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Handout on Crop Diversification Index Measurements: Essential for Sustainable Livelihood of Farm Households

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SUMMARY

Crop diversification means addition of other crops to an existing cropping pattern by a farmer and that considered to be most economically viable, reasonable, and eco-friendly ways to reduce agricultural uncertainty, especially for marginal and small farmers in the country. Agricultural diversification serves as an essential for sustainable livelihood. Several ways were constructed to measure crop diversification, but the most commonly used methods in the field of Agriculture are the Herfindahl Index (HI), Simpson Diversity Index (SDI), Ogive Index (OI), Entropy Index (EI) and Modified Entropy Index (MEI). These measures serve as a useful tool for evaluating the potential cropping strategies used in a given region at the farm, district, and state levels by providing a easy to understand measure.

INTRODUCTION

Agricultural diversification helps in lowering the risk of agriculturist and it provides them access to a wide range of alternatives for sustainable, profitable livelihoods options. Crop diversification can be defined as the replacing or addition of other crops to an existing farming system. It is considered as one of the most economically viable, reasonable, and eco-friendly ways to reduce agricultural uncertainty, especially for marginal and small farmers in the country. In India, the degree of diversification shows massive differences between various geographical locations. Crop diversification increases cropping intensity and productivity of crop. Farmers' capacity to assume risk and secure their income can be improved by diversifying their crops to produce more profitable ones like fruits, vegetables, plantations, etc (Acharya, 2011). Research has shown that, particularly for smallholders, the chance of poverty is inversely associated with the degree of diversification

Crop diversification for sustainable livelihood

The origin of sustainability in development can be traced to the first UN conference on human development held in 1972 at Stockholm, when global consciousness on ecology, environment and poverty emerge. Crop diversification is the addition or expansion of existing crops to the present agricultural system that could be considered as horizontal diversification (Joshi, 2003). However, it simply adds various crops to the same cropping system by using methods like multiple cropping techniques *etc*., with other effective management measures. Crop diversification is one of the key approaches in sustainable agricultural practises since it minimizes crop monoculture and failure of cropping system. Crop diversification leads to sustainable yield, a variety of nutritious foods, and good health. It can also be a better alternative for the use pesticides to retain soil health and managing pests. Further, several assume that crop diversification mitigates the effects of climate change since native flora may retain more carbon than monocultures can, resulting in lower carbon dioxide emissions. In order to achieve the goals of ensuring food security, nutrition security, income growth, poverty alleviation, employment generation, wise use of land and water resources, sustainable agricultural development, and crop diversification (horizontal and vertical) has been recognized as an effective strategy.

Measurement of Crop Diversification

A traditional approach was practised initially for measuring crop diversification that was to count the number of crops a farmer grows in his land. Later on, different ways were framed to measure crop diversification, but the most prominent methods are the Herfindahl Index (HI), Simpson Diversity Index (SDI), Ogive Index (OI), Entropy Index (EI) and Modified Entropy Index (MEI) (Narmadha and Karunakaran, 2022).

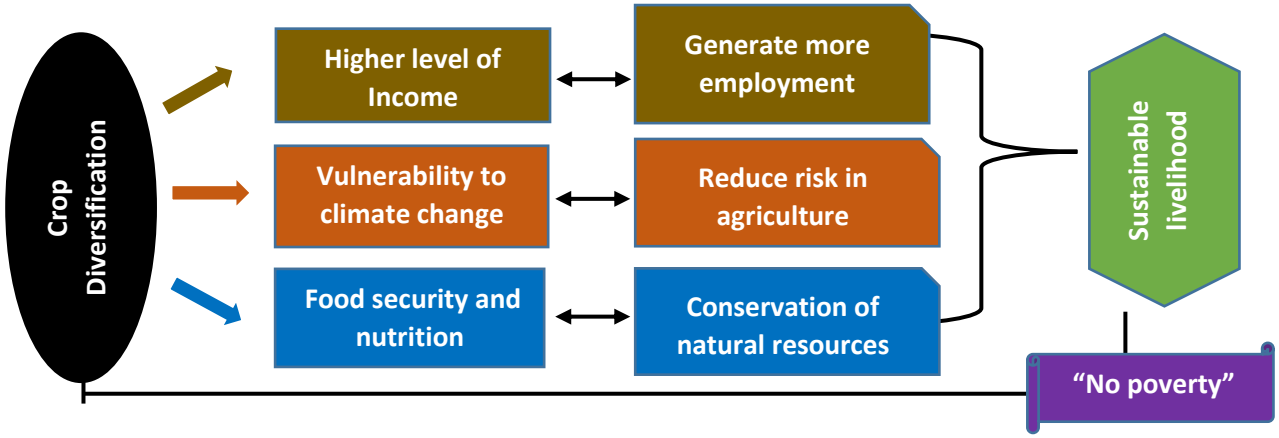

Fig. 1. Conceptual diagram of crop diversification as sustainable livelihood

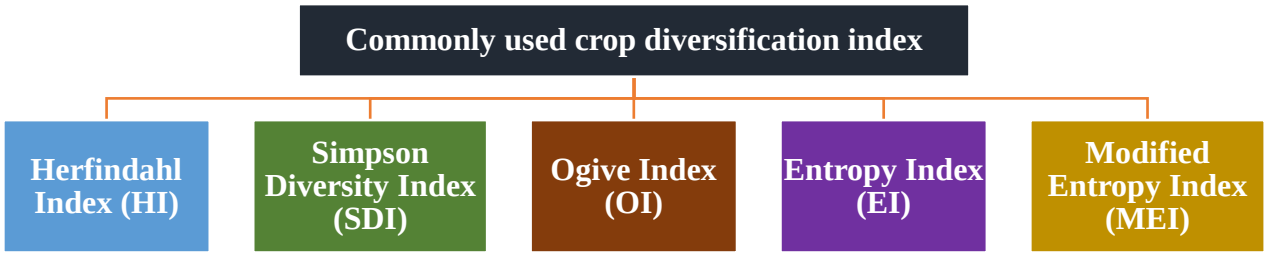

Fig. 2. Most commonly used indices for measuring crop diversification

Herfindahl Index

The HI concept was developed by economist Orris C. Herfindahl (1945) and Albert O. Hirschman (1950) as indicator in the field of competition. It is also called as Herfindahl-Hirschman Index (HHI). It was initially used as concentration index to determine the concentration of industry and later applied in the field of agriculture to determine crop diversification at the state level. The formula for calculating Herfindahl Index (HI) was given below

$$\mathbf{HI} = \sum_{i=1}^{N} p^2{}_i$$

p_i = Proportion of area under ith crop

N = Total number of crops cultivated

Where, $\mathbf{p_i} = \frac{A_i}{\sum A_i}$, in which Ai was area under ith crop and $\sum_{i=1}^{n} A_i$ was the total cropped area.

The value of Herfindahl index ranges from zero (0) to one (1). Higher values of Herfindahl index indicate a lower extent of diversification and vice versa. When there is no diversification, it takes the value 1, and as the crop diversity increases, it tends to move towards 0.

Simpson Diversity Index

The SDI was developed by Edward H. Simpson in 1949 to calculate the level of concentration for the individuals classified under groups. Sometimes SDI is also called as Transformed Herfindahl Index (THI). The economist Albert O. Hirschman already proposed the square root of the Simpson Diversity Index in 1945. As a result, the same measurement is frequently referred to as the Simpson index in ecology and the Herfindahl Index or Herfindahl-Hirschman Index (HHI) in economics. Therefore, SDI is now widely used to analyse the level of horizontal crop diversification in agriculture. The formula for calculating SDI was given below

$$\mathbf{SDI} = 1 - \sum_{i=1}^{N} p^2{}_i$$

p_i = Proportion of area under ith crop (calculated as the same in HI index)

N = Total number of crops cultivated

The value of SDI ranges from zero (0) to one (1). The Simpson Diversity Index (SDI) takes a value close to zero (0) when crop diversification is minimal, but a value close to one (1) under high diversification situations.

Ogive Index

The OI was developed to assess the specialisation and concentration of nations and later it has also been used to calculate the degree of diversification at farm-level. The formula for calculating OI was given below

$$\mathbf{OI} = \frac{\sum_{i=1}^{n}\left[p_i - \left(\frac{1}{N}\right)\right]^2}{\left(\frac{1}{N}\right)}$$

p_i = Proportion of area under i^{th} crop (calculated as the same in HI index)
N = Total number of crops cultivated

Entropy Index

The EI was developed to evaluate the concentration using logarithmic terms with the inverse measure and has often been used to assess the crop diversification in Agriculture at the state and farm levels. The formula for calculating EI was given below

$$\mathbf{EI} = \sum_{i=1}^{N} p_i \ \log(p_i)$$

p_i = Proportion of area under i^{th} crop (calculated by $p_i = \frac{1}{N}$)
N = Total number of crops cultivated

The value of EI like SDI ranges from zero as lower value and one as upper value. When increase in diversification then the value of EI also increases and *vice versa*. When ln (p_i) reaches its highest value, maximum diversification takes place and there was only one crop cultivated like specialisation takes place, then the value decreases to a minimum and reaches zero.

Modified Entropy Index (MEI)

The EI has the limitation of being unable to be used to compare the degree of diversity in various locations where different numbers of crops were grown because its maximum limit is ln (pi), which depends on N. Therefore, the modification was incorporated into EI to overcome the limitation and named as MEI which was used to measure the extent of crop diversification.

$$\mathbf{MEI} = \sum_{i=1}^{N} p_i \ \ln(p_i)$$

p_i = Proportion of area under i^{th} crop (calculated as the same in EI index)
N = Total number of crops cultivated

The limitation of EI was overcome by modification of shifting the base of logarithm from 10 to natural logarithm. As a result, the MEI values assume an upper limit of one in the event of perfect diversification and a lower limit of zero in the case of no diversification.

Measuring crop diversification by using Index approach has

Advantages

- It is easily comprehendible.
- It can be used across different levels *i.e.,* from individual to state level.

Disadvantages

- It does not give overall quantitative information.
- Gives an aggregate value only.

CONCLUSION

Diversification is undoubtedly one of the most important terms that has been used the most often in reference to agricultural growth. It is essential for the nations like India, where majority of livelihood depends on agriculture and allied activities. Crop diversification on its own carries a wide range of benefits such as lowering the risk of total crop failure, strengthening food security, raising the profitability of small farm holdings and even improving the soil fertility. Therefore, the Crop Diversification Index serves as a useful tool for evaluating the potential cropping strategies used in a given region at the farm, district, and state levels by providing a easy to understand measure.

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