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Kaveri G Sonawane
Ph. D. Scholar, Department of Agricultural Economics, VNMKV, Parbhani, Maharashtra, India

Sachin S More
Associate Professor, Department of Agricultural Economics, VNMKV, Parbhani, Maharashtra, India

Digambar S Perke
Head of Department, Department of Agricultural Economics, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
Kaveri G Sonawane
Ph. D. Scholar, Department of Agricultural Economics, VNMKV, Parbhani, Maharashtra, India

A review on determinants of crop diversification

Kaveri G Sonawane, Sachin S More and Digambar S Perke

Abstract
In the era of liberalized world, Indian agriculture is different from that of green revolution period. The agriculture growth was largely achieved by supply driven policy instruments such as irrigation, power, extension services, price support during the period of green revolution; whereas in the post reform period, the agriculture growth is demand driven, urbanization, increase in per capita income and changing consumption taste and pattern have shifted the consumer demand from food grains to live stocks and horticulture products.

Several forces influence the nature and speed of agricultural diversification from staple food to high value commodities. Earlier evidence suggests that the process of diversification out of staple food production is triggered by rapid technological change in agricultural production, improved rural infrastructure, climate related, demand and supply side factors at state as well as country level. So, the study of determinants of agriculture diversification enables us to know the dominating factors in a particular region that control the agriculture practice.

The literature review on the topic offers ample scope for a critical and retrospective examination of the previous work done. Hence, because of conspicuous lack of research studies and inadequate empirical evidence regarding diversification, it is extremely important to examine the determinants of diversification at macro level.

Keywords: Determinants, crop diversification, green revolution

Introduction
In the era of liberalized world, Indian agriculture is different from that of green revolution period. The agriculture growth was largely achieved by supply driven policy instruments such as irrigation, power, extension services, price support during the period of green revolution whereas in the post reform period the agriculture growth is demand driven, urbanization, increase in per capita income and changing consumption taste and pattern have shifted the consumer demand from food grains to live stocks and horticulture products. (Deogharia, 2018) [5].

The Post-Green Revolution period saw diversification of the agricultural sector towards the crops that have experienced higher growth in the yield, which was characterized as technology-led diversification. Much of the area was diverted towards high value food-grain crops including rice, wheat and maize. This has led to emerging scenarios of specialization in many states of the country.

Different social researchers have come to the conclusion that agriculture diversification is a major cause of rural upliftment leading to rural diversification. Literature argues that agricultural diversification geared to increasing labour absorption can be so designed as to meet national demand for agriculture to earn foreign exchange required for economic development (Hayami, 1991) [9]. There is a considerable scope for exploiting the potential of non-traditional crops, such as horticultural produce, since it could motivate diversification from traditional low profit commodities Diversification is also argued to be the single most important source of poverty reduction for small farmers. These small farmers become semi-commercial when they market part of their output, produce some high-value cash crops and livestock products, purchase inputs and hire labour. In agriculture, however, diversification relies on profitability, which is constrained by market availability and size, land suitability and rights, irrigation infrastructure, and labour supply. Diversification invariably leads to income variability and changes the rural scenario.

Determinants and factors of Agriculture Diversification
Several forces influence the nature and speed of agricultural diversification from staple food to high value commodities. Earlier evidence suggests that the process of diversification out of

staple food production is triggered by rapid technological change in agricultural production, improved rural infrastructure, and diversification in food demand patterns (Pingali and Rosegrant, 1995) [26].

The physical and socio-economic factors are the most important in controlling the agricultural practices in any region, so the study of determinants of agriculture diversification enable us to know the dominating factors in a particular region who control the agriculture practice. Moreover, it helps us in knowing the contemporary competition among crops (Bhalsing, 2009) [2]. Forces that drive agricultural diversification in a particular socio-economic set up may be different in another set up (Jha *et al*, 2009) [14]. Broadly these factors may be categorized as: natural factors, resource factors, technology-related factors, household factors, price factors and institutional and infrastructure-related factors.

Natural Factors

Natural and physical factors including the soil, drainage, slope, rainfall, temperature, humidity etc. are the basic factors modifying the cropping pattern. Any effort to modify these natural and physical conditions is quite difficult and also economically non-viable. But the introduction of technology in some other circumstances can modify these conditions.

Resource factors

Resource factors include a soil fertility status, rainfall and irrigation facility which influences the crop diversification.

Technology related factors

It includes use of high yielding variety seeds, use of fertilizers and infrastructure related factors as marketing and storage which speed ups the process of crop diversification.

Household factors

Household factors such as regional nutrient traditions, availability of food, fodder, fuel and investment capacity of the farmers decides the crop diversification.

Price factors

Price factors includes input and output prices, trade policies, economics polices which influences the crop diversification, directly or indirectly.

Institutional Factors

These are the most important factors which determine the diversification of agriculture is the market. Diversification in agriculture is the result of profit maximization, price response, etc. Equally important is the market infrastructure and institutional arrangements.

Diversification in agriculture is also governed by two main forces. These are broadly classified as demand and supply side forces. The demand side forces that have been hypothesized to influence the diversification include per capita income and urbanization. On supply side forces, the diversification is largely influenced by infrastructure (markets and roads), technology (Joshi *et al*, 2007) [15].

Demand Side Factors

There are a number of socio-economic, cultural, environmental and geographical factors which influence the consumption pattern. Beside these general factors, there are other drivers also such as income and urbanization which play an important role in shaping the consumption pattern. (Joshi *et al*, 2007) [15]

Rising Income

Improvement in the per capita income is un-doubted an important determinant of changing consumption pattern (Rao *et al*, 2008) [27]. As income increases consumer's preference shifts from staple food items such as rice, wheat and coarse cereals to high value food items like fruits, vegetables, dairy, poultry, meat, and fish products. The above changes in the consumption pattern encourage the farming community to diversify its production portfolio in favour of high value food items. The per capita (GDP) Gross Domestic Products in South Asia has increased by an annual rate of 3.4 percent during 1990's as compared to 3.2 percent during 1980's with this increase in the GDP. Both the poor and rich have shifted their consumption in the favour of non-cereals. (Joshi *et.al*, 2007; Joshi *et.al*, 2004; IFPRI, 2007) [15, 16, 12]

Urbanization

Urbanization is another important factor of demand side that influences the consumption pattern. The rate of urbanization in South Asian countries is very high, rising from the 23.3 percent in 1980's to 1990's in 2000. (Joshi *et.al*, 2007) [15]. Lifestyle in the rural and urban areas is very much different so is their consumption pattern. Urban people consume higher quantity of (HVC) high value commodities and allocate higher budget than the rural people. (Joshi *et.al*, 2007; IFPRI, 2007) [15, 12]. An analysis of higher income group from the Asian countries shows that urbanization has led to a significant decline in the consumption of cereals and a rise in the consumption of meat, fruits and vegetables. (Huang and Bouis, 2001) [11]. The share of high value commodities in the total food expenditure in India has increased from 31 percent in 1983 to 39 percent in 1999-2000 in rural areas and from 42 percent in 1983 to 50 percent in 1999-2000 in the urban areas (Kumar and Mruthyunjaya, 2003) [18].

Supply side factors

Infrastructure (markets and roads

Infrastructure development includes two important variables *viz:* markets, and roads. The better markets and road network induced diversification in favor of high value commodities as it results in low marketing cost and easy and quick disposal of commodities. It also reduces the risk of post-harvest losses in case of perishable commodities.

Technology

The technology is defined by area under high-yielding variety of food grains, irrigated area and extent of mechanization.

There is lots of research carried out on factors influencing crop diversification in India using various models. The Earlier literatures were reviewed for identifying, assessing and interpreting the determinants of crop diversification. All these author(s) estimated and reported their results at various places. A comprehensive review documentation of these results is lacking; accordingly effort was made to critically review some of the important research papers and make one comprehensive document in this area which may helpful to scientific community.

Specification of the model

The several researchers used following regression model to examine the determinants of diversification with less or more variables.

Dc or Dl = f (TECH, INFR, PROF, KNOW, DEMA, RAIN)

The dependent variable was diversification index which is estimated in study; whereas, independent variables were broadly grouped into (i) technology (TECH) related, (ii) infrastructure (INFR) related, (iii) profitability (PROF) related, (iv) resources and information (KNOW) related, (v) demand (DEMA) side, and (vi) climate (RAIN) related. To capture their effect, few proxy variables were used in the model. For technology (TECH), these included: proportionate area under high yielding varieties of food grain crops (%), fertilizer use (kg per ha), proportion of gross irrigated area to gross cultivated area (%), mechanization (number of tractors per 1000 ha area). For infrastructure (INFR) the proxy variables were market density (number of markets per 1000 ha of gross cropped area) and roads length (square km per 1000 ha of gross cropped area). Relative profitability of high value enterprises with cereals and other crops was the proxy for profitability (PROF) related variables. Average size of land holding (ha) and proportion of small landholder in total holdings were used proxy for available resources, and rural literacy (%) for information (KNOW) related variables. On demand side (DEMA) variables, urbanization (% urban population) and per capita income (rupees per person) were used in the model. Annual rainfall (mm) was used to define the climate (RAIN) related variable in the model. (Joshi *et al*, 2003; Mithiya *et al*, 2018) [17, 20].

Literature Review

Joshi *et al.,* (2003) [17] studied the key determinants for high-value commodities, in Indian context for the period of 1980-81 to 1999-2000 by using Generalized Least Square (GLS) technique with fixed-effect model. The study reported that, markets and road network, irrigated area and rainfall variables were the key determinants. There was a positive relationship between growth of horticultural commodities and the proportion of small holders. The demand-side factors such as urbanization and per capita income also showed positive and significant impact on crop diversification.

Parthasarathy *et al.,* (2004) [24] had used ordered probit model and modified version of tobit model to examine the factors influencing diversification towards high value commodities (HVCs) covering period from 1980 to 1994. The spatial analysis had showed that urbanization, technological, agro-climatic, agrarian structure and infrastructure variables had significantly influenced diversification towards high value commodities (HVCs). Density of small farms was positively influencing whereas; irrigation, adoption of high-yielding varieties or high input agriculture in the better-endowed regions had a negative influence on high value commodities (HVCs). Rainfall also played important role in diversification.

Birthal *et al.,* (2006) [3] used a logit model to identify the factors that influenced household's decision to grow high-value crops (fruits and vegetables). The coefficient of labour, occupation of the household, road density and assess to institutional credit were identified as the significant determinants of diversification.

Singh *et al* (2006) [3] studied the determinants of diversification in Indian agriculture using data period covering from 1990-2002. Agricultural diversification was influenced by a number of factors, *viz*; road density, number of regulated markets, number of villages electrified; area under high-yielding varieties, percent irrigated area and fertilizer consumption per hectare.

Parthasarathy *et al.,* (2008) [25] carried out the regression analysis to identify the important drivers of agricultural diversification in Andhra Pradesh, India. The results Ordinary Least Squares (OLS) estimates revealed that, urbanization from demand-side was an important driver for production of high value commodities (HVCs), with the exception of fruits and milk; whereas, processing industry infrastructure, farm wages, credit and agro climatic factors from the supply-side, were the important drivers of agricultural diversification.

Jha *et al.,* (2009) [14] examined the determinants of agricultural diversification in Haryana with the help of Ordinary Least Squares (OLS) and Generalized Least Squares (GLS) regression techniques. The percent area under non-food grain crops was positively affected by the per capita income. Road density was emerging as important variable whereas, irrigation had affected increase in area under non-food crops adversely. State level analysis revealed that, there was negative relationship of alternate measures of diversification with irrigation intensity De and Chattopadhyay in their study (2010) [4] performed a multiple regression analysis. They reported that, the growth of irrigation, number of electric pump-sets and storage facility had significant positive impact on the inter-district variations in growth of proportion of area under boro paddy in West Bengal. Also, percentage of agricultural labour force to total working force and proportion of area under small and marginal farms had significant positive impact on inter-district variations. The impact of use of machines such as tractor and tiller were not found significant in crop diversification.

Acharya *et al.,* (2011) [1] carried out stepwise regression analysis for the period from 1982-83 to 2007-08. Per capita income and urbanization were negatively influencing on diversification of vegetables & spices and fruit crop diversification, respectively. Diversification of commercial crops was found to be significantly affected by proportion of area under high-yielding varieties and the proportion of gross irrigated area to gross cropped area.

Kumar and Gupta (2015) [19] in their study used fixed effect model (FEM) for a state level empirical analysis of crop diversification towards high-value crops in India. They reported that, most of the parameters under consideration, *viz*; cropping intensity, annual rainfall and gross irrigated area had been found to influence the nature and extent of crop diversification in India,

More (2016) [21] adopted panel data regression approach to find out the factors influencing crop diversification from the year 1970-71 to 2011-12 in Gujrat state. The consumption of fertilizers, number of pump sets and number of markets, urbanization and maximum temperature had negative and significant impact on the process of crop diversification whereas, a positive impact of gross irrigated area, small and marginal farms was observed on crop diversification.

Devi and Prasher (2018) [6] performed step wise regression analysis to identify the determinants of agricultural diversification in Himachal Pradesh from 1972-73 to 2011-12. The results showed that, average size of land holding, regulated market infrastructure, irrigated area and per capita income were the important factors in promoting crop diversification. Former three factors were positively while; the per capita income was negatively related with the crop diversification, at the state level.

Mithiya *et al* (2018) [20] used fixed effect model (FEM) with standard Ordinary Least Squares (OLS) for 17 districts in West Bengal from 1990 to 91 to 2013 to 14. They reported

that, rural literacy and the proportion of smallholder's area under high yielding variety (HYV) for food grains, magnitude of rainfall and extension of crop insurance facility yielded significant influence on crop diversification. Whereas, number of markets, road length and per-capita income had positive influence on diversification, but size of the urban population had shown a negative impact on crop diversification.

George (2019) [8] studied the multiple regression analysis using time series data from 1987-88 to 2016-17 in Kerala. He reported that, factors such as wage rate of agricultural laborers, literacy rate and population density, population density were found to be significant. However, the wage rate of laborers and literacy rate had a negative effect on crop diversification.

Nayak and Kumar (2019) [23] examined the determinants of crop diversification in Odisha for the period from 1993-94 to 2012-13. The results revealed that, all determinants of diversification *viz;* seed quality, irrigation intensity, cropping intensity, rural road density, agricultural income and credit were significant, except rainfall. High yielding variety of paddy, irrigation intensity and credit lead to crop concentration, whereas cropping intensity, rural roads and district domestic product from agriculture per capita lead to crop diversification.

Nasim *et al* (2020) [22] did stepwise multiple regression analysis using time series data from 2000-01 to 2014-15. The results showed that, a significant and negative effect of rainfall was noticed in case of cereal crops; while the coefficients of variables such as percentage of urban population, population density were found negative and significant in case of pulses. NPK consumption showed positive and significant effect on diversification while percentage of gross irrigated area to gross cropped area recorded negative and significant effect, in oilseed crops. However, the percentage of high yielding variety (HYV) area of paddy, wheat and maize in total cereal's area was estimated negative and significant.

Specification of the model used by different researchers

Researchers	Specified Model	Selected Variables	Positive impact	Negative impact
Joshi *et al.*, (2004) [16]	Generalized Least Square (GLS) technique with fixed-effect model	Area under high-yielding variety (HYV), fertilizer use, irrigated area, extent of mechanization, market density, roads length, per capita income, percentage of urban population, relative profitability, percentage of small and marginal landholder in total holding, Rural literacy, urbanization and per capita income, annual rainfall	Market density, roads length, relative profitability, Proportion of small holders, urbanization and per capita income	Irrigated area, annual rainfall, rural literacy
Parthasarathy *et al.*, (2004) [24]	Regression analysis techniques (Ordered probit and to bit models	Urban population, human population density, per capita value of agricultural production, cross-bred cattle percentage, improved poultry percentage, density of veterinary institutes, normal rainfall, fertilizer use, marginal & small land holdings, size of land holding, road density, market density, density of tractors, irrigated area, area under high yielding Varieties	Urban population, human population density, per capita value of agricultural production, cross-bred cattle percentage, improved poultry percentage, density of veterinary institutes, normal rainfall, fertilizer use, marginal & small land holdings	Size of land holding, density of tractors, irrigated area, area under high yielding varieties
Birthal *et al.*, (2006) [3]	Logit model	Age of the head of the household, gender of the head of the household main occupation of the household, labour availability, farm size, access to irrigation, access to institutional credit, road density,	Age of the head of the household, main occupation of the household, labour availability, access to irrigation, access to institutional credit, road density	Gender of the head of the household, farm size
Singh *et al* (2006) [3]	Ordinary Least Squares (OLS) method	road density, number of regulated markets, number of villages electrified, area under high-yielding varieties, percent irrigated area, fertilizer consumption and per capita value of agricultural output and population density	Fertilizer consumption	value of agricultural output, road density, number of villages electrified, population density
Parthasarathy *et al* (2008) [25]	Ordinary Least Squares (OLS) method	Urbanization, rainfed area covered under watershed program, share of smallholders, wage rate and proportion of poor, rainfall, irrigation	Urbanization, rainfed area covered under watershed program, share of smallholders, rainfall	Wage rate and proportion of poor, irrigation
Jha *et al.*, (2009) [14]	Generalized Least Square with the random effect model	Per capita income, percentage of small and marginal holdings, average size of operational holdings, irrigation intensity, road density, urbanization, institutional credit	Per capita income, irrigation intensity, institutional credit, road density	Percentage of small and marginal holdings
De and Chattopadhyay (2010) [4]	Multiple regression analysis	Fertilizer consumption, road density, market density, number of electric pump set, agricultural labourer as percentage of total working force, number of tractor and power tiller, percentage of GCA under canal irrigation, storage facility,	Growth of irrigation (both minor and major), number of electric pump-sets and storage facility, percentage of agricultural labour force to total working force and proportion of area under small and marginal farms, fertilizer consumption, storage capacity, number of tractor and power tiller	Market density, road density

Researchers	Specified Model	Selected Variables	Positive impact	Negative impact
Acharya *et al*., (2011) [1]	Multiple regression analysis	Per capita income, percentage of urban population, percentage of area under high-yielding variety (HYV) of cereals, percentage of gross irrigated area to gross cultivated area, annual rainfall, Average size of landholding, market density, fertilizer use, roads length, percentage of small and marginal landholder in total holding, mechanization	Percentage of gross irrigated area to gross cultivated area, annual rainfall	Per capita income, percentage of urban population, percentage of area under high-yielding variety (HYV) of cereals, fertilizer use
Kumar and Gupta (2015) [19]	Fixed Effect Model	Cropping intensity, annual rainfall, gross irrigated area,	Cropping intensity and annual rainfall, gross irrigated area	-
More (2016) [21]	Panel data regression	Consumption of fertilizers, number of pump sets, number of markets, maximum temperature, urbanization, gross irrigated area, small and marginal farms, high yielding variety, minimum temperature, annual rainfall	Gross irrigated area, small and marginal farms, area under high yielding variety, minimum temperature and annual rainfall	Consumption of fertilizers, number of pump sets and number of markets, urbanization and maximum temperature, urbanization
Devi and Prasher (2018) [6]	Step wise linear regression analysis	Annual Rainfall, percent area under high yielding cereals crops Fertilizer use, percent of gross irrigated area to gross cultivated area, road length, mechanization, percent of urban population per capita income, average size of land holding, number of regulated markets.	Annual Rainfall, , and irrigated area, road length, average size of land holding, regulated markets	Fertilizer use

Researchers	Specified Model	Selected Variables	Positive impact	Negative impact
Mithiya *et al* (2018) [20]	Fixed effect model (FEM) with standard Ordinary Least Squares (OLS)	Area under high yielding crops, fertilizer use, percent of gross irrigated area to gross cultivated area, number of markets, road length, relative revenue of high-value enterprises with cereals and other crops, average size of holding, proportion of small holders, rural literacy and and per-capita income, size of the urban population, rainfall and crop insurance facility (NAIS)	Average size of holding, proportion of small holders, rural literacy, number of markets, road length and per-capita income, rainfall, relative revenue of high-value enterprises with cereals, crop insurance facility (NAIS)	Area under high yielding crops,fertilizer use, percent of gross irrigated area to gross cultivated area, urban population
George (2019) [8]	Multiple regression analysis	Rainfall, gross irrigated area, per capita state income, wage rate of agricultural workers, literacy rate, population density, farm credit, fertilizer consumption, average size of land holding and crop intensity	Population density, per capita state income, crop intensity	Wage rate of laborers, literacy rate, rainfall, gross irrigated area, farm credit, fertilizer consumption, average size of land holding
Nayak and Kumar (2019) [23]	Panel data models with fixed effects (FE)	Irrigation intensity, cropping intensity, high yielding varieties, per capita district domestic product from agriculture, agricultural credit, rural road density, rainfall	Cropping intensity, rural road density, per capita district domestic product from agriculture, rainfall	High yielding varieties, irrigation intensity, agricultural credit
Nasim *et al* (2020) [22]	Multiple regression analysis	Rainfall, urban population, population density, percentage of gross irrigated area to gross cropped area, percentage of high yielding variety (HYV), NPK consumption	NPK consumption	Rainfall, urban population, population density, percentage of gross irrigated area to gross cropped area, percentage of high yielding variety (HYV)

Conclusion

The above studies related to determinants of diversification concluded that, there were number of technological, infrastructural, climate related, demand and supply side factors which together influenced the process of crop diversification at country level. The major factors responsible for crop diversification reported by most of the researchers were irrigation facilities, use of chemical fertilizers, road length, market density, rainfall, percentage of urban population, percentage area under high yielding cereal crops, percentage of small and marginal landholders in total holdings, average size of land holding, mechanization and per capita income.

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