 0.04) and it was negatively correlated with bajra (-0.28), gram (-0.31), oil seeds (-0.30) and barley (-0.19). coefficient of determination of rice was 9 percent, 3 percent for cotton, and 3 percent for wheat which reflected that irrigation impact on cropping pattern was not so much high although it was positive with rice, cotton, and wheat.

From 2005 to 2008, the irrigation intensity was positively/negatively correlated with rice (r 0.49), bajra (-0.41), sugarcane(0.28), cotton (0.23), wheat (0.26), gram (-0.27), mustard (-0.50). the cropping intensity is positively/ negatively corelated with rice(0.23), bajra (-0.04), cotton (0.23), wheat (-0.34), gram (0.19).

During 2019-2022, the irrigation intensity was positively correlated with rice (0.50), sugarcane (0.41), cotton(0.20) & wheat (0.28) and negatively correlated with bajra(-0.49), gram(-0.01), oil seeds(-0.39) and barley(-0.34). the intensity of cropping was also positively correlated with rice (0.47), sugarcane (0.27) & and wheat (0.14) and negatively with bajra (-0.19), cotton (-0.38), gram (-0.32), oilseeds (-0.18) and barley (-0.18). coefficient determination is 24 percent for rice with irrigation intensity, 4 percent with cotton, 7 percent with wheat, and 31.1 percent with cropping intensity. So, irrigation facilities played a vital role in cropping pattern change within the state as it was positively associated with rice, wheat, cotton, and also cropping intensity.

Table 3.12 showed that irrigation intensity positively affected areas under rice, wheat, cotton, and sugarcane but it negatively correlated with bajra, barley, gram, and oil seeds. It is also positively correlated with cropping intensity by 0.56 during 1991-1994 and 0.37 during 2019-2022. If we talk about the separate average irrigation intensity of all the tehsils, it was more than Haryana NCR.

Fig. 3.23- Irrigation Intensity and Rice Cropped Area

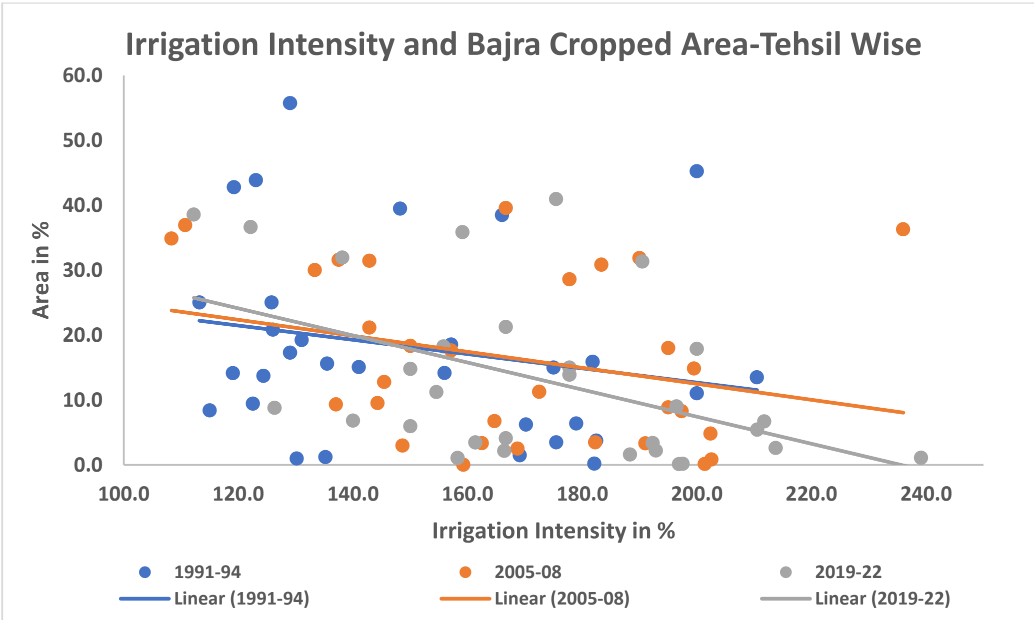


(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Paddy is the main foodgrain in the study area and the above diagram shows that the area under the crop is increasing with increasing irrigation facilities. Rice cropped area was positively correlated with irrigation intensity with an r value of 0.30 during 1991-

94, 0.49 from 2005 to 2008 and 0.50 during 2019-2022. The coefficient of correlation was significant at one percent or 0.01 level. So, as irrigation intensity increased, the area under rice crops also increased (fig 3.23).

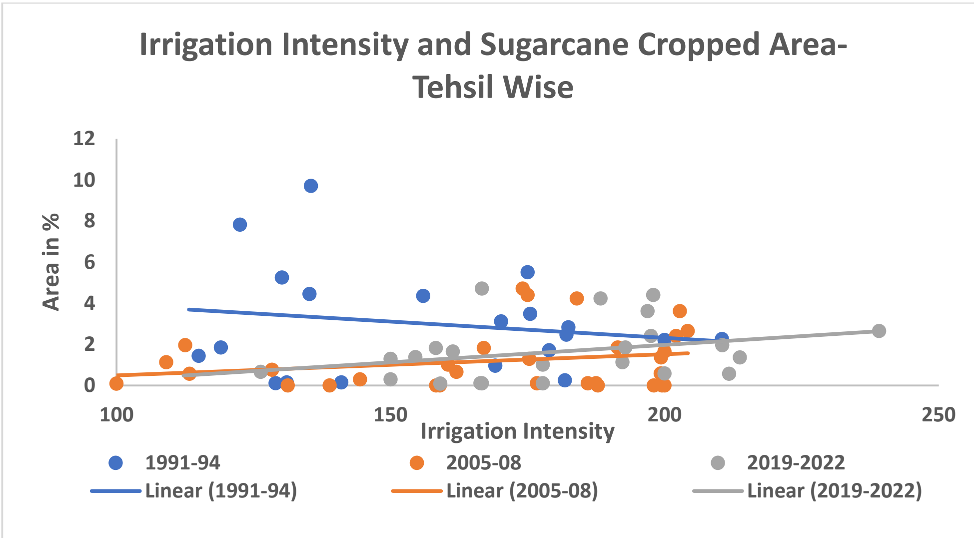
Fig. 3.24- Irrigation Intensity and Bajra Cropped Area



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Bajra is also an important kharif crop within the study region and is grown in many tehsils. Fig. showed that bajra had a negative correlation with the irrigation intensity during 1991-94, 2005-2008 and 2019-2022. As irrigation facilities were increased, the area under the crop was decreased. The correlation coefficient is also highly negatively significant at the 0.01 level. Here the hypothesis is proved because the bajra crop was replaced by the more profitable crops like rice. Due to increasing irrigation intensity, the farmers prefer to grow other kharif crops due to their high value (fig. 3.24).

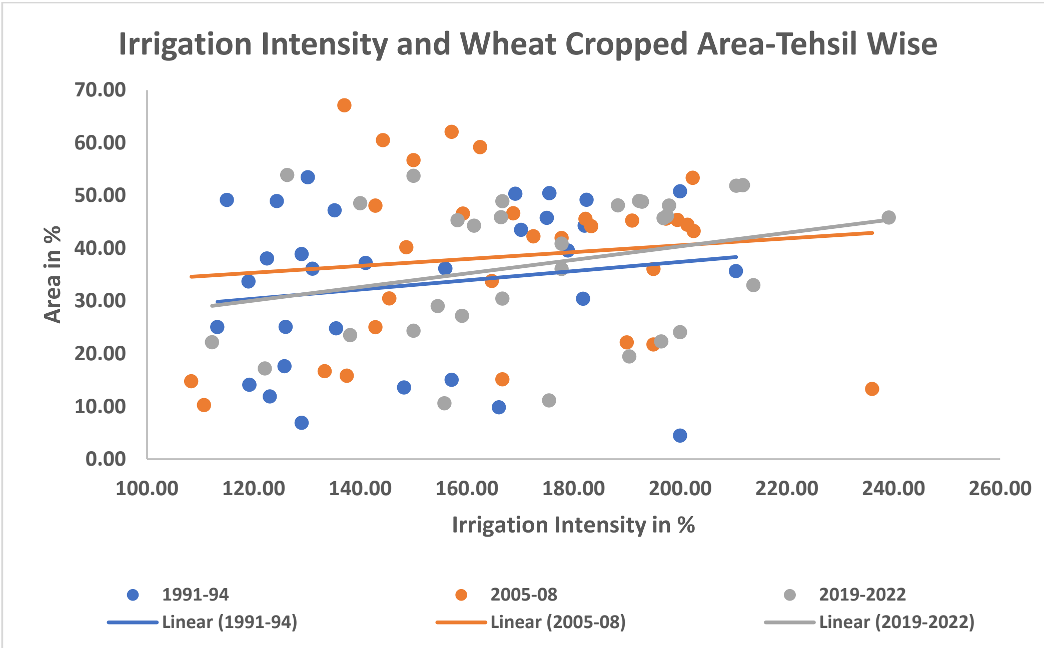
Fig. 3.25- Irrigation Intensity and Sugarcane Cropped Area



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Sugarcane cropped area is positively correlated with irrigation intensity during 1991-94, 2005-08 and 2019-2022. The r value was -0.18 during 1991-94, 0.28 during 2005-08 and 0.40 during 2019-22. Sugarcane is a commercial crop and the area under sugarcane cultivation has been decreasing since 1991 to 2022. The correlation coefficient is also not significant during 1991-94 because the crop is limited within a few tehsils. But the coefficient is significant at 0.05 level and moderately correlated with irrigation intensity as the area has decreased but the number of tehsils has increased which started growing sugarcane and because the area under the crop decreasing due to many local problems of the farmers like labour shortage, mismanagement by the mills at the time of crop harvesting. That's why, farmers prefer other short-duration crops (fig. 3.25).

Fig. 3.26- Irrigation Intensity and Wheat Cropped Area

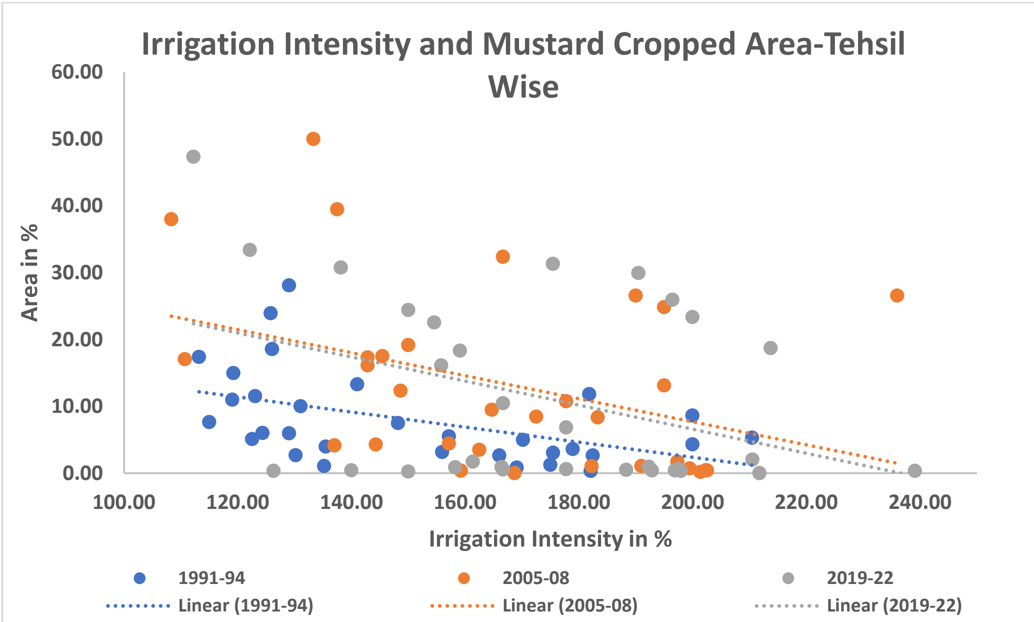


(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Wheat is a principal food crop in NCR Haryana and the area under the crop has continuously increased since 1991 to 2022. Fig. no.3.26 shows the positive trend line which proved the positive correlation between wheat area and irrigation intensity with an r value 0.17 during 1991-94, 0.26 during 2005-08 and 0.28 during 2019-2022. The coefficient of determination also increased from 3 percent during 1991-94 to 8 percent during 2019-2022. Irrigation facilities help the growth of area under wheat crop at low rate because it is a rabi and it requires only two/three watering during the rabi season. Other factors like MSP, HYV seeds, machinery etc. played a vital role in the growth of wheat area (fig. 3.26).

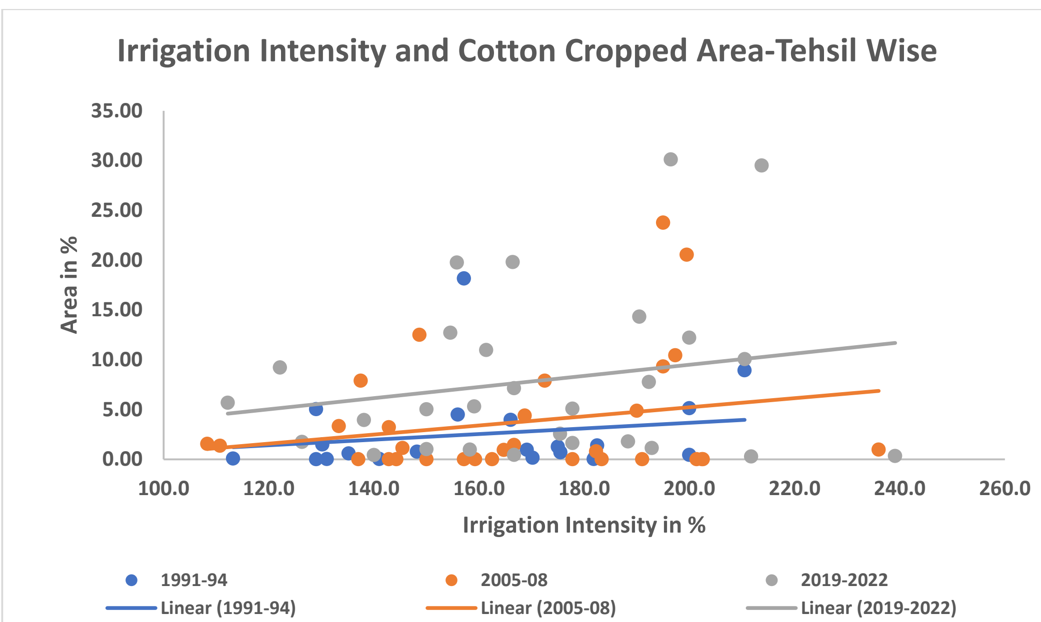
Mustard is the important rabi crop within the study area. The area under mustard shows growth but the trend line shows a negative correlation between mustard area and irrigation intensity. The reason behind this negative correlation is that it is primarily grown in a few districts or tehsils of the Haryana NCR. The mustard area also had rabi season crops and required very little amount of water (fig. 3.27).

Fig. 3.27- Irrigation Intensity and Mustard Cropped Area



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Fig. 3.28- Irrigation Intensity and Cotton Cropped Area

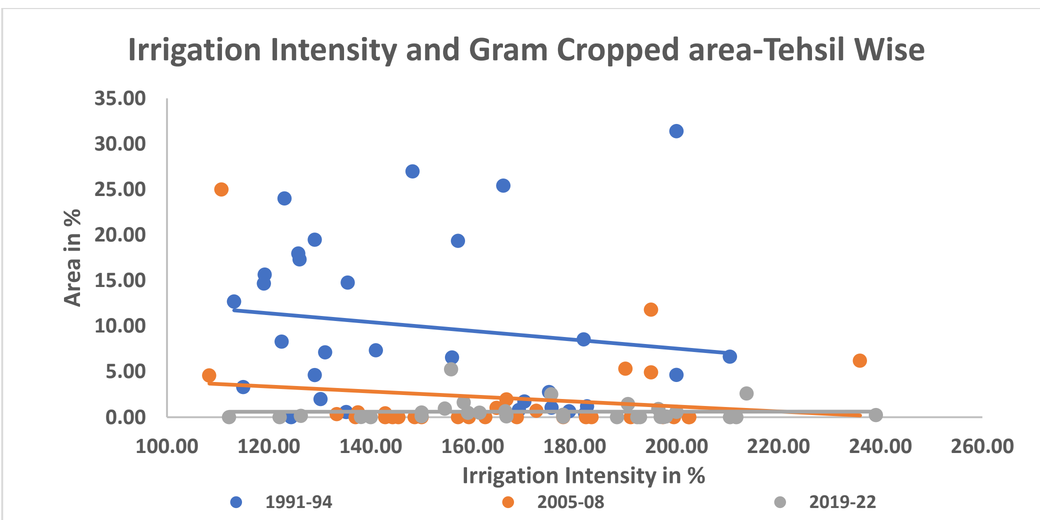


(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Cotton is a very important cash crop within the study area. Many tehsils in NCR Haryana grow cotton and it is also an important kharif crop in areas where irrigation facilities are low because most of the tehsils with good irrigation intensity and facilities prefer rice. The trend line reflects the positive growth of the cotton area with irrigation intensity and correlation was low but positive and the r value is 0.18 during 1991-94 and 0.20 during 2019-2022. The area under cotton cultivation was 60 thousand hectares during 1991-1994 and it reached at 269 thousand hectares. Areas with low irrigation facilities prefer cotton because it has dual benefits for them in the form of cash and fuel (fig. 3.28).

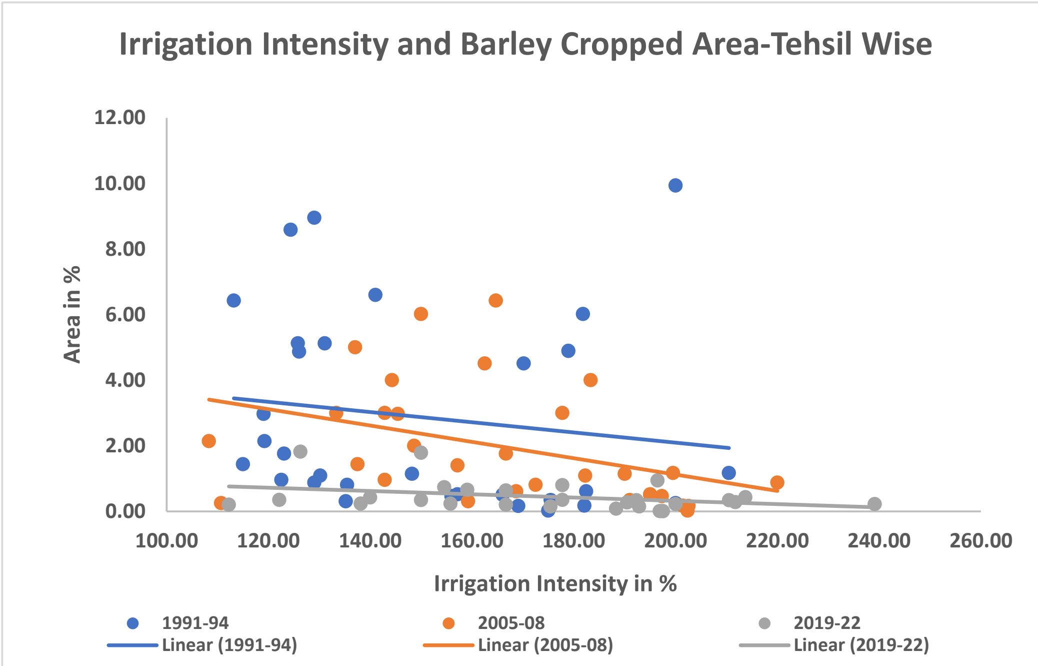
Gram is a rabi crop and is sown during the winter season. It also showed a negative trend line and a negative association with irrigation intensity. The area under gram cultivation was decreased due to expansion in irrigation facilities which proves the hypothesis. The r value is -0.15 during 1991-94 and -0.01 almost no relation between gram area and irrigation intensity.

Fig. 3.29- Irrigation Intensity and Gram-Cropped Area



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

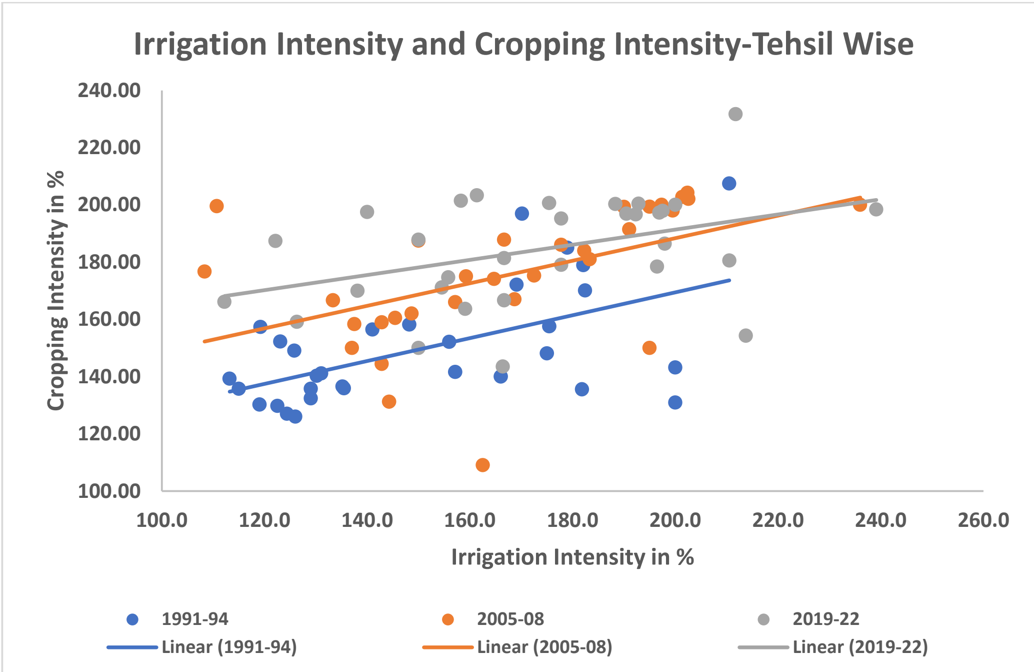
Fig. 3.30- Irrigation Intensity and Barley Cropped Area



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Gram, and barley are the rabi crops and sown during the winter season in Haryana. However, due to the expansion of irrigation facilities and green revolution technology, the area under gram and barley had decreased and replaced by other crops like mustard and wheat. The area under barley cultivation has shown a negative trend since 1991 to 2022. The trendline also reflected the negative correlation and the r value is -0.15 during 1991-94 and -0.34 during 2019-2022. The coefficient of correlation is not significant. The adopted hypothesis is also proved as less profitable crops like gram, barley, and bajra are replaced by other more profitable crops like wheat, rice, mustard and cotton. This is a matter of great concern for crop diversification within the region as it is decreasing due to the adoption of mono-culture by the farmers (fig. 3.29, 3.30).

Fig. 3.31- Irrigation Intensity and Cropping Intensity



(Source:- District Statistical Abstracts- 1991-94, 2005-08 and 2019-2022)

Both irrigation intensity and cropping intensity increased from 1991 to 1994, 2005 to 2008 and 2019-2022 and there is a positive correlation between these two during 1991-94 (0.57), 2005-2008 (0.30) and 2018-2021 (0.37). so, it is reflected that as irrigation intensity increases, the cropping intensity also increases. Both the diagrams Fig. 3.31 show the positive trend line and is also significant at 0.01 level during 1991-94 and 0.05 level during 2005-08 and 2019-2022. The average irrigation intensity was 150.7 percent during 1991-94 and reached at 173.6 percent during 2019-2022 and the average cropping intensity during 1991-94 was 149.8 percent and reached at 184.07 percent during 2019-2022. So, it was clear that cropping intensity changed as irrigation intensity changed because water availability helps the farmers in crop selection in any particular area.

3.3. Final Results

In the present chapter, a study of changes in cropping pattern, cropping intensity, crop rank and crop diversification has been done. These are the results of the present chapter-

- Net sown area of the NCR Haryana has reduced from 88.6 percent to 80.9 percent from 1991 to 22 and the reason behind this reduction is the growth of other sectors which occupied the agricultural land.
- During 1991-94, bajra and rice remained the main crops of the kharif season and wheat and gram remained the major crops of rabi season. During 2021-2022, rice, bajra & cotton remained the major crops of the Kharif season and in the rabi season, wheat and mustard remained major crops in all over Haryana NCR.
- Rice and wheat are the principal crops within the study area and both require high amounts of water. The increasing area under paddy played a vital role in the decreasing groundwater level in Haryana.
- During 1991-1994, wheat acquired almost 32 percent area of the gross cropped area and bajra covered 18 percent area but during 2019-2022, wheat and paddy are the principal crops within the study area as both of them acquired 57 percent area of the total cropped area.
- In the eastern and central part of the NCR Haryana, most of the area is devoted to wheat and rice. The northeastern part of the state is also known as the wheat and rice basket of the study area as it comprised almost 57 percent of the total cropped area
- During 1991-94, an area under rice was 8.5 percent of the total cropped area and it reached at 19.7 percent during 2019-2022. There is a remarkable growth in the area under paddy and growth in irrigation facilities through tubewell, supply of electricity, canal and package technology.
- Rice is the highest-paid crop for the farmers due to higher demand and also no other strong option available for the farmers. Even tehsils with low irrigation facilities also grow rice due to its high output value. The demand of rice as a food crop is also higher as compared to other crops. economic values of rice crops also play a vital role in the cropping pattern change in Haryana NCR.

- Bajra is a very important kharif crop but the area under this crop has decreased from 17% to 11% from 1991-94 to 2019-22. The area under bajra decreased but production increased from 417 thousand tonnes to 955 thousand tonnes because of HVY seeds and chemical fertilizers (fig. 2.4). Mostly bajra was replaced by cotton and rice. The economic value of rice and cotton is much higher than bajra. Bajra is also not so much demanding food crop as compared to rice. So, demand and economic value play a vital role in cropping pattern changes under the Bajra crop.
- Gram-cropped area has been decreased due to irrigation expansion which promotes wheat and mustard farming in Haryana NCR. It decreased from 9.9% in 1991-94 to 2.3% in 2019-22.
- Cropping intensity has increased from 149 percent during 1991-94 to 184 percent during 2019-2022 and the reasons behind that are the development of irrigation facilities, HYV seeds, mechanization, fertilizers etc.
- Crop diversification is also decreasing in North East tehsil namely districts Karnal, Panipat, Sonipat, Safidon tehsil and Bawal tehsil and the crop diversification index is above 30 in this area as all of them follow mono-culture. The crop diversification index is positive in tehsils with poor soil and fewer irrigation facilities as they grow 4 to 5 crops during a single cropping year.
- Irrigation intensity within the study area has been increased from 150.7% in 1991-94 to 173% in 2019-22. Irrigation intensity plays a vital role in the agriculture development in Haryana NCR.
- Karl Pearson correlation applied on irrigation intensity and cropping intensity with area under different crops. It resulted in that area under rice, wheat, sugarcane and cotton positively correlated with irrigation intensity and cropping intensity. It is significant with 0.01 and 0.05 levels.
- To show their relation strength, scatter diagrams are formed to validate the correlation between the area under different crops and the intensity of irrigation and cropping. They also show a positive correlation of the area under rice, cotton, wheat and sugarcane with irrigation intensity.

- Irrigation intensity is negatively correlated with bajra, barley, gram and mustard as due to expansion in irrigation facilities, farmers started to grow other crops like rice, and cotton in place of bajra. Gram and barley were replaced by mustard as it is also a very important cash crop but mustard is also negatively correlated with irrigation intensity as it is sown as a prime crop in southern Haryana.
- Irrigation intensity and cropping intensity are also positively correlated and significant at the level of 0.01 and 0.05.

Chapter-4

SOCIO-ECONOMIC CONDITIONS OF THE FARMERS AND THEIR PERSPECTIVE ABOUT AGRICULTURE SUSTAINABILITY

4. Introduction

In this chapter, a comprehensive exploration unfolds as we research the intricate study of Haryana NCR's agricultural landscape. The essence of our investigation revolves around the profound impact of the prevailing agricultural system on the socio-economic conditions of the local farmers, unveiling their experiences in sampled villages. The occurrence of package technology has catalysed substantial growth within the state, pushing it to the forefront as a major food producer in India. This technological intervention, however, is not without consequences, as it intricately alters the agricultural structure and cropping patterns within the region. Simultaneously, dynamic forces such as population growth, urbanization, industrialization, and institutional development are exerting transformative pressures on the land use/land cover (LULC) in Haryana, particularly in the NCR region tightly connected to Delhi. The consequential shifts in LULC and cropping patterns have been massive, significantly impacting the sustainability of agriculture in this vital region. Our focus, therefore, is not merely on the changes themselves but on their implications for the lives of farmers struggling with the evolving landscape.

This chapter stands as a source of light, aiming to illuminate the multifaceted dimensions of change in Haryana NCR's agriculture. Our objective is crystal clear - to assess the profound impact of these transformative forces on the socio-economic conditions of the farmers and to understand their perspectives on the sustainability of agriculture. The narrative unfolds in three distinct parts, meticulously designed to unravel the layers of this complex web:

1. Demographic and Socio-economic Profile of the Farmers: - An in-depth exploration of the contextual factors that shape the lives of farmers, providing a foundation to comprehend the nuanced socio-economic conditions prevailing in the region.
2. Relation of Socio-economic Conditions with Selected Indicators: - Delving deeper, we analyze the interplay between socio-economic conditions and specific indicators,

drawing connections that illuminate the intricate dynamics shaping the farmers' livelihoods.

3. Farmers' Perspective about Agriculture Sustainability: - Finally, we navigate the intricate terrain of farmers' perspectives, seeking to understand their unique insights and experiences in the face of evolving agricultural practices.

As we embark on this journey of inquiry, our aim is to not only document the transformations but to empower our understanding of the intricate relationship between agriculture, socio-economic conditions, and sustainability in Haryana NCR.

4.1 Data Base and Methodology

A comprehensive primary survey has been undertaken to assess the prevailing ground-level conditions among farmers. The third objective of this survey aims to delve into the socio-economic status of farmers and gather insights into their perspectives on agricultural sustainability. To achieve this, a meticulously crafted questionnaire has been developed, covering aspects such as farmers' socio-economic conditions and the current challenges faced by farmers including unawareness regarding sustainability, declining water tables, soil degradation, health issues, and excessive use of fertilizers. To ensure a representative sample for the primary survey, the stratified random sampling method has been employed in the selection of villages. This approach takes into account various strata, considering factors like water conditions, market facilities, and social elements, among others. The accurate sample size has been determined using a precise formula, thereby enhancing the reliability and validity of the survey results. Through this methodical approach, the survey seeks to obtain a nuanced understanding of the multifaceted issues affecting farmers and their agricultural practices at the local level. Accurate sample has been calculated with the help of the following formula:-

Taro Yamnee:- $n=N/(1+N(e)^2)$

N=number of total cultivators

(e) = sampling error(0.05)

Table 4.1. List of Selected Block and Villages for the Primary Survey

Sr.no	District	Block	Villages	No. of cultivaters	Sample size
1	Karnal	Indri	Jundla	543	20
			Bahlolpur	217	8
			Gularpur	580	20
2	Panipat	Panipat	Sewah	912	32
			Rajakheri	403	14
			Palheri	118	5
3	Panipat	Smalakha	Raksehra	371	13
			Kiwana	566	20
			Haldana	257	9
4	Bhiwani	Tohsham	Sandwa	1940	68
			Nigana	236	8
			Khawa	387	10
5	Jhajjar	Beri	Majra	1462	53
			Malikpur	268	10
			Palra	288	10
6	Mahendergarh	Nagal Choudry	Sirohi	569	20
			Morund	241	8
			Amarpura	148	5
7	Nuh	Nuh	Ujina	442	16
			Rehna	287	10
			Chhapera	133	5
8	Rewari	Bawal	Sulkha	288	10
			Rasiawas	230	8
			teekla	212	8
Total	7	8	24	11098	390

(Sources: - Census Handbook and Calculated by the Researcher)

Sampling has been done in three stages. In the first stage, all the districts have been divided into three classes based on net sown area namely high, medium & low net sown area and selected seven districts with the help of systematic random sampling technique. In the second stage, all the blocks of the seven districts were classified into three categories based on net sown area and then selected the eight blocks with a systematic random sampling method. In the third stage, all the villages of each block were divided into three classes and chose the very first village from each class. After the list of the village-wise cultivators has been downloaded from the census and then calculated 3.5% of the total cultivators. After this, the number of cultivators was divided into three groups based on their social category. in Haryana, 40% of the total population belongs to the General category, 40% belongs to the Bacward category(BC) 20% to the Schedule class(SC). There are 11098 cultivators in all the selected villages, according to the formula, 390 is the accurate sample number and it covered almost 3.5% of the total cultivators.

4.2. Results and Discussion

Following the exhaustive field survey, a meticulous analysis has been conducted, leading to the preparation of tables that summarize the gathered data. Utilizing the insights derived from the detailed questionnaire, the subsequent section delves into a comprehensive discussion of the calculated results. This examination serves as a pivotal component in unravelling the intricate layers of information obtained during the survey, shedding light on the socio-economic conditions of farmers, their perspectives on agricultural sustainability, and the myriad challenges they face at the grassroots level. The ensuing discussion aims to provide a nuanced interpretation of the findings, paving the way for informed insights and actionable recommendations in the realm of agricultural practices and sustainability.

4.2.1. Demographic and socio-economic profile of the farmers

Agriculture growth is not only the outcome of natural factors like relief, soil, water and air but also the results of the combined effects of physical and socio-economic factors. So, it is very important to pay attention towards the socio-economic conditions of the farmers as they are very helpful in farming decisions and production. All the activities done by the farmers on their farms depend on their age, income, social status and also accessibility to various resources. In this section, important demographic and socio-economic indicators have been analysed from the farmer's perspective. Indicators namely age, gender, educational status, income, source of irrigation, fertilizer use, and farm sizes have been discussed.

4..2.1.1. Age structure

age is a very important parameter for the present study as it depicts the knowledge and experience of the farmers. The age of the respondents affects the productivity and crop selection according to the suitability of the farm. The age of the farmers is very useful for seed selection, use of modern technologies and information regarding new government policies about agriculture.

Table 4.2. Age structure of the Respondents

Blocks	Villages	Age Groups						Total Sample
		40 to 50		50 to 60		Above 60		
		NO.	%	NO.	%	NO.	%	NO.
Indri block	Jundla	2	10	10	50	8	40	20
	Bahlolpur	1	12.5	4	50	3	37.5	8
	Gularpur	5	25	8	40	7	35	20
	Total	8	16.7	22	45.8	18	37.5	48
Panipat block	Sewah	4	12.5	18	56.3	10	31.3	32
	Rajakheri	1	7.1	9	64.4	4	28.6	14
	Palheri	0	0	4	80	1	20	5
	Total	5	9.8	31	60.8	15	29.4	51
Smalakha block	Raksehra	1	7.7	8	61.5	4	30.8	13
	Kiwana	2	10	11	55	7	35	20
	Haldana	2	22.2	4	44.4	3	33.3	9
	Total	5	11.9	23	54.8	14	33.3	42
Tohsham block	Sandwa	11	16.2	32	47.1	25	36.8	68
	Nigana	1	12.5	5	62.2	2	25	8
	Khawa	2	20	5	50	3	30	10
	Total	14	16.3	42	48.8	30	34.9	86
Beri block	Majra	7	13.2	30	56.6	16	30.2	53
	Malikpur	2	20	5	50	3	30	10
	Palra	2	20	6	60	2	20	10
	Total	11	15.1	41	56.2	21	28.8	73
Nagal choudry	Sirohi	4	20	10	50	6	30	20
	Morund	1	12.5	4	50	3	37.5	8
	Amarpura	0	0	2	40	3	60	5
	Total	5	15.2	16	48.5	12	36.4	33
Nuh block	Ujina	1	6.3	10	62.2	5	31.3	16
	Rehna	1	10	6	60	3	30	10
	Chhapera	0	0	3	60	2	40	5
	Total	2	6.5	19	61.3	10	32.3	31
Bawal block	Sulkha	1	10	6	60	3	30	10
	Rasiawas	1	12.5	4	50	3	37.5	8
	teekla	1	12.5	5	62.5	2	25	8
	Total	3	11.5	15	57.7	8	30.8	26
	Final total	53	13.6	209	53.6	128	32.8	390

(Source- Primary Survey)

Table 4.1 reflects that among 390 respondents, a considerable percentage of the respondents exist in the age groups of 50 to 60 years and above 60 years that is, 209(53.6%) & 128(32.8%) respectively. Only 13.6% of respondents belong to the 40 to 50 years age group. In block-wise distribution, the percentage of the respondents belong to different age groups namely 40 to 50, 50 to 60 and above 60 years are respectively 16.7%, 45.8% and 37.5% in Indri block; 9.8%, 60.8% and 29.4% in Panipat block; 11.9%, 54.8% and 33.3% in Smalakha block; 16.3%, 48.8% and 34.9% in Tohsham block; 15.1%, 56.2% and 28.8% in beri block; 15.2%, 48.5 and 36.4% in Nagal Choudary; 6.5%, 61.3% and 32.3% in Nuh block; 11.5%, 57.7% and 30.8% in Bawal block.

The highest percentage of the respondents belong to 50 to 60 and above 60 years age groups which shows the less interest of the younger population in agriculture. It is also a matter of great concern as farmers do not want their children to do farming as it has very little chance of growth due to the small size of land holdings. Due to population growth, the land holding sizes are decreasing continuously which affects the income and also growth chances.

4.2.1.2-Gender of the Respondents

In Indian society, gender classification is a very important social parameter for showing gender distribution. It measures the participation level of both the genders in different aspects of the society. In this current study, the head of the farming activities in every house was surveyed. So, it reflects the women's participation rate in farming works and decision formation. According the Table 4.2, almost 94.1% of the houses are headed by male farmers which proves that it is a male-dominated society. Only 8.5% of houses were headed by females and all the 34 females were widows. It also reflects the backwardness of the rural society due to the discrimination against females and not giving them equal rights as far as men are concerned. In block-wise distribution, 93.8% of the respondents of the Indri block are male and only 6.3% are females. In Panipat block, 96.1% of families are headed by males and only 3.9% are headed by females whereas in Smalakha block, 95.2% of houses are headed by male respondents and 4.8% are headed by females.

Table 4.3. Gender Distribution of the survey villages

Blocks	Villages	Male		Female		Total
		NO.	%	NO.	%	NO.
Indri block	Jundla	18	90	2	10	20
	Bahlolpur	8	100	0	0	8
	Gularpur	19	95	1	5	20
	Total	45	93.8	3	6.3	48
Panipat block	Sewah	30	93.8	2	6.2	32
	Rajakheri	14	100	0	0	14
	Palheri	5	100	0	0	5
	Total	49	96.1	2	3.9	51
Smalakha block	Raksehra	12	92.3	1	7.7	13
	Kiwana	19	95	1	5	20
	Haldana	9	100	0	0	9
	Total	40	95.2	2	4.8	42
Tohsham block	Sandwa	65	95.6	3	4.4	68
	Nigana	7	87.5	1	12.5	8
	Khawa	10	100	0	0	10
	Total	82	95.3	4	4.7	86
Beri block	Majra	50	94.3	3	5.7	53
	Malikpur	9	90	1	10	10
	Palra	10	100	0	0	10
	Total	69	94.5	4	5.5	73
Nagal choudry	Sirohi	18	90	2	10	20
	Morund	8	100	0	0	8
	Amarpura	5	100	0	0	5
	Total	31	93.9	2	6.1	33
Nuh block	Ujina	14	87.5	2	12.5	16
	Rehna	9	90	1	10	10
	Chhapera	5	100	0	0	5
	Total	28	90.3	3	9.7	31
Bawal block	Sulkha	8	80	2	20	10
	Rasiawas	8	100	0	0	8
	teekla	7	87.5	1	12.5	8
	Total	23	88.5	3	11.5	26
	Final total	367	94.1	23	5.9	390

(Source- Primary Survey)

In the Tohsham block of Bhiwani district, 95.3% of families are headed by males and only 4.7% are headed by females. In Beri block, 94.5% of respondents are male and 5.5% are females whereas in Nagal Choudry block, 93.9% of families are headed by males and 6.1% are headed by females. In the Nuh block of Mewat, 90.3% of families are headed by males and only 9.7% are headed by females. In the Bawal block of

Rewari, 88.5% are male respondents and only 11.5% of families are headed by females (table 3.2)

Female work participation is equal in farm work but all the decisions related to the farm are taken by the male members. The land is also not distributed equally between boys and girls. In Haryana's rural areas, people think that land ownership is only for boys because girls migrate to another house after marriage which affects the social and economic status of the women.

4.2.1.3. Social Groups: -

There are three social groups within the study area namely General (Gen), Bacward class(BC) and Schedule class (SC). All these classes depict the social status and accessibility of resources of all the caste including in all the social groups. All the castes were formed mainly based on occupation in ancient times but over time, factors like purity, hierarchy, endogamy and work became main parameters for caste formation.

Table 4.4. Social Group of the Respondents

Blocks	Villages	Gen		BC		SC		Total
		NO.	%	NO.	%	NO.	%	NO.
Indri block	Jundla	8	40	8	40	4	20	20
	Bahlolpur	3	37.5	3	37.5	2	25	8
	Gularpur	8	40	8	40	4	20	20
	Total	19	39.6	19	39.6	10	20.8	48
Panipat block	Sewah	13	40.6	13	40.6	6	18.8	32
	Rajakheri	14	100	0	0	0	0	14
	Palheri	5	100	0	0	0	0	5
	Total	32	62.7	13	25.5	6	11.8	51
Smalakha block	Raksehra	5	38.6	5	38.5	3	23.1	13
	Kiwana	8	40	8	40	4	20	20
	Haldana	7	77.8	0	0	2	22.2	9
	Total	20	47.6	13	30.9	9	21.4	42
Tohsham block	Sandwa	27	39.7	27	39.7	14	20.6	68
	Nigana	3	37.5	3	37.5	2	25	8
	Khawa	4	40	4	40	2	20	10
	Total	34	39.5	34	39.5	18	20.9	86
Beri block	Majra	27	50.9	26	49.1	0	0	53
	Malikpur	5	50	5	50	0	0	10
	Palra	4	40	4	40	2	20	10
	Total	36	49.3	35	47.9	2	2.7	73
Nagal choudry	Sirohi	10	50	10	50	0	0	20
	Morund	3	37.5	3	37.5	4	25	8
	Amarpura	2	40	3	60	0	0	5
	Total	15	45.5	16	48.5	4	12.1	33

Nuh block	Ujina	6	37.5	6	37.5	4	25	16
	Rehna	0	0	8	80	2	20	10
	Chhapera	2	40	2	40	1	20	5
	Total	8	25.8	16	51.6	7	22.6	31
Bawal block	Sulkha	10	100	0	0	0	0	10
	Rasiawas	8	100	0	0	0	0	8
	teekla	6	100	0	0	0	0	8
	Total	24	100	0	0	0	0	26
	Final total	188	48.2	146	37.4	56	14.4	390

(Source- Primary Survey)

According to Table 4.3, the highest number of respondents belong to the General category which is almost 188(48.2%) out of 390, on the other hand, 146(37.4%) belong to the Backward category and only 56(14.4%) respondents belong to the Scheduled category. This distribution clearly shows the predominance of the General category and BC on agricultural assets and negligence of the SC category on the ownership of the agricultural land resources. In block-wise distribution of the social groups, the percentage of the respondents among different social categories namely general, BC and SC are respectively 39.6%, 39.6% and 20.8 in Indri block; 62.7%, 25.5% and 11.8% in Panipat block; 47.6%, 30.9% and 21.4% in Smalakha; 39.5%, 39.5% and 20.9% in Tohsham block; 49.3%, 47.9% and 2.7% in Beri block; 45.5%, 48.5% and 12.1% in Nagal Choudry; 25.8%, 51.6% and 22.6% in Nuh block and all the respondents of Bawal block belong to General category.

So, the agricultural land is mostly owned by the General and BC categories farmers around 85.6% and five villages namely Rajakheri, Palheri, Sulkha, Teekla and Rasiawas have no agricultural land under SC castes. It is also a big discrimination with SC in rural areas of the Haryana state. Around 77% of SC and 90% of the ST population are landless and those who have ownership exist only as marginal land-holding class (Mohanth, B.B., 2002).

4.2.1.4-Education Status of Respondents

Education is a powerful tool for society's transformation and national development. It plays a vital role in decision-making and adopting & understanding the current world scenarios. decision related to agriculture like the use of seeds, fertilizers, pesticides, latest technologies etc. depends on the mindset and education level of the farmers. Farm productivity and outcome mainly depend on the education and practices adopted by the farmers. In rural societies, education did not get so much attention in previous times as people thought that for doing agricultural activities, education was not of much help. Even farmers having big land holdings, also neglected the importance of education. But time is changing and the population is also increasing which affects the land holding size and also growth chances from agricultural sources. Nowadays, farmers pay so much attention towards the education of their children as it is a powerful signal asset to change the world. So, it is a very important asset to understand the changing world scenarios. Based on education level, all the farmers are divided into six categories namely uneducated, Primary, Middle, 10^{th}, 12^{th} and Graduation & above

Table 4.5. Education status of the Respondents

Blocks	Villages	Uneducated	Primary	Middle	10^{th}	12^{th}	Graduation+	Total
		No	NO.	NO.	NO.	NO.	NO.	NO.
Indri	Jundla	0	2 (10%)	4 (20%)	7 (35%)	5 (25%)	2 (10%)	20
	Bahlolpur	0	0	3 (37.5%)	4 (50%)	1 (12.5%)	0	8
	Gularpur	0	5 (25%)	7 (35%)	2 (10%)	5 (25%)	1 (5%)	20
	Total	0	7 (14.6%)	14 (29.2%)	13 (27.1%)	11 (22.9%)	3 (6.3%)	48
Panipat	Sewah	1 (3.1%)	9 (28.1%)	9 (28.1%)	10 (31.3%)	2 (6.3%)	1 (3.1%)	32
	Rajakheri	0	3 (21.4%)	4 (28.6%)	5 (35.7%)	2 (14.3%)	0	14
	Palheri	0	1 (20%)	2 (40%)	2 (40%)	0	0	5
	Total	1 (2%)	13 (25.5%)	15 (29.4%)	17 (33.3%)	4 (7.8%)	1 (2%)	51
Smalakha	Raksehra	0	1 (7.7%)	2 (15.4%)	5 (38.5%)	4 (30.8%)	1 (7.7%)	13
	Kiwana	1 (5%)	4 (20%)	7 (35%)	6 (30%)	2 (10%)	0	20
	Haldana	0	1 (11.1%)	3 (33.3%)	4 (44.4%)	1 (11.1%)	0	9
	Total	1 (2.4%)	6 (14.3%)	12 (28.6%)	15 (35.7%)	7 (16.7%)	1 (2.4%)	42
Tohsham	Sandwa	3 (4.4%)	12 (17.6%)	20 (29.9%)	25 (36.8%)	6 (8.8%)	2 (2.9%)	68
	Nigana	2 (25%)	3 (37.5%)	0	2 (25%)	1 (12.5%)	0	8
	Khawa	0	2 (20%)	3 (30%)	4 (40%)	1 (10%)	0	10
	Total	5 (5.8%)	17 (19.8%)	23 (26.7%)	31 (36%)	8 (9.3%)	2 (2.3%)	86
Be	Majra	2 (3.8%)	7 (13.2%)	10 (18.9%)	25 (47.2%)	8 (15.1%)	1 (1.9%)	53

	Malikpur	0	1 (10%)	5 (50%)	2 (20%)	2 (20%)	0	10
	Palra	0	0	4 (40%)	3 (30%)	2 (20%)	1 (10%)	10
	Total	2 (2.7%)	8 (11%)	19 (26%)	30 (41.1%)	12 (16.4%)	2 (2.7%)	73
Nagal choudry	Sirohi	1 (5%)	2 (10%)	1 (5%)	6 (30%)	6 (30%)	4 (20%)	20
	Morund	0	0	2 (25%)	1 (12.5%)	4 (50%)	1 (12.5%)	8
	Amarpura	0	0	0	2 (40%)	2 (40%)	1 (20%)	5
	Total	1 (3%)	2 (6.1%)	3 (9.1%)	9 (27.3%)	12 (36.4%)	6 (18.2%)	33
Nuh	Ujina	1 (6.3%)	0	2 (12.5%)	5 (31.3%)	7 (43.8%)	1 (6.3%)	16
	Rehna	0	0	1 (10%)	3 (30%)	4 (40%)	2 (20%)	10
	Chhapera	0	1 (20%)	0	1 (20%)	3 (60%)	0	5
	Total	1 (3.2%)	1 (3.2%)	3 (9.7%)	9 (29%)	14 (45.2%)	3 (9.7%)	31
Bawal	Sulkha	2 (20%)	1 (10%)	2 (20%)	2 (20%)	2 (20%)	1 (10%)	10
	Rasiawas	0	0	1 (12.5%)	3 (37.5%)	4 (50%)	0	8
	teekla	0	0	0	3 (37.5%)	4 (50%)	1 (12.5%)	8
	Total	2 (7.7%)	1 (3.8%)	3 (11.5%)	8 (30.8%)	10 (38.5%)	2 (7.7%)	26
	Final total	13 (3.3%)	55 (14.1%)	92 (23.6%)	132 (33.8%)	78 (20%)	20 (5.1%)	390

(Source- Primary Survey)

According to Table 4.4, the highest number of respondents were educated up to the 10th level 132(33.8%), 92(23.6%) were educated up to the middle, 78 (20%) were studied upto 12th level, 55(14.1%) were educated upto primary class, 20(5.1%) are graduated & above, 13(3.3%) were uneducated. Respondents said that education is not important for doing agriculture as they learnt about it from their parents since childhood.

According to table 3.4, in the Indri block of Karnal district, 29.2% of the respondents were educated up to middle, 27.1% up to 10th, 22.9% up to 12th, 14.6 up to primary and 6.3% up to graduation. In the Panipat block, 33.3% of respondents studied up to 10th, 29.4% up to the middle, 25.5% up to primary, 7.8% up to 12th, and only 2% studied up to graduation. In Samalakha block, 35.7% of respondents were educated up to 10th, 28.6% up to the middle, 16.7% up to 12th, 14.3% up to primary and 2.4% up to graduation. In Tohsham block, 36% of respondents studied up to 10th, 26.7% up to the middle, 19.8% up to primary, 9.3% up to 12th and 5.8% were uneducated. In Beri block, 41.1% of respondents are educated up to 10th, 26% up to middle, 16.4% up to 12th, 11% up to primary and 2.7% are graduated. In Nagal Choudry block, 36.4% of respondents were educated up to 12th standard, 27.3% up to 10th, 18.2% up to graduation, 9.1% up to the middle and 6.1 up to the primary. In Nuh block, 45.2% of respondents were educated up to 45.2% 12th, 29% up to 10th, 9.7% up to middle & graduation. In Bawal block, 38.5% of respondents were educated up to the 12th level, 30.8% up to the 10th, 11.5% up to the middle, 7.7% of respondents were graduated and 7.7% were uneducated and only 3.8% were educated upto the primary level.

The above table concluded that the highest number of the farmers are educated up to 10th standard as the younger population's interest is decreasing towards agriculture which is a matter of concern. Most of the farmers want to engage their children in jobs or business instead of agriculture. They think that due to the decreasing size of the holdings, the income is also decreased and it also affects the interest rate of the younger population. It is also a big threat to agriculture sustainability because to understand and adapt to new technologies in the field of agriculture worldwide, education is the biggest asset. In order to ensure agriculture sustainability and to retain interest of younger generation, the need of the hour is to make agriculture economically viable.

4.2.1.5- Land-holding size & category

Being an agricultural economy, land is the single largest asset in the rural areas of Haryana. Land-holding size is a matter of concern for the economic as well as social status of the farmers in rural areas. In NCR Haryana, the highest number of farmers have semi-medium-sized land holdings followed by small-size land holdings. But farm outcome depends on the soil, water and also farmer knowledge. Farmers' perspective about farming techniques and methods totally depends on the farm size and also the cluster availability or bifurcated land under one farmer. There are six land-holding categories which are derived from govt. documents namely Marginal(upto 2.5acres), small(up to 5 acres), semi-medium(upto 10acres), medium(10 to 25) and Large (Above 25 acres)

Table 4.6. Distribution of the respondents according to land holding size

Blocks	Villages	Marginal	Small	Semi-Medium	Medium	Large	Total
		NO.	NO.	NO.	NO.	NO.	NO.
Indri block	Jundla	7 (35%)	6 (30%)	4 (20%)	2 (10%)	1 (5%)	20
	Bahlolpur	4 (50%)	2 (25%)	0	2 (25%)	0	8
	Gularpur	8 (40%)	5 (25%)	4 (20%)	2 (10%)	1 (5%)	20
	Total	19 (39.6%)	13 (27.1%)	8 (16.7%)	6 (12.5%)	2 (4.2%)	48
Panipat block	Sewah	8 (25%)	12 (37.5%)	6 (18.8%)	4 (12.5%)	2 (6.3%)	32
	Rajakheri	4 (28.6%)	6 (42.9%)	1 (7.1%)	2 (14.3%)	1 (7.1%)	14
	Palheri	2 (40%)	2 (40%)	0	1 (20%)	0	5
	Total	14 (27.5%)	20 (39.2%)	7 (13.7%)	7 (13.7%)	3 (5.9%)	51
Smalakha block	Raksehra	5 (38.5%)	3 (23.1%)	2 (15.4%)	2 (15.4%)	1 (7.7%)	13
	Kiwana	8 (40%)	5 (25%)	3 (15%)	3 (15%)	1 (5%)	20
	Haldana	4 (44.4%)	3 (33.3%)	1 (11.1%)	1 (11.1%)	0	9
	Total	17 (40.5%)	11 (26.2%)	6 (14.3%)	6 (14.3%)	2 (4.8%)	42
Tohsham block	Sandwa	31 (45.6%)	19 (27.9%)	11 (16.2%)	5 (7.4%)	2 (2.9%)	68
	Nigana	4 (50%)	2 (25%)	1 (12.5%)	1 (12.5%)	0	8
	Khawa	5 (50%)	2 (20%)	2 (20%)	1 (10%)	0	10
	Total	40 (46.5%)	23 (26.7%)	14 (16.3%)	7 (8.1%)	2 (2.3%)	86
Beri block	Majra	22 (41.5%)	16 (30.2%)	9 (17%)	4 (7.5%)	2 (3.8%)	53
	Malikpur	4 (40%)	3 (30%)	1 (10%)	2 (20%)	0	10
	Palra	5 (50%)	2 (20%)	2 (20%)	1 (10%)	0	10
	Total	31 (42.5%)	21 (28.8%)	12 (16.4%)	7 (9.6%)	2 (2.7%)	73
Nagal choudry	Sirohi	8 (40%)	4 (20%)	5 (25%)	2 (10%)	1 (5%)	20
	Morund	2 (25%)	2 (25%)	2 (25%)	1 (12.5%)	1 (12.5%)	8
	Amarpura	1 (20%)	1 (20%)	1 (20%)	1 (20%)	1 (20%)	5
	Total	11 (33.3%)	7 (21.2%)	8 (24.2%)	4 (12.5%)	3 (9.1%)	33
Nuh	Ujina	4 (25%)	5 (31.3%)	3 (18.8%)	2 (12.5%)	2 (12.5%)	16

	Rehna	4 (40%)	4 (40%)	2 (20%)	0	0	10
	Chhapera	1 (20%)	1 (20%)	1 (20%)	1 (20%)	1 (20%)	5
	Total	9 (29%)	10 (32.3%)	6 (19.4%)	3 (9.7%)	3 (9.7%)	31
Bawal block	Sulkha	4 (40%)	2 (20%)	2 (20%)	1 (10%)	1 (10%)	10
	Rasiawas	2 (25%)	2 (25%)	3 (37.5%)	1 (12.5%)	0	8
	teekla	4 (50%)	3 (37.5%)	1 (12.5%)	0	0	8
	Total	10 (38.5%)	7 (26.9%)	6 (23.1%)	2 (7.7%)	1 (3.8%)	26
	Final total	151 (38.7%)	112 (28.7%)	67 (17.2%)	42 (10.8%)	18 (4.6%)	390

(Source- Primary Survey)

According to Table 4.5, in the Indri block, most of the farmers belong to marginal and small land holding categories by 39.6% & 27.1%, 16.7% of respondents belong to semi-medium category, 12.5% to medium and only 4.2% of respondents have large land holdings. In the Panipat block, 39.2% of respondents have small land holdings, 27.5% have marginal, 13.7% have semi-medium & medium holdings and only 5.9% have large land holdings. In the Smalakha block, the highest number of the farmers belong to marginal land holdings at 40.5%, 26.2% belong to small, 14.3% belong to semi-medium & medium holding categories and 4.8% have large holdings. In Tohsham block, 46.5% of farmers have marginal land holdings, 26.7% have small, 16.3% have semi-medium, 8.2% have medium and only 2.3% have large holdings. In the Beri block, the highest proportion of the respondents have marginal land holdings, 28.8% have small, 16.4% have semi-medium, 9.6% have medium and only 2.7% have large land holdings. In Nagal Choudry, 33.3% of respondents have marginal land holdings, 24.2% have semi-medium, 21.2% have small, 12.1% have medium holdings and only 9.1% have large land holdings. In Nuh block, 32.3% of respondents have small land holdings, 29% have marginal, 19.4% have semi-medium, and 9.7% have medium & large land holdings. In the Bawal block, 38.5% of respondents have marginal land holdings, 26.9% have small, 23.1% have semi-medium, 7.7% have medium and 3.8% have large land holdings.

The block-wise and overall distribution is showing the decreasing size of land holdings which affects the interest of the farmers in agriculture. As marginal land holding is increasing due to population growth and family bifurcation, profit from agriculture and growth chances have also decreased. It is a big threat to agriculture sustainability within the study area.

4.2.1.6. Dispersal of Income

Income means the money received for a set of periods in exchange of goods & services. Income is a powerful tool to assess the economic value, life standard and availability of resources of a household. It is also an important factor in understanding d the livelihood surroundings of a household and also helpful in understanding the farmer's potential for using new farm technologies. There could be various sources of income of a household like agriculture, livestock, service, business etc. but for the present study, those respondents have been selected whose main source of income is agriculture. To assess the impact of LULC and cropping pattern change, the family must have agriculture as a main source of income. To show the income of the farmers, the income is divided into five categories namely up to 1.5 lakhs, 1.5 to 3 lakhs, 3 to 4.5 lakhs, 4.5 to 6 lakhs and above 6 lakhs.

Table 4.7. Total income of the surveyed farmers

Blocks	Villages	Up to 1.5	1.5 to 3 lakh	3 to 4.5 lakh	4.5 to 6 lakh	Above 6 lakh	Total
		NO.	NO.	NO.	NO.	NO.	NO.
Indri block	Jundla	0	5 (25%)	7 (35%)	5 (25%)	3 (15%)	20
	Bahlolpur	0	2 (25%)	3 (37.5%)	1 (12.5%)	2 (25%)	8
	Gularpur	0	5 (25%)	7 (35%)	3 (15%)	5 (25%)	20
	Total	0	12 (25%)	17 (35.4%)	9 (18.8%)	10 (20.8%)	48
Panipat block	Sewah	2 (6.3%)	17 (53.1%)	5 (15.6%)	3 (9.4%)	5 (15.6%)	32
	Rajakheri	0	4 (28.6%)	1 (7.1%)	6 (42.9%)	3 (21.4%)	14
	Palheri	0	2 (40%)	2 (40%)	0	1 (20%)	5
	Total	2 (3.9%)	23 (45.1%)	8 (15.7%)	9 (17.6%)	9 (17.6%)	51
Smalakha block	Raksehra	0	1 (7.7%)	4 (30.8%)	5 (38.5%)	3 (23.1%)	13
	Kiwana	0	2 (10%)	7 (35%)	5 (25%)	6 (30%)	20
	Haldana	0	2 (22.2%)	2 (22.2%)	4 (44.4%)	1 (11.1%)	9
	Total	0	5 (11.9%)	13 (31%)	14 (33.3%)	10 (23.8%)	42

Tohsham block	Sandwa	26 (38.2%)	15 (22.1%)	16 (23.5%)	11 (16.2%)	0	68
	Nigana	2 (25%)	2 (25%)	4 (50%)	0	0	8
	Khawa	1 (10%)	5 (50%)	3 (30%)	1 (10%)	0	10
	Total	29 (33.7%)	22 (25.6%)	23 (26.7%)	12 (14%)	0	86
Beri block	Majra	0	11 (20.8%)	15 (28.3%)	16 (30.2%)	11 (20.8%)	53
	Malikpur	0	2 (20%)	2 (20%)	4 (40%)	2 (20%)	10
	Palra	0	1 (10%)	5 (50%)	3 (10%)	1 (10%)	10
	Total	0	14 (19.2%)	22 (30.1%)	23 (31.5%)	14 (19.2%)	73
Nagal choudry	Sirohi	0	8 (40%)	7 (35%)	4 (20%)	1 (5%)	20
	Morund	1 (12.5%)	3 (37.5%)	2 (25%)	0	2 (25%)	8
	Amarpura	1 (20%)	2 (40%)	1 (20%)	1 (20%)	0	5
	Total	2 (6.1%)	12 (36.4%)	10 (30.3%)	5 (15.2%)	4 (12.1%)	33
Nuh block	Ujina	1 (6.3%)	6 (37.5%)	5 (31.3%)	2 (12.5%)	2 (12.5%)	16
	Rehna	0	4 (40%)	3 (30%)	3 (30%)	0	10
	Chhapera	1 (20%)	2 (40%)	0	1 (20%)	1 (20%)	5
	Total	2 (6.5%)	12 (38.7%)	8 (25.8%)	6 (19.4%)	3 (9.7%)	31
Bawal block	Sulkha	0	4 (40%)	4 (40%)	1 (10%)	1 (10%)	10
	Rasiawas	1 (12.5%)	3 (37.5%)	3 (37.5%)	1 (12.5%)	0	8
	teekla	1 (12.5%)	4 (50%)	2 (25%)	1 (12.5%)	0	8
	Total	2 (7.7%)	11 (42.3%)	9 (34.6%)	3 (11.5%)	1 (3.8%)	26
	Final total	34 (8.7%)	109 (27.9%)	110 (28.2%)	87 (22.3%)	50 (12.8%)	390

(Source- Primary Survey)

As Table 4.9, out of 390 respondents, Almost 28.2% respondents have a 3 to 4.5 lakh total income, 27.9% have a 1.5 to 3 lakh total income, 22.3% have 4.5 to 6 lakh total income, 12.8% have more than six lakh total income and 8.7% have upto 1.5 lakh total income. About 60% of the farmers have total income between 1.5 lakh to 4.5 lakh. In block-wise distribution, In Indri block of Karnal district, 35.4% of respondents have a total income of 3 to 4.5 lakh, 25% have 1.5 to 3 lakh, 20.8% have more than 6 lakh and 18.8% have 4.5 to 6 lakh total income of the family. In Panipat block, 45.1% of respondents have a 1.5 to 3 lakh total income, 17.6% have 3 to 4.5 lakh, 15.7% have more than six lahks and 13.7% have 4.5 to 6 lakh & above 6lakh both, 15.7% have 3 to 5 lakh and 3.9% have up to 1.5 lakh total income. In Smalakha block, 33.3% of respondents have 4.5 to 6 lakh total income, 31% have 3 to 4.5 lakh total income, 23.8% have more than 6 lakh income and 11.9% have 1.5 to 3 lakh annual income from all sources. In Tohsham block, 33.7% of respondents have 1.5 to 3 lakh total income from all sources per annum, 26.7% have 4.5 to 6 lakh, 25.6% have 3 to 4.5 lakh and 14% have more than six lakhs. In Beri block, 31.5% of respondents have 4.5 to 6 lakh income from all sources, 30.1% have 3 to 4.5 lakh, 19.2% have 1.5 to 3 lakh and more than six lakh income both. In Nagal Choudry block, 36.4% of respondents have a 1.5 to 3 lakh total income, 30.3% have 3 to 4.5 lakh income, 15.2% have 4.5 to 6 lakh income and 12.1% have more than 6 lakh total income. In Nuh block, 38.7% of respondents have 1.5 to 3 lakh total income per annum, 25.8% have 3 to 4.5 lakh total income, 19.4% of the respondents have 4.5 to 6 lakh annual income, 9.7% have more than 6 lakh total income and 6.5% have 1.5 lakh total annual income. In the Bawal block of Rewari district, the highest proportion 42.3% of the farmers have 1.5 to 3 lakh annual income, 34.6% have 3 to 4.5 lakh, and 11.5% have 4.5 to 6 lakh income.

The total income of the farmers of the Indri, Panipat, Smalakha and Beri block is higher due to better irrigation facilities and the growing of more demanding crops in their fields. Nearly 70% of the respondents have 3 to 6 and more than six lakh total income. Block namely Nagal Choudry, Bawal, Nuh and Tohsham have poor soil and poor irrigation facilities which automatically affects their overall income. As they are growing bajra, cotton, mustard, wheat & gram and yield of these crops is lesser than rice & wheat which are grown in the above blocks. Demand for these crops is also less as compared to wheat and rice.

Table 3.10 shows the income of the respondents from agriculture only and shows that 28.7% of the respondents have 1.5 to 3 lakh income, 30.3% have 3 to 4.5 lakh, 17.2% have 4.5 to 6 lakh, 12.1% have more than six lakhs and 11.8% have upto 1.5 lakh income from agriculture alone. To evaluate the impact of cropping patterns on the socio-economic conditions of the farmers, those families selected for the survey whose income mainly comes from agriculture almost 70% and above.

Table 4.8. Income from agriculture alone from total income

Blocks	Villages	Up to 1.5	1.5 to 3 lakh	3 to 4.5 lakh	4.5 to 6 lakh	Above 6 lakh	Total
		NO.	NO.	NO.	NO.	NO.	NO.
Indri block	Jundla	0	5 (25%)	7 (35%)	5 (25%)	3 (15%)	20
	Bahlolpur	0	2 (25%)	3 (37.5%)	1 (12.5%)	2 (25%)	8
	Gularpur	0	5 (25%)	7 (35%)	3 (15%)	5 (25%)	20
	Total	0	12 (25%)	17 (35.4%)	9 (18.8%)	10 (20.8%)	48
Panipat block	Sewah	2 (6.3%)	15 (46.9%)	7 (21.9%)	3 (9.4%)	5 (15.6%)	32
	Rajakheri	0	4 (28.6%)	1 (7.1%)	6 (42.9%)	3 (21.4%)	14
	Palheri	0	2 (40%)	2 (40%)	0	1 (20%)	5
	Total	2 (3.9%)	21 (41.2%)	10 (19.6%)	9 (17.6%)	9 (17.6%)	51
Smalakha block	Raksehra	0	1 (7.7%)	4 (30.8%)	5 (38.5%)	3 (23.1%)	13
	Kiwana	0	4 (20%)	5 (25%)	5 (25%)	6 (30%)	20
	Haldana	0	2 (22.2%)	2 (22.2%)	4 (44.4%)	1 (11.1%)	9
	Total	0	7 (16.7%)	11 (26.2%)	14 (33.3%)	10 (23.8%)	42
Tohsham block	Sandwa	26 (38.2%)	15 (22.1%)	16 (23.5%)	11 (16.2%)	0	68
	Nigana	2 (25%)	2 (25%)	4 (50%)	0	0	8
	Khawa	3 (30%)	2 (20%)	5 (50%)	0	0	10
	Total	31 (36%)	19 (22.1%)	25 (29.1%)	11 (12.8%)	0	86
Beri block	Majra	0	20 (37.7%)	16 (30.2%)	9 (17%)	8 (15.1%)	53
	Malikpur	0	2 (20%)	3 (30%)	3 (30%)	2 (20%)	10
	Palra	0	3 (30%)	4 (40%)	2 (20%)	1 (10%)	10
	Total	0	25 (34.2%)	23 (31.5%)	14 (19.2%)	11 (15.1%)	73
Nagal choudry	Sirohi	6 (30%)	3 (15%)	8 (40%)	2 (10%)	1 (5%)	20
	Morund	1 (12.5%)	3 (37.5%)	2 (25%)	0	2 (25%)	8
	Amarpura	1 (20%)	1 (20%)	1 (20%)	1 (20%)	1 ((20%)	5
	Total	8 (24.2%)	7 (21.2%)	11 (33.3%)	3 (9.1%)	4 (12.1%)	33
N uh	Ujina	1 (6.3%)	7 (43.8%)	4 (25%)	2 (12.5%)	2 (12.5%)	16

	Rehna	1 (10%)	3 (30%)	3 (30%)	3 (30%)	0	10
	Chhapera	1 (20%)	2 (40%)	2 (40%)	0	0	5
	Total	3 (9.7%)	12 (38.7%)	9 (29%)	5 (16.1%)	2 (6.5%)	31
Bawal block	Sulkha	0	4 (40%)	4 (40%)	1 (10%)	1 (10%)	10
	Rasiawas	1 (12.5%)	1 (12.5%)	5 (62.5%)	1 (12.5%)	0	8
	teekla	1 (12.5%)	4 (50%)	3 (37.5%)	0	0	8
	Total	2 (7.7%)	9 (34.6%)	12 (46.2%)	2 (7.7%)	1 (3.8%)	26
	Final total	46 (11.8%)	112 (28.7%)	118 (30.3%)	67 (17.2%)	47 (12.1%)	390

(Source- Primary Survey)

As due to the decreasing land holding sizes, marginal land holding are increasing in numbers which impacts the agriculture income as well as a big reason for decreasing interest of the present and future generations in agriculture. The percentage of the respondents in different income groups namely upto 1.5 lakh, 1.5 to 3 lakh, 3 to 4.5 lakh, 4.5 to 6 lakh and above 6 lakh are respectively in indri, Smalakha and Beri blocks no one in first income group after that 25%, 35%, 25% and 15% in Indri block; 3.9%, 41.2%, 19.6%, 17.6% and 17.6% in Panipat block; 16.7%, 26.2%, 33.3%, 23.8% in Smalakha block; 36%, 22.1%, 29.1%, 12.8% in Tohsham block; 34.2%, 31.5%, 19.2% and 15.1% in Beri block; 24.2%, 21.2%, 33.3%, 9.1% and 12.1% in Nagal Choudry block; 9.7%, 38.7%, 29%, 16.1% and 6.5% in Nuh Block; 7.7%, 34.6%, 46.2%, 7.7% and 3.8% in Bawal block.

Table 4.10 shows that respondents of the block with better irrigation facilities have a higher income as compared to the blocks that have poor irrigation and soil conditions. The reason behind this income difference is the production of the more demanding crops namely wheat and rice. If we talk about harvesting expenses, they are also good in wheat and rice fields as they are harvested through machines if labour is not available. In the case of crops like bajra, mustard or cotton, these depend on labour and now a days, labour costs are much higher than machines. No doubt, overall input is higher in wheat and rice, but production overcomes all the costs.

Table 4.11 shows the percent share of agriculture income in the total income of the sampled villages and results that 42.6% of respondents have only agriculture as a source of income, 29% have 80 to 89.9% income from agriculture alone, 16.2% have 70 to 79.9% income, 11.3% respondents have 90 to 99.9% share of agriculture income in the total income.

Table 4.9. Share of Agriculture Income in total income

Blocks	Villages	Up to 69.9%	70 to 79.9%	80 t0 89.9%	90 to 99.9%	100%	Total
		NO.	NO.	NO.	NO.	NO.	NO.
Indri block	Jundla	0	4 (20%)	7 (35%)	0	9 (45%)	20
	Bahlolpur	0	3 (37.5%)	1 (12.5%)	1 (12.5%)	3 (37.5%)	8
	Gularpur	2 (10%)	6 (30%)	5 (25%)	1 (5%)	6 (30%)	20
	Total	2 (4.2%)	13 (27.1%)	13 (27.1%)	2 (4.2%)	18 (37.5%)	48
Panipat block	Sewah	2 (6.3%)	8 (25%)	7 (21.9%)	1 (3.1%)	14 (43.8%)	32
	Rajakheri	0	3 (21.4%)	5 (35.7%)	1 (7.1%)	5 (35.7%)	14
	Palheri	0	0	2 (40%)	0	3 (60%)	5
	Total	2 (3.9%)	11 (21.6%)	14 (27.5%)	2 (3.9%)	22 (43.1%)	51
Smalakha block	Raksehra	0	0	5 (38.5%)	1 (7.7%)	7 (53.8%)	13
	Kiwana	0	1 (5%)	4 (20%)	3 (15%)	12 (60%)	20
	Haldana	0	0	4 (44.4%)	0	5 (55.6%)	9
	Total	0	1 (2.4%)	13 (31%)	4 (9.5%)	24 (57.1%)	42
Tohsham block	Sandwa	0	10 (14.7%)	20 (29.4%)	3 (4.4%)	35 (51.5%)	68
	Nigana	0	1 (12.5%)	2 (25%)	0	5 (62.5%)	8
	Khawa	0	3 (30%)	1 (10%)	0	6 (60%)	10
	Total	0	14 (16.3%)	23 (26.7%)	3 (3.5%)	46 (53.5	86
Beri block	Majra	0	9 (17%)	17 (32.1%)	2 (3.8%)	25 (47.2%)	53
	Malikpur	0	2 (20%)	3 (30%)	0	5 (50%)	10
	Palra	0	3 (30%)	1 (10%)	0	6 (60%)	10
	Total	0	14 (19.2%)	21 (28.8%)	2 (2.7%)	36 (49.3%)	73
Nagal choudry	Sirohi	0	1 (5%)	6 (30%)	9 (45%)	4 (20%)	20
	Morund	0	0	4 (50%)	2 (25%)	2 (25%)	8
	Amarpura	0	0	2	2	1	5

				(40%)	(40%)	(20%)	
	Total	0	1 (3%)	12 (36.4%)	13 (39.4%)	7 (21.2%)	33
Nuh block	Ujina	0	2 (12.5%)	4 (25%)	7 (43.8%)	3 (18.8%)	16
	Rehna	0	2 (20%)	5 (50%)	3 (30%)	0	10
	Chhapera	0	1 (20%)	1 (20%)	2 (40%)	1 (20%)	5
	Total	0	5 (16.1%)	10 (32.3%)	12 (38.7%)	4 (12.9%)	31
Bawal block	Sulkha	0	1 (10%)	4 (40%)	1 (10%)	4 (40%)	10
	Rasiawas	0	1 (12.5%)	2 (25%)	3 (37.5%)	2 (25%)	8
	teekla	0	2 (25%)	1 (12.5%)	2 (25%)	3 (37.5%)	8
	Total	0	4 (15.4%)	7 (26.9%)	6 (23.1%)	9 (34.6%)	26
	Final total	4 (1%)	63 (16.2%)	113 (29%)	44 (11.3%)	166 (42.6%)	390

(Source- Primary Survey)

In tehsil-wise distribution, 37.5% of the respondents have only an agriculture source of income, 62% have 70 to 89.9% income and 4.2% have up to 69.9% income share of the agriculture income in the total income in Indri block. In Panipat block, 43.1% of respondents have only agriculture as a source of income, 27.5% have 80 to 89.9% income share, 21.6% have 70 to 79.9% income share, 3.9% have 90 to 99.9% income share and 3.9% have up to 69.9% share in income in total income. In Smalakha block, 57.1% of respondents are doing only agriculture, 31% have 80 to 89.9% income share in total income, and 9.5% have 90 to 99.9% income share in the total income of the family. In Tohsham block, 53.5% of respondents depend only on agriculture income, 26.7% have 80 to 89.9% share, 16.3% have 70 to 79.9% and 3.5% have 90 to 99.9% income share in total family income. In Beri block, 49.3% of respondents have only agriculture as a means of income, 28.8% have 80 to 89.9%

Table 4.11 shows that around 43% of respondents have only agriculture as a source of income and the highest number of respondents lies in 80 to 89.9% and 100% income groups which is an important parameter to assess the impact of agriculture change on the socio-economic conditions of the farmers

4.2.1.7. Source of Irrigation of the Respondents

Agriculture development is not possible without good irrigation facilities as it is a vital input for the growth and production of crops. Today, whatever development we are seeing in the agriculture sector in India and especially in Haryana, it is possible only because of the development of irrigation facilities. It plays a key role in crop productivity, cropping systems, diversification, cropping intensity and also in yield. Major sources of irrigation in NCR Haryana are tube wells and canals which involve all the major and minor canals derived from rivers. Table 4.6 depicts the source of irrigation in sampled villages in NCR Haryana 53.3% of respondents have only tubewell as a means of irrigation, 37.4% have both the means of irrigation, 7.4% have only canal as a means of irrigation and 1.8% have barani agriculture which means they have no source of irrigation.

Table 4.10. Source of Irrigation

Blocks	villages	Tubewell		Canal		Both		Barani		Total
		NO.	%	NO.	%	NO.	%	NO.	%	NO.
Indri	Jundla	12	60	0	0	8	40	0	0	20
	Bahlolpur	5	62.5	0	00	3	37.5	0	0	8
	Gularpur	9	45	0	0	11	55	0	0	20
	Total	26	54.2	0	0	22	45.8	0	0	48
Panipat	Sewah	24	75	0	0	8	25	0	0	32
	Rajakheri	14	100	0	0	0	0	0	0	14
	Palheri	5	100	0	0	0	0	0	0	5
	Total	43	84.3	0	0	8	15.7	0	0	51
Smalakha	Raksehra	13	100	0	0	0	0	0	0	13
	Kiwana	20	100	0	0	0	0	0	0	20
	Haldana	9	100	0	0	0	0	0	0	9
	Total	42	100	0	0	0	0	0	0	42
Tohsham	Sandwa	35	51.5	10	14.7	20	29.4	3	4.4	68
	Nigana	3	37.5	2	25	0	0	3	37.5	8
	Khawa	5	50	2	20	3	30	0	0	10
	Total	43	50	14	16.3	23	26.7	6	7.0	86
Beri	Majra	10	18.9	0	0	43	81.1	0	0	53
	Malikpur	0	0	0	0	10	100	0	0	10
	Palra	0	0	0	0	10	100	0	0	10
	Total	10	13.7	0	0	63	86.3	0	0	73
Nagal	Sirohi	3	15	12	60	5	25	0	0	20
	Morund	8	100	0	0	0	0	0	0	8
	Amarpura	3	60	0	0	2	40	0	0	5

	Total	14	42.4	12	36.4	7	21.2	0	0	33
Nuh	Ujina	4	25	0	0	12	75	0	0	16
	Rehna	4	40	3	30	2	20	1	10	10
	Chhapera	1	20	0	0	4	80	0	0	5
	Total	9	29	3	9.7	18	58.1	1	3.2	31
Bawal	Sulkha	7	70	0	0	3	30	0	0	10
	Rasiawas	6	75	0	0	2	25	0	0	8
	teekla	8	100	0	0	0	0	0	0	8
	Total	21	80.8	0	0	5	19.2	0	0	26
	Final total	208	53.3	29	7.4	146	37.4	7	1.8	390

(Source- Primary Survey)

In the Indri block, 54.2% of respondents have used tubewell as a means of irrigation and 45.8% have both the means of irrigation namely tubewell and canal whereas in the Panipat block, 84.3% of the respondents have used tubewell for irrigation and only 15.7% are using both tubewell as well as canal for irrigation. In the Smalakha block, all the respondents are using only tubewell as a means of irrigation. In Tohsham block, half of the respondents are using tubewell, 26.7% are using both tubewell & canal, 16.3% are using only canal and 7% of the respondents have no means of irrigation which is called barani agriculture. In Beri block, 86.3% have both the means of irrigation namely canal & tubewell and 13.7% are using only tubewell for irrigation. In Nagal Choudry block, 42.4% of respondents are using only tubewell, 36.4% are using only canal and 21.2% are using both sources of irrigation. In Nuh block, 58.1% have both the source of irrigation, 29% are using only tubewell, 9.7% are using only canal and 3.2% have no means of irrigation or barani agriculture. In the Bawal block, 80.8% have only tubewell as a mean of irrigation and 19.2% are using both means of irrigation (table 4.6).

So, nowadays, tubewell is the main source of irrigation than canal irrigation which highly affects the groundwater level in concerned areas. Almost 60 to 65 percent is irrigated by ground water and only 30 to 35 percent area is irrigated through canals. In Karnal, Panipat, Smalakha and Beri blocks, rice and wheat are the major crops that affect the groundwater level highly. Rice is a water consumable crop but the price of the crop and demand is high which prompts the farmers to grow this crop. Tubewell irrigation intensity has been increased in Haryana which causes severe future water threats within the state. Due to the continued exploitation of underground water, many blocks fall under dark zone situations. So, it is imperative to make better plans to save groundwater by government.

4.2.1.8. Use of Fertilizer

Fertilizer is a very essential ingredient for soil health as well as plant growth which is helpful for more production and yield. Organic fertilizer is very good for the plant as well as human health. But after the invention of chemical fertilizers, the use of organic fertilisers has decreased as HYV seeds demand more fertilizer and water and also suck more nutrition from the soil. The green revolution enhanced production and yield but it led to a negative impact on soil as well as human health as it introduced the use of more and more fertilisers. The use of manure is decreasing due to the faster results of chemical fertilizers. Among all the respondents, nobody does soil testing which makes this issue very serious. Table 4.7 shows the use of fertilizer by the respondents and results that no one is using only organic/manure for agriculture. But there were 45.4% of respondents were using only chemical fertilizers and 54.6% of respondents were using both chemical as well as manure. The manure quantity is much less than chemical fertilizers which makes the situation very critical.

Table 4.11. Use of fertilizers in selected villages

Blocks	Villages	organic		Chemical		Both		Total
		NO.	%	NO.	%	NO.	%	NO.
Indri block	Jundla	0	0	13	65	7	35	20
	Bahlolpur	0	0	6	75	2	25	8
	Gularpur	0	0	14	70	6	30	20
	Total	0	0	33	68.8	15	31.3	48
Panipat block	Sewah	0	0	20	62.5	12	37.5	32
	Rajakheri	0	0	9	64.3	5	35.7	14
	Palheri	0	0	4	80	1	20	5
	Total	0	0	33	64.7	18	35.3	51
Smalakha block	Raksehra	0	0	8	61.5	5	38.5	13
	Kiwana	0	0	14	70	6	30	20
	Haldana	0	0	7	77.8	2	22.2	9
	Total	0	0	29	69	13	31	42
Tohsham block	Sandwa	0	0	10	14.7	58	85.3	68
	Nigana	0	0	6	75	2	25	8
	Khawa	0	0	2	20	8	80	10
	Total	0	0	18	20.9	68	79.1	86
Ber i blo	Majra	0	0	30	56.6	23	43.4	53
	Malikpur	0	0	6	60	4	40	10

	Palra	0	0	3	30	7	70	10
	Total	0	0	39	53.4	34	46.6	73
Nagal choudry	Sirohi	0	0	2	10	18	90	20
	Morund	0	0	3	37.5	5	62.5	8
	Amarpura	0	0	1	20	4	80	5
	Total	0	0	6	18.2	27	81.8	33
Nuh block	Ujina	0	0	0	0	16	100	16
	Rehna	0	0	0	0	10	100	10
	Chhapera	0	0	0	0	5	100	5
	Total	0	0	0	0	31	100	31
Bawal block	Sulkha	0	0	6	60	4	40	10
	Rasiawas	0	0	7	87.5	1	12.5	8
	teekla	0	0	6	75	2	25	8
	Total	0	0	19	73.1	7	26.9	26
	Final total	0	0	177	45.4	213	54.6	390

(Source- Primary Survey)

In the Indri block, 68.8% of respondents are using only chemical fertilizers and only 31.3% are using both chemical & manure whereas in the Panipat block, 64.7% are using chemical fertilizers and 35.3% are using both fertilizers. In the Smalakha block, 69% are using only chemicals and 31% are using both. In Tohsham block, 20.9% are using chemicals whereas 79.1% are using chemicals as well as manure. In the Beri block, 53.4% are using chemicals and 46.6% are using both fertilizers. In the Nagal Choudry block, 18.2% are using chemicals and 81.8% are using both chemicals and manure. In the Nuh block, all the respondents are using both fertilizers and in the Bawal block, 73.1% are using chemical fertilizers and 26.9% are using both fertilizers.

Table 4.11 showed that no block used only manure/organic fertilizer. Almost 45% are using only chemical fertilizers in their farms due to unavailability of organic fertilizers or manure. Around 55% are using both fertilizers and in rural societies, keeping animals for milk is a normal thing. However, the quantity of manure is very low as compared to chemical fertilizers because due to family bifurcation, many families left keeping animals. Those families who kept animals are also rearing very few animals because family sizes are decreasing which affects the work quality of the household and requirements.

Table 4.12. Quantity of Chemical Fertilizer

Blocks	Villages	Up to 3 bags	4 to 5	6 to 7	8 to 9	Above 9	Total
		NO.	NO.	NO.	NO.	NO.	NO.
Indri block	Jundla	0	0	7 (35%)	11 (55%)	2 (10%)	20
	Bahlolpur	0	0	5 (62.5%)	3 (37.5%)	0	8
	Gularpur	0	0	8 (40%)	10 (50%)	2 (10%)	20
	Total	0	0	20 (41.7%)	24 (50%)	4 (8.3%)	48
Panipat block	Sewah	0	0	9 (28.1%)	20 (62.5%)	3 (9.4%)	32
	Rajakheri	0	0	6 (42.9%)	6 (42.9%)	2 (14.3%)	14
	Palheri	0	0	0	4 (80%)	1 (20%)	5
	Total	0	0	15 (29.4%)	30 (58.8%)	6 (11.8%)	51
Smalakha block	Raksehra	0	0	5 (38.5%)	6 (46.2%)	2 (15.4%)	13
	Kiwana	0	0	5 (25%)	12 (60%)	3 (15%)	20
	Haldana	0	0	1 (11.1%)	7 (77.8%)	1 (11.1%)	9
	Total	0	0	11 (26.2%)	25 (59.5%)	6 (14.3%)	42
Tohsham block	Sandwa	68 (100%)	0	0	0	0	68
	Nigana	8 (100%)	0	0	0	0	8
	Khawa	10 (100%)	0	0	0	0	10
	Total	86 (100%)	0	0	0	0	86
Beri block	Majra	0	0	16 (30.2%)	34 (64.2%)	3 (5.7%)	53
	Malikpur	0	0	3 (30%)	7 (70%)	0	10
	Palra	0	0	3 (30%)	6 (60%)	1 (10%)	10
	Total	0	0	22 (30.1%)	47 (64.4%)	4 (5.5%)	73
Nagal choudry	Sirohi	14 (70%)	6 (30%)	0	0	0	20
	Morund	6 (75%)	2 (25%)	0	0	0	8
	Amarpura	3 (60%)	2 (40%)	0	0	0	5
	Total	23 (69.7%)	10 (30.3%)	0	0	0	33
Nuh block	Ujina	16 (100%)	0	0	0	0	16
	Rehna	10	0	0	0	0	10

		(100%)					
	Chhapera	3 (60%)	0	0	2 (40%)	0	5
	Total	29 (93.5%)	0	0	2 (6.5%)	0	31
Bawal block	Sulkha	5 (50%)	5 (50%)	0	0	0	10
	Rasiawas	4 (50%)	4 (50%)	0	0	0	8
	teekla	6 (75%)	2 (25%)	0	0	0	8
	Total	15 (57.7%)	11 (42.3%)	0	0	0	26
	Final total	153 (39.2%)	21 (5.4%)	68 (17.4%)	128 (32.8%)	20 (5.1%)	390

(Source- Primary Survey)

Table 4.8 shows the consumption of chemical fertilizer per acre by the respondents and results that 39.7% of the respondents are using three bags per acre, 32.3% are using 8 to 9 bags per acre, 17.4% are using 6 to 7 bags per acre, 5.1% are using more than nine bags per acre and 5.4% are using 4 to 5 bags per acre. Blocks with better irrigation facilities use more fertilizers namely Indri Block, Panipat Block, Smalakha block and Beri block whereas blocks with low irrigation facilities use less fertilizer per acre namely Tohsham, Nagal Choudry, Nuh and Bawal. In Tohsham and Nuh block, all the respondents are using 3 bags per acre whereas in Bawal block, 57.7% are using 3 bags and 42.3% are using 4 to 5 bags. In Nagal Choudry block, 69.7% are using 3 bags and 30.3% are using 4 to 5 bags per acre.

The results concluded that districts with better irrigation facilities are using more chemical fertilizers and blocks. It concluded that fertilizer is an essential part of agriculture because there is no space for soil to regain its strength again. Everyone is aware of the harmfulness of chemical fertilizers but they have no option. Block namely Indri, Panipat, Smalakha and Beri are using mostly 8 to 10 bags per acre per year as they are growing only two crops viz. wheat & rice. These crops extract higher nutrients from the soil which is fulfilled by chemical fertilizers. Earlier there were more joint families and people used to keep many animals but, now families have become smaller and people have stopped keeping animals. Manure quantity has decreased which fulfils the soil requirements naturally.

4.2.2. Relation of socio-economic conditions with some selected indicators

To assess the change in socio-economic conditions of the farmers through agriculture, the responses have been recorded about house assets, housing type etc. In this way, the questionnaire was created and the results were calculated. In this part, the impact of the present agriculture system on the socio-economic conditions of the farmers has been analysed through some important socio-economic indicators. Farmers' responses about some socio-economic factors like housing condition, family type, house assets, agricultural work pattern and school type of the children were recorded and results were calculated. Chi-square test of independence have been applied for checking the association between theses selected indicators and results are as follow: -

4.2.2.1- Housing Conditions

Housing conditions mean what type of house, the respondents are living and it also reflects the standard of living and economic status of the respondents. In our study area, two types of houses are found namely semi-pacca and pacca. Semi-pacca houses are those houses that are made with bricks and clay and pacca houses are those houses that are made of bricks and cement. Pacca houses are well-built and also more secure than semi-pucca houses.

Table 4.12 shows the housing structure of the farmers and reflects that 227(58.2%) respondents are living in semi-pacca housing conditions and 163(41.8%) are living in fully pacca houses. It reflects that those respondents who have better income from agriculture having fully pacca houses and those who have less income are still struggling to improve their socio-economic conditions.

Table 4.13. Housing structure

Blocks	Villages	Semi-Pacca		Pacca		Total
		NO.	%	NO.	%	NO.
Indri block	Jundla	11	55	9	45	20
	Bahlolpur	5	62.5	3	37.5	8
	Gularpur	12	60	8	40	20
	Total	28	58.3	20	41.7	48
Panipat block	Sewah	17	53.1	15	46.9	32
	Rajakheri	6	42.9	8	57.1	14
	Palheri	2	40	3	60	5
	Total	25	49	26	51	51
Smalakha block	Raksehra	6	46.2	7	53.8	13
	Kiwana	8	40	12	60	20

	Haldana	4	44.4	5	55.6	9
	Total	18	42.9	24	57.1	42
Tohsham block	Sandwa	50	73.5	18	26.5	68
	Nigana	5	62.5	3	37.5	8
	Khawa	4	40	6	60	10
	Total	59	68.6	27	31.4	86
Beri block	Majra	28	52.8	25	47.2	53
	Malikpur	4	40	6	60	10
	Palra	6	60	4	40	10
	Total	38	52.1	35	47.9	73
Nagal choudry	Sirohi	13	65	7	35	20
	Morund	5	62.8	3	37.5	8
	Amarpura	3	60	2	40	5
	Total	21	63.6	12	36.4	33
Nuh block	Ujina	11	68.8	5	31.2	16
	Rehna	6	60	4	40	10
	Chhapera	4	80	1	20	5
	Total	21	67.7	10	32.3	31
Bawal block	Sulkha	6	60	4	40	10
	Rasiawas	5	62.5	3	37.5	8
	teekla	6	75	2	25	8
	Total	17	65.4	9	34.6	26
	Final total	227	58.2	163	41.8	390

(Source- Primary Survey)

If we talk about tehsil, in Indri tehsil, 28(58.3%) farmers have semi-pucca houses and 20(41.7%) have fully pacca houses. In Panipat tehsil, the number and percentage of the farmers having semi-pucca and fully pacca houses are respectively 25(49%) and 26(51%); in Smalakha block it is 18(42.9%) and 24(57.1%); In Tohsham block, it is 59(68.6%) and 27(31.4%); in Beri block, it is 38(52.1%) and 35(47.9%); In Nagal Choudry it is 21(63.6%) and 12(36.4%); In Nuh block, it is 21(67.7%) and 12(32.3%); in Bawal block it is 17(65.4%) and 9(34.6%). So, housing conditions or structure is a very important socio-economic indicator to assess the change in farmer's socio-economic conditions. The above table concluded that a significant percentage of the farmers are living in fully pacca housing conditions as they have better income from agricultural sources which is around 42% and those respondents who have less income are living in semi-pucca housing conditions (table 4.12).

Now to check whether the housing conditions of the respondents were related to their social group, land holding, income and education status.

Table 4.14. (a): Distribution of the respondents on the basis of house type related with their social category and holding size

	semi-pacca	pacca	total
SC	56 (24.7%)	0	56 (14.4%)
BC	102 (44.9%)	43 (26.4%)	145 (37.2%)
Gen	69 (30.4%)	120 (73.6%)	189 (48.5%)
Total	227 (58.2)	163 (41.8%)	390 (100%)
Chi-square- 85.6, df-2 and the chi-square statistic is significant at the 0.05 level			
Marginal	141 (62.1%)	12 (7.4%))	153 (39.2%)
small	62 (27.3%)	50 (30.7%)	112 (28.7%)
semi-medium	17 (7.5%)	54 (33.1%)	71 (18.2%)
medium	7 (3.1%)	29 (17.8%)	36 (9.2%)
large	0	18 (11%)	18 (4.6%)
Total	227 (58.2%)	163 (41.8%)	390 (100%)
Chi-square- 154.4, df-4 and the chi-square statistic is significant at the 0.05 level			

(Computed and calculated by the researcher)

Table 4.13(a) shows that out of 227 respondents who are living in semi-pacca houses 56(24.7%) from SC, 102(44.9%) from BC and 69(30.4%) from GEN category. On the other hand, 163(41.8%) respondents living in fully pacca houses come from Gen and BC categories 120(73.6%) and 43(26.4%). Most of the fully pacca houses are owned by the General class as they have more land holdings and income from agriculture. The chi-square is 85.6 with 2 df and the test is significant at the level of 0.05 which shows that there is a notable relation between the social groups and housing conditions.

Whereas in terms of land holding categories, out of 227 respondents who are living in semi-pucca houses, 141 belong to marginal, 62(27.3%) small, 17(7.5%) semi medium and 7(3.1%) medium land holding categories. On the other hand, out of 163(41.8%) respondents who are living in fully pacca houses belong to marginal, small, semi-medium, medium and large land holding categories by 12(7.4%), 50(30.7%), 54(33.1%), 29(17.8%) and 18(11%) respectively. The X^2=154.4, df=4 and the result is significant at the level of 0.05 which indicates that there is a significant relationship between the land-holding categories and housing structure.

Table 4.14 (b): Distribution of the respondents on the basis of house type related to their Income and Education Level

Income	Semi -Pacca	Pacca	total
Up to 150000	43 (18.9%)	3 (1.8%)	46 (11.8%)
150000-300000	96 (42.3%)	16 (9.8%)	112 (28.7%)
300000-450000	68 (30%0	50 (30.7%)	118 (30.3%)
450000-600000	19 (8.4%)	48 (29.4%)	67 (17.2%)
above 600000	1 (0.4%)	46 (28.2	47 (12.1%)
Total	227 (58.2)	163 (41.8%)	390 (100%)
Chi-square- 143.7, df-4 and the chi-square statistic is significant at the 0.05 level			
uneducated	13 (5.7%)	0	13 (3.3%)
Primary	63 (27.8%)	5 (3.1%)	68 (17.4%)
Middle	48 (21.1%)	42 (25.8%)	90 (23.1%)
10th	62 (27.3%)	67 (41.1%)	129 (33.1%)
12th	33 (14.5%)	39 (23.9%)	72 (18.5%)
graduation+	8 (3.5%)	10 (6.1%)	18 (4.6%)
Total	227 (58.2)	163 (41.8%)	390 (100%)
Chi-square- 54.759, df-5 and the chi-square statistic is significant at the 0.05 level			

(Computed and calculated by the researcher)

Table 4.13(b) recorded the responses of the respondents on the bases of their agricultural income and resulted that respondents who are living in semi-pucca houses, 43(18.9%) belong to upto 1.5 lakh income group, 96(42.3%) belong to 1.5 to 3 lakh income group, 68(30%) belong to 3 to 4.5 lakh income group, 19(8.4%) belong to 4.5 to 6 lakh income group and only 1 respondent belong to above 6 lakh income group whereas highest number of the fully pacca houses are owned by up to 1.5 lakh 3(1.8%), 1.5 to 3 lakh 16(9.8%), 3 to 4.5 lakh 50(30.7%), 4.5 to 6 lakh 48(29.4%) and above 6 lakh 46(28.2%) income groups. The chi-square is 143.7 with 4 df and the result is significant at the level of 0.05 which shows the strong relationship between income and the housing type of the respondents.

Whereas in terms of their education status, 13(5.7%), 63(27.8%), 48(21.1%), 62(27.3%), 33(14.5%) and 8(3.5) semi-pucca houses are owned by uneducated, primary, middle, 10th, 12th and graduated and above level educated respondents respectively. On the other hand, fully pacca houses are owned by the respondents who are educated up to primary, middle, 10th, 12th and graduation plus by 5(3.1%), 42(25.8%), 67(41.1%), 39(23.9%) and 10(6.1%) respectively. The chi-square is 54.7 with 5 df and the result is significant on 0.05 level which shows that the housing conditions are significantly associated with the education level of the respondents.

4.2.2.2- Family structure

Family is the key unit of society and change in the type of the family is the result of the mindset of the people. Family formation has the quickest impact on the formation of the decision about agriculture activities on their farms and also agricultural production & performance. For the present research, the interviewed farmers were divided into two categories namely joint family and nuclear family. Table 4.14 shows the trend of nuclearization of the families as now only 63(16.2%) respondents are living in joint families and the rest of the respondents have nuclear families.

Table no. 4.15. Change in Family Types

Blocks	Villages	Joint		Nuclear		Total
		NO.	%	NO.	%	NO.
Indri block	Jundla	2	10	18	90	20
	Bahlolpur	2	25	6	75	8
	Gularpur	3	15	17	85	20
	Total	7	14.6	41	85.4	48
Panipat block	Sewah	4	12.5	28	87.5	32
	Rajakheri	2	14.3	12	85.7	14
	Palheri	0	0	5	100	5
	Total	6	11.8	45	88.2	51
Smalakha block	Raksehra	1	7.7	12	92.3	13
	Kiwana	3	15	17	85	20
	Haldana	2	22.2	7	77.8	9
	Total	6	14.3	36	85.7	42
Tohsham block	Sandwa	12	17.6	56	82.4	68
	Nigana	2	25	6	75	8
	Khawa	3	30	7	70	10
	Total	17	19.8	69	80.2	86

Beri block	Majra	5	9.4	48	90.6	53
	Malikpur	1	10	9	90	10
	Palra	2	20	8	80	10
	Total	8	11	65	89	73
Nagal choudry	Sirohi	2	10	18	90	20
	Morund	2	25	6	75	8
	Amarpura	00	0	5	100	5
	Total	4	12.1	29	87.9	33
Nuh block	Ujina	4	25	12	75	16
	Rehna	2	20	8	80	10
	Chhapera	2	40	3	60	5
	Total	8	25.5	23	74.2	31
Bawal block	Sulkha	3	30	7	70	10
	Rasiawas	3	37.5	5	62.5	8
	teekla	1	12.5	7	87.5	8
	Total	7	26.9	19	73.1	26
	Final total	63	16.2	327	83.8	390

(Source- Primary Survey)

In block wise distribution of the family type, only 7(14.6%) of the respondents are living in joint family structure and 41(85.4%) are living in nuclear families in Indri block; in Panipat block,the number and percentage are respectively 6(11.8%) and 45(88.2%); in samalkhan block it is 6(14.3%) and 36(85.7%); in Tosham block it is 17(19.8%) and 69(80.2%); in Beri block it is 8(11%)and 65(89%); in Nangal Chaudhary it is 4(12.1%) and 29(87.9%); in Nuh block it is 8(25.5%) and 23(74.2%); in Bawal block it is 7(26.9%) and 19(73.1%). So, the highest number of the respondents are living in nuclear families (table 4.14).

nowadays, there is a trend of nuclearization. Due to increasing the number of nuclear families, the land holding sizes are also decreasing which affects the production, farming techniques and perspective about agriculture. Due to the small sizes of land holdings, farmers do not want to include their children in agriculture which causes a big threat to agriculture sustainability.

Now to check whether the family structure of the respondents is associated with their income, education, land holding and social category. To see the relation, the independent chi-square test has been adopted at the significance level of 0.05.

Table 3.16. Distribution of the respondents based on Family type related to their social category, holding size, Income and education

	Nuclear	Joint	Total
SC	56 (17.1%)	0	56 (14.4%)
BC	140 (42.8%)	5 (7.9%)	145 (37.2%)
Gen	131 (40.1%)	58 (92.1%)	189 (48.8%)
Total	327 (83.8%)	63 (16.2%)	390
Chi-square- 57.5, df-2 and the chi-square statistic is significant at the 0.05 level			
Marginal	153 (46.8%)	0	153 (39.2%)
Small	105 (32.1%)	7 (11.1%)	112 (28.7%)
Semi-medium	50 (15.3%)	21 (33.3%)	71 (18.2%)
Medium	16 (4.9%)	20 (31.7%)	36 (9.2%)
Large	3 (0.9%)	15 (23.8%)	18 (4.6%)
Total	327 (83.8%)	63 (16.2%)	390
Chi-square- 148.3, df-4 and the chi-square statistic is significant at the 0.05 level			
Up to 150000	46 (12.1%)	0	46 (11.8%)
150000-300000	110 (33.6%)	2 (3.2%)	112 (28.7%)
300000-450000	98 (30%)	20 (31.7%)	118 (30.3%)
450000-600000	52 (15.9%)	15 (23.8%)	67 (17.2%)
above 600000	21 (6.4%)	26 (41.3%)	47 (12.1%)
Total	327 (83.8%)	63 (16.2%)	390
Chi-square- 81.139, df-4 and the chi-square statistic is significant at the 0.05 level			
uneducated	13 (4%)	0	13 (3.3%)
Primary	66 (20.2%)	2 (3.2%)	68 (17.4%)
Middle	77 (23.5%)	13 (20.6%)	90 (23.1%)
10th	108 (33%)	21 (33.3%)	129 (33.1%)
12th	54 (16.5%)	18 (28.6%)	72 (18.5%)
graduation+	9 (2.8%)	9 (14.3%)	18 (4.6%)

total	327 (83.8%)	63 (16.2%)	390
Chi-square- 30.849, df-5 and the chi-square statistic is significant at the 0.05 level			

(Computed and calculated by the researcher)

Table 4.15 shows that out of 327 respondents who are living in a nuclear family structure 56(17.1%) from SC, 140(42.8%) from BC and 131(40.1%) from the GEN category. On the other hand, 58(92.1%) respondents having joint family structure come from Gen and 5(7.9%) from BC category out of 63. The general class have the highest number of joint families. The chi-square is 57.5 with 2 df and the test is significant at the level of 0.05 which shows that there is a notable relation between the social groups and housing conditions.

Whereas in terms of land holding categories, out of 327 respondents who are living in nuclear families 153(46.8%) belong to marginal, 105(32.1%) belong to small, 50(15.3%) belong to semi medium and 16(4.9%) belong to medium and 3(0.9%) belong to large land holding category. On the other hand, out of 63(41.8%) respondents who are living in joint families belong to small, semi-medium, medium and large land holding categories by 7(11.1%), 21(33.3%), 20(31.7%) and 15(23.8%) respectively. The X^2=148.3, df=4 and the result is significant at the level of 0.05 which indicates that there is a significant relationship between the land holding categories and their family type. Which have a large size of holding having joint family structure as compared to other classes.

Table 4.15 recorded the responses of the respondents on the bases of their agriculture income and showed that respondents who are living in nuclear families, 46(12.1%) belong to up to 1.5 lakh income group, 110(33.6%) belong to 1.5 to 3 lakh income group, 98(30%) belong to 3 to 4.5 lakh income group, 52(15.9%) belong to 4.5 to 6 lakh income group and21(6.4%) respondents belong to above 6 lakh income group whereas highest number of the joint families belongs to the highest income groups by 2(3.2%) belong to 1.5 to 3 lakh income group; 20(31.7%) belong to 3 to 4.5 lakh income group; 15(23.8%) belong to 4.5 to 6 lakh and 26(41.3%) belong to above 6 lakh income group. The chi-square is 81.139 with 4 df and the result is significant at the level of

0.05 which shows the strong relationship between income and the housing type of the respondents.

Whereas in terms of their education status, 13(4%), 66(20.2%), 77(23.5%), 108(33%), 54(16.5%) and 9(2.8) nuclear families are owned by uneducated, primary, middle, 10th, 12th and graduated and above level educated respondents respectively. On the other hand, joint families are owned by the respondents who are educated up to primary, middle, 10th, 12th and graduation plus by 2(3.2%), 13(20.6%), 21(33.3%), 18(28.6%) and 9(14.3%) respectively. The chi-square is 54.7 with 5 df and the result is significant at 0.05 level which shows that the housing conditions are significantly associated with the education level of the respondents.

4.2.2.3- School type of the family children

Type of the school is a matter of the socio-economic status of the family and it depends on the income level of the household. During 1991, most of the children studied in government schools as private schools were very limited and their fees were also not affordable by the large number of households due to low-income levels. There were large numbers of joint families and many children lived together in those families, so joint families could not afford the fees of these children for private school. So, almost 95.9% of respondents replied that they studied in government schools. But nowadays, there is a trend of nuclearization and most of the families have one or two children. They are sending their children to private schools which means that their income has increased that's why they can afford private schools' expenses. As we see that agricultural land has decreased but the cropping intensity has been increased which enhanced the income of the farmers. Table 4.16 is showing that 80.3% of respondent's children are studying in private schools and only 19.7% children of the respondents are studying in government schools.

Table 4.17. School of the family children

Blocks	Villages	Govt.		Private		Total
		NO.	%	NO.	%	NO.
Indri block	Jundla	4	20	16	80	20
	Bahlolpur	2	25	6	75	8
	Gularpur	3	15	17	85	20
	Total	9	18.8	39	81.3	48
Panipat block	Sewah	4	12.5	28	87.5	32

	Rajakheri	1	7.1	13	92.9	14
	Palheri	0	0	5	100	5
	Total	5	9.8	46	90.2	51
Smalakha block	Raksehra	3	23.1	10	76.9	13
	Kiwana	1	5	19	95	20
	Haldana	2	22.2	7	77.8	9
	Total	6	14.3	36	85.7	42
Tohsham block	Sandwa	15	22.1	53	77.9	68
	Nigana	3	37.5	5	62.5	8
	Khawa	3	30	7	70	10
	Total	21	24.4	65	75.6	86
Beri block	Majra	8	15.1	45	84.9	53
	Malikpur	1	10	9	90	10
	Palra	0	0	10	100	10
	Total	9	12.3	64	87.7	73
Nagal choudry	Sirohi	5	25	15	75	20
	Morund	0	0	8	100	8
	Amarpura	1	20	4	80	5
	Total	6	18.2	27	81.8	33
Nuh block	Ujina	4	25	12	75	16
	Rehna	7	70	3	30	10
	Chhapera	3	60	2	40	5
	Total	14	45.2	17	54.8	31
Bawal block	Sulkha	2	20	8	80	10
	Rasiawas	2	25	6	75	8
	teekla	3	37.5	5	62.5	8
	Total	7	26.9	19	73.1	26
	Final total	77	19.7	313	80.3	390

(Source- Primary Survey)

In block wise distribution, the percentage of the respondent who are sending their children in govt. and private schools are respectively 18.8% and 81.3% in Indri block; 9.8% and 90.2% in Panipat block; 14.3% and 85.7% in Smalakha block; 24.4% and 75.6% in Tohsham block; 12.3% and 87.8% in Beri block; 18.2% and 81.8% in Nagal Choudry; 26.9% and 73.1% in Bawal block; 45.2% and 54.8% in Nuh block. So, the table 4.16 concluded that due to the trend of nuclearization of families, the parents want to give the best education to their children as education is the most important weapon to survive in the coming years. The land holding sizes are decreasing day by day and growth chances in agriculture are also decreasing, so that, every parent wants to provide better education facilities according to their economic status. If you are unable to bear all the expanses of the private schools, then you can send their children to these schools.

So, it also reflected that the farmer's income has been increased from agriculture which is related from their socio-economic conditions.

Table 4.18. (a): Distribution of the respondents based on school type related to their social category and holding size

	Govt	Private	Total
SC	44 (60.3%)	12 (3.8%)	56 (14.4%)
BC	22 (30.1%)	123 (38.8%)	145 (37.2%)
Gen	7 (9.6%)	182 (57.4%)	189 (48.5%)
Total	73 (18.7%)	317 (81.3%)	390
Chi-square- 161.1, df-2 and the chi-square statistic is significant at the 0.05 level			
Marginal	67 (91.8%)	86 (27.1%)	153 (39.2%)
small	5 (6.8%)	107 (33.8%)	112 (28.7%)
semi-medium	1 (1.4%)	70 (22.1%)	71 (18.2%)
medium	0	36 (11.4%)	36 (9.2%)
large	0	18 (5.7%)	18 (4.6%)
Total	73 (18.7%)	317 (81.3%)	390
Chi-square- 104.6, df-4 and the chi-square statistic is significant at the 0.05 level			

(Computed and calculated by the researcher)

A total of 317(81.3%) respondent's children are studied in private schools of which 12(3.8%) belong to the SC category; 123(38.8%) from the BC category and 182(57.4%) belong to the Gen category whereas 73(18.7%) respondents study in govt. schools in which 44(60.3%) belong to SC category; 22(20.1%) belong to BC and 7(18.7%) belong to Gen category. The chi-square is 161.1 with df-2 and the test is significant at the level of 0.05 which indicates the relation between social groups and the type of school children (4.17-a).

Out of 317 respondents, 86(27.1%) respondents children studied in private schools belong to marginal; 107(33.8%) belong to small; 70(22.1%) belong to semi-medium; 36(11.4%) belong to medium and 18(5.7%) belong to large land holding category. Whereas 73 respondent's children are studied in govt. schools in which 67(91.8%)

belong to Marginal; 5(6.8%) to small and 1(1.4%) belong to semi-medium. The chi-square value is 104.6 with df-4 and the test statistics are significant at the 0.05 level (table 4.17-a)

Table 4.18. (b): Distribution of the respondents based on school type related to their Income and Education Level

	Govt	Private	Total
upto 150000	26 (35.6%)	20 (6.3%)	46 (11.8%)
150000-300000	40 (54.8%)	72 (22.7%)	112 (28.7%)
300000-450000	7 (9.6%)	111 (35%)	118 (30.3%)
450000-600000	0	67 (21.1%)	67 (17.2%)
above 600000	0	47 (14.8%)	47 (12.1%)
Total	73 (18.7%)	317 (81.3%)	390
Chi-square- 103.4, df-4 and the chi-square statistic is significant at the 0.05 level			
uneducated	11 (15.1%)	2 (0.6%)	13 (3.3%)
Primary	40 (54.8%)	28 (8.8%)	68 (17.4%)
Middle	7 (9.6%)	83 (26.2%)	90 (23.1%)
10th	8 (11%)	121 (38.2%)	129 (33.1%)
12th	6 (8.2%)	66 (20.8%)	72 (18.5%)
graduation+	1 (1.4%)	17 (5.4%)	18 (4.6%)
Total	73 (18.7%)	317 (81.3%)	390
Chi-square- 136.51, df-5 and the chi-square statistic is significant at the 0.05 level			

(Computed and calculated by the researcher)

Out of 317 respondents whose children study in private schools are coming from 20(6.3%) up to 1.5 lakh income group; 72(22.7%) from 1.5 to 3 lakh; 111(35%) from 3 to 4.5 lakh; 67(21.1%) from 4.5 to 6 lakh; 47(14.8%) from above 6 lakh income group. Whereas 73 (18.7%) respondents children study in govt. school are belong to 26(35.6%) up to 1.5 lakh income group; 40(54.8%) belong to 1.5 lakh to 3 lakh and 7(9.6%) belong to 3 to 4.5 lakh income group. The chi-square is 103.4 with df-4 and the result is significant at the level of 0.05 (4.17-b).

On the education basis, the number and the percentage of the respondents whose children study in private schools belong to the different education groups respectively 2(0.6%) uneducated category; 28(8.8%) educated up to primary; 83(26.2%) up to matric; 121(38.2%) up to 10th; 66(20.8%) up to 12th and 17(5.4%) are graduates and above. People whose children study in government schools also belong to different education groups respectively 11(15.1%) are uneducated; 40(54.8%) educated up to primary; 7(9.6%) up to middle; 8(11%) up to 10th standard; 6(8,2%) up to 12th and 1(1.4%) up to graduation. The chi-square value is 136.51 with df-5 and the result is significant at 0.05 level which shows the association between the education level and the school selection of the children (4.17-b).

4.2.2.4-Change in House Assets

The resources which have economic value are owned by the individual or household. There are two types of assets- current assets, fixed assets, financial assets and intangible assets. Here we talking about fixed assets which means that resources that have an expected life to serve like equipment, buildings etc. house assets are a very important economic indicator to show the change in the living standard of the family. Table 4.18 shows the house assets of the respondents which depend on the income level of the household. Out of 390 respondents, there are 51(13.1%) had t.v., W.M., fridge & bicycle; 150(38.5%) had t.v., W.M., fridge, bicycle & bike; 96(24.6%) had t.v., W.M., fridge, bicycle, bike & tractor; 42(10.8%) had t.v., W.M., fridge, bicycle, bike & car and 51(13.1%) had all the above said house assets available in their houses.

Table 4.19. House Assets

Block	Villages	H.A.C.-1- t.v., WM, fridge, Cycle		H.A.C.-2- t.v., WM, fridge, Cycle, bike		H.A.C.-3- t.v., WM, fridge, Cycle, bike tractor		H.A.C.-4- t.v., WM, fridge, bike car,		H.A.C.-5- All of them		Total
		NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.
Indri	Jundla	1	5.0	3	15.0	5	25.0	8	40.0	3	15.0	20
	Bahlolpur	0	0.0	2	25.0	3	37.5	1	12.5	2	25.0	8
	Gularpur	0	0.0	6	30.0	6	30.0	4	20.0	4	20.0	20
	Total	1	2.1	11	22.9	14	29.2	13	27.1	9	18.8	48
Panipat	Sewah	2	6.3	18	56.3	6	18.8	1	3.1	5	15.6	32
	Rajakheri	0	0.0	2	14.3	8	57.1	2	14.3	2	14.3	14
	Palheri	0	0.0		0.0	4	80.0		0.0	1	20.0	5
	Total	2	3.9	20	39.2	18	35.3	3	5.9	8	15.7	51
S	Raksehra	1	7.7	4	30.8	0	0.0	4	30.8	4	30.8	13

	Kiwana	0	0.0	8	40.0	5	25.0	2	10.0	5	25.0	20
	Haldana	1	11.1	2	22.2	3	33.3	2	22.2	1	11.1	9
	Total	2	4.8	14	33.3	8	19.0	8	19.0	10	23.8	42
Tohsham	Sandwa	26	38.2	27	39.7	8	11.8	7	10.3	0	0.0	68
	Nigana	2	25.0	2	25.0	3	37.5	1	12.5	0	0.0	8
	Khawa	3	30.0	3	30.0	2	20.0	2	20.0	0	0.0	10
	Total	31	36.0	32	37.2	13	15.1	10	11.6	0	0.0	86
Beri	Majra	0	0	26	49.1	15	28.3	4	7.5	8	15.1	53
	Malikpur	0	0	5	50.0	3	30.0	0	0.0	2	20.0	10
	Palra	0	0	7	70.0	2	20.0	0	0.0	1	10.0	10
	Total	0	0	38	52.1	20	27.4	4	5.5	11	15.1	73
Nagal choudry	Sirohi	6	30.0	5	25.0	6	30.0	0	0	3	15.0	20
	Morund	1	12.5	5	62.5	0	0.0	0	0	2	25.0	8
	Amarpura	1	20.0	1	20.0	1	20.0	0	0	2	40.0	5
	Total	8	24.2	11	33.3	7	21.2	0	0	7	21.2	33
Nuh	Ujina	2	12.5	7	43.8	2	12.5	2	12.5	3	18.8	16
	Rehna	1	10.0	2	20.0	7	70.0	0	0	0	0	10
	Chhapera	1	20.0	2	40.0	1	20.0	1	20.0	0	0	5
	Total	4	12.9	11	35.5	10	32.3	3	9.7	3	9.7	31
Bawal	Sulkha	0	0.0	6	60.0	1	10.0	1	10.0	2	20.0	10
	Rasiawas	1	12.5	4	50.0	2	25.0	0	0	1	12.5	8
	teekla	2	25.0	3	37.5	3	37.5	0	0	0	0.0	8
	Total	3	11.5	13	50.0	6	23.1	1	3.8	3	11.5	26
	Final total	51	13.1	150	38.5	96	24.6	42	10.8	51	13.1	390

(Source- Primary Survey) Note:- H.A.C.-House Assets Class

The distribution of number and percentage of different house assets namely H.A.C.1, 2, 3, 4 & 5 at block level are respectively in Indri block it is 1(2.2%), 11(22.9%), 14(29.2%), 13(27.1%) & 9(18.8%); in Panipat block it is 2(3.9%), 20(39.2%), 18(35.3%), 3(5.9%) & 8(15.7%); in Smalakha block it is 2(4.8%), 14(33.3%), 8(19%), 8(19%) & 10(23.8%); Tohsham block it is 31(36%), 32(37.2%), 13(15.1%) & 10(11.6%); in Beri block, 38(52.1), 20(27.4%), 4(5.5%) & 11(15.1%); in Nagal Choudry block it is 8(24.2%), 11(33.3%), 7(21.2%) & 7(21.2%); in Nuh block it is 4(12.9%), 11(35.5%), 10(32.3%), 3(9.7%) & 3(9.7%) and in Bawal block it is 3(11.5%), 13(50%), 6(23.1%), 1(3.8%) & 3(11.5%).

Table 4.18 concludes that there is a slight increase in income from agriculture of the respondents that's why they are unable to purchase more and more house assets. So, the results said that the income has increased from agriculture but the agricultural practices are not sustainable for present as well as future agriculture growth.

To check the association between house assets and their income, social category, education and land holding size, the chi-square test has been applied.

Table 4.20. Distribution of the respondents based on house assets related to their social category, holding size, Income and education

Social Groups	H.A.C.-1	H.A.C.-2	H.A.C.-3	H.A.C.-4	all of them	Total
SC	25 (48.1%)	31 (20.8%)	0	0	0	56 (14.4%)
BC	23 (44.2%)	66 (44.3%)	41 (42.7%)	11 (26.2%)	4 (7.8%)	145 (37.2%)
Gen	4 (7.7%)	52 (34.9%)	55 (57.3%)	31 (73.8%)	47 (92.2%)	189 (48.5%)
Total	52 (13.3%)	149 (38.2%)	96 (24.6%)	42 (10.8%)	51 (13.1%)	390
Chi-square- 140, df-8 and the chi-square statistic is significant at the 0.05 level						
Marginal	51 (98.1%)	84 (56.4%)	17 (17.7%)	1 (2.4%)	0	153 (39.2%)
small	1 (1.9%)	44 (28.5%)	57 (59.4%)	10 (23.8%)	0	112 (28.7%)
semi-medium	0	21 (14.1%)	21 (21.9%)	16 (38.1%)	13 (25.5%)	71 (18.2%)
medium	0	0	1 (1%)	11 (26.2%)	24 (47.1%)	36 (9.2%)
large	0	0	0	4 (9.5%)	14 (27.5%)	18 (4.6%)
Total	52 (13.3%)	149 (38.2%)	96 (24.6%)	42 (10.8%)	51 (13.1%)	390
Chi-square- 375.76, df-16 and the chi-square statistic is significant at the 0.05 level						
Up to 150000	46 (88.5%)	0	0	0	0	46 (11.8%)
150000-300000	4 (7.7%)	93 (62.4%)	14 (14.6%)	1 (2.4%)	0	112 (28.7%)
300000-450000	2 (3.8%)	54 (36.2%)	54 (56.2%)	8 (19%)	0	118 (30.1%)
450000-600000	0	2 (1.3%)	28 (29.2%)	29 (69%)	8 (15.7%)	67 17.2%)
above 600000	0	0	0	4 (9.5%)	43 (84.3%)	47 (12.1%)
Total	52 (13.3%)	149 (38.2%)	96 (24.6%)	42 (10.8%)	51 (13.1%)	390
Chi-square- 811.3, df-16 and the chi-square statistic is significant at the 0.05 level						
uneducated	4 (7.7%)	9 (6%)	0	0	0	13 (3.3%)
Primary	28 (53.8%)	35 (23.5%)	1 (1%)	1 (2.4%)	3 (5.9%)	68 (17.4%)
Middle	12 (23.1%)	39 (26.2%)	16 (16.7%)	9 (21.4%)	14 (27.5%)	90 (23.1%)
10th	3 (5.8%)	37 (24.8%)	55 (57.3%)	16 (38.1%)	18 (35.3%)	129 (33.1%)
12th	5	24	18	14	11	72

	(9.6%)	(16.1%)	(18.8%)	(33.3%)	(21.6%)	(18.5%)
graduation+	0	5 (3.4%)	6 (6.2%)	2 (4.8%)	5 (9.8%)	18 (4.6%)12
Total	52 (13.3%)	149 (38.2%)	96 (24.6%)	42 (10.8%)	51 (13.1%)	390
Chi-square- 128.7, df-20 and the chi-square statistic is significant at the 0.05 level						

(Computed and calculated by the researcher)

The distribution of house assets namely H.A.C. 1,2,3,4 & 5 according to their social category, in H.A.C.1, the number and percentage are respectively 25(48.1%) from SC; 23(44.2%) from BC & 4(7.7%) from General category, whereas in H.A.C.2, 31(20.8%) from SC; 66(44.3%) from BC & 52(34.9%) from General category. in rest of the three classes, all the assets owned by the BC and General categories. The Chi-square value is 140 with df-8 and the test is significant at the level of 0.05 which proves the association between social groups and ownership of the house assets (table 4.19).

The distribution of house assets based on land holding is as follows, in H.A.C.1, 51(98.1%) respondents belong to marginal and 1(1.9%) belong to the small land holding group whereas in H.A.C.-2, 84(56.4%) belong to marginal, 44(28.5%) to small and 21(14.1%) to semi-medium. In H.A.C.3, 17(17.7%) belong to marginal, 57(59.4%) to small, 21(21.9%) to semi-medium and 1(1%) to medium whereas most of the H.A.C.4 & 5 are owned by the semi-medium, medium and large landholders. The chi-square value is 375.76 with df 16 and the result is significant at the level of 0.05 (Table 4.19).

In the distribution of house assets based on their income, the number and percentage in H.A.C.1 are respectively 46(88.5%) belong to up to 1.5lakh income group, 7(7.7%) belong to 1.5 to 3 lakh and 2(3.8%) belong to 3 to 4.5 lakh income group whereas in H.A.C.2, 93(62.4%) belong to 1.5 to 3 lakh income group, 54(36.2%) belong to 3 to 4.5 lakh group and 2(1.3%) belong to 4.5 to 6 lakh income group. In H.A.C.3, 14(14.6%) belong to 1.5 to 3 lakh income group, 54(56.2%) belong to 3 to 4.5 lakh group and 28(29.2%) belong to 4.5 to 6 lakh income group. H.A.C. 4 & 5 are mostly owned by higher-income groups. The chi-square value is 811.3 with df-16 and the result is significant at the level of 0.05 (Table 4.19).

In the distribution of the house assets based on their education level, the number and percentage of the H.A.C.1 are respectively 4(7.7%) owned by uneducated respondents;

28(53.8%) by primary level; 12(23.1%) belong to educated up to middle; 3(5.8%) up to 10th standard and 5(9.6%) up to 12th standard, whereas H.A.C.2 owned by 9(6%) belong to uneducated category, 35(23.5%) up to primary, 39(26.2%) belong to middle, 37(24.8%), belong to 10th standard, 24(16.1%) up to 12th standard and 5(3.4%) belong to graduation plus category. H.A.C.3 owned by 1(1%) belong to primary, 16(16.7%) belong to middle, 55(57.3%) belong to 10th, 18(18.8%) belong to 12th and 6(6.2%) belong to graduation plus category. most of the H.A.C.4 & 5 are owned by the respondents who are educated up to 10th and above. The chi-square value is 128.7 with df-20 and the test is significant at the level of 0.05 which proves the association between education and the availability of the house assets (Table 4.19).

4.2.2.2.5-Agriculture work pattern

Agricultural work pattern mean how the respondents work on their farms – themselves or with the help of the labourers. It is a very important socio-economic indicator as it totally depends on income and also family size. Nowadays, there is a trend of nuclearization which changed agricultural work sharing. In past, there were so many joint families and all family members did their work on their own. But due to decreasing family sizes and also holding sizes, the work has been shifted towards the labour part. For the present research, the agriculture work pattern has been divided into three categories namely self, self with labour and total labour. Table 20 shows that only 20% of the respondents are doing their agricultural work with their family members and all these belong to the marginal land-holding class; 39.2% are does their work self with labour and 40.8% are doing their farm work with the labour support.

Table 4.21:-Agriculture work pattern

How to do Agricultural work									
Blocks	Villages	Self		Self with labour		Labour		Total	
		NO.	%	NO.	%	NO.	%	NO.	%
Indri	Jundla	4	20	3	15.0	13	65.0	20	100
	Bahlolpur	2	25	2	25.0	4	50.0	8	100
	Gularpur	4	20	4	20.0	12	60.0	20	100
	Total	10	20.8	9	18.8	29	60.4	48	100
Panipat	Sewah	7	21.9		0.0	25	78.1	32	100
	Rajakheri		0	4	28.6	10	71.4	14	100
	Palheri	2	40	3	60.0		0.0	5	100
	Total	9	17.6	7	13.7	35	68.6	51	100

Smalakha	Raksehra	4	30.8	1	7.7	8	61.5	13	100
	Kiwana	4	20	4	20.0	12	60.0	20	100
	Haldana	2	22.2	2	22.2	5	55.6	9	100
	Total	10	23.8	7	16.7	25	59.5	42	100
Tohsham	Sandwa	20	29.4	37	54.4	11	16.2	68	100
	Nigana	3	37.5	4	50.0	1	12.5	8	100
	Khawa	4	40	4	40.0	2	20.0	10	100
	Total	27	31.4	45	52.3	14	16.3	86	100
Beri	Majra	0	0.0	26	49.1	27	50.9	53	100
	Malikpur	0	0.0	4	40.0	6	60.0	10	100
	Palra	2	20.0	3	30.0	5	50.0	10	100
	Total	2	2.7	33	45.2	38	52.1	73	100
Nagal	Sirohi	7	35.0	10	50.0	3	15.0	20	100
	Morund	2	25.0	4	50.0	2	25.0	8	100
	Amarpura	1	20.0	2	40.0	2	40.0	5	100
	Total	10	30.3	16	48.5	7	21.2	33	100
Nuh block	Ujina	3	18.8	8	50.0	5	31.3	16	100
	Rehna	4	40.0	6	60.0		0.0	10	100
	Chhapera	1	20.0	1	20.0	3	60.0	5	100
	Total	8	25.8	15	48.4	8	25.8	31	100
Bawal	Sulkha	0	0.0	8	80.0	2	20.0	10	100
	Rasiawas	0	0.0	7	87.5	1	12.5	8	100
	teekla	2	25.0	6	75.0		0.0	8	100
	Total	2	7.7	21	80.8	3	11.5	26	100
	Final total	78	20.0	153	39.2	159	40.8	390	100

(Source- Primary Survey)

In block-wise distribution, the number and the percentage of the respondents in different agriculture work pattern categories namely with family, family with labour and fully labour are respectively 10(20.8%), 9(18.8%) & 29(60.4%) in Indri block; 9(17.6%), 7(13.7%) & 35(68.6%) in Panipat block; 10(23.8%), 7(16.7%) & 25(59.5%) in Smalakha block; 27(31.4%), 45(52.3%) & 14(16.3%) in Tohsham block; 2(2.7%), 33(45.2%) & 38(52.1%) in Beri block; 10(30.3%), 16(48.5%) & 7(21.2%) in Nagal Choudry; 8(25.8%), 15(48.4%) & 8(25.8%) in Nuh block; 2(7.7%), 21(80.8%) & 3(11.5%) in Bawal block (Table 4.20).

the trend of nuclearization modifies the family sizes and now only 4 to 6 members are living in large number of nuclear families which also affects the spirit of work in fields. However, the income from agriculture has increased which unable the farmers from hiring the labour and machines in their farms. So, it also shows that the socio-economic conditions of the respondents have been changed due to changes in cropping patterns and land use/land cover.

The responses of the respondents about their work patterns in farms were further related to their social groups, land holdings, income and education with the help of the chi-square.

Among all the social groups namely SC, BC & General, the number and percentage of the respondents who did their farm work with family are respectively 55(72.4%) from SC and 21(27.6%) from BC whereas the respondents who did their work family with labour are 1(0.7%) from SC, 78(51.3%) from BC & 73(48%) from General category. those respondents who are doing all the farm work with only labour belong to BC and General categories. The chi-square value is 289.4 with df-4 and the test is statistically significant at the level of 0.05. it means that the work pattern of the respondents is associated with their social class.

Table 4.22:- Distribution of the respondents based on their agriculture work pattern related to their social category, holding size, Income and education

	Self	Self with labour	Only labour	
SC	55 (72.4%)	1 (0.7%)	0	56 (14.4%)
BC	21 (27.6%)	78 (51.3%)	46 (28.4%)	145 (37.2%)
Gen	0	73 (48%)	116 (71.6%)	189 (48.5%)
Total	76 (19.5%)	152 (38.9%)	162 (41.5%)	390
Chi-square- 289.4, df-4 and the chi-square statistic is significant at the 0.05 level				
Marginal	76 (100)	77 (50.7%)	0	153 (39.2%)
small	0	43 (28.3%)	69 (42.6%)	112 (28.7%)
semi-medium	0	32 (21.1%)	39 (24.1%)	71 (18.2%)
medium	0	0	36 (22.2%)	36 (9.2%)
large	0	0	18 (11.1%)	18 (4.6%)
Total	76 (19.5%)	152 (38.9%)	162 (41.5%)	390
Chi-square- 266.4, df-8 and the chi-square statistic is significant at the 0.05 level				
Up to 150000	35 (46.1%)	10 (6.6%)	1 (0.6%)	46 (11.8%)
150000-300000	30 (39.5%)	70 (46.1%)	12 (7.4%)	112 (28.7%)

300000-450000	11 (14.5%)	65 (42.8%)	42 (25.9%)	118 (30.3%)
450000-600000	0	7 (4.6%)	60 (37%)	67 (17.2%)
above 600000	0	0	47 (29%)	47 (12.1%)
Total	76 (19.5%)	152 (38.9%)	162 (41.5%)	390
Chi-square- 286.4, df-8 and the chi-square statistic is significant at the 0.05 level				
uneducated	12 (15.8%)	1 (0.7%)	0	13 (3.3%)
Primary	47 (61.8%)	16 (10.5%)	5 (3.1%)	68 (17.4%)
Middle	7 (9.2%)	41 (27%)	42 (25.9%)	90 (23.1%)
10th	5 (6.6%)	53 (34.9%)	71 (43.8%)	129 (33.1%)
12th	4 (5.3%)	33 (21.7%)	35 (21.6%)	72 (18.5%)
graduation+	1 (1.3%)	8 (5.3%)	9 (5.6%)	18 (4.6%)
Total	76 (19.5%)	152 (38.9%)	162 (41.5%)	390
Chi-square- 194.3, df-10 and the chi-square statistic is significant at the 0.05 level				

(Computed and calculated by the researcher)

The distribution of the respondents based on their holding categories, all the respondents who did their farm work with their family members belong to the marginal land holding category whereas who did their farm work with family and labour are respectively 77(50.7%) belong to marginal; 43(28.3%) belong to small and 32(21.2%) belong to semi-medium. respondents who are doing their farm work with the help of the labour only are respectively 69(42.6%) belong to small land holding; 39(24.1%) belong to semi-medium; 36(22.2%) belong to medium and 18(11.1%) belong to large land holding categories. The Chi-square value is 266.4 with df-8 and the test is significant at the level of 0.05 (Table 4.21).

The distribution of the respondents based on their income categories, the number and percentage of the respondents who did their farm work with family members are respectively 35(46.1%) belong to up to 1.5 lakh income group; 30(39.5%) belong to 1.5 to 3 lakh; 11(14.5%) belong to 3 to 4.5 lakh income group whereas the respondents who did their farm work with family and labour help are respectively 10(6.6%) belong to up to 1.5 lakh income group; 70(46.1%) belong to 1.5 to 3 lakh; 65(42.8%) belong to 3 to 4.5 lakh and 7(4.6%) belong to 4.5 to 6 lakh income group. Most of the respondents who are doing their farm work with labour only belong to higher income groups. The chi value is 286.4 with df-8 and the test is statistically significant at the level 0.05 (Table 4.21).

The distribution of the respondents based on their education level, the number and percentage who did their farm work with family members are respectively 12(15.8%) belong to the uneducated education group; 47(61.8%) belong to primary; 7(9.2%) belong to the middle; 5(6.6%) belong to 10th; 4(5.3%) belong to 12th and 1(1.3%) belong to graduation plus education group. The respondents who are doing their farm work with family & labour are respectively 1(0.7%) belong to uneducated group; 16(10.5%) belong to primary; 41(27%) belong to middle; 53(34.9%) belong to 10th; 33(21.7%) belong to 12th and 8(5.3%) belong to graduation plus education group whereas who are doing their farm work with labour only are respectively 5(3.1%) belong to primary; 42(25.9%) belong to middle; 71(43.8%) belong to 10th; 35(21.6%) belong to 12th and 9(5.6%) belong to graduation plus education group. The chi-square value is 194.3 with df-10 and the test is statistically significant at the level 0.05 (Table 4.21)

4.2.3 Farmers perspective regarding sustainability

We cannot measure agricultural sustainability unless we know the level of awareness of people about it. In this part, we are going to discuss about the farmers knowledge regarding sustainability, cropping pattern and cropping system followed by them, economic sustainability of the present income and some major agriculture problems faced by the farmers.

4.2.3.1-Awareness regarding sustainability concept

It is a prior condition to have knowledge of any concept or method before adopting it. We want to check the awareness about agricultural sustainability of the farmers whether they are aware about this concept or not. If we want to reform present agricultural system and make it sustainable, it is necessary to spread awareness regarding this concept as it is a new concept for the farmers. It is very crucial phenomenon but a sound attempt was done to decide whether the respondents familiar or not with this concept.

Table 4.23- Awareness regarding Sustainability

Villages	Yes		No		Total
	NO.	%	NO.	%	
Jundla	2	10	18	90	20
Bahlolpur	0	0	8	100	8
Gularpur	1	5	19	95	20
Total	3	6.3	45	93.8	48
Sewah	0	0.0	32	100.0	32
Rajakheri	1	7.1	13	92.9	14
Palheri	1	20.0	4	80.0	5
Total	2	3.9	49	96.1	51
Raksehra	0	0.0	13	100.0	13
Kiwana	0	0.0	20	100.0	20
Haldana	0	0.0	9	100.0	9
Total	0	0.0	42	100.0	42
Sandwa	1	1.5	67	98.5	68
Nigana	0	0.0	8	100.0	8
Khawa	0	0.0	10	100.0	10
Total	1	1.2	85	98.8	86
Majra	2	3.8	51	96.2	53
Malikpur	0	0.0	10	100.0	10
Palra	0	0.0	10	100.0	10
Total	2	2.7	71	97.3	73
Sirohi	2	10.0	18	90.0	20
Morund	0	0.0	8	100.0	8

Amarpura	0	0.0	5	100.0	5
Total	2	6.1	31	93.9	33
Ujina	1	6.3	15	93.8	16
Rehna	2	20.0	8	80.0	10
Chhapera	1	20.0	4	80.0	5
Total	4	12.9	27	87.1	31
Sulkha	0	0.0	10	100.0	10
Rasiawas	1	12.5	7	87.5	8
teekla	1	12.5	7	87.5	8
Total	2	7.7	24	92.3	26
Final total	16	4.1	374	95.9	390

(Source- Primary Survey)

The table 4.22 showing that only 4.1% of the respondents said that they are aware about agriculture sustainability concept and 95.9% of the farmers said that they did not know anything about agriculture sustainability. So, it is a big issue as most of the respondents are unaware about the concept though it is very old. So, there is an urgent need of spreading awareness regarding this concept among the farmers if we want to make the agriculture sustainable. The number of the respondents who said yes to this concept are respectively 3 in Indri block; 2 in Panipat block; 1 in Tohsham block; 2 in Beri block; 2 in Nagal Choudry block; 4 in Nuh block and 2 in Bawal block. There are many factors which are responsible for unawareness of the respondents about this concept like lack of education and govt. efforts. If we ask them about organic farming, they said yes to it but if we ask sustainability, they are fully unaware about that.

Table 4.24:- Distribution of the respondent's awareness level on the basis of education and land holding sizes

Education Classes	Awareness regarding Sustainability concept				
	Yes		No		Total
	No.	%	No	%	No/%
Uneducated	0	0	13	3.5	13(3.3%)
Primary	0	0	68	18.2	68(17.4%)
Middle	0	0	90	24.1	90(23.1%)
10th	0	0	129	34.5	129(33.1%)
12th	6	37.5%	66	17.6	72(18.5%)
graduation+	10	62.5%	8	2.1	18(4.6%)
Total	16	4.1%	374	95.9	390
The chi square is 137.2 with 5 df and result is significant at the level of 0.05					

(Computed and calculated by the researcher)

On the basis of education level, the number and percentage of the respondents who said yes to knowledge about sustainability concept are respectively; 6(37.5%)) to 12th ; 10(62.5%) to graduation plus educational group. The respondents who said no are respectively 13(3.5%) belong to uneducated group; 68(18.2%) belong to primary; 90(24.1%) to middle; 129(34.5%) to 10th; 66(17.6%) to 12th; 8(2.1%) to graduation plus educational group. The chi value is 137.2 with df-5 and the result is statistically significant. It means that there is an association between education level and their responses about awareness of sustainability concept (table 4.23).

4.2.3.2-Cropping Pattern

Cropping pattern is the spatial arrangement of the different crops with respect to the time and area. It is the percentage of the areas under different crops and their sequence. If any change occurred in the cropping pattern in any area may cause change in the area under a crop and also its spatial sequence with respect to the time. Cropping pattern of any country/ state/ district is the results of the physical, social and economic indicators available here. Physical factors include rainfall, temperature, moisture, climatic conditions and soil type whereas economic indicators include the price & demand of the particular crop and social indicators include social background, size of the land holding, age, educational status, category and also the experience and knowledge about the new technologies emerged in the agricultural field. In Haryana, two cropping system are following by the farmers namely mixed farming and mono-culture. Mixed cropping pattern means growing multiple crops on the same farm at the same period of time ie growing wheat and mustard together. Mixed cropping pattern is a good method for soil health as well as risk management during failure of one crop. Mono-culture means growing same crops every year at the same piece of land and it is very harmful for the soil and water conditions of the area and it also increase the risk of diseases which affects the crop health and production. The most remarkable change in the cropping pattern of NCR Haryana is shifting of mixed cropping pattern towards growing only two crops namely rice and wheat or mono-culture. This mono-culture spreads in all the district which have good soil conditions, irrigation facilities and market facilities. District namely Bhiwani, Mahendergarh, Nuh, Gurgaon, Jhajjar and Rewari are following the mixed farming at present but due to the increasing irrigation facilities, there is a slight shift in their crops sown in their farms like gram replaced by wheat and mustard.

Among all the surveyed villages, the percentage of the respondents who followed different cropping patterns are respectively 55.6% sowing only W-R, 0.5% sowing W-R-S, 7.4% sowing M-B-W-C, 23.3% B-M-W-G, 4.4% sowing C-W and 8.7% sowing B-W-M. highest number of the respondents are following mono-culture as they are growing only two crops namely wheat-rice, wheat-cotton. Among all the respondents 60.5% are following mono-culture and only 39.5% are following mixed cropping pattern. So, it is a big hinderance in the way of agricultural sustainability within the region (table 4.24,25).

Table 4.25:- Distribution of Respondents on the Basis of Cropping Pattern

Cropping Pattern													
Villages	W-R		W-R-S		M-B-W-C		M-B-W-G		C-W		B-W-M		Total
	NO.	%	NO.	%	No	%	No	%	No	%	No	%	No.
Jundla	20	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20
Bahlolpur	8	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	8
Gularpur	20	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20
Total	48	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	48
Sewah	32	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	32
Rajakheri	14	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	14
Palheri	5	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5
Total	51	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	51
Raksehra	13	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	13
Kiwana	20	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20
Haldana	9	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	9
Total	42	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	42
Sandwa	0	0.0	0	0.0	0	0.0	58	85.3	0	0.0	10	14.7	68
Nigana	0	0.0	0	0.0	0	0.0	4	50.0	0	0.0	4	50.0	8
Khawa	0	0.0	0	0.0	5	50.0	1	10.0	4	40.0	0	0.0	10
Total	0	0.0	0	0.0	5	5.8	63	73.3	4	4.7	14	16.3	86
Majra	53	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	53
Malikpur	10	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10
Palra	10	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10
Total	73	100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	73
Sirohi	0	0.0	0	0.0	0	0.0	16	80.0	0	0.0	4	20.0	20
Morund	0	0.0	0	0.0	0	0.0	5	62.5	0	0.0	3	37.5	8
Amarpura	0	0.0	0	0.0	3	60.0	0	0.0	2	40.0	0	0.0	5
Total	0	0.0	0	0.0	3	9.1	21	63.6	2	6.1	7	21.2	33
Ujina	0	0.0	0	0.0	12	75.0	0	0.0	4	25.0	0	0.0	16

Rehna	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	100	10
Chhapera	3	60.	2	40	0	0.0	0	0.0	0	0.0	0	0.0	5
Total	3	9.7	2	6.5	12	38.7	0	0.0	4	12.9	10	32.3	31
Sulkha	0	0.0	0	0.0	0	0.0	7	70.0	0	0.0	3	30.0	10
Rasiawas	0	0.0	0	0.0	4	50.0	0	0.0	4	50.0	0	0.0	8
teekla	0	0.0	0	0.0	5	62.5	0	0.0	3	37.5	0	0.0	8
Total	0	0.0	0	0.0	9	34.6	7	26.9	7	26.9	3	11.5	26
Final total	217	55.6	2	0.5	29	7.4	91	23.3	17	4.4	34	8.7	390

(Source- Primary Survey)

Note:- W (wheat), R (rice), S(Sugarcane), C(cotton), M (mustard), G(gram)

Table 4.26- Distribution of Respondents on the Basis of Cropping System

Blocks	Villages	Mono-culture		Mixed-cropping		Total
		No	%	No	%	No
Indri	Jundla	20	100	0	0	20
	Bahlolpur	8	100	0	0	8
	Gularpur	20	100	0	0	20
	Total	48	100	0	0	48
Panipat	Sewah	32	100	0	0	32
	Rajakheri	14	100	0	0	14
	Palheri	5	100	0	0	5
	Total	51	100	0	0	51
Smalakha	Raksehra	13	100	0	0	13
	Kiwana	20	100	0	0	20
	Haldana	9	100	0	0	9
	Total	42	100	0	0	42
Tohsham	Sandwa	0	0	68	100	68
	Nigana	0	0	8	100	8
	Khawa	4	40	6	60	10
	Total	4	4.7	82	95.3	86
Beri	Majra	53	100.0	0	0.0	53
	Malikpur	10	100.0	0	0.0	10
	Palra	10	100.0	0	0.0	10
	Total	73	100.0	0	0.0	73
Nangal Choudry	Sirohi	0	0.0	20	100.0	20
	Morund	0	0.0	8	100.0	8
	Amarpura	2	40.0	3	60.0	5
	Total	2	6.1	31	93.9	33
Nuh	Ujina	4	25.0	12	75.0	16
	Rehna	0	0.0	10	100.0	10
	Chhapera	5	100.0	0	0.0	5
	Total	9	29.0	22	71.0	31
Bawal	Sulkha	0	0.0	10	100.0	10
	Rasiawas	4	50.0	4	50.0	8
	teekla	3	37.5	5	62.5	8
	Total	7	26.9	19	73.1	26
	Final total	236	60.5	154	39.5	390

(Source- Primary Survey)

At block level, all the respondents of Indri block, Panipat, Smalakha & Beri are growing only two crops wheat and rice whereas the number and percentage of the respondents who following different cropping pattern in blocks namely Tohsham, Nagal Choudry, Nuh and Bawal are respectivrly 5(5.8%) growing M-B-W-C, 63(73.3%) M-B-W-G, 4(4.7%) C-W, 14(16.3%) B-W-M; 3(9.1%) growing M-B-W-C, 21(63.2%) M-B-W-G, 2(6.1%) C-W, 7(21.2%) B-W-M; 3(9.7%) growing W-R, 2(6.5%) W-R-S, 12(38.3%) growing M-B-W-C, 4(12.9%) C-W, 10(32.3%) B-W-M; 9(34.6%) growing M-B-W-C, 7(26.9%) M-B-W-G, 7(26.9%) C-W, 3(11.5%) B-W-M. if we talk about cropping system, four blocks namely Indri, Panipat, Smalakha and Beri are following mono-culture in the form of wheat and rice and all these are also said yes to the decreasing water table in their areas (table 4.25).

Further to check the association between the cropping pattern adopted by the farmers with income, land holding, education and social groups, the chi-square test of independence has been applied.

Table 4.27- Distribution of the respondents on the basis of Cropping pattern related with their social category, holding size, Income and education

	W-R	W-R-S	M-B-W-C	M-B-W-G	C-W	B-W-M	Total
SC	28 (12.9%)	0	5 (17.2%)	17 (18.7%)	3 (17.6%)	3 (8.8%)	56 (14.4%)
BC	81 (37.3%)	0	8 (27.6%)	36 (39.6%)	5 (29.4%)	15 (44.1%)	145 (37.2%))
Gen	108 (49.8%)	2 (100%)	16 (55.2%)	38 (41.8%)	9 (52.9%)	16 (47.1%)	189 (48.5%)
Total	217 (55.6%)	2 (0.5%)	29 (7.4%)	91 (23.3%(	17 (4.4%)	34 (8.7%)	390
The chi-square 7.5, df-10 and significant is not at the 0.05 level							
Marginal	85 (39.2%)	0	8 (27.6%)	43 (47.3%)	7 (41.2%)	10 (29.4%)	153 (39.2%)
small	66 (30.4%)	0	9 (31%)	23 (25.3%)	4 (23.5%)	10 (29.4%)	112 (28.7%)
semi-medium	38 (17.5%)	1 (50%)	6 (20.7%)	12 (13.2%)	3 (17.6%)	11 (32.4%)	71 (18.2%)
medium	20 (9.2%)	0	3 (10.3%)	8 (8.8%)	2 (11.8%)	3 (8.8%)	36 (9.2%)
large	8 (3.7%)	1 (50%)	3 (10.3%)	5 (5.5%)	1 (5.9%)	0	18 (4.6%)
Total	217 (55.6%)	2 (0.5%)	29 (7.4%)	91 (23.3%)	17 (4.4%)	34 (8.7%)	390
The chi-square 25.3, df-20 and not significant at the 0.05 level							
Up to 150000	3 (1.4%)	0	2 (6.9%)	32 (35.2%)	5 (29.4%)	4(11.8%)	46 (11.8%)

150000-300000	67 (30.9%)	0	12 (41.4%)	23 (25.3%)	3 (17.6%)	7(20.6%)	112 (28.7%)
300000-450000	61 (28.1%)	2 (100%)	11 (37.9%)	22 (24.2%)	6 (35.3%)	16(47.1%)	118 (30.3%)
450000-600000	46 (21.2%)	0	2 (6.9%)	11 (12.1%)	2 (11.8%)	6(17.6%)	67 (17.2%)
above 600000	40 (18.4%)	0	2 (6.9%)	3 (3.3%)	1 (5.9%)	1(2.9%)	47 (12.1%)
Total	217 (55.6%)	2(0.5%)	29 (7.4%)	91 (23.3%)	17 (4.4%)	34(8.7%)	390
The chi-square 103.1, df-20 and significant at the 0.05 level							
uneducated	7(3.2%)	0	1(3.4%)	4(4.4%)	0	1 (2.9%)	13 (3.3%)
Primary	28(12.9%)	0	5(17.2%)	26(28.6%)	5 (29.4%)	4 (11.8%)	68 (17.4%)
Middle	59(27.2%)	0	4(13.8%)	21(23.1%)	2 (11.8%)	4 (11.8%)	90 (23.1%)
10th	81(37.3%)	0	12(41.4%)	22(24.1%)	2 (11.8%)	12 (35.3%)	129 (33.1%)
12th	35 (16.1%)	2(100%)	6(20.7%)	14(15.4%)	7(41.2%)	8(23.5%)	72 (18.5%)
graduation+	7 (3.2%)	0	1 (3.4%)	4 (4.4%)	1 (5.9%)	5 (14.7%)	18 (4.6%)
Total	217 (55.6%)	2 (0.5%)	29 (7.4%)	91 (23.3%(	17 (4.4%)	34 (8.7%)	390
The chi-square 47.6 df-25 and significant at the 0.05 level							

(Computed and calculated by the researcher)

On the basis of their social groups, the number and percentage of the respondents who adopt W-R are respectively 28(12.9%) belong to SC, 81(37.3%) to BC, 108(49.8%) to General category whereas who adopt M-B-W-C are respectively 5(17.2%) belong to SC, 8(27.6%) to BC, 16(55.2%) TO General category. Respondents who adopt M-B-W-G are as follow 17(18.7%) belong to SC, 36(39.6%) to BC and 38(41.8%) to General category. most of the B-W-M and C-W pattern are adopt by the BC and general categories. The chi value is 7.5 with df-10 and the test is not significant which indicate that there is no association between the social groups and their cropping pattern (Table 4.26).

On the basis of holding size, the number and percentage of the respondents who adopt W-R are respectively 85(39.2%) belong to marginal, 66(30.4%) to small, 38(17.5%) to semi-medium, 20(9.2%) to medium and 8(3.7%) to large land holding category; who adopt W-R-S are 2(100%) belong to General category; who adopt M-B-W-C are 8(27.6%) belong to marginal, 9(31%) to small, 6(20.7%) to semi-medium, 6(20.6%) to medium & large holding categories; who adopt M-B-W-G are 43(47.3%) ti marginal, 23(25.3%) to small, 12(13.2%) to semi-medium, 8(8.8%) to medium and 5(5.5%) to large; who adopt C-W are 7(41.2%) to marginal, 4(23.5%) to small, 3(17.6%) to semi-medium and rest of belong to medium and large land holding categories. The chi value is 25.3 with df-20 and the result is not significant.

On the basis of income, the number and percentage of the respondents who adopt W-R are respectively 3(1.4%) belong to up to 1.5 lakh income group, 67(30.9%) to 1.5 to 3 lakh, 61(28.1%) to 3 to 4.5 lakh, 46(21.2%) to 4.5 to 6 lakh & 40(18.4%) to above 6 lakh income group; who adopt M-B-W-C are 2(6.9%) belong to up to 1.5 lakh income group, 12(41.4%) to 1.5 to 3 lakh, 11(37.9%) to 3 to 4.5 lakh, 2(6.9%) to 4.5 to 6 lakh & 2(6.9%) to above 6 lakh income group; who adopt M-B-W-G are 332(35.2%) belong to up to 1.5 lakh income group, 23(25.3%) to 1.5 to 3 lakh, 22(24.2%) to 3 to 4.5 lakh, 11(12.1%) to 4.5 to 6 lakh & 3(3.3%) to above 6 lakh income group; who adopt C-W are 5(29.4%) belong to up to 1.5 lakh income group, 3(17.6%) to 1.5 to 3 lakh, 6(35.3%) to 3 to 4.5 lakh, 2(11.8%) to 4.5 to 6 lakh & 1(5.9%) to above 6 lakh income group. The chi square value is 103.1 with df-20 and the test is significant at the 0.05 level which indicate the association between the cropping pattern and income of the respondents.

On the basis of education level, the number and percentage of the respondents who adopt W-R are respectively 7(3.2%) belong to uneducated group, 28(12.9%) to primary, 59(27.2%) to middle, 81(37.3%) to 10th, 35(16.1%) to 12th & 7(3.2%) to graduation+ education group; who adopt M-B-W-C are 1(3.4%) belong to uneducated group, 5(17.2%) to primary, 4(13.8%) to middle, 12(41.4%) to 10th, 6(20.7%) to 12th & 1(3.4%) to graduation+ education group; who adopt M-B-W-G are 4(4.4%) belong to uneducated group, 26(28.6%) to primary, 21(23.1%) to middle, 22(24.1%) to 10th, 14(15.4%) to 12th & 4(4.4%) to graduation+ education group; who adopt B-W-M are 1(2.9%) belong to uneducated group, 4(11.8%) to primary, 4(11.8%) to middle, 12(35.3%) to 10th, 8(23.5%) to 12th & 5(14.7%) to graduation+ education group. The chi value is 47.6 with df-25 and the test is significant at the level of 0.05 (Table 4.26).

Cropping pattern adopted by the respondents is associated with their income and education as farmers prefer more profitable crops and education is also a helping agent in this selection process of crops. There is no association between cropping pattern and social group and land holding size which means that these factors are important for cropping pattern change.

The main results of the table shows that the cropping system of NCR Haryana is transformed from mixed farming to mono-culture. This shift is causing so many problems in agriculture filed like decreasing soil fertility, depletion of water table, loss of biodiversity, negative impact on human health and environment degradation. The villages where tubewell is the only source of irrigation, the water table is falling drastically due to mono-culture which causing a threat for future food sustainability as no water no crop and no food.

Table 4.28:- Distribution of the respondents on the basis of Cropping system and cropping pattern related with their responses regarding ground water level

Ground water level			
Cropping System	Decreased	As it is	total
mixed cropping	140 (47.3%)	14 (14.9%)	154 (39.5%)
Mono-culture	156 (52.7%)	80 (85.1%)	236 (60.5%)
Total	296 (75.9%)	94 (24.1%)	390
Chi square is 31.4,df-1 and significant at 0.05 level			
W-R	141 (47.6%)	76 (80.9%)	217 (55.6%)
W-R-S	1 (0.3%)	1 (1.1%)	2 (0.5%)
M-B-W-C	20 (6.8%)	9 (9.6%)	29 (7.4%)
M-B-W-G	90 (30.4%)	1 (1.1%)	91 (23.3%)
C-W	14 (4.7%)	3 (3.2%)	17 (4.4%)
B-W-M	30 (10.1%)	4 (4.3%)	34 (8.7%)
Total	296 (75.9%)	94 (24.1%)	390
Chi square is 45.2,df-5 and significant at 0.05 level			

(Computed and calculated by the researcher)

On the basis of cropping system, the number and percentage of the respondents who said yes to fall of ground water are respectively 140(47.3%) doing mixed cropping and 156(52.7%) doing mono-culture whereas those who said no to ground water level are 14(14.9%) doing mixed farming and 80(85.1%) doing mono-culture. The chi square is

31.4 with df-1 and the result is significant at the level of 0.05. it means the cropping system and ground water level are associated to each other.

On the basis of cropping pattern, the number and percentage of the respondents who said yes to ground water fall are respectively 141(47.6%) growing W-R; 1(0.3%) W-R-S; 20(6.8%) M-B-W-C; 90(30.4%) M-B-W-G; 14(4.7%) C-W; 30(10.1%) B-W-M whereas who said no to fall of ground water level are 76(80.9%) growing W-R; 1(1.1%) W-R-S; 9(9.6%) B-M-W-C; 1(1.1%) M-B-W-G; 3(3.2%) C-W; 4(4.3%) B-W-M. the chi square is 45.2 with df-5 and the test is significant at the level of 0.05 (Table 4.27).

Table 4.29:- Distribution of the respondents on the basis of Cropping system and cropping pattern related with their responses regarding quantity of fertilizers

Pattern	up to 3 bags	4 to 5 bags	6 to 7 bags	8 to 9 bags	more than 9 bags	total
mixed cropping	136 (88.9%)	18 (85.7%)	0	0	0	154 (39.5%)
Mono-culture	17 (11.1%)	3 (14.3%)	68 (100%)	128 (100%)	20 (100%)	236 (60.5%)
Total	153 (39.2%)	21 (5.4%)	68 (17.4%)	128 (32.8%)	20 (5.1%)	390
Chi square is 315.9,df-4 and significant at 0.05 level						
W-R	3 (2%)	0	68 (100%)	126 (98.4%)	20 (100%)	217 (55.6%)
W-R-S	0	0	0	2 (1.6%)	0	2 (0.5%)
M-B-W-C	24 (15.7%)	5 (23.8%)	0	0	0	29 (7.4%)
M-B-W-G	84 (54.9%)	7 (33.3%)	0	0	0	91 (23.3%)
C-W	14 (9.2%)	3 (14.3%)	0	0	0	17 (4.4%)
B-W-M	28 (18.3%)	6 (28.6%)	0	0	0	34 (8.7%)
Total	153 (39.2%)	21 (5.4%)	68 (17.4%)	128 (32.8%)	20 (5.1%)	390
Chi square is 389,df-20 and significant at 0.05 level						

On the basis of cropping system, the number and percentage of the respondents in different fertilizer categories among both the cropping systems namely mixed and mono-culture are respectively 136(88.9%) & 17(11.1%) using up to 3 bags; 18(85.7%) & 3(14.3%) 4 to 5 bags and after that all the bags are used by the respondents who are following mono-culture. The chi-square is 315.9 with df-4 and the test is significant at the level of 0.05.

On the basis of cropping pattern, the number and percentage of the respondents who are using up to 3 bags are mostly growing M-B-W-C, M-B-W-G, C-W, B-W-M and who are using fertilizer more than 5 bags are growing wheat and rice. The chi square value is 389 with df-20 and the test is significant at the level of 0.05. it shows that the cropping pattern is associated with the fertilizer consumption.

Table 4.30:- Distribution of the respondents on the basis of Cropping system and cropping pattern related with their source of irrigation

	Tubewel	Canal	Both	Barani	Total
mixed cropping	79 (35.1%)	29 (100%)	42 (31.8%)	4 (100%)	154 (39.5%)
Mono-culture	146 (64.9%)	0	90 (68.2%)	0	236 (60.5%)
Total	225 (57.7%)	29 (7.4%)	132 (33.8%)	4 (1.0%)	390
Chi square is 55.6,df-3 and significant at 0.05 level					
W-R	136 (60.4%)	0	81 (61.4%)	0	217 (55.6%)
W-R-S	0	0	2 (1.5%)	0	2 (0.5%)
M-B-W-C	16 (7.1%)	1 (3.4%)	12 (9.1%)	0	29 (7.4%)
M-B-W-G	46 (20.4%)	21 (72.4%)	21 (15.9%)	3 (75%)	91 (23.3%)
C-W	10 (4.4%)	0	7 (5.3%)	0	17 (4.4%)
B-W-M	17 (7.6%)	7 (24.1%)	9 (6.8%)	1 (25%)	34 (8.7%)
Total	225 (57.7%)	29 (7.4%)	132 (33.8%)	4 (1.0%)	390
Chi square is 75.6,df-15 and significant at 0.05 level					

(Computed and calculated by the researcher)

The number and percentage of the respondents in mixed and mono farming are respectively 79(35.1%) and 146(64.9%) using tubewell; 29(100%) using canal; 42(31.8%) and 90(68.2%) using both and all the respondents who have no source of irrigation are following mixed culture. The chi square is 55.6 with df-3 and the test is significant at the level of 0.05.

The number and percentage of the respondents who are using tubewell as a mean of irrigation 136(60.4%) growing W-R; 16(7.1%) growing M-B-W-C; 46(20.4%)

growing M-B-W-G; 10(4.4%) growing C-W; 17(7.6%) growing B-W-M whereas who are using canal are 1(3.4%) growing M-B-W-C; 21(72.4%) growing M-B-W-G; 7(24.1%) growing B-W-M. most of the respondents who have both of sources of irrigation are growing W-R. The chi square is 75.6with df-15 and the test is significant at the level of 0.05.

4.2.3.3 Economic Viability of the Agriculture

Sustainability is based on three parameters namely socially acceptance, economically viability and environmental concern. Here we want to check whether the present agriculture outcome is sufficient for the family needs or not. If it is sufficient and fulfil the requirements of the respondents then it is economically viable and sustainable. But if it is not fulfilling the present requirements of the respondents than it is not economically sustainable and it affects the farmers willingness negatively about doing agriculture. Here the respondents were asked whether the current income from agriculture is sufficient for them or not? And are they doing any other work with farming?

Table 4.31:- Distribution of the respondents about whether the present agriculture income is self-sufficient for them

Blocks	Villages	yes		No		Total
		NO.	%	NO.	%	
Indri	Jundla	11	55.0	9	45.0	20
	Bahlolpur	4	50.0	4	50.0	8
	Gularpur	8	40.0	12	60.0	20
	Total	23	47.9	25	52.1	48
Panipat	Sewah	17	53.1	15	46.9	32
	Rajakheri	11	78.6	3	21.4	14
	Palheri	2	40.0	3	60.0	5
	Total	30	58.8	21	41.2	51
Smalakha	Raksehra	9	69.2	4	30.8	13
	Kiwana	12	60.0	8	40.0	20
	Haldana	7	77.8	2	22.2	9
	Total	28	66.7	14	33.3	42
Tohsham	Sandwa	26	38.2	42	61.8	68
	Nigana	3	37.5	5	62.5	8
	Khawa	3	30.0	7	70.0	10
	Total	32	37.2	54	62.8	86
Ber i	Majra	24	45.3	29	54.7	53
	Malikpur	3	30.0	7	70.0	10

	Palra	4	40.0	6	60.0	10
	Total	31	42.5	42	57.5	73
Nagal choudry	Sirohi	9	45.0	11	55.0	20
	Morund	7	87.5	1	12.5	8
	Amarpura	3	60.0	2	40.0	5
	Total	19	57.6	14	42.4	33
Nuh	Ujina	10	62.5	6	37.5	16
	Rehna	5	50.0	5	50.0	10
	Chhapera	4	80.0	1	20.0	5
	Total	19	61.3	12	38.7	31
Bawal	Sulkha	5	50.0	5	50.0	10
	Rasiawas	4	50.0	4	50.0	8
	teekla	1	12.5	7	87.5	8
	Total	10	38.5	16	61.5	26
	Final total	192	49.2	198	50.8	390

(Source- Primary Survey)

As above table 4.30 results that 49.2% of the respondents said that the income they are getting from agriculture is sufficient for them, on the other hand 50.8% respondents said that the income from agriculture is not sufficient for them. At block level, the respondents who answered yes and no are as follows 23(47.9%) & 25(52.1%) in Indri block; 30(58.8%) & 21(41.2%) in Panipat block; 28(66.7%) & 14(33.3%) in Smalakha block; 32(37.2%) & 54(62.8%) in Tohsham block; 31(42.5%) & 42(57.5%) in Beri block; 19(57.6%) & 14(42.4% in Nagal Choudry block; 19(61.3%) & 12(38.7%) in Nuh block; 10(38.5%) & 16(61.5%) in Bawal block. As results shows that 51% of the respondents said that the profit from agriculture is not sufficient which affects the passion level of the farming among the farmers. It is also a big threat for the agriculture sustainability within the region.

Further to check the association between the responses of the farmers regarding sufficiency of the agriculture profit with income, land holding, education and social groups, the chi-square test of independence has been applied.

Table 4.32- Distribution of the respondents on the basis of their responses regarding the self-sufficiency of the present agriculture income related with their social category, holding size, Income and education

Self-sufficient			
Social Groups	Yes	No	Total
SC	1 (0.5%)	55 (27.8%)	56 (14.4%)
BC	55 (28.6%)	90 (45.5%)	145 (37.2%)
Gen	136 (70.8	53 (26.8%)	189 (48.5%)
Total	192 (50.8%)	198 (49.2%)	390
Chi-square-96.9, df-2 and significant at 0.05 level			
Marginal	11 (5.7%)	142 (71.7%)	153 (39.2%)
small	63 (32.8%)	49 (24.7%)	112 (28.7%)
semi-medium	64 (33.3%)	7 (3.5%)	71 (18.2%)
medium	36 (18.8%)	0	36 (9.2%)
large	18 (9.4%)	0	18 (4.6%)
Total	192 (50.8%)	198 (49.2%)	390
Chi-square-213.6, df-4 and significant at 0.05 level			
Up to 150000	0	46 (23.2%)	46 (11.8%)
150000-300000	25 (13%)	87 (43.9%)	112 (28.7%)
300000-450000	64 (33.3%)	54 (27.3%)	118 (30.3%)
450000-600000	56 (29.2%)	11 (5.6%)	67 (17.2%)
above 600000	47 (24.5%)	0	47 (12.1%)
Total	192 (50.8%)	198 (49.2%)	390
Chi-square-158.3, df-4 and significant at 0.05 level			
uneducated	0	13 (6.6%)	13 (3.3%)
Primary	9 (4.7%)	59 (29.8%)	68 (17.4%)
Middle	35	55	90

	(18.2%)	(27.8%)	(23.1%)
10th	90 (46.9%)	39 (19.7%)	129 (33.1%)
12th	46 (24%)	26 (13.1%)	72 (18.5%)
graduation+	12 (6.2%)	6 (3%)	18 (4.6%)
Total	192 (50.8%)	198 (49.2%)	390
Chi-square-81.9, df-5 and significant at 0.05 level			

(Computed and calculated by the researcher)

On the basis of their social groups, the number and percentage of the respondents who said yes to agriculture profit sufficiency are respectively 1(0.5%) belong to SC category; 55(28.6%) to BC; 136(70.8%) to General category whereas who said no are 55(27.8%) belong to SC; 90(45.5%) to BC; 53(26.8%) to General category. the chi square is 96.9 with df-2 and the test statistically significant at 0.05 level (table 4.31).

On the basis of their land holding, the number and percentage of the respondents who said yes to agriculture profit sufficiency are respectively 11(5.7%) belong to marginal; 63(32.8%) belong to small; 64(33.3%) belong to semi-medium; 36(18.8%) belong to medium and 18(9.4%) belong to large land holding categories whereas who say no are respectively 142(71.7%) belong to marginal; 49(24.7%) belong to small; 7(3.5%) belong to semi-medium land holding categories. The chi square value is 213.6 with df-4 and the statistic is significant at level 0.05 (table 4.31).

On the basis of income, the number and percentage of the respondents who said yes to agriculture profit sufficiency are respectively 25(13%) belong to 1.5 to 3 lakh; 64(33.3%) belong to 3 to 4.5 lakh; 56(29.2%) belong to 4.5 to 6 lakh and 47(24.5%) belong to above 6 lakh income group. the respondents who said no are respectively 46(23.2%) belong to up to 1.5 lakh income group; 87(43.9%) belong to 1.5 to 3 lakh; 54(27.3%) belong to 3 to 4.5 lakh; 11(5.6%) belong to 4.5 to 6 lakh income group. The chi square is 158.3 with df 4 and the test is significant at the level of 0.05 (table 4.31).

On the basis of their education level, On the basis of income, the number and percentage of the respondents who said yes to agriculture profit sufficiency are respectively 9(4.7%) belong to primary level; 35(18.2%) to middle; 90(46.9%) to 10th; 46(24%) to

12^{th} ; 12(6.2%) to graduation plus educational group. The respondents who said no are respectively 13(6.6%) belong to uneducated class; 59(29.8%) belong to primary; 55(27.8%) to middle; 39(19.7%) to 10^{th}; 26(13.1%) to 12^{th} ; 6(3%) to graduation plus educational group. The chi value is 81.9 with df-5 and the result is statistically significant. It means that there is association between education level and their responses about self-sufficiency of the profit from agriculture (table 4.31).

After that the respondents are inquired about whether they are doing any other work along with farming. The table no. is showing the response of the farmers whether they are doing other work or not?

Table 4.33. Responses of the farmers whether they are doing any other work along with agriculture

Block	Villages	yes		No		Total
		No.	%	No.	%	
Indri	Jundla	7	35.0	13	65.0	20
	Bahlolpur	4	50.0	4	50.0	8
	Gularpur	8	40.0	12	60.0	20
	Total	19	39.6	29	60.4	48
Panipat	Sewah	14	43.8	18	56.3	32
	Rajakheri	4	28.6	10	71.4	14
	Palheri	2	40.0	3	60.0	5
	Total	20	39.2	31	60.8	51
Smalakha	Raksehra	5	38.5	8	61.5	13
	Kiwana	8	40.0	12	60.0	20
	Haldana	4	44.4	5	55.6	9
	Total	17	40.5	25	59.5	42
Tohsham	Sandwa	42	61.8	26	38.2	68
	Nigana	4	50.0	4	50.0	8
	Khawa	5	50.0	5	50.0	10
	Total	51	59.3	35	40.7	86
Beri block	Majra	28	52.8	25	47.2	53
	Malikpur	4	40.0	6	60.0	10
	Palra	5	50.0	5	50.0	10
	Total	37	50.7	36	49.3	73
Nagal choudry	Sirohi	10	50.0	10	50.0	20
	Morund	4	50.0	4	50.0	8
	Amarpura	1	20.0	4	80.0	5
	Total	15	45.5	18	54.5	33
Nuh block	Ujina	7	43.8	9	56.3	16
	Rehna	7	70.0	3	30.0	10
	Chhapera	3	60.0	2	40.0	5
	Total	17	54.8	14	45.2	31

Bawal	Sulkha	4	40.0	6	60.0	10
	Rasiawas	2	25.0	6	75.0	8
	teekla	4	50.0	4	50.0	8
	Total	10	38.5	16	61.5	26
	Final total	186	47.7	204	52.3	390

(Source- Primary Survey)

The table 4.32 resulted that 47.7% of the respondents are doing other work along with agriculrue and 52.3% said that they are not doing any other job except agriculture. At block level, the respondents who said yes and no to other works are respectively 19(39.6%) & 29(60.4%) in Indri block; 20(39.2%) & 31(60.8%) in Panipat block; 17(40.5%) & 25(59.5%) in Smalakha block; 51(59.3%) & 35(40.7%) in Tohsham block; 37(50.7%) & 36(49.3%) in Beri block; 15(45.5%) & 18(54.5%) in Nagal Choudry; 17(54.8%) & 14(45.2%) in Nuh block; 10(38.5%) & 16(61.5%) in Bawal block. So, almost 48% of the respondents are doing other works along with agriculture but higher proportion are still doing on agriculture. Further, the responses of the respondents have been recorded about why they are doing other work?

Further to check the association between the responses of the farmers regarding doing other work along with agriculture with income, land holding, education and social groups, the chi-square test of independence has been applied (table 4.33).

Table 4.34:- Distribution of the respondents on the basis of their responses regarding the doing other work or not related with their social category, holding size, Income and education

Doing job	Yes	No	total
SC	55 (29.6%)	1 (0.5%)	56 (14.4%)
BC	97 (52.2%)	48 (23.5%)	145 (37.2%)
Gen	34 (18.3%)	155 (76%)	189 (48.5%)
Total	186 (47.7%)	204 (52.3%)	390
Chi square is 145,df-2 and significant at 0.05 level			
Marginal	153 (82.3%)	0	153 (39.2%)
small	31 (16.7%)	81 (39.7%)	112 (28.7%)
semi-medium	1 (0.5%)	70 (34.3%)	71 (18.2%)
medium	0	36 (17.6%)	36 (9.2%)

large	1 (0.5%)	17 (8.3%)	18 (4.6%)
Total	186 (47.7%)	204 (52.3%)	390
Chi square is 292.4,df-4 and significant at 0.05 level			
upto 150000	45 (24.2%)	1 (0.5%)	46 (11.8%)
150000-300000	106 (57%)	6 (2.9%)	112 (28.7%)
300000-450000	35 (18.8%)	83 (40.7%)	118 (30.3%)
450000-600000	0	67 (32.8%)	67 (17.2%)
above 600000	0	47 (23%)	47 (12.1%)
Total	186 (47.7%)	204 (52.3%)	390
Chi-square is 264.6, df-4 and significant at 0.05 level			
uneducated	13 (7%)	0	13 (3.3%)
Primary	61 (32.8%)	7 (3.4%)	68 (17.4%)
Middle	43 (23.1%)	47 (23%)	90 (23.1%)
10th	40 (21.5%)	89 (43.6%)	129 (33.1%)
12th	23 (12.4%)	49 (24%)	72 (18.5%)
graduation+	6 (3.2%)	12 (5.9%)	18 (4.6%)
Total	186 (47.7%)	204 (52.3%)	390
The chi-square 85.4, df-5 and significant at the 0.05 level			

(Computed and calculated by the researcher)

On the basis of their social groups, the number and percentage of the respondents who said yes to doing other work are respectively 55(29.6%) belong to SC category; 97(52.2%) to BC; 34(18.3%) to General category whereas who said no are 1(0.5%) belong to SC; 48(23.5%) to BC; 155(76%) to General category. the chi square 145 with df-2 and the test statistically significant at 0.05 level (table 4.33).

On the basis of their land holding, the number and percentage of the respondents who said yes to doing other job are respectively 153(82.3%) belong to marginal; 31(16.7%) belong to small; 1(0.5%) belong to semi-medium; and 1(0.5%) belong to large land holding categories whereas who say no are respectively 81(39.7%) belong to small; 70(34.3%) belong to semi-medium; 36(17.6%) to medium and 17(8.3%) to large holding categories. The chi square value is 292.4 with df-4 and the statistic is significant at level 0.05 (table 4.33).

On the basis of income, the number and percentage of the respondents who said yes to other job are respectively 45(24.2%) belong to up to 1.5 lakh income group; 106(57%) to 1.5 to 3 lakh; 35(18.8%) belong to 3 to 4.5 lakh income group whereas the respondents who said no are respectively 1(0.5%) belong to up to 1.5 lakh income group; 6(2.9%) belong to 1.5 to 3 lakh; 83(40.7%) belong to 3 to 4.5 lakh; 67(32.8%) belong to 4.5 to 6 lakh income group; 47(23%) to above 6 lakh income group. The chi square is 264.6 with df 4 and the test is significant at the level of 0.05 (table 4.33).

On the basis of their education level, On the basis of income, the number and percentage of the respondents who said yes to other job are respectively 13(7%) belong to uneducated; 61(32.8%) belong to primary level; 43(23.1%) to middle; 40(21.5%) to 10^{th}; 23(12.4%) to 12^{th} ; 6(3.2%) to graduation plus educational group. The respondents who said no are respectively 7(3.4%) belong to primary; 47(23%) to middle; 89(43.6%) to 10^{th}; 49(24%) to 12^{th} ; 12(5.9%) to graduation plus educational group. The chi value is 85.4 with df-5 and the result is statistically significant. It means that there is association between education level and their responses about doing other job along with agriculture.

Now talk about the possible reasons of doing other work along with agriculture by the respondents and take three major possible reason namely small size of land holding, less agriculture income and increase standard of life. The table no. resulted that 43.5% of the respondents choose option one small size of land holding because due to decreasing size of land holding, the income from agriculture have decreased and to fulfil their basic needs, they have to do some other work along with agriculture. Whether 39.2% of the respondents choose option 2-less agriculture income as a reason of their other work and 17.2% doing other jobs for increasing their standard of life.

Table 4.35 Responses of the farmers about reasons doing any other work along with agriculture

Block	Villages	Reason of doing job						
		Small size of holding		Less agriculture income		Increase standard of life		Total
		NO.	%	NO.	%	No	%	
Indri block	Jundla	6	85.7	0	0.0	1	14.3	7
	Bahlolpur	4	100.0	0	0.0	0	0.0	4
	Gularpur	7	87.5	0	0.0	1	12.5	8
	Total	17	89.5	0	0.0	2	10.5	19
Panipat block	Sewah	9	64.3	0	0.0	5	35.7	14
	Rajakheri	2	50.0	0	0.0	2	50.0	4
	Palheri	1	50.0	0	0.0	1	50.0	2
	Total	12	60.0	0	0.0	8	40.0	20
Smalakha block	Raksehra	4	80.0	0	0.0	1	20.0	5
	Kiwana	8	100.0	0	0.0	0	0.0	8
	Haldana	2	50.0	0	0.0	2	50.0	4
	Total	14	82.4	0	0.0	3	17.6	17
Tohsham block	Sandwa	5	11.9	34	81.0	3	7.1	42
	Nigana	0	0.0	4	100.0	0	0.0	4
	Khawa	0	0.0	5	100.0	0	0.0	5
	Total	5	9.8	43	84.3	3	5.9	51
Beri block	Majra	24	85.7	0	0.0	4	14.3	28
	Malikpur	4	100.0	0	0.0	0	0.0	4
	Palra	5	100.0	0	0.0	0	0.0	5
	Total	33	89.2	0	0.0	4	10.8	37
Nagal choudry	Sirohi	0	0.0	8	80.0	2	20.0	10
	Morund	0	0.0	1	25.0	3	75.0	4
	Amarpura	0	0.0	1	100.0	0	0.0	1
	Total	0	0.0	10	66.7	5	33.3	15
Nuh block	Ujina	0	0.0	4	57.1	3	42.9	7
	Rehna	0	0.0	5	71.4	2	28.6	7
	Chhapera	0	0.0	1	33.3	2	66.7	3
	Total	0	0.0	10	58.8	7	41.2	17
Bawal block	Sulkha	0	0.0	4	100.0	0	0.0	4
	Rasiawas	0	0.0	2	100.0	0	0.0	2
	teekla	0	0.0	4	100.0	0	0.0	4
	Total	0	0.0	10	100.0	0	0.0	10
	Final total	81	43.5	73	39.2	32	17.2	186

(Source- Primary Survey)

At block level, the number and percentage of the respondents for doing other works along with agriculture under different reasons namely small size of land holding, less agriculture income and increase standard of life are respectively 17(89.5%) & 2(10.5%) in Indri block; 12(60%) & 8(40%) in Panipat block; 14(82.4%) & 3(17.6%) in

Smalakha; 5(9.8%), 43(84.3%) & 3(5.9%) in Tohsham block; 33(89.2%) & 4(10.8%) in Beri block; 10(66.7%) & 5(33.3%) in Nagal Choudry; 10(58.8%) & 7(41.2%) in Nuh block; 10(100%) choose second option as a reason for their other work in Bawal block.

Further to check the association between the responses of the farmers regarding reasons doing other work along with agriculture with income, land holding, education and social groups, the chi-square test of independence has been applied.

On the basis of their social groups, the number and percentage of the respondents who choose option-1 as a reason for doing other work are respectively 32(39.5%) belong to SC category; 39(48.1%) to BC; 10(12.3%) to General category whereas who choose option-2 are 22(30.1%) belong to SC; 38(52.1%) to BC; 13(17.8%) to General category and option-3 choose by 1(3.1%) SC, 20(62.5%) by BC and 11(34.4%) by General category. the chi square 17.3 with df-4 and the test is statistically significant at 0.05 level.

On the basis of their land holding, the number and percentage of the respondents who option-1 as a reason for doing other job are respectively 79(97.5%) belong to marginal; 2(2.5%)%) belong to small whereas who choose option-2 are 63(86.3%) belong to marginal; and 10(13.7%) belong to small land holding categories and who choose option-3 are respectively 11(34.4%) belong to marginal; 19(59.4%) belong to small; 1(3.1%) belong to semi-medium; and 1(3.1%) to large holding categories. The chi square value is 66.2 with df-6 and the statistic is significant at level 0.05.

Table 4.36:- Distribution of the respondents on the basis of their responses about reasons of doing other work related with their social category, holding size, Income and education

Reason of Doing job	Small size of holding	Less agriculture income	Increase standard of life	Total
SC	32 (39.5%)	22 (30.1%)	1 (3.1%)	55 (29.6%)
BC	39 (48.1%)	38 (52.1%)	20 (62.5%)	97 (52.2%)
Gen	10 (12.3%)	13 (17.8%)	11 (34.4%)	34 (18.3%)
Total	81 (43.5%)	73 (39.2%)	32 (17.2%)	186
The chi-square 17.3, df-4 and significant at the 0.05 level				
Marginal	79 (97.5%)	63 (86.3%)	11 (34.4%)	153 (82.3%)

small	2 (2.5%)	10 (13.7%)	19 (59.4%)	31 (16.7%)
semi-medium	0	0	1 (3.1%)	1 (0.5%)
medium	0	0	0	0
large	0	0	1 (3.1%)	1 (0.5%)
Total	81 (43.5%)	73 (39.2%)	32 (17.2%)	186
The chi-square 66.2, df-6 and significant at the 0.05 level				
upto 150000	6 (7.4%)	39 (53.4%)	0	45 (24.2%)
150000-300000	50 (61.7%)	33 (45.2%)	23 (71.9%)	106 (57%)
300000-450000	25 (30.9%)	1 (1.4%)	9 (28.1%)	35 (18.8%)
450000-600000	0	0	0	0
above 600000	0	0	0	0
Total	81 (43.5%)	73 (39.2%)	32 (17.2%)	186
The chi-square 65.8, df-4 and significant at the 0.05 level				
uneducated	10 (12.3%)	3 (4.1%)	0	13 (7%)
Primary	28 (34.6%)	30 (41.1%)	3 (9.4%)	61 (32.8%)
Middle	21 (25.9%)	20 (27.4%)	2 (6.2%)	43 (23.1%)
10th	15 (18.5%)	8 (11%)	17 (53.1%)	40 (21.5%)
12th	5 (6.2%)	10 (13.7%)	8 (25%)	23 (12.4%)
graduation+	2 (2.5%)	2 (2.7%)	2 (6.2%)	6 (3.2%)
Total	81 (43.5%)	73 (39.2%)	32 (17.2%)	186
The chi-square 45, df-10 and significant at the 0.05 level				

(Computed and calculated by the researcher)

On the basis of income, the number and percentage of the respondents who said yes to first option are respectively 6(7.4%)%) belong to up to 1.5 lakh income group; 50(61.7%) to 1.5 to 3 lakh; 25(30.9%) belong to 3 to 4.5 lakh income group whereas the respondents who choose second option are respectively 39(53.4%) belong to up to 1.5 lakh income group; 33(45.2%) belong to 1.5 to 3 lakh; 1(1.4%) belong to 3 to 4.5 lakh; and 3rd option choose by 23(71.9%) belong to 1.5 to 3 lakh income group; 9(28.1%) to 3 to 4.5 lakh income group. The chi square is 65.8 with df 4 and the test is significant at the level of 0.05.

On the basis of their education level, On the basis of income, the number and percentage of the respondents who choose option 1 are respectively 10(12.3%) belong to uneducated; 28(34.6%) belong to primary level; 21(25.9%) to middle; 15(18.5%) to 10th; 5(6.2%) to 12th ; 2(2.5%) to graduation plus educational group. The respondents who choose option 2 are respectively 3(4.1%) belong to uneducated group; 30(41.4%) belong to primary; 20(27.4%) to middle; 8(11%) to 10th; 10(13.7%) to 12th ; 2(2.7%) to graduation plus educational group whereas 3rd option choose by 3(9.4%) belong to primary; 2(6.2%) to middle; 17(53.12%) to 10th ; 8(25%) to 12th; 2(6.2%) belong to graduation & above education group. The chi value is 45with df-10 and the result is statistically significant. It means that there is association between education level and their reasons given by the respondents for doing other work.

4.2.3.4. Change in Underground water level

Irrigation is very essential for the plan growth and development of the agriculture. Haryana is the leading food supplier in the central pool of India. The main source of irrigation in Haryana are tube wells as surface water is very restricted and bounded with other states. But the present scenario of the agriculture and population is reflected that the demand of water is going to be increased in future for the agriculture. The consumption of underground water is increasing day by day due to population growth, industrial development and also modernization. Underground water is the main source of irrigation in Haryana NCR but the misuse of this valuable resource is also increasing which cause a severe depletion in water table. This trend of depletion would cause a severe threat for the agriculture sustainability for present as well as future. Government has declared many blocks as dark zone due to over exploitation of the underground water but, farmers are growing same crops continuously which makes the situation worst in many block in NCR Haryana (Kaushik, S and Jitender-2017 and Working Group Report). From 1974 to 2018, the average ground water level in Haryana NCR is 8.6 metres in 1974 whereas it is 18.6 metres in 2018. It recorded almost 10 metres of average downfall in Haryana NCR. Both the district which are following mixed as well as mono-culture showing negative fall in ground water level. Highest fall has been recorded in Mahendergarh followed by Gurgaon, Faridabad, Panipat, Rewari, Karnal etc (Ground Water Cell of Haryana).

Out of 390 respondents, 75.9% said yes to the ground water level change and the change is negative which is also a matter of concern for the agricultural development within the region. Only 24.1% of the respondents replied that there has been no change in their water table (table 4.36).

Table 4.37:- Distribution of Respondents on the Basis of their responses regarding ground water level change

Blocks	Villages	Ground water table change				
		yes		No		Total
		NO.	%	NO.	%	
Indri block	Jundla	20	100	0	0	20
	Bahlolpur	8	100	0	0	8
	Gularpur	20	100	0	0	20
	Total	48	100	0	0	48
Panipat block	Sewah	32	100	0	0	32
	Rajakheri	14	100	0	0	14
	Palheri	5	100	0	0	5
	Total	51	100	0	0	51
Smalakha block	Raksehra	13	100	0	0	13
	Kiwana	20	100	0	0	20
	Haldana	9	100	0	0	9
	Total	42	100	0	0	42
Tohsham block	Sandwa	68	100	0	0	68
	Nigana	3	37.5	5	62.5	8
	Khawa	10	100	0	0	10
	Total	81	94.2	5	5.8	86
Beri block	Majra	0	0	53	100	53
	Malikpur	0	0	10	100	10
	Palra	0	0	10	100	10
	Total	0	0	73	100	73
Nagal choudry	Sirohi	20	100	0	0	20
	Morund	8	100	0	0	8
	Amarpura	5	100	0	0	5
	Total	33	100	0	0	33
Nuh block	Ujina	4	25	12	75	16
	Rehna	10	100	0	0	10
	Chhapera	1	20	4	80	5
	Total	15	48.4	16	51.6	31
Bawal block	Sulkha	10	100	0	0	10
	Rasiawas	8	100	0	0	8
	teekla	8	100	0	0	8
	Total	26	100	0	0	26
	Final total	296	75.9	94	24.1	390

(Source- Primary Survey)

At block level, all the respondents of the Indri, Panipat, Smalakha, Nagal Choudry and Bawal block are reports that their ground water level has been decreased whereas in Tohsham block, 94.2%; & 48.4% in Nuh block also reported negative fall in water level. All the respondents of the beri block; 5.8% of Tohsham and 51.6% of the Nuh block have been reported that the water level of these villages is same as in past (table 4.36).

So, these comparative tables resulted that the ground water level has been going down continuously due to growing more water consuming crops namely wheat, rice and cotton. The situation has been very serious in the blocks which are following mono-culture namely Indri, Panipat, Beri and Smalakha as they are growing only two crops wheat and rice. The water level of the other blocks has also gone down as there cropping pattern is also showing the sharp shift from bajra to cotton and gram to wheat . these crops also consume more water than pervious crops. In blocks namely Indri, Panipat, Smalakha and Beri have good water quality but other block have no good ground water which cause soil solidification and salinization. It is also a big threat for limited water resources and agriculture sustainability.

The responses of the respondents about the downfall in ground water level were further related with their social groups, land holdings, income and education with the help of the chi square.

Table 4.38- Distribution of the respondents on the basis of their responses regarding ground water level change related with their social category, holding size, Income and education

Ground water level	Decreases	As it is	total
SC	50 (16.9%)	6 (6.4%)	56 (14.4%)
BC	101 (34.1%)	44 (46.8%)	145 (37.2%)
Gen	145 (49%)	44 (46.8%)	189 (48.5%)
Total	296 (75.9%)	94 (24.1%)	390
Chi-square- 8.646, df-2 and the chi-square statistic is significant at the 0.05 level			
Marginal	113 (38.2%)	40 (42.6%)	153 (39.2%)
small	85 (28.7%)	27 (28.7%)	112 (28.7%)
semi-medium	58 (19.6%)	13 (13.8%)	71 (18.2%)

medium	27 (9.1%)	9 (9.6%)	36 (9.2%)
large	13 (4.4%)	5 (5.3%)	13 (4.6%)
Total	296 (75.9%)	94 (24.1%)	390
Chi-square- 1.8, df-4 and the chi-square statistic is not significant at the 0.05 level			
upto 150000	43 (14.5%)	3 (3.2%)	46 (11.8%)
150000-300000	79 (26.7%)	33 (35.1%)	112 (28.7%)
300000-450000	89 (30.1%)	29 (30.9%)	118 (30.3%)
450000-600000	51 (17.2%)	16 (17%)	67 (17.2%)
above 600000	34 (11.5%)	13 (13.8%)	47 (12.1%)
Total	296 (75.9%)	94 (24.1%)	390
Chi-square- 9.87, df-4 and the chi-square statistic is significant at the 0.05 level			
uneducated	13 (4.4%)	0	13 (3.3%)
Primary	56 (18.9%)	12 (12.8%)	68 (17.4%)
Middle	68 (23%)	22 (23.4%)	90 (23.1%)
10th	93 (31.4%)	36 (38.3%)	129 (33.1%)
12th	51 (17.2%)	21 (22.3%)	72 (18.5%)
graduation+	15 (5.1%)	3 (3.2%)	18 (4.6%)
Total	296 (75.9%)	94 (24.1%)	390
Chi-square- 8.3, df-5 and the chi-square statistic is not significant at the 0.05 level			

(Computed and calculated by the researcher)

The responses of the farmers further divided into their social groups and the number and percentage of the respondents who say yes to negative fall in ground water level are respectively 50(16.9%) belong to SC; 101(34.1%) belong to BC and 145(49%) belong to General whereas who say no to water table change are 6(6.4%) belong to SC; 44(46.8%) belong to BC and 44(46.8%) Belong to General category. the Chi square value is 8.646 with df-2 and the test is significant at the level of 0.05 (table 4.37).

Among different land holding categories, the number and percentage of the respondents who say yes to negative fall are respectively 113(38.2%) belong to marginal; 85(28.7%) belong to small; 58(19.6%) belong to semi-medium; 27(9.1%) belong to medium and

13(4.4%) belong to large land holding categories whereas who say no are respectively 40(42.6%) belong to marginal; 27(28.7%) belong to small; 13(13.8%) belong to semi-medium; 9(9.6%) belong to medium and 5(5.3%) belong to large land holding categories. The chi square value is 1.8 with df-4 and the statistic is not significant at level 0.05 (table 4.37).

In distribution of the responses according to the income level, the number and percentage of the respondents who say yes to negative fall are respectively 43(14.5%) belong to up to 1.5 lakh income group; 79(26.7%) belong to 1.5 to 3 lakh; 89(30.1%) belong to 3 to 4.5 lakh; 51(17.2%) belong to 4.5 to 6 lakh and 34(11.5%) belong to above 6 lakh income groups whereas who say no are respectively 3(3.2%) belong to up to 1.5 lakh; 33(35.1%) belong to 1.5 to 3 lakh; 29(30.9%) belong to 3 to 4.5 lakh; 16(17%) belong to 4.5 to 6 lakh and 13(13.8%) belong to above 6 lakh income group. The chi square value is 9.87 with df-4 and the test is significant at the level of 0.05 (table 4.37).

In distribution of the responses according to the education level, the number and the percentage of the respondents who say yes to negative fall are respectively 13(4.4%) belong to uneducated group; 56(18.9%) belong to primary level; 68(23%) to middle; 93(31.4%) to 10th; 51(17.2%) to 12th and 15(5.1%) to graduation & above education group. The respondents who say no to change in water level are respectively 12(12.8%) belong to primary; 22(23.4%) to middle; 36(38.3%) to 10th; 21(22.3%) to 12th and 3(3.2%) belong to graduation & above educational group. The chi value is 8.3 with df-5 and the result is statistically not significant. It means that there is no association between education level and their responses regarding water level change (table 4.37).

Table 4.39:- Distribution of the respondents on the basis of source of irrigation related with their answer about ground water level change

	Source of irrigation				
Ground water level	Tubewel	Canal	Both	Barani	Total
No	15 (6.7%)	3 (10.3%)	76 (57.6%)	0	94 (24.1%)
Yes	210 (93.3%)	26 (89.7%)	56 (42.4%)	4(100%)	296 (75.9%)
total	225	29	132	4	390

	(57.7%)	(7.4%)	(33.8%)	(1%)	
The Chi square is 122.5 with df-3 and significant at 0.05 level					

(Computed and calculated by the researcher)

The number and percentage of the respondents who said no and yes to ground water level change are respectively 15(6.7%) and 210(93.3%) using tubewell as a mean of irrigation; 3(10.3%) and 26(89.7%) canal; 76(57.6%) and 56(42.4%) both tubewell & canal whereas all the respondents who have no mean of irrigation said no to water level change. The chi square is 122.5 with df-3 and test is significant at the level of 0.05 (table 4.38).

4.2.3.5 Farmers responses regarding health issues

There are many health issues which are directly or indirectly related to the agriculture because while working in fields, farmers are exposed toward life threatening issues due to improper use of farming inputs. Despite these, excessive use of fertilizers and pesticides are also creating so many health related problems for mankind as well as animals. Due to the exposure of the different agrochemical, people are facing many diseases like food poisoning, breath problem, mental health, cancer etc. farmers are not aware about the proper use of the chemical fertilizers and pesticides which are causing severe threat to their lives as well as soil & water conditions. Improper use of fertilizers and pesticides are causing soil, water and environmental pollution. While thrashing the crops like wheat is also a big problem for environment quality as well as for the breath problem to people (Gandhi et al 2012). In developing countries, many farmers died without safety precaution while using agrochemical(Rakesh et al 2013). In present research, respondents' replies have been recorded wheither they are facing any health issue and also what are the reasons responsible for these health issues.

Table 4.40:- Distribution of Respondents on the Basis of their responses regarding facing any health issue

Block	Villages	Facing any health issue				
		yes		No		Total
		NO.	%	NO.	%	
Indri block	Jundla	20	100	0	0	20
	Bahlolpur	8	100	0	0	8
	Gularpur	20	100	0	0	20
	Total	48	100	0	0	48
Pan.	Sewah	32	100	0	0	32

	Rajakheri	14	100	0	0	14
	Palheri	5	100	0	0	5
	Total	51	100	0	0	51
Smalakha block	Raksehra	13	100	0	0	13
	Kiwana	20	100	0	0	20
	Haldana	9	100	0	0	9
	Total	42	100	0	0	42
Tohsham block	Sandwa	52	76.5	16	23.5	68
	Nigana	5	62.5	3	37.5	8
	Khawa	6	60.0	4	40.0	10
	Total	63	73.3	23	26.7	86
Beri block	Majra	41	77.4	12	22.6	53
	Malikpur	10	100.0	0	0.0	10
	Palra	10	100.0	0	0.0	10
	Total	61	83.6	12	16.4	73
Nagal choudry	Sirohi	19	95.0	1	5.0	20
	Morund	6	75.0	2	25.0	8
	Amarpura	5	100.0	0	0.0	5
	Total	30	90.9	3	9.1	33
Nuh block	Ujina	12	75.0	4	25.0	16
	Rehna	9	90.0	1	10.0	10
	Chhapera	5	100.0	0	0.0	5
	Total	26	83.9	5	16.1	31
Bawal block	Sulkha	10	100.0	0	0.0	10
	Rasiawas	8	100.0	0	0.0	8
	teekla	6	75.0	2	25.0	8
	Total	24	92.3	2	7.7	26
	Final total	345	88.5	45	11.5	390

(Source- Primary Survey)

As table 4.39 is resulted that 88.5% of the respondents are facing health issues and only 11.5% are not facing any health issues. At block level, all the respondents of Indri block, Panipat and Smalakha are facing health issues whereas the number and percentage of the respondents who are facing health issues in other blocks namely Tohsham, Beri, Nagal Choudry, Nuh and Bawal are respectively 63(73.3%), 61(83.6%), 30(90.9%), 26(83.9%) and 24(92.3%). the respondents who are not facing any health issues as follow 23(26.7%) in Tohsham; 12(16.4%) in Beri; 3(9.1%) in Nagal Choudry, 5(16.1%) in Nuh and 2(7.7%) in Bawal block.

The responses of the respondents about the downfall in ground water level were further related with their social groups, land holdings, income and education with the help of the chi square. Is there any association between health issues and their important socio-economic indicators.

Table 4.41:- Distribution of the respondents on the basis of their responses regarding facing any health issue related with their social category and holding size

Health problem	YES	NO	total
SC	47 (13.6%)	9 (20%)	56 (14.4%)
BC	121 (35.1%)	24 (53.3%)	145 (37.2%)
Gen	177 (51.3%)	12 (26.7%)	189 (48.5%)
Total	345 (88.4%)	45 (11.5%)	390 (100%)
Chi-square- 9.68, df-2 and the chi-square statistic is significant at the 0.05 level			
Marginal	134 (38.8%)	19 (42.2%)	153 (39.2%)
small	97 (28.1%)	15 (33.3%)	112 (28.7%)
semi-medium	65 (18.8%)	6 (13.3%)	71 (18.2%)
medium	32 (9.3%)	4 (8.9%)	36 (9.2%)
large	17 (4.9%)	1 (2.2%)	18 (4.6%)
Total	345 (88.4%)	45 (11.5%)	390
Chi-square- 1.794, df-4 and the chi-square statistic is not significant at the 0.05 level			

(Computed and calculated by the researcher)

Table 4.42:- Distribution of the respondents on the basis of their responses regarding facing any health issue related with their income and education level

Income	Yes	No	total
upto 150000	31 (9%)	15 (33.3%)	46 (11.8%)
150000-300000	101 (29.3%)	11 (24.4%)	112 (28.7%)
300000-450000	110 (31.9%)	8 (17.8%)	118 (30.3%)
450000-600000	63 (18.3%)	4 (8.9%)	67 (17.2%)
above 600000	40 (11.6%)	7 (15.6%)	47 (12.1%)

Total	345 (88.4%)	45 (11.6%)	390
Chi-square- 25.5, df-4 and the chi-square statistic is significant at the 0.05 level			
uneducated	11 (3.2%)	2 (4.4%)	13 (3.3%)
Primary	57 (16.5%)	11 (24.4%)	68 (17.4%)
Middle	80 (23.2%)	10 (22.2%)	90 (23.1%)
10th	112 (32.5%)	17 (37.8%)	129 (33.1%)
12th	67 (19.4%)	5 (11.1%)	72 (18.5%)
graduation+	18 (5.2%)	0	18 (4.6%)
Total	345 (88.4%)	45 (11.6%)	390
Chi-square- 5.8, df-5 and the chi-square statistic is not significant at the 0.05 level			

(Computed and calculated by the researcher)

Table 4.12 is showing the farmers responses about health problems according various indicators. If we talk about social groups, the number and percentage of the respondents who are suffering through health issues are respectively 47(13.6%) belong to SC; 121(35.2%) belong to BC and 177(51.3%) belong to general category whereas the respondents who are not suffering any health issue are respectively 9(20%) belong to SC; 24(53.3%) belong to BC and 12(26.7%) belong to General category. the Chi square is 9.68 with df-2 and the test is statistically significant at the level of 0.05. so, it clarifies the association between the response regarding health issues and their social groups.

On the basis of land holding size, the number and the percentage of the respondents who are suffering any health issue are respectively 134(38.8%) belong to marginal; 97(28.1%) belong to small; 65(18.8%) belong to semi-medium; 32(9.3%) belong to medium and 17(4.9%) belong to large land holding class. the respondents who are not suffering any health issue are respectively 19(42.2%) belong to marginal; 15(33.3%) to small; 6(13.3%) to semi-medium; 4(8.9%) to medium and 1(2.2%) to large land holding category. the chi square is 1.794 with df-4 and the test is not significant which indicate that there is no association between farmers responses regarding their health issues and social groups (table 4.40).

On the basis of income, the number and percentage of the respondents who are suffering through health issues are respectively 31(9%) belong to up to 1.5 lakh income group;

101(29.3%) belong to 1.5 to 3 lakh; 110(31.9%) belong to 3 to 4.5 lakh; 63(18.3%) belong to 4.5 to 6 lakh and 40(11.6%) belong to above 6 lakh income group. the respondents who are not suffering any health issue are respectively 15(33.3%) belong to up to 1.5 lakh income group; 11(24.4%) belong to 1.5 to 3 lakh; 8(17.8%) belong to 3 to 4.5 lakh; 4(8.9%) belong to 4.5 to 6 lakh and 7(15.6%) belong to above 6 lakh income group. The chi square is 25.5 with df 4 and the test is significant at the level of 0.05 (table 4.41).

On the basis of their education level and income, the number and percentage of the respondents who are suffering from health issues are respectively 11(3.2%) belong to uneducated group; 57(16.5%) belong to primary level; 80(23.2%) to middle; 112(32.5%) to 10th; 67(19.4%) to 12th and 18(5.2%) to graduation & above education group. The respondents who are not suffering any health issue are respectively 2(4.4%) belong to uneducated class; 11(24.4%) belong to primary; 10(22.2%)%) to middle; 17(37.8%) to 10th; 5(11.1%) to 12th educational group. The chi value is 5.8 with df-5 and the result is statistically not significant. It means that there is no association between education level and their responses about their health issues (table 4.41).

Further the respondents were asked about the reasons of their health issues and the table 4.42 is showing the most expected reasons of the health problems and answers of the farmers. Highest number of the respondents accepted that overuse of the chemical fertilizers and pesticides are responsible for many health issues by 189(54.8%) whereas 103(29.9%) of the respondents said that all the reason are responsible for these health issues. 37(10.7%) of the respondents choose climate change and pollution as a biggest reason of their health issues whereas 16(4.6%) said that both overuse of chemical fertilizers and soil & water pollution are responsible for the health issues.

Table 4.43:- Distribution of Respondents on the Basis of their responses regarding reason of health issues

Blocks	Villages	Reasons of health issues								
		Class-1 Overuse of fertilizer		Class-2 Climate change & pollution		Class-3 1+2		Class-4 All of them		Total
		NO.	%	NO.	%	NO.	%	NO.	%	NO.
Indri	Jundla	14	70.0	0	0.0	0	0.0	6	30.0	20
	Bahlolpur	8	100.0	0	0.0	0	0.0		0.0	8
	Gularpur	14	70.0	0	0.0	0	0.0	6	30.0	20
	Total	36	75.0	0	0.0	0	0.0	12	25.0	48
Panipat	Sewah	15	46.9	7	21.9	7	21.9	3	9.4	32
	Rajakheri	3	21.4	2	14.3	0	0.0	9	64.3	14
	Palheri	4	80.0	0	0.0	0	0.0	1	20.0	5
	Total	22	43.1	9	17.6	7	13.7	13	25.5	51
Smalakha	Raksehra	8	61.5	0	0.0	0	0.0	5	38.5	13
	Kiwana	9	45.0	0	0.0	9	45.0	2	10.0	20
	Haldana	9	100.0	0	0.0	0	0.0	0	0.0	9
	Total	26	61.9	0	0.0	9	21.4	7	16.7	42
Tohsham	Sandwa	29	55.8	13	25.0	0	0.0	10	19.2	52
	Nigana		0.0	3	60.0	0	0.0	2	40.0	5
	Khawa	3	50.0	2	33.3	0	0.0	1	16.7	6
	Total	32	50.8	18	28.6	0	0.0	13	20.6	63
Beri	Majra	30	73.2	0	0.0	0	0.0	11	26.8	41
	Malikpur	8	80.0	0	0.0	0	0.0	2	20.0	10
	Palra	7	70.0	0	0.0	0	0.0	3	30.0	10
	Total	45	73.8	0	0.0	0	0.0	16	26.2	61
Nagal choudry	Sirohi	8	42.1	1	5.3	0	0.0	10	52.6	19
	Morund	3	50.0	3	50.0	0	0.0		0.0	6
	Amarpura	1	20.0	1	20.0	0	0.0	3	60.0	5
	Total	12	40.0	5	16.7	0	0.0	13	43.3	30
Nuh	Ujina	6	50.0	0	0.0	0	0.0	6	50.0	12
	Rehna	3	33.3	0	0.0	0	0.0	6	66.7	9
	Chhapera	2	40.0	0	0.0	0	0.0	3	60.0	5
	Total	11	42.3	0	0.0	0	0.0	15	57.7	26
Bawal	Sulkha	1	10.0	3	30.0	0	0.0	6	60.0	10
	Rasiawas	4	50.0	0	0.0	0	0.0	4	50.0	8
	teekla		0.0	2	33.3	0	0.0	4	66.7	6
	Total	5	20.8	5	20.8	0	0.0	14	58.3	24
	Final total	189	54.8	37	10.7	16	4.6	103	29.9	345

(Source- Primary Survey)

At block level, the responses of the farmers regarding different health issues namely overuse of chemical fertilizers & pesticides, climate change & soil & water pollution, both and all of them are respectively 36(75%) choose class-1 and 12(25%) choose class-4 in Indri block; 22(43.1%) choose class-1, 9(17.6%) class-2, 7(13.7%) class-3 and 13(25.5%) class-4 in Panipat block; 26(61.9%) choose class-1, 9(21.4%) class-3 and 7(16.7%) class-4 in Smalakha block; 32(50.8%) choose class-1, 18(28.6%) class-2 and 13(26.8%) class-4 in Tohsham block; 45(73.8%) choose class-1 and 16(26.2%) class-4 in Beri block; 12(40%) choose class-1, 5(16.7%) class-2 and 13(43.3%) class-4 in Nagal Choudry; 11(42.3%) class-1 and 15(57.7%) class-4 in Nuh block; 5(20.8%) choose class-1, 5(20.8%) class-2 and 14(58.3%) class-4 in Bawal block (table 4.42).

Now to check wheither the responses of the farmers are associated with income, land holding, education and social groups, the chi square test of independence has been applied at the significance level of 0.05 (table 4.43).

Table 4.44- Distribution of the respondents on the basis of their responses regarding reasons of health problems related with their social category, holding size, Income and education

Reasons of Health problem	C-1 Overuse of fertilizers	C-2 Soil & water and climate change	C-3 1+2	C-4 All of them	Total
SC	36 (18.7%)	11 (29.7%)	0	0	47 (13.6%)
BC	67 (35.4%)	14 (37.8%)	8 (50%)	32 (31.1%)	121 (35.1%)
Gen	86 (45.5%)	12 (32.4%)	8 (50%)	71 (68.9%)	177 (51.3%)
Total	189 (54.8%)	37 (10.7%)	16 (4.6%)	103 (29.9%)	345
Chi-square- 38.968, df-6 and the chi-square statistic is significant at the 0.05 level					
Marginal	83 (43.9%)	19 (51.4%)	4 (25%)	28 (27.2%)	134 (38.8%)
small	48 (25.4%)	12 (32.4%)	8 (50%)	29 (28.2%)	97 (28.1%)
semi-medium	33 (17.5%)	3 (8.1%)	2 (12.5%)	27 (26.2%)	65 (18.8%)
medium	17 (9%)	3 (8.1%)	1 (6.2%)	11 (10.7%)	32 (9.3%)
large	8 (4.2%)	0	1 (6.2%)	8 (7.8%)	17 (4.9%)
Total	189 (54.8%)	37 (10.7%)	16 (4.6%)	103 (29.9%)	345

Chi-square- 20.56, df-12 and the chi-square statistic is not significant at the 0.05 level					
upto 150000	14 (7.4%)	11 (29.7%)	0	6 (5.8%)	31 (9%)
150000-300000	54 (28.6%)	16 (43.2%)	6 (37.5%)	25 (24.3%)	101 (29.3%)
300000-450000	70 (37%)	8 (21.6%)	2 (12.5%)	30 (29.1%)	110 (31.9%)
450000-600000	26 (13.8%)	0	7 (43.8%)	30 (29.1%)	63 (18.3%)
above 600000	25 (13.2%	2 (5.4%)	1 (6.2%)	12 (11.1%)	40 (11.6%)
Total	189 (54.8%)	37 (10.7%)	16 (4.6%)	103 (29.9%)	345
Chi-square- 52.76, df-12 and the chi-square statistic is significant at the 0.05 level					
uneducated	10 (5.3%)	0	0	1 (1%)	11 (3.2%)
Primary	32 (16.9%)	21 (56.8%)	0	4 (3.9%)	57 (16.5%)
Middle	59 (31.2%)	7 (18.9%)	9 (56.2%)	5 (4.9%)	80 (23.2%)
10th	88 (46.6%)	9 (24.3%)	7 (43.8%)	8 (7.8%)	112 (32.5%)
12th	0	0	0	67 (65%)	67 (19.4%)
graduation+	0	0	0	18 (17.5%)	18 (5.2%)
Total	189 (54.8%)	37 (10.7%)	16 (4.6%)	103 (29.9%)	345
Chi-square- 314.8, df-15 and the chi-square statistic is significant at the 0.05 level					

(Computed and calculated by the researcher)

Note: - C-1(Class-1)

On the basis social groups, the number and percentage of the respondents who choose C-1 for the reason of health issues are respectively 36(18.7%) belong to SC, 67(35.4%) belong to BC and 86(45.5%) belong to general category whereas who choose C-2 are respectively 11(29.7%) belong to SC, 14(37.8%) to BC and 12(32.4%) to General category; who choose C-3 are respectively 8(50%) belong to BC and 8(50%) belong to general category. the respondents who choose C-4 belong to only BC & General categories. The chi square is 38.9 with df-6 and the result is significant at the level of 0.05 which prove the association between social group and the reasons about health issues (table 4.43).

On the basis of land holding, the number and percentage of the respondents who choose C-1 for the reason of health issues are respectively 83(43.9%) belong to marginal category, 48(25.4%) to small, 33(17.5%) to semi-medium, 17(9%) to medium and 8(4.2%) to large land holding whereas who choose C-2 are respectively 19(51.4%) belong to marginal, 12(32.4%) to small, 3(8.1%) to semi-medium and 3(8.1%) to medium land holdings. The respondents who choose C-3 are 4(25%) belong to marginal, 8(50%) to small, 2(12.5%) to semi-medium, 1(6.2%) to medium and 1(6.2%) to large land holding category whereas C-4 choose respectively 28(27.2%) by marginal, 29(28.2%) by small, 27(26.2%) by semi-medium, 11(10.7%) by medium and 8(7.8%) by large. The chi square is 20.6 with df 12 and the test is not significant.

On the basis of income, the number and percentage of the respondents who choose C-1 for the reason of health issues are respectively 14(7.4%) belong to up to 1.5 lakh income category, 54(1.5 to 3 lakh, 70(37%) to 3 to 4.5 lakh, 26(13.8%) to 4.5 to 6 lakh and 25(13.2%) to above 6 lakh income category whereas respondents who choose C-2 are 11(29.7%) belong to upto 1.5 lakh, 16(43.2%) to 1.5 to 3 lakh, 8(21.6%) to 3 to 4.5 lakh and 2(5.4%) to above 6 lakh income category. the respondents who choose C-3 are 6(37.5%) belong to 1.5 to 3 lakh income category, 2(12.5%) to 3 to 4.5 lakh, 7(43.8%) to 4.5 to 6 lakh and 1(6.2%) to above 6 lakh income group whereas who choose C-4 are 6(5.8%) belong to up to 1.5 lakh income category, 25(24.3%) to 1.5 to 3 lakh, 30(29.1%) to both 3 to 4.5 lakh & 4.5 to 6 lakh and 12(11.1%) to above 6 lakh income category. the chi square is 52.8 with df-12 and the result is statistically significant at the level of 0.05 (table 4.43).

On the basis of education, the respondents who are educated up to 12th and above choose the C-4 as they are much more aware about the impact of these reason on human health by 67(65%) belong to 12th and 18(17.5%) belong to graduation & above education group. The chi value is 314.8 with df-15 and the result is statistically significant at the level of 0.05 which indicates that there is an association between the education level and their responses regarding health issues (table 4.43).

4.2.3.6 Decreasing land holding size

In rural economy of Haryana state, agriculture is one of the most important economic assets for the people living in villages. But due the decreasing size of land holdings, the growth, interest, income and way of farming are getting hampered. Continuous decreasing size of farm is the biggest issue and challenge for the agriculture in Haryana as well as for India and it could potentially make this profession unviable for the future generations(Bakshi, P. article, 2013). Agriculture sector is going through heavy pressure due to the decreasing average size of the holdings continuously. If the average land holding is halved in size, the input and the consumption of time is double which increase input cost. Due to the decreasing size of the holdings, the younger generation does not take interest in farming which is a big threat for agriculture sustainability. As present chapter is dealing with socio-economic change in farmers 'life, there are fewer joint families which automatically lead the bifurcation of agriculture land. In table 4.21, Out of 390 respondents, 341(87.4%) said that their agriculture land has been changed and only 49(12.6%) reported that their land holding size has remained same. If we talk about reasons behind this change almost 68.6% reported that it has happened due to family bifurcation, 17.6% said that they have buy new land and 13.8% said that they have sold out some part of their land holdings. So, the biggest reason behind the decreasing land holding size is family bifurcation which puts a negative impact on agricultural growth (Table 4.44 (a,b).

Table 4.45 (a)- Responses of the farmers about whether their holding size has been changed

Blocks	Villages	Yes		No		Total
		NO.	%	NO.	%	
Indri	Jundla	18	90.0	2	10.0	20
	Bahlolpur	7	87.5	1	12.5	8
	Gularpur	18	90.0	2	10.0	20
	Total	43	89.6	5	10.4	48
Panipat	Sewah	21	65.6	11	34.4	32
	Rajakheri	13	92.9	1	7.1	14
	Palheri	4	80.0	1	20.0	5
	Total	38	74.5	13	25.5	51
Smalakha	Raksehra	11	84.6	2	15.4	13
	Kiwana	20	100.0	0	0.0	20
	Haldana	9	100.0	0	0.0	9
	Total	40	95.2	2	4.8	42

Tohsham	Sandwa	64	94.1	4	5.9	68
	Nigana	7	87.5	1	12.5	8
	Khawa	9	90.0	1	10.0	10
	Total	80	93.0	6	7.0	86
Beri	Majra	51	96.2	2	3.8	53
	Malikpur	9	90.0	1	10.0	10
	Palra	10	100.0	0	0.0	10
	Total	70	95.9	3	4.1	73
Nagal Choudry	Sirohi	14	70.0	6	30.0	20
	Morund	6	75.0	2	25.0	8
	Amarpura	3	60.0	2	40.0	5
	Total	23	69.7	10	30.3	33
Nuh	Ujina	10	62.5	6	37.5	16
	Rehna	10	100.0	0	0.0	10
	Chhapera	4	80.0	1	20.0	5
	Total	24	77.4	7	22.6	31
Bawal	Sulkha	8	80.0	2	20.0	10
	Rasiawas	7	87.5	1	12.5	8
	teekla	8	100.0	0	0.0	8
	Total	23	88.5	3	11.5	26
	Final total	341	87.4	49	12.6	390

(Source- Primary Survey)

Table 4.45 (b)- Responses of the farmers about the reasons of their holding changes

Villages	Family bifurcation		Buy new land		Sold out		Total
	No	%	No	%	No	%	No
Jundla	15	83.3	2	11.1	1	5.6	18
Bahlolpur	5	71.4	2	28.6		0.0	7
Gularpur	15	83.3	1	5.6	2	11.1	18
Total	35	81.4	5	11.6	3	7.0	43
Sewah	16	76.2	3	14.3	2	9.5	21
Rajakheri	10	76.9	1	7.7	2	15.4	13
Palheri	0	0.0	4	100.0	0	0.0	4
Total	26	68.4	8	21.1	4	10.5	38
Raksehra	7	63.6	3	27.3	1	9.1	11
Kiwana	15	75.0	3	15.0	2	10.0	20
Haldana	6	66.7	1	11.1	2	22.2	9
Total	28	70.0	7	17.5	5	12.5	40
Sandwa	38	59.4	10	15.6	16	25.0	64
Nigana	4	57.1	2	28.6	1	14.3	7
Khawa	4	44.4	2	22.2	3	33.3	9
Total	46	57.5	14	17.5	20	25.0	80
Majra	43	84.3	3	5.9	5	9.8	51
Malikpur	7	77.8	2	22.2	0	0.0	9
Palra	7	70.0	2	20.0	1	10.0	10

Total	57	81.4	7	10.0	6	8.6	70
Sirohi	8	57.1	4	28.6	2	14.3	14
Morund	4	66.7	2	33.3	0	0.0	6
Amarpura	3	100		0.0	0	0.0	3
Total	15	65.2	6	26.1	2	8.7	23
Ujina	5	50.0	3	30.0	2	20.0	10
Rehna	5	50.0	3	30.0	2	20.0	10
Chhapera	2	50.0	2	50.0	0	0.0	4
Total	12	50.0	8	33.3	4	16.7	24
Sulkha	5	62.5	2	25.0	1	12.5	8
Rasiawas	4	57.1	1	14.3	2	28.6	7
teekla	6	75.0	2	25.0	0	0.0	8
Total	15	65.2	5	21.7	3	13.0	23
Final total	234	68.6	60	17.6	47	13.8	341

(Source- Primary Survey)

At block level, the number and percentage of the respondents who said yes and no to holding change are respectively 43(89.6%) and 5(10.4%) in Indri block; 38(74.5%) and 13(25.5%) in Panipat block; 40(95.2%) and 2(4.8%) in Smalakha block; 80(93%) and 6(7%) in Tohsham block; 70(95.9%) and 3(4.1%) in Beri block; 23(69.7%) and 10(30.3%) in Nangal Choudry; 24(77.4%) and 7(22.6%) in Nuh block; 23(88.5%) and 3(11.5%) in Bawal block. If we about the reasons behind this change, the number and percentage in family bifurcation, buy new land and sold out options are respectively 35(81.4%), 5(11.6%), 3(7%) in Indri block; 26(68.4%), 8(21.1%), 4(10.4%) in Panipat block; 28(70%), 7(17.5%), 5(12.5%) in Smalakha block; 46(57.5%), 14(17.5%), 20(25%) in Tohsham block; 57(81.4%), 7(10%), 6(8.6%) in beri block; 15(65.2%), 6(26.1%), 2(8.7%) in Nangal Choudry block; 12(50%), 8(33.3%), 4(16.7%) in Nuh block; 15(65.2%), 5(21.7%), 3(13%) in Bawal block (table 4.44 (a,b).

So, the above table resulted that decreasing land holding size is the biggest problem in the agriculture. Whereas problems related to input, output, production, profit and loss are secondary to decreasing land holding size . More or less, all the things related to the agriculture are closely bound with farm size. But due to increasing population, the land holding sizes are continuously decreasing which affected the mindset of the farmers and coming generations about agriculture.

Further the responses of the respondents relate with their social group, land holding size, income and education level and check their association with the help of chi square test of independence.

Table 4.46:- Distribution of the respondents on the basis of their responses about their holding size has been changed related with their social category, holding size, Income and education

Holding change	No	Yes	Total
SC	6 (12.2%)	50 (14.7%)	56 (14.4%)
BC	6 (12.2%)	139 (40.8%)	145 (37.2%)
Gen	37 (75.5%)	152 (44.6%)	189 (48.5%)
Total	49 (12.6%)	341 (87.4%)	390
Chi square is 18.0,df-2 and significant at 0.05 level			
Marginal	7 (14.3%)	146 (42.8%)	153 (39.2%)
small	5 (10.2%)	107 (31.4%)	112 (28.7%)
semi-medium	3 (6.1%)	68 (19.9%)	71 (18.2%)
medium	16 (32.7%)	20 (5.9%)	36 (9.2%)
large	18 (36.7%)	0	18 (4.6%)
Total	49 (12.6%)	341 (87.4%)	390
Chi square is 178.6,df-4 and significant at 0.05 level			
upto 150000	1 (2%)	45 (13.2%)	46 (11.8%)
150000-300000	8 (16.3%)	104 (30.5%)	112 (28.7%)
300000-450000	9 (18.4%)	109 (32%)	118 (30.3%)
450000-600000	9 (18.4%)	58 (17%)	67 (17.2%)
above 600000	22 (44.9%)	25 (7.3%)	47 (12.1%)
Total	49 (12.6%)	341 (87.4%)	390
Chi-square is 60.4, df-4 and significant at 0.05 level			
uneducated	0	13 (3.8%)	13 (3.3%)
Primary	9 (18.4%)	59 (17.3%)	68 (17.4%)
Middle	10 (20.4%)	80 (23.5%)	90 (23.1%)
10th	16	113	129

	32.7%)	(33.1%)	(33.1%)
12th	9 (18.4%)	63 (18.5%)	72 (18.5%)
graduation+	5 (10.2%)	13 (3.8%)	18 (4.6%)
Total	49 (12.6%)	341 (87.4%)	390
The chi-square 5.9, df-5 and not significant at the 0.05 level			

(Computed and calculated by the researcher)

On the basis of their social groups, the number and percentage of the respondents who said no to holding change are respectively 6(12.2%) belong to SC category; 6(12.2%) to BC; 37(75.5%) to General category whereas who said yes are 50(14.7%) belong to SC; 139(40.8%) to BC; 152(44.6%) to General category. the chi square is 18 with df-2 and the test statistically significant at 0.05 level (Table 4.45).

On the basis of their land holding, the number and percentage of the respondents who said yes to agriculture profit sufficiency are respectively 146(42.8%) belong to marginal; 107(31.4%) belong to small; 68(19.9%) belong to semi-medium; 20(5.8%) belong to medium land holding categories whereas who say no are respectively 7(14.3%) belong to marginal; 5(10.3%) belong to small; 3(6.1%) belong to semi-medium; 16(32.7%) to medium; 18(36.7%) beling to large land holding categories. The chi square value is 178.6 with df-4 and the statistic is significant at level 0.05 (Table 4.45).

On the basis of income, the number and percentage of the respondents who said yes to holding change are respectively 45(13.2%) belong to up to 1.5 lakh; 104(30.5%) belong to 1.5 to 3 lakh; 109(32%) to 3 to 4.5 lakh; 58(17%) belong to 4.5 to 6 lakh and 25(7.3%) belong to above 6 lakh income group. the respondents who said no are respectively 1(2%) belong to up to 1.5 lakh income group; 8(16.3%) belong to 1.5 to 3 lakh; 9(18.4%) belong to 3 to 4.5 lakh; 9(18.4%) belong to 4.5 to 6 lakh; 22(44.9%) to 6 lakh income group. The chi square is 60.4 with df 4 and the test is significant at the level of 0.05 (Table 4.45).

On the basis of their education level, the number and percentage of the respondents who said yes to holding change are respectively 13(3.8%) belong to uneducated group; 59(17.3%) belong to primary level; 80(23.5%) to middle; 113(33.1%) to 10^{th}; 63(18.5%) to 12^{th} ; 13(3.8%) to graduation plus educational group. The respondents who said no are respectively 9(18.4%) belong to primary; 10(20.4%) to middle; 16(32.7%) to 10th; 9(18.4%) to 12th ; 5(12.6%) to graduation plus educational group. The chi value is 5.9 with df-5 and the result is statistically not significant. It means that there is no association between education level and their responses about holding change (Table 4.45).

Table 4.47:- Distribution of the respondents on the basis of their responses about possible reasons for holding change related with their holding size and Income

	Sold out	Buy new land	Family bifurcation	total
Marginal	20 (41.7%)	32 (54.2%)	94 (40.2%)	146 (42.8%)
small	18 (37.5%)	10 (16.9%)	79 (33.8%)	107 (31.4%)
semi-medium	10 (20.8%)	15 (25.4%)	43 (18.4%)	68 (19.9%)
medium	0	2 (3.4%)	18 (7.7%)	20 (5.9%)
large	0	0	0	
Total	48 (14.1%)	59 (17.3%)	234 (68.6%)	341
Chi square is 13.1,df-6 and significant at 0.05 level				
upto 150000	10 (20.8%)	17 (28.8%)	18 (7.7%)	45 (13.2%)
150000-300000	15 (31.2%)	13 (22%)	76 (32.5%)	104 (30.5%)
300000-450000	14 (29.2%)	16 (27.1%)	79 (33.8%)	109 (32%)
450000-600000	5 (10.4%)	9 (15.3%)	44 (18.8%)	58 (17.0%)
above 600000	4 (8.3%)	4 (6.8%)	17 (7.3%)	25 (7.3%)
Total	48 (14.1%)	59 (17.3%)	234 (68.6%)	341
Chi-square is 22.748, df-8 and significant at 0.05 level				

(Computed and calculated by the researcher)

Table 4.46 is showing the relation of the reasons of holding change with their holding size and income. It resulted that highest number of the respondents answer family bifurcation is the biggest reason of holding change by 234(68.6%). Most of the marginal farmers said that family bifurcation is the reason of their holding change followed by the small land holding farmers. The chi square value is 13.1 with df-6 and the test if significant at the level of 0.05. On the basis of income, lower income groups from 1.5 to 4.5 lakh choose family bifurcation as a reason of their holding change. The chi square value is 22.7 with df-8 and the test if significant at the level of 0.05. it shows that there is a relation between the income and the reason of holding change of the respondents.

4.2.3.7. Major agricultural problems faced by the respondents

Here a sound effort has been made to note down the responses of the farmers regarding major agricultural issues which are faced by them. No doubt, green revolution made the state self-sufficient in foodgrains production but this package technology led to so many negative impacts on the natural resources. So, the table 4.24 is showing the farmers responses regarding these issues by giving rank 1 to 5.

Table 4.48:- Major agricultural problems faced by the respondents and their mean with rank

Major agricultural problems	Mean score	Rank
Depletion of ground water	2.18	1
higher use of fertilizers	2.76	3
Decreasing size of holding	2.27	2
soil depletion	3.92	4
stagnation of productivity	3.87	5

(Computed and calculated by the researcher)

Table 4.49- Friedman Rank Test

Test Statistics	
N	390
Chi-Square	445.876
df	4
Asymp. Sig.	.000
a. Friedman Test	

(Computed and calculated by the researcher)

As table 4.47 is resulted that highest number of the respondents gives first rank to depletion of ground water as it has least mean score 2.18, second rank is going to decreasing land holding size with 2.27 mean score. The results of Friedman rank test are depicted in table 4.48 and concludes that the chi square value is 445.876 and with 4 degree of freedom. The p value of this rank test is statistically significant at 0.05 level which prove that there is a significant difference between the mean rank of the major agricultural problems faced by the respondents.

4.3. Final Results

- Almost 85% of the respondents belong to the 50 to 60 years and above 60 years of age groups which is a threat to agricultural sustainability because the younger generation does not take so much interest in agricultural works due to less chance of growth.
- Around 95% of the respondents were male and only 5% were females and all these were widows. It shows that Haryana's rural societies are male-dominated. Female work participation is equal in farms but all the decisions about farms and houses are taken by males. Though having the legal right to land ownership, there are few female land owners as they are always treated as "Paraya Dhan"
- Land distribution is not significant according to social groups as most of the agricultural lands are owned by General and BC categories which also shows the social backwardness of rural societies. So, all the benefits that come from the agriculture sector impact mainly the general and BC classes as most of the land is owned by them. 85.6% of the respondents belong to the general and BC categories which cause a huge income gap between different social groups.
- The highest proportion of the farmers educated up to 10^{th} and 8^{th} standard as the ratio of the younger population is very less in agricultural works due to decreasing land holding sizes and less growth chances. Education is a single powerful asset to change the present agriculture scenario and for adopting new technologies but most of the respondents are not highly qualified which is also a threat to agriculture sustainability.
- Most of the respondents (67.4%) have marginal and small land holdings which is also a big reason for the decreasing interest towards agriculture of the younger generations. Decreasing land holding size is a very serious issue in India as well as Haryana's agriculture. Family bifurcation is the biggest reason behind the decreasing land holding size.

- tubewells are the main source of irrigation within the study area as around 54% of respondents are using tubewells for irrigation. Villages namely Rajakheri, Rakshera, Kiwana, Haldana, Palheri, Morund and Teekla are only tubewell as a means of irrigation and no canal water is available here. Due to the over-exploitation of groundwater resources, the water table in many blocks has gone down which is also a big threat to future food production. Due to over-irrigation through canals, the soil structure has been changed which affects crop production and also causes soil depletion.
- 45.4% of the respondents are using only chemical fertilizers whereas 54.6% of respondents are using both chemical and manure in their farms. The quantity of manure is very low as compared to chemical fertilizers. Continuous uses of chemical fertilizers cause depletion of soil, food, health and environment quality. All the farmers are using chemical fertilizers without soil testing which makes the situation worse.
- Quantity of the fertilizer per acre is not equal in all the villages as those villages which have good irrigation and soil facilities are using more chemical fertilizers as they are following mono-culture which extracts more nutrition from the soil. Those farmers who are growing rice-wheat, are using 6 to 9 bags per acre which causes a big threat to human health. After the green revolution, the soil stress has increased which causes a serious depletion of the nutrition values of the soil. Farmers do not prefer soil testing, and as a result, they unknowingly use more fertilizers and also chemical pesticides which are very harmful to soil and human health. So, there is an urgent need to spread awareness among the farmers about the importance of soil and water resources for present as well as future food security. Agriculture sustainability is already in danger in NCR Haryana due to changing LULC patterns and existing cropping systems.
- As Table 4.9, out of 390 respondents, almost 28.2% respondents have a 3 to 4.5 lakh total income, 27.9% have a 1.5 to 3 lakh total income, 22.3% have 4.5 to 6 lakh total income, 12.8% have more than six lakh total income and 8.7% have up to 1.5 lakh total income. About 60% of the farmers have total income between 1.5 lakh to 4.5 lakh.

- Table 4.10 shows the income of the respondents from agriculture only and shows that 28.7% of the respondents have 1.5 to 3 lakh income, 30.3% have 3 to 4.5 lakh, 17.2% have 4.5 to 6 lakh, 12.1% have more than six lakhs and 11.8% have up to 1.5 lakh income from agriculture alone. To evaluate the impact of cropping patterns on the socio-economic conditions of the farmers, those families selected for the survey whose income mainly comes from agriculture almost 70% and above.
- Table 4.11 shows the percent share of agriculture income in the total income of the sampled villages and results that 42.6% of respondents have only agriculture as a source of income, 29% have 80 to 89.9% income from agriculture alone, 16.2% have 70 to 79.9% income, 11.3% respondents have 90 to 99.9% share of agriculture income in the total income.
- Table 4.12 shows the housing structure of the farmers and reflects that 227(58.2%) respondents are living in semi-pacca housing conditions and 163(41.8%) are living in fully Pacca houses. It reflects that those respondents who have better income from agriculture having fully pacca houses and those who have less income are still struggling to improve their socio-economic conditions. The chi-square is significant at the level of 0.05 showing the strong association of house type with their social groups, income, land holding size and education. All the respondents of the SC category lived in semi-pacca housing conditions whereas the highest number of the respondents of the general category lived in fully pacca houses. Most of the respondents who have semi-medium, medium and large land holdings are living fully-pacca houses. The respondents who belong to higher income groups are also living in fully Pacca houses and a higher number of fully pacca houses are owned by the respondents who are educated above primary level. So, all these are modifiers in the housing conditions of the respondents.
- Table 4.15 shows the trend of nuclearization of the families as now only 63(16.2%) respondents are living in joint families and the rest of the respondents have nuclear families. The associations between family type with their social groups, land holding, income and education are significant at the level of 0.05 which clearly indicates their relation with each other. A higher

number of the respondents are living in nuclear family structures in all the social categories whereas most of the respondents of all the land-holding categories except medium and large, living in nuclear family structures. The higher number of respondents who have more income are living in a joint family structure.

- Table 4.17 shows that 80.3% of respondents' children are studying in private schools and only 19.7% children of the respondents are studying in government schools. The association between school of the children with social groups, income, holding sizes and education is significant at the level 0.05 which clarifies their relation with each other. Most of the Gen and BC category respondent's children are going to private schools whereas most of SC children are going to govt. schools. Respondents belonging to medium and large land holdings are sending their children only to private schools whereas most of the children of small and semi-medium landholders are also going to private schools. Highest number of the respondent's children who are going to govt. schools belong to the marginal land-holding category. on the basis of income, all the respondents who belong to higher income groups are sending their children to private schools and those who are going to govt. schools, most of them belong to lower-income groups. Respondents who are educated above primary, most of them are sending their children to private schools.
- Out of 390 respondents, there are 51(13.1%) had t.v., W.M., fridge & bicycle; 150(38.5%) had t.v., W.M., fridge, bicycle & bike; 96(24.6%) had t.v., W.M., fridge, bicycle, bike & tractor; 42(10.8%) had t.v., W.M., fridge, bicycle, bike & car and 51(13.1%) had all the above said house assets available in their houses. The association between house assets with social groups, income, land holding sizes and education is statistically significant and resulted that higher vaue house assets are owned by the General and BC categories whereas on the basis of holding size, owned by semi-medium, medium and large land holders. On the basis of income an education groups, higher income groups have more house assets and respondents who were educated above primary have more house assets.
- Table 4.21 shows that only 20% of the respondents are doing their agricultural work with their family members and all these belong to the marginal land-

holding class; 39.2% are doing their work self with labour and 40.8% are doing their farm work with the labour support. The highest number of the respondents who are taking help of labour for agricultural work belong to Gen and BC categories and those who are doing their agriculture work with family belong to SC categories. Those who have big size of land holdings and more income groups are taking help of labour. Respondents who have an income more than 6 lakh, are doing their agricultural work with only labour. Highly educated people also taking more help from labour. The association between agriculture work patterns with income, holding size, social groups and education is significant at the level 0f 0.05.

- Awareness regarding sustainability is very less among all the respondents. The table 4.22 shows that only 4.1% of the respondents said that they are aware about agriculture sustainability concept and 95.9% of the farmers said that they did not know anything about agriculture sustainability. It is a matter of grave concern if the farmers are not even aware of the concept, then how in the first place they would work for agricultural sustainability. The association of awareness of this concept with education is significant at the level of 0.05 as education is the best tool for spreading awareness regarding new concepts. All the respondents who said that they knew the concept are educated up to 12th and above. They are only read about the concept in books.
- Among all the surveyed villages, the percentage of the respondents who followed different cropping patterns are respectively 55.6% sowing only W-R, 0.5% sowing W-R-S, 7.4% sowing M-B-W-C, 23.3% B-M-W-G, 4.4% sowing C-W and 8.7% sowing B-W-M. highest number of the respondents are following mono-culture as they are growing only two crops namely wheat-rice, wheat-cotton. Among all the respondents 60.5% are following mono-culture and only 39.5% are following mixed cropping pattern. So, it is a big hinderance in the way of agricultural sustainability within the region.
- Cropping pattern adopted by the respondents is associated with their income and education as farmers prefer more profitable crops and education is also a helping agent in the selection process of crops. There is no association between

crop ping pattern and social group and land holding size which means that these factors are not important for cropping pattern change.

- The association of cropping pattern and cropping system with responses regarding groundwater changes is significant which means that cropping pattern and cropping system plays a vital role in groundwater level change. The association of cropping pattern and cropping system with the quantity of fertilizers is also significant and shows that cropping pattern and cropping system both are responsible for the increase and decrease in the quantity of fertilizer per acre. Their association is also significant with source of irrigation as irrigation is the prime indicator for shaping the agriculture system in a region.
- Out of 390 respondents, 75.9% said yes to the ground water level change and the change is negative which is also a matter of concern for the agricultural development within the region. Only 24.1% of the respondents replied that there has been no change in their water table.
- Out of 390 respondents, 75.9% said yes to the ground water level change and the change is negative which is also a matter of concern for the agricultural development within the region. Only 24.1% of the respondents replied that there has been no change in their water table. The association of responses regarding ground water level change is significant with social groups and income but it is not significant with holding size and education as they are not affected any impact of the responses of the farmers regarding ground water level change. There is a significant relation between the farmers responses regarding water level and their source of irrigation. Most of the respondents who have tubewell is the only source of irrigation said yes to ground water level change.
- As table 4.40 is resulted that 88.5% of the respondents are facing health issues and only 11.5% are not facing any health issues. Their test of association with social groups and income is significant and it is not significant with holding size and education as they are not affecting their responses related with health.
- Highest number of the respondents accepted that overuse of the chemical fertilizers and pesticides are responsible for many health issues by 189(54.8%) whereas 103(29.9%) of the respondents said that all the reason are responsible for these health issues. 37(10.7%) of the respondents choose climate change and

pollution as a biggest reason of their health issues whereas 16(4.6%) said that both overuse of chemical fertilizers and soil & water pollution are responsible for the health issues. Their responses regarding reasons of health issues are significantly associated with social groups, income and education and not significant with holding size as holding size is not affecting their possible reasons of health issues.

- As above table 4.31 results that 49.2% of the respondents said that the income they are getting from agriculture is sufficient for them, on the other hand 50.8% respondents said that the income from agriculture is not sufficient for them. Their responses regarding sufficiency of present agriculture income are significantly associated with social groups, income, holding size and education. All these factors are affecting the farmers responses as most of the SC respondents said no to present income sufficiency. Most of the respondents who have more income and large holding size said yes that present agriculture income is sufficient for them.
- The table 4.33 resulted that 47.7% of the respondents are doing other work along with agriculture and 52.3% said that they are not doing any other job except agriculture. Their responses regarding doing job are associated significantly with social groups, income, holding sizes and education. Most of the respondents who belong to BC and SC categories are doing job and very fewer from general category are also doing job. Most of the Respondents who belong to less income groups and small size of holding said yes to doing job. So, these are important indicators which affecting the farmers responses about doing other work with agriculture.
- In table 4.45(a,b), Out of 390 respondents, 341(87.4%) said that there agriculture land has been changed and only 49(12.6%) reported that their land holding size has been remained same. The association of responses regarding holding size changes with social groups, income and holding size is significant which means that these are the important socio-economic indicators which related with the decreasing holding size. It is not significant with education level as education is not affecting it. If we talk about reasons behind this change almost 68.6% reported that it is happened due to family bifurcation, 17.6% said

that they have bought new land and 13.8% said that they have sold out some part of their land holdings. So, the biggest reason behind the decreasing land holding size is family bifurcation which is putting a negative impact on agricultural growth. The reasons of holding change were further related with holding size and income and it resulted that there is a significant association between them on the level of 0.05.

- Lastly farmers were asked to give rank to the present major agricultural problems, and it resulted that majority of the respondents give first rank to ground water depletion, second rank to decreasing holding size, 3^{rd} rank to higher use of fertilizers, 4^{th} rank to soil depletion and 5^{th} rank to stagnation of productivity. Then applied Friedman Rank test which is significant at the level of 0.05 which indicates that significant difference is found between the mean ranks of the major agricultural problems faced by the respondents.

Results and Conclusion

SUSTAINABLE AGRICULTURAL MEASURES

5.1 Summary

The present research "Sustainable Agriculture Development in Haryana: A Study Of NCR Region" is a sound effort to evaluate the changing agricultural scenarios in NCR Haryana due to change in LULC and cropping pattern. Agriculture is the backbone of the economy as rural people depend on the agricultural income for their livelihood. Green revolution gave a new path of development to agriculture production and made the state self-sufficient in food grains and also a major food supplier in central pool of India. This package technology includes HYV seeds, chemical fertilizer, pesticides and modern farm technologies which enhanced the food production at a great extent. All are happy with the growth in production and yield per hectares but the negative impacts of this package technology began to appear in the form of serious agricultural problems. This revolution put huge pressure on agricultural resources within the state in the form of soil degradation, ground water table depletion, health risk of human as well as animals and also for degraded ecological conditions. High production of foodgrains was not possible without HYV seeds but these seeds require more soil nutrient, fertilizers and water which degraded the soil fertility and also responsible for downfall of ground water table. Higher use of fertilizers and pesticides also affected the soil and environmental health conditions. Excess use of chemical fertilizers without soil testing starts affected the human and animal health as both are related with food and environment. There is numerous research about agriculture development in Haryana but no one did research about agricultural development in Haryana NCR as this region is suffering from huge LULC changes due to nearness of Delhi. So, the purpose of the present research is to assess the agricultural sustainability in NCR Haryana. There is a big threat for agriculture sustainability because Haryana is a agricultural sound state and agriculture land is continue decreasing. The present research mainly focused on the LULC changes occurred in NCR Haryana due to population growth, urbanization and proximity of Delhi which causing a threat for agricultural sustainability in the form of increasing built-up section. If the valuable agriculture land is continuously buried under construction, it will cause a danger for future crop production and food security. Agriculture sustainability is a broad concept which includes three important parameters for human growth as well as nature's health. Sustainable agriculture includes three major goal- good quality of habitat, fine economic reward and communal balance and there is a utter need of long term management of the available resources and should make unified policies for better agricultural development (Brodt et.all(2011). With respect to these important parameters, three objectives have been framed to find out the results and conclusion about agricultural sustainability development in Haryana NCR namely-

Objectives Of the Study

1. To examine the land use changes in NCR region of Haryana.

2. To evaluate the changing cropping pattern of NCR region of Haryana.

3. To suggest the appropriate measures in order to attain the sustainable development of agriculture.

To find out the results and conclusions, the data has been collected from secondary as well as primary sources. Secondary data have been collected from various sources namely District Statistical Handbook, Census Handbook, Directorate of economics and statistics, Statistical Abstract of Haryana, Central statistical Newspaper, Books, Journals, Internet etc. primary data has been collected from selected villages with the help of the detailed questionnaire. Sample selection has been done with the help of the multistage sampling technique. The sampling procedure have been done in three stages namely first district selection, second block selection and third villages selection. First of all, all the fourteen district were divided into three category high, medium and low on the basis of net sown area and select the district with systematic random sample method. On second stage, block list of the selected district have been prepared and all the block also divide into three category on the basis of net sown area and after that village list of the selected block have been prepared into three classes and very first village from each class have been selected for primary survey. For educate sample number, Taro Yamnee method have adopted and after that village wise cultivators list have been collected from Census of India website. There are 11098 cultivators in all the 24 selected village and 390 is the accurate sampling number according to the Taro Yamnee method which is 3.5% of the total number of the cultivators. So, from each village, 3.5% of the total cultivators have been calculated. Primary survey is the very important parameter of the present research and to fulfil this objective, personal household interviews have been done.

Chapter 2:- To examine the land use changes in the NCR region of Haryana

In the current study, Landsat satellite imagery from 1991, 2006, and Landsat 8 imagery were utilized to create Land Use/Land Cover (LULC) maps. The focus was on the National Capital Region (NCR) in Haryana. The results revealed a significant decrease in agricultural land from 22463.3 km² (88.7%) in 1991 to 20487.3 km² (80.9%) in 2022. The primary drivers behind this decline are identified as population growth and urbanization, with a substantial portion of agricultural areas being converted into built-up spaces to meet the residential needs of the growing population. Simultaneously, the study observed a rapid increase in built-up areas, escalating from 936.4 km² in 1991 to 3469.5 km² in 2022. This expansion is attributed to the rising population (from 11.1 million to 16.5 million between 1991 and 2011) and urbanization (increasing from 30.3 to 36.2 between 1991 and 2011). The transformation of agricultural land into built-up areas is highlighted as a significant concern for the region's resources, emphasizing the need for sustainable land-use planning and resource management in the face of population and urban growth. The study also notes instances of misclassification, where built-up areas were erroneously categorized as agriculture, water bodies, vegetation, or barren land, underscoring the challenges in accurately assessing land use changes.

The study analysed land-use changes in Haryana from 1991 to 2022 using satellite imagery, revealing significant transformations in various land categories. Barren land, including ridges, sand dunes, and river sand, decreased notably from 1218.3 km² in 1991 to 865.1 km² in 2022. Most of this barren land converted into agriculture and built-up areas. Tehsil-wise variations showed decreasing trends in barren land in most regions, except for Bawani khera, Dadri, Loharu, and Kosli, where activities like stone breaking in the Aravalli hills contributed to an increase in barren land.

Vegetation cover also witnessed a decline, reducing from 218.1 km² in 1991 to 100.4 km² in 2022, with agriculture and built-up areas absorbing most of the converted land. All tehsils displayed decreasing trends in vegetation cover, indicating extensive land-use changes. Water bodies experienced a 0.3% decrease between 1991 and 2022, attributed to the drying up of ponds and small canals. Tehsil-wise analysis revealed negative growth in all regions, with water bodies transforming into agriculture and built-up areas.

Agriculture land exhibited a continuous decrease throughout the study period, converting into built-up areas due to population growth and infrastructural activities. While some tehsils showed temporary positive growth from 1991 to 2006, overall trends indicated a decline in agriculture land. Built-up areas displayed the most drastic changes, increasing consistently across all tehsils from 1991 to 2022. The strong positive correlation ($r=0.91$) between built-up areas and population growth highlighted the impact of rapid urbanization. The coefficient of determination ($R^2=0.83$) further emphasized the significant role of population growth in driving the substantial expansion of built-up areas during the study period.

Chapter 3- To evaluate the changing cropping pattern of the NCR region of Haryana

The study focused on the changing agricultural landscape in NCR Haryana from 1991 to 2022, highlighting key trends and factors influencing land use and crop patterns. The net sown area in NCR Haryana reduced from 88.6% to 80.9% during this period, attributed to the growth of other sectors encroaching on agricultural land.

Crop patterns exhibited notable shifts, with rice, bajra, wheat, gram, and mustard being major crops during different periods. The increasing area under paddy, a water-intensive crop, contributed to a decline in groundwater levels. Rice and wheat dominated the eastern and central parts, making up 57% of the total cropped area, showcasing the significance of these crops in the region.

Bajra, an essential kharif crop, saw a decrease in area but an increase in production due to the adoption of high-yielding seeds and fertilizers. Gram-cropped area decreased due to irrigation expansion favouring wheat and mustard farming. Cropping intensity increased from 149% to 184%, attributed to developments in irrigation, high-yield seeds, mechanization, and fertilizers.

Crop diversification reduced in certain tehsils, emphasizing the prevalence of mono-culture, particularly in areas with poor soil and limited irrigation facilities. Irrigation intensity increased from 150.7% to 173%, playing a vital role in agriculture development.

Correlation analyses revealed positive associations between irrigation intensity, cropping intensity, and the area under rice, wheat, sugarcane, and cotton. Negative correlations were observed with bajra, barley, gram, and mustard, indicating a shift in crop preferences due to expanded irrigation facilities. Scatter diagrams validated these correlations, showcasing the strength of the relationships between different crops and irrigation/cropping intensity. Overall, the study provided insights into the dynamic changes in land use, crop patterns, and their associations with irrigation and cropping intensities in NCR Haryana over the specified period.

Chapter 4:- To examine the implications of cropping patterns on the socio-economic conditions and perspective about agriculture sustainability

The study presents a comprehensive overview of challenges and threats to agricultural sustainability in NCR Haryana based on a survey of respondents. Key findings include:

1. Demographic Concerns: A significant portion (85%) of respondents falls within the 50 to 60 years and above age groups, posing a potential threat to agricultural sustainability. The lack of interest from the younger generation, with fewer growth opportunities in agriculture, exacerbates this concern.

2. Gender Disparities: - The survey reflects a male-dominated rural society in Haryana, with 95% of respondents being male. Female work participation is evident but decision-making, land ownership, and societal roles remain skewed towards males, reinforcing gender disparities.

3. Social Group Dynamics: - Land distribution does not align significantly with social groups, indicating that General and BC categories own most agricultural land. This highlights social backwardness and an income gap, with 85.6% of respondents belonging to these categories.

4. Educational Challenges: - The majority of farmers are educated up to 10th and 8th standards. The lack of highly qualified individuals poses a threat to agriculture sustainability, as education is crucial for adopting new technologies and improving farming practices.

5. Land Holding Size: - A significant proportion (67.4%) of respondents have marginal and small land holdings, contributing to diminishing interest in agriculture among younger generations. Family bifurcation emerges as a primary reason for decreasing land holding sizes.

6. Irrigation Practices:- Tubewells are the primary source of irrigation (54% of respondents). Over-exploitation of groundwater resources has led to declining water tables, posing a serious threat to future food production and causing soil structure changes.

7. Fertilizer Usage: - A notable percentage (45.4%) of respondents rely solely on chemical fertilizers, while 54.6% use a combination of chemical and manure. Continuous use of chemical fertilizers without soil testing raises concerns about soil, food, and environmental quality.

8. Regional Disparities: - Disparities exist in fertilizer usage quantity per acre, with villages practicing mono-culture using more chemical fertilizers. Lack of soil testing and awareness about the impact on soil and human health contribute to the urgent need for farmer education.

9. Overall Threats to Sustainability: - The study emphasizes the overall threat to agricultural sustainability in NCR Haryana due to changing land use patterns, existing cropping systems, and the depletion of soil and water resources. Urgent awareness and intervention are recommended for securing future food security in the region.

The survey, conducted with 390 respondents, provides insights into the income distribution among farmers in the studied region:

10 Total Income Distribution: - Among the respondents, 28.2% reported a total income ranging from 3 to 4.5 lakh, 27.9% had a total income between 1.5 to 3 lakh, 22.3% fell in the 4.5 to 6 lakh category, 12.8% reported an income exceeding six lakhs, and 8.7%

had a total income of up to 1.5 lakh. Notably, around 60% of the farmers fell within the 1.5 to 4.5 lakh total income range.

11. Agricultural Income Breakdown: - Focusing on income derived solely from agriculture, the distribution indicated that 28.7% of respondents had an income between 1.5 to 3 lakh, 30.3% reported an income of 3 to 4.5 lakh, 17.2% fell in the 4.5 to 6 lakh category, 12.1% had an income exceeding six lakhs, and 11.8% had an income of up to 1.5 lakh from agriculture alone. The study selected families with 70% or more income originating from agriculture to evaluate the impact of cropping patterns on socio-economic conditions.

12. agriculture Income Share in Total Income: - Regarding the percent share of agriculture income in the total income of sampled villages, findings revealed that 42.6% of respondents relied solely on agriculture for income. Additionally, 29% reported having 80 to 89.9% of their income from agriculture, 16.2% fell in the 70 to 79.9% income range, and 11.3% had a substantial 90 to 99.9% share of agriculture income in their total income.

The data underscores the significant dependence of a considerable portion of the surveyed farmers on agriculture for their livelihood. The distribution patterns shed light on the diverse income sources within the agricultural community, highlighting the need for targeted interventions and policies to support sustainable income generation in the region.

The survey highlights several aspects of the socio-economic conditions and lifestyle of the surveyed farmers:

1. Housing Structure: - A significant proportion of respondents (58.2%) reside in semi-pacca housing, while 41.8% live in fully Pacca houses. Notably, farmers with better incomes tend to have fully Pacca houses, indicating a socio-economic divide. The association of house type with social groups, income, land holding size, and education is significant, demonstrating the strong correlation between housing conditions and these factors.

2. Family Structure:- The trend indicates a shift towards nuclearization, with only 16.2% of respondents living in joint families. The association between family type and

social groups, land holding, income, and education is significant, emphasizing the influence of these factors on the choice of family structure. Nuclear families are more prevalent across all social categories and most land holding categories, except medium and large, while higher-income groups tend to have joint family structures.

3. Education of Children: - A substantial majority (80.3%) of respondents' children attend private schools, with only 19.7% enrolled in government schools. The association between the type of school and social groups, income, holding sizes, and education is significant. General and BC category respondents predominantly send their children to private schools, while SC category respondents are more likely to opt for government schools. Higher-income groups and those with higher education levels also show a preference for private schools.

4. Household Assets: - Respondents possess varying combinations of household assets, with associations found between asset ownership and social groups, income, land holding sizes, and education. Higher-value assets are predominantly owned by the General and BC categories, as well as those with larger land holdings, higher incomes, and higher education levels.

5. Agricultural Work Patterns:- Only 20% of respondents engage in agricultural work with their family members, while 39.2% work independently with hired labour, and 40.8% collaborate with labour for farm work. The association between agricultural work patterns and income, holding size, social groups, and education is significant. General and BC categories, larger landholders, higher-income groups, and those with higher education levels are more likely to hire labour for agricultural tasks.

Overall, the findings illustrate the intricate connections between socio-economic factors and various aspects of farmers' lives, including housing, family structure, education choices, possession of assets, and agricultural work patterns.

The study indicates a significant lack of awareness regarding agricultural sustainability among the respondents, with only 4.1% claiming awareness of the concept. A noteworthy 95.9% of farmers expressed no knowledge about agricultural sustainability. This lack of awareness poses a substantial challenge for achieving sustainable agriculture. The study highlights a statistically significant association between awareness and education, emphasizing that education plays a crucial role in spreading awareness about new concepts. Notably, all respondents who claimed awareness of agricultural sustainability were educated up to the 12th grade or beyond, and their knowledge was primarily derived from reading about the concept in books.

The survey conducted across various villages revealed diverse cropping patterns among the respondents, with 55.6% adopting mono-culture, primarily sowing only wheat-rice or wheat-cotton. Mixed cropping patterns, involving the cultivation of more than two crops, were followed by 39.5% of the respondents. The prevalence of mono-culture, especially the cultivation of wheat-rice and wheat-cotton, poses a significant obstacle to achieving agricultural sustainability in the region. The choice of cropping patterns exhibited associations with income and education levels, indicating that farmers tend to select crops based on profitability, and education plays a role in their decision-making process. Notably, there was no discernible association between cropping patterns and social group or landholding size.

Furthermore, the survey identified significant associations between cropping patterns, cropping systems, and respondents' perceptions of changes in groundwater levels. This suggests that the chosen cropping patterns and systems have a substantial impact on groundwater dynamics. Similarly, the quantity of fertilizers used per acre was significantly associated with both cropping patterns and cropping systems, indicating their influence on fertilizer application practices. The source of irrigation, a pivotal factor in shaping regional agricultural systems, also showed a significant association with cropping patterns and cropping systems. Overall, these findings underscore the interconnectedness of cropping choices with agricultural sustainability, resource management, and the socio-economic characteristics of the respondents.

Among the 390 respondents surveyed, a significant 75.9% acknowledged a negative change in groundwater levels, raising concerns for agricultural development in the region. Only 24.1% reported no change in their water table. The association between responses on groundwater level change and social groups, as well as income, was found to be significant. However, no significant relationship was observed with landholding size and education, suggesting these factors did not influence farmers' perceptions of groundwater level changes. A noteworthy finding was the significant correlation between farmers' responses about groundwater level changes and their source of irrigation. Specifically, those relying solely on tubewells for irrigation were more likely to report a negative change in groundwater levels. This highlights the potential impact of irrigation practices on the observed changes in groundwater and emphasizes the importance of considering the source of irrigation in discussions about sustainable water management in the region.

The survey revealed that a significant majority of the respondents, accounting for 88.5%, are experiencing health issues, while only 11.5% reported being free from health concerns. The association of health issues with social groups and income was found to be significant, indicating that these factors play a role in shaping the respondents' health conditions. However, no significant association was observed with landholding size and education, suggesting that these variables did not impact the reported health issues.

Concerningly, a considerable number of respondents, 54.8%, attributed their health problems to the overuse of chemical fertilizers and pesticides, while 29.9% believed that all mentioned factors contributed to their health issues. A smaller percentage, 10.7%, pointed to climate change and pollution as major reasons, and 4.6% identified both the overuse of chemical fertilizers and soil & water pollution. Notably, responses regarding the reasons for health issues were significantly associated with social groups, income, and education. However, landholding size did not exhibit a significant association with the perceived reasons for health problems, indicating that it did not influence respondents' views on the causes of health issues.

The survey found that opinions on the sufficiency of income from agriculture are divided among respondents, with 49.2% stating that their agricultural income is sufficient, and 50.8% expressing dissatisfaction. Notably, responses on income sufficiency were significantly associated with social groups, income, landholding size, and education. Specifically, farmers from Scheduled Caste (SC) backgrounds were more likely to report insufficiency in income. Respondents with higher incomes and larger landholdings were more likely to consider their agricultural income sufficient. Furthermore, the survey revealed that 47.7% of respondents engage in additional work alongside agriculture, while 52.3% focus solely on farming. The decision to undertake additional employment was significantly associated with social groups, income, landholding size, and education. Those belonging to Backward Classes (BC) and SC categories, as well as individuals with lower incomes and smaller landholdings, were more likely to engage in other work. These findings underscore the influence of socio-economic factors on farmers' decisions regarding the sufficiency of agricultural income and the pursuit of additional employment opportunities.

Among the 390 respondents, a substantial 87.4% reported changes in their agricultural land holdings, with only 12.6% indicating that their land size remained the same. The association between responses about holding size changes and socio-economic indicators such as social groups, income, and holding size itself was found to be significant. Education level, however, did not exhibit a significant association with changes in holding size. The study delved into the reasons behind these changes, revealing that the majority, 68.6%, attributed it to family bifurcation, while 17.6% mentioned purchasing new land, and 13.8% cited selling part of their land holdings. Notably, family bifurcation emerged as the primary reason, impacting agricultural growth negatively. Furthermore, the reasons for holding changes were analyzed in relation to holding size and income, indicating a significant association at the 0.05 significance level. This underscores the complex interplay between socio-economic factors and the dynamic nature of agricultural land holdings, shedding light on the challenges posed by family dynamics and economic considerations in influencing changes in land sizes among farmers.

In the final segment of the survey, farmers were asked to rank the major agricultural problems they currently face. The majority of respondents assigned the first rank to ground water depletion, the second rank to decreasing holding size, the third rank to higher use of fertilizers, the fourth rank to soil depletion, and the fifth rank to stagnation of productivity. Subsequently, the Friedman Rank test was applied, revealing significance at the 0.05 level. This suggests a noteworthy difference in the mean ranks of the identified major agricultural problems, indicating that farmers perceive these issues with varying degrees of concern. The findings highlight the multifaceted nature of challenges in agriculture and the need for comprehensive strategies to address the array of issues affecting farmers in the surveyed region.

5.2 Suggestions

Based on the summarized findings highlighting challenges and trends in agriculture, here are suggestions to enhance sustainability in the agricultural practices in the surveyed region:

1. Promote Sustainable Farming Practices: - Encourage farmers to adopt sustainable farming techniques such as crop rotation, agroforestry, and organic farming. These practices can improve soil health, reduce reliance on chemical inputs, and enhance overall farm resilience. Diversify the cropping pattern.

2. Awareness Programs on Agricultural Sustainability: - Conduct awareness campaigns and educational programs to inform farmers about the importance of sustainable agriculture. Emphasize the benefits of conservation practices, water-use efficiency, and soil health management.

3.Water Conservation and Integrated Pest Management (IPM): - Implement water-saving technologies such as drip irrigation and rainwater harvesting to conserve water resources. Advocate for the adoption of Integrated Pest Management practices to minimize the use of chemical pesticides.

4. Support for Small and Marginal Farmers: - Implement policies and programs that specifically address the challenges faced by small and marginal farmers. Provide access to credit, training, and resources to enhance their productivity and income levels.

5. Invest in Agricultural Infrastructure through education: - Upgrade agricultural infrastructure, including irrigation systems, storage facilities, and market access. Prioritize education and skill development programs for farmers to enhance their knowledge about modern farming practices, technology adoption, and sustainable agriculture.

6. Incentivize Sustainable Practices: - Introduce financial incentives, subsidies, or rewards for farmers adopting sustainable practices. This can motivate farmers to make the transition towards more sustainable and environmentally friendly farming methods.

7. Addressing the challenge of decreasing agriculture area due to urbanization and built-up expansion requires a combination of land-use planning, policy interventions, and sustainable development practices. Here are suggestions to mitigate the impact of urbanization on agricultural land:

8. Effective Land-Use Planning: - Implement robust land-use planning that designates specific areas for urban development while safeguarding agricultural land. Enforce zoning regulations that restrict the conversion of prime agricultural land for non-agricultural purposes.

9. Smart Growth Policies: - Advocate for smart growth policies that prioritize infill development, redevelopment of brownfield sites, and the utilization of existing urban areas. This approach minimizes the need for expanding into agricultural lands.

10. Buffer Zones and Greenbelts: - Establish buffer zones and greenbelts around urban areas to act as protective barriers for agricultural land. These areas can serve ecological purposes, prevent urban sprawl, and provide recreational spaces.

11. Incentives for Agricultural Conservation: - Introduce financial incentives or tax breaks for landowners who commit to maintaining agricultural land. This can include reduced property taxes for those preserving farmland within designated zones.

12. Rural-Urban Linkages: - Strengthen linkages between rural and urban areas to ensure a symbiotic relationship. Support initiatives that connect farmers with urban markets, promote agro-tourism, and enhance the economic viability of rural communities.

13. Environmental Impact Assessments and data driven planning: - Mandate comprehensive environmental impact assessments before approving major development projects. Strengthen legislation related to land-use conversion and enforce regulations that protect agricultural lands. Utilize data and technology for informed decision-making.

By implementing these suggestions, it is possible to strike a balance between urban development and agricultural preservation, ensuring sustainable land use that meets the needs of both present and future generations. By integrating these suggestions into agricultural policies and practices, there is potential to enhance the sustainability of agriculture in the surveyed region, leading to improved environmental resilience, economic stability, and overall well-being of farming communities.

5.3 Conclusion: -

The comprehensive analysis of the survey data reveals critical challenges and opportunities within the agricultural landscape of the surveyed region. The following conclusion highlights key findings and suggests a way forward for sustainable agriculture:

Key Findings:

1. Awareness and Education Gap: - The survey indicates a significant lack of awareness regarding agricultural sustainability, with only a small percentage of respondents aware of key concepts. Education emerges as a critical factor influencing awareness levels.

2. Cropping Patterns and Sustainability: - The predominance of mono-culture and specific cropping patterns poses a significant hindrance to agricultural sustainability. The correlation between cropping patterns, income, and education underscores the need for diversification.

3. Groundwater Depletion and Irrigation Practices: - The reported negative changes in groundwater levels and the association with cropping patterns highlight the importance of sustainable irrigation practices. The need for water conservation measures and efficient irrigation technologies is evident.

4. Health Concerns and Chemical Usage: - The high percentage of respondents facing health issues and the association with the overuse of chemical fertilizers and pesticides underscore the urgent need for sustainable farming practices to safeguard both the environment and human health.

5. Income Disparities and Land Holding Changes: - Income disparities, changing land holding sizes, and the reported reasons for holding changes reveal complex socio-economic dynamics. Strategies to address these issues should be inclusive and considerate of different social groups.

6. LULC Changes and Urbanization Impact: - The observed changes in land use and the encroachment of built-up areas into agricultural land emphasize the pressing need for balanced urbanization policies that protect prime agricultural areas.

In conclusion, the trajectory of agriculture sustainability is at a critical juncture, shaped by the alarming trends of LULC changes, diminishing agriculture land, and the pervasive shift towards mono-culture which creating such severe issues namely decreasing ground water level, and deteriorating soil health. The substantial reduction in agricultural land due to urbanization and expansion of built-up areas poses a severe threat to food production capacity. Simultaneously, the increasing prevalence of mono-culture, often driven by economic pressure, exacerbates ecological vulnerabilities and undermines the long-term resilience of farming system. The dwindling interest of the younger generation in agriculture, driven in part by the decreasing size of land holdings and limited growth opportunities, is an urgent concern. Moreover, the economic viability of farming is increasingly becoming a challenge. Balancing the economic aspects of farming with environmentally friendly practices is essential to the long-term prosperity of agriculture sector. To secure the future of sustainable agriculture, it is imperative to address these interconnected challenges comprehensively. Policies that prioritize land conservation, incentivize diversified farming practices, and support small holder's farmers are crucial. Additionally, fostering an environment that encourages innovation, technology adoption, and sustainable agricultural practices can revitalize the sector and attract the new generation of farmers.

Achieving agriculture sustainability is paramount for ensuring the well-being of our planet, its inhabitants and future generations. The intricate balance between environmental conservation, economic viability, and social equity is at the core of sustainable agriculture. Embracing practices that promote soil health, biodiversity and efficient resource use will not only safeguard the environment but also enhance the resilience of our food systems in the face of climate change and other challenges. The adoption of innovative technologies, precision farming and agroecological approaches can play a vital role in fostering sustainability within the agriculture sector. Additionally, the promotion of fair-trade practices, equitable distribution of resources, youth engagement, providing substitute of chemical fertilizers and reward for the farmers are essential for creating a sustainable and inclusive agricultural landscape.

Governments, industries and individual must collaborate to implement policies that support sustainable farming practices, invest in research and development and educate stakeholders about the importance of responsible agricultural management. By recognizing the interconnection of agriculture with broader environmental and societal goals, we can pave the way for a more resilient, equitable and sustainable future in which agriculture thrives without compromising the health of mankind and environment. Embracing a holistic approach to agriculture sustainability is not just a choice; it is a necessity for the continued prosperity of our global community.

Engaging in public awareness campaigns and educational initiatives is essential to rekindle interest among the youth and highlight the importance of sustainable farming. Encouraging community-based initiatives, cooperative farming models and providing financial support for smallholders can help counteract the trend of diminishing farm sizes.

Ultimately, achieving agriculture sustainability in the face of declining agriculture land changing farming dynamics requires a concerted effort from policymakers, communities and farmers alike. By embracing a holistic approach that balance economic viability with environment and social considerations, we can build a resilient and sustainable agricultural future for generations to come. Furthermore, fostering education and awareness programmes can empower farmers to make informed decision that benefit both their livelihood and environment.

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List of Appendices

Table 1.1:- LULC Change Matrix in Assandh Tehsil- 1991 and 2022

LULC Classes Assandh		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	506.9	0.1	25.0	0.1	2.5	534.5
	Barren Land	0.3	0.3	0.0	0.0	0.1	0.6
	Built Up	1.1	0.0	13.3	0.0	0.3	14.6
	Vegetation	0.6	0.0	0.0	1.5	0.0	2.2
	Water Body	1.5	0.0	0.4	0.0	3.2	5.1
	Total	510.3	0.4	38.8	1.6	6.0	557.0

Table 1.2:- LULC Change Matrix in Karnal Tehsil- 1991 and 2022

LULC Classes Karnal		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	1724.0	0.7	181.9	2.6	5.8	1915.0
	Barren Land	11.7	1.7	1.3	0.1	1.5	16.3
	Built Up	4.2	0.1	58.4	0.1	0.2	62.9
	Vegetation	2.0	0.0	0.6	1.3	0.0	3.9
	Water Body	8.4	0.3	1.5	0.0	20.3	30.6
	Total	1750.3	2.8	243.7	4.2	27.8	2028.8

Table 1.3:- LULC Change Matrix in Panipat Tehsil- 1991 and 2022

LULC Classes Panipat		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	973.5	2.8	135.0	2.6	1.5	1115.4
	Barren Land	12.4	9.4	0.7	0.6	1.8	24.8
	Built Up	0.8	0.4	49.6	0.1	0.3	51.1
	Vegetation	4.3	0.3	0.9	0.2	0.1	5.9
	Water Body	5.8	0.7	2.0	0.1	19.6	28.1
	Total	996.8	13.6	188.2	3.5	23.3	1225.3

Table 1.4:- LULC Change Matrix in GanourTehsil- 1991 and 2022

LULC Classes Ganour		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	289.7	2.4	31.3	0.3	1.0	324.7
	Barren Land	1.0	0.1	0.1	0.0	0.0	1.3
	Built Up	0.6	0.1	7.6	0.0	0.0	8.2
	Vegetation	0.7	0.4	0.5	0.0	0.1	1.8
	Water Body	1.1	0.1	0.3	0.1	4.0	5.6
	Total	293.1	3.2	39.8	0.4	5.0	341.6

Table 1.5:- LULC Change Matrix in Gohana Tehsil- 1991 and 2022

LULC Classes Gohana		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	788.4	0.4	53.0	1.6	3.9	847.2
	Barren Land	0.8	0.0	0.0	0.0	0.0	0.9
	Built Up	1.1	0.0	14.4	0.0	0.1	15.6
	Vegetation	1.4	0.1	0.6	0.4	0.1	2.6
	Water Body	3.5	0.0	5.0	0.1	12.0	20.7
	Total	795.2	0.5	73.0	2.2	16.0	886.9

Table 1.6:- LULC Change Matrix in Sonipat Tehsil- 1991 and 2022

LULC Classes Sonipat		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	777.2	0.5	135.7	2.0	2.6	918.0
	Barren Land	5.9	1.2	1.3	0.1	2.2	10.8
	Built Up	1.3	0.0	34.3	0.0	0.1	35.7
	Vegetation	2.2	0.0	1.6	0.2	0.0	4.0
	Water Body	4.3	0.1	1.1	0.0	12.8	18.3
	Total	790.8	1.8	174.0	2.3	17.8	986.8

Table 1.7:- LULC Change Matrix in Jind Tehsil- 1991 and 2022

LULC Classes Jind		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	929.4	0.2	57.1	0.5	0.7	987.9
	Barren Land	0.1	0.0	0.2	0.0	0.0	0.2
	Built Up	2.6	0.0	34.1	0.0	0.2	36.9
	Vegetation	0.5	0.0	0.7	3.9	0.0	5.1
	Water Body	0.0	0.0	1.2	0.1	10.0	11.4
	Total	932.5	0.2	93.2	4.6	11.0	1041.5

Table 1.8:- LULC Change Matrix in Safidon Tehsil- 1991 and 2022

LULC Classes Safidon		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	470.2	0.1	31.4	0.3	1.5	503.4
	Barren Land	0.0	0.0	0.2	0.0	0.0	0.2
	Built Up	2.1	0.0	14.6	0.0	0.1	16.8
	Vegetation	1.7	0.0	0.2	0.1	0.0	2.0
	Water Body	1.0	0.0	0.3	0.0	7.8	9.2
	Total	475.0	0.1	46.8	0.3	9.5	531.7

Table 1.9:- LULC Change Matrix in Narwana Tehsil- 1991 and 2022

LULC Classes Narwana		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	1058.3	0.2	47.4	0.0	2.2	1108.2
	Barren Land	0.4	0.0	0.0	0.0	0.0	0.5
	Built Up	2.4	0.1	26.5	0.0	0.2	29.1
	Vegetation	0.9	0.0	0.2	0.2	0.0	1.3
	Water Body	9.1	0.0	0.6	0.0	12.0	21.7
	Total	1071.3	0.3	74.7	0.2	14.4	1160.9

Table 1.10:- LULC Change Matrix in Rohtak Tehsil- 1991 and 2022

LULC Classes Rohtak		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	965.8	2.9	109.3	0.3	3.8	1082.2
	Barren Land	3.1	2.1	2.0	0.1	0.1	7.3
	Built Up	1.9	0.0	43.0	0.0	0.4	45.3
	Vegetation	2.3	0.0	0.3	0.0	0.0	2.6
	Water Body	6.0	0.1	1.6	0.0	18.3	26.0
	Total	979.1	5.1	156.1	0.4	22.7	1163.4

Table 1.11:- LULC Change Matrix in Maham Tehsil- 1991 and 2022

LULC Classes Maham		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	469.1	1.2	31.7	0.1	0.2	502.4
	Barren Land	0.1	0.8	0.2	0.0	0.0	1.1
	Built Up	1.0	0.0	9.5	0.0	0.0	10.5
	Vegetation	1.3	0.2	1.1	0.3	0.0	2.9
	Water Body	1.3	0.0	0.7	0.0	4.0	6.1
	Total	472.9	2.2	43.2	0.5	4.3	523.1

Table 1.12:- LULC Change Matrix in Jhajjar Tehsil- 1991 and 2022

LULC Classes Jhajjar		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	813.1	1.7	58.4	0.3	8.3	881.8
	Barren Land	5.4	1.4	0.1	0.0	0.0	7.0
	Built Up	2.5	0.0	18.9	0.0	0.1	21.5
	Vegetation	4.7	0.2	1.9	0.2	0.1	7.2
	Water Body	11.2	0.1	5.1	0.0	9.2	25.6
	Total	836.9	3.4	84.5	0.6	17.7	943.1

Table 1.13:- LULC Change Matrix in Bahadurgarh Tehsil- 1991 and 2022

LULC Classes Bahadurgarh		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	444.7	0.1	58.4	0.6	2.7	506.6
	Barren Land	0.3	0.1	0.3	0.0	0.0	0.7
	Built Up	1.3	0.0	23.2	0.0	0.1	24.5
	Vegetation	1.7	0.0	2.3	0.0	0.1	4.1
	Water Body	1.6	0.0	1.0	0.0	11.1	13.7
	Total	449.5	0.3	85.2	0.7	13.9	549.6

Table 1.14:- LULC Change Matrix in Faridabad Tehsil- 1991 and 2022

LULC Classes Faridabad		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	114.9	1.6	109.2	0.7	2.1	228.3
	Barren Land	10.5	89.6	23.5	5.9	1.1	130.7
	Built Up	0.0	0.1	56.8	0.0	0.5	57.4
	Vegetation	2.1	9.5	4.1	8.3	0.4	24.3
	Water Body	2.4	1.1	1.5	0.1	2.7	7.9
	Total	129.9	101.8	195.0	15.0	6.8	448.7

Table 1.15:- LULC Change Matrix in Ballabgarh Tehsil- 1991 and 2022

LULC Classes Ballabgarh		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	308.4	1.9	56.0	0.2	1.2	367.6
	Barren Land	3.6	1.6	1.3	0.0	1.4	8.0
	Built Up	0.1	0.0	6.4	0.0	0.0	6.4
	Vegetation	1.5	0.2	0.4	0.2	0.0	2.3
	Water Body	2.2	0.1	0.3	0.0	4.7	7.3
	Total	315.7	3.8	64.5	0.4	7.3	391.6

Table 1.16:- LULC Change Matrix in Gurgaon Tehsil- 1991 and 2022

LULC Classes Gurgaon		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	565.3	6.1	264.6	0.0	8.0	843.9
	Barren Land	18.5	87.1	13.2	0.0	0.3	119.2
	Built Up	1.0	0.1	59.2	0.0	0.0	60.3
	Vegetation	5.5	8.8	6.6	16.6	0.1	37.6
	Water Body	0.6	0.0	0.1	0.0	2.1	2.8
	Total	590.9	102.2	343.7	16.7	10.4	1063.8

Table 1.17:- LULC Change Matrix in Patoudi Tehsil- 1991 and 2022

LULC Classes Patoudi		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	192.4	0.2	19.3	0.2	0.1	212.2
	Barren Land	0.1	0.0	0.0	0.1	0.0	0.2
	Built Up	1.1	0.0	6.2	0.0	0.0	7.3
	Vegetation	1.2	0.0	0.1	0.2	0.0	1.5
	Water Body	0.7	0.0	0.1	0.0	0.7	1.6
	Total	195.6	0.2	25.7	0.4	0.9	222.7

Table 1.18:- LULC Change Matrix in Palwal Tehsil- 1991 and 2022

LULC Classes Palwal		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	751.7	1.5	85.5	0.8	5.5	844.9
	Barren Land	7.6	0.7	0.3	0.1	1.2	9.9
	Built Up	1.1	0.0	27.7	0.0	0.1	29.0
	Vegetation	4.4	0.0	0.4	1.2	0.0	6.0
	Water Body	3.1	0.2	0.9	0.1	11.4	15.7
	Total	768.0	2.4	114.8	2.1	18.3	905.5

Table 1.19:- LULC Change Matrix in Hathin Tehsil- 1991 and 2022

LULC Classes Hathin		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	359.1	0.8	25.4	0.2	1.7	387.2
	Barren Land	1.4	1.0	0.2	0.0	0.0	2.6
	Built Up	1.9	0.0	15.4	0.0	0.0	17.4
	Vegetation	1.2	0.0	0.7	0.1	0.0	2.0
	Water Body	1.7	0.0	1.2	0.0	7.1	10.0
	Total	365.3	1.8	42.9	0.3	8.9	419.2

Table 1.20:- LULC Change Matrix in Bhiwani Tehsil- 1991 and 2022

LULC Classes Bhiwani		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	1143.0	5.7	69.0	1.0	0.0	1218.7
	Barren Land	12.8	8.3	2.0	0.2	0.0	23.2
	Built Up	2.9	0.1	34.0	0.0	0.0	37.0
	Vegetation	1.2	0.7	0.2	0.3	0.0	2.5
	Water Body	2.9	0.0	0.7	0.0	6.9	10.5
	Total	1162.7	14.8	105.9	1.6	6.9	1291.9

Table 1.21:- LULC Change Matrix in Bawani khera Tehsil- 1991 and 2022

LULC Classes Bawani khera		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	552.4	3.3	20.1	0.2	0.9	576.9
	Barren Land	0.1	2.6	0.2	0.0	0.0	3.0
	Built Up	2.3	0.0	13.4	0.1	0.0	15.8
	Vegetation	0.6	0.0	0.3	0.1	0.0	1.0
	WaterBody	0.0	0.0	2.0	0.0	7.6	9.6
	Total	555.4	5.9	36.0	0.4	8.5	606.2

Table 1.22:- LULC Change Matrix in Dadri Tehsil- 1991 and 2022

LULC Classes Dadri		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	1199.8	8.2	48.2	1.6	0.0	1257.8
	Barren Land	3.2	23.9	0.7	0.1	0.0	27.9
	Built Up	10.0	1.3	45.9	0.0	0.5	57.6
	Vegetation	2.7	3.0	1.5	0.4	0.1	7.6
	Water Body	6.1	0.0	1.6	0.0	17.9	25.7
	Total	1221.7	36.5	97.9	2.1	18.5	1376.7

Table 1.23:- LULC Change Matrix in Loharu Tehsil- 1991 and 2022

LULC Classes Loharu		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	545.7	3.5	15.7	0.4	0.0	565.3
	Barren Land	2.6	5.9	0.8	0.5	0.0	9.8
	Built Up	1.8	0.3	9.1	0.0	0.1	11.3
	Vegetation	3.2	1.5	1.6	0.6	0.0	7.0
	Water Body	4.2	0.0	0.2	0.0	13.2	17.6
	Total	557.5	11.2	27.5	1.5	13.2	611.0

Table 1.24:- LULC Change Matrix in Siwani Tehsil- 1991 and 2022

LULC Classes Siwani		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	358.4	1.7	16.8	1.0	0.1	378.0
	Barren Land	189.9	153.8	5.6	0.7	0.0	350.0
	Built Up	1.8	0.7	12.7	0.0	0.0	15.2
	Vegetation	0.4	0.0	0.0	0.1	0.0	0.6
	Water Body	1.2	0.0	0.1	0.0	5.2	6.5
	Total	551.7	156.3	35.2	1.8	5.3	750.2

Table 1.25:- LULC Change Matrix in Mahendergarh Tehsil- 1991 and 2022

LULC Classes Mahendergarh		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	790.5	5.2	52.7	1.8	0.7	850.9
	Barren Land	16.5	73.1	3.1	1.3	0.0	94.0
	Built Up	4.6	0.4	21.7	0.0	0.0	26.8
	Vegetation	6.8	1.5	2.4	3.4	0.0	14.1
	Water Body	0.8	0.0	0.8	0.1	4.6	6.3
	Total	819.2	80.3	80.7	6.5	5.4	992.1

Table 1.26:- LULC Change Matrix in Narnoul Tehsil- 1991 and 2022

LULC Classes Narnoul		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	750.3	6.9	87.2	0.1	0.6	845.0
	Barren Land	13.7	54.6	4.4	0.5	0.1	73.3
	Built Up	1.3	0.0	16.1	0.0	0.0	17.4
	Vegetation	2.1	2.0	0.5	2.5	0.0	7.1
	Water Body	0.8	0.0	0.2	0.0	1.0	2.0
	Total	768.2	63.6	108.4	3.1	1.7	944.9

Table 1.27:- LULC Change Matrix in Rewari Tehsil- 1991 and 2022

LULC Classes Rewari		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	837.9	2.5	84.7	0.4	1.0	926.4
	Barren Land	8.5	31.1	6.3	0.2	0.1	46.2
	Built Up	2.1	0.0	29.7	0.0	0.0	31.8
	Vegetation	5.3	0.2	1.5	0.3	0.9	8.1
	Water Body	0.2	0.0	0.1	0.0	2.9	3.2
	Total	854.0	33.7	122.3	0.9	4.8	1015.7

Table 1.28:- LULC Change Matrix in Kosli Tehsil- 1991 and 2022

LULC Classes Kosli		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	533.7	6.9	42.6	1.8	0.7	585.7
	Barren Land	2.2	4.8	0.7	0.8	0.0	8.5
	Built Up	0.8	0.0	10.4	0.1	0.0	11.4
	Vegetation	3.3	3.6	0.2	2.0	0.0	9.2
	Water Body	1.2	0.0	0.2	0.0	5.0	6.4
	Total	541.2	15.4	54.2	4.7	5.7	621.1

Table 1.29:- LULC Change Matrix in Bawal Tehsil- 1991 and 2022

LULC Classes Bawal		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	185.4	2.4	30.9	0.0	0.2	218.8
	Barren Land	0.6	5.8	1.1	0.0	0.0	7.5
	Built Up	0.3	0.0	4.3	0.1	0.0	4.6
	Vegetation	0.7	0.4	0.1	2.8	0.0	3.9
	Water Body	1.2	0.0	0.2	0.0	2.1	3.5
	Total	188.1	8.6	36.6	2.9	2.2	238.4

Table 1.30:- LULC Change Matrix in Nuh Tehsil- 1991 and 2022

LULC Classes Nuh		2022					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	461.7	2.1	53.0	0.2	0.7	517.8
	Barren Land	10.9	62.8	2.7	1.3	0.0	77.6
	Built Up	1.9	0.3	14.0	0.0	0.1	16.3
	Vegetation	3.2	13.5	1.2	3.3	0.0	21.2
	Water Body	2.4	0.0	0.3	0.0	5.7	8.4
	Total	480.1	78.7	71.2	4.8	6.5	641.3

Table 1.31:- LULC Change Matrix in Firojpur Zirkha Tehsil- 1991 and 2022

LULC Classes Firojpur Zirkha		**2022**					
		Agriculture	Barren Land	Built Up	Vegetation	Water Body	Total
1991	Agriculture	620.6	6.2	59.4	0.0	1.1	687.4
	Barren Land	14.7	83.8	3.3	0.3	0.0	102.1
	Built Up	1.0	0.1	17.0	0.0	0.0	18.1
	Vegetation	0.4	10.5	0.4	1.0	0.0	12.2
	Water Body	1.2	0.1	0.3	0.0	4.4	6.0
	Total	637.9	100.6	80.4	1.3	5.5	825.8

Questionnaire

Part A- BASIC DETAIL

Name of farmer	Age	Sex	Marital Status	Education Status
1.Respondent				

1. Social Group: (i) SC (ii) ST (iii) OBC (iv) Non-Scheduled (v) Minority (vi) Other
2. Farm size in acres------------------
3. Farming details in acres
    - Farm own
    - Farm leased out
    - Farm leased in
4. source of irrigation- canal /tubewell / both / Barani
5. cropped area during kharif season

Sr. no.	crops	area	No. of watering	HYV seed	Desi seed	production
1	Rice					
2	Bajra					
3	Sugarcane					
4	Cotton					
5	Jowar					
6	Fodder					
7	Other					

6. Cropped area during Rabi season

Sr. no	crops	area	No. of watering	HYV seed	Desi seed	production

1	Wheat					
2	Mustard					
3	Gram					
4	Barley					
5	Fodder					
6	other					

7. Type of fertilizer used by the farmers- Organic/ organic chemical/ only chemical
8. Quantity of fertilizer per acre- up to 3 bags/ 4 to 5 bags/ 6 to 7 bags/ 8 to 9 bags / more than 9 bags
9. Income from all sources

   Less than 1.5 lakh

   1.5 to 3 lakh

   3 to 4.5 lakh

   1.5 to 6 lakhs

   Above 6 lakhs
10. Income from Agriculture alone

    Less than 1.5 lakh

    a. to 3 lakh

    3 to 4.5 lakh

    1.6 to 6 lakh

    Above 6 lakh
11. school of the family children- Govt./ Private
12. House Assets-
13. House type- fully Pacca/ semi-Pacca
14. Family type- nuclear/ joint
15. How to do agriculture work- with family/ family with labour/ fully labour

<u>PART B- Farmers perspective regarding Sustainability</u>

1. Awareness regarding agriculture sustainability- Yes/ No
2. Did you face any problems related to health in recent years? Yes/ No

3. If yes, what do you think is the cause of these health-related problems?

(Tick as appropriate)

a) Overuse of chemical fertilisers and pesticides

b) Water and soil pollution, Climate change

c) a+b

d) All of them

4. is that present agriculture income is self-sufficient for you? YES/ NO

5. Are you doing any other work along with agriculture? YES/NO

6. What are the possible reasons of doing other work along with agriculture?

a. small size of holdings

b. less agriculture income

c. increased standard of life

7. is your agriculture land holding size same as it was before? Yes / no

16. if no, why?

2. Sold out
3. Buy new land
4. Family bifurcation
5. Other

17. Change in ground water level- yes/no

18. Major agricultural problems faced by the respondents- Give rank 1 to 5

SR. NO.	Major agricultural problems	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
1	Depletion of ground water					
2	higher use of fertilizers					
3	Decreasing size of holding					
4	soil depletion					
5	stagnation of productivity					

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Dynamics of land use land cover and its impact on land surface temperature: a study of Faridabad District, India

Sanju Bala · Sajad Nabi Dar

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Abstract The rapid urbanization and land transformation in India have sparked apprehension regarding the ensuing alterations in land surface temperature and their linked environmental ramifications. This research paper endeavors to explore the dynamics of land use and land cover and their impact on land surface temperature, with a specific focus on the Faridabad district in India. Rapid urbanization, an 80% increase in population, and in-migration have significantly expanded the built-up area from 1993 to 2023. Remote sensing and GIS techniques were used to analyze 30 years of land use and land cover changes, integrating satellite, topographic, and meteorological data. Transition Potential Modeling (TPM) identified trends in built-up areas, while Normalized Difference Built-up Index (NDBI) and Normalized Difference Vegetation Index (NDVI) correlated with changes in vegetation and built-up areas. Findings reveal altered LULC patterns, mainly due to urban expansion, industrial growth, and changes in agriculture. This shift from natural land cover to built-up areas has increased land surface temperature. The study shows a decrease in arable land (71.8% in 1993 to 53.4% in 2023) and a significant 21.9% growth in built-up areas during this period, leading to a 7% rise in land surface temperature. Strong positive correlations were found between mean land surface temperature and NDBI, and negative correlations with NDVI. The study emphasizes the need for proper planning in Faridabad, recommending increased open spaces, green cover, and the introduction of green belts to stabilize land surface temperature.

Keywords Sustainable · Transforming · Urbanization · Migration · Impermeable · Correlation

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Introduction

In recent years, concern regarding the dynamics of land use and land cover (LULC) changes and their impact on the earth's climate system has garnered significant attention among researchers and policymakers (Lambin et al., 2001; Dar et al., 2017). The conversion of natural landscapes into urban or agricultural areas has the potential to alter various environmental parameters, leading to adverse consequences such as an increase in land surface temperature (Olesen & Bindi, 2002; Dar et al., 2022). The unprecedented interaction of man with nature has resulted in rapid urban development activities, hence transforming the LULC drastically (Paudel et al., 2016, Dar et al., 2019). Growing population, urbanization, and industrialization are the prime causes that give rise to huge LULC conversion in urban as well as rural areas (Singh et al., 2022). People move towards

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LIST OF PRESENTATIONS


CERTIFICATE

OF PARTICIPATION

PROUDLY PRESENTED TO

MS. SANJU BALA - DEPARTMENT OF GEOGRAPHY, LOVELY PROFESSIONAL UNIVERSITY

For his/her active and invaluable participation and presentation of paper on **'Sustainable agriculture and food security - Needs and challenges'**during the conduct of the online international conference on the topic **"Future Challenges and Sustainable Development Goals: Science to Policy Framework"** held on 16th, 17th and 18th April, 2021.

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INTERNATIONAL CONFERENCE (ONLINE) on

"Exploring the Application of Solidarity Approach in Geography"

April 05-06, 2021

LETTER OF PARTICIPATION AND PRESENTATION

Dear **Sanju Bala,**

The Department of Geography, Shaheed Bhagat Singh College, University of Delhi, India is pleased to provide this 'Letter of Participation and Presentation' to you, for attending and presenting in the Online International Conference, held on April 5-6, 2021. The title of the paper being presented orally in the **Technical Session VIII: Global Food Security, National Resource Management and Solidarity**, of the conference is "**Role of Solidarity in Food Security and Sustainability in Agriculture - A Study of NCR Haryana**". We believe that the participants of this international conference have got enormous benefits through interaction with you during the conference.

We appreciate your kind consideration and cooperation and keep in touch with you in regard to the publication of the participants' papers being presented in the conference.

Sincerely yours,

Dr. Kavita Arora	**Dr. V. A. V. Raman**	**Dr. Anil Sardana**
Conference Convener	Conference Director	Conference Patron
Associate Professor of Geography	Associate Professor of Geography	Principal
Shaheed Bhagat Singh College	Shaheed Bhagat Singh College	Shaheed Bhagat Singh College
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Certificate of Participation

This is to certify that **Dr./Mr./Ms. Sanju Bala** of Lovely Professional University, Punjab has presented a paper on **Land use/land cover change in NCR Haryana** in the International Conference on **"Clean Water, Good Health, Sustainable Cities & Communities (CWGHSCC)"** held from **18th to 19th October, 2023** organized by School of Liberal and Creative Arts in collaboration with National Association of Geographers, India (NAGI) at Lovely Professional University, Punjab.

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