RESEARCH ARTICLE

TREND, GROWTH RATE AND INSTABILITY ANALYSIS OF PRODUCTION, PRODUCTIVITY, AREA AND SUPPLY OF POTATO IN KAVREPALANCHOK DISTRICT, NEPAL

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ABSTRACT

A study was carried out to assess the trend of area, production, productivity and supply of potato in Kavre district, Nepal. The time-series data (1999/00 to 2017/18) were collected from the "Statistical Information on Nepalese Agriculture" published yearly by the Ministry of Agriculture and Livestock Development, Nepal and the data of potato (red and white) supply from Kavre to Kalimati wholesale market from 2000/01 to 2019/20 was collected from the official website of Kalimati market. The data were entered and analyzed using Microsoft Excel and XLSTAT. Mann-Kendall test (M-K) and Sen's slope method were used for trend analysis. The results showed that the potato cultivation area increased by 341.786 ha/year, production increased by 8323.933 Mt/year and productivity increased by 0.231 Mt/ha/year from 1999/00 to 2017/18. Similarly, the red potato supply from Kavre to the Kalimati market increased by 13.412 Mt/year and the white potato supply decreased by 234.174 Mt/year during the period from 2000/01 to 2019/20. The instability analysis showed 34.41%, 41.36% and 11.16% coefficient of variation for area, production and productivity while red potato and white potato supply showed 11.64% and 107.86% variation. The average annual growth rates for area, production and productivity of potato were 6.02%, 8.83% and 2.43%, respectively. Similarly, growth rate of red potato supply was 3.91% per annum while white potato supply decreased at the compound annual growth rate of 19.61%. Thus, an increasing trend of area, production and productivity and supply of potato along with a positive growth rate for the potato can be seen in the Kavre district. Findings from this study could be used to suggest necessary policy guidelines for future production and marketing strategies of potato in Kavre.

KEYWORDS

Productivity, Trend analysis, Supply, Instability, Policy

1. INTRODUCTION

Agriculture is the major occupation of Nepalese and it shares a great part of the national economy in Nepal (Ghimire et al., 2018). The agriculture sector contributed 27.58% of the total GDP of the country in the year 2017/18, which in monetary terms accounts to be 9.8 billion dollars (MoF, 2019; MoALD, 2018). About 60.4% population of Nepal is involved in agriculture (AITC, 2020). Horticulture is an inseparable component of Nepalese agriculture. as 21.42% of AGDP (Agricultural GDP) has been contributed by the horticulture sector with vegetables holding the share of 8-10% (Ahamad et al., 2020). The prevalence of varied topography and diverse microclimatic conditions in Nepal favors the cultivation of different types of vegetables ranging from tropical to subtropical to temperate (Banjade et al., 2019).

Potato (*Solanum tuberosum*) is one of the major vegetables of Nepal (Banjade et al., 2019). The share of potato to Gross Domestic Product (GDP) and Agriculture Gross Domestic Product (AGDP) during 2016/17 was 2.17% and 6.57%, respectively (ABPSD, 2016). Potatoes are grown in a wider ecological zone in Nepal ranging from 100 masl in the south to 4000 masl in the north (Shrestha and Yadav, 2018). Kavre, Dadeldhura,

Kailali and Nuwakot are major potato producing districts of Nepal (MoALD, 2017). Potato is an important crop in our country. But, the area coverage, production and productivity are very low as compared to our neighboring countries. Nepal lags behind Pakistan, India, Bangladesh and Sri Lanka where the productivity of potato is 22.517 Mt/ha, 22.306 Mt/ha, 20.443 Mt/ha and 16.459 Mt/ha respectively (Potatopro, 2017). The productivity of potato in the world is 20.1108 Mt/ha (Potatopro, 2017) while in Nepal it is 14.765 Mt/ha (MoALD, 2017). Nepal is facing problems in the production of potatoes with optimum efficiency. The productivity averaged over 3 years (2014/2015, 2015/2016, 2016/2017) is 14.3 Mt/ha and the production potential is 17 Mt/ha (ADS, 2016). So, there is a productivity gap of almost 3 Mt/ha.

In terms of production and productivity, Kavre district ranks first in Nepal (Banjade et al., 2019). Despite being the top producer, there is still a lack of knowledge among farmers regarding the selection of the right seed and proper use of chemical and organic fertilizers (The Himalayan Times, 2005). Farmers' own stored seed was very high in Kavre while the quantity of seed obtained from agro-vets and government R&D programs was very low (Gairhe et al., 2017). In Kavre, only 8.33% of the households are food secure for 12 months while 9.99% of the households are self-

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sufficient for 9 to 12 months (MoAD, 2016). This indicates the majority of the households are not food self-sufficient. Kavre is connected to Kathmandu by the Araniko highway. The temporal growth in potato area, production, productivity and supply in Kavre has not been assessed and analyzed. Potato is a high value cash crop for Nepalese farmers. It can be a good source of income for the farmers in Kavre as potato harbors more return per unit area compared to wheat and mustard that share the same growing season (Dhital, 2017).

In this light, our study analyses the data of production, area, productivity and supply to help understand the status of potato cultivation, formulate necessary policies, make plans for mechanization and prepare for agribusiness activities. The information from this study will also help in planning related to trade, and march towards import substitution and export promotion. The other significance of the study could be that the stakeholders will be able to realize the potential and work collectively to maintain the optimum level of production. The study will be a guideline for policy formulation regarding agriculture land use, production pattern, management of collection centers, marketing activities and program implementation (Aryal et al., 2021). Furthermore, the study will help to identify the time periods, where insufficient growth has been observed and further study on the agricultural policies could be made (Ghimire et al., 2018). This study focuses on production trend and factors affecting production which is of utmost need to commercialize the potato subsector. The productivity trend will aware the farmers about the use of the right source of seed. Thus, conducting this type of trend research can assist farmers to get an optimum benefit from the produce and get insight on marketing situation. The overall aim of the research is to analyze the trend of potato production and supply, and make necessary plans for agricultural land use and opt for better marketing and supply system. In a nutshell, it will help farmers to optimize their production and productivity owing to the factors of production.

2. MATERIALS AND METHODS

2.1 Site of the study

This study was carried out for the Kavre district of Nepal. This district was selected for study due to its availability of the required data and its popularity for potato production in Nepal. Farmers in Kavre can raise and harvest potato thrice a year in Magh/Falgun, Baisakh/Jestha and Ashoj/Kartik (The Himalayan Times, 2005). Different projects from government and non-government sectors are being implemented in the district to support the commercialization of the potato sub-sector. The government of Nepal-led 'Prime Minister Agriculture Modernization Project (PMAMP)' is in the active implementation stage with the establishment of the Potato superzone in Kavre. In addition, the Value Chain Development of Fruit and Vegetables Project (VCDP), Nepal, has been implementing different activities to support potato growers and markets in Kavre.

2.2 Collection of the data and data analysis

The data for the study were mainly collected from secondary sources. The time-series data were collected, focusing more on quantitative data related to production, area, productivity and supply of potato from 1999/00 to 2017/18. The major sources of secondary data were various publications from MoALD and the official website of KFVMD (2019) (Kalimati Fruits and Vegetable Market Development Board). Time series data on area, production and productivity of potato was collected from "Statistical Information on Nepalese Agriculture" published each year by MoALD for 19 years period from 1999/2000 to 2017/2018. Similarly, the quantity of red and white potato supplied to Kalimati fruits and vegetable market from Kavre district from 2000/2001 to 2019/2020 was collected from Kalimati Fruit and Vegetable Market Development Board official website. The data gathered were coded, and entered in Microsoft Excel. The data were analyzed to draw meaningful inferences by using MS Excel and XLSTAT. The data were analyzed using descriptive and statistical tools for the mean comparison, correlation analysis, instability analysis, regression analysis. For the trend analysis, the Mann-Kendall test was used for time series data of area, production, productivity and supply of potato. The findings were presented as tables, figures and graphs. The following analysis were carried out.

2.3 Trend analysis of area, production, productivity and supply

Mann-Kendall test is a non-parametric test initially developed by Mann (in 1945) and Kendall (in 1975) that is used to detect a monotonic trend in time-series data. A monotonic trend means the gradual change over time that is consistent in direction. The null hypothesis (H_0) for this test is, "there is no monotonic trend in time series" and the alternative hypothesis (H_1) for this test is, "there is a monotonic trend in time series" (Meals et al., 2011). In this study, the conclusion about if monotonic trends existed in the given time series data was made using the p-value obtained in the Mann-Kendall test. If the p-value was less than the level of significance ($\alpha = 1\%$) i.e., 0.01 null hypothesis was rejected, and it was concluded that there was a monotonic trend in the time series data. Failure to reject the null hypothesis ($p > 0.01$) would conclude that there is no monotonic trend in the time series data.

The conclusion about how strongly the two variables were monotonically related was made based on Kendall's correlation coefficient, generally known as the Kendall's tau (τ). The correlation coefficient is the measure of quantifying and testing the strength of a monotonic relationship between two variables. Kendall's tau (τ) is an effective and general non-parametric method of measuring the correlation between two variables. Kendall's correlation coefficient 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 the absolute value indicates the strength of the relationship (Hirsch and Helsel, 1993). In this study, the magnitude of the trend was computed by a simple non-parametric method developed by Sen (in 1968) which is commonly called Sen's slope. The linear model assumed was:

$$Y = \alpha + \beta t$$

Where,

β = slope, α = intercept, Y = dependent variable and, t = time i.e. independent variable.

The positive value of Sen's slope (β) indicates an upward trend and the negative value represents a downward trend. The regression line was plotted based on the Sen's slope and intercept to visualize the trend. These methods were used to analyze time series data for area, production, and productivity as well as supply of red and white potato from Kavre to Kalimati market and further to detect the presence of linear trend as well. Microsoft Excel program and XLSTAT tool for Ms. Excel program were used for data analysis and visualization of data.

2.4 Regression of production on area

The regression analysis was done by fitting a regression line to the scattered plot diagram of area vs production. The regression equation thus obtained was used for further interpretation of the R^2 value.

2.5 Growth rates of area, production, productivity and supply of potato

The annual growth rate of area, production, productivity and supply of potato for each year was calculated in percentage terms and an overall average annual growth rate was calculated.

$$\begin{aligned} \text{Annual Growth Rate}_t &= \frac{\text{value in } t^{\text{th}} \text{ year} - \text{value in } (t-1)^{\text{th}} \text{ year}}{\text{value in } (t-1)^{\text{th}} \text{ year}} \\ &\quad * 100\% \end{aligned}$$

$$\text{Average Annual Growth Rate} = \frac{\text{sum of annual growth rates}}{\text{Total no of years in between}}$$

Also, compound annual growth rate (CAGR) was computed assuming the trend as linear

$$\text{CAGR} = \left(\frac{\text{Final value}}{\text{Initial value}} \right)^{1/\text{years}} - 1 * 100\%$$

2.6 Instability analysis

The coefficient of variation (CV) is a statistical measure of the dispersion of data points around the mean. The coefficient of variation represents the ratio of the standard deviation to the mean. Standard deviation is a measure of the amount of variation of a set of values while mean is the central value of a discrete set of numbers. Coefficient of variation (CV) is calculated as:

$$CV = \frac{\sigma}{\mu} * 100\%$$

Where, σ =standard deviation, μ =mean

The CV calculated was used to analyze the stability of area, production, productivity and supply.

2.7 Coefficient of skewness estimation

The coefficient of skewness is a statistical measure that shows how much the sample distribution differs with normal distribution. The sign of the skewness value shows the direction of skewness. Coefficient of skewness (CS) is calculated as;

$$CS = \frac{3(\mu - Md)}{\sigma}$$

Where;

σ =standard deviation, μ =mean and Md = median.

3. RESULTS AND DISCUSSION

3.1 Trend of potato production and supply

3.1.1 Trend of potato production and area under cultivation

The observation of the original series as seen in Figure 1. below, shows an increased production during the period 1999/2000 to 2003/2004. The production then declined slightly in the next year 2004/2005. The production again increased consistently till 2008/2009. The production rose sharply in the next year 2009/2010 which remained consistent for 3 years until it declined in the year 2012/2013. After that, production increased continuously. The area under potato was more or less increasing during the whole period from 1999/2000 to 2017/2018. The area rose sharply in the year 2009/2010 and this is one of the reasons for increased production in the year 2009/2010. The percentage increase in area and production of potato in 2017/2018 compared to 1999/2000 was 144.62% and 267.87% respectively. The highest production during the period was 198653 Mt in the year 2017/2018. The least production was observed in the year 1999/2000 with production of 54000 Mt. Similarly, maximum area coverage was observed in two different years 2015/2016 and 2017/2018 with area 9785 ha. There was least area coverage under potato in the year 1999/2000 with area coverage of 4000 ha. The area of potato is continuously increasing since 1999/00. However, the production of potato is increasing at a faster rate than the increment in area. According to the area under potato cultivation and production in Kavre increased by 1.37% and 0.7% from 2003/04 to 2007/08 (YAU-JICA, 2016). However, productivity decreased by 0.68% during the period.

Table 1: Mann-Kendall test and Sen's slope estimators for area, production and productivity of potato in Kavre, Nepal.

Parameter	p-value	Tau(τ)	Sen's slope	Trend	Significance	Alpha(α)
Area (ha)	< 0.0001	0.928	341.786	Increasing	significant	0.01
Production (Mt)	< 0.0001	0.921	8323.933	Increasing	significant	0.01
Productivity	< 0.0001	0.761	0.231	Increasing	significant	0.01

It is evident from Table 1 that area and production had increasing trend during the period of 1999/2000 to 2017/2018 as indicated by positive value of Tau (τ). The p-value signifies that trend of area and production was statistically significant at 99% confidence level. The Sen's slope method revealed that the area of potato increased at the rate of 341.786 ha per year

and production increased at the rate of 8323.933 Mt per year during the period. The Kendall's tau value showed that there was very strong correlation between area and time as well as strong correlation between production and time.

Figure 1: Production trend of potato in Kavre from 1999/00-2017/18

3.1.2 Productivity trend

From the Figure 2. below, productivity was seen more or less increasing

during the whole period from 1999/2000 to 2017/2018. There was a sharp rise in the productivity of potato during the period from 2001/02 to 2003/04. During the whole period of study, productivity increased by

50.39%. The highest productivity was observed in the year 2017/18 and the lowest productivity was observed in the initial year of study 1999/2000. Less fluctuation was observed in the productivity trend compared to area and production trend. The result of the Mann-Kendall test and Sen's slope estimators for variation in productivity is shown in Table 1 above, which revealed that productivity had an increasing trend during the period of study as indicated by the positive value of tau (τ). The p-value is less than

alpha which signifies that the increasing trend of productivity is statistically significant even at 99% confidence interval. Sen's slope value from the table depicted that productivity was increasing at the rate of 0.231 Mt/ha annually during the period from 1999/2000 to 2017/2018. There was a strong correlation between productivity and time as indicated by the tau value; however, the correlation was weak compared to the correlation of area and time; production and time.

Figure 2: Trend of productivity of potato in Kavre from 1999/00-2017/18.

3.1.3 Supply trend

The observation of the original series from Figure 3. below revealed that there were fluctuations in the supply of red potato from Kavre to Kalimati market. However, the supply never decreased below the initial year's supply. During the period of study from 2000/01 to 2019/20, the supply of red potato increased by 54.58%. In the case of white potato, supply decreased constantly with a marked fluctuation in the midyear. The supply of white potato from Kavre to the Kalimati market decreased by 98.4% from 2000/01 to 2019/20. From table 2 below, the Mann-Kendall test showed that the trend of supply of red potato was increasing as indicated

by the positive value of tau. However, the increase was not significant at 99% and even 95% confidence interval as p-value exceeded alpha value. Sen's slope method quantified that the supply was increasing at the rate of 13.412 Mt per year. In the case of white potato supply, a decreasing trend was observed as indicated by the negative tau value. p-value was lower than alpha which revealed that the trend is significant. The supply decreased by 234.174 Mt per year during the period as revealed by Sen's slope value. The slope for red potato is almost constant as the production is increasing constantly. However, the slope for white potato is declining as the supply has been decreasing severely.

Table 2: Mann-Kendall test and Sen's slope estimators for potato supplied from Kavre to Kalimati market.						
Parameter	p-value	Tau(τ)	Sen's slope	Trend	Significance	Alpha(α)
Red potato supply	0.922	0.021	13.412	Increasing	Insignificant	0.01
White potato supply	< 0.0001	-0.674	-234.174	Decreasing	Significant	0.01

Figure 3: Trend of supply of potato from Kavre to Kalimati market from 2000/01-2019/20.

Volume of red potato received in Kalimati market based on source in 2019/2020

Figure 4: Volume of red potato received in Kalimati market based on source in 2019/2020.

While evaluating the supply of red potato to the Kalimati market from different sources, as seen in figure 4 above, in the year 2019/20, India occupied the highest market share of the red potato, which accounted to 58% of the total red potato in the Kalimati market. This was followed by Kavre which supplied 19% of the produce. Similarly, Kathmandu, Dolakha, Sindhupalchok, Nuwakot and Makwanpur were the other major suppliers that contributed 6%, 4%, 3%, 2% and 1%, respectively.

Volume of White Potato received in Kalimati market based on source in 2019/2020

Figure 5: Volume of white potato received in Kalimati market based on source in 2019/2020.

While evaluating the supply of white potato from different sources to the Kalimati market, as seen in figure 5, it was observed that in the year 2019/20, India was the major supplier of white potato in the Kalimati market accounting 92% of the supply followed by Kavre district, contributing 2% of the total supply of white potato to the Kalimati market from different sources. Makwanpur, Kathmandu, Dolakha and Rupandehi were the other major suppliers of the white potato which contributed 1% each to the total supply. The dependency of Nepalese potato market on India has existed from long time ago. Out of the 76 Mt of potato arriving daily to the Kalimati Market, 10% are imported from India. A huge supply comes from Kavre district but when it runs out of stock, potato from India and Bhutan occupy the major share in the Kalimati fruit and vegetable market (Kathmandu Post, 2014).

3.1.4 Regression of area and production

Figure 6 :1 Regression of area and production of potato

The coefficient of determination r^2 computed from the linear regression method was found to be 0.981, which reveals that 98.1% of the variation in production can be explained by the variation in area. Remaining 1.9% variation is unexplained by the variation in area.

3.1.5 Growth rates of area, production and productivity of potato

The growth rates have been shown in table 3 in appendices. During the period of study from 1999/2000 to 2017/2018, varying growth rates for area under potato cultivation was observed. Annual Growth rate for the area ranged from -0.41% to 70.8% with no or null growth rate in 6 different years. On an average, the area under potato cultivation increased at the rate of 6.02% per annum. Area under potato increased by 12.5% in the second year of study (2000/01) compared to the first year. Null growth was observed in the following year. Furthermore, the area again increased and remain constant till 2013/14. The area decreased by 0.15% in the year 2014/15 compared to the previous year. The area is increasing in the whole period except 2014/15 and 2016/17 where it decreased by 0.15% and 0.41% than the previous year respectively.

Table 3: Growth rates of the area, production and productivity of potato in Kavre

Year	Area AGR (%)	Production AGR (%)	Productivity AGR (%)
1999/00			
2000/01	12.5	12.96	0.41
2001/02	0	0	0
2002/03	11.11	31.31	18.18
2003/04	0	15.48	15.48
2004/05	1	-6.86	-7.79
2005/06	0	3.48	3.48
2006/07	0	0	0
2007/08	5.94	5.61	-0.31
2008/09	1.01	0.49	-0.51
2009/10	70.80	80.47	5.67
2010/11	0	0	0
2011/12	5.04	5.04	0
2012/13	0	-6.68	-6.68
2013/14	0.77	8.34	7.51
2014/15	-0.15	0.05	0.20
2015/16	0.31	1.77	1.46
2016/17	-0.41	0.67	1.08
2017/18	0.41	6.88	6.45
Average annual growth rate	6.02	8.83	2.48
Compound annual growth rate	5.09	7.51	2.29

Similarly, annual growth rate of potato production ranged from -6.86% to 80.47%. No growth was observed in the 3 different years. Average annual growth rate for the potato production was found to be 8.83% per annum. The production is increasing in the whole period of study from 1999/00 to 2017/18 except for 2004/05 and 2012/13, where it decreased by 6.86% and 6.68% compared to the previous years, respectively. In the case of productivity, the annual growth rates ranged from -7.79% to 18.18%. Compared to area and production, productivity changed by relatively few percentages. This could be due to the productivity being a more fixed character and it is determined mostly by the genotype of potato. On an average, the productivity increased by 2.48% per annum. The productivity was increasing in the whole period of study from 1999/00 to 2017/18 except 2004/05, 2007/08, 2008/09 and 2012/13

3.1.6 Growth rates of the supply of white and red potatoes

The growth rates of supplies have been shown in table 4 in appendices. The supply of red potato from Kavre to the Kalimati market increased by 3.91 % per annum during the period of 19 years from 2000/01 to 2019/20. Maximum of 39.549 % annual growth rate was observed while growth rate reached negative value up to -22.699%. The supply of red potato is increasing throughout the period except the years 2003/04, 2005/06, 2007/08, 2009/10, 2011/12, 2012/13, 2014/15, 2015/16 and 2016/17 where it decreased by 3.096%, 12.23%, 22.69 %, 16.21%, 2.96%, 16.87%, 13.05%, 0.39% and 14.81% than their previous years, respectively. In the case of white potato supply, the supply increased by 92.73% each year according to formula for average annual growth rate which is not possible as it is in decreasing trend. Hence, Compound annual growth rate was calculated.

Table 4: Growth rates of the supply of red and white potato from Kavre to Kalimati market

Year	Red potato AGR (%)	White potato AGR (%)
2000/01		
2001/02	31.323	24.7985
2002/03	6.871	-35.1092
2003/04	-3.096	-27.75
2004/05	2.108	-26.8891
2005/06	-12.230	12.46563
2006/07	16.872	143.1702
2007/08	-22.699	-41.0129
2008/09	37.403	-68.0107
2009/10	-16.211	-27.1987
2010/11	8.364	-85.6957
2011/12	-2.968	108.3945
2012/13	-16.871	321.0676
2013/14	39.549	-18.2895
2014/15	-13.052	-76.2166
2015/16	-0.398	-83.7188
2016/17	-14.807	1781.172
2017/18	3.492	-34.9125
2018/19	1.133	-35.7031
2019/20	29.451	-68.6122
Average annual growth rate	3.907	92.73419
Compound annual growth rate	2.31	-19.61

Area under potato coverage in Kavre district is increasing at the rate of 321.38 ha per year during the period from 1999/00 to 2017/18 which is compounding at the rate of 5.09% per annum. Similarly, production increased at the rate of 8036.28 Mt per year, compounding at the rate of 7.51% per annum. In the case of productivity, the annual increase is 0.38 Mt/ha that is compounding at the rate of 2.29% per annum. The supply of red potato from Kavre to the Kalimati market increased at the rate of 226.89 Mt per year during the period of 2000/01 to 2019/20, which is compounding at the rate of 2.31% per annum. But, the supply of white potato is decreasing, annually by 247.87 Mt per year, declining at the compound rate of 19.61% per annum.

3.1.7 Descriptive statistics of area, production, productivity and supply over the period

The average area, production and productivity of potato during the period was 7136.52 ha, 127470.39 Mt and 17.41 Mt/ha respectively. Similarly, the average supply of red potato was 10307.21 Mt while 1804.05 Mt of white potato was supplied to Kalimati market on an average from Kavre district to Kalimati market during the study period.

Table 5: Descriptive statistics for different parameters.

Parameter	Min value	Max value	Mean	Median	Standard deviation
Area (ha)	4000	9785	7136.52	5404	2456.52
Production (Mt)	54000	198653	127470.39	94615	52768.25
Productivity (Mt/ha)	13.5	20.31	17.41	17.65	1.94
Red potato supply (Mt)	7899.2	12214.81	10307.21	10553.93	1200.21
White potato supply (Mt)	30.54	5971.6	1804.05	876.96	1945.87

3.1.8 Instability analysis of area, production, productivity and supply of potato

In order to study the instability in the area, production and productivity along with the supply of potato in Kavre, coefficient of variation was worked out for the overall time period. The table 6 shown below revealed that the maximum variability 107.86% was observed in supply of white potato while the minimum variability 11.16% was observed in the productivity. Compared to the supply of white potato, very low variability was observed in the supply of red potato indicating the unstable supply of white potato. Similarly, medium variability was observed in the area and production. The coefficient of variation for area was 34.41% while it was 41.39% for the production.

Table 6: Instability analysis of the production and supply of potato in Kavre, Nepal.

Parameter	Coefficient of Variation (%)
Area (ha)	34.41933055
Production (Mt)	41.39648073
Productivity (Mt/ha)	11.16232905
Supply (red) (Mt)	11.64433644
Supply(white) (Mt)	107.8611318

3.1.9 Coefficient of skewness for the area, production, productivity and supply of potato

The table 7 revealed that the area, production and supply of the white potato were positively skewed while productivity and supply of red potato were negatively skewed. This signifies that mass of distribution is concentrated on the left in case of area, production and supply of white potato while mass of distribution is concentrated on the right in case of productivity and supply of the red potato. The sample distribution differs by maximum from normal distribution in case of area and by the least in case of the productivity.

Table 7: Coefficient of skewness for the area, production, productivity and supply of potato in Kavre, Nepal.

Parameter	Coefficient of skewness
Area (ha)	2.11
Production (Mt)	1.87
Productivity (Mt/ha)	-0.37
Supply of red potato (Mt)	-0.61
Supply of white potato (Mt)	1.42

Similar results on the increment in the trend of potato and vegetables have been reported by some trend analysis research. A group researchers reported that the trend of vegetable productivity has been increasing in Nepal from 1992 to 2017 (Pandey et al., 2017). Similarly, a study reported that between 1977/78 and 2016/17 the area under vegetable cultivation has jumped by 222.8% while production has increased by 728.21% and productivity has increased by 156.6% (Ghimire et al., 2018). The increasing trend of vegetable production and productivity, especially potato could be attributed to favorable climatic condition, availability of

quality seed tuber and fertilizers to some extent, improved management practices, mechanization in potato farming along with area expansion and the use of new high yielding varieties, along with the introduction of PMAMP project and implementation of ADS (Siddique et al., 2015). It could also be due to the change in the cropping pattern from seasonal to off seasonal and use of improved seed and technology extension as explained (Gurung, 2005).

The overall increment in the area and supply of potato could be attributed to the profitability and commercialization advantage of the vegetables sector, especially potato (Bajracharya and Sapkota, 2017). The difference in the trend results and growth rate with other literature could be due to data sets of different years. The increase in the supply of red potato could be attributed to the development of road infrastructure and high demand for potato in Kathmandu while the decrease in the supply of white potato could be due to the decrease in area of cultivation and low demand (Yau-Jica, 2016). Besides, the potato growers of Nepal are now more receptive to new red-potato varieties than white-skinned ones (Upadhyay et al., 2020). Thus, the production can be further enhanced by the timely supply of quality seed and fertilizer to all commercial and marginalized farmers. To maintain the comparative advantages, the Kavre potato industry needs improvement in the research facility and modern technology. The pricing policy of the government also plays a key role in increasing potato production and income. Likewise, the increasing supply of red potato can assist the government to plan for import substitution.

4. CONCLUSION

From our current study, the potato cultivation area was found to increase by 341.786 ha/year, production increased by 8323.933 Mt/year, and productivity increased by 0.231 Mt/ha/year. Similarly, the red potato supply increased by 13.412 Mt/year and the white potato supply decreased by 234.174 Mt/year. The average annual growth rates for area coverage, production, and productivity of potato were 6.02%, 8.83%, and 2.43% respectively. Similarly, the supply of red potato increased by a growth rate of 3.91% per annum while the compound annual growth rate was 2.31% per annum. In the case of white potato supply, supply decreased at the compound annual growth rate of 19.61%. Thus, there is an overall increasing trend of area, production, and productivity of potato in Kavre district, Nepal. The supply of red potato is also increasing at a good rate. Findings from this study could be used to suggest necessary policy guidelines for future production and marketing strategies of potato in the district.

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ABBREVIATIONS

Ha = hectares, Mt = metric tonnes, PMAMP = Prime Minister Agriculture Modernization Project, R&D = Research and Development.

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