International Journal of Ecology and Environmental Sciences
www.ecologyjournal.in
Online ISSN: 2664-7133; Print ISSN: 2664-7125; Impact Factor: RJIF 5.28
Received: 02-10-2020; Accepted: 17-10-2020; Published: 03-11-2020
Volume 2; Issue 4; 2020; Page No. 298-306

Evaluating banana and mango cultivation in Tamil Nadu to determine their efficient cropping zones

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Abstract
Fruits have always been an integral part of our diet, rich with all the nutrients essential for human body. Indian horticultural sector is excelling with two major fruit crops *viz*., banana and mango, dominating the global market. For both the crops, Tamilnadu holds a prime place in production and changes in the share of these crops could affect the national GDP. Trend analysis of area, production and productivity was done to understand the performance of banana and mango. It was observed that the trend of banana and mango cultivation in Tamilnadu is growing rapidly over the years (1985-2015). Identifying Efficient Cropping Zones for both the crops in the recent 15 years (2001-2015) was also done using the calculated Relative Spread Index and Relative Yield Index. Banana crop was efficiently grown in Tiruchirappalli, Thanjavur, Pudukkottai, Madurai, Theni, Thoothukudi, Coimbatore, Karur, Tirunelveli and Kanniyakumari districts. But concern has to be taken over Tirunelveli and Thoothukudi districts, which are at a risk of losing their status. Thiruvallur, Vellore, Dharmapuri, Krishnagiri, Madurai, Theni, Dindigul and Tirunelveli districts were possessing good performance under Mango cultivation during the study period. Vellore and Theni districts have given a positive evolution in mango cropping, but Kanniykumari had a setback. Efficient Cropping Zone analysis of both the fruit crops was able to determine the need for storage and processing facilities on the zones. Export regulations can also be created for the farmers of both the crops to reach global market.

Keywords: mango, banana, relative spread index (RSI), relative yield index (RYI), efficient cropping zones

Introduction

India has a wide variability of climate and soils, where its geographical patterns supports with a conducive environment creating a large belt for horticultural crops throughout the country. Mango (*Mangifera indica*) which known as "king of fruits" is the leading fruit crop of India and produced more or less in all the Indian states. Mango fruit is very popular due to its wide range of adaptability, delicious taste, excellent flavour and attractive fragrance, rich in vitamin A and C (cancer fighting agent) and high nutritive value (20% of total soluble sugars) (Yadav and Pandey, 2016) [21]. Among mango producing countries in the world, India has the richest collection of mango cultivars and fruit from almost all the cultivars are utilized at all stages in various ways ranging from chutney, pickles and curries, various types of syrups, nectar, jams and jelly. Mango wood is used as timber, and dried twigs are used for religious purposes. The mango kernel contains about 8-10% good quality fat which can be used for saponification and the kernels are used as fodder in piggery (nhb.gov.in/). In India, 39 per cent area (1.23 million ha) is under mango cultivation out of total fruit crop cultivable area which accounts for 23 per cent of national production (Negi, 2000) [11]. Mango's share from India is around 57.18 per cent of the total world production which is 12 million tonnes as against world's production of 23 million tonnes (2002-03). An increasing trend has been observed in world mango cultivation with average of 22 million metric tonnes per year (Mitra, 2014). Cultivable area of Mango in Tamil Nadu is about 1.25 lakh ha with total production around 5.38 lakh tonnes and average productivity of 4.30 t /ha. Dharmapuri, Krishnagiri, Vellore, Dindigul, Tiruvallur and Theni districts are considered to be major mango growing districts over Tamil Nadu (Agritech portal, TNAU).

Banana (*Musa sp.*) known as "Apple of paradise" is 2nd most important fruit crop in India next to Mango. Entire parts of Banana are used by humans, hence is named as plant of virtues (*kalpataru*). Banana is favourite fruit for almost all classes of people due to its year-round availability, affordability, varietal range, taste, nutritive and medicinal value (Alagumani, 2005) [2]. Bananas are the fifth largest agricultural commodity in world trade after cereals, sugar, coffee and cocoa. Global level production of banana is about 86 million tonnes and. India is leading producer with an annual output of about 14.2 million tonnes (33% of the production of total fruits) and third in area among fruit crops (13% of the total area). Main banana growing states are Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh and Karnataka. Tamil Nadu holds 2nd position in Banana production followed by Maharashtra and stands 1st in terms of productivity. Among 32 districts of Tamil Nadu, Tiruchirappalli district ranks first in exporting banana (Murasoli and Jambulingam, 2016) [9].
In Tamil Nadu, banana is considered to be one of the three important fruits along with mango and Jack which are called "Mukkani". Banana, "Tree of knowledge" is the cheapest fruit and also a rich source of energy (104 Kcal/100g) (Vinayagamoorthi *et al.*, 2019) [19]. Recently, European children had favoured for the Indian red banana and Njalipoovan or Ney Poovan (Elakki) which brought hope to Tamil Nadu banana growers (New Indian Express, 2018). Hence, Tamil Nadu farmers have started to export long-shelf life, high-quality bananas to European countries. The production of banana in Tamil Nadu has showed an increasing trend over the years to more than eight million tonnes in 2012-13. Several studies have used RSI and RYI to identify efficient crop zones of various crops

in Tamil Nadu. With the basics of those studies, investigation was carried out to identify the best efficient cropping zones for Mango and Banana crops and to notify the trend changes in area, production and productivity of both the crops.

2. Materials and Methods

2.1. Study area

Analysis on trends of banana and mango cultivation was done for the entire state of Tamilnadu (1985-2015) followed by district level delineation of the efficient cropping zones (2001-2015). Tamilnadu state is the southern part of India surrounded by Andhra Pradesh, Karnataka and Kerala states in its Northern and North-west boundaries, whereas the East and Southern sides are influenced.

By Bay of Bengal and Indian Ocean, respectively. The efficient cropping zone identification for both the crops was done in the study period of 15 years (2001-2015) when there were 32 districts, at present 38 districts after bifurcation.

Fig 1: Districts map of Tamilnadu used during the study period (2001-2015)

2.2. Data

Area, Production and Productivity data for 30 years (1985-2015) of all the districts and total cultivable area of Tamilnadu for 15 years (2000-2015) was collected from crop production statistics information system and respective season and crop reports (SCR).

2.3. Trend analysis

Trend analysis of the collected area, production and productivity was done for both the crops after which the trend line was plotted as follows

$$Y_t = abt\ e^{ut}$$

Where,

Y_t = Dependent variable in period t (Area/ Production/ Productivity)

a = Intercept

b = Regression coefficient= (1+g)

t = Years which takes values, 1, 2,…,n

ut = Disturbance term for the year

2.4. Efficient Cropping Zone

Efficient Cropping Zones identification for Banana and Mango crops was done using Relative Spread Index (RSI) and Relative Yield Index (RYI) based on the formulas given below along with the classification criteria of ECZ from Table 1 (Pradipa *et al.*, 2018 [13] and Sankar *et al.*, 2019) [16],

$$RSI = \frac{\text{Area of particular crop expressed as \% of total cultivable area in the district}}{\text{Area of crop expressed as percentage to the total cultivable aarea in the state}} \times 100$$

$$RYI = \frac{\text{Mean yield of a particular crop in a district}}{\text{AMean yield of the crop in the state}} \times 100$$

Table 1: Criteria for classification of ECZ

RSI	RYI	Cropping Zone
>100 (High)	>100 (High)	Most Efficient Cropping Zone (MECZ)
>100 (High)	< 100 (Low)	Efficient Cropping Zone (ECZ)
< 100 (Low)	>100 (High)	Not Efficient Cropping Zone (NECZ)
< 100 (Low)	< 100 (Low)	Highly Inefficient Cropping Zone (HICZ)

2.5. Mapping

District level Efficient Cropping Zones of Banana and Mango crops over Tamilnadu state mapping was created for 5 year average time periods (2001-2005, 2006-2010, 2011-2015) which were then compared with the base period (1995-2000). Average ECZ maps for the entire study period (2001-2015) was also prepared. All the maps were created using Arcgis v10.3 software.

3. Results and Discussion

3.1 Trend Analysis

3.1.1. Banana

Trend analysis on banana crop cultivation has been produced in Figure 2, where the state average area, production and productivity of the crop were 83.8 '000 ha, 3346.1 '000 tonnes and 38.8 t/ha, respectively over the 1985-2015 study period. The production and area of cultivation of banana have undergone fluctuation over the years with a maximum production of 5384.8 '000 tonnes (2007-2008) and maximum area of 115.8 '000 ha (2008-2009). We could also observe that since the year 2007, production and area are in falling phase with a serious note, though on the whole there had been an increasing trend of area cultivation and production for the crop. In the perspective of productivity, it has fluctuated comparatively less than area and production, while the trend is quite stable and increasing during the entire study. Rajendran (2018) [14] had also found similar results where the growth rate of area and production of banana crop is declining. Senthilkumar and Kannan (2019) were able to state that area, production and productivity of banana in Tamilnadu was not growing in a satisfactory level.

Trend in banana production over Tamilnadu (1985-2015) revealed that in 25-50 per cent years production had ranged between 3.62-5.48 lakh tonnes, while 51-75 per cent years resulted in 5.48 – 6.57 lakh tonnes (Figure 4)

3.1.2. Mango

Trend on Mango crop cultivation is represented in Figure 3, where the average area, production and productivity of the entire state during 1985-2015 were 97,271.6 ha, 5,39,997.5 tonnes and 5.5t/ha, respectively. Area of the crop had reached a peak value of 1, 44, 509 ha in 2012-2013, while production reaching the maximum of 11, 89, 270 tonnes during the same year. The overall trend of area has been quite stable, surprisingly the production is in the increasing phase. Productivity of mango had also seen its maximum value of 8.2 t/ha in 2012-2013, with a stable trend. The preference of off-seasonal mango crop production by farmers had helped the growing trend of mango cultivation in Tamilnadu (Mishra *et al.*, 2013) [7].

Trend of mango production over Tamilnadu (1985-2015) resulted in 22.75 – 35.03 lakh tonnes during 25-50 per cent of years, while 51-75 per cent years gave in 35.03 – 42.79 lakh tonnes (Figure 5)

3.2. Efficient Cropping Zone (ECZ)

An Efficient Cropping Zone is a resultant of several factors like suitable soil, climate and crop performance resulting in higher yields. ECZs are classified with higher RSI and RYI, where the former is determined by seeds, fertilizers, water, pesticides, availability of labour, technology, Government policies etc., whereas, later one is determined by the climate of the particular domain along with prevailing weather within that climate (Kanwar, 1972) [6].

3.2.1. Banana

Efficient Cropping Zone analysis of Banana crop over Tamilnadu (2001-2015) had resulted in Tiruchirappalli, Thanjavur, Pudukkottai, Madurai, Theni and Thoothukudi districts being excelling in banana cropping, while Coimbatore, Karur, Tirunelveli and Kanniyakumari districts were Efficiently Cropping Zones (Figure 6a-6d). During the base period study Tiruchirappalli, Theni, Thoothukudi and Theni districts were MECZs followed by Coimbatore, Namakkal, Karur, Thanjavur, Pudukkottai, Thiruvallur, Tirunelveli and Kanniyakumari in ECZs. Throughout the average time periods (2001-2005, 2006-2010 and 2011-2015) there had been fluctuations with all the districts. Thus, the entire study period average (2001-2015) map as given by Figure 8, reveals that Tiruchirappalli, Thanjavur, Pudukkottai, Madurai, Theni, Vellore and Thoothukudi districts are MECZs. The yield and area effect had significant contribution in Tamilnadu, especially in Theni and Vellore districts contributing towards increasing production (Angles and Sundar, 2012; Basha and Jacob, 2013; Saravanapandeeswari and Vanitha, 2018) [17]. Coimbatore, Erode, Karur, Cuddalore, Tirunelveli and Kanniyakumari have been ECZs. Surprisingly, Vellore and Erode districts were upgraded from the HNECZ and NECZ into MECZ and ECZ, respectively during the study. But Tirunelveli district which had been a MECZ during the start of study period has reduced into ECZ, which is to be taken into concern. Vincy (2016) [20] was able to provide few reasons on the difficulties faced by banana farmers owing to the seasonality of production, but inelastic demand; while the economics of cultivation is higher in spite of profitable remuneration, farmers do experience loan shortages. Thoothukudi district, which had been classified as MECZ is relatively under the declining phase of growth rate in area and production according to Rajendran (2018) [14].

3.2.2. Mango

Mango has always been a favourite seasonal tropical fruit crop of our country. Tamilnadu state during 2001-2015 has produced Thiruvallur, Vellore, Dharmapuri, Krishnagiri, Madurai, Theni, Dindigul and Tirunelveli districts as benevolent areas of mango

crop (Figure 7a-7d). During the base period only Dharmapuri and Tirunelveli districts have been MECZs, while Tiruvallur, Vellore, Madurai, Theni, Dindigul and Kanniyakumari districts are ECZs. Later Vellore and Theni districts have grown into MECZs at the end of study (2001-2015), but Kanniyakumari has fallen into HNECZ. Social and economic shifts of Kanniyakuamri district have caused rapid decline of cultivable area (Ramesh, 2018)

In the major mango belt, Dharmapuri was holding its MECZ position, Vellore Has improved from ECZ into MECZ while Krishnagiri has gone back from MECZ to ECZ.

Within the Southern districts, Theni has fallen into ECZ during the last few years, when Tirunelveli has got into MECZ (Figure 9). Adopting High Density Planting in mango during the recent years has become a boon to farmers in boosting up the production.

Which could have been a possible reason on expanding mango cultivation (Biswas and Kalit Kumar, 2011).

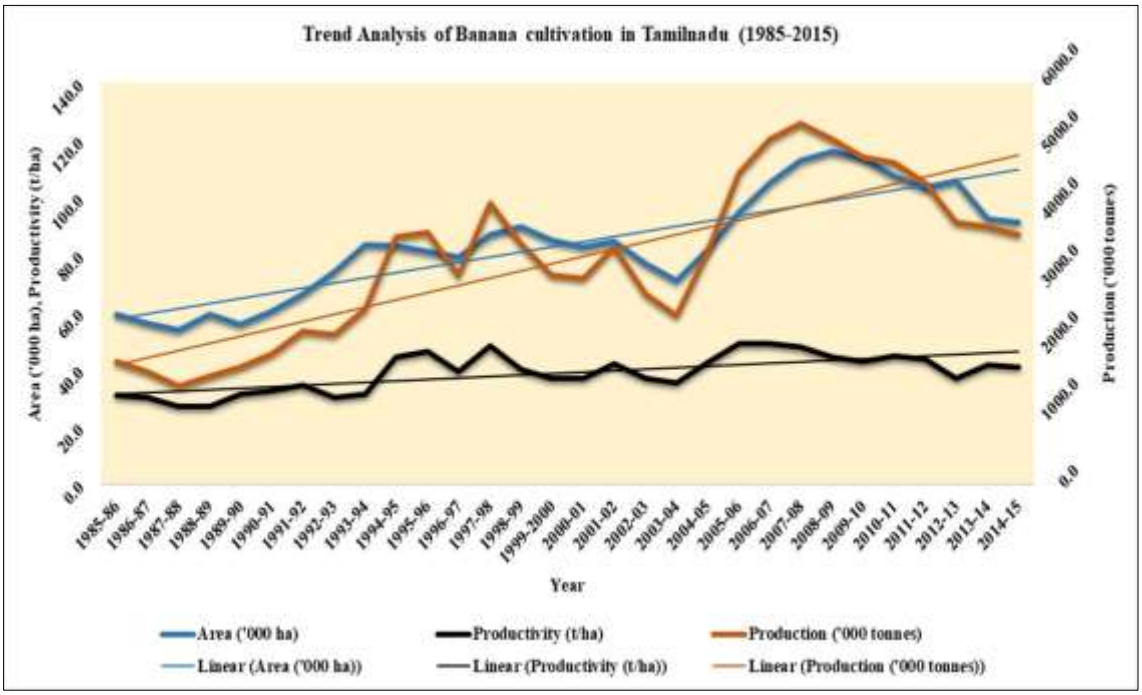

Fig 2: Trend of Area, Production and Productivity of Banana crop in Tamilnadu (1985-2015)

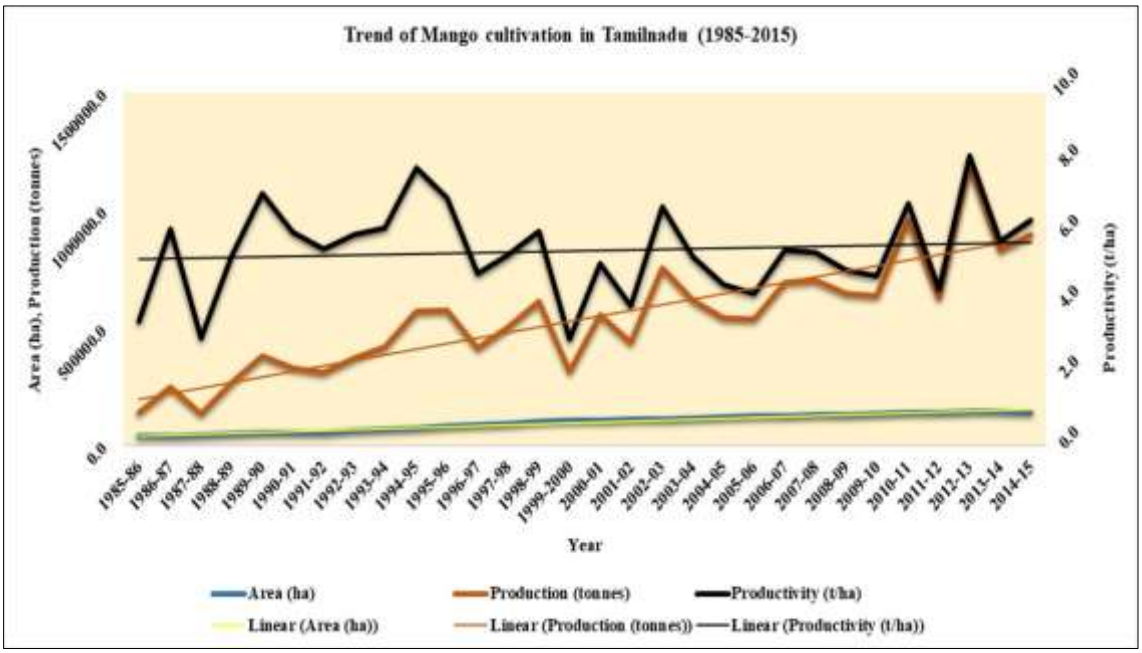

Fig 3: Trend of Area, Production and Productivity of Mango crop in Tamilnadu (1985-2015)

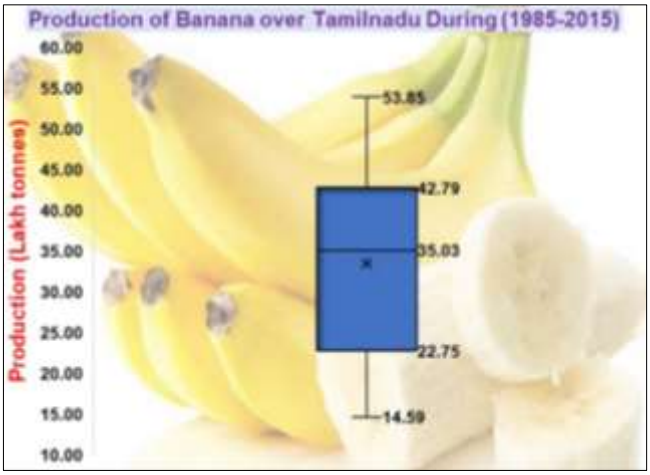

Fig 4: Production strategy of Banana crop in Tamilnadu (1985-2015)

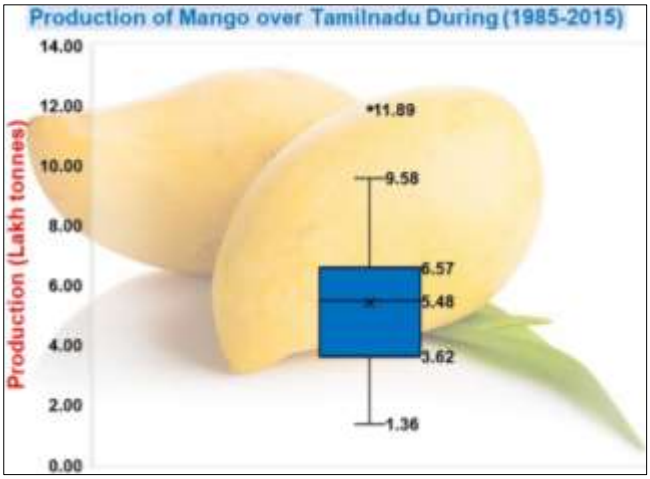

Fig 5: Production strategy of Mango crop in Tamilnadu (1985-2015)

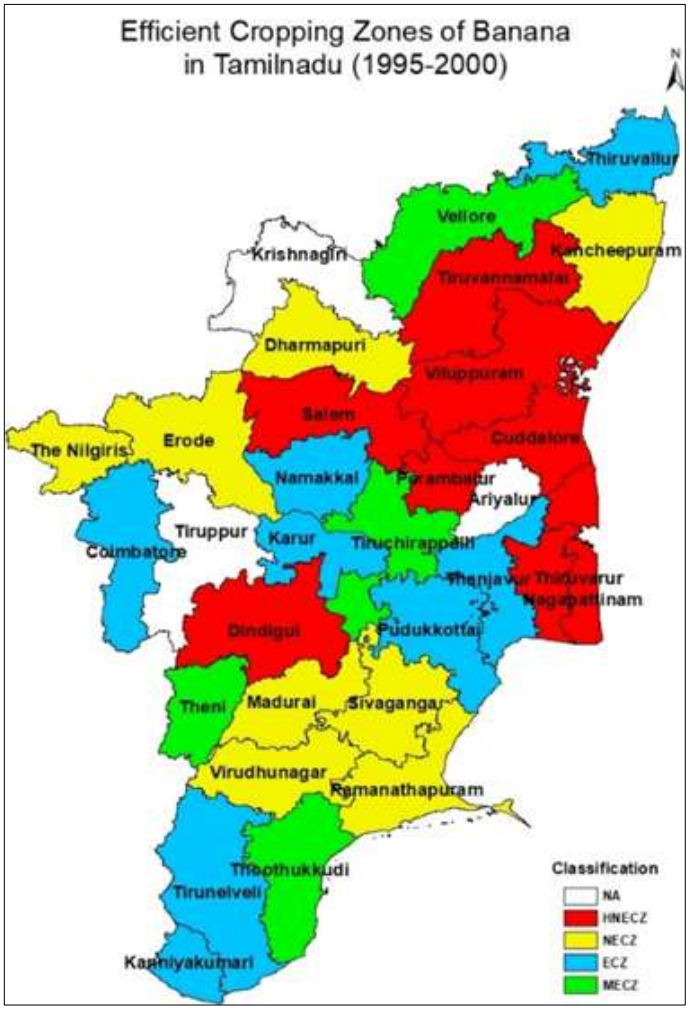

Fig 6a

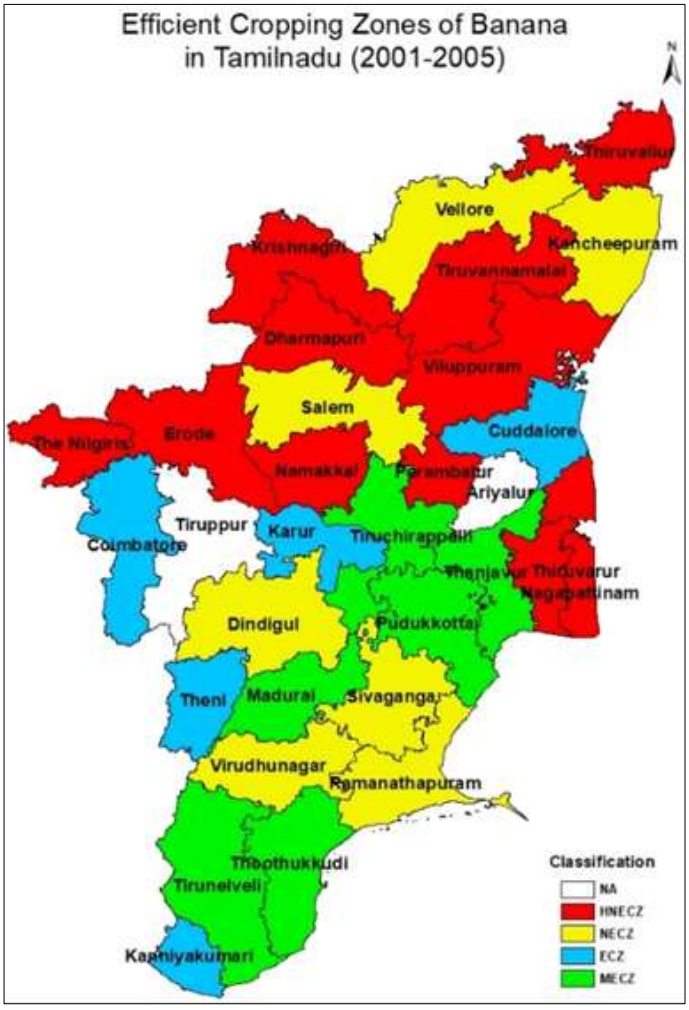

Fig 6b

Fig 6c

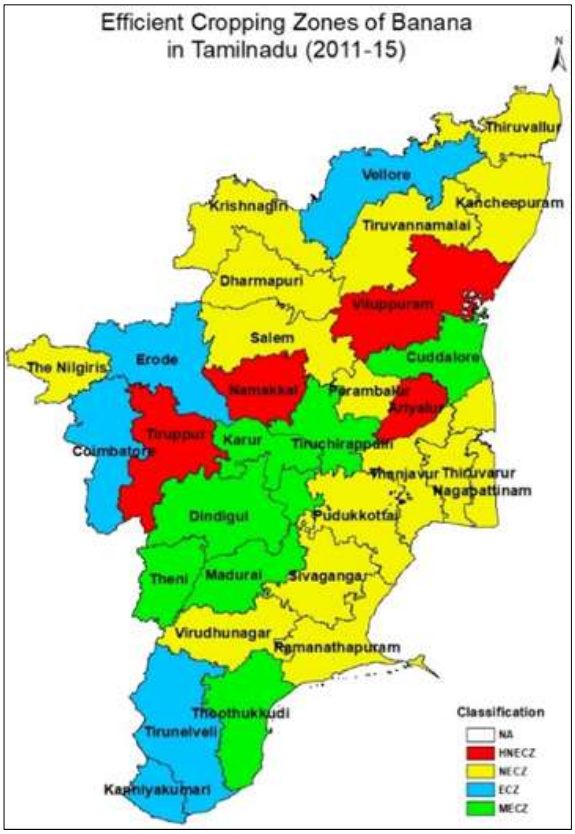

Fig 6d

Fig 6a-6d: Efficient Cropping Zones of Banana in Tamilnadu

Fig 7a

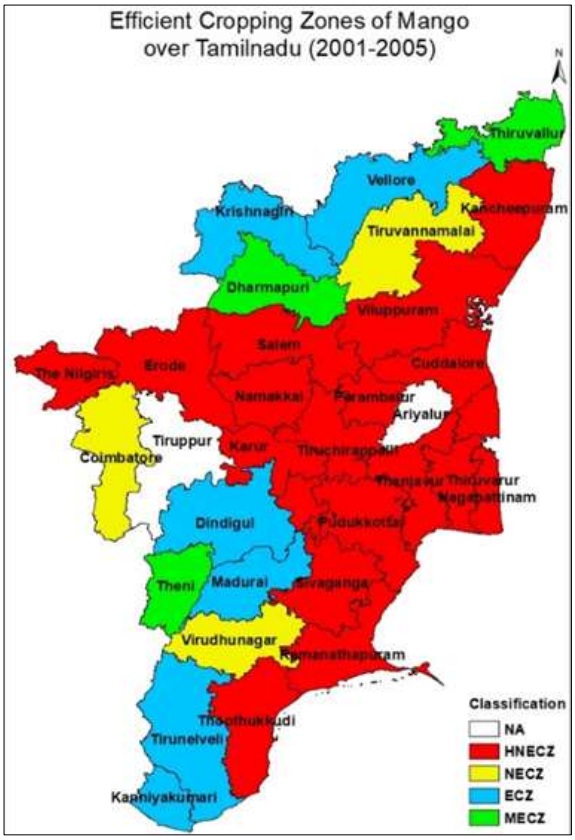

Fig 7b

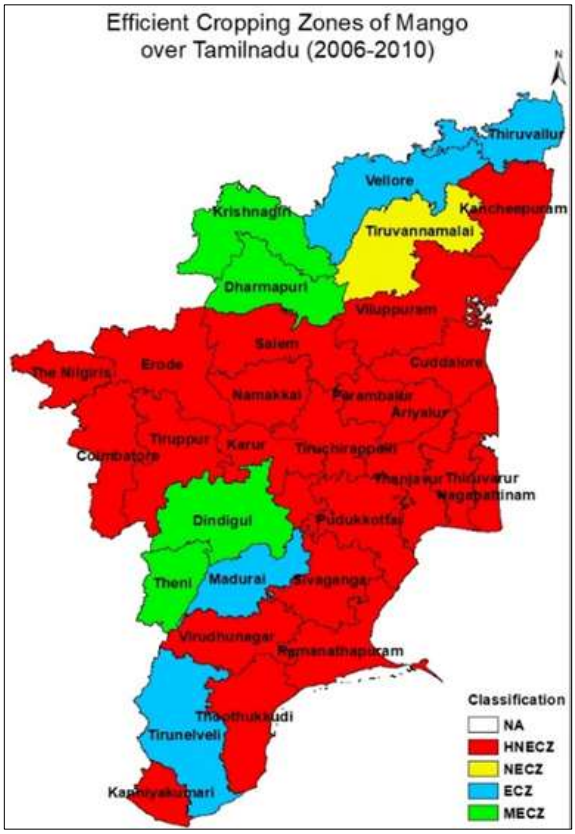

Fig 7c

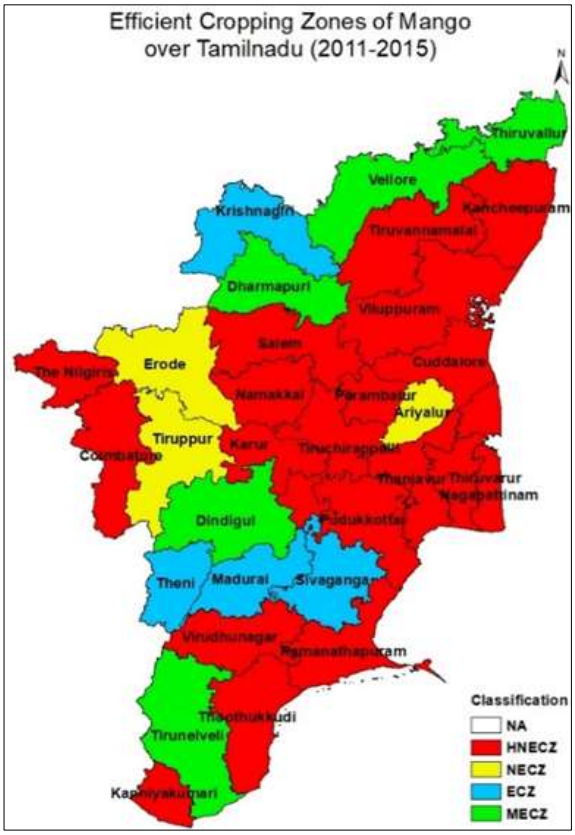

Fig 7d

Fig 7a-7d: Efficient Cropping Zones of Mango in Tamilnadu

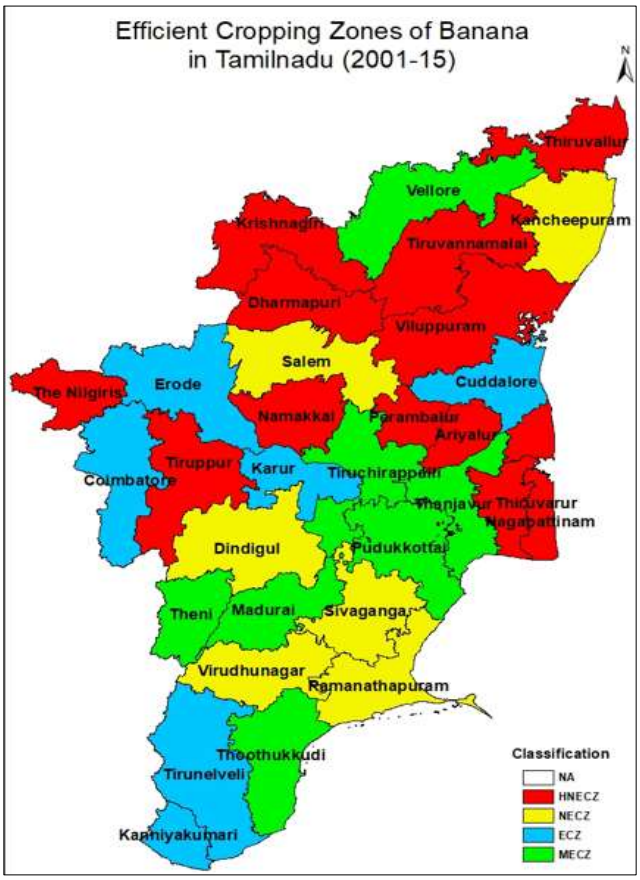

Fig 8: Efficient Cropping Zones of Banana in Tamil Nadu during overall study period (1985-2015)

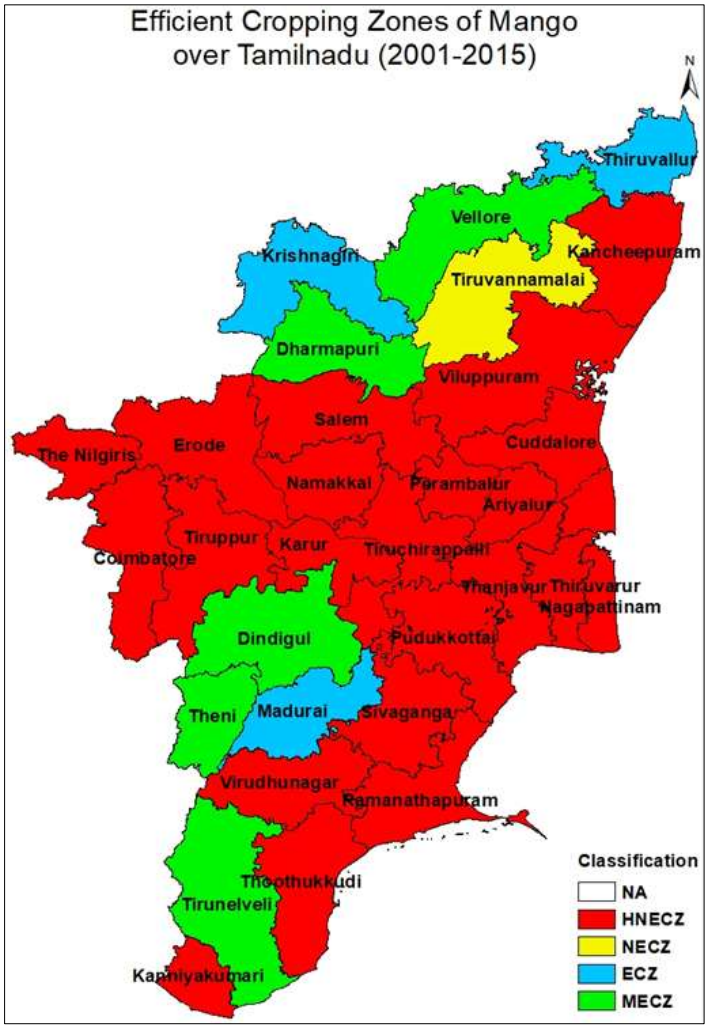

Fig 9: Efficient Cropping Zones of Banana in Tamil Nadu during overall study period (1985-2015)

Conclusion

Banana and Mango are fruits of immense nutrients among the "Mukkani" fruits of Tamil literature. Both the fruits are consumed raw and in processed form like chips, purees, squashes etc., being popular tropical fruits of the global market. Farmers have been benefitted with greater remuneration on fruit cultivation though lack of proper storage and processing units along with fragmented knowledge about export facilities are still the lacunas. Both the fruits are oriented with different climatic zones, where Banana is concentrated in the Delta districts, while Mango is grown in North West districts and Southern districts have supported both the crops. Trend analysis of area production and productivity of banana and mango crops revealed an increasing phase of both. Improved varieties and high-density planting have opened more venture over the cultivation of these fruits. Banana crop is Most Efficiently grown in Tiruchirappalli, Thanjavur, Pudukkottai, Madurai, Theni, Vellore and Thoothukudi districts; Coimbatore, Erode, Karur, Cuddalore, Tirunelveli and Kanniyakumari have been ECZs. Mango crop had Thiruvallur, Vellore, Dharmapuri, Krishnagiri, Madurai, Theni, Dindigul and Tirunelveli districts as efficient hotspots of cultivation, but Kanniykumari has a setback. Researchers, stake holders and policy makers could benefit from this study in identifying. the potential fruit growing areas. Improving the available facilities for inputs, cultivation practises, post-harvest technologies and value-added products development could further enhance the farmer's livelihood.

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