

## A Risk Management Technique Adopted by Farmers of North India to Mixes a Wide Variety of Crops within a Portfolio

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### Abstract

India has made tremendous progress in agriculture over the past decades. Technological change with the introduction of short duration high yielding varieties of wheat and rice in the sixties increased productivity of these crops manifold. The effective price policy coupled with relatively better technology has resulted in the emergence of paddy in kharif and wheat in rabi as the most secured and profitable crops in several states. Consequently, production of wheat and rice in India has increased from 23.8 and 42.2 million tonnes in 1970-71 to 95.8 and 106.3 million tonnes in 2013-14. This translates into a growth rate of 2.82 and 1.86 per cent per annum for wheat and rice during this period. The output of wheat and rice in the country has reached a saturation point. But, farmers in agriculturally advanced states like Punjab and Haryana two landlocked states in northern India.

**Keywords:** Crops; Agriculture; Technology; Wheat; Rice

### Background

Punjab and Haryana still prefer to grow wheat and rice despite being aware of problems created by this crop rotation in terms of deteriorating soil health and depleting water table. The production, productivity and profitability which reached a plateau in leading green revolution states, started plummeting in early eighties. These developments made clear that the country would have a surplus of superior cereals and therefore, farmers should diversify towards other crops by increasing area under pulses, oilseeds, fruits, vegetables and commercial crops.

With this realization, crop pattern in several states experienced significant change with diversification from traditional food crops to commercial crops, plantation crops and horticultural crops. However, cropping pattern in leading green revolution states of Punjab and Haryana has not witnessed significant change and remained skewed towards wheat paddy monoculture which has created ecological problems in the long run sustainability of agriculture.

Agriculture occupies a dominant place in the economy of Haryana and is favorably placed in terms of water resources and soil potential. The old and new alluviums are ideal for the production of wheat and rice under irrigated conditions. Of the total cropped area, more than two-third is shared by food grains. In addition, cash crops such as oilseeds and cotton are also grown. The legumes are gradually losing area. The introduction of these crops in crop rotation may increase production of fine food grains due to complementary relationship between grains and legumes. Since legumes are known for nitrogen fixing quality, this will reduce cost of production and improve incomes. The farmer must search for the combinations through diversification of crops that will provide higher farm business income from his limited land and economic resources. It is imperative to determine the most profitable and environmentally sustainable crop rotation, with low yield and price risk using value productivity and cost of production per hectare for each crop over a period of three to four agricultural years.

There has been a sharp shift in area under various crops in Haryana during the past three decades. It has shifted in favor of those crops which provide higher returns per unit of land due to increasing productivity or increasing prices or both i.e. rice, wheat, rapeseed-mustard and American cotton. For these crops, growth in area and yield has been impressive but growth in area was comparatively higher. In view of higher proportion of area under rice-wheat rotation and rice being major consumer of irrigation water, the state is experiencing

sharp decline in groundwater table and deterioration in the agro-economic systems. It is therefore, important to reduce area under this crop rotation in order to sustain production and agro-eco-systems of the state in the long run.

So far, potential of the new seed-fertilizer technology has been fully exploited in Haryana. The limited scope for expansion of irrigation facilities via canals was circumvented by increasing number of tube wells and pumping sets from 28,000 to over five lakh. Haryana has been catapulted to the forefront of agricultural scene in the country. The higher growth in various sectors of economy could help in visualizing overall perspective. During the period from 1981 to 1991, GSDP of Haryana grew at 6-7 per cent per annum, sustained by a 7-8 per cent per annum growth in the industrial and service sectors and a 4 per cent growth in the agricultural sector. It has been contributing about 3 per cent to the gross domestic product (GDP). The share of industrial sector in the GSDP in 1980-81 was 19.46 per cent, which rose to 29.07 per cent in 2010-11. Conversely, though agriculture continues to have a dominant place in economy, its share in GSDP has come down from 53.78 per cent in 1980-81 to 20.92 per cent in 2010-11. The share of the service sector has appreciated from 26.76 per cent to 50.01 per cent during this period.

Thus, the monoculture of rice wheat crop rotation in several districts of Haryana particularly in areas with assured irrigation has led to over exploitation of natural resources, degradation in soil fertility and higher susceptibility of crops to the attack of various insects, pests and diseases. Moreover, profitability from these crops has almost stagnated due to stagnating yields and rising input costs including human labour. In such circumstances, crop diversification towards coarse cereals, pulses, oilseeds, fruits, vegetables and commercial crops is being advocated as a future strategy in order to improve income of the farmers and to save natural resources from further degradation.

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In this backdrop, diversification from paddy to alternative/competing crops in kharif season in Haryana assumes special significance and this study is planned to address these concerns.

### Need for the study

Before analyzing need for the study, it would be useful to review recent literature on crop diversification to understand the issues related to the theme.

The available literature on crop diversification comprises two sets of studies. First, macro studies at the national, state and district levels based on secondary data from different literature sources [1-15] and Second, micro studies based on primary data collected by the researchers through field surveys [16-18]. Now, we present a brief review of these studies.

Bhatia [1] analyzed crop pattern of India on a regional basis with a view to bringing out real concentration and diversification of crops on the basis of secondary data. The regional character of crop distribution was determined by comparing proportion of sown area under different crops and ranking them. Second, author compared crop density in each of the component at regional level with the corresponding density for the country as a whole.

Pinagli and Rosegrant [2] studied agricultural commercialization and diversification through gradual replacement of integrated farming systems by specialized enterprises for crops, livestock, and aquaculture products. Changes in product mix and input use are determined largely by the market forces during this transition. Commercialization of agricultural production is an endogenous process and is accompanied by economic growth, urbanization and withdrawal of labor from the agricultural sector. This paper provides a selective overview and synthesis of the issues involved in the commercialization and diversification process of agriculture. Based on an assessment of the process observed in selected countries, findings show that the commercialization process should not be expected to be a frictionless process as significant equity and environmental consequences may occur at least in the short to medium term, particularly when inappropriate policies are followed. Findings highlight that appropriate government policies including investment in rural infrastructure and crop improvement, research and extension, establishment of secure rights to land and water development and liberalization of capital markets can help alleviate many of the possible adverse transitional consequences.

Joshi et al. [3] analyzed the emerging concerns about the viability of small farm agriculture, particularly in the context of on-going process of globalization. It is contended that viability of small farms can be improved through diversification of agriculture towards higher-value crops like fruits and vegetables. The study has assessed the impact of diversification of agriculture towards vegetables on farm income and employment using household level information from the state of Uttar Pradesh. The results clearly reveal that vegetable production is more profitable and labor-intensive therefore, it fits well in the small farm production systems. The smallholders are relatively more efficient in production and own more family labor in contrast to large farmers. Vegetable production is the emerging sector in agricultural diversification that would augment income of smallholders and generate employment opportunities in rural areas. Women are also benefited as the vegetable production engages relatively higher women labor in various operations. However, prevailing constraints do not allow smallholders to explore the emerging opportunities in vegetable production. Major constraints in vegetable production are lack of assured markets and a well-developed seed sector. Since, vegetables are

perishable in nature, lack of efficient marketing system and appropriate infrastructure is extremely important.

Elzaki et al. [4] in their study "Comparative Advantage Analysis of the Crops Production in the Agricultural Farming Systems in Sudan" state that most of the rural people in developing countries are highly dependent on resource-based subsistence economies using products obtained from plants and animals. The study proposed to assess the efficiency and sustainability of the domestic resources and tradable inputs for crop production in the dominating farming systems, to analyze the comparative advantage and protection of major agricultural crops. The study was conducted in irrigated, traditional and mechanized rain fed farming systems and applied linear programming (Policy Analysis Matrix) to determine competitiveness and policy effects of crop production in the farming systems in Sudan. The primary data were collected through the field survey using questionnaire. Findings suggest that agriculture remains as the main source of livelihood of the rural people in the surveyed farms as more than half of the population derives their livelihood from land. Majority of the rural households in traditional farms (78.4%) were fully occupied with their tenancies (had no off-farm occupation). The results further indicate that farmers owned agricultural land but lack appropriate technology and removal of subsidies from the production inputs (e.g. from fertilizer) would escalate cost. Most of land is not occupied efficiently to satisfy the needs of rural households. Sorghum crop did not appear in the optimal farm plan despite the fact that it is the main food staple in the farms, particularly in the irrigated farms. The groundnut crop also disappeared from the irrigated and traditional farms, while in the mechanized farms, it was the only crop that appeared at optimal solution and its area has increased in the optimal solution. The optimal crop plan in the mechanized, irrigated and traditional farms are groundnut, vegetables and watermelon crops, respectively. There are significant differences in the degree of policy transfer for crops across farms. The government policies on main crops and self-sufficiency lead to allocation inefficiency.

Bhattacharyya [5] examines crop diversification as a search for an alternative source of income for farmers in the state of West Bengal in India to meet the challenges of a globalizing market in agriculture as well as growing and changing needs of the population. Many countries in South East Asia have undertaken crop diversification to enhance productivity and cultivate high value crops with positive outcomes. These countries are gradually diversifying their crop sector in favor of high value commodities, especially fruits, vegetables and spices. Diversification is taking place either through area augmentation or by crop substitution. If carried out appropriately, diversification can be used as a tool to augment farm income. The study covers a period of eight years from 1997-98 to 2004-05. There are two obvious reasons for choosing this period. First, whatever diversification has taken place, it has occurred during the late nineties and second, availability of meaningful data from reliable sources regarding the high value crops. It was hypothesized that gradual slowing down of the green revolution in terms of yield levels of cereals and opening up of the economy are paving way for diversification, employment generation, alleviate poverty, water resources and conserve precious soil. Studies by Pingali and Rosegrant [2], support this positive impact of diversification. The nature of crop diversification is first examined through changes in allocation of land for cultivation of different crops grown over the years. Different diversity indices have been used to measure the degree of diversification taking place in the state. Inter-crop variation in output is also considered for the period under consideration. Compound growth rates of area under high value crops are also

calculated to show the trends in diversification. Diversification index is calculated for the state as well as for the districts. Diversification may be broadly defined as a shift of resources from the low value agriculture to high value agriculture. It can also be considered as a shift of resources from farm and non-farm activities or simply a larger mix of diverse and complementary activities within agriculture. There are different methods of measuring diversification. The study reveals that fruits and vegetables have shown good performance during the period under consideration. Though, share of area under fruits is relatively low in the state as compared to the major crops, an increasing trend is observed in area allocation under most of the fruit crops. Of the fruit crops grown in West Bengal, mango accounted for bulk of the total area (36.57 per cent) under fruit crops followed by banana (17.46 per cent), other fruits (11.3 per cent) and Jackfruit (8.4 per cent). The maximum area under mango is in Malda district followed by Murshidabad district. Nadia followed by Hooghly is the largest producer of banana. The share of area has gone up considerably in case of most of the fruits like other fruit groups (455 per cent), orange and citrus fruits (196 per cent), banana (86 per cent), guava (78 per cent) and jackfruit (68 per cent). Production of fruits also has shown a remarkable increase during this period. In case of sapota, litchi and jackfruit, increase in production has been tremendous amounting to 393, 266 and 216 per cent respectively. The results of the study show that agricultural sector in West Bengal is gradually diversifying towards high value commodities such as fruits, vegetables and flowers. Detail investigations reveal that most of the diversification has come through individual efforts of the small farmers with little support from the government. It is because food security issues are still critical in the state as well as in the country and government policy is still obsessed with self-sufficiency in cereals. However, speed of diversification in West Bengal is rather slow and is much less than that of the country as a whole. Moreover, diversification is not evenly distributed over the districts. While some of the districts are picking up diversification quite rapidly, others are lagging behind. Vegetable cultivation is eco-friendly and uses less water than cereals, especially paddy, necessitating withdrawal of less amount of ground water from wells and tube-wells and thus, helps in conservation of ground water. It may be noted that widespread cultivation of summer paddy (boro) has now resulted in reduction of water table and consequent non-availability of ground water for irrigation and even for drinking in many areas. If diversification can be efficiently managed to reduce risk and augment income of the small farmers, environmental degradation may be checked to a certain extent.

Jha et al. [6] in their study discuss factors responsible for agricultural diversification at different levels: country (India), state (Haryana) and farms of Kurukshetra district in Haryana. The study used alternate measures of diversification namely, the Simpson index and concentration of non-food crops on several possible factors such as income, land distribution, irrigation intensity, institutional credit, road density, urbanization and market penetration. The determinants of resource diversification have been studied at the macro and micro-levels. At macro-level, resource diversification has been studied for the country and the states. Subsequently, one of the progressive states, Haryana has been chosen purposively to study diversification at the regional level, which is referred as diversification at mesa level. The state of Haryana as compared to many other states is relatively uniform and it would be easy to understand the role of various factors in agricultural diversification. Average farms have subsequently been chosen to study diversification at the micro-level. The authors use different type of regression models to analyze the factors responsible for diversification. The regression results suggest that increased road density, urbanization, encouraged commercialization of agriculture in

a region boost specialization of some crops and crop-groups as per the resource, infrastructure and institutions of the region. The country-level analysis of regression with the Simpson Index often goes against the established findings on determinants of agricultural diversification in the country. The regression results with diversification indices are clear at the state-level. A negative relationship of alternate measures of diversification with irrigation intensity reveals that an increase in irrigation is leading to specialization under paddy and wheat crops. This process is strengthened with the penetration of the regulated markets. During the last decade, urbanization has emerged as an important factor which has a positive effect on agricultural diversification. Farm level diversification suggests that small farms are less diversified in Kurukshetra district of Haryana. Interestingly, diversification with crops is increasing risk in the farm portfolio whereas; diversification with livestock reduces risk in farm income.

Chakrabarti and Kundu [7] attempted to examine the rural non-farm economy and impact of crop diversification in India. Results show that crop diversification under the integral institutional set up of contract farming, processing, packaging and retailing may display the petty manufacturing and services that mattered over the years in different parts of rural India as constituent of an endogenous process driven by agricultural growth and changing land relations. The authors show that sectorial policies such as crop diversification in agricultural land, conversion of land for industrialization should not be formulated in isolation. Such policies should particularly take into account the corresponding impact in the case of rural labor and intensive non-farm sector which is accepted as a dynamic segment of the economy having employment generation potential. They further argue that policies of crop diversification to raise farm income and land conversion for rapid industrial progress should form part of a more comprehensive broader project encompassing all major sectors of the economy. It can socially benefit when it is complimented with intensive infrastructural facilities, financial and technological support, etc, especially for the localized micro (labor-intensive) enterprises engaged in processing, storing and packaging.

Kalaiselvi [8] in his paper has evaluated crop diversification in India. The paper based on secondary sources of data has tried to assess crop diversification in the Indian perspective. The author concludes that India with wide variations in agro-climatic conditions being a vast country of continental dimension presents excellent opportunities for crop diversification. Such variations lead to the evolution of regional niches for various crops. Historically, regions were associated with dominant crops in which they specialized due to agronomic, climatic, hydro-geological and historical reasons. But, with technological change encompassing bio-chemical and irrigation technologies in the sixties, agronomic niches have undergone significant changes. Results show that there is a mixed scenario regarding the typology of diversification within the states. Some states exhibit more diversification, while others lack it. The pattern is completely diverse across India.

Recently, Das and Mili [9] conducted a study of Dibrugarh district in Assam to analyze the pattern of crop diversification and nature of changes in cropping pattern for the period 1999–2000 to 2009–10 by using secondary data. Gibb's and Martin Index of crop diversification were computed to fulfill the objectives. They observed that crop diversification is slow in Dibrugarh district. Findings suggest that crop diversification is above 62.9 per cent for large farmers with higher cropped area while this ratio was only 37.04 per cent in the medium category and there was no diversification in the lower category of farmers. But, crop diversification has declined in case of large category and reached to 16.43 percent in the year 2009–10 while it has increased

in the case of medium category and reached to 70.84 per cent during the same year. It is worth noting that index for the lower category of farmers has increased in 2009–10 which was zero in 1999–2000. The authors conclude that diversification index for the year 2009–10 in comparison to 1999–2000 exhibits a declining trend which is indicative of poor crop diversification.

In order to analyze different measures of crop diversification, Pal and Kar [10] conducted a study of Malda district in West Bengal and compared district and state level diversification for the period 2001 to 2008. The authors used different methods to measure extent of crop diversification. Results show that there is hardly any change in the number of crops cultivated by the farmers except tea in a few northern districts of West Bengal. Moreover, under aman and boro paddy, potato and mustard together increased from 64% of GCA in 1970–73 to 77% in 2002–2005 despite some inter-district variations, owing to important factors such as use of chemical fertilizer and irrigation. Findings show that blocks with urban or rural urban tendencies registered higher level of crop diversification. Most of the poor farmers are still addicted to mono cropping.

Sharma and Mohan [11] conducted a study to find out growth and challenges of diversification of agricultural sector in the state of Punjab. The study based on secondary data has covered a time period of 1970–71 to 2010–11. The study has evaluated major indicators of diversification and provided alternative diversification strategy for the economy. Findings show that Green Revolution was limited in its impact in terms of crops, regions and farmers. At present, agricultural sector of the state is passing through severe economic crisis. Currently, slowing down of agricultural growth, paddy-wheat monoculture, over exploitation of natural resources, increasing debt burden of the farmers, rapidly rising labor force, declining land man ratio, higher use of fertilizers and pesticides, steep rise in land prices, inadequate financial facilities, poor human capital formation, increasing income inequalities, etc. are the major issues creeping in the agricultural economy of the state. Looking at the crisis, authors suggest immediate need to diversify economy of the state instead of advocating only crop diversification.

A study based on secondary data from 2007 to 2010 by Pinki et al. [12] examined spatial pattern of crop diversification by dividing Haryana state into three parts which consist of districts with high diversification, districts with medium diversification and districts with low diversification. They point out that higher crop diversification was found in western part of Haryana, medium crop diversification in northern and southern parts of the state while eastern part of the state showed low crop diversification. The districts with wheat paddy rotation in cropping systems are facing the problems of soil degradation and declining crop yield per unit of land. These districts require immediate attention for achieving a high degree of crop diversification.

Singh et al. [13] also made an attempt to analyze crop diversification in the state of Punjab. The study was based on time series data for the period 1980–81 to 2008–09. The authors used various concentration indices i.e., Herfindahl and Entropy to work out agricultural diversification. Findings reveal that cultivation of crops is determined by a set of indices like technology, market forces, government policies, climate and global factors. These factors directly and indirectly impact cropping pattern in a region. Although, growth rate of agricultural production and yield have decelerated, there is hardly any major diversification in cropping pattern since 1981–82. The authors conclude that Punjab agriculture is moving towards specialization of crops primarily, paddy and wheat in most of the districts except American cotton in Malwa region, sugarcane and moong in Gurdashpur,

Jalandhar, Kapurthala and Hoshiarpur districts. Findings suggest that there is a need to shift production profile. A farmer needs to diversify crop pattern in favor of crops such as soybean, maize, fruits and vegetables. Developing dairy sector to produce milk and milk products for urban centers of north India is additional method of diversification in the crop base of Punjab. Also, establishing processing plants for vegetables, fruits, dairy and poultry products are efficient methods of diversifying the agricultural base. For achieving the objectives of crop diversification and agro-industrialization, building a golden triangle with farmers, agro-industry and banker as the corner of the triangle appear to be a pragmatic policy.

Reddy [14] conducted an important study to examine agricultural growth and crop diversification towards pulses, oilseeds and other high value crops in the state of Orissa. The study used secondary data and covered a time period from 1971 to 2008 which is divided into two sub-periods i.e. pre-liberalization and post liberalization period. The author used the Battese and Coelli stochastic production function model. In particular, production of pulses seems to have stagnated in the state during this period. Results show dominance and increased importance of paddy in the state. However, productivity of paddy is still low and increased at a slow rate, while productivity of pulses and oilseeds declined during the same period. The author concludes that cost of production of pulses, oilseeds and other crops are low as compared to paddy, hence net returns per hectare to the economy and to the farmers are higher compared to paddy. He suggests that it is necessary to improve infrastructure, services and human capital for crop diversification.

Saha [15] examined crop diversification in Indian agriculture with special reference to emerging crops. The author used secondary data to explore the levels and trends of crop diversification and identify major emerging crops. The study has covered a time period of 1990–91 to 2008–2009. Results show that crop diversification is taking place gradually and most of states are associated with this process. Although, dependence on food crops persists, commercial and horticultural crops are emerging as a fast alternative. The study has found that leading states like Rajasthan, Gujarat, Maharashtra and Karnataka are setting examples for other states and defining strategy through which diversification and self-sufficiency could be achieved in crop sector.

Blank [16] analyzed returns from limited crop diversification in terms of absolute risk levels and the number of crops included in a portfolio. These are expected to be similar to those for stock market portfolios. Risk is reduced significantly at first as additional securities are added to a one-product portfolio, but the rate of decline in risk levels declines as the portfolio grows. In other words, possible risk reduction is achieved by including a few products in a portfolio. Data used in the study are annual observations reported by country extension staff for every product grown in the region. The study suggests that a new SIM application approach which enables growers or extension personnel to more accurately assess the returns/risk tradeoff among crop portfolios should be adopted. A new performance measure is derived from the SIM in ranking crop portfolios based on that tradeoff. It is shown that the new performance measure and its application can be a useful addition to, or substitute for, more complicated methods. This method also adds in avoiding data sensitivity problems of both Quadratic Programming (QP) and standard SIM procedures. In particular, using betas for portfolios, rather than for crops, may give more accurate results while establishing rankings. Crop betas vary through time, but betas become increasingly stable for more diversified portfolios. The betas became stationary for portfolios with at least four crops. It is further shown that the new index derived in this study is

superior to the standard Treynor-Black appraisal ratio in ranking crop portfolios. Performance measures from the finance literature, such as the Treynor-Black ratio, are likely to fail when evaluating agricultural markets because they are based on the assumption that portfolios will be composed of a small percentage of the assets in a market. To apply the SIM in agriculture, small regions must be used as the market proxy to produce results relevant to individual decision makers. This means that actual crop rotations may include a high percentage of enterprises in the market proxy.

Ashfaq et al. [17] tried to understand factors impacting farm diversification in rice-wheat in Pakistan. The study is based on the primary data collected from two districts of Punjab comprising 200 farm households and used multiple regression analysis to examine the factors which directly affect crop diversification in wheat paddy. Results show that holding size is positively related to diversification. The referred diversification is more common among the large farmers. The coefficient of age of the farmers was negative and insignificant. Findings further show that education and experience are positively and significantly related to diversification while off-farm income does not show any impact on diversification. However, distance from main road is negatively and significantly related to crop diversification. The authors suggest that cooperative groups based on the self-help principle, infrastructure like roads and access to market should be enhanced for farm diversification.

Lin [18] in her study "Resilience in agriculture through Crop Diversification: Adaptive Management for Environmental Change" has recognized that climate change may have negative consequences for agricultural production unless resilience is built into agricultural systems. One rational and cost-effective solution could be implementation of increased agricultural crop diversification. Although, idea of building resilience has been studied in a broad range of ecosystems from coral reefs to forests, it is not studied well for the agro-ecosystems which are important for the survival of human society. The development of resilient agricultural systems is essential because societies greatly depend on the provisioning through agriculture (food, fodder, and fuel) for their livelihoods. Several agriculture based economies have a few other livelihood strategies and small family farms have little capital to invest in expensive adaptation strategies, which increase vulnerability of rural agricultural communities to a changing environment. Recent evidences suggest that climate change will affect both biotic (pest, pathogens) and abiotic (solar radiation, water, temperature) factors in crop systems, threatening crop sustainability and production. More diverse agro-ecosystems with a broader range of traits and functions will be better able to perform under changing environmental condition which is important given the expected changes in biotic and abiotic conditions. It is clear that farmers are facing growing stress from climate change. The greater implementation of diversified agricultural systems may be a productive way to build resilience into agricultural systems. The challenges in increasing adoption of diversified agricultural management strategies are both scientific and policy based. In the scientific realm, the adoption of diversified agricultural systems could be bolstered if farmers had a better idea of how to optimize a diversified structure to maximize production and profits. Crop and landscape simulation models that can model a range of climate scenarios and landscape modeling with farm profitability scenarios would help farmers find optimal strategies for maintaining production and profit. Stakeholder-based participatory research would also be highly beneficial as researchers could model strategies that seem plausible to farmers. Diversified farming strategies are supported by international research efforts,

including the International Assessment on Agricultural Knowledge, Science and Technology for Development, a global report of more than 400 scientists that concluded that locally adapted seed and ecological farming can better address the complexities of climate change, hunger, poverty and productive demands on agriculture in the developing world.

To sum up, all the reviewed studies deal with crop diversification and indicate that crop diversification is continuing over time and most of the states are associated with this phenomenon.

Although, dependence on food crops persists, importance of commercial and horticultural crops is emerging fast. The analyses show that leading states in terms of crop diversification such as Rajasthan, Gujarat, Maharashtra and Karnataka are paving way for other states by achieving diversity and self-sufficiency both in the crop sector. The leading green revolution states such as Punjab and Haryana are showing a fatigue in crop sector due to paddy wheat dominance, over exploitation of natural resources, increased burden of debt for the farmers, rapidly rising labor force, declining land man ratio, higher use of fertilizer and pesticides, increasing income inequality. These are the major issues creeping in these states.

Some of the studies analyzed factors affecting crop diversification and concluded that there is a strong correlation between factors like education, distance from main road, distance from nearest city/town, infrastructure, machinery and crop diversification. However, other studies indicate that size of land holding is the main factor which is responsible for crop diversification. In particular, large land size provides farmer an alternative to produce different crops at the same time.

A number of studies have been conducted in India on methodological issues for estimating crop diversification, but most of these studies are either based on secondary data available from different sources for depicting macro scenario at the state and national level. These studies do not provide breakup of household data by socio-economic characteristics such as size of operational holdings. Majority of available micro studies on crop diversification in different strata of households ignored in-depth analysis. Literature based on in depth village studies at the micro level is limited to some states and therefore, there is an urgent need to conduct in-depth micro level studies. Such studies provide important insight that cannot be derived from secondary data based studies due to availability of limited information. The present study aims to address some of the deficiencies in the earlier literature on the subject and will be useful to frame future policy initiatives.

## Objectives of the Study

Food security, nutritional security, sustainability and profitability are the main focus of present and future agricultural development. The crop rotation of rice-wheat largely adopted in irrigated areas of Haryana has posed serious challenges in future for sustainability of agriculture in the state. Crop diversification through adopting alternative crops and cropping systems could improve productivity and also the agro-eco-systems of the region. Further, irrigation requirements of the area could be reduced through adoption of alternate cropping systems, thereby reducing pressure on depleting water table. In addition, alternate cropping systems based on cash crops/high value crops will help in reducing production risk in mono-cropping and will raise income of the farmers. This study aims to analyze issues related to crop diversification from paddy to alternative/competing crops in kharif season in Haryana.

The specific objectives of the study are as under:

- To examine the production and procurement pattern of paddy in Haryana.
- To work out the relative economics of paddy vis-à-vis competing/alternative crops.
- To bring out the constraints in adoption of alternative crops.
- To suggest policy measures to overcome the constraints in adoption of alternative crops to paddy in Haryana.

## Study Design and Methodology

This study is conducted in the state of Haryana. It is based on published and un-published sources of secondary and primary data. The relevant information about the state and districts was obtained from various issues of the Statistical Abstract of Haryana, Government of Haryana, and Panchkula. Further, the time series data on area, production and yield of paddy and alternative/competing crops for selected districts and state were also culled out from this source. The required preliminary information regarding the selection of blocks and villages was obtained from the district officials. The meetings with the Deputy Director of Agriculture of selected districts were useful and informative. The crops for the study were decided as per the study design provided by the coordinator.

The scope of the study is confined to kharif crops i.e. paddy and alternative/competing crops such as bajra, maize and cotton grown by the farmers in Haryana. Six districts namely, Panchkula, Sonapat, Faridabad, Palwal, Jind and Fatehabad with diversification of crops in kharif season were selected for in-depth study. The selection of respondents is based on multistage sampling design. At the first and second stages, paddy and alternative crops producing districts and blocks in these districts were selected. At the third stage, villages were selected on the same criterion. A questionnaire was canvassed to the farmers growing these crops. All farm size categories i.e. small, medium and large were covered in the sample. The number of farm households in each category was decided according to their proportion at the district level. The primary data pertaining to the year 2012-13 were collected from 210 farmers.

## Results

### Analytical framework

The methodology followed for each aspect is different. For measuring the state and district level growth rates of area, production and yield of paddy and alternative/competing crops for the period 1970-71 to latest available period, following semi-log equation was used

$$\text{Log } y = a + bt$$

Where,

y= area/production/yield of the crop

a= intercept

b= slope

t= time

The entire time period for computation of compound growth rates of area, production and yield of various crops is divided into three sub-periods i.e. 1970-71 to 1984-85; 1985-86 to 1999-2000 and 2000-01 to 2011-12. Finally, growth rates were computed for the entire period from 1970-71 to 2011-12.

In Haryana, paddy is the dominant crop during the kharif season. The alternative/competing crops could be bajra, maize and cotton. Although, yield rates of bajra and cotton in the state are second highest in the country, farmers prefer to grow paddy due to higher yields, assured market and net returns. They often use inputs especially irrigation, fertilizer and pesticides indiscriminately in cultivation of paddy due to lack of knowledge about optimal use. The over use of these resources is resulting in depleting water table and environmental problems in addition to escalated cost of cultivation. In order to save precious resources and environment, it is imperative to analyze resource use efficiency of paddy and alternate/competing crops grown by the sampled farmers in Haryana.

We have used Cobb-Douglas type of yield function to assess the resource use efficiency. This function is widely used in agricultural research and is convenient for the comparison of elasticity coefficients. In order to determine resource use efficiency of major inputs, a double log regression model of the following form was used.

$$y = ax_1^{b_1} .x_2^{b_2} .x_3^{b_3} .x_4^{b_4} .x_5^{b_5} + u$$

$$\text{log } y = \text{log } a + b_1 \text{log } x_1 + b_2 \text{log } x_2 + b_3 \text{log } x_3 + b_4 \text{log } x_4 + b_5 \text{log } x_5 + u$$

Where,

y : Yield of the crop (qtls/ha.)

a : Intercept

x<sub>1</sub> : Human labor (days/ha.)

x<sub>2</sub> : Machine labor (hrs/ha.)

x<sub>3</sub> : Seed (Kg/ha)

x<sub>4</sub> : Fertilizer (Kg./ha.)

x<sub>5</sub> : Irrigation (hrs./ha.)

b<sub>1</sub> - b<sub>5</sub> : Regression coefficients

u : Random Error.

The estimated coefficients of the considered independent variables were used to compute the Marginal Value Productivity (MVP) and Marginal Factor Cost (MFC).

## Conclusion

The resource use efficiency could be judged on the basis of marginal value productivity (MVP), which indicates the increase in the productivity from the use of an additional unit of a given input while keeping the level of other inputs constant. The marginal value productivity (MVP) of the i-th input was measured by using the following formula:

$$\text{MVP} = b_i (Y/X_i) P_y$$

Where Y= Average yield of the crop per hectare at geometric mean level of all inputs.

X<sub>i</sub>= Geometric mean level of i-th resource,

b<sub>i</sub>= Production elasticity of i-th input,

P<sub>y</sub>= Price of the product.

Resource use efficiency was measured by comparing the MVP of each resource with corresponding marginal factor cost (MFC) by sampled farmers.

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