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**ARAŞTIRMA MAKALESİ** **RESEARCH ARTICLE**

# Measuring the Progress of Organic Farming in Indian States: Are There any Agro-Climatic Implications?

**Nilojyoti KONER[1*], Arindam LAHA[2]**

## Abstract

In the quest for a sustainable farming system around the world, organic farming has emerged as the most promising alternative system that can offer solutions to the growing sustainability issues associated with the current input-intensive agriculture system. Organic farming is also becoming increasingly important due to a significant rise in the demand for organic food across the world. Realizing the importance of organic agriculture in the current Indian agricultural scenario, the Government of India has taken several initiatives to promote organic farming across the country. As a result, there has been a considerable increase in different dimensions of organic farming especially in India over the last decade. However, studies have found that organic farming practices in India are more suited to a few specific regions (such as rain-fed zones, low-productivity areas, hills, and arid zones) as compared to the other parts of the country. In this backdrop, this paper attempts to evaluate the state-wise progress of organic farming in India. To measure the inter-state variation in the performance of organic farming, a composite index has been constructed by taking into account four different performance dimensions viz. area covered under organic cultivation, volume of organic production, volume of organic export, and number of producers practicing organic farming. The result suggests a wide disparity in performances in respect of organic farming among the states in India. Interestingly, the states that have performed well in organic farming are found to have a higher level of organic carbon stock in their soil. This shows the influence of agro-climatic conditions on the organic cultivation practices as popularly postulated in the literature.

**Keywords:** Agro-climatic condition, Organic carbon stock, Organic farming, Organic index, Indian states

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## 1. Introduction

In the quest for a sustainable agriculture system, organic farming has emerged as the most popular alternative farming system (Crowder and Reganold, 2015), as it promises to offer solutions to the problems relating to agricultural sustainability. "Organic agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on the ecological processes, biodiversity, and cycles adapted to local conditions rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved" (IFOAM, 2021). Considering its potential wide range of environmental, economic, and social benefits (Seufert et al., 2012), many countries across the globe have made significant efforts to promote organic farming. As a result, the organic farming movement is gaining gradual momentum worldwide. Organic farming is practiced in 187 countries (Willer et al., 2021). The global market for organic products is also increasing at a rapid pace fueled by the growing health awareness of consumers. Available data shows that the global organic market reached 106.4 billion US dollars in 2019 with the U.S.A, Germany, and France contributing nearly 64% of the total market (Willer et al., 2021). In India, the interest in organic farming is also growing. According to the latest available data, India ranks 8$^{th}$ in terms of the world's organic agricultural land and 1$^{st}$ in terms of total number of producers as per 2020 data (Willer et al., 2021).

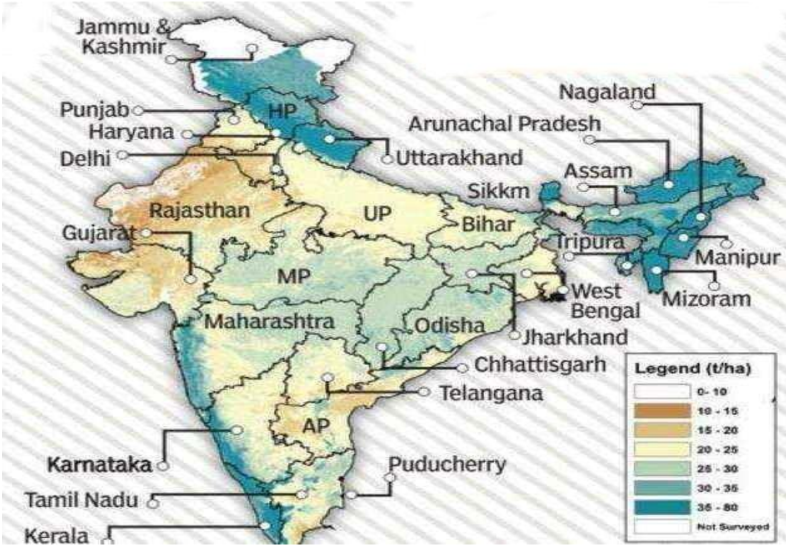
Before the introduction of the green revolution in the 1960s, the agricultural practices in the country were entirely based on organic farming techniques (Sruthy and Vibini, 2019). With the introduction of green revolution technologies, India has not only achieved food self-sufficiency but has also become a major exporter of foods. However, the extensive dependence on green revolution technologies (such as the use of synthetic inputs like chemical fertilizers and pesticides) has already started to show its ill effects on the environment, human health, and agriculture itself (Pingali, 2012; Turkboylari and Yuksel, 2021) and thus became a major cause of concern. Therefore, the time has come for the government to rethink its agricultural policy to make agriculture more sustainable. The introduction of the 'National Mission of Sustainable Agriculture' (NMSA) seems to be a step in this direction. Under the NMSA, the government of India has launched 'Paramparagat Krishi Vikash Yojana' (PKVY), a flagship programme designed to promote organic cultivation in the country. The scheme follows a cluster approach in promoting organic farming across the country. Since the implementation of this scheme in 2015, a total of 29,859 certified organic clusters have formed across Indian states covering about 0.59 million hectares of land and registering 13.9 million organic farmers (Reddy et al., 2022).

The potential of organic farming to provide improved livelihood opportunities and increased income for small-scale farmers with limited resources has made organic farming a popular strategy for economic development and poverty reduction (Qiao et al., 2016). Realizing the importance of organic farming in the Indian agricultural scenario, the government of India has taken several initiatives to promote organic farming. As a result, there has been a resurgence of interest in organic farming practices across the country. A considerable increase in different dimensions of organic farming (such as the size of the organic area, the volume of production, the quantity of exports, etc.) highlights the progression of the organic farming movement (see *Figure A.1- A.4*) in India. Therefore, the available data shows that India has recently made significant strides in different dimensions of organic farming. However, one pertinent question may arise in this context: has the advancement of the organic farming movement spread uniformly across the country? Or are there any particular regions (or states) that excelled more in organic farming than the other parts (or states) of the country? Is there any factor that can explain the variation in organic farming practices across India?

However, there is a lack of information on the state-wise progress of organic farming. Only a few studies in the existing literature shed some light on the status of organic farming in India (Deshmukh and Babar, 2015; Mitra and Devi, 2016; Yes Bank and ISCR, 2016; Wani et al, 2017; Babu and Karunakaran, 2021). To make a comparative assessment across Indian states, the performance in organic farming is evaluated based on one or two individual indicators (Deshmukh and Babar, 2015; Yes Bank and ISCR, 2016). However, such a comparison fails to depict an overall picture of the present state of organic farming in India. By addressing this gap of information in the existing literature, this paper objectively evaluates the state-wise progress of organic farming in India through a comprehensive organic index.

### *1.1. Agro-climatic region for organic farming:*

Studies in the existing literature observed that organic farming is generally practiced in rain-fed zones, low-productivity areas, hills, and arid zones (Vaidya et al., 2007; Mitra and Devi, 2016; Wani et al., 2017; Babu and Karunakaran, 2021). In this context, ICAR-National Bureau of Soil Survey and Land Use Planning (NBSS and LUP), ICAR-Indian Institute of Social Science, Bhopal, and Food Agricultural Organizations jointly prepared a geospatial digital map identifying the regions holding high potential for organic farming based on the presence of organic carbon stock in soils. This map can be a guide to the government in targeting their organic farming policies (Behl, 2017).




Note: Figures signify contents of organic carbon in tone per hectare. More the organic carbon, the better the potential for organic farming

***Figure 1: Organic carbon stock across states in India (Source: Behl, 2017)***

This map highlighted strong potential for organic farming in the entire North- Eastern Region (including Sikkim, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura) and parts of Kerala, Karnataka, Goa, and Maharashtra in Western Ghats (*Figure 1*). It also pointed out that among the northern Indian states Uttarakhand, Himachal Pradesh, and Jammu & Kashmir are the best zones to support organic farming, while states with black soils like Madhya Pradesh, Odisha, and Chhattisgarh have moderate potential for organic farming. However states like Punjab, Haryana, Uttar Pradesh, and West Bengal have low potential for organic farming as the organic carbon stock level of these states is depleted by their intensive cultivation practices.

The geospatial digital map has demarcated the regions (or states) with high potential for organic farming across the country. Therefore, it is important to know how these states have performed so far in different dimensions of organic farming. Further, it will be also interesting to know whether the recent progression of organic farming in the country is limited to these regions (or states) only. In this context, the following testable hypothesis can be drawn:

*Hypothesis: Progress of organic farming in a state is contingent upon its agro-climatic condition (the level of organic carbon stock in the soil in particular).*

## 2. Materials and Methods

### *2.1. Construction of organic index: Methodological issues*

Progress of organic farming in a state can be measured by several dimensions like the size of the area covered under organic farming, the volume of organic production and exports, etc. The existing literature attempted to measure the performance of a state in organic farming by considering one or two individual indicators (Deshmukh and Babar, 2015; Yes Bank and ISCR, 2016). Such analyses are solely based on an absolute performance (rather than relative performance) of a state in the individual indicators. However, this partial analysis fails to depict the overall position of a state in a national context. For instance, inter-state comparison based on the size of the organic area may provide misleading results as the larger states such as Rajasthan, Gujarat, and Madhya Pradesh are more likely to have a higher organic area in comparison to the smaller states like Sikkim, Meghalaya, and Goa. However, a comparative assessment of performance based on relative terms (e.g. the percentage of organic land to total cultivable land of the state) may bring out the overall picture. Therefore, this paper considers all performance dimensions in relative terms so that the inter-state comparison brings out the overall picture. To measure the progress of organic farming across the states of India, the present study has formulated a comprehensive index of organic farming (termed as Organic Index). This index is essentially built on four broad dimensions i.e., size of area, volume of production, volume of export, and number of producers. For each dimension, the performance of the state is evaluated in reference to the national average. For instance, to measure the performance concerning the organic area, first, the ratio of the organic area of a state to the total organic farming area of the country is computed. The dimension of the organic area is then worked out as a ratio between the share of a state regarding the organic area and the share of the total sown area of the state. A score higher than one indicates higher organic area vis-à-vis the proportion of total sown area in the state. Similarly, the performance metric for the other three dimensions is also measured (*Table 1*).

***Table 1: Details of dimensions for measuring organic index***

| Dimension | Description | Proportional measure | Data sources |
|---|---|---|---|
| Size of Area ($D_1$) | Share of organic area as a proportion of the share of the total sown area of the state | $D_1$= A/B Where A indicates the ratio of the organic area of the state to the total organic area in India, and B indicates the ratio of the total sown area of the state to the total sown area in India | Agricultural Processed Foods and Export Development Authority (APEDA, 2019-20)and Department of Agriculture, Cooperation and Farmers' Welfare (as of 29.10.2020) |
| Volume of Production ($D_2$) | Share of the volume of organic production as a proportion of the share of the total volume of agricultural production of the state | $D_2$= C/D Where C indicates the ratio of the organic production of the state to the total organic production in India, and D indicates the ratio of the total agricultural production of the state to the total agricultural production in India | APEDA and Ministry of Agriculture and Farmers Welfare (2019-20) |
| Volume of Export ($D_3$) | Share of the volume of organic export as a proportion of the share of the total volume of agricultural export of the state | $D_3$= E/F Where E indicates the ratio of the volume of organic export of the state to the total volume of organic export in India, and F indicates the ratio of the total volume of agricultural export of the state to the total volume of agricultural export in India | APEDA and Ministry of Agriculture and Farmers Welfare (2019-20) |
| Number of Producers ($D_4$) | Share of the number of organic producers as a proportion of the share of the total number of cultivators of the state | $D_4$= G/H Where G indicates the ratio of the number of organic farmers in the state to the total number of organic farmers in India, and H indicates the ratio of the total number of cultivators in the state to the total number of cultivators in India | Lok Sabha Unstarred question no. 1496 dated 11 February 2020 and Agriculture Census Report, 2015-16 |

Source: Authors' own composition

Considering these three dimensions, a composite Organic Index (OI) is formed. It captures as much as information common to individual indicators. However, there is a certain drawback of this method: multicollinearity problems may arise if there is a high degree of correlation between the individual indicators (Tripathi and Seth, 2014). Factor analysis can be used to address this issue. Earlier studies have shown that factor analysis helps significantly reduce the dimension of data (when the original variables are highly correlated) so that the multicollinearity problem is eliminated (Brooks, 2014; Maji et al., 2020). Therefore, to construct a comprehensive index for organic farming data-driven weighting systems of Principal Component Analysis (PCA) have been used (following Research Centre-European Commission, 2008). In other words, the PCA method is used to derive the corresponding weights of several dimensions of the index. The weighting system under PCA intervenes to correct for overlapping information between two or more correlated indicators. The estimation process generally involves the following three steps. In the first step, the correlation matrix is calculated to check the correlation structure of the data to know whether the individual indicators share common factors. If the correlation between individual indicators is small, then it is highly unlikely that they will share common factors. In the second step, two principal components (or factors) are identified for the analysis as they had maximum variances. Successive components explain progressively smaller portions of the variance and are all uncorrelated with each other. The third step deals with the construction of the weights from the factor loadings which involves rotating the number of factors chosen (from the earlier step) to enhance their interpretability. This is followed by the normalization of factor loadings by scaling to units sum.

The comprehensive index can be written as

$$OI = \frac{\sum_{i=1}^{4} W_i D_{is}}{\sum_{i=1}^{4} W_i} \quad \text{(Eq. 1)}$$

Where $W_i$(i=1, 2, 3, 4) are the corresponding weights of the dimensions. The weights (as per the PCA method) used to construct the organic index are 0.32 for dimension 1, 0.28 for dimension 2, 0.28 for dimension 3, and 0.12 for dimension 4 (see *Table A.1*). Finally, to make a comparison, states are classified into two categories depending on the values of OI. States with an organic index (OI) value below 1 (i.e., national average) have performed poorly, whereas, states having an organic index value above 1 have performed well in organic farming.

## 3. Results and Discussion

This paper aims to evaluate the state-wise progress of organic farming in India. For this purpose, the study has used four broad dimensions of organic farming i.e., size of area covered under this mode of cultivation, volume of organic production, volume of organic export, and number of producers practicing organic farming to measure a comprehensive organic index. Due to the non-availability of data relating to all four dimensions for all the states of India, the study is restricted to the 21 Indian states. For the inter-state analysis, a disaggregated analysis is carried out by taking each dimension of the index and then an overall analysis is conducted based on a comprehensive organic index.

### 3.1. *Current status of organic farming in India: a disaggregated analysis*

First, a state-level analysis for individual dimensions (i.e., size of area, volume of production, volume of export, and number of producers) of the index is carried out. Moreover, states' performances are compared with the national average to assess their relative progress in organic farming. The results are described as follows:

*Spread of organic area across the Indian states (Dimension 1):* One of the common measures of outreach of organic farming is the size of the area covered under this mode of cultivation. Therefore, area coverage is taken as one of the dimensions for measuring the state-wise performances of organic farming. The dimension size of the area ($D_1$) is worked out (shown in *Table 2*) as a ratio of two components: share of the organic area of a state to the total organic area in the country (denoted by A) and share of the sown area of the state to the total sown area in the country (indicated by B). Hence, it evaluates the performance of a state by comparing the share of the organic area of the state against its proportion of the total sown area. Therefore, if the share of the organic area of a state is higher vis-à-vis the proportion of total sown area (reflected by a $D_1$ value of more than 1), the state has recorded a better performance in organic farming and vice versa. So, the higher the value of $D_1$, the better the state's organic outreach.

Ranking of states based on dimension 1 (*Table 2*) shows that Sikkim (1st), Meghalaya (2nd), and Goa (3rd) hold the top positions while Punjab (19th), Haryana (20th), and West Bengal (21st) are at the bottom. Interestingly, Sikkim, Meghalaya, and Goa were also among the states with the highest share of the organic area to net sown area in the country in 2019, while the shares of the organic area to the net sown area of Punjab, Haryana, and West Bengal were among the lowest in the country (Khurana and Kumar, 2020). Moreover, a comparative analysis of performance between the states and the national average suggests that only eight states i.e., Sikkim (59.50), Meghalaya (11.21), Goa (5.79), Uttarakhand (3.65), Madhya Pradesh (3.57), Jammu & Kashmir (2.43), Himachal Pradesh (1.32), and Kerala (1.25) has performed better than the national average (1.00). It indicates that the proportion of organic area to total organic area in the country for each of these eight states is higher than their respective proportion of total sown area to the country's total sown area. However, all other states are lagging behind the national average. Khurana and Kumar (2020) also observed that a considerable portion of the total organic area in India is concentrated only in a few states. The authors found that the top three states (i.e., Madhya Pradesh, Rajasthan, and Maharashtra) accounted for more than 40 percent of the total area under organic farming in 2019. However, most states had only a minor percentage of their net sown area under organic cultivation. The authors observed that despite having the largest area under organic farming, each of the top three states accounted for less than 5 percent of their net sown area under organic cultivation. The inter-state variation in dimension 1 is presented in *Figure 2*.

***Table 2: Ranking of states on the basis of dimension 1***

| State | Organic area (in thousands Ha.) | Sown area (in thousands Ha.) | Share of each state to total organic area (A) | Share of each state to total sown area (B) | $D_1$ (A ÷ B) | Rank on the basis of $D_1$ |
|---|---|---|---|---|---|---|
| Sikkim | 75.72 | 77 | 0.0360 | 0.0006 | 59.5012 | 1 |
| Meghalaya | 45.38 | 245 | 0.0216 | 0.0019 | 11.2083 | 2 |
| Goa | 12.44 | 130 | 0.0059 | 0.0010 | 5.7886 | 3 |
| Uttarakhand | 42.05 | 698 | 0.0200 | 0.0055 | 3.6450 | 4 |
| Madhya Pradesh | 892.90 | 15149 | 0.4248 | 0.1191 | 3.5665 | 5 |
| Jammu & Kashmir | 30.28 | 754 | 0.0144 | 0.0059 | 2.4297 | 6 |
| Himachal Pradesh | 12.05 | 551 | 0.0057 | 0.0043 | 1.3237 | 7 |
| Kerala | 41.78 | 2023 | 0.0199 | 0.0159 | 1.2497 | 8 |
| Maharashtra | 282.50 | 17192 | 0.1344 | 0.1352 | 0.9943 | 9 |
| Rajasthan | 287.58 | 18024 | 0.1368 | 0.1417 | 0.9654 | 10 |
| Assam | 26.69 | 2801 | 0.0127 | 0.0220 | 0.5767 | 11 |
| Gujarat | 95.21 | 10302 | 0.0453 | 0.0810 | 0.5592 | 12 |
| Karnataka | 81.07 | 10006 | 0.0386 | 0.0787 | 0.4902 | 13 |
| Andhra Pradesh | 37.20 | 6209 | 0.0177 | 0.0488 | 0.3626 | 14 |
| Tamil Nadu | 26.01 | 4833 | 0.0124 | 0.0380 | 0.3256 | 15 |
| Chhattisgarh | 22.44 | 4651 | 0.0107 | 0.0366 | 0.2919 | 16 |
| Uttar Pradesh | 60.95 | 16469 | 0.0290 | 0.1295 | 0.2239 | 17 |
| Telengana | 8.74 | 4175 | 0.0042 | 0.0328 | 0.1267 | 18 |
| Punjab | 8.51 | 4137 | 0.0040 | 0.0325 | 0.1244 | 19 |
| Haryana | 6.16 | 3522 | 0.0029 | 0.0277 | 0.1058 | 20 |
| West Bengal | 6.39 | 5243 | 0.0030 | 0.0412 | 0.0738 | 21 |
| India (Total) | 2102.02 | 127191 | 1.000 | 1.0000 | 1.000 | |

*Source: Author's own calculation*

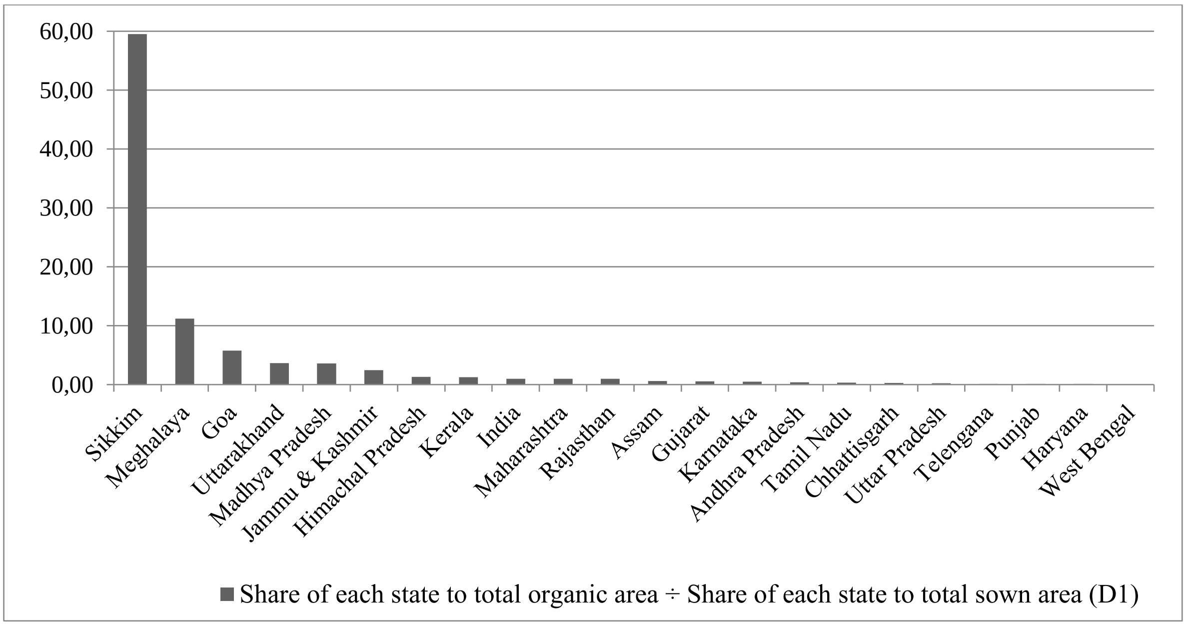



***Figure 2: Spread of organic area across states in India***

*Volume of organic production across the states of India (Dimension 2):* Volume of production can be considered an important measure of performance concerning organic farming. Hence, it is taken as the second dimension ($D_2$) of the inter-state performance evaluation of organic farming. As a relative measure, it compares the share of the volume of organic production of a state (C) against its share of the total volume of agricultural production (D) (shown in *Table 3*). Therefore, if the share of the volume of organic production of a state is higher (C) vis-à-vis the proportion of total volume agricultural production (D), the state has performed better in organic farming and vice versa.

Analysis based on dimension 2 (*Table 3*) indicates that among the states included in the study Kerala (1st), Goa (2nd), and Madhya Pradesh (3rd) are at the top, whereas Haryana (19th), Telangana (20th), and Punjab (21st) are the bottom. Moreover, analysis also reveals that states like Kerala (10.70), Goa (5.89), Madhya Pradesh (5.36), Jammu & Kashmir (4.55), Maharashtra (2.65), Sikkim (1.91), Rajasthan (1.36) and Uttarakhand (1.07) have obtained higher score on dimension 2 in comparison to all national average score (1.00). It indicates that the proportion of organic production to total organic production in India for each of these eight states is higher than their respective proportion of total agricultural production to the country's total agricultural production. Interestingly, a report published by Yes Bank and ISCR (2016) shows that six (i.e., Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Uttarakhand, and Jammu & Kashmir) out of these eight states have contributed 62 percent of the country's total organic production in the year 2014-15. However, the organic production of the rest of the states is lower than the national average. The inter-state variation in dimension 2 is given in *Figure 3*.

***Table 3: Ranking of states on the basis of dimension 2***

| State | Organic production (in thousands tons) | Agricultural production (in thousands tons) | Share of each state to total organic production (C) | Share of each state to total agricultural production (D) | $D_2$ (C ÷ D) | Rank on the basis of $D_2$ |
|---|---|---|---|---|---|---|
| Kerala | 29.88 | 739.9 | 0.01157 | 0.00108 | 10.69807 | 1 |
| Goa | 2.50 | 112.68 | 0.00097 | 0.00016 | 5.88751 | 2 |
| Madhya Pradesh | 980.61 | 48447.1 | 0.37962 | 0.07080 | 5.36151 | 3 |
| Jammu & Kashmir | 28.01 | 1630.47 | 0.01084 | 0.00238 | 4.54996 | 4 |
| Maharashtra | 904.95 | 90414 | 0.35033 | 0.13214 | 2.65124 | 5 |
| Sikkim | 0.73 | 100.94 | 0.00028 | 0.00015 | 1.90991 | 6 |
| Rajasthan | 169.22 | 33078.4 | 0.06551 | 0.04834 | 1.35512 | 7 |
| Uttarakhand | 35.82 | 8847.3 | 0.01387 | 0.01293 | 1.07235 | 8 |
| Himachal Pradesh | 5.42 | 1542.1 | 0.00210 | 0.00225 | 0.93064 | 9 |
| Assam | 23.11 | 7468 | 0.00895 | 0.01091 | 0.81983 | 10 |
| Karnataka | 118.82 | 46942.8 | 0.04600 | 0.06861 | 0.67049 | 11 |
| Gujarat | 70.45 | 33670.5 | 0.02727 | 0.04921 | 0.55424 | 12 |
| Meghalaya | 1.87 | 1100.78 | 0.00072 | 0.00161 | 0.44958 | 13 |
| Chhattisgarh | 13.60 | 9186.5 | 0.00527 | 0.01343 | 0.39222 | 14 |
| Andhra Pradesh | 16.61 | 22693.6 | 0.00643 | 0.03317 | 0.19382 | 15 |
| Tamil Nadu | 17.82 | 25135.8 | 0.00690 | 0.03674 | 0.18780 | 16 |
| West Bengal | 18.56 | 29202.7 | 0.00718 | 0.04268 | 0.16832 | 17 |
| Uttar Pradesh | 138.36 | 234592.5 | 0.05356 | 0.34285 | 0.15623 | 18 |
| Haryana | 3.84 | 29315 | 0.00149 | 0.04284 | 0.03472 | 19 |
| Telengana | 2.29 | 20449.9 | 0.00089 | 0.02989 | 0.02972 | 20 |
| Punjab | 0.64 | 39562.2 | 0.00025 | 0.05782 | 0.00429 | 21 |
| India(Total) | 2583.11 | 684233 | 1.00000 | 1.00000 | 1.00000 | |

Source: Author's own calculation

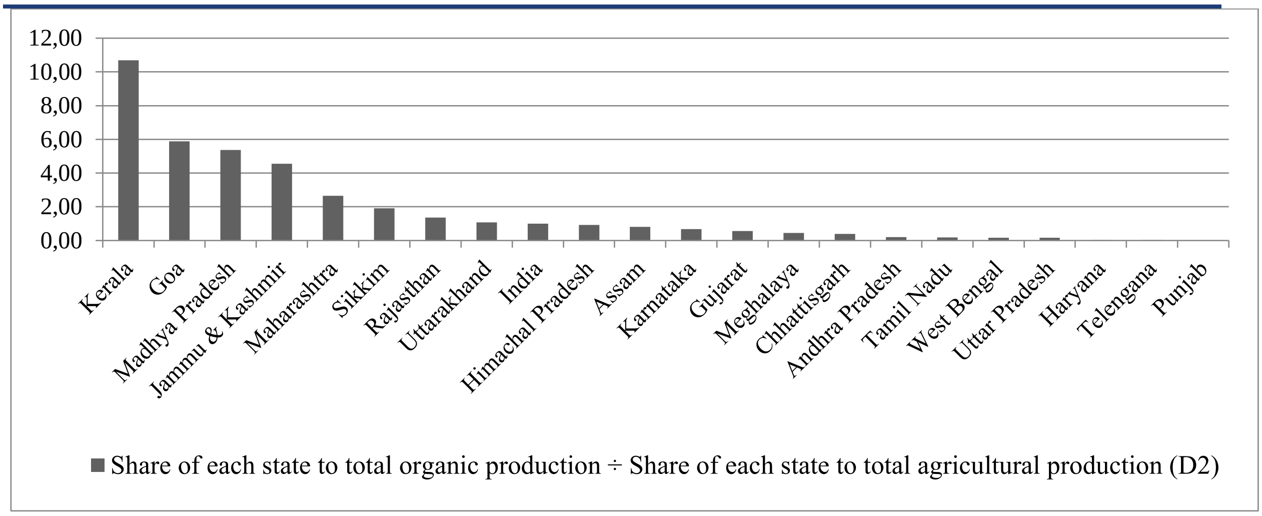



***Figure 3: Volume of organic production across states in India***

*Volume of organic export across the states of India (Dimension 3):* The size of the market is used as an indicator to measure the organic outreach of states. However, due to the lack of sufficient trade data on the domestic market, the study has focused solely on foreign markets (relying on international trade data) and the volume of organic export is used as a dimension ($D_3$) for the inter-state performance analysis. Like the other two dimensions, it is also computed (shown in *Table 4*) as a ratio of the share of the volume of organic export (E) and the share of the total volume of agricultural export (F) of the state. Therefore, if the value of $D_3$ is higher than 1 (indicates a higher share of the organic export vis-à-vis the proportion of the total agricultural export), it will reflect a better organic farming performance of the state.

***Table 4: Ranking of states on the basis of dimension 3***

| State | Organic export (value in Crore) | Agricultural export (value in Crore) | Share of each state to total organic export (E) | Share of each state to total agricultural export (F) | $D_3$ (E ÷ F) | Rank on the basis of $D_3$ |
|---|---|---|---|---|---|---|
| Madhya Pradesh | 1670.20 | 5197.83 | 0.3864908 | 0.0352449 | 10.9658550 | 1 |
| Goa | 20.02 | 66.47 | 0.0046322 | 0.0004507 | 10.2773916 | 2 |
| Jammu & Kashmir | 14.45 | 89.53 | 0.0033440 | 0.0006071 | 5.5083863 | 3 |
| Meghalaya | 0.17 | 1.77 | 0.0000395 | 0.0000120 | 3.2871255 | 4 |
| Sikkim | 0.04 | 0.46 | 0.0000087 | 0.0000031 | 2.7776630 | 5 |
| Kerala | 310.34 | 7233.41 | 0.0718147 | 0.0490476 | 1.4641848 | 6 |
| Telengana | 112.89 | 2692.15 | 0.0261237 | 0.0182547 | 1.4310672 | 7 |
| Karnataka | 285.51 | 7010.25 | 0.0660683 | 0.0475344 | 1.3899052 | 8 |
| West Bengal | 270.82 | 6695.7 | 0.0626679 | 0.0454015 | 1.3803023 | 9 |
| Rajasthan | 107.13 | 3771.69 | 0.0247903 | 0.0255747 | 0.9693285 | 10 |
| Uttarakhand | 7.25 | 297.83 | 0.0016785 | 0.0020195 | 0.8311243 | 11 |
| Maharashtra | 471.44 | 21110.44 | 0.1090923 | 0.1431436 | 0.7621178 | 12 |
| Gujarat | 509.17 | 33589.97 | 0.1178244 | 0.2277636 | 0.5173101 | 13 |
| Haryana | 265.42 | 18301.5 | 0.0614197 | 0.1240970 | 0.4949328 | 14 |
| Uttar Pradesh | 100.71 | 9351.48 | 0.0233057 | 0.0634096 | 0.3675422 | 15 |
| Tamil Nadu | 79.60 | 7522.56 | 0.0184199 | 0.0510082 | 0.3611155 | 16 |
| Himachal Pradesh | 0.57 | 55.64 | 0.0001309 | 0.0003773 | 0.3469711 | 17 |
| Andhra Pradesh | 81.22 | 13154.99 | 0.0187937 | 0.0892001 | 0.2106918 | 18 |
| Assam | 6.99 | 2256.87 | 0.0016169 | 0.0153032 | 0.1056554 | 19 |
| Chhattisgarh | 4.82 | 1945.87 | 0.0011164 | 0.0131944 | 0.0846111 | 20 |
| Punjab | 2.69 | 7130.96 | 0.0006218 | 0.0483529 | 0.0128598 | 21 |
| India(Total) | 4321.45 | 147477 | 1.0000000 | 1.0000000 | 1.0000000 | |

*Source: Author's own calculation*

Ranking of states based on dimension 3 (*Table 4*) shows that Madhya Pradesh (1st), Goa (2nd), and Jammu & Kashmir (3rd) hold the top positions while Assam (19th), Chhattisgarh (20th), and Punjab (21st) are at the bottom. Moreover, a comparative analysis of performance between the states and the national average suggests that only nine states Madhya Pradesh (10.97), Goa (10.28), Jammu & Kashmir (5.51), Meghalaya (3.29), Sikkim (2.78), Kerala (1.46), Telangana (1.43), Karnataka (1.39) and West Bengal (1.38) has performed better compared to the national average (1.00). The inter-state variations in dimension 3 are presented in *Figure 4*.

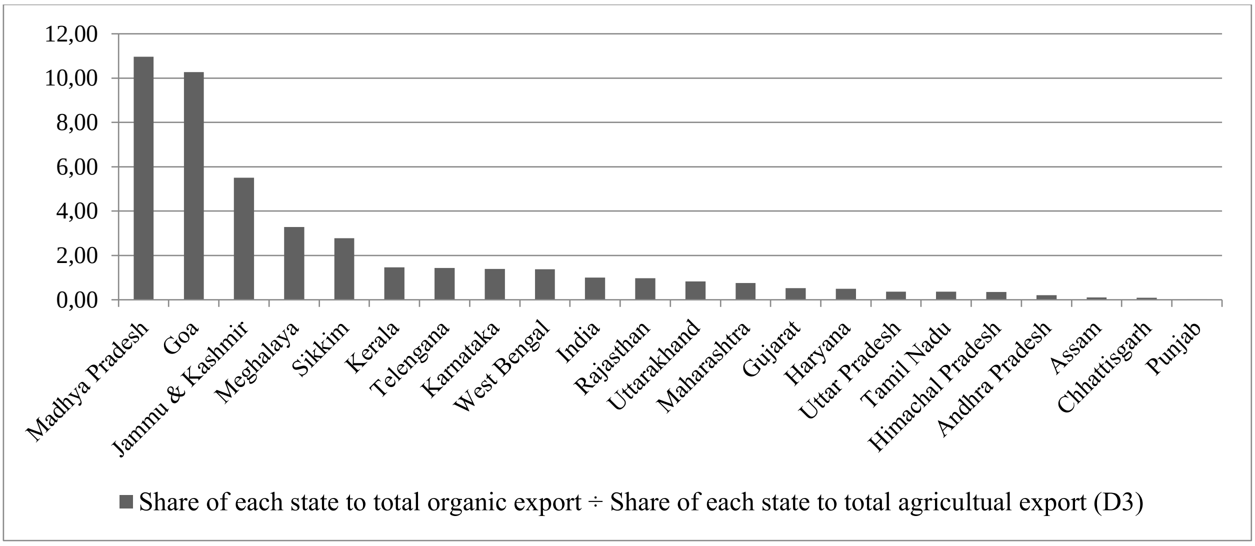



***Figure 4: Volume of organic export across states in India***

***Table 5: Ranking of states on the basis of dimension 4***

| State | Organic farmers (in thousands) | Total farmers (in thousands) | Share of each state to total organic farmers (G) | Share of each state to total cultivators (H) | $D_4$ (G ÷ H) | Rank on the basis of $D_4$ |
|---|---|---|---|---|---|---|
| Goa | 25.2 | 74 | 0.01891 | 0.00059 | 31.81436 | 1 |
| Uttarakhand | 224.25 | 869 | 0.16827 | 0.00698 | 24.10833 | 2 |
| Sikkim | 7.5 | 71 | 0.00563 | 0.00057 | 9.86864 | 3 |
| Rajasthan | 307.5 | 7996 | 0.23073 | 0.06422 | 3.59275 | 4 |
| Andhra Pradesh | 265 | 8928 | 0.19884 | 0.07171 | 2.77298 | 5 |
| Madhya Pradesh | 191.4 | 10513 | 0.14362 | 0.08444 | 1.70086 | 6 |
| Chhattisgarh | 60 | 4124 | 0.04502 | 0.03312 | 1.35921 | 7 |
| Punjab | 12.5 | 1110 | 0.00938 | 0.00892 | 1.05206 | 8 |
| Himachal Pradesh | 10.5 | 1012 | 0.00788 | 0.00813 | 0.96931 | 9 |
| Meghalaya | 2.25 | 242 | 0.00169 | 0.00194 | 0.86860 | 10 |
| Telengana | 34.5 | 6117 | 0.02589 | 0.04913 | 0.52691 | 11 |
| Assam | 11 | 2751 | 0.00825 | 0.02210 | 0.37356 | 12 |
| Maharashtra | 62.9 | 15993 | 0.04720 | 0.12845 | 0.36743 | 13 |
| Kerala | 30.95 | 7917 | 0.02322 | 0.06359 | 0.36522 | 14 |
| Karnataka | 27.25 | 9057 | 0.02045 | 0.07274 | 0.28108 | 15 |
| Tamil Nadu | 15.6 | 7868 | 0.01171 | 0.06319 | 0.18523 | 16 |
| Uttar Pradesh | 31 | 24025 | 0.02326 | 0.19296 | 0.12055 | 17 |
| Jammu & Kashmir | 1.4 | 1404 | 0.00105 | 0.01128 | 0.09316 | 18 |
| Gujarat | 5 | 5510 | 0.00375 | 0.04426 | 0.08478 | 19 |
| West Bengal | 6 | 7292 | 0.00450 | 0.05857 | 0.07687 | 20 |
| Haryana | 1 | 1632 | 0.00075 | 0.01311 | 0.05724 | 21 |
| India(Total) | 1333 | 124505 | 1.00000 | 1.00000 | 1.00000 | |

*Source: Author's own calculation*

<u>*Number of organic Farmers across the states of India (Dimension 4)*</u>: The number of organic farmers in a state is considered an individual indicator of organic farming outreach. The dimension number of producers ($D_4$) is computed (shown in *Table 5*) as a ratio of the share of the number of organic producers (G) and the share of the total number of cultivators (H) of the state. Therefore, if the share of the number of organic producers of a state (G) is higher than its share of the total number of producers (H), then the state has recorded a better performance in organic farming and vice versa.

Analysis based on dimension 4 (*Table 5*) indicates that among the states included in the study Goa (1st), Uttarakhand (2nd), and Sikkim (3rd) are the top-performing states. In addition, the share of organic farmers in Rajasthan (3.59), Andhra Pradesh (2.77), Madhya Pradesh (1.70), Chhattisgarh (1.36) and Punjab (1.05) are greater than the share of the state to total cultivators. These top eight states (i.e., Goa, Uttarakhand, Sikkim, Rajasthan, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, and Punjab) account for more than 71 percent of the country's organic farmers registered under the PKVY scheme (Khurana and Kumar, 2020). However, the rest of the states have fared poorly regarding their representation of organic farmers. The inter-state variations in dimension 4 are presented in *Figure 5*.

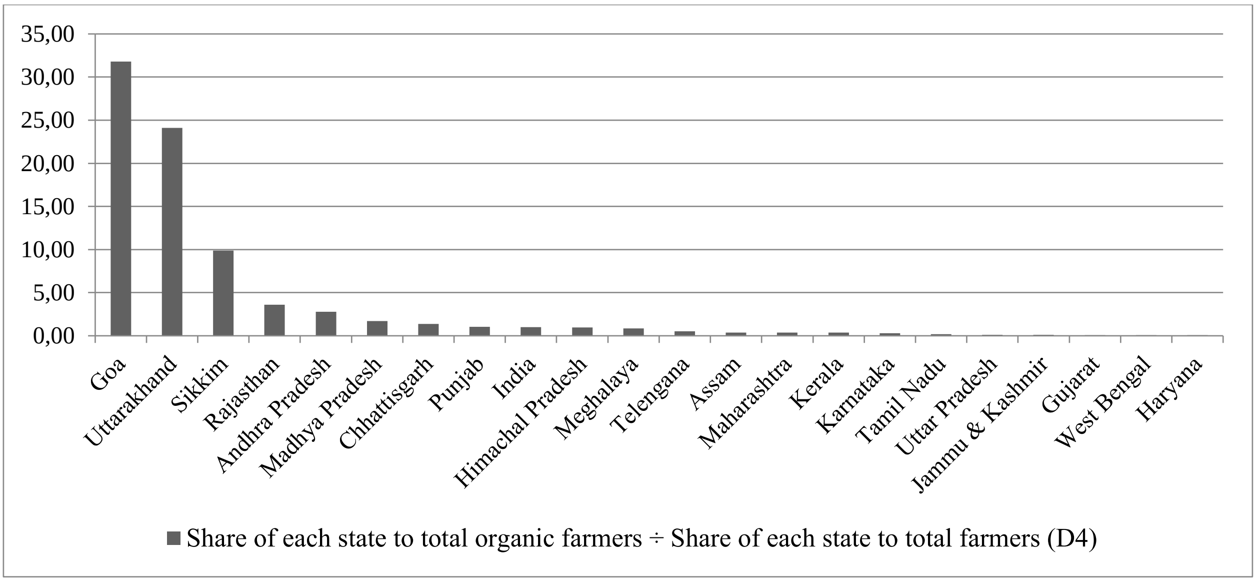



***Figure5: Population of organic producers across states in India***

### 3.2. *State of organic farming in India: Composite analysis based on organic index*

A disaggregated analysis of all four dimensions suggests that the performances of the states are not uniform in all the dimensions of organic farming. States such as Jammu & Kashmir and Kerala have performed poorly in terms of their representation of organic farmers, but the performance of these states regarding other dimensions of organic farming (i.e., volume of production and export) is found to be more than satisfactory. On the other hand, there is a stable representation of organic farmers in states like Andhra Pradesh, Chhattisgarh, and Punjab, however, the performance of these states regarding other dimensions of organic farming is found to be very poor. Similarly, Telangana, Karnataka, and West Bengal performed better in organic export, but the performance of these states regarding other dimensions of organic farming is found to be very poor. Thus a composite analysis considering all these dimensions is desirable to provide an overall picture of the state of organic farming in Indian States. To measure the inter-state variations in the practice of organic farming in a comprehensive way, the study has considered four dimensions of organic farming namely, size of the area (share of the organic area as a proportion of the share of the total sown area of the state), the volume of production (share of the volume of organic production as a proportion of the share of the total volume of agricultural production of the state), the volume of export (share of the volume of organic export as a proportion of the share of the total volume of agricultural export of the state) and the number of producers (share of the number of organic producers as a proportion of the share of the total number of producers of the state). Accordingly, the relative position of Indian states in the organic index is shown in *Table 6* and *Figure 6*.

***Table 6: Organic index across states of India***

| State | Dimension 1 ($D_1$) | Dimension 2 ($D_2$) | Dimension 3 ($D_3$) | Dimension 4 ($D_4$) | Organic Index | Rank |
|---|---|---|---|---|---|---|
| Sikkim | 59.501 | 1.910 | 2.778 | 9.869 | 21.537 | 1 |
| Goa | 5.789 | 5.888 | 10.277 | 31.814 | 10.196 | 2 |
| Madhya Pradesh | 3.566 | 5.362 | 10.966 | 1.701 | 5.917 | 3 |
| Meghalaya | 11.208 | 0.450 | 3.287 | 0.869 | 4.737 | 4 |
| Uttarakhand | 3.645 | 1.072 | 0.831 | 24.108 | 4.592 | 5 |
| Kerala | 1.250 | 10.698 | 1.464 | 0.365 | 3.849 | 6 |
| Jammu & Kashmir | 2.430 | 4.550 | 5.508 | 0.093 | 3.605 | 7 |
| Rajasthan | 0.965 | 1.355 | 0.969 | 3.593 | 1.391 | 8 |
| Maharashtra | 0.994 | 2.651 | 0.762 | 0.367 | 1.318 | 9 |
| Himachal Pradesh | 1.324 | 0.931 | 0.347 | 0.969 | 0.898 | 10 |
| Karnataka | 0.490 | 0.670 | 1.390 | 0.281 | 0.768 | 11 |
| Andhra Pradesh | 0.363 | 0.194 | 0.211 | 2.773 | 0.562 | 12 |
| Telangana | 0.127 | 0.030 | 1.431 | 0.527 | 0.513 | 13 |
| Gujarat | 0.559 | 0.554 | 0.517 | 0.085 | 0.489 | 14 |
| Assam | 0.577 | 0.820 | 0.106 | 0.374 | 0.488 | 15 |
| West Bengal | 0.074 | 0.168 | 1.380 | 0.077 | 0.466 | 16 |
| Chhattisgarh | 0.292 | 0.392 | 0.085 | 1.359 | 0.390 | 17 |
| Tamil Nadu | 0.326 | 0.188 | 0.361 | 0.185 | 0.280 | 18 |
| Uttar Pradesh | 0.224 | 0.156 | 0.368 | 0.121 | 0.233 | 19 |
| Haryana | 0.106 | 0.035 | 0.495 | 0.057 | 0.189 | 20 |
| Punjab | 0.124 | 0.004 | 0.013 | 1.052 | 0.171 | 21 |
| India | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | |

*Source: Author's own calculation*

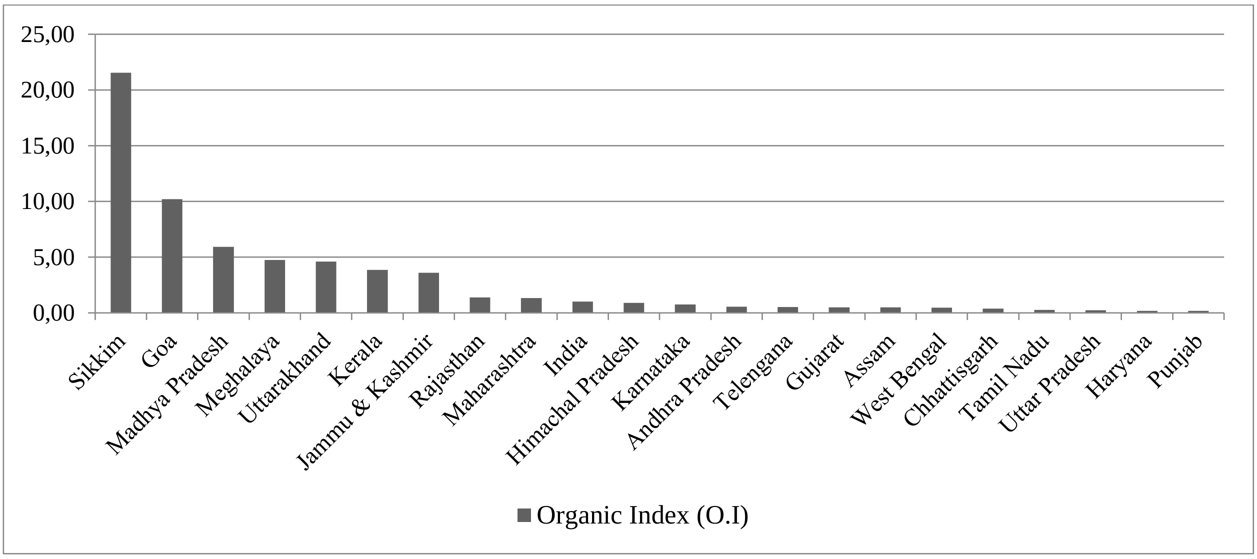



***Figure 6: Positions of states across India as per the organic index***

*Table 6* indicates that Sikkim occupies the highest ranking in the OI with a value of 21.54 and Punjab is at the bottom position with a low OI value of 0.17. Incidentally, Sikkim which holds the top position as per our analysis became the first Indian state to be declared as a fully organic state in 2016 (Yadav, 2018). Among the 21 states included in the study, only nine states (i.e., Sikkim, Goa, Madhya Pradesh, Meghalaya, Uttarakhand, Kerala, Jammu & Kashmir, Rajasthan, and Maharashtra) performed well (i.e., above the national average) in organic farming outreach. The results also highlight that the majority of states (57 percent) bear low OI values (lying between 0.171 and 0.898) and thus show poor performance concerning organic farming. These include states like Himachal Pradesh (10$^{th}$), Karnataka (11$^{th}$), Andhra Pradesh (12$^{th}$), Telangana (13$^{th}$), Gujarat (14$^{th}$), Assam ($15^{th}$), West Bengal ($16^{th}$), Chhattisgarh ($17^{th}$), Tamil Nadu ($18^{th}$), Uttar Pradesh ($19^{th}$), Haryana ($20^{th}$), and Punjab ($21^{st}$).

The results of the study mostly correspond with the observations of the geospatial digital map. For instance, states such as Sikkim, Goa, Madhya Pradesh, Meghalaya, Uttarakhand, Kerala, Jammu & Kashmir, and Maharashtra which have performed well as per our analysis are also listed as the best regions in the geospatial digital map. Moreover, our analysis shows that states such as West Bengal, Uttar Pradesh, Haryana, and Punjab which are known for their achievements in conventional agricultural practices have performed very poorly in organic farming. Similar observations were also made by the map which suggested very little potential for organic cultivation in these four states due to their intensive cultivation practices. However, there are a few cases in which the findings of our study and the observations of the geospatial digital map differ. For instance, our analysis reveals that a few states such as Himachal Pradesh, Karnataka, Assam, and Chhattisgarh, despite their rich potential for organic cultivation practices have failed to register a noteworthy performance in organic farming. This may be due to the lack of initiatives by their state governments to promote organic farming in their states. On the other hand, the state of Rajasthan despite its limited potential has performed considerably well in the different dimensions of organic farming. The success of Rajasthan can be attributed to the efforts of its state government, which undertook a separate policy on organic farming in 2017 intending to promote an inclusive development of agriculture as organic, facilitating the environment of organic farming, and most importantly, making organic farming remunerative for farmers (GoR, 2017).

## 4. Conclusions and Policy Implications

In light of growing concern over the sustainability of the existing agriculture system, the quest for an alternative farming system has begun worldwide. Consequently, organic farming has emerged as an alternative farming system because it offers solutions to the problems of the agriculture sector in terms of environmental protection, conservation of non-renewable resources, and improved food quality. The organic farming movement has also gained considerable momentum worldwide due to a significant rise in the demand for organic food because of increasing consciousness about health problems arising from chemical pesticides and fertilizers-contaminated food. From the economic perspective, organic farming is becoming increasingly attractive to farmers as it not only involves lower costs but also generates higher returns as compared to conventional farming (Delate et al., 2003; Raj et al., 2005; Bektas and Miran, 2006; Gibbon and Bolwig, 2007; Singh and Grover, 2011). In the context of India, where the agriculture sector is currently in distress with reducing profitability due to the rising cost of inputs and stagnant output price, wider adoption of organic farming is considered to be a key strategy in effectively addressing these issues (Seufert et al., 2012; Reddy, 2017). Keeping these in focus, the government of India is promoting organic farming through the introduction of various initiatives. As a result, there has been a considerable improvement in different dimensions of organic farming (i.e., the size of the organic area, the volume of organic production, the volume of organic export, and the number of organic cultivators, etc.) in India over time. Each of these dimensions is analyzed individually to evaluate the state-wise practice of organic farming. However, a dimension-wise disaggregated analysis fails to depict the overall picture of organic farming. The reason is the lack of uniformity in dimension-wise performance across Indian states (for instance, some states are performing better in some dimensions but lagging in other dimensions of organic farming). Thus, a composite analysis based on all these dimensions is desirable to provide a composite picture of the present scenario of organic farming in India. The composite index of organic farming (referred to as the organic index) shows a wide disparity in performances concerning organic farming among the states in India. An inter-state analysis revealed that only nine states (Sikkim, Goa, Madhya Pradesh, Meghalaya, Uttarakhand, Kerala, Jammu & Kashmir, Rajasthan, and Maharashtra) have recorded a better performance in organic farming than the national average. However, more importantly, the analysis points out that the performance of the majority of states is far from satisfactory. Interestingly, it is observed that the states that are known for their achievements in conventional agriculture (such as West Bengal, Uttar Pradesh, Haryana, and Punjab) performed very poorly in terms of organic agriculture. More importantly, the result shows that the states that have performed well in organic farming also have a higher level of organic carbon stock in their soil. Therefore, the findings of this paper support our hypothesis that highlights the influence of agro-climatic conditions on the country's organic cultivation practices.

The results also point out that the progress of organic farming is mainly concentrated in certain parts of the country, and the majority of the states failed to register a noteworthy performance. This is evident from the fact that only 2 percent of the country's net sown area is farmed under the organic farming system, and just 1.3 percent of the Indian farmers are registered for organic farming (Khurana and Kumar, 2020). To address this issue, public policies on organic agriculture can be designed as follows:

First, to remove the regional disparity in organic farming performances, the government may encourage a larger number of farmers (in the states that are performing poorly) to adopt organic farming. For this purpose, awareness campaigns can be organized among the farmers to highlight the importance of organic agriculture and its potential benefits. There is also a need to study the perceptions of farmers in these states regarding organic farming as it can be helpful in the effective design of these awareness initiatives and improve their understanding of this alternative mode of cultivation.

Secondly, while designing the state's agricultural policies specific emphasis can be given to organic farming. It has been seen that states adopting separate organic agriculture policies made significant strides in different dimensions of organic farming. For instance, after the adoption of an exclusive policy on organic agriculture in 2003, Sikkim became a fully organic state in 2016. Few other states like Madhya Pradesh, Meghalaya, Uttarakhand, Kerala, and Rajasthan that have done well in organic farming have also adopted separate organic farming policies. However, at the policy level, there are apprehensions about the efficacy of organic farming in feeding the country's vast population (Reddy et al., 2022). The recent Sri Lankan experience shows that an unplanned nationwide shift from conventional to organic farming resulted in a substantial reduction in crop yield and created a food crisis in the country. Therefore, the central and the state governments need to adopt a well-calibrated approach, instead of an unplanned blanket adoption of organic farming. Considering the implications of agro-climatic factors on the performance of organic agriculture, a location-specific strategy would be more effective than the nation or state-wide blanket adoption. Many have advocated for prioritizing by default, rainfed, hilly, and tribal areas where the farmers use less chemical fertilizers for the conversion toward organic farming (Ramesh et al., 2005; Reddy et al., 2022). Apart from the agro-climatic factors, it has been observed that various agro-economic factors such as cost of cultivation, yield, prices of crops, access to markets, etc. play a significant role in organic conversion decisions. Therefore, it is also necessary to evaluate the prospect of organic farming from the agro-economical perspective. In this context, state-wise farm-level studies on organic farming can be undertaken to examine the economic feasibility of this alternative mode of cultivation and identify the challenges faced by organic farmers across the country.

**Ethical Statement**

There is no need to obtain permission from the ethics committee for this study.

**Conflicts of Interest**

We declare that there is no conflict of interest between us as the article authors.

**Authorship Contribution Statement**

Concept: Koner, N., Laha, A.; Design: Laha, A., Koner, A.; Data Collection or Processing: Koner, A.; Statistical Analyses: Koner, A.; Literature Search: Koner, A.; Writing, Review and Editing: Koner, A., Laha, A.

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**Appendix**

***Figure A.1: Year-wise Progression of Organic Farming Area in India***

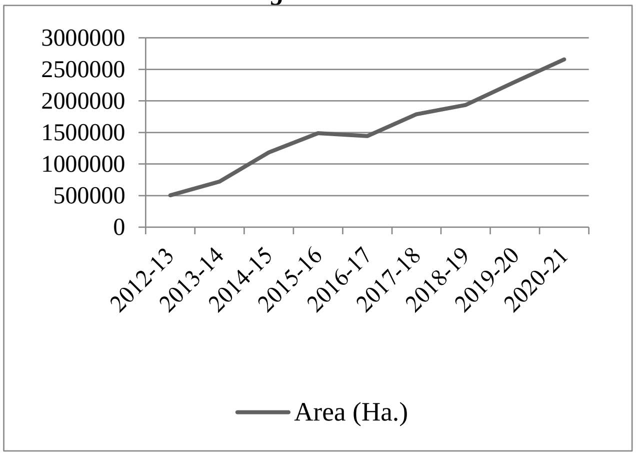



***Figure A.2: Year-wise Progression of Organic Production in India***

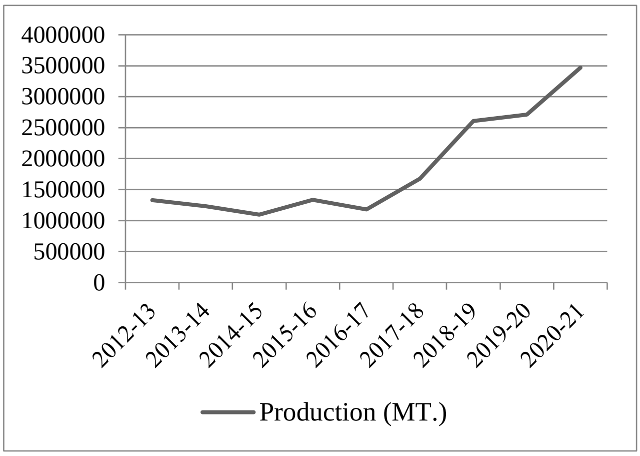



***Figure A.3: Year-wise Progression of Organic Exports in India***

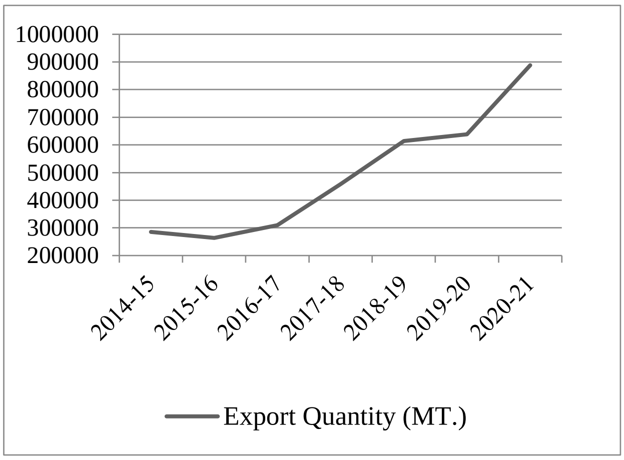
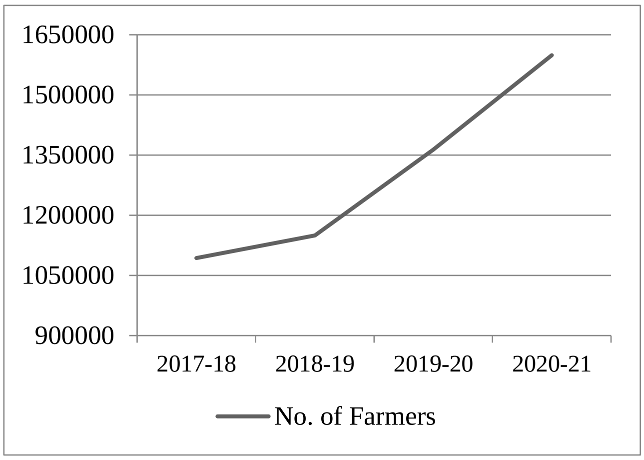



***Figure A.4: Year-wise Progression of Organic Farmers in India***




***Source: Authors own calculation based on the data published by APEDA***

***Table A.1: Result of PCA and Determination of Final Weights***

| Component | Initial Eigen Values | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | Percent of Variance | Cumulative Percent | Total | Percent of Variance | Cumulative Percent |
| $D_1$ | 1.916 | 47.89 | 47.89 | 1.916 | 47.89 | 47.89 |
| $D_2$ | 1.01 | 25.251 | 73.141 | 1.01 | 25.251 | 73.141 |
| $D_3$ | 0.686 | 17.154 | 90.294 | KMO Measure of Sample Adequacy = 0.592 | | |
| $D_4$ | 0.388 | 9.706 | 100 | $\chi^2$=11.820 (p value = 0.066) | | |

**Principal Component OI**

| Factors | Factor Loadings (A) | Factor Loadings (B) | Squared Factor Loadings (C) | Squared Factor Loadings (D) | Normalized by scaled to unity sum (E) = (C)/EV | (F) = (D)/EV | (G) = Higher of (E) or (F) | Weight H = (G) × EV/TV | Normalized by scaled to unity sum (I) = H/∑H | Final Weight (J) = (I) |
|---|---|---|---|---|---|---|---|---|---|---|
| $D_1$ | -0.039 | 0.913 | 0.001521 | 0.833569 | 0 | 0.7 | 0.7 | 0.29 | 0.32 | 0.32 |
| $D_2$ | 0.856 | -0.077 | 0.732736 | 0.005929 | 0.42 | 0 | 0.42 | 0.25 | 0.28 | 0.28 |
| $D_3$ | 0.856 | 0.209 | 0.732736 | 0.043681 | 0.42 | 0.04 | 0.42 | 0.25 | 0.28 | 0.28 |
| $D_4$ | 0.514 | 0.558 | 0.264196 | 0.311364 | 0.15 | 0.26 | 0.26 | 0.11 | 0.12 | 0.12 |
| Total | 2.19 | 1.6 | 1.73 | 1.19 | 1 | 1 | 1.8 | 0.89 | 1 | 1 |

Explained Variation (EV) = ∑Squared factor loadings
Total Variation (TV) = ∑Explained Variation 2.93

***Source: Author's own composition***