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Techniques and status of crop diversification: A review

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Abstract
In order to face the increasing population pressure and changing consumption pattern, to enhance the income of rural people and to boost the employment opportunities, diversification of rural economy is necessary to lessen the burden on agriculture. Diversification in crop sector results in overall development of any region. So, there is great need to diversify the agriculture from traditional low-valued crops to high valued horticulture and livestock commodities. The policy makers are also emphasizing on changing the way the agriculture sector works in order to tackle the inconsistencies in the farm sector and achieve food security. On this backdrop, the diversification of agriculture towards high-value commodities (HVCs) like fruits, vegetables, diary, poultry, meat and fish products, etc. is suggest as a viable solution to stabilize and raise farm income, enhance agricultural growth, increase employment opportunities and conserve natural resources.
The literature review on the topic offers ample scope for a critical and retrospective examination of the work done on diversification of crops and other related enterprises. Hence, because of conspicuous lack of research studies and inadequate empirical evidences regarding diversification, it is extremely important to examine the techniques and status of diversification at macro level.

Keywords: Crop diversification, rural economy, structural transformation, agricultural economics

Introduction
Indian agriculture is predominantly a small and marginal peasant-based economy with approximately 85% of the operational holdings being below two hectares and at the same time, only 44.58% of the agricultural land is cultivated by them (Agriculture Census 2010-11, Government of India, 2010). Because of small operational holdings, it is very difficult for the small farmers to improve their earnings only by raising the yields of the existing crops, mainly cereals. If the productivity in agriculture and horticulture improves with the help of mechanization, advanced technology, this sector may have a leading role in India's economic development. However, with the availability of modern farm inputs in the current decades, farmers have a ready option to generate higher levels of income by introducing high value crops commonly known as cash crops in their farming units. Thus, the high-value crops being more labour intensive usually provide stable employment and income to a large section of the rural households who face the severe problem of seasonal unemployment and underemployment under the mono-crop economy (De and Chattopadhyay, 2010) [1]. Therefore, diversification from low-value crop to high-value crop at farm level can solve many of the problems faced by small and marginal farmers.

Diversification is an integral part of the process of structural transformation of an economy (Singh *et al*, 2006) [2]. In Indian agriculture, diversification has occurred both between crops and across activities (that is, crop cultivation, livestock raising, forestry, and fishing). Within agriculture, the share of output and employment in the non-crop sectors, *i.e.* animal husbandry, forestry, and fisheries, has been gradually increasing (Joshi *et al*, 2004) [3]. Thus, significant diversification is taking place in terms of moving away from crop production to other agriculture-allied activities. Simultaneously, similar significant changes are taking place even within the crop sector which is evident from changes in cropping pattern (Singh *et al*, 2006) [2].

Need of the study
To combat the emerging challenges in agriculture, diversification in agriculture is essential to lessen the burden on agriculture in the face of increasing population pressure, shifting consumption pattern, global climate change and overall development of any region. The literature review on the topic offers ample scope for a critical and retrospective examination of the work done on diversification of crops and other related enterprises.

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Hence, because of conspicuous lack of research studies and inadequate empirical evidences regarding diversification, it is extremely important to examine the techniques and status of diversification at macro level. The study thoroughly reviewed the previous studies, various estimation techniques and discusses the results in length. It provides a better under-standing of the previous crop diversification.

Objective of the study
Review of the crop diversification studies, its measures and results in agricultural research

Concept of Agriculture Diversification
A deviation from agriculture towards industries and services denotes diversification (across sectors) at the macro level. But there is a lack of clarity when it comes to diversification within agriculture. The concept of diversification admits varying interpretations and connotes different meanings to different peoples.

Agricultural diversification indicates the changes in crop-mix, enterprises-mix and activity-mix at household level (Chand, 1999) [4]. The process of diversification is defined as a shift of the cultivated area from cereals and low-value crops to high value cash crops, including fruits and vegetables. The diversification of agriculture towards selective high-value cash crops including fruits and vegetables, compatible with the comparative advantage of the region, is suggested as a viable solution to stabilize and arise farm incomes, increase employment opportunities for small and marginal farmers, boost exports and conserve and enhance the natural resource base, principally land and water (Sharma, 2005) [5].

Within the agriculture sector, diversification is a shift from the traditional cropping pattern of less remunerative crops to high value added differed production. In other words, diversification involves the changes in the production portfolio from the low-value to high value commodities like vegetables, milk, meat, eggs and fish based on the market demand that creates the new horizon for the rural income source (IFPRI, 2007) [6]. From a narrow point of view, agricultural diversification implies increasing the variety of agricultural commodities produced at the farm level (Hayami, 1991) [7]. But a broader view suggests that agricultural diversification is a process of a gradual movement out of subsistence food crops (particularly staple foods) toward diversified market-oriented cash crops that have a larger potential for returns to land. At the conceptual plain diversification of agriculture could be classified into the following three categories:

1. Shift of resources from farm to non-farm activities;
2. Shift of resources within agriculture from less profitable crop or enterprise to more profitable crop or enterprise;
3. Use of resources in diverse but complimentary activities

Agricultural diversification in favor of horticulture and livestock products is desirable to increase farm employment and income; reduce disparities across space and time; check degradation of natural resources; and enhance export (Joshi, *et al*, 2004) [3]. Horticulture and livestock products utilize more workforce than the traditional crops. Apart from effect on direct employment, diversification also provides scope for indirect generation of employment through boosting agro-processing industries. (Chand, 1999) [4].

The process of agriculture diversification is triggered by the availability of improved rural infrastructure, rapid technological advancements in agricultural production, and changing food demand patterns. Hence, this process of diversification towards high-value crops is likely to accelerate agricultural growth and usher in a new era of rural entrepreneurship and generate employment opportunities. There appears immense scope for diversification of agriculture towards high-value commodities in India. Diversification of agriculture being a strategy would open up opportunities, to a large extent, for value addition in agriculture and will also lead to better crop planning and improve the earning opportunities in the farm community. From this discussion it is clear that diversification means not only to produce more than one crop, but to involve the entire rural economy and broadening the income sources. The process involves not only the crops but also new marketing and agro food based industrial activities (Goletti, 1999) [8]. Agro-climatic conditions, resource endowments and infrastructural facilities at the regional level within a country may affect the level of diversification (Rao, 2004) [9].

Crop diversification takes into account the economic returns from different value-added crops. It also implies the effective use of environmental as well as human resources to grow a mix of crops with complementary marketing opportunities, and it entails shifting of resources from low value crops to high value crops. Due to globalization, crop diversification in agriculture is also a means to increase the total crop productivity in terms of quality, monetary and quantity value under specific, diverse agro-climatic situations all over the world. (Satyasai and Viswanathan, 1997) [10]. Many economists advocate crop diversification as a tool of risk management. It is a strategy that involves doing more than one activity at any given time. It involves in mitigating price risks and production risks of falling output (Chaplin, 2000) [11].

The process of diversification can be classified into horizontal and vertical diversification. Horizontal diversification is one of the most common phenomena in India. Through this approach the diversification takes place by adding more crops in the existing cropping system as a way to improve the overall productivity of a farm or region's farming economy, or a shift from subsistence farming to high value crops, whereas vertical diversification stands for the addition of value in the existing cropping system through processing, packaging and branding or other efforts to enhance the product value (Jana, 2006) [11].

Materials and Methods
Earlier literatures were reviewed for identifying, assessing and interpreting the techniques and status determinants of crop diversification. For the present paper, reviewed articles studied in India published during 2010-2019. The researchers have utilized various methods to study the crop diversification *viz*; Index of maximum proportion, number of activities, Bhatia's method, Jasbir Singh's method, Herfindahl Index (HI), Ogive Index, Simpson Index (SI), Entropy Index (EI), Modified Entropy Index (MEI) and Composite Entropy Index (CEI). Each method has its own merits and demerits depending upon estimation procedure, interpretation and data requirement. The Composite Entropy Index (CEI) is found most suitable index which possess all desirable properties. The estimation procedure of these indices are as follows:

Index of maximum proportion
The Index of maximum proportion is bound by zero (complete diversification) to one (complete specialization). This index is however silent about the share of other enterprises on total farm income/cropped area. It is computes as:

(Index of maximum proportion = Max Pi)

Where,
Pi = Proportion of acreage under crop to total cropped area.

1. Number of Activities
Simplest measure, which describes total number of activities as an indicator of extent of diversification but it ignores distribution among activities.

2. Bhatia's Method
Crop diversification index (Icd) is inversely proportional to the degree of diversification.

$$Icd = \frac{\text{Percentage of total cropped area under 'n' crops}}{\text{Number of 'n' crops}}$$

Here those 'n' crops are identified whose proportion is more than 10% of the cropped area.

3. Jasbir Singh's Method
The notion is similar to Bhatia but 'n' crops are identified whose proportion is 5% of the cropped area.

$$Icd = \frac{\text{Percentage of total cropped area under 'n' crops}}{\text{Number of 'n' crops}}$$

4. Herfindahl- Hirschman Index (HI)
Herfindahl- Hirschman Index is most commonly used index which is bounded by zero (perfect diversification) and one (complete specialization). (Ghosh, 2010) [12].

$$H.I. = \sum_{i=1}^{N} P_i^2$$

Where N = the total number of crops and Pi = area proportion of the ith crop in total cropped area. But this index has demerit that it gives greater importance to high proportionate activities and lower importance to small proportioned activities.

Ogive Index (OI)
It is used to compute the index value on the deviation from the ideal or equal distribution of acreage. Ogive Index is also a measure of concentration. Hence it is transformed as (1 – O.I.). It was used by Mithiya *et al.*, (2018) [13].

Ogive Index (O.I.) = Σ {Pi – (1/N)}2 / [1/N]

It creates problem in comparing diversity across the region and over time when N is not same. It can provide misleading information about diversity present in two separate cases.

5. Simpson Index of diversification (SID)
It provides a clear dispersion of crops over a geographical area. The Simpson's index ranges between 0 (concentration) and 1 (diversification). Singh *et al.*, (2006) [2] used this index to estimate the magnitude of diversification.

Simpson Index (SI) = 1– Σ Pi

6. Entropy Index (EI)
It is a direct measure of diversification having a logarithmic character. The Entropy index approaches zero when the farm is specialized and takes a maximum value when there is perfect diversification. The upper limit of Entropy Index is

determined by the base of logarithms and number of crops. But it does not give standard scale for assessing the degree of diversification.

$$E.I. = -\sum_{i=1}^{N} P_i \times \log P_i \quad or \ E.I. = \sum_{i=1}^{N} P_i \times \log\left(1/P_i\right)$$

7. Modified Entropy Index (MEI)
Modified Entropy Index is used to overcome the limitation of Entropy Index by using variable base of logarithm instead of fixed based logarithm. This index has demerit that it measures the deviation from equal distribution among the existing activities, *i.e.* number of crops only and does not incorporate the number of activities in it. (Gaikwad, 2018) [14].

$$M.E.I. = -\sum_{i=1}^{N}(Pi \times \log_N Pi)$$

8. Composite Entropy Index (CEI)
This index possesses all desirable properties of Modified Entropy Index and is used to compare diversification across situations having different and large number of crops since it gives due weightage to the number of crops. The CEI has two components *viz.* distribution and number of crops, or diversity. The value of C.E.I. ranges between zero to one (More, 2016) [15].
The formula of C.E.I. is given by:

$$C.E.I. = -[\sum_{i=1}^{N} Pi \times \log_N Pi] \times \{1 - (1/N)\}$$

There are lot of research carried out on crop diversification in India where the extent of crop diversification is estimated using various methods. 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.

Literature Review
De and Chattopadhyay (2010) [1] have intensively studied nature and extent of crop diversification across the districts of West Bengal for the period from 1970 to 2005. The Herfindahl Index, Simpson Index, Entropy and Modified Entropy Index were computed to assess the crop diversification. Results showed that, computed value of diversification index has increased at a slow rate. Reallocation of land towards few crops has been taking place continuously. Among the various crops, cultivation of summer paddy, potato and mustard has been accelerating over the past three decades, whereas, the cultivation of wheat, other cereals, pulses, jute, sugarcane etc have been declining over the years. Results of district wise rank correlations of indices between any two years indicated that, the districts where the level of diversification in the early stage was high, maintained the same position over the later years also during study period.
Acharya *et al.* (2011) [16] have observed nature and extent of crop diversification in Karnataka state looking to area of different crops for a period of twenty-six years (1982-83 to 2007-08). Composite Entropy Index (CEI) was worked out for crop groups such as cereals, pulses, oilseeds, commercial crops, vegetables and spices, fruits and nuts and for over all crops sector. Figures of composite entropy indices showed that, all the crop groups had a higher crop diversification index during post-WTO period than during pre-WTO period, except for oilseeds and vegetable crops. There was an

immense increase in diversification of commercial crops after WTO. The diversification towards cereals, pulses, and commercial crops was noticed during recent years. The cereals ranked first and pulses remained second in overall level of crop diversification during the study period.

Sharma (2011) [17] has explained nature and extent of crop diversification at state level in Himachal Pradesh by analyzing temporal changes in the cropping patterns, area under fruit and vegetable crops and contribution of horticulture including vegetables crops to the net state domestic product originating in agriculture. The extent of crop diversification on different categories of farm households has been estimated by computing per cent gross cropped area under high value crops. Results indicated that, the temporal changes in cropping pattern at the state level bring out the process of crop diversification towards fruit and vegetable crops. The area under crops *viz;* rice, wheat, barley, other cereals and pulses was declined by varying degree. The area under fruit and vegetable crops increased over the period. The extent of process of crop diversification varies across the districts depending upon agro-climatic conditions. The result from household level analysis also confirmed that, farmers from all categories were devoted significant proportion of their gross cropped area towards cultivation of high value crops.

Shinde *et al.* (2013) [18] have studied region wise changes in cropping pattern and status of crop diversification in Maharashtra using time series data for 43 years (1960-2002). The crop diversification among different crop groups has been estimated using Composite Entropy Index. The study has revealed that, the share of cereals has declined steadily, whereas share of fruits has increased remarkably during the study period. The cropping pattern of Western Maharashtra has diversified with time for all the crop groups except vegetables. The Marathwada region witnessed a more diversified cropping pattern during early period of study compared to later period. At state level, considerable diversification has been noticed in fruits and pulses groups.

Kumar and Gupta (2015) [19] studied the emerging trends, determinants and policy implications of crop diversification in India. Simpson Index approach was used to assess the extent of diversification for the group of cereals, pulses, foodgrain crops, cash crops, food crops, oilseeds, non-food crops and the total crop sector in Indian agriculture during 1980-81 to 20011-12. The results revealed that, the Simpson index for crop diversification was more or less constant for all the crop groups with minute fluctuations. The only noticeable variation in Simpson index was seen in the crop sector whose Simpson index had consistently increased over the years with an average of 0.615 (1980-81 to 1989-90) to 0.675 in the post reform decade (2000-01 to 2011-2012). It indicated that, there was rise in crop diversification through a rise in area under non food grain crops. It implied that cropping pattern had shifted from the traditional cropping system involving specialization in foodgrain crops, towards of high value crops which mainly include horticulture crops and commercial crops such as cotton, tea, coffee, tobacco etc.

More (2016) [15] studied economic impact of climate change on agriculture sector of Gujarat. In his research, district level crop diversification status in cereals, pulses, foodgrains, oilseeds, commercial crops and total crop sector of Gujarat state were assessed from the year 1970-71 to 2011-12 using Composite Entropy Index (CEI). Based on magnitude of diversification, all the districts were ranked by computing the Kendall's coefficient of concordance [W]. The results revealed that, estimated Composite Entropy Index(CEI) value

for the state were lied in between 0.632 to 0.679, reflected that no single cereal crop had dominated the cereal base cropping system in the state. Bharuch and Vadodara districts had showed maximum crop diversification in cereal crops whereas, the top three least diversified districts in the state during 1971-75 were Dang (0.360), Banaskantha (0.395) and Kachchh (0.415). Low level of crop diversity in Amreli and Jamnagar districts was mainly because, farmers of the districts preferred cultivation of groundnut and cotton crop. In Surendranagar district, low level of crop diversification was due to supremacy of cotton cultivation.

Gaikwad (2018) [14] examined the extent of crop diversification by computing Herfindal index, Modified Entropy index (MEI) and Composite index (CI) was used for determination of spatial variations across four regions of the Maharashtra state. The study covered the period from 1960-61 to 2012-13. The results revealed that, Herfindahl index (HI) for cereals in Maharashtra reduced from 0.33 to 0.24 indicating diversification at state level. In case of pulses and oilseeds, Herfindahl index showed increasing trend which indicated no diversification correspondingly confirmed by reduced Modified entropy index also. However, in case of commercial crops, Herfindahl index showed declining trend from 0.76 to 0.52 and increased modified entropy index from 0.68 to 0.70 which indicated that, diversification had happened in commercial crops at state level. The development for agriculture exhibited wide variations as the highest weight was found for cropping intensity (5.96) while the lowest weight was observed for number of tractors (0.33). Ahmednagar district had a higher level of agricultural development whereas Sindhudurg district had a lower level of agricultural development.

Devi and Prasher (2018) [20] studied agricultural diversification in Himachal Pradesh. The extent and trend of diversification was estimated using Simpson Index of Diversification (SID) covering data period from 1972-73 to 2011-12. The analysis of Simpson indices over a period revealed that, Kinnaur, Lahaul & Spiti, Shimla and Sirmour were the districts depicting a trend towards diversified agriculture at varying extents. The pace of specialization was observed to be the highest in Hamirpur and the lowest in Kullu during the study period. Likewise, the highest rate of diversification was recorded in Kinnaur and the lowest in Shimla over the study period. The diversification within different crop groups' *viz.*, cereals, pulses, fruits, vegetables, non-food group and all crops together for the State at different periods of time showed that, situation with regard to cereals had remained almost same as shown by the values of Simpson index for this crop group which ranged from 0.695 to 0.616. Similar trend was observed in case of pulses and non-food crops, though the value of Simpson index differs between these crop groups. The increasing trend of diversification in the vegetable group was observed where the Simpson index value ranged from 0.409 in 1972-73 to 0.795 in 2011-12. So, the agriculture in the state remained highly diversified over the years from 1972-73 and 2011-12 with marginal tendency towards specialization as denoted by the decreasing values of Simpson index. This implied that, farmers in the state were still growing several crops instead of specialization in a few crops. Small size of operational holdings and fear from risk might be, among others, were the main restraints to the specialization of agriculture in the state.

Mithiya *et al* (2018) [13] studied the trend, pattern and determinants of crop diversification of small holders in West Bengal. A district-wise panel data analysis was carried out for

17 districts in West Bengal from 1990 to 91 to 2013 to 14. Simpson's index had been used to compute diversification. The results revealed that, Simpson's index was highest in Nadia followed by Murshidabad in all the sub-periods. This indicated that, Nadia showed the highest crop diversification followed by Murshidabad. Malda was an important district in terms of crop diversification which consistently showed high value of Simpson's index. North 24 Parganas, Coochbihar and Hoogly also had a high value of Simpson's index. Burdwan was agriculturally the most developed district in West Bengal, but the speed of crop diversification was not very high. The magnitude of crop diversification indices of Burdwan, Birbhum (except sub-Period I), Howrah, East Midnapore and West Midnapore were more or less the same in all the sub-period under analysis. The value of Simpson's index in Purulia was less than 0.40 which indicated that, there was no tendency of crop diversification. In South 24 Parganas and Bankura, the magnitudes of crop diversification indices were also low. During sub-Period I, South 24 Parganas showed the lowest value of Simpsons index followed by Purulia. Darjeeling showed the same pattern of diversifying tendency with the value of diversification index being 0.69, 0.80, and 0.79 during the three sub-periods. The state of West Bengal as a whole indicated diversifying tendency in crop cultivation with the value of Simpson's index being 0.66, 0.76, and 0.77 in three consecutive sub-periods. It was observed that, the crop sector in the West Bengal, in general, had been diversifying towards high-value crops from the traditional ones. However, there are considerable variations in terms of intensity of the diversification across the districts.

Summary and conclusions
After critically scrutinizing above reviews, we can sense that, farmers were diversifying horizontally more within the crop sector compared to allied sector and vertical diversification towards non-farm activities was very less. Various researchers have employed diverse methods to access the extent and speed of crop diversification. These methods were mainly index base. The summary of above review can be stated that, there was rise in crop diversification through a rise in area under non-food grain crops. It implied that, cropping pattern had shifted from the traditional cropping system involving specialization in food grain crops, towards of high value crops which mainly include horticulture crops and commercial crops *i.e.* non-food grain crops. The study concluded that, diversification in total crop sector was increased in various states of India.

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