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*Research Note*

# Crop Diversification in Karnataka: An Economic Analysis§

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**Abstract**

The nature and extent of crop diversification in the Karnataka state has been analyzed by collecting secondary data for a period of 26 years from 1982-83 to 2007-08. Composite Entropy Index (CEI) and multiple linear regression analysis have been used to analyze the nature and extent of crop diversification in the state. The CEI for different crop groups has shown that almost all the crop groups have higher crop diversification index during post-WTO (1995-96 to 2007-08) than during pre-WTO (1982-83 to 1994-95) period, except for oilseeds and vegetable crops. There has been a vast increase in diversification of commercial crops after WTO. Crop diversification is influenced by a number of infrastructural and technological factors. The results have revealed that crop diversification influences production. The study has suggested that the creation of basic infrastructural facilities like sustained supply of irrigation water, markets, fertilizer availability, proper roads and transportation is an essential pre-requisite for creating enabling conditions for fostering the process of agricultural development and crop diversification, as most of these parameters are found to influence the nature and extent of crop diversification.

**Key words:** Crop diversification, Composite entropy index, Multiple linear regression, Karnataka

**JEL Classification:** Q16, Q12

## Introduction

Crop diversification is a strategy to maximize the use of land, water and other resources and for the overall agricultural development in the country. It provides the farmers with viable options to grow different crops on their land. The diversification in agriculture is also practised with a view to avoid risk and uncertainty due to climatic and biological vagaries. It minimizes the adverse effects of the current system of crop specialization and monoculture for better resource use, nutrient recycling, reduction of risks and uncertainty and better soil conditions. It also provides better economic viability with value-added products and improvement of ecology. The specific objectives of this paper were: to analyze the nature and extent of crop diversification in Karnataka, to study the factors affecting crop diversification and to assess the impact of crop diversification on agricultural production in the state.

## Methodology

For the purpose of analyzing the economics of crop diversification, Karnataka state of India was purposively selected. Data used for the study was collected from various published sources from the Directorate of Economics and Statistics (DES), Bangalore, Karnataka. Time series data pertaining to area, production, productivity of different crops, total food production, crop-wise area under irrigation,

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season-wise crops grown, area under high-yielding varieties of different crops, net cultivated area, area sown more than once, gross cropped area, annual and month-wise rainfall, source-wise irrigation, year-wise fertilizer consumption, livestock population, average size of holding, farm harvest prices and other infrastructural facilities like number of regulated markets, number of tractors, agricultural advances, road length, number of working population, proportion of rural population, per capita income, state GDP and state income, etc. were collected for the period 1982-83 to 2007-08. Time series data pertaining to area, production, productivity of vegetables and fruits crops were collected for the same period from Centre for Monitoring Indian Economy (CMIE) report. The time series data for a period of 26 years were divided into two sub-periods as pre-WTO (1982-83 to 1994-95) and post-WTO (1995-96 to 2007-08) for measuring crop diversification index for different periods.

There are quite a few methods, which explain either concentration (i.e. specialization) or diversification of crops or activities over time and space. Each method has some limitation and/or superiority over the other (Shiyani, 1998). Considering the objective of assessing the extent of crop diversification, Composite Entropy Index was used in the present analysis. To examine the nature of crop diversification within different crop groups and within all crops taken together, the Composite Entropy Index (CEI) was worked out for different crop groups such as cereals, pulses, oilseeds, commercial crops, vegetables and spices, fruits and nuts and for all crops.

$$C.E.I. = \left[\sum_{i=1}^{N} p_i \log_n^{pi}\right] \times \left\{1 - \left(\frac{1}{N}\right)\right\}$$

where, $N$ is the total number of crops and $p_i$ is the average proportion of the $i^{th}$ crop in total cropped area.

Cereals groups included rice, jowar, bajra, maize, ragi and minor millet crops. The pulses group included tur, black gram, green gram and bengal gram crops. Oilseeds group included groundnut, sesamum, sunflower and safflower crops. Commercial crops group included cotton, tobacco, chilies and sugarcane crops. Vegetables and spices group included onion, cardamom, ginger, coriander, okra and brinjal crops. Fruits and nuts group included coconut, areca nut, banana, cashew nut, papaya and chicoo crops. Total crops group included cereals, pulses, oilseeds, commercial crops, vegetables and spices, fruits and nuts crops.

Multiple regression analysis was carried out using the time series data for the period from 1982-83 to 2007-08 to identify the important factors affecting crop diversification (Joshi *et al.*, 2004; 2006; Kebebe, 2000). Linear and non-linear (log form) multiple regression functions have been attempted in the study. The one which provided god fit was considered for presentation. Also, step-wise regression analysis was estimated to single out most important determinants of crop diversification. The Composite Entropy Index (Y) was specified as a function of the following independent variables.

$$Y = a + b_1X_1 + b_2X_2 + \ldots\ldots\ldots + b_nX_n + U$$

The explanatory variables considered were:

$X_1$ = Per capita income (₹/ person),

$X_2$ = Percentage of urban population,

$X_3$ = Percentage of area under high-yielding variety (HYV) of cereals,

$X_4$ = Percentage of gross irrigated area to gross cultivated area,

$X_5$ = Annual rainfall (mm),

$X_6$ = Average size of landholding (ha),

$X_7$ = Market density (number of markets per 1,000 ha of gross cropped area),

$X_8$ = Fertilizer use (kg/ha),

$X_9$ = Roads length (square km per 1,000 ha of gross cropped area),

$X_{10}$ = Percentage of small and marginal landholders in total holdings,

$X_{11}$ = Mechanization (number of tractors per 1,000 ha of gross cropped area), and

U = Error-term.

To assess the impact of crop diversification on agricultural production a simple regression analysis was specified and estimated. Here also, both the linear and log linear regression functions were estimated. The functional form which showed significant results with expected signs and a higher $R^2$ was selected for presentation.

$$Y = a + bX + u$$

where,

Y = Total production of different crop groups (Mt),

**Table 1. Nature and extent of crop diversification in Karnataka: 1982-83 to 2007-08**

| Year | Cereals | Pulses | Oilseeds | Commercial crops* | Vegetable and spices* | Fruits and nuts* | Total crops* |
|---|---|---|---|---|---|---|---|
| 1982-83 | 0.703 | 0.709 | 0.567 | 0.480 | 0.714 | 0.559 | 0.606 |
| 1983-84 | 0.706 | 0.704 | 0.608 | 0.482 | 0.711 | 0.567 | 0.611 |
| 1984-85 | 0.688 | 0.709 | 0.640 | 0.495 | 0.710 | 0.561 | 0.609 |
| 1985-86 | 0.684 | 0.718 | 0.643 | 0.544 | 0.720 | 0.559 | 0.608 |
| 1986-87 | 0.679 | 0.721 | 0.644 | 0.628 | 0.736 | 0.563 | 0.588 |
| 1987-88 | 0.683 | 0.719 | 0.635 | 0.604 | 0.738 | 0.560 | 0.619 |
| 1988-89 | 0.705 | 0.707 | 0.620 | 0.566 | 0.697 | 0.560 | 0.633 |
| 1989-90 | 0.695 | 0.712 | 0.589 | 0.566 | 0.717 | 0.559 | 0.633 |
| 1990-91 | 0.688 | 0.714 | 0.577 | 0.577 | 0.735 | 0.533 | 0.639 |
| 1991-92 | 0.710 | 0.706 | 0.563 | 0.592 | 0.710 | 0.604 | 0.657 |
| 1992-93 | 0.694 | 0.712 | 0.556 | 0.594 | 0.705 | 0.598 | 0.653 |
| 1993-94 | 0.687 | 0.722 | 0.542 | 0.629 | 0.697 | 0.605 | 0.654 |
| 1994-95 | 0.699 | 0.709 | 0.593 | 0.605 | 0.689 | 0.610 | 0.673 |
| 1995-96 | 0.707 | 0.721 | 0.561 | 0.604 | 0.674 | 0.610 | 0.672 |
| 1996-97 | 0.707 | 0.722 | 0.562 | 0.611 | 0.649 | 0.581 | 0.664 |
| 1997-98 | 0.724 | 0.643 | 0.568 | 0.652 | 0.642 | 0.556 | 0.665 |
| 1998-99 | 0.720 | 0.722 | 0.534 | 0.624 | 0.635 | 0.566 | 0.668 |
| 1999-00 | 0.713 | 0.720 | 0.529 | 0.640 | 0.553 | 0.567 | 0.662 |
| 2000-01 | 0.730 | 0.720 | 0.536 | 0.632 | 0.549 | 0.558 | 0.664 |
| 2001-02 | 0.705 | 0.721 | 0.545 | 0.631 | 0.542 | 0.548 | 0.686 |
| 2002-03 | 0.728 | 0.722 | 0.532 | 0.664 | 0.549 | 0.544 | 0.692 |
| 2003-04 | 0.744 | 0.721 | 0.510 | 0.647 | 0.567 | 0.621 | 0.705 |
| 2004-05 | 0.740 | 0.722 | 0.525 | 0.647 | 0.516 | 0.583 | 0.697 |
| 2005-06 | 0.731 | 0.721 | 0.505 | 0.656 | 0.524 | 0.549 | 0.677 |
| 2006-07 | 0.726 | 0.719 | 0.508 | 0.648 | 0.522 | 0.583 | 0.698 |
| 2007-08 | 0.722 | 0.722 | 0.518 | 0.658 | 0.454 | 0.588 | 0.679 |
| Pre-WTO | 0.698 | 0.717 | 0.607 | 0.569 | 0.716 | 0.578 | 0.634 |
| Post-WTO | 0.729 | 0.722 | 0.544 | 0.647 | 0.572 | 0.609 | 0.683 |
| Overall | 0.722 | 0.721 | 0.644 | 0.616 | 0.649 | 0.600 | 0.661 |

*Note:* *The values are composite entropy indices for the selected crops only.

X = Composite entropy index of the respective crop group (%), and

u = Random-error

## Results and Discussion

The year-wise crop diversification indices for different crop groups in Karnataka for the period of twenty six years are given in Table 1. The value of indices increased successively implying increasing level of diversification. The decrease in the values of the index indicates towards increasing specialization. The calculated Composite Entropy Indices for different crop groups showed that almost 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 a vast increase in diversification of commercial crops after WTO. The values of the indices for cereals indicated relatively more diversification in recent years compared to the initial years. The composite entropy index for cereals during pre-WTO and post-WTO was 0.698 and 0.729, respectively. In general, the trend of CEI was almost same within the pulses group with all values lying in the range of 0.704 and 0.722.

No specific trend of diversification was noticed in the case of oilseeds and the index varied between 0.505 and 0.644 for the years 2005-06 and 1986-87, respectively. Commercial crops showed lowest CEI (0.480) for the year 1982-83 and highest index (0.658) for 2007-08. The overall diversification index for commercial crops was 0.616. It may be observed that CEI, in general, was higher in the initial years of the study and relatively less in recent years in the case of vegetables and oilseeds. No single crop group showed higher CEI in the initial years, which in turn, resulted in more diversification in recent years. The diversification towards cereals, pulses and commercial crops was noticed during recent years. It was interesting to note that cereals ranked first and pulses remained second in the overall level of crop diversification during the study period. The crop diversification index over the years for the total crops was 0.661 with least value in the year 1982-83 and highest in the year 2003-04. The post-WTO diversification index was found to be more (0.683) compared to pre-WTO (0.634).

Table 2 presents the results of double log regression analysis estimates to study the factors affecting crop diversification. The analysis revealed that the per capita income has exerted a negative influence on crop diversification in oilseeds, commercial crops, vegetables and spices crop and fruits and nuts crop groups. It produced a positive influence on crop diversification of cereals, pulses and total crops. Its positive effect on diversification was insignificant for pulses while significant for cereals and total crops. It was noticed that the negative effect of per capita income on diversification was significant in all the cases except for fruits and nuts crops.

The proportion of urban population showed a significant negative impact on fruits and nuts diversification and insignificant positive impact on oilseeds and vegetables and spices crop groups. There was an insignificant negative relationship between urbanization and diversification of cereals, pulses and commercial crops. The regression coefficient for proportion of area under HYV of cereals was negative in oilseeds, fruits and nuts and total crops and the coefficient was significant for oilseeds category. The influence was insignificant positive in the case of cereals, pulses, commercial crops and vegetables and spices. The coefficient of determination for cereals function was 0.778 and the coefficient was significant at one per cent level.

The proportion of gross irrigated area to gross cultivated area exerted a positive impact on diversification for all crop groups, except for cereals. This effect was significant at 10 per cent for oilseeds. Though insignificant, the proportion favoured diversification in all the crop categories, except in cereals. Insignificant positive impact of annual rainfall on the diversification of cereals, oilseeds and commercial crop was noticed. Rainfall showed a negative effect on diversification of pulses, vegetables and spices, fruits and nuts and total crops. The impact of rainfall on diversification was insignificant for all crop categories. It was observed that the effect of average size of holding on crop diversification was mixed. It showed an insignificant positive effect on diversification of crop categories like pulses, oilseeds and fruits, while insignificant negative effect on cereals, commercial crop, vegetables and spices and total crops taken together. Fertilizer consumption has dampening effect on diversification of all crop categories barring insignificant positive impact on diversification of oilseeds. The negative impact on fruits and nuts was significant at 10 per cent.

The number of regulated markets exhibited a mixed influence on diversification. While it enhanced the diversification of cereals and total crops taken together, it depressed the diversification of pulses, oilseeds, commercial crops, vegetables and spices and fruits and nuts. The negative impact observed in the diversification of oilseeds was highly significant. Road length exerted an insignificant negative influence on diversification of cereals, pulses, oilseeds and total crops and an insignificant positive effect on diversification of commercial crop, vegetable and spices crop and fruit and nuts crop groups. Proportion of marginal and smallholders in total holdings had a significant (at 10%) dampening effect on diversification of pulses and total

**Table 2. Estimated regression function for the determinants of crop diversification**

| Factors | Cereals | Pulses | Oilseeds | Commercial crops | Vegetable and spices | Fruits and nuts | Total crops |
|---|---|---|---|---|---|---|---|
| Constant | 1.2802 | 3.8161 | 3.4433 | 2.7447 | 4.1401 | 7.181 | 4.279 |
| $X_1$ | 0.2297*** | 0.0901 | -0.7502* | -0.6707** | -0.8219* | -0.1222 | 0.0360 |
| | (0.1145) | (0.1649) | (0.1911) | (0.3087) | (0.2708) | (0.2341) | (0.1072) |
| $X_2$ | -0.0425 | -0.4237 | 0.0815 | -0.3174 | 0.0621 | -2.0841* | -0.598*** |
| | (0.3279) | (0.4724) | (0.5472) | (0.8842) | (0.7756) | (0.6703) | (0.3070) |
| $X_3$ | 0.0552 | 0.00272 | -0.262*** | 0.2911 | 0.0985 | -0.1143 | -0.0602 |
| | (0.0826) | (0.1191) | (0.1379) | (0.2229) | (0.1955) | (0.1690) | (0.0774) |
| $X_4$ | -0.1207 | 0.00914 | 0.3162** | 0.2180 | 0.1442 | 0.1251 | 0.0846 |
| | (0.0855) | (0.1231) | (0.1426) | (0.2305) | (0.2022) | (0.1747) | (0.0800) |
| $X_5$ | 0.0627 | -0.2490 | 0.1287 | 0.1549 | -0.2846 | -0.3259 | -0.1358 |
| | (0.1253) | (0.1806) | (0.2092) | (0.3380) | (0.2965) | (0.2563) | (0.1174) |
| $X_6$ | -0.0638 | 0.2413 | 0.2799 | -0.4070 | -0.2660 | 0.0731 | -0.0581 |
| | (0.1188) | (0.1711) | (0.1983) | (0.3204) | (0.2810) | (0.2429) | (0.1112) |
| $X_7$ | 0.2381 | -0.2988 | -0.8351* | -0.6254 | -0.3176 | -0.2895 | 0.2176 |
| | (0.1643) | (0.2367) | (0.2742) | (0.4430) | (0.3886) | (0.3359) | (0.1538) |
| $X_8$ | -0.0158 | -0.0719 | 0.0832 | -0.0165 | -0.1060 | -0.1755*** | -0.0342 |
| | (0.0421) | (0.0607) | (0.0703) | (0.1136) | (0.0997) | (0.0861) | (0.0394) |
| $X_9$ | -0.0573 | -0.1467 | -0.1094 | 0.0211 | 0.1628 | 0.0597 | -0.0181 |
| | (0.0725) | (0.1044) | (0.1210) | (0.1955) | (0.1715) | (0.1482) | (0.0678) |
| $X_{10}$ | 0.0571 | -0.624** | -0.4590 | 0.1400 | 0.6141 | -0.2003 | -0.394*** |
| | (0.2296) | (0.3308) | (0.3832) | (0.6192) | (0.5432) | (0.4694) | (0.2150) |
| $X_{11}$ | -0.0959 | 0.1406 | 0.4698* | 0.2984 | 0.0915 | 0.1550 | 0.0157 |
| | (0.0838) | (0.1207) | (0.1399) | (0.2260) | (0.1983) | (0.1714) | (0.0785) |
| $R^2$ | 0.7786 | 0.4098 | 0.929 | 0.877 | 0.959 | 0.619 | 0.948 |
| F-value | 4.4777* | 0.8837 | 16.76* | 9.081* | 30.43* | 2.072*** | 23.22* |

*Notes:* Figures within the parentheses are standard errors

* **, ** and * denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively

crops taken together. Though insignificant, the proportion of marginal and smallholders favoured diversification in cereals, commercial crops and vegetables and spices. The number of tractors had affected diversification negatively among cereals which was insignificant. It had a positive effect on diversification of other crop categories (pulses, oilseeds, commercial crops, vegetables and spices, fruits and nuts and total crops). Its positive effect on diversification of oilseeds was highly significant.

The most important factors affecting crop diversification were identified by using step-wise regression analysis (Table 3). A significant negative impact of per capita income on diversification of vegetables and spices was noticed. A per unit change

**Table 3. Step-wise regression function for the determinants of crop diversification**

| Factors | Cereals | Oilseeds | Commercial crops | Vegetables and spices | Fruits and nuts | Total crops |
|---|---|---|---|---|---|---|
| Constant | 1.891 | 1.618 | 1.202 | 5.335 | 5.449 | 2.183 |
| $X_1$ | - | - | - | -0.474* (0.027) | - | - |
| $X_2$ | - | - | - | - | -2.012* (0.450) | - |
| $X_3$ | - | - | 0.401* (0.042) | - | - | - |
| $X_4$ | - | - | - | - | 0.236* (0.107) | - |
| $X_5$ | - | - | - | -0.501* (0.120) | - | - |
| $X_6$ | -0.125* (0.091) | 0.403* (0.044) | - | - | - | -0.121** (0.045) |
| $X_7$ | - | - | - | - | - | 0.226* (0.058) |
| $X_8$ | - | - | - | - | -0.163* (0.051) | - |
| $R^2$ | 0.632 | 0.775 | 0.786 | 0.940 | 0.535 | 0.917 |
| F-value | 43.94* | 82.465* | 92.97* | 180.46* | 8.44* | 126.69* |

*Notes:* Figures within the parentheses are standard errors
* **, ** and * denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively

in per capita income would lead to a decrease in diversification of vegetables crop by 0.47 unit. Similarly, urbanization also exerted a significant negative impact on fruit crop diversification. Diversification of commercial crops was found to be significantly affected by proportion of area under high-yielding varieties. The proportion of gross irrigated area to gross cropped area exerted significant positive impact on diversification of fruits and nuts. Thus, one unit change in rainfall would lead to decrease in diversification of vegetables by 0.5 unit. Average size of holding showed different results for different crop groups. It showed negative relation with cereals and total crop diversification while significant positive relation with diversification of oilseeds. The study revealed significant declining effect of fertilizer consumption on diversification of fruits and nuts.

To study the impact of crop diversification on agricultural production, regression estimates were made and are presented in Table 4. The coefficient of crop diversification on cereals crop production was positive and significant (0.46). It would be possible to say that one unit increase in Composite Entropy Index of cereals leads to increase in production of cereals by 0.46 unit. The coefficient of determination ($R^2$) was 28.8 per cent. There was a direct relationship between crop diversification of pulses and its linear form on its production. The coefficient was estimated to be 0.103. The impact of diversification on oilseed production was found to be insignificant. Table 4 depicts that the double log functional form of equation showed a significant positive impact of crop diversification on production of commercial crops. The direct relationship between diversification and production of pulses was noticed as the coefficient estimated was 2.29 (significant at 1%). Significant negative impact of crop diversification on vegetable and spices production was observed. The impact of vegetables crop diversification on its

**Table 4. Impact of crop diversification on production**

| Crop groups | Functional form | Constant | CEI | $R^2$ | F-value |
|---|---|---|---|---|---|
| Cereals | Linear form | -25.287 | 0.4613* (0.1479) | 0.288 | 9.726* |
| Pulses | Linear form | -6.465 | 0.1033*** (0.0571) | 0.1199 | 3.269*** |
| Oilseeds | Linear form | 2.432 | -0.0206 (0.0146) | 0.0768 | 1.998 |
| Commercial crop | Double log form | -2.714 | 2.291* (0.619) | 0.363 | 13.69* |
| Vegetables and spices | Double log form | 2.9773 | -1.649* (0.4027) | 0.411 | 16.77* |
| Fruits and nuts | Linear form | -9.128 | 0.2046* (0.0626) | 0.3076 | 10.66* |
| Total crops | Double log form | -5.710 | 4.0037* (0.8748) | 0.460 | 20.942* |

*Notes:* Figures within the parentheses are standard errors
* **, ** and * denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively

production showed a decline of 1.64 units in production for one unit change in diversification. The linear form of regression equation explained a better relationship showing a significant positive impact of crop diversification on production of fruits and nuts with $R^2$ value of 30.76 per cent. The crop diversification registered a significant positive impact on production of total crops with 46 per cent of $R^2$ value. The low $R^2$ value implied that there are other factors which influence production. The aim here was only to assess the impact of diversification on production which in many cases showed a positive impact on production of crops.

## Conclusions

The nature and extent of crop diversification have been analyzed by using composite entropy index and the results have shown that except for oilseeds and vegetables, all other crop categories had higher diversification in post-WTO period than pre-WTO period. Cereals have ranked first and pulses have remained second in the overall crop diversification during the study period.

Multiple linear regression and step-wise regression have been used to identify the factors responsible for changes in crop diversification. The results have revealed that the major factors responsible for the changes in crop diversification are per capita income, proportion of urban population, proportion of area under HYV of cereals, proportion of gross irrigated area to gross cropped area, rainfall, average size of holding, market density and fertilizer consumption.

Simple linear regression has been employed to know the influence of crop diversification on production of crops. The results have revealed that the composite entropy indices for cereals, commercial crops, vegetables and spices, fruits and nuts and total crops influence production of their respective crop, while there is no influence of crop diversification on the production of pulses and oilseeds.

The creation of basic infrastructural facilities like sustained supply of irrigation water, markets, fertilizer availability, proper roads and transportation is an essential pre-requisite for creating enabling conditions for fostering the process of agricultural development and crop diversification as most of these parameters are found to influence the nature and extent of crop diversification.

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