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Dahima SR
Ph.D Scholar, Department of Agril. Economics, CP College of Agriculture, SDAU, Sardarkrushinagar, Gujarat, India

Thakar KP
Professor and Head, Department of Agril. Economics, CP College of Agriculture, SDAU, Sardarkrushinagar, Gujarat, India

Umang B Patel
Ph.D, Scholar, Department of Agril. Economics, N M College of Agriculture, NAU, Navsari, Gujarat, India

Corresponding Author:
Dahima SR
Ph.D Scholar, Department of Agril. Economics, CP College of Agriculture, SDAU, Sardarkrushinagar, Gujarat, India

Crop diversification on different crop among the different region of Gujarat

Dahima SR, Thakar KP and Umang B Patel

Abstract
Crop diversification in Gujarat plays a vital role in ensuring agricultural sustainability, economic growth, and food security. It enables farmers to adapt to changing market demands and environmental conditions. The cultivation of diverse crops contributes to the overall development of the region. The present study takes into consideration area, production and productivity of major food grain and non-food grain crops of Gujarat State and thus 12 major crops were selected. The overall period of study between 1982-83 to 2017-18 (over 36 years) divided into period I (pre-WTO 1982-83 to 1994-95) and period II (post-WTO 1995-96 to 2017-18). Economic analysis among four regions of state (North, Saurashtra, Central, and South Gujarat) was done in respect of compound growth rates of principle crops in cereals, pulses, oilseeds and commercial crops. The revealed that, the overall the state, the considerable slightly diversification was noticed in all group of crops (0.64 to 0.66%). In generally Gujarat indicated that the farmers have attentive their area to most remunerative crops in particular crop group.

Keywords: Crop diversification, Gujarat

Introduction
Agriculture can also be a source of growth for the national economy, provides investment opportunities for the private sector, a prime regulator of agriculture-related industries and the rural non-farm economy. Sixty-seven percentage of the world's agricultural value added is created by developing countries. In agriculture-based countries, it also generates around 29 per cent of the gross domestic product (GDP) and also employs 65 per cent of the labour force. The industries and services related to agriculture in value chains often responsible for more than 30 per cent of GDP in transforming and developed countries.

Gujarat is the important state of India as far as its share to the agriculture development of the country is concerned. It is also one of the progressive states in the country but it has been claimed to be a deficit state for very long when one considers the main pursuit of economic activity which is agriculture. The soil, rainfall, topography and climate in Gujarat are in general not so conductive to agriculture, resulting in relatively low in yields of crops in the state as compared with others in India. This can be attributed to many various reasons, the major one being the lack of natural funding necessary for prosperous agriculture. However, since the state came in to being in 1960-61, there has been significant investment in agriculture in the form of increasing availability of fertilizers, irrigation resources and development of high yielding varieties.

Agricultural crop yield growth with efficient use of the inputs can only help in exploiting agricultural potential of Gujarat state as guided by the output sources of growth. Crop diversification can give insight into chances for commercialization of agriculture by raising income levels of the farming community and also promotes social welfare. So, the present study investigation on the crop diversification in different crop among the different region of Gujarat.

Methodology
Study Area: Present study entire Gujarat state was selected along with four regions (i.e., North Gujarat, Middle Gujarat, South Gujarat, Saurashtra regions) of state

Period of study: The time period was divided as under:

Pre WTO	(Period I)	1981-82 to 1994-95
Post WTO	(Period II)	1995-96 to 2017-18
Entire period	(Overall)	1981-82 to 2017-18

The overall period 1981-82 to 2017-18 was considered to understand the overall performance of agriculture over the long period of 36 years.

Crops covered

The state has diversified crop pattern in different regions depending upon agro- climatic conditions and hence the important principal crops in cereals *viz*., wheat, pearl millet, paddy, maize, in pulses *viz.*, gram, green gram and black gram, in oilseeds *viz.*, groundnut, castor, soybean and commercial (cash) crops *viz.*, cotton and sugarcane were selected for the present study.

Selected crops based on highest triennium average area for the study (2015-16 to 2017-18)

Cereals	Pulses	Oilseeds	Cash crops
Rice	Green gram	Groundnut	Sugarcane
Wheat	Black gram	Castor	Cotton
Pearl millet	Gram	Soybean	
Maize			

Nature of data and their sources

Secondary time series data were used for analysis in the present investigation to fulfill the objectives. The data was collected from secondary sources *i.e.,* different published records of the state government, cooperative and private institutions etc.,

Crop diversification

Following two measures of crop diversification were used in this empirical analysis HI and MEI formula is refer from research article of Shinde *et al*, (2013) [9] for studies region wise changes in crop pattern and levels of the crop diversification of different crops in Vidarbha region of Maharashtra.

Herfindahl index

$$\text{Herfindahl index} = \sum_{i=1}^{N} P_i^2$$

Where

N =Total number of crops

Pi = Acreage proportion of the i^{th} crop in total cropped area

With the increase in diversification the Herfindahl index decreases. This index takes a value one when there is complete specialization and approaches zero as N gets large i.e., if the diversification is perfect. Thus the Herfindahl index is bounded by zero and one. It is a measure of concentration.

(ii) Modified Entropy index

Entropy index is regarded as inverse measure of concentration having logarithmic character. The index would increase with the increase in diversification and approaches zero when there is perfect concentration i.e. when Pi equals one. The upper bound of index is log N.

Modified Entropy index (MEI) using variable base of logarithm, instead of fixed based logarithm overcomes the limitations of entropy index. The MEI, however is equal to El/log N. It is worth mentioning that, the base of logarithm is shifted to 'N' numbers of crops. This index has a lower limit equal to 'zero' when there is complete concentration and it assumes upper limit of 'one' in the case of perfect dispersion i.e., bounded by zero and one.

$$\text{Modified Entropy index} = \sum_{i=1}^{N} P_i Log\left(1/P_i\right)$$

Results and Discussion

The region wise and period wise results of these indices are postpended and discussed in subsequent paragraphs.

North Gujarat region

The results of the diversification indices for North Gujarat region during different time periods are presented in Table 1.

The crop pattern of the North Gujarat region has historically revolved around pearl millet, groundnut, and horticulture crops. The region experienced a slight diversification in its crop pattern during the period 2015-17 compared to 1985-87, as indicated by the Herfindahl Index values of 0.62 and 0.66, respectively.

Among the various crop groups, the magnitude of Herfindahl Index for all crops in pre-WTO period 1985-87 was observed as 0.62 which was increased to 0.66 in 1995-97 and slightly decreased to 0.65 in 2015-17. In cereals in 1985-87 HI was observed as 0.62 which increased to 0.66 in 1995-97 and slightly increased to 0.67 in 2015-17. Among major cereals, in rice crop during 1985-87 HI was observed as 0.51 which decreased in 1995-97 (0.15) and slightly increased in 2015-17 (0.20). In pearl millet in 1985-87 HI was observed 0.24 which decreased in 1995-97 (0.14) and also decreased to 0.13 in 2015-17. in maize crop in 1985-87 HI was observed 0.43 which highly decreased to 0.16 in 1995-97 and also decreased in 2015-17 (0.06). in wheat crop in 1985-87 HI was observed as 0.94 which decreased to 0.57 in 1995-97 and also decreased in 2015-17 (0.40). In pulses in 1985-87 HI was observed as 0.58 which increased to 0.65 in 1995-97 and slightly decreased to 0.64 in 2015-17. Among major pulse in gram crop in 1985-87 HI was observed as 0.80 which decreased to 0.77 in 1995-97 and increased to 0.86 in 2015-17. In black gram crop in 1985-87 HI was observed as 0.91 which decreased to 0.85 in 1995-97 and increased to 0.96 in 2015-17. In green gram crop in 1985-87 HI was observed as 0.45 which increased to 0.79 in 1995-97 and also increased to 0.89 in 2015-17. In oilseeds in 1985-87 HI was observed as 0.64 which increased to 0.65 in 1995-97 and slightly increased to 0.66 in 2015-17. Among major oilseeds in groundnut crop in 1985-87 HI was observed 0.59 which increased to 0.85 in 1995-97 and slightly decreased to 0.83 in 2015-17. In castor crop in 1985-87 HI was observed as 0.86 which increased to 0.90 in 1995-97 and slightly decreased to 0.88 in 2015-17. In soyabean crop HI was observed as 0.69 in 2015-17. In commercial crops in 1985-87 HI was observed as 0.62 which increased to 0.66 in 1995-97 and slightly decreased to 0.65 in 2015-17. Among major commercial crop in cotton HI was observed as 0.88 which increased to 0.91 in 1995-97 and also increased to 0.92 in 2015-17. In sugarcane crop HI was observed as 0.93 in 1985-87 which decreased to 0.90 in 1995-97 and increased to 0.91 in 2015-17. In horticulture crops harfindahl index for 2015-17 was observed 0.66.

Herfindahl index for cereals was only 0.62 and showed smallest variations and in pulses it increased from 0.58 in 1985-87 to 0.64 during 2015-17. This has happened in the group, because more and more land was brought under Pearl millet, spices, horticulture crops and groundnut cultivation during latter periods. The perfect diversification was noticed

for pulses during both periods under study.

Modified Entropy Index (M.E.I.) imparts uniformity and fixity to the scale used as norm to examine the extent of diversification. 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. The values of MEI for all crops were observed as 0.93 in the year 1985-87 which increased up to 0.98 in year 2015-17 that indicated specialization has taken place in case of all crops. The values of MEI for cereals were observed as 0.93 in the year 1985-87 which increased up to 0.98 in the year 2015-17 indicating that specialization has taken place in case of all crops. The values of MEI for rice crop was observed as 0.42 which increased to 0.66 in the year 1995-97 and highly decreased to 0.10 in the year 2015-17. In pearl millet crop MEI was observed as 0.87 in the year 1985-87 which decreased to 0.72 in the year 2015-17. The values of MEI for maize crop was observed as 0.85 in the year 1985-87 which decreased to 0.55 in the year 2015-17. In wheat crop MEI was observed as 0.26 in the year 1985-87 which slightly increased to 0.27 in the year 1995-97 and decreased to 0.23 in the year 2015-17.

Table 1: Crop diversification indices in North Gujarat region

Crop	Pre-WTO 1985-87	Post-WTO 1995-97	Post-WTO 2015-17
Harfindahl Index (1-HI)			
All crops	0.625	0.666	0.657
Rice	0.510	0.151	0.206
Pearl millet	0.245	0.140	0.135
Maize	0.43	0.161	0.064
Wheat	0.94	0.571	0.403
Cereals	0.623	0.666	0.676
Gram	0.803	0.772	0.863
Black gram	0.916	0.856	0.963
Green gram	0.458	0.794	0.899
Pulses	0.583	0.656	0.642
Groundnut	0.595	0.853	0.832
Castor	0.861	0.903	0.889
Soybean	NA	NA	0.695
Oilseeds	0.644	0.659	0.666
Commercial crops	0.620	0.665	0.654
Cotton	0.887	0.913	0.921
Sugarcane	0.938	0.902	0.917
Horticulture	NA	NA	0.665
Modified Entropy Index [Pi * (Log N (1/Pi)			
All crops	0.937	0.999	0.981
Rice	0.425	0.662	0.104
Pearl millet	0.875	0.767	0.723
Maize	0.859	0.809	0.559
Wheat	0.260	0.277	0.232
Cereals	0.933	0.999	0.989
Gram	0.594	0.857	0.987
Black gram	0.762	0.621	0.869
Green gram	0.591	0.865	0.757
Pulses	0.861	0.989	0.965
Groundnut	0.989	0.911	0.872
Castor	0.928	0.882	0.863
Soybean	NA	NA	0.972
Oilseeds	0.967	0.976	0.999
Cotton	0.799	0.807	0.889
Sugarcane	0.982	0.963	0.959
Commercial crops	0.930	0.988	0.996
Horticulture	NA	NA	0.986

The values of MEI for pulses was observed as 0.86 in the year 1985-87 which increased up to 0.96 in year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for gram crop was observed as 0.59 in the year 1985-87 which increased up to 0.98 in the year 2015-17. In black gram crop MEI was observed as 0.762 in the year 1985-87 which decreased to 0.62 in the year 1995-97 and increased to 0.86 in the year 2015-17. The value of MEI for green gram crop was observed 0.59 in the year 1985-87 which increased to 0.86 in the year 1995-97 and decreased to 0.75 in the year 2015-17. The values of MEI for oilseeds were observed as 0.96 in the year 1985-87 which increased up to 0.99 in year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for groundnut was observed as 0.98 in the year 1985-87 which decreased to 0.87 in the year 2015-17. The values of MEI for castor was observed as 0.92 in the year 1985-87 which was decreased to 0.86 in the year 2015-17. In soybean crop the value of MEI was observed as 0.97 in the year 2015-17. The values of MEI for commercial crop were observed as 0.93 in the year 1985-87 which increased up to 0.99 in year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for cotton was observed as 0.79 in the year 1985-87 which increased up to 0.88 in year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for sugarcane was observed as 0.98 in the year 1985-87 which decreased up to 0.95 in year 2015-17 indicated that specialization has taken place in case of all crops.

Saurashtra region

The results of the diversification indices for Saurashtra region during different time periods are presented in Table 2.

Among the various crop groups, the magnitude of Herfindahl Index for all crops in Saurashtra region for pre-WTO period (1985-87) was recorded as 0.65, which remain almost same in the year 1995-97 (0.65) and slightly increased in the year 2015-17 (0.66). For cereals diversification indices was observed as 0.66 in the year 1985-87 and was slightly decreased in the year 2015-17 (0.65). Among cereal crops magnitude of Herfindahl Index for rice crop decreased from 0.73 in the year 1985-87 to 0.23 in the year 2015-17. In pearl millet in 1985-87 HI was observed as 0.32 which decreased to 0.31 in the year 1995-97 and increased to 0.34 in the year 2015-17. In maize crop HI was recorded as 0.64 in the year 1985-87 and highly decreased to 0.15 in the year 2015-17. In wheat crop Herfindahl Index was observed as 0.72 in the year 1985-87 and decreased to 0.66 in the year 1995-97 and increased in the year 2015-17 (0.81). In pulses during 1985-87 Herfindahl index was observed as 0.64, was slightly increased to 0.65 in the year 1995-97 and decreased to 0.61 in the year 2015-17. Among group of pulses, in gram crop Herfindahl Index was observed as 0.72 in the year 1985-87, was increased to 0.78 in the year 1995-97 and highly decreased to 0.62 in the year 2015-17. In black gram HI was recorded as 0.71 in the year 1985-87 and increased to 0.87 in the year 1995-97 and again decreased to 0.74 in the year 2015-17. For green gram HI was observed as 0.66 in the year 1985-87, and increased over a period and recorded to 0.88 in the year 1995-97. In oilseeds Hefindahl index was slightly increased over period from 0.65 to 0.67 during 1985-97 and 2015-17, respectively. In groundnut HI was recorded as 0.92 in the year 1985-87 and increased to 0.99 in the year 1995-97 and decreased to 0.89 in the year 2015-17. In castor crop HI was decreased from 0.91 to 0.90 in the year 1985-87 and 2015-17, respectively. In soybean crop HI was recorded as 0.89 in the year 2015-17. For commercial crop the index was

observed increasing from 0.63 to 0.65 in the year 1985-87 to 2015-17, respectively. Among commercial crop in cotton crop HI was increased from 0.98 in the year 1985-87 to 0.92 in the year 2015-17. For sugarcane crop HI was also increased over a period and recorded 0.86 in the year 1985-87 to 0.89 in the year 1995-97 and 0.90 in the year 2015-17. Herfindahl index for horticultural crop was observed 0.66 during 2015-17.

The value of Modified Entropy Index (M.E.I.) for all crops in Saurashtra region was 0.97 in the year 1985-87 which increased to 0.99 in the year 2015-17. The values of MEI for cereal crops was observed as 0.99 in the year 1985-87 which decreased up to 0.97 in year the 2015-17. In rice crop MEI was recorded as 0.55 in the year 1985-87 was increased up to 0.82 in the year 1995-97 and decreased to 0.71 in the year 2015-17. The value of MEI in pearl millet crop was decreased from 0.83 to 0.69 in the year 1985-87 to 2015-17, respectively. For maize crop MEI was increased from 0.44 in the year 1985-87 to 0.73 in the year 2015-17. In wheat crop MEI was observed as 0.47 in the year 1985-87 and increased up to 0.67 in the year 1995-97 and was decreased to 0.38 in the year 2015-17. The values of MEI for pulses were observed as 0.97 in the year 1985-87 which decreased to 0.92 in the year 2015-17. In maize crop MEI was observed as 0.44 in the year 1985-87 and increased to 0.72 in the year 2015-17. The value of MEI in black gram crop was increased over period from 0.55 to 0.89 in the year 1985-87 to 2015-17, respectively. In green gram MEI was recorded 0.62 in the year 1985-87, and increased to 0.79 in 1995-97 and was decreased some extent to 0.78 in 2015-17. The value of MEI in oilseeds was increased over a period from 0.97 to 0.99 in the year 1985-87 to 2015-17, respectively. In groundnut crop MEI was decreased from 0.97 in the year 1985-87 to 0.80 in the year 2015-17. In castor crop the value of MEI was increased from 0.85 to 0.89 in the year 1985-87 to 2015-17, respectively. The value of MEI was observed as 0.88 in soybean crop in the year 2015-17. In commercial crops the MDI was increased from 0.95 to 0.98 in the year 1985-87 to 2015-17, respectively. In cotton crop MEI was observed 0.83 in the year 1885-87 and increased in the year 2015-17 to 0.86. For sugarcane crop the MEI value was observed 0.80 in the year 1885-87 and increased to 0.89 in the year 2015-17. For horticultural crops the MEI value was recorded 0.99 in the year 2015-17.

Table 2: Crop diversification indices in Saurashtra region

Crop	Pre-WTO 1985-87	Post-WTO 1995-97	Post-WTO 2015-17
Harfindahl Index (1-HI)			
All crops	0.652	0.656	0.660
Rice	0.735	0.609	0.234
Pearl millet	0.325	0.315	0.347
Maize	0.645	0.467	0.150
Wheat	0.724	0.661	0.813
Cereals	0.662	0.665	0.655
Gram	0.742	0.786	0.627
Black gram	0.710	0.872	0.749
Green gram	0.665	0.727	0.884
Pulses	0.647	0.658	0.618
Groundnut	0.920	0.993	0.894
Castor	0.919	0.892	0.902
Soybean	NA	NA	0.897
Oilseeds	0.651	0.666	0.676
Cotton	0.982	0.937	0.921
Sugarcane	0.862	0.892	0.904
Commercial crops	0.638	0.646	0.651
Horticulture	NA	NA	0.665
Modified Entropy Index [Pi * (Log N (1/Pi)			
All crops	0.979	0.982	0.991
Rice	0.557	0.827	0.716
Pearl millet	0.839	0.602	0.698
Maize	0.448	0.641	0.734
Wheat	0.470	0.676	0.389
Cereals	0.993	0.989	0.978
Gram	0.594	0.761	0.729
Black gram	0.553	0.791	0.891
Green gram	0.621	0.797	0.782
Pulses	0.971	0.988	0.926
Groundnut	0.977	0.818	0.802
Castor	0.857	0.843	0.891
Soybean	NA	NA	0.889
Oilseeds	0.975	0.993	0.999
Cotton	0.833	0.867	0.867
Sugarcane	0.806	0.847	0.891
Commercial crops	0.957	0.978	0.980
Horticulture	NA	NA	0.998

Central Gujarat region

Crop diversification indices in Central Gujarat region presented in table 3. From table it can be observed that the magnitude of Herfindahl Index for all crops in pre-WTO period 1985-87 was observed 0.66 which slightly increased to 0.67 in the year 2015-17. In rice crop HI was decreased from 0.29 to 0.23 in the year 1985-87 to 2015-17, respectively. For pearl millet crop HI was highly decreased from 0.78 in the year 1985-87 to 0.23 in the year 2015-17. In maize crop HI was observed as 0.27 in the year 1985-87 and highly decreased to 0.07 in the year 2015-17. In wheat crop HI was recorded as 0.22 in the year 1985-87 and increased to 0.54 in the year 1995-97 and then decreased to 0.32 in the year 2015-17. For group of pulses the Herfindahl Index was observed as 0.66 in the year 1985-87 and slightly decreased over study period and recorded as 0.65 in the year 2015-17. Among pulses, gram crop showed increased magnitude of Herfindahl Index from 0.59 in the year1985-87 to 0.71 in the year 2015-17. For black gram HI was also increased from 0.50 to 0.70 in the year 1985-87 to 2015-17, respectively. In green gram crop HI was slightly decreased from 0.88 to 0.87 in the year 1985-87 to 2015-17, respectively. In oilseeds the Herfindahl Index was observed increased some extent from 0.67 to 0.68 in the year 1985-87 to 2015-17. In groundnut crop HI was observed as 0.66 in the year 1985-87, and increased to 0.78 in the year 2015-17. For castor crop HI was decreased from 0.94 in the year 1985-87 to 0.89 in the year 2015-17. In soybean crop HI was recorded as 0.83 in the year 2015-17. For commercial crop the Herfindahl Index was observed as 0.65 in the year 1985-87, which increased to 0.67 in the year 2015-17. In cotton crop HI was increased from 0.78 in the year 1985-87 to 0.89 in the year 2015-17. In sugarcane crop HI was increased from 0.77 in the year 1985-87 to 0.86 in the year 2015-17. For horticulture the diversification indices was observed as 0.66 in the year 2015-17.

The value of Modified Entropy Index (M.E.I.) for all crops in Central Gujarat region was observed as 0.98 in the year 1985-87 which increased to 0.99 in the year 2015-17. For cereal crops MEI was observed as 0.98 in the year 1985-87, which increased to 0.99 in the year 1995-97 and slightly decreased to 0.97 in the year 2015-17. Among cereals, in rice crop MEI was highly decreased from 0.52 to 0.19 in the year 1985-87 to 2015-17, respectively. In pearl millet MEI was also decreased from 0.86 in the year 1985-87 to 0.73 in the year 2015-17. The magnitude of MEI in maize crop was also decreased from 0.13 to 0.10 in the year 1985-87 to 2015-17, respectively. In wheat crop MEI was highly decreased from 0.68 in the year 1985-87 to 0.21 in the year 2015-17. For pulses the MEI was slightly decreased from 0.99 to 0.97 in the year 1985-87 to 2015-17, respectively. In gram crop MEI was observed as 0.65 in the year 1985-87 and increased to 0.89 in the year 1995-97 and slightly decreased to 0.85 in the year 2015-17. In black gram MEI was highly increased from 0.59 to 0.78 in the year 1985-87 to 2015-17, respectively. In green gram MEI was recorded as 0.65 in the year 1985-87 and increased to 0.84 in the year 2015-17. For oilseeds the value of MEI was almost remain same (0.99) over study period of 1985-87 to 2015-17. Among oilseeds, in groundnut crop MEI was slightly increased from 0.83 in the year 1985-87 to 0.84 in the year 2015-17. In castor crop MEI was highly increased from 0.78 in the year 1985-87 to 0.90 in the year 2015-17. In soybean crop iMEI was observed as 0.86 in the year 2015-17. For commercial crop the magnitude of MEI was slightly increased from 0.98 to 0.99 in the year 1985-87 to 2015-17, respectively. In cotton crop MEI was highly increased from 0.63 in the year 1985-87 to 0.87 in the year 2015-17. In sugarcane MEI was observed as 0.66 in the year 1985-87, which increased to 0.76 in the year 1995-97 and decreased to 0.74 in the year 2015-17. For horticulture the magnitude of MEI was recorded as 0.99 in the year 2015-17.

South Gujarat region

The results of the diversification indices for South Gujarat region during different time periods are presented in Table 4.

Due to arid and semi-arid agro-climatic conditions, crop pattern of the South Gujarat region has centered around rice, wheat, maize groundnut and horticulture crops. It is observed from the table that the crop pattern of South Gujarat region was somewhat diversified during period 2015-17 than 1985-87 as the magnitudes of Herfindahl Index was observed 0.67 and 0.66, respectively.

Among the various crop groups, the magnitude of Herfindahl Index for all crops in pre-WTO period 1985-87 was observed as 0.67 which decreased to 0.66 in the year 1995-97 and steady to 0.65 in the year 2015-17. In cereals in 1985-87 HI was observed as 0.66 which slightly decreased to 0.64 in the year 2015-17. Among major cereals in rice crop in the year 1985-87 HI was observed as 0.072 which increased to 0.30 in the year 1995-97 and slightly increased to 0.39 in the year 2015-17. In pearl millet in the year 1985-87 HI was observed as 0.22 which increased to 0.51 in the year 2015-17. in maize crop in the year 1985-87 HI was observed 0.066 which decreased to 0.055 in the year 2015-17. in wheat crop in the year 1985-87 HI was observed 0.86 which decreased to 0.29 in the year 2015-17. In pulses in the year 1985-87 HI was observed 0.65 which steady to 0.65 in the year 2015-17. Among major pulse in gram crop in the year 1985-87 HI was observed as 0.52 which decreased to 0.41 in the year 2015-17. In black gram crop in the year 1985-87 HI was observed as 0.89 which increased to 0.96 in the year 2015-17. In green gram crop in the year 1985-87 HI was observed as 0.76 which increased to 0.91 in the year 2015-17. In Oilseeds in the year 1985-87 observed 0.64 which was to some extent to 0.65 in 2015-17. Among major oilseeds in groundnut crop in 1985-87 observed 0.88 which was steady to 0.88 in the year 2015-17. In castor crop in the year 1985-87 HI was observed as 0.80 which increased to 0.87 in the year 2015-17. In soyabean crop HI was observed as 0.85 in the year 2015-17. In commercial crops in the year 1985-87 HI was observed as 0.67 which slightly decreased to 0.66 in the year 2015-17. Among major commercial crop in cotton HI was observed as 0.80 which increased to 0.84 in the year 1995-97 and also increased to 0.89 in the year 2015-17. in sugarcane crop HI was observed as 0.82 in the year 1985-87 which increased to 0.91 in the year 2015-17. In horticulture crops harfindahl index for 2015-17 was observed as 0.66.

Herfindahl index for cereals was only 0.66 and showed smallest variations and pulses steady 0.65 in the year 1985-87 to 0.65 in the year 2015-17. This has happened in the group, because more and more land was brought under rice, spices, horticulture crops and groundnut cultivation during latter periods. The perfect diversification was noticed for pulses during both periods under study.

Modified Entropy Index (M.E.I.) imparts uniformity and fixity to the scale used as norm to examine the extent of diversification. 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. The values of MEI for all crops was observed as 0.99 in the year 1985-87 which steady to 0.99 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for cereals were observed 0.99 in the year 1985-87 which decreased up to 0.97 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for rice crop was observed as 0.009 which highly increased up to 0.73 in the year 2015-17. In pearl millet crop MEI was observed as 0.98 in the year 1985-87 which decreased to 0.69 in the year 2015-17. The values of MEI for maize crop was observed as 0.18 in the year 1985-87 which decreased to 0.14 in the year 2015-17. In wheat crop MEI was observed as 0.58 in the year 1985-87 which decreased to 0.32 in the year 2015-17. The values of MEI for pulses were observed 0.98 in the year 1985-87 which steady to 0.98 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for gram crop was observed as 0.72 in the year 1985-87 which increased to 0.86 in the year 2015-17. In black gram crop MEI was observed 0.77 in the year 1985-87 which decreased to 0.75 in the year 1995-97 and increased to 0.86 in the year 2015-17. The value of MEI for green gram crop was observed as 0.63 in the year 1985-87 which increased up to 0.86 in the year 2015-17. The values of MEI for oilseeds were observed as 0.97 in the year 1985-87 which increased up to 0.98 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for groundnut was observed as 0.81 in the year 1985-87 which was decreased to 0.80 in the year 2015-17. The values of MEI for castor was observed as 0.95 in the year 1985-87 which decreased to 0.93 in the year 2015-17. In soybean crop the value of MEI was observed as 0.88 in the year 2015-17. The values of MEI for commercial crop were observed 0.99 in the year 1985-87 which was steady to 0.99 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for cotton was observed 0.79 in the year 1985-87 which increased up to 0.87 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for sugarcane was observed 0.76 in the year 1985-87 which increased up to 0.89 in the year 2015-17 indicated that specialization has taken place in case of all crops.

Table 3: Crop diversification indices in Central Gujarat region

Crop	Pre-WTO 1985-87	Post-WTO 1995-97	Post-WTO 2015-17
Harfindahl Index (1-HI)			
All crops	0.666	0.646	0.676
Rice	0.298	0.284	0.236
Pearl millet	0.786	0.257	0.231
Maize	0.270	0.188	0.077
Wheat	0.225	0.543	0.326
Cereals	0.654	0.665	0.656
Gram	0.598	0.684	0.718
Black gram	0.503	0.689	0.704
Green gram	0.889	0.826	0.871
Pulses	0.664	0.657	0.652
Groundnut	0.667	0.646	0.781
Castor	0.947	0.923	0.897
Soybean	NA	NA	0.832
Oilseeds	0.673	0.666	0.686
Cotton	0.787	0.863	0.892
Sugarcane	0.777	0.813	0.869
Commercial crops	0.653	0.666	0.677
Horticulture	NA	NA	0.666
Modified Entropy Index [Pi * (Log N (1/Pi)			
All crops	0.985	0.976	0.999
Rice	0.521	0.392	0.192
Pearl millet	0.865	0.804	0.735
Maize	0.139	0.108	0.109
Wheat	0.682	0.532	0.219
Cereals	0.983	0.997	0.978
Gram	0.652	0.895	0.854
Black gram	0.593	0.618	0.789
Green gram	0.651	0.797	0.844
Pulses	0.996	0.987	0.977
Groundnut	0.839	0.821	0.849
Castor	0.789	0.863	0.907
Soybean	NA	NA	0.861
Oilseeds	0.995	0.984	0.992
Cotton	0.633	0.789	0.879
Sugarcane	0.663	0.762	0.743
Commercial crops	0.981	0.999	0.997
Horticulture	NA	NA	0.999

Table 4: Crop diversification indices in South Gujarat region

Crop	Pre-WTO 1985-87	Post-WTO 1995-97	Post-WTO 2015-17
Harfindahl Index (1-HI)			
All crops	0.676	0.666	0.663
Rice	0.072	0.304	0.392
Pearl millet	0.227	0.205	0.510
Maize	0.066	0.194	0.055
Wheat	0.865	0.632	0.295
Cereals	0.662	0.654	0.641
Gram	0.522	0.499	0.417
Black gram	0.892	0.959	0.962
Green gram	0.762	0.842	0.913
Pulses	0.658	0.661	0.659
Groundnut	0.882	0.782	0.883
Castor	0.808	0.841	0.879
Soybean	NA	NA	0.853
Oilseeds	0.642	0.661	0.653
Cotton	0.802	0.849	0.892
Sugarcane	0.829	0.871	0.912
Commercial crops	0.677	0.664	0.662
Horticulture	NA	NA	0.666
Modified Entropy Index [Pi * (Log N (1/Pi)			
All crops	0.999	0.984	0.999
Rice	0.009	0.476	0.739
Pearl millet	0.982	0.688	0.693
Maize	0.182	0.162	0.147
Wheat	0.589	0.571	0.322
Cereals	0.998	0.986	0.978
Gram	0.721	0.652	0.866
Black gram	0.775	0.758	0.861
Green gram	0.637	0.797	0.868
Pulses	0.982	0.991	0.987
Groundnut	0.810	0.791	0.804
Castor	0.954	0.942	0.933
Soybean	NA	NA	0.889
Oilseeds	0.976	0.992	0.983
Cotton	0.791	0.813	0.873
Sugarcane	0.763	0.804	0.892
Commercial crops	0.991	0.999	0.993
Horticulture	NA	NA	0.999

Gujarat State

The results of the diversification indices for Gujarat State during different time periods are presented in Table 5.

Due to dry semi-arid and dry sub-humid agro-climatic conditions, crop pattern of the Gujarat has centered around Rice Wheat, Maize, Horticulture crops, groundnut, castor, cotton and wheat. It is observed from the table that the crop pattern of Gujarat was somewhat diversified during period 2015-17 than 1985-87 as the magnitudes of Herfindahl Index was 0.66 and 0.65, respectively.

Among the various crop groups, the magnitude of Herfindahl Index for all crops in pre-WTO period in the year 1985-87 was observed as 0.65 which to some extent to 0.66 in the year 1995-97 and steady to 0.66 in the year 2015-17. In cereals in 1985-87 HI was observed as 0.65 which was to slightly raised to 0.66 in the year 1995-97 and steady to 0.66 in the year 2015-17. Among major cereals in rice crop during 1985-87 HI was observed as 0.013 which increased to 0.28 in the year 1995-97 and decreased to 0.18 in the year 2015-17. In pearl millet in 1985-87 HI was observed as 0.79 which decreased to 0.58 in the year 1995-97 and also decreased to 0.29 in the year 2015-17. in maize crop in 1985-87 HI was observed as 0.32 which was highly decreased to 0.10 in the year 1995-97 and also decreased to 0.039 in the year 2015-17. in wheat crop in 1985-87 HI was observed as 0.27 which increased to 0.46 in the year 1995-97 and decreased to 0.34 in the year 2015-17. In pulses in 1985-87 HI was observed as 0.65 which some extent to 0.66 in the year 1995-97 and slightly decrease to 0.65 in the year 2015-17. Among major pulse in gram crop in 1985-87 HI was observed as 0.69 which decreased to 0.55 in the year 1995-97 and increased to 0.84 in the year 2015-17. In black gram crop in 1985-87 HI was observed as 0.49 which decreased to 0.38 in the year 1995-97 and increased to 0.43 in the year 2015-17. In green gram crop in 1985-87 HI was observed as 0.78 which increased to 0.84 in the year 1995-97 and decreased to 0.75 in the year 2015-17. In Oilseeds in 1985-87 HI was observed as 0.64 which some extent to 0.66 in the year 1995-97 and steady to 0.66 in the year 2015-17. Among major oilseeds in groundnut crop in 1985-87 HI was observed 0.91 which decreased to 0.86 in the year 1995-97 and increased to 0.91 in the year 2015-17. In castor crop in 1985-87 HI was observed as 0.98 which decreased to 0.87 in the year 1995-97 and slightly increased to 0.93 in the year 2015-17. In soyabean crop HI was observed as 0.96 in the year 2015-17. In commercial crops in 1985-87 HI was observed 0.64 which some extent to 0.66 in the year 1995-97

and steady to 0.66 in the year 2015-17. Among major commercial crop in cotton HI was observed as 0.96 which decreased to 0.91 in the year 1995-97 and slightly increased to 0.93 in the year 2015-17. In sugarcane crop HI was observed as 0.91 in the year 1985-87 which increased to 0.92 in the year 1995-97 and also slightly increased to 0.93 in the year 2015-17. In horticulture crops harfindahl index for 1995-97 was observed 0.66 which was steady to 0.66 in the year 2015-17.

Herfindahl index for cereals was only 0.62 and showed smallest variations and pulses increased from 0.58 in the year 1985-87 to 0.64 in the year 2017-18. This has happened in the group, because more and more land was brought under Pearl millet, spices, horticulture crops and groundnut cultivation during latter periods. The perfect diversification was noticed for pulses during both periods under study.

Modified Entropy Index (M.E.I.) imparts uniformity and fixity to the scale used as norm to examine the extent of diversification. 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. The values of MEI for all crops was observed as 0.97 in the year 1985-87 which increased up to 0.99 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for cereals were observed as 0.98 in the year 1985-87 which increased up to 0.99 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for rice crop was observed as 0.46 which highly decreased to 0.21 in the year 2015-17. In pearl millet crop MEI was observed as 0.16 in the year 1985-87 which was increased to 0.36 in the year 2015-17. The values of MEI for maize crop was observed as 0.13 in the year 1985-87 which decreased to 0.09 in the year 2015-17. In wheat crop MEI was observed as 0.58 in the year 1985-87 which decreased to 0.14 in the year 2015-17. The values of MEI for pulses were observed as 0.98 in the year 1985-87 which was steady to 0.98 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for gram crop was observed as 0.69 in the year 1985-87 which increased to 0.86 in the year 2015-17. In black gram crop MEI was observed as 0.24 in the year 1985-87 which increased to 0.45 in the year 2015-17. The value of MEI for green gram crop was observed as 0.63 in the year 1985-87 which increased to 0.86 in the year 1995-97 and decreased to 0.69 in the year 2015-17. The values of MEI for oilseeds were observed as 0.97 in the year 1985-87 which increased up to 0.99 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for groundnut was observed as 0.81 in the year 1985-87 which increased to 0.89 in the year 2015-17. The values of MEI for castor was observed as 0.86 in the year 1985-87 which was increased 0.87 in the year 2015-17. In soybean crop the value of MEI was observed as 0.97 in the year 2015-17. The values of MEI for commercial crop were observed 0.97 in the year 1985-87 which increased up to 0.99 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for cotton was observed as 0.81 in the year 1985-87 which increased up to 0.90 in the year 2015-17 indicated that specialization has taken place in case of all crops. The values of MEI for sugarcane was observed as 0.87 in the year 1985-87 which decreased up to 0.89 in the year 2015-17 indicated that specialization has taken place in case of all crops.

Table 5: Crop diversification indices in Gujarat

Crop	Pre-WTO 1985-87	Post-WTO 1995-97	Post-WTO 2015-17
Harfindahl Index (1-HI)			
All crops	0.651	0.667	0.661
Rice	0.013	0.281	0.180
Pearl millet	0.798	0.581	0.299
Maize	0.325	0.107	0.039
Wheat	0.274	0.468	0.343
Cereals	0.653	0.666	0.667
Gram	0.693	0.553	0.848
Black gram	0.491	0.381	0.439
Green gram	0.784	0.840	0.752
Pulses	0.652	0.663	0.654
Groundnut	0.914	0.867	0.919
Castor	0.984	0.878	0.932
Soybean	NA	NA	0.962
Oilseeds	0.649	0.666	0.665
Cotton	0.967	0.917	0.929
Sugarcane	0.912	0.929	0.934
Commercial crops	0.648	0.663	0.661
Horticulture	NA	0.661	0.666
Modified Entropy Index [Pi * (Log N (1/Pi)			
All crops	0.978	0.999	0.998
Rice	0.469	0.353	0.213
Pearl millet	0.164	0.157	0.368
Maize	0.133	0.177	0.097
Wheat	0.589	0.295	0.142
Cereals	0.981	0.999	0.999
Gram	0.697	0.842	0.860
Black gram	0.241	0.286	0.457
Green gram	0.637	0.863	0.692
Pulses	0.983	0.999	0.980
Groundnut	0.819	0.837	0.892
Castor	0.863	0.821	0.879
Soybean	NA	NA	0.971
Oilseeds	0.976	0.993	0.999
Cotton	0.816	0.867	0.901
Sugarcane	0.876	0.882	0.896
Commercial crops	0.972	0.996	0.995
Horticulture	NA	0.991	0.999

Conclusion

The study concludes**,** the slightly increased trends were observed in the magnitudes of diversification indices during entire study period. For food grains crops together, the increased diversification was observed in all four regions of the state. The magnitudes of diversification indices Slightly rise in North Gujarat for pulses crops; however, it was for commercial crops in Saurashtra region as well as central Gujarat regions and diversification indices slightly rise in oilseeds crops in South region of Gujarat State. However, at overall the state, the considerable slightly diversification was noticed in all group of crops (0.64 to 0.66%). In generally Gujarat indicated that the farmers have attentive their area to most remunerative crops in particular crop group.

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