



ZIBELINE INTERNATIONAL™
P U B L I S H I N G
ISSN: 2785-9002 (Online)
CODEN: FAERCS

Food and Agri Economics Review (FAER)

DOI: <http://doi.org/10.26480/faer.01.2021.10.17>



RESEARCH ARTICLE

TREND ANALYSIS OF AREA, PRODUCTIVE AREA, PRODUCTION AND PRODUCTIVITY OF MAJOR CITRUS SPECIES CULTIVATED IN KASKI DISTRICT, NEPAL

Anish Aryal^a, Rabin Thapa^{a*}, Ritesh Kumar Yadav^b

^a *Agriculture and Forestry University, Nepal.*

^b *Faculty of Agriculture, Agriculture and Forestry University, Nepal.*

*Corresponding author email: rabinth007@gmail.com

This is an open access article distributed under the Creative Commons Attribution License CC BY 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ARTICLE DETAILS

Article History:

Received 05 April 2021

Accepted 07 May 2021

Available online 21 May 2021

ABSTRACT

Kaski is one of the potential districts for citrus production in Nepal. A study was carried out with the objective to assess and analyze the status and trend of area, productive area, production and productivity of citrus in Kaski district, Nepal. For the study, secondary data were collected from “Statistical Information on Nepalese Agriculture” published yearly by MoALD from 1999/00 to 2017/18. Microsoft Excel and XLSTAT were used for data analysis and visualization of data. Mann-Kendall test (M-K test), Sen’s slope method and Standard Normal Homogeneity (SNH) test were used for trend analysis. The results showed that area, productive area and production of overall citrus and mandarin has significantly increasing trend whereas lime, lemon and sweet orange are undermined. The significant change points for area, productive area, production and productivity of citrus were detected from 2007/08 to 2011/12. The result from Sen’s slope showed that the production of overall citrus, and mandarin increased at the rate of 219.67 mt, 236.25 mt and 1.329 mt per year whereas the production of lime and sweet orange decreased at the rate of 3.53 mt and 3.55 mt per year during the study period. The average annual productivity was 10.35 mt/ha for overall citrus, 10.55 mt/ha for mandarin orange, 8.20 mt/ha for sweet orange, 6.58 mt/ha for lime, and 5.70 mt/ha for lemon during the study period from 1999/00 to 2017/18. The findings of this study will aid effective policy formulation for strengthening land use, citrus rejuvenation, marketing activities and program implementation in Kaski.

KEYWORDS

Citrus, Man-Kendall test, Sen’s slope, Trend analysis, Policy.

1. INTRODUCTION

Agriculture is the major occupation of about 65.6% population of Nepal (MOALD, 2019). It contributes 28.8% of the overall Gross Domestic Product of Nepal which is equivalent to 9.8 billion United States Dollar (MOF, 2018; MoALD, 2018). Fruit contributes about 7 percent of total AGDP (MoALD, 2018). Citrus is an important fruit grown in Nepal. It ranks first in sub-tropical fruits and contributes to about 22.57 % of the total fruit production in Nepal (MoALD, 2018). Nepal has suitable agro-climatic conditions for quality citrus fruits production in mid-hills ranging from 800-1400m altitude (Pokhrel, 2011). The optimum temperature of 18-21°C with well distributed annual rainfall of 1250 to 1800 mm and well drained loams and sandy loams soil with pH 5.5 to 6.5 is considered ideal for citrus cultivation (Acharya, 2015/16). The major citrus species grown in Nepal are mandarin (*Citrus reticulata* Blanco), sweet orange (*Citrus sinensis*), acid lime (*Citrus aurantifolia* Swing), lemon (*Citrus lemon*), pummelo (*Citrus grandis*), citron (*Citrus medica*), and rough lemon (*Citrus jambhiri* Lush.). Citrus is grown in more than 62 districts of Nepal and Kaski is one of the major producers of citrus (Panth and Dhakal, 2019). Kaski is a mid-hill district with total area of 2017 sq. km situated at an

altitude of 450-8091 masl with a geographical diversity favorable for cultivating wide range of citrus fruits. The total production of citrus in Kaski district was reported to be 6057 MT grown in 564 ha of productive area with a productivity of 10.74 MT/ha in 2017/18 (MoALD, 2018). Mandarin, lime, lemon and sweet orange are the major citrus grown in Kaski.

The productivity of citrus in the world is 13.68 MT/ha in 2018, whereas in Nepal the productivity of citrus is 9.4 MT/ha and 10.74 MT/ha in Kaski in 2017/18 (FAO, 2019; MoALD, 2018). The productivity of citrus in Nepal is relatively low and stagnant around 9-10 MT/ha since long period of time (Dhakal et al., 2005). Despite the tremendous potentialities of citrus production in the mid-hills of the country and continuous efforts from the governmental sector, citrus farmers are yet facing several production constraints and ending up with unsatisfactory production. The reason is predominantly due to the use of traditional technology and lack of technical knowledge of the farmers along with lack of good orchard management practices (TCP, 2011). In addition to this, prevalence of insect pest and disease, lack of healthy seedlings, poor access to market information, price uncertainty, etc. are also major production constraints of citrus. The temporal growth in citrus production area, production and

Quick Response Code



Access this article online

Website:
www.faer.org.my

DOI:
10.26480/faer.01.2021.10.17

productivity in Kaski has not been assessed and analyzed and thus, meagre information is available to throw light on policy decision to invest accordingly for the short and long-term plans and to provide an appropriate direction of research. As a consequence, governmental bodies are facing set back in sound and pertinent policy formulation, planning and implementation of the interventions.

Kaski is one of the major citrus growing districts of Nepal and has a great possibility for citrus production. The exponential increase in population implies its greater demand, so the increased quantities need to be produced from the same or even shrinking land to meet the consumer's demand. Understanding the temporal fluctuations in citrus production is crucial for aiding effective policy decision phenomena for short-term and long-term plans and interventions and to enhance citrus production in the wake of exponential population increase and shrinkage of the production area. Nevertheless, no any and systematic study has been carried out with regard to trends of area, production, productivity and other various aspects of citrus in Kaski, despite its major role in household economy. Further, the comparative advantage of this region has not been thoroughly analyzed and tapped. Estimates and information on temporal trends of production and different factors affecting production of citrus is substantial for devising effective and long-term planning. However, the state of paltry information on the trend and growth rate of production area, productive area, production and productivity of citrus in Kaski has hindered the policy makers to develop effective policy and strategic policy interventions for augmenting the citrus production. Therefore, this study was carried out to analyze the trend of area, production and productivity of citrus of Kaski district and generate significant information for effective and sound policy formulation and program design for higher production and productivity with minimum cost of cultivation of citrus. In nutshell, the findings of study will generate evidence-based information useful for the policy makers, governmental bodies, researchers and students.

2. METHODS AND METHODOLOGY

2.1 Study area and time of research

The study site was Kaski district. Whole district was considered for study because data of citrus production, area, productive area and productivity was available for the entire district. The study was focused on the trend analysis of area, productive area production and productivity of various citrus fruit species in Kaski. The research was conducted from May 2020 to July 2020 focusing mainly on the citrus grown within Kaski district.

2.2 Preliminary field visit

A preliminary field visit was conducted to gather preliminary information about the field conditions, socio-cultural settings, and topographic features of the study area. The information gathered during those visits was used to plan and select the major citrus to be analyzed during the study.

2.3 Study procedure

The time series data on production of various citrus species, area and productive area cultivated under particular citrus species and productivity in Kaski district from 1999/00 AD to 2017/18 AD was collected from various secondary sources. Trend analysis was conducted on overall citrus production status in the district along with trend analysis of citrus species viz., mandarin, sweet orange, lime, and lemon. Data from government publications was relied over non-governmental and other institutional publications. The main source of data for production was Statistical Information on Nepalese Agriculture published by MoALD from 1999/00 to 2017/18.

2.4 Data collection

Secondary time-series data was collected focusing more on quantitative data related to production, area and productivity of citrus over a period of time. The main sources of secondary data were by reviewing various publications from MoALD, MOF, ADS, NGO's, INGO's, Agriculture Departments, Agriculture Knowledge Centre of Syangja, journal articles from various reputed national and international universities along with various authentic websites related to agriculture.

2.5 Methods and techniques of data analysis

The collected data was screened and refined before analysis. It was then coded and entered in Excel sheet. The data was analyzed to draw meaningful results using MS Excel and XLSTAT. Simple descriptive statistics like minimum, maximum, mean, median, standard deviation,

coefficient of variation and Pearson's coefficient of skewness were computed. The following analyses were performed.

2.5.1 Trend analysis

The time series data collected was used to draw trend lines. Many statistical approaches are available for detecting and estimating trends that may be present in time series data. In this study, Mann-Kendall test was used to determine the monotonic trend in a given time series data and Sen's slope method was used to quantify the trend. Mann-Kendall test (M-K test) is a non-parametric test which was developed by Mann, 1945 and Kendall, 1975 and it analyses the sign of the difference between later measurements with earlier measurement in time series data (Meals et al., 2011). Each later measured value is compared to all values measured earlier which results total $\frac{n(n-1)}{2}$ possible pairs of data, n being the total observations. The null hypothesis (H_0) for this test is, "there is no monotonic trend in time series" and the alternative hypothesis (H_A) for this test is, "there is monotonic trend in time series" (Meals et al., 2011).

The Mann-Kendall Statistics was calculated as:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{sgn}(x_j - x_i)$$

Where,

n = total observations,
 x_i and x_j are sequential data values and
 $\text{sgn}(x_j - x_i)$ is the sign function which was computed as:

$$\text{sgn}(x_j - x_i) = \begin{cases} 1, & \text{if } (x_j - x_i) > 0 \\ 0, & \text{if } (x_j - x_i) = 0 \\ -1, & \text{if } (x_j - x_i) < 0 \end{cases}$$

For independent, normally distributed random variables with no tied data values, we have $E(S) = 0$ and the variance was calculated as:

$$\text{Var}(S) = \frac{n(n-1)(2n+5)}{18}$$

When some of the data values are tied, the variance was calculated as:

$$\text{Var}(S) = \frac{1}{18} \left[n(n-1)(2n+5) - \sum_t t(t-1)(2t+5) \right]$$

Where,

Where, n = length of time series and
 t = extent of any given tie

When n is larger than 10, the Z-statistics for the test was computed as:

$$Z_{MK} = \begin{cases} \frac{S-1}{\sqrt{\text{Var}(S)}} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ \frac{S+1}{\sqrt{\text{Var}(S)}} & \text{if } S < 0 \end{cases}$$

The hypothesis was accepted or rejected by comparing computed Z-value to Z-value from standard Z-probability table at 5% level of significance and conclude if monotonic trend occurred (Dinpashoh et al., 2011). The increasing trend was considered for the positive value of Z and the decreasing trend was considered for the negative of Z (Gajbhiye et al., 2016). In this study, the p-value obtained in Mann-Kendall test was used to conclude about if monotonic trend existed in the given time series data. The null hypothesis was rejected if the p-value was less than the level of significance ($\alpha = 5\%$) i.e. 0.05 and it was concluded that there was monotonic trend in the time series data. The failure to reject the null hypothesis ($p > 0.05$) would conclude that there is no monotonic trend in the time series data. Based on Kendall's correlation coefficient, known as Kendall's tau (τ), the conclusion was drawn about how strongly the two variables were monotonically related. It is an effective and general non-parametric method of measuring correlation between two variables which takes values between -1 to +1. The sign of the coefficient indicates the sign of the slope of relation i.e. increasing or decreasing trend and its absolute

value indicates the strength of the relationship (Hirsch et al., 1993). The Kendall's correlation coefficient was calculated as:

$$\tau = \frac{s}{n(n-1)/2}$$

Where,

s = Mann-Kendall Statistics and

n = length of time series.

The median is least affected by gross errors or outliers compared to weighted average and hence estimation of regression coefficient (i.e. slope) based on median will be more robust than slope obtained from method of least square or simple linear regression (Sen, 2012). So, in this study, the magnitude of the trend was computed by simple non-parametric method developed by Sen which is commonly called Sen's slope. The positive value of Sen's slope (β) indicates upward trend in a time series and the negative value represents downward trend. The Sen's slope was computed as:

$$\text{Sen's slope } (\beta) = \text{Median} \left(\frac{x_j - x_i}{j - i} \right), j > i$$

Where,

x denotes the variable and i, j are indices.

The intercepts were computed for each time step 't' as:

$$\alpha_t = Y_t - \beta \times t$$

Finally, the regression line was plotted based on the Sen's slope and intercept to visualize the trend.

2.5.2 Change point detection

The change point detection is an important aspect to assess the period from where significant change has occurred in a time series. Standard Normal Homogeneity (SNH) test was applied for change point detection.

The statistic T(k) is used to compare the mean of first (n) observations with the mean of the remaining (n-k) observations with 'n' data points.

$$T(k) = k\bar{z}_1^2 + (n - k)\bar{z}_2^2$$

Where,

$$\bar{z}_1 = \frac{1}{n} \frac{\sum_{i=1}^k (Y_i - \bar{Y})}{S}$$

$$\bar{z}_2 = \frac{1}{n - k} \frac{\sum_{i=k+1}^n (Y_i - \bar{Y})}{S}$$

$$S = \frac{1}{n} \sum_{i=1}^n (Y_i - \bar{Y})^2$$

If a break is located at year k, then T(k) reaches maximum near the year k=k. The test statistic T₀ is defined as

$$T_0 = \max T(k) \quad 1 \leq k \leq n$$

2.5.3 Average annual productivity

The average annual productivity was calculated by the following formula:

$$\text{Average annual productivity} = \frac{\sum \text{Productivity in each year}}{\text{Total number of years}}$$

This average annual production was considered as a base production to compare production during each year on how it is above or below the base production.

2.5.4 Annual growth rate

Annual growth rate for each year was calculated by following formula and expressed in percentage.

$$\text{Annual growth rate}_t = \frac{\text{Value in } t^{\text{th}} \text{ year} - \text{Value in } (t - 1)^{\text{th}} \text{ year}}{\text{Value in } (t - 1)^{\text{th}} \text{ year}} \times 100\%$$

3. RESULTS AND DISCUSSIONS

3.1 Citrus

During the period 1999/00 to 2017/18 the percentage increase in area, productive area, production and productivity of citrus fruit in Kaski was found to be 78.88%, 64.91%, 74.55% and 5.85% respectively. The descriptive statistics for area, productive area, production and productivity is tabulated in Table 1. The maximum area, productive area, production and productivity of citrus during this period was 1449 ha, 850 ha, 7050 MT and 13.29 MT/ha respectively. From Table 1, the area and productive area were right skewed whereas production and productivity were left skewed. The average annual productivity of citrus fruits for 19 years period from 1999/00 to 2017/18 was 10.35 MT/ha. The productivity was below this annual average from the period of 1999/00 to 2002/03 and from 2012/13 to 2016/17. The trend of different parameters have been shown in Figure 1 and 2 below.

It is evident from Table 2 that all parameters had increasing trend during the period of 1999/00 to 2017/18 as indicated by positive value of Kendall's tau (τ). The trend of area, productive area and production was statistically significant at 95% confidence level as indicated by p-values (0.05) but the trend of productivity was statistically insignificant. Sen's slope method quantified that the area of citrus fruits increased at the rate of 27.004 ha per year, productive area increased at the rate of 18 ha per year, production increased at the rate of 219.667 MT per year and productivity increased at the rate of 0.016 MT/ha during the study period. There was strong (≥ 0.7) correlation between productive area and time and production and time, moderate (between 0.3 and 0.7) correlation between area and time and weak (≤ 0.3) correlation between productivity and time as indicated by absolute value of Kendall's tau.

Table 1: Descriptive statistics for area, productive area, production and productivity of citrus (1999/00-2017/18)

Parameters	Minimum	Maximum	Mean	Median	S.D.	Coefficient of variation (CV) %	Pearson's coefficient of skewness
Area (ha)	570.77	1449	896.788	718.8	345.564	38.533	1.545
Productive area (ha)	223	850	522.947	449	204.423	39.09	1.085
Production (MT)	2279	7050	5192.053	5341	1399.395	26.95	-0.319
Productivity (MT/ha)	7.74	13.29	10.347	10.51	1.623	15.68	-0.302

Table 2: Mann-Kendall test and Sen's Slope estimators for overall area, productive area, production and productivity of citrus in Kaski

Parameters	p-value	Kendall's tau (τ)	Sen's slope	Trend	Significance
Area (ha)	0.001**	0.593	27.004	Increasing	Significant
Productive area (ha)	< 0.0001**	0.740	18.00	Increasing	Significant
Production (MT)	< 0.0001**	0.747	219.667	Increasing	Significant
Productivity (MT/ha)	0.674	0.076	0.016	Increasing	Insignificant

**denotes significant at 1% level of significance

The Standard Normal Homogeneity (SNH) test revealed that there was significant break in a trend of area (p-value=0.0001) and productive area (p-value=0.0004) of citrus in the year 2011/12 at 95% confidence level. The average area of cultivation of citrus was 678.69 ha before change point

and 1369 ha after change point. The average productive area was 399.07 ha before change point and 791.33 ha after change point. The increase in area and productive area may be due to effective governmental programs, loan package at nominal interest rate and provision of subsidy to the

farmers. Similarly, there was significant break in a trend of production (p -value<0.0001) in the year 2007/08. The average production was 3935 MT before change point and 6324 MT after the change point.

The increase in area, availability of quality saplings, adoption of new technologies, effective plant protection measures and timely pruning may have resulted in the increment of production. There was significant break in a trend of productivity (p -value=0.002) in the year 2011/12. The average productivity was 11.16 MT/ha before change point and 8.59 MT/ha after the change point. Poor orchard management increase in non-bearing trees, disease and insect-pest infestation may have resulted in decrease in productivity. A group researcher found the area and production of citrus in Nepal is in increasing trend but increment of area is greater than increment in production due to which productivity of citrus decrease in recent years (Pandey et al., 2017).

Table 3: Results of Standard Normal Homogeneity test for overall area, productive area, production and productivity of citrus in Kaski

Parameters	p-value	Change point	Mean before change point (μ_1)	Mean after change point (μ_2)
Area (ha)	0.001**	2011/12	678.69	1369
Productive area (ha)	0.0004**	2011/12	399.07	791.33
Production (MT)	<0.0001**	2007/08	3935	6324
Productivity (MT/ha)	0.002**	2011/12	11.16	8.59

**denotes significant at 1% level of significance

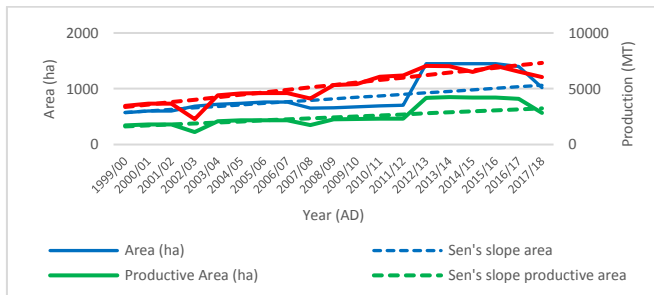


Figure 1: Trend of overall area, productive area and production of citrus in Kaski (1999/00 -2017/18)

Table 4: Descriptive statistics for area, productive area, production and productivity of mandarin (1999/00-2017/18)

Parameters	Minimum	Maximum	Mean	Median	S.D.	Coefficient of variation (CV) %	Pearson's coefficient of skewness
Area (ha)	480.79	1400	837.284	660	353.784	42.25	1.503
Productive area (ha)	177	814	485.421	449	208.366	42.93	0.524
Production (MT)	1930	6720	4880.105	5341	1468.375	30.09	-0.942
Productivity (MT/ha)	7.70	13.33	10.551	10.9	1.673	15.86	-0.627

Table 5: Mann-Kendall test and Sen's Slope estimators for overall area, productive area, production and productivity of mandarin in Kaski

Parameters	p-value	Kendall's tau (τ)	Sen's slope	Trend	Significance
Area (ha)	< 0.0001**	0.869	27.780	Increasing	Significant
Productive area (ha)	< 0.0001**	0.763	21.250	Increasing	Significant
Production (MT)	< 0.0001**	0.791	236.256	Increasing	Significant
Productivity (MT/ha)	0.944	0.018	0.004	Increasing	Insignificant

** denotes significant at 1% level of significance

The Standard Normal Homogeneity (SNH) test revealed that there was significant break in a trend of area (p -value=0.0003) and productive area (p -value=0.0001) of mandarin in the year 2011/12 at 95% of confidence

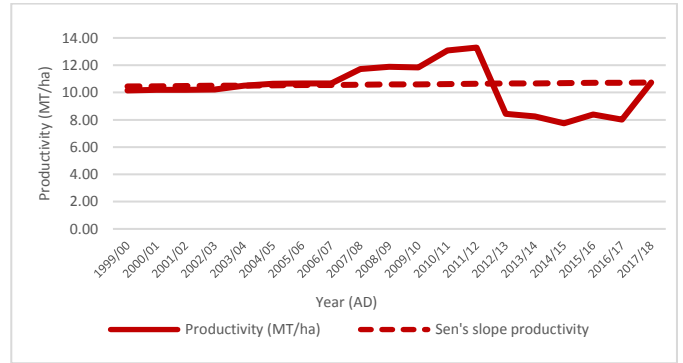


Figure 2: Trend of overall productivity of citrus in Kaski (1999/00 -2017/18)

3.2 Mandarin

During the period 1999/00 to 2017/18 the percentage increase in area, productive area, production and productivity of mandarin was 101.13%, 81.94%, 86.35% and 2.42% respectively. The descriptive statistics for area, productive area, production and productivity is tabulated in Table 4. The maximum area, productive area, production and productivity of mandarin during this period was 1400 ha, 814 ha, 6,720 MT and 13.33 MT/ha respectively. From Table 4, the area and productive area were right skewed whereas production and productivity were left skewed. The average annual productivity of mandarin for 19 years period from 1999/00 to 2017/18 was 10.55 MT/ha. The productivity was below this annual average in year from 2012/13 to 2016/17. The trend of different parameters has been shown in Figure 3 and 4 below.

It is evident from Table 5 that all parameters had increasing trend during the period of 1999/00 to 2017/18 as indicated by positive value of Tau (τ), but only the trend of area, productive area and production were statistically significant at 95% confidence level as indicated by p-values. Sen's slope method quantified that the area of mandarin increased at the rate of 27.780 ha per year, productive area increased at the rate of 21.250 ha per year, production increased at the rate of 236.250 MT per year and productivity increased at the rate of 0.004 MT/ha during this period. There was strong correlation between area and time, productive area and time and production and time and weak correlation between productivity and time as indicated by absolute value of Kendall's tau.

level. The average area of cultivation of mandarin was 614.72 ha before change point and 1320 ha after the change point. The average productive area was 361.31 ha before change point and 754.33 ha after the change point. The increase in area and productive area may be due to effective governmental programs, loan package at nominal interest rate, subsidy to the farmers and prioritization of mandarin over other citrus. Similarly, there was significant break in the trend of production (p -value<0.0001) in the year 2007/08. The average production was 3506 MT before change point and 6117 MT after the change point.

The increase in area, availability of quality saplings, adoption of new technologies, effective plant protection measures and timely pruning may have resulted in the increment of production. There was significant break in the trend of productivity (p -value=0.0003) in the year 2011/12. The average productivity was 11.46 MT/ha before change point and 8.58 MT/ha after the change point. Citrus decline, citrus greening disease and increase in non-bearing trees may have resulted in decrease in productivity of mandarin. The destructive diseases like citrus greening and root rot have hit mandarin orchards in Kaski, forcing farmers to quit their profession (Sharma, 2016).

Table 6: Results of Standard Normal Homogeneity test for area, productive area, production and productivity of mandarin in Kaski

Parameters	p-value	Change point	Mean before change point (μ_1)	Mean after change point (μ_2)
Area (ha)	0.0003**	2011/12	614.72	1320
Productive area (ha)	0.0001**	2011/12	361.31	754.33
Production (MT)	<0.0001**	2007/08	3506	6117
Productivity (MT/ha)	0.0003**	2011/12	11.46	8.58

**denotes significant at 1% level of significance

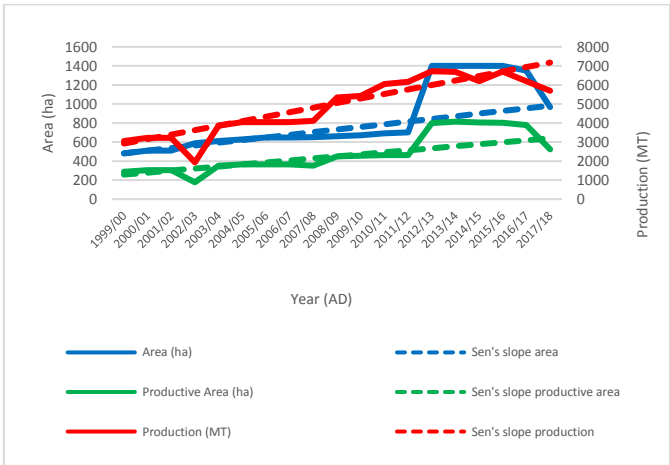


Figure 3: Trend of area, productive area and production of mandarin in Kaski (1999/00 - 2017/18)

Table 7: Descriptive statistics for area, productive area, production and productivity of lime (1999/00-2017/18)

Parameters	Minimum	Maximum	Mean	Median	S.D.	Coefficient of variation (CV) %	Pearson's coefficient of skewness
Area (ha)	0	52.9	26.129	20	19.191	73.446	0.958
Productive area (ha)	0	39	15.932	13	11.454	71.894	0.768
Production (MT)	0	289	120.421	111	85.349	70.876	0.331
Productivity (MT/ha)	0	9	6.580	7.54	2.984	45.350	-0.961

Table 8: Mann-Kendall test and Sen's Slope estimators for overall area, productive area, production and productivity of lime in Kaski

Parameters	p-value	Kendall's tau (τ)	Sen's slope	Trend	Significance
Area (ha)	0.478	-0.129	-1.011	Decreasing	Insignificant
Productive area (ha)	0.286	-0.192	-0.621	Decreasing	Insignificant
Production (MT)	0.325	-0.174	-3.533	Decreasing	Insignificant
Productivity (MT/ha)	0.017*	0.413	0.079	Increasing	Significant

*denotes significant at 5% level of significance

The SNH test revealed that there was significant break in the trend of area (p-value<0.0001), productive area (p-value<0.0001) and production (p-value<0.0001) of lime in the year 2006/07 and there was homogeneous trend of productivity (p-value=0.396) at 95% of confidence level. The average area of cultivation of lime was 45.81 ha before change point and 11.82 ha after the change point. The average productive area was 27.21 ha before change point and 7.73 ha after the change point. Land fragmentation, out-migration, industrialization, urbanization and less prioritization to lime may be the major reasons for the decrease of area

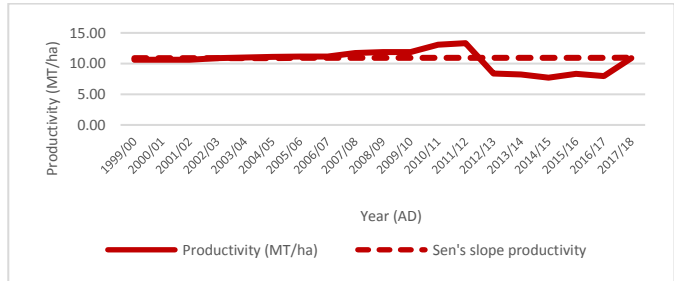


Figure 4. Trend of productivity of mandarin in Kaski (1999/00 - 2017/18)

3.3 Lime

During the period 1999/00 to 2017/18 the percentage decrease in area, productive area and production of lime was 41.96%, 35.48% and 24.84% respectively and the percentage increase in productivity during this period was 16.50%. The descriptive statistics of area, productive area, production and productivity of lime is tabulated in table 7. The maximum area, productive area, production and productivity of mandarin during this period was 52.9 ha, 39 ha, 289 MT and 9.00 MT/ha respectively. From Table 7, the area, productive area and production were right skewed whereas productivity was left skewed. The average annual productivity of citrus fruits for 19 years period from 1999/00 to 2017/18 was 6.58 MT/ha. The productivity was below this annual average in year from 2007/08 to 2009/10. The trend of different parameters have been shown in figure 5 and 6 below.

It is evident from Table 8 that area, productive area and production had decreasing trend during the period of 1999/00 to 2017/18 as indicated by negative value of Tau (τ), and the trend of area, productive area and production were statistically insignificant at 95% confidence level as indicated by p-values. Sen's slope method quantified that the area of lime decreased at the rate of 1.011 ha per year, productive area decreased at the rate of 0.621 ha per year, production decreased at the rate of 3.533 MT per year and productivity increased at the rate of 0.079 MT/ha during this period. There was weak correlation between area and time, productive area and time and production and time and moderate correlation between productivity and time as indicated by absolute value of Kendall's tau.

and productive area of lime production. The average production was 200.88 MT before change point and 61.91 MT after the change point. Decrease in area of lime production, disease, insect-pest and less technical knowledge of farmer may have resulted in decrease in production of lime.

Table 9: Results of Standard Normal Homogeneity test for area, productive area, production and productivity of lime in Kaski

Parameters	p-value	Change point	Mean before change point (μ_1)	Mean after change point (μ_2)
Area (ha)	<0.0001**	2006/07	45.81	11.82
Productive area (ha)	<0.0001**	2006/07	27.21	7.73
Production (MT)	0.0001**	2006/07	200.88	61.91
Productivity (MT/ha)	0.396			

**denotes significant at 1% level of significance

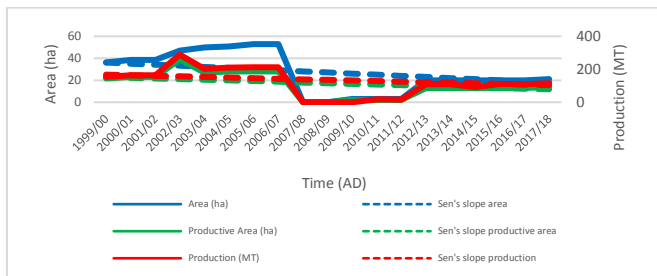


Figure 5: Trend of area, productive area and production of lime in Kaski (1999/00-2017/18)

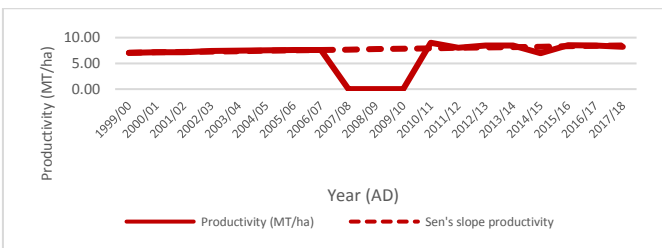


Figure 6: Trend of productivity of lime in Kaski (1999/00-2017/18)

3.4 Lemon

During the period 1999/00 to 2017/18 the percentage decrease in area and productive area of lemon was 44.98% and 27.01% respectively. During this period, the percentage increase in production and productivity of lemon was 1% and 38.37%. The descriptive statistics of area, productive area, production and productivity of lemon is tabulated in table 10. The maximum area, productive area, production and productivity during this period was 21.81 ha, 17 ha, 131 MT and 10.10 MT/ha respectively. From Table 10, the area was right skewed whereas productive area, production and productivity were left skewed. The average annual productivity of lemon for 19 years period from 1999/00 to 2017/18 was 5.70 MT/ha. The productivity was below this annual average in year from 1999/00 to 2002/03 and from 2007/08 to 2012/13. The trend of different parameters has been shown in Figure 7 and 8 below. It is evident from Table 11 that area, productive area and production had decreasing trend during the period of 1999/00 to 2017/18 as indicated by negative value of Tau (τ), but only the trend of area was statistically significant at 95% confidence level as indicated by p-values. Sen's slope method quantified that the area of lemon decreased at the rate of 0.577 ha per year, productive area decreased at the rate of 0.10 ha per year and productivity increased at the rate of 0.039 MT/ha during this period. The Sen's slope of production of lemon is zero. There was moderate correlation between area and time and weak correlation between productive area and time, production and time productivity and time as indicated by absolute value of Kendall's tau.

Table 10: Descriptive statistics for area, productive area, production and productivity of lemon (1999/00-2017/18)

Parameters	Minimum	Maximum	Mean	Median	S.D.	Coefficient of variation (CV) %	Pearson's coefficient of skewness
Area (ha)	0	21.81	12.337	12	9.517	77.140	0.106
Productive area (ha)	0	17	8.458	10	6.982	82.552	-0.663
Production (MT)	0	131	70.579	100	55.947	79.268	-1.578
Productivity (MT/ha)	0	10.10	5.702	7.642	4.178	73.283	-1.394

Table 11: Mann-Kendall test and Sen's Slope estimators for overall area, productive area, production and productivity of lemon in Kaski

Parameters	p-value	Kendall's tau (τ)	Sen's slope	Trend	Significance
Area (ha)	0.018*	-0.445	-0.577	Decreasing	Significant
Productive area (ha)	0.246	-0.214	-0.100	Decreasing	Insignificant
Production (MT)	0.540	-0.115	0.00	Decreasing	Insignificant
Productivity (MT/ha)	0.142	0.264	0.039	Increasing	Insignificant

*denotes significant at 5% level of significance

The SNH test showed that there was significant break in the trend of area (p-value=0.0002) and productive area (p-value=0.016) of lemon in the year 2006/07 at 95% of confidence level and there was homogeneous trend of production (p-value=0.159). The average area of cultivation of lemon was 21.80 ha before change point and 5.46 ha after the change point. The average productive area was 13.84 ha before change point and 4.55 ha after the change point. Land fragmentation, out-migration, industrialization, urbanization and less prioritization to lemon may be the major reasons for the decrease in area and productive area under lemon. Similarly, there was significant break in the trend of productivity (p-value=0.028) in the year 2012/13. The average productivity was 4.16 MT/ha before change point and 10.02 MT/ha after the change point. Citrus rejuvenation, proper orchard management and adoption of new technologies may have resulted in increase in productivity of lemon.

Table 12: Results of Standard Normal Homogeneity test for area, productive area, production and productivity of lemon in Kaski

Parameters	p-value	Change point	Mean before change point (μ_1)	Mean after change point (μ_2)
Area (ha)	0.0002**	2006/07	21.80	5.46
Productive area (ha)	0.016*	2006/07	13.84	4.55
Production (MT)	0.159			
Productivity (MT/ha)	0.028*	2012/13	4.16	10.02

**denotes significant at 1% level of significance and *denotes significant at 5% level of significance

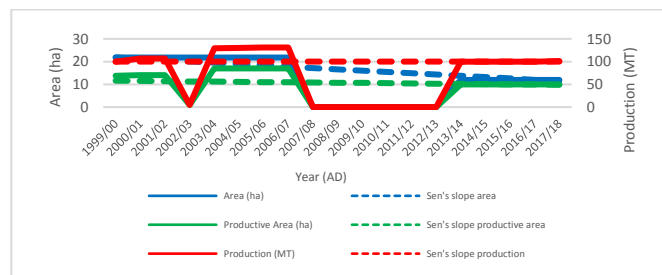


Figure 7: Trend of area, productive area and production of lemon in Kaski (1999/00-2017/18)

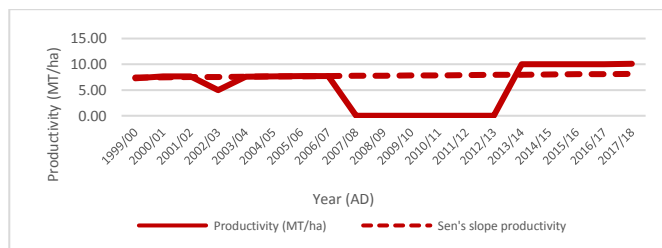


Figure 8: Trend of productivity of lemon in Kaski (1999/00-2017/18)

3.5 Sweet Orange

During the period 1999/00 to 2017/18 the percentage decrease in area, productive area, production and productivity of sweet orange was 78.35%, 76.38%, 77.05% and 2.84% respectively. The descriptive statistics of area, productive area, production and productivity of sweet orange is tabulated in table 13. The maximum area, productive area, production and productivity during this period was 28 ha, 16 ha, 167 MT and 11.00 MT/ha. From Table 13, the area was right skewed whereas productive area, production and productivity were left skewed. The average annual productivity of citrus fruits for 19 years period from 1999/00 to 2017/18 was 8.20 MT/ha. The productivity was below this annual average in year from 2007/08 to 2009/10. The trend of different parameters have been shown in Figure 9 and 10 below.

It is evident from Table 14 that all parameters had decreasing trend during the period of 1999/00 to 2017/18 as indicated by negative value of Tau

(τ), and all the trend of area, productive area and production were statistically insignificant at 95 % confidence level as indicated by p-values. Sen's slope method quantified that the area of citrus fruits decreased at the rate of 1.124 ha per year, productive area decreased at the rate of 0.308 ha per year, production decreased at the rate of 3.545 MT per year and

productivity decreased at the rate of 0.040 MT/ha during this period. There was weak correlation between productive area and time, production and time, area and time and productivity and time as indicated by absolute value of Kendall's tau.

Table 13: Descriptive statistics for area, productive area, production and productivity of sweet orange (1999/00-2017/18)

Parameters	Minimum	Maximum	Mean	Median	S.D.	Coefficient of variation (CV) %	Pearson's coefficient of skewness
Area (ha)	0	28	13.544	13	11.798	87.114	0.138
Productive area (ha)	0	16	7.668	10	6.433	83.895	-1.087
Production (MT)	0	167	75.263	90	65.760	87.373	-0.672
Productivity (MT/ha)	0	11.0	8.202	9.33	3.707	45.186	-0.916

Table 14: Mann-Kendall test and Sen's Slope estimators for overall area, productive area, production and productivity of sweet orange in Kaski

Parameters	p-value	Kendall's tau (τ)	Sen's slope	Trend	Significance
Area (Ha)	0.155	-0.253	-1.124	Decreasing	Insignificant
Productive area (Ha)	0.125	-0.275	-0.308	Decreasing	Insignificant
Production (MT)	0.169	-0.242	-3.545	Decreasing	Insignificant
Productivity (MT/ha)	0.284	-0.193	-0.040	Decreasing	Insignificant

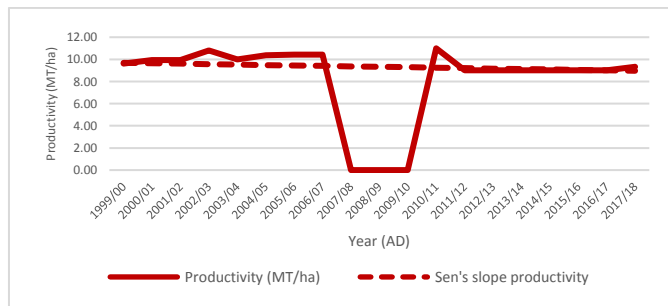


Figure 10: Trend of productivity of sweet orange in Kaski (1999/00 - 2017/18)

The SNH test showed that there was significant break in the trend of area (p-value<0.0001), productive area (p-value=0.002) and productivity (p-value=0.001) of sweet orange in the year 2006/07 at 95% of confidence level and there was homogeneous trend of productivity (p-value=0.418). The average area of cultivation of sweet orange was 26.04 ha before change point and 4.46 ha after the change point. The average productive area was 13.46 ha before change point and 3.46 ha after the change point. Land fragmentation, out-migration, industrialization, urbanization and less prioritization to sweet orange may be the major reasons for the decrease of area and productive area of sweet orange production. Similarly, the average production was 136.75 MT before change point and 30.55 MT after the change point.

Table 15: Results of Standard Normal Homogeneity test for area, productive area, production and productivity of sweet orange in Kaski

Parameters	p-value	Change point	Mean before change point(μ_1)	Mean after change point (μ_2)
Area (ha)	<0.0001**	2006/07	26.04	4.46
Productive area (ha)	0.002*	2006/07	13.46	3.46
Production (MT)	0.001**	2006/07	136.75	30.55
Productivity (MT/ha)	0.418			

**denotes significant at 1% level of significance and *denotes significant at 5% level of significance

4. CONCLUSION

Overall citrus and mandarin have significantly increasing trend whereas lime, lemon, sweet orange is undermined. The gradual increase in adoption of improved citrus production technology by the farmers, technical know-how among the farmers, introduction of improved cultivars and rootstocks, and increasing market demand of citrus are the crucial factors that have contributed to enhanced production and productivity of citrus in Kaski. However, with the limited area for expansion of cultivation area of citrus, increasing the production efficiency is the only way to meet their growing demand. Production efficiency can be further enhanced by overcoming several production related barriers such as poor-quality sapling, lack of commercialization, poor orchard management, dependency over local varieties having low yield, few rejuvenation programs, technology associated constraints, inadequate training to farmers, limitation on land holding, etc.

ACKNOWLEDGEMENT

The authors would like to acknowledge Agriculture and Forestry University as well as PMAMP for giving an opportunity to carry out the secondary data analysis as a part of our internship. We would like to thank all the helping hands who helped us during the data analysis.

CONFLICT OF INTEREST

The authors indicate no conflict of interest.

REFERENCES

Acharya, B.B., 2015/16. Technology of Citrus Fruit Cultivation (in Nepali). Kritipur, Kathmandu: National Citrus Development Programmed.

ADS. 2016. Agriculture Development Strategy. Kathmandu: Ministry of Agricultural Development.

APP. 1995. Agriculture Perspective Plan. National Planning Commission.

Bhattarai, R.R., Rijal, R.K., Mishra, P., 2013. Post-harvest losses in mandarin orange: A case study of Dhankuta District, Nepal. African Journal of Agriculture Research, 8 (9), Pp. 763-767.

Devkota, S. 2017. Retrieved from academia.edu

Dhakal, D.D., Tripathi, K.M., Bhattarai, S., 2005. Marketing Survey of Acid Lime and Hill Lemon in Nepal. Journal of the Institute of Agriculture and Animal Science, Pp. 26.

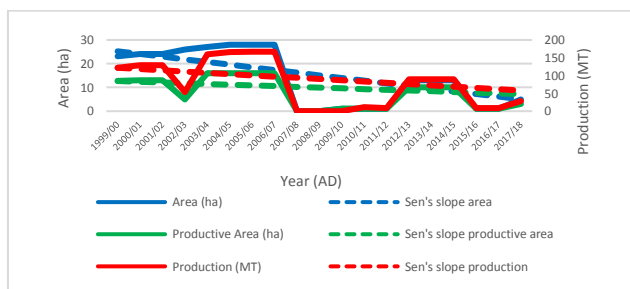


Figure 9: Trend of area, productive area and production of sweet orange in Kaski (1999/00 -2017/18)

- Dinpashoh, Y., Jhajharia, D., Fakheri-Fard, A., Singh, V.P., Kahya, E., 2011. Trends in reference crop evapotranspiration over Iran. *Journal of Hydrology*, Pp. 422-433.
- FAO. 2019. FAOStat. Food and Agriculture Organization.
- Gajbhiye, S., Meshram, C., Mirabbasi, R., Sharma, S.K., 2016. Trend Analysis of rainfall time series for Sindhu river basin in India. *Theoretical and Applied Climatology*.
- Godara, C.P., Bhonde, S.R., 2006. Market Arrivals and Price Trend of Important Fruits at Azadpur Mandi, Delhi. *Indian Journal of Marketing*, 36 (11).
- Hirsch, R.M., Helsel, D.R., Cohn, T.A., Gilroy, E.J., 1993. Statistical analysis of hydrologic data. In *Handbook of hydrology*, 17, Pp. 11-55.
- Kaini, B.R., 2019. myRepublica. Retrieved from <https://myrepublica.nagariknetwork.com/news/can-nepal-export-citrus-fruits/>
- Karki, S., Rizal, G., Manandhar, R., Atreya, P.N., Gotame, T.P., 2017. Minor Fruits in Nepal: Utilization and Conservation Efforts. *Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal*.
- Kendall, M.G., 1975. Rank correlation methods (4 ed.). (C. Griffin, Ed.) London.
- LGCDP. 2020. Map of Kaski District. Retrieved from <http://lgcdp.gov.np/>
- Mann, H.B., 1945. Nonparametric Tests Against Trend. *Econometrica*, 13 (3), Pp. 245-259.
- Meals, D.W., Spooner, J., Dressing, S.A., Harcum, J.B., 2011. TechNotes 6. Retrieved from <https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/nonpoint-source-monitoring-technical-notes>.
- MoALD. 2018. Information on Nepalese Agriculture Statistics (2074/75). Kathmandu: Ministry of Agriculture and Livestock Development.
- MOALD. 2019. Krishi Diary. Kathmandu: Agriculture Information and Training Centre.
- MOF. 2018. Economic Survey 2017/18. Kathmandu: Ministry of Finance.
- NCDP. 2015/16. National Citrus Development Programme.
- NCDP. 2018. National Citrus Development Programme.
- NHPC. 2017. Fruit Development Project Report. Fruit Development Directorate.
- NPC. 2019/20. 15th Plan (2019/20-2023/24). National Planning Commission.
- Pandey, G., Basnet, S., Pant, B., Bhattarai, K., Gyawali, B., Tiwari, A., 2017. An Analysis of Vegetables and Fruits Production. *Asian Research Journal of Agriculture*, 6 (3), Pp. 1-10.
- Panth, B.P., Dhakal, S.C., 2019. Determinants of Mandarin Productivity and Causes of Citrus Decline in Parbat District, Nepal. *Acta Scientifica Agriculture*, 3 (10).
- Pokhrel, C.N., 2011. Analysis of market chain of mandarin in Nepal: A case of Lamjung district. Van Hall Larenstein University of Applied Science.
- Scora, R.W., 1975. On the history and origin of citrus. *Bulletin of the Torrey Botanical Club*, Pp. 369-375.
- Sen, P.K., 2012. Estimates of the Regression Coefficient Based on Kendall's Tau. *Journal of the American Statistical Association*, Pp. 1379-1389.
- Sharma, L.P., 2016. Diseases wiping out orange crop in Pokhara. *The Kathmandu Post*.
- Silalahi, D.J., 2002. Anticancer and health protective properties of citrus fruit components. *Asia Pacific Journal of Clinical Nutrition*.
- TCP. 2011. Combating Citrus Decline problem in Nepal. Technical Cooperation Project.
- Thapa, M.B., Dhimal, S., 2017. Horticulture Development in Nepal: Prospects, Challenges and Strategies. *Universal Journal of Agricultural Research*, 5 (3), Pp. 177-189.
- Turner, T., Burri, B.J., 2013. Potential Nutritional Benefits of Current Citrus Consumption. *Agriculture*, 3 (1), Pp. 170-187.

