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RESEARCH ARTICLE

Impact of climate change on major fruits in India

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ABSTRACT : Horticulture sector contributes about 24.5 per cent of the GDP from about 8 per cent of the area under Horticulture. A large variety of fruits are grown in India. India accounts for 10 per cent of the total world production of fruits. India accounts for an area of 3.73 million ha under fruit crops with a production of 44.04 million tonnes. This study is conducted to asses Growth, variability in weather parameter, correlation in area, production and productivity of fruit crops, Shift in area among fruit crops and to forecast area under these fruits. The study is conducted based on secondary data taken from Metrological Department, NHB. To asses data various sophisticated tools was used using markov chain analysis, CGR, Correlation etc. The study reveals that CGR was significant in case of productivity of banana (1.7%) and mango (2.35%) at 1 per cent. CV was more in production of papaya with 35.04 per cent. There was negatively correlated in case of rainfall and minimum temperature with area production and productivity but in case of maximum rainfall it shows positively correlated, papaya production with 52 per cent. Highest area is retained by mango (80.31%) followed by banana (49.89 %), citrus (39.34 %) and it has been forecast that area under all fruit crops increases.

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Horticulture sector encompasses a wide range of crops e.g., fruit crops, vegetables crops, potato and tuber crops, ornamental crops, medicinal and aromatic crops, spices and plantation crops. While the first few Five Year Plans assigned priority to achieving self-sufficiency in food grain production, over the years, horticulture has emerged as an indispensable part of agriculture, offering a wide range of choices to the farmers for crop diversification (Aggarwal, 2008). It also provides ample opportunities for sustaining large number of agro-industries which generate substantial employment opportunities. The horticulture sector contributes about 24.5 per cent of the GDP from about 8 per cent of the area. As a result of the above efforts, significant progress has been made in area expansion resulting in higher production (Maria Blanco *et al.*, 2014). Besides, use of modern technologies has also brought about improvement in productivity. A large variety of fruits are grown in India. Of these mango, banana, citrus, pineapple, papaya, guava, sapota, jackfruit, litchi and grape, among the tropical and sub-tropical fruits; apple, pear, peach, plum, apricot, almond and walnut among the temperate fruits and aonla, ber, pomegranate, annona, fig, phalsa among the arid zone fruits are important. India accounts for 10 per cent of the total world production of fruits. It leads the world in the production of mango, banana, sapota and acid lime and has recorded highest productivity in grape. India accounts for an area of 3.73 million ha under fruit crops with

a production of 44.04 million tonnes.

The definition provided by UNFCCC 'a change that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods'.

Land-use change is related to climate change as both a causal factor and a major way in which the effects of climate change are expressed. As a causal factor, land use influences the flux of mass and energy, and as land-cover patterns change, these fluxes are altered. Projected climate alterations will produce changes in land-cover patterns at a variety of temporal and spatial scales, although human uses of the land are expected to override many effects. A review of the literature dealing with the relationship between land-use change and climate change clearly shows that (1) in recent centuries land-use change has had much greater effects on ecological variables than has climate change; (2) the vast majority of land-use changes have little to do with climate change or even climate; and (3) humans will change land use, and especially land management, to adjust to climate change and these adaptations will have some ecological effects. In India, an increase in the linear trend of about 0.4^0C in the surface air temperature has been observed in the past century. Indian monsoon rains are the backbone of Indian economy as most of our agricultural activities, rivers and replenishment of ground water sources have a direct dependence on monsoon rains. Monsoon rains are a manifestation of the complex interactions between land, ocean and atmosphere. The All-India rainfall data do not show any significant trend in monsoon rains, however, there are some regional variations. A trend of about 10 to 12 per cent (of the normal) increase in monsoon rains were reported along the west coast, northern Andhra Pradesh and north-western India during the last century. A decreasing trend of about 6 to 8 per cent is observed over the last 100 years over eastern Madhya Pradesh, North-Eastern India and some parts of Gujarat and Kerala (Mall, 2006).

Every small change in temperature and rainfall has significant effect on the quality and quantity of fruits, vegetables, tea, coffee, basmati rice and aromatic and medicinal plants. Hence, the present study was undertaken with the objectives of assessing Growth and variability in area, production and productivity of fruit crops in India over last ten years. To know correlation between rainfall, temperature and area, production and productivity under fruit crops. Shift in area among fruit crops and to forecast five years area under these fruits.

EXPERIMENTAL METHODOLOGY

The study was conducted mainly based on secondary data. The area production productivity of 10 major fruits in India was taken from 2003-04 to 2012-13 for the 10 years from Indian horticulture database 2013. The fruits were selected based on highest average area under fruits from past 3 years. The fruits selected for the study was namely Mango, Banana, Citrus, Apple, Guava, Sapota, Papaya, Grape, Pineapple and litchi. Data on average annual rainfall, minimum and maximum temperature was obtained from Meteorological Department of India. the data was analysed using Compound Growth Rate, Correlation of variation, Regression and Markov Chain analysis.

For evaluating the trend in area, production and productivity under major fruits in India the compound growth model of the type $Y_t = ab^t u_t$ was employed. Equation was converted into the logarithmic form in order to facilitate the use of linear regression. The linear regression of the above farm was fitted separately for area, production and productivity. Average annual compound growth rate was calculated as g = b-1. To obtain percentage compound growth rate the values of 'g' was multiplied by 100.To know the variation in area, production and productivity over the years co-efficient of variation (CV) was worked out.

Correlation between rainfall and area, production and productivity of major fruits was estimated. Correlation of minimum and maximum temperature with area, production and productivity was also calculated separately using formula for correlation co-efficient. Markov analysis was applied to know Shift in cultivable area among the major fruits crops in the last ten years and to predicted values for area under selected fruits for next five years.

EXPERIMENTAL FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Growth and variation in area, production and productivity of major fruit crops in India :

Compound growth rate of area, production and

productivity of fruits is presented in Table 1. Among the different fruits, area under grapes (9.64%) showed highestgrowth followed by papaya(8.78%) and banana (5.46%), the lowest was observed in case of pineapple, mango and sapota with annual growth of 2.73, 2.77, and 3.10 per cent respectively. In case of production papaya (12.42 %) showed highest growth rate followed by banana (7.94 %) and guava (6.71 %). The least growth was seen in grape, pineapple and litchi with growth rate of 2.34 per cent, 2.44 per cent and 3.781 per cent respectively. Growth in productivity of fruits was more in banana (2.35%), guava (2.17%) and sapota (1.74%). There is no growth in productivity of grape, apple, pineapple and litchi. Co-efficient of variation of area highest in grape, papaya, banana with 29.33 per cent, 26.12 per cent and 16.53 per cent, and less variation was observed in case of pineapple, mango and sapota with 8.38 per cent, 9.48 per cent and 10.00 per cent, respectively. As shown in Table 1 the area under mango, banana, citrus, apple, guava, sapota, papaya, grape, pineapple and litchi is significant at 5 per cent. The production of apple and grape are significant at 1 per cent but mango, banana, citrus, guava, sapota, papaya, pineapple and litchi. The productivity of mango and banana are significant at one per cent and sapota and papaya are significant at five per cent but remaining fruits like citrus, apple, guava, grape, pineapple and litichi are non-significant.

Correlation between rainfall, temperature and area, production and productivity under fruit crops :

Correlation between climatic parameters such as rainfall, maximum temperature and minimum temperature with respect to area under cultivation of major fruit crops are presented in Table 2. Area under cultivation of fruit crops are negatively correlated with rainfall. Since these are perennial crops they depend not only on rainfall instead on ground water resources also. Rainfall is negatively correlated with production grapes and apple was positively correlated (Chaturvedi, 2013). In case of

Table 1 : Growth and co-efficient of variation in area production and productivity of fruit crops in India

Crop	CGR			CV		
	Area	Production	Productivity	Area	Production	Productivity
Mango	2.7709**	4.5401**	1.7151*	8.3878	14.5209	7.5067
Banana	5.4616**	7.9469**	2.3571*	16.5350	22.9446	9.4211
Citrus	4.3028**	5.5892**	1.2152^{NS}	14.0073	19.4330	5.8533
Apple	4.8839**	3.9053*	-0.9951^{NS}	14.4698	19.7967	15.3694
Guava	4.4274**	6.7136**	2.1774^{NS}	13.8315	21.9176	8.5222
Sapota	3.1027**	4.9025**	1.7491**	9.4842	14.2894	5.4036
Papaya	8.7811**	12.4205**	1.7491**	26.1275	35.0497	10.8048
Grape	9.6429**	2.3458*	-6.6712^{NS}	29.3329	27.1435	30.5500
Pineapple	2.73339**	2.4439**	-0.2804^{NS}	10.0016	8.2481	2.7302
Litchi	4.6090**	3.7810**	-0.0075^{NS}	13.4529	14.9260	13.1895

Note : * and ** indicate significance of values at P=0.01 and 0.05, respectively NS=Non-significant

Table 2 : Correlation of area, production and productivity of major vegetables with rainfall, maximum temperature and minimum temperature

Crop	Rainfall			Min temp			Max temp		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Mango	-0.4350	-0.3990	-0.2577	-0.0272	0.0462	0.1237	0.2751	0.3937	0.4402
Banana	-0.4180	-0.3096	-0.0700	0.1807	0.1828	0.1551	0.4545	0.3955	0.2247
Citrus	-0.6258	-0.6582	-0.7033	-0.0636	-0.0144	0.1042	0.3305	0.3774	0.4680
Apple	-0.4214	0.2094	0.6975	0.0268	0.2584	0.3014	0.3409	0.2091	-0.0831
Guava	-0.5779	-0.5382	-0.4184	0.3523	0.3227	0.2411	0.3523	0.3227	0.2411
Sapota	-0.3870	-0.3786	-0.3398	0.3811	0.3744	0.3563	0.3811	0.3744	0.3563
Papaya	-0.4360	-0.4970	-0.6084	-0.0897	0.0005	0.2134	0.2263	0.3267	0.5423
Grape	-0.4705	0.2583	0.5257	0.0841	-0.6582	-0.5392	0.4171	-0.6699	-0.7881
Pineapple	-0.4980	-0.4408	0.4625	-0.4980	-0.4408	0.4625	0.2485	0.2992	0.0199
Litchi	-0.4980	-0.4408	0.4625	0.0328	-0.0705	-0.1187	0.3224	0.2490	-0.0624

productivity, apple (69.75%), grapes (52.57%), pineapple (46.25%) and litchi (46.25%) are positively correlated with rainfall. If rainfall increases productivity of apple, grape, pineapple and litchi also increase. Remaining fruits like banana, mango, sapota, guava, papaya, citrus are negatively correlated with rainfall ranging from -7 per cent to -70.33 per cent. Hence, there is significant correlation between rainfall and productivity of apple and grapes.With respect to minimum temperature and the area under sapota (38.11%), guava (35.23%), banana (18.07%), grape (8.41%), litchi (3.28%) and apple (2.68%) showing positive correlation whereas pineapple (49.8%), papaya (8.97%), citrus (6.37%), mango (2.72%) shows negative growth. With reference to minimum temperature and production the sapota and guava with 38.11 per cent and 35.23 per cent is positively correlated but grape and pineapple are negatively correlated with 65 per cent and 44 per cent. The pineapple (46.25%), sapota (35.63%), apple (30.14%), guava (24.11%), papaya (21.34%), banana (15.51%), mango (12.37%), citrus (10.42) are positively correlated but only grapes (53%), litchi (11.87%) are negatively correlated with minimum temperature and productivity of these fruits (Shinu, 2008). As shown in Table 2 there was positive correlation with temperature and area under major fruits, banana and grapes are show 45.45 per cent and 41.71 per cent, sapota Guava, Apple, Citrus, Litchi are showing positively correlation with 38.11 per cent to 32.24 per cent whereas mango, pineapple and papaya is also showing low positively correlated with 27.51 per cent to 22.63 per cent. The correlation between production and max temperature of banana, mango showed highest correlation with 39.55 per cent and 39.37 per cent and there was negatively correlated in case of grape with 66.99 per cent. The correlation between productivity and max temperature of papaya showed highest correlation with 54.24 which shows significance fallowed by citrus and mango with 46.8 per cent and 44.02 per cent respectively but in case of grape, apple, litchi there was negative growth with 78.81 per cent, 8.31 per cent and 6.24 per cent, respectively.

Table 3 : Shift in cultivable area among the major fruits crops in India

	Mango	Citrus	Banana	Apple	Guava	Others
Mango	0.8031	0.1155	0.0000	0.0717	0.0097	0.0000
Citrus	0.2226	0.3934	0.3667	0.0000	0.0173	0.0000
Banana	0.0846	0.0000	0.4989	0.1587	0.0019	0.2558
Apple	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
Guava	0.0000	0.0000	0.2025	0.0000	0.0000	0.7975
Others	0.3486	0.0000	0.0000	0.0000	0.3178	0.3336

Table 4 : Forecast of area under major fruits in India (2013-14 to 2017-18)(in '000 Ha)

Year	Mango	Citrus	Banana	Apple	Guava	Others
2003-04	1906.70	683.30	498.60	201.20	166.40	371.20
2004-05	1970.40	708.20	589.60	230.70	161.00	411.20
2005-06	2080.70	742.30	569.50	226.60	166.50	419.10
2006-07	2154.00	798.00	604.00	252.00	176.00	438.00
2007-08	2201.00	867.00	658.00	264.00	179.00	452.00
2008-09	2309.00	923.00	709.00	274.00	204.00	490.00
2009-10	2312.30	987.30	770.30	282.90	219.70	527.30
2010-11	2297.00	846.00	830.00	289.10	205.00	544.00
2011-12	2378.10	915.10	796.50	321.90	219.90	579.60
2012-13	2500.00	1042.50	776.00	311.50	235.60	601.60
2013-14(e)	2518.48	990.55	825.78	310.16	230.02	592.22
2014-15(e)	2519.31	990.75	821.80	311.77	231.37	592.20
2015-16(e)	2519.68	992.53	820.16	311.20	231.37	592.25
2016-17(e)	2520.26	992.71	820.00	310.97	231.42	591.85
2017-18(e)	2520.60	992.61	819.99	310.98	231.30	591.71

e: estimated

Shift in area among major fruit crops and to forecast five years area under these fruits :

Shift in area under fruit crops is presented are Table 3. Among the selected fruit crops highest area was retained by mango (80.31%) followed by banana (49.89 %), citrus (39.34 %). Mango lost its share to citrus to the extent of 11 per cent and 9 per cent to guava. Citrus retained its share of 39 per cent and lost 36 per cent, 22 per cent and 1 per cent to banana, mango and guava, respectively. Banana lost its share to apple (15.87%), mango (8.46 %), and guava (0.19 %). Apple lost its complete share to guava and guava lost its share to banana (20.25 %). Other crops such as papaya, grapes, pine apple, litchi, sapota etc. retained their share of 33.36 per cent and lost some of its area to mango (34.86 %) and guava (31.78 %). By the results we can say that banana and mango are the most stable fruits crops in India (Kunihisa, 2007). The forecasts for area under cultivation of fruits are presented in the Table 4. In 2014-15 area under mango would be 2519000.31 Ha. Least area is projected to be under guava (231000.37 Ha) and apple (311000.77 Ha). In the next four years mango area would be around 2520000 Ha. By 2017-18 area under guava would be 231000.30 Ha. Apple area would reduce from 311000.50 Ha to 310000.98. Citrus and mango area would increase from 990000.55 Ha to 992000.61 Ha and Ha to 2520000 Ha.

Conclusion :

The area under major fruits have been over the 10 years from now area under Mango, Banana, Citrus, Apple, Guava, Sapota, Papaya, Grape, Pineapple and Litchi are likely to increase as forecasted. There is not much correlation between fruits area, production and productivity with rainfall since most of this are grown under irrigation. But in case of productivity of fruits with respect to max temperature there is significant correlation, with increase of temperature there is increase in productivity of fruits. Hence, there is no much impact of climatic changes on in area production, productivity of major fruits.

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