ZIBELINE INTERNATIONAL™ PUBLISHING

Malaysian Journal of Sustainable Agriculture (MJSA)

DOI: http://doi.org/10.26480/mjsa.01.2022.29.37

ISSN: 2521-2931 (Print)
ISSN: 2521-294X (Online)
CODEN: MJSAEJ

RESEARCH ARTICLE

TREND ANALYSIS OF AREA, PRODUCTION, PRODUCTIVITY, AND SUPPLY OF POTATO IN SINDHULI DISTRICT AND NEPAL: A COMPARATIVE STUDY

Amrita Paudel*, Koshis Babu Basnet, Anish Paudel, Bikash Gurung, Uttam Poudel

Agriculture and Forestry University, Chitwan, Nepal
****Corresponding Author E-Mail: Pdlamr1998@gmail.com***

ARTICLE DETAILS

Article History:

Received 02 August 2021
Accepted 15 September 2021
Available online 14 October 2021

ABSTRACT

The study; conducted from January, 2020 to June, 2020; focuses on the comparative study of the area, production, and productivity trend of potatoes over 50 years in Sindhuli district and Nepal and a brief overview on quantity supply to the Kalimati fruits and vegetable market. The time-series data from 1968/69 to 2017/18 of Sindhuli and Nepal along with 6 years supply data (2013/14-2018/19) from different districts to Kalimati market were collected from reliable sources (Ministry of Agriculture and Livestock Development and Kalimati Fruits and Vegetable Market Development Board) and analysis was done using Microsoft Excel. Between 1968/69 and 2017/18, the area under potato cultivation in Nepal and Sindhuli has changed by 573 percent and -46 percent respectively while production increased by 907.6 percent in Nepal and 46 percent in Sindhuli. After 1982 dramatic shift in production was observed in Nepal as there was 7 percent of growth rate while in Sindhuli, the production trend highly fluctuates throughout the period. The average yield was 9.75mt/ha and 8.75mt/ha for Nepal and Sindhuli district. Sindhuli district contributes 1.16 percent of Nepalese potato growing area and 0.91 percent of Nepalese potato production. The trend of quantity supply reveals that during 6 years, Indian potato contributes 58 percent of the total amount that came into Kalimati market, while within-country Kavre has the largest share of 19 percent followed by Kathmandu-6 percent and Dolakha-4 percent. However, the trend of quantity supply of potatoes seems highly fluctuating and the Nepalese market is dominated by Indian imports.

KEYWORDS

Trend analysis, Potato Production, Annual Growth Rate, Supply.

1. INTRODUCTION

Agriculture is an important practice in the Nepalese community as a source of food, employment, income generation, and well-being. Agriculture occupies 65.1 percent of people, contributing 31.23 percent of GDP, with the horticulture sub-sector accounting for 21.42 percent (Ghimire et al., 2018). There is a 2.4 percent annual increase in agricultural production but could not maintain with a 2.6 percent annual increase in population (Wikipedia, 2020).

Potato *(Solanum tuberosum)* is a major vegetable crop which is more productive than cereal and has high economic value than cereals and it is cultivated in altitude of 100m in southern terai and up to 4000 m in the northern range, where it is used as subsidiary food in terai but it is used as a staple food in mountain and hills. It is the fourth most important crop in Nepal after cereal in terms of production area but it ranks first in terms of productivity, which is 9.89 tons per hectare (ha) and production 2,586,287 mt in Nepal (NPDP, 2016). The major potato growing district is Kavre, Bara, Jhapa, Solukhumbu, Illam, Khotang, Kailali, Bardiya, Bhojpur, Makawanpur, Nuwakot, Rupandehi, etc (MOALD, 2012). The current five-year plan (2075/76-2080/81) aimed at increasing vegetable productivity from 14.1 Mt/ha (2075/66) to 20 Mt/ha (2080/81) by the end of the period (NPC, 2019). For the total area under potato, 20% is in the high hills, the mid-hills hold the highest 41.5% and the terai region is 38.5% (Gotame et al., 2021).

From the past few decades, Sindhuli has also been one of the largest producers and suppliers of potatoes. The average productivity during three years (2014-2015, 2015-2016, 2016-2017) is 14.3 Mt/ha/year, whereas the potential productivity is 17 Mt/ha/year (MOAD, 2015). So, there is a productivity gap of almost 3 Mt/ha/year. In the year 2076, Sindhuli has supplied 57928kg which is 0.09% of the total quantity arrival (KFVMDB, 2019). According to the Kalimati fruit and vegetables market development board, approximately 76 tons of potatoes arrived daily on the Kalimati market, 10 percent of which are imported from India (The Kathmandu Post, 2014). With exports worth Rs.3.11 billion, India is Nepal's leading potato exporter (Spotlight, 2014).

Horticultural crops including potatoes can contribute to food security improve nutritional status and provide employment, increase the income,

Quick Response Code	Access this article online	
	Website: www.myjsustainagri.com	**DOI:** 10.26480/mjsa.01.2022.29.37

Cite the Article: Amrita Paudel, Koshis Babu Basnet, Anish Paudel, Bikash Gurung, Uttam Poudel (2022). Trend Analysis of Area, Production, Productivity, and Supply of Potato in Sindhuli District and Nepal: A Comparative Study. *Malaysian Journal of Sustainable Agriculture, 6(1): 29-37.*

and overall GDP of the country (Bhandari & Aryal, 2014). Potatoes are produced in areas such as Africa's tropical highlands, South America's Andes, and South Asia's Indo-Gangetic basin where there is significant rates of deprivation, malnutrition, and food insecurity (FAO Perspective, 2015).

The average growth rate of potato production is 214.49 kg per hectare per year, which has risen at a compound annual growth rate of 1.76 percent per year (Timsina et al., 2019). So talking about production in Nepal seed cost occupied a major portion 33.33% of the cost of production followed by human labor (26.3%), FYM (12.3%), chemical fertilizer cost (7%) irrigation cost 1.7% micronutrient (0.8%) and pesticide (5.2%) lastly packaging storage and transportation cost jointly attribute 3.3% to total variable costs and lack of quality seed in sowing time is one of the major causes for higher seed cost and government subsidiary on fertilizer is major causes for lower fertilizer cost (Subedi et al., 2019). The national potato development program (NPDP) focuses to assist the government in making plans and policies for potato development, organizing training, seminar, research, and studies as well as coordinating with concerned stakeholders for import substitution and export promotion (NPDP, 2016). A study finding revealed that during the fiscal year 1977/78 to 2016/17 the area under vegetable cultivation has sharply increased by 222.8% with its increased production of 728.2%. However, compared to an increase in area, the rate of vegetable production was not ideal due to a shortage of quality seeds and timely supply of fertilizer (Ghimire et al., 2018).

1.1 Statement of the problem

Agriculture generates about 54 percent of Nepal's jobs and contributes 27 percent to Gross Domestic Product (GDP), but only 2.8 percent of the overall budget was allocated to agriculture in the 2020/21 fiscal year (MOAD, 2015). In comparison, the total land ownership of people engaged in agriculture is just 0.6 ha/household (MOAD, 2015). Nepalese people's socio-economic status is likewise critically poor. The food and nutrition security situation is highly fragile since in 2015 AD, stunting was reported at about 37.4 percent, underweight at 30.1 percent, overweight at 11.3 percent, and women with low BMI at 18.1 percent (MOAD, 2015). Despite being the active producer, there is still a lack of awareness among farmers about correct seed selection and proper use of chemical and organic fertilizers (Parajuli, 2005). The stored seed was very high in Sindhuli, while the volume of seed collected from agro-vets and government research and development programs was very small (Gairhe et al., 2017). Compared to other districts Sindhuli has lower supplies to Kalimati Fruits and Vegetable Market mainly because of rapid urbanization, poor tuber quality, and use of conventional technologies (KFVMDB, 2019).

1.2 Rationale of the study

Potato is an important sub-sector in both Nepal and the Sindhuli district. The commercialization of potatoes not only uplifts people's economic status in the Sindhuli but also helps in import substitution and promotion of exports in Nepal. Potato is a high-value cash crop since can be a good source of income for the farmers in mid-hills and high hills where there is a high comparative advantage of growing potato. It can aid in food security as it has high calorific value. This study will assist stakeholders to get insight into the marketing situation; also contribute to planning and policy making for the marketing of potato by increasing the area, production, and productivity. Thus, the global reach on potato trend overs 50 years in terms of area, production and productivity aims at encouraging youths for expansion of potato business.

1.3 Objectives

The broad objective is to study the trend of potato production, area, and productivity in the Sindhuli district and Nepal.

Specific objectives

- To figure out how the area, productivity, and their interactions affect potato production.
- To estimate the magnitude of variability in area, production, and productivity of potato in Sindhuli and compare it to the national level.
- To determine the average annual yield and annual growth rate.
- To estimate the trend of quantity supply of potato to Kalimati Fruits and Vegetable Market.

1.4 Limitation of the study

The followings are the limitation of the study.

- The time-series data might have been fitted to exponential, logarithmic, cubic, polynomial, or other non-monotonic trends but this study only considered a monotonic trend and linear trend.
- The analysis did not consider the entire commodity supply as data for all supplies were not available.

2. METHODOLOGY

2.1 Data and its type

All the data that has been published and available were used for this research. Time series data from 1968/69 to 2017/2018 on area, production, and productivity of potato were collected from "statistical Information on Nepalese Agriculture: Time series Information published by MoALD (Ministry of Agriculture and Livestock Development) (MOALD, 2020). To analyze supply trend data from 2070B.S to 2076B.S (2013/14-2018/19 A.D), information was also collected from the Kalimati Fruits and Vegetable Market Board website (KFVMDB, 2019).

The quantitative data was gathered and entered in MS Excel. The data was analyzed to draw meaningful inferences by using, R programming and MS-Excel. The data was analyzed by using tools like descriptive statistics for mean comparison, frequency distribution, correlation analysis, and Mann Kendall test analysis, etc. The findings were represented and demonstrated by using tables, figures, line diagrams, pie charts, etc.

Mann Kendall test helps to know the linear trend between time-series data, correlation helps to know the relation between parameters like production and production area, mean comparison is useful in performing t-test, descriptive analysis, and frequency distribution are useful tools for understanding the present and past condition of potato subsector in Sindhuli district and Nepal.

2.2 Interpolation of data

The time-series data which was taken from MoALD (Ministry of Agriculture and Livestock Development) sites has some missing values for a particular year. To fulfill that interpolation technique was used. The simplest type of interpolation technique is linear interpolation that makes a mean between the values before the missing data and the value after.

$$Missing\ data = \frac{previous\ data(last\ data - previous\ data)}{no\ of\ missing\ period}$$

2.3 Data analysis technique

2.3.1 Mann-Kendall test

Mann-Kendall test was used in this analysis to detect the existence of a monotonic pattern in time series (Hess et al., 2001). Mann-Kendall test analyses the sign of the difference between later measurements with earlier measurements in time series data. Each later measured value is compared to all values measured earlier which results in a total $(n-1)2$ possible pairs of data, n being the total observations. The null hypothesis (H0) for this test is, "there is no monotonic trend in time-series" and the alternative hypothesis (H1) for this test is, "there is a monotonic trend in time-series" (Meals et al., 2021).

The measured Z-value was then compared with the Z-value from the standard Z-probability table at a sensible level of 5 percent to accept or reject the hypothesis and to conclude whether there was a monotonous pattern. The trend was presumed to increase if Z was favorable and if Z was considered negative, the decreasing trend was concluded (Alhaji et al., 2018). In this study, the conclusion about whether there was a monotonic trend in the given time series data was drawn from the p-value obtained in the Mann-Kendall test. If the p-value was less than the meaning level (α = 5 %), i.e. 0.05, the null hypothesis was rejected, and it was concluded that

the time series data had a monotonous trend. Failure to reject the null hypothesis ($p > 0.05$) would lead to the conclusion that there is no monotonous trend in data from the time series.

The conclusion about how strongly the two variables were monotonically related was drawn based on the Kendall correlation coefficients, generally known as the tau of Kendall. The coefficient of correlation for the Kendall takes values from -1 to +1. The coefficient sign indicates the sign of the relation slope, i.e. increasing or declining trend, and the absolute value indicates the relationship intensity (Helsel & Hirsch, 1993).

2.3.2 Sen's slope

Where linear trends are present in time series data, the slope (change rate per unit time) or trend magnitude can be estimated using the least square or simple linear regression method. But the least square estimation of the regression coefficient (i.e. slope) is vulnerable to gross errors, and the confidence interval obtained is sensitive to parent distribution non-normality (Sen, 1968). Besides, the slope determined with this method will deviate considerably from the true slope if there are gross errors or outliers in the data (Gilbert, 1987). (Sen, 1968) argued that the median is less influenced by gross errors or outliers than the weighted average and that the median-based regression coefficient (i.e. slope) calculation is more robust than the slope obtained from the least square method. Thus, in this analysis, the magnitude of the trend was calculated using a simple non-parametric method developed by Sen commonly known as Sen's slope.

The linear model assumed was

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

Where,

β= slope

$\alpha =$ Intercept

Y= time i.e. independent variable

Sen's estimator of the slope is associated with the Mann Kendall test and was derived firstly by computing slopes of all data pairs as

$$\beta_{ij} = \frac{y_j - y_i}{j - i}$$

Where

β_{ij}= all the slope of lines connecting each pair of points (t_i, y_i) and (t_j, y_j) and $t_i \neq t_j$

If there are n values in the series we obtained exactly $N = \frac{n(n-1)}{2}$ slope estimates β_{ij}. The N values of slopes are arranged in ascending order of magnitude and the median was calculated which is the Sen estimator of a slope.

$$\beta = \begin{Bmatrix} \frac{1}{2}\left(\beta_{\frac{N}{2}} + \beta_{\frac{N}{2}+1}\right), if\ N\ is\ even \\ \beta_{\frac{N+1}{2}}, if\ N\ is\ odd \end{Bmatrix}$$

The intercept was computed according to the Sens method for each time step t as

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

And the respective intercept value (α) is the mean of all αt values (Alhaji et al., 2018). Sen's positive slope (β) value reflects an upward trend, and the negative value represents a downward trend. The line of regression was plotted to visualize the trend, based on the slope and intercept of the Sen.

This method was used to analyze and detect the linear trend present in time-series data for, production, area, and productivity, of potatoes in Nepal, and Sindhuli. The Microsoft Excel program and the Ms. Excel program XLSTAT tool developed by Addinsoft (2020) have been used for data analysis and data visualization.

2.3.3 T-test

H_0= There is no significant difference between the two sample mean

H_1= There is a significant difference between the two sample mean

Table 1: t-test

Group	Size of sample	Sample Mean	Sample (SD) Standard Deviation
1	n_1	$\bar{x}_1$	s_1
2	n_2	$\bar{x}_2$	s_2

To check the null hypothesis that either mean population, μ1, and μ2, is equal differences between two sample mean need to be calculated.

Difference= $\bar{x}_1 - \bar{x}_2$

Secondly pooled standard deviation needs to be computed as,

$$s_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^1}{n_1 + n_2 - 2}}$$

Thirdly standard error of the difference between the mean must be estimated.

$$SE(\bar{x}1 - \bar{x}2) = s_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

Calculation of t-statistics which is given by $T = \frac{\bar{x}1 - \bar{x}2}{SE(\bar{x}1 - \bar{x}2)}$. Under the null hypothesis, this statistic follows a t-distribution with n_1+n_2-2 degree of freedom.

At last, we use t-distribution table to compare the value for "t" to the $t_{n1+n2-2}$ this gives a p-value for an unpaired t-test.

2.3.4 Average annual yield

The average yield per annum is calculated by dividing the revenue earned from an investment by the period it has been owned (Hayes, 2021b).

$$average\ annual\ Yield = \frac{\sum production\ in\ all\ year}{\sum area\ of\ production\ in\ all\ year}$$

2.3.5 Trend line

Production, area supplies, and productivity data were illustrated in trend lines and the inference was made based on the nature of the trend line.

2.3.6 Annual growth rate

The annual growth rate for each year was calculated in percentage terms and thereby doing overall average; annual growth rate was calculated (Hayes, 2021a).

$$annual\ growth\ rate_t = \frac{value\ in\ t^{th}\ year - value\ in\ (t-1)^{th} year}{value\ in\ (t-1)^{th} year} * 100\%$$

Also, the compound annual growth rate (CAGR) was computed:

$$production\ at\ t^{th}\ year = production\ at\ first\ year * (1 + CAGR)^t$$

Here CAGR was computed by MS Excel.

3. Result and Discussion

3.1 Trend of production, area, and productivity of potato in Nepal

3.1.1 Trend of potato production in Nepal

It is found that there is an increase in production from 1968 to 2015,

production pattern is erratic. It is observed that the minimum production is in 1968 with 245000mt but after 1968 it started to rise steadily until 1976. But for the next 5 years after 1976, it continues to drop until 1982. After 1982 dramatic shifts in production can be observed. By comparing the CAGR trend from 1968 to 1982, we can observe the 1.8 percent growth rate. We witnessed maximum production in 2015; production unexpectedly increased in 2015 relative to the projected rate of growth as it grew 110 percent more than the previous year. After 2015 we observed a similar trend of growth except for 2017, where the output graph fell. The overall percentage increase in production from 1965 to 2018 is about 907.6 percent.

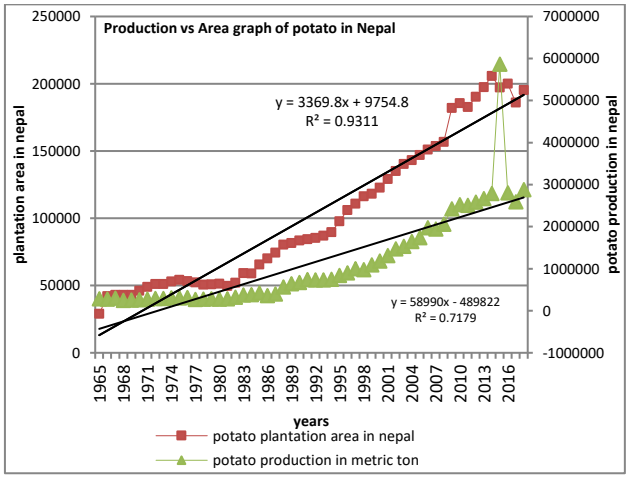

Figure 1: Production vs Area graph in case of Nepal since 1968/69-2017/18

The R square value for production and area trend line is 0.7179 and 0.9311 respectively which are closer to 1. This indicates that the data is more precisely represented by the trend line. The coefficient of determination R^2 computed from the linear regression method was found to be 0.931 which reveals that 93.11% of the variation in production can be explained by the variation in the area. The remaining 6.89% variation is unexplained by variation in the area.

3.1.2 Trend of potato production area in Nepal

In the past 5 decades, the production area has grown by 3.7 percent. We observed the lowest output area in 1968 with just 29,000 ha in the country as a whole but over the next 10 years, it is continuously grown and reach 522,27 ha in 1977. There is quite a fluctuation in data afterward with an erratic trend of rising and falling up to 1982. After 1983 the production area increases continuously until 2014 and became maximum with a productive area of 205725 ha so during that time the growth rate was highest with an increase of 4 percent per annum and the overall increase in the production area is about 573 percent.

3.1.3 Trend of productivity of potato in Nepal

Productivity is a factor depending on both the area and the production, the trend curve varies from both. The compound growth rate (CAGR) was found to be 0.8 percent from the last 5-decade and its average annual yield is 9.27mt / ha so Nepalese potato productivity was below this annual level up to 1998. In 1965, where productivity was 9857 kg/ha, its value decreased continuously until 1971, when it reached 5603 kg/ha, but production remained more or less similar. From 1971 to 1987 we observed quite an unusual curve pattern of up and down but after 1988 there is continuous growth in potato production due to which productivity has also increased significantly and in 2018 it has become maximum with the productivity of 14765 kg/ha. There are a lot of ups and downs in data in the productivity graph and the overall percentage rise is also comparatively smaller i.e. just 49 percent.

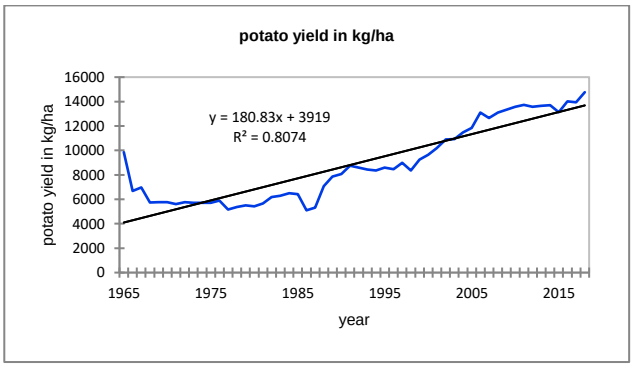

Figure 2: Productivity graph in Nepal since 1968/69-2017/18

3.1.4 Mann Kendal and Sen slope analysis for Nepalese trend of potato

All parameters had an increasing trend from 1965 to 2018 as indicated by the positive Tau value. It is also statistically significant at a 95% confidence level as indicated by the p-value. Sen Slope quantified that area of potato production increase by the rate of 3442 ha, productivity by 194 kg/ha, and production by 50864 Mt per year annually. Kendall tau value which is positive in all the cases shows that there is very a strong correlation between production and time, area and time and it shows a strong relationship between productivity and time.

Table 2: Result of Mann Kendall and Sen slope for production, area, and productivity of potato in Nepal

Parameter	P-value	Kendall Tau (τ)	Sen Slope	Trend	Significance	Alfa value
Production (mt)	<0.0001	0.901	50864	Increasing	significant	0.05
Area (ha)	<0.0001	0.933	3442	Increasing	significant	0.05
Productivity(kg/ha)	<0.0001	0.719	194	Increasing	Significant	0.05

3.2 Trend of production, area, and productivity of potato in Sindhuli

3.2.1 Trend of potato production in the Sindhuli district

The average production of Sindhuli district from 1968 to 2018 was 10846.14 Mt. The annual production of Sindhuli up to 1994 was below the overall average, i.e. 10846.14 Mt. After 1994, production increased significantly, besides that there was also a significant drop in a year like 2009, 2017,2018. Minimum production was observed in 2009 with the production of only 1928Mt, and the highest production was observed in 2015 with a production of 49200Mt. 2015 has also been a turning point in a production trend as the production sum drops significantly after that year. When moving from 2015 to 2016 production amount declined by 31 percent, going forward further i.e. from 2016 to 2017 there is a drop of 85 percent which is very serious and the highest percentage drop in the case of Sindhuli district. At the last from 2017 to 2018 there is a growth of 3.9 percent in production. Overall trends in the Sindhuli district are severely hindered by the output statistics of the last few years, where the percentage rise in production is also just 46 percent.

3.2.2 Trend of potato production area in Sindhuli district

The production area in Sindhuli is very close to the trend graph of production. The average area of production over the last 5 decades is 1238.5 ha where the annual productive area was below this figure up to 1982. The productive area reaches the maximum in 2015 with 2900 ha and reaches the minimum point with only 323 ha just after leaving 1-year i.e.in 2017. Thus, two extremes of the production line were observed within 1 year because of this overall growth rate, i.e.the CAGR rate was -46 percent. Nonetheless, as we analyze until 2015, the situation is somewhat different, a rise of approximately 383.3% and a growth of 3% can be observed.

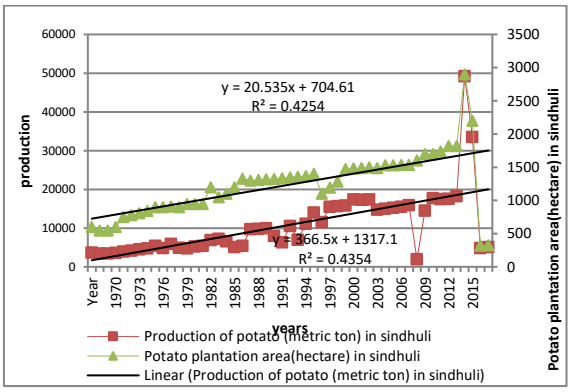

Figure 3: Production vs area graph in Sindhuli district since 1968/69-2017/18

The R square value for the production and area trend line is 0.435 and 0.4254 respectively which are not closer to 1. This indicates that the data is less precisely represented by the trend line. The coefficient of determination R^2 computed from the linear regression method was found to be 0.425, which reveals that 42.5% of the variation in production can be explained by the variation in the area. The remaining percentage is unexplained by variation in the area.

3.2.3 Trend of productivity of potato in Sindhuli district

The highest yield was obtained in 2015(17mt / ha) from the evaluation of the initial data set and the minimum was obtained in 2009(1.2mt / ha). Over the last 5 decades, the average annual yield was estimated as 8.75mt / ha, and annual production was below the average annual yield up to 1994. As there was a serious drop in area and production since 2015, productivity was unlikely to be affected as the declining ratio in both cases was more or less equal due to which there is no significant drop in productivity like that of production and area. The productivity growth was 157.3 percent.

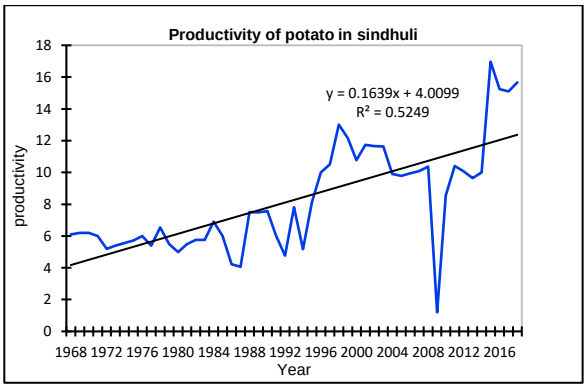

Figure 4: Productivity graph in Sindhuli since 1968/69-2017/18

3.2.4 Mann Kendal analysis for potato production in Sindhuli district

It is evident from the table that all parameters had an increasing trend during the period 1968 to 2018 as indicated by positive tau value, all the trends of the area, production, and productivity were statistically significant at a 95% confidence level as indicated by the p-value. Sen slope method quantifies that area of potato production increases at the rate of 24.24 ha per year, and production increase at the rate of 337.87mt per year, and productivity increase at the rate of 0.146mt/ha per year. Kendal tau is positive which represents an increasing trend. The magnitude of the Kendal tau value shows that there is only a moderate correlation of production, area, and productivity with time.

Table 3: Result of Mann Kendall and Sen slope for production, area, and productivity in Sindhuli district

Parameter	p-value	Kendall tau(τ)	Sen slope	Trend	Significance	Alfa value
Production(mt)	<0.0001	0.680	337.87	Increasing	significant	0.05
Area(ha)	<0.0001	0.769	24.42	Increasing	significant	0.05
Productivity(mt/ha)	<0.0001	0.500	0.146	increasing	significant	0.05

3.3 Comparison between Sindhuli district and Nepal in different aspects

3.3.1 Production Comparison between Sindhuli district and Nepal

Production amount data and its statistics were compared through an unpaired t-test with an equal variance which is presented below.

Table 4: Result of t-test for production in Nepal and Sindhuli district

Parameter	Production in Nepal	Production in Sindhuli
Mean (metric ton)	1182095.73	10846.14
Standard deviation	1107359.59	8257.33
Coefficient of variation	93.67%	76.13%
Df	100	
t-stat	7.55	
P(T<=t) one tailed	<0.001	

The production level of Nepal (M=1182095.75, SD=1107359.54, n=51) was hypothesized to be greater than the production level of Sindhuli (M=10846.14, SD=1156.26, n=51). The difference was significant t (100) =7.55, p=<0.0001(one-tailed value).

3.3.2 Productivity comparison between Sindhuli and Nepal

Table 5: Result of t-test for productivity in Nepal and Sindhuli

Parameter	Productivity of Nepal	Productivity of Sindhuli
Mean(mt/ha)	9.27	8.27
Standard deviation	4.37	3.36
Coefficient of variation	47.14%	40.62%
Degree of freedom	100	
t-stat	1.30	
P(T<=t) one-tailed	0.09	

The productivity of Nepal (M=9.27, SD=4.37, n=51) was hypothesized to be greater than the productivity level of Sindhuli (M=8.27, SD=3.36, n=51). The difference was significant t (100) =1.30, p=0.09(one-tailed)

3.3.3 Production area comparison between Sindhuli district and Nepal

Table 6: Result of t-test for production area in Nepal and Sindhuli

Parameter	Production area of Nepal	Production area of Sindhuli
Mean(ha)	106213.19	1238.50
Standard deviation	54159.45	468.0377
Coefficient of variation	51%	37.79%
Df	100	
t-stat	13.84	
P(T<=t)	<0.0001	

Statistically, the production area of Nepal is greater than in the Sindhuli district. The production area of Nepal (M=106213.19, SD=54159.45, n=51) was hypothesized to be greater than the production area of Sindhuli (M=1238.50, SD=468.0377, n=51). The difference was significant t (100) =13.84, p=<0.0001(one-tailed).

From the t-test table, we find the difference of 1171249.59 metric tons in production, 104974.69ha in the production area, and 1mt/ha in productivity. The overall contribution of the Sindhuli district to Nepal in the case of potato production is 0.91% and in the case of potato production area is 1.16%. The production coefficient of variation of Nepal is 93.67% wherein the case of Sindhuli is 76.13% which shows Nepalese potato production is highly dispersed from its mean than Sindhuli. In the case of productivity, variation is moderate but it is still higher in the case of Nepal i.e. COV of Nepal is 47.14% and COV of Sindhuli is 40.62%. Similarly in the case of production area variation of Nepal is 51% and of Sindhuli is 37.79%.

3.4 Growth rate of area, production, and productivity

3.4.1 Annual Growth Rate (AGR) in Sindhuli

During the period of study from 1968/69 to 2017/018 varying growth rates for the area as was observed under potato cultivation in Sindhuli district. The annual growth rate varies from 37% to -581%. The average annual growth rate was found to be -10% (which represents a decreasing trend) and the compound growth rate is -1%. Since 2014/15 we can observe a severe drop in growth rate as it has dropped down by -32% in 2015/16 and -581% in 2016/17. The production growth rate varies from 87% to -728%. The average annual growth rate is -22 % (decreasing trend) and the compound growth rate is -1%. The maximum growth rate was seen in the year 2009/10 and the minimum was seen in 2008/09. After 2015 growth of production is similar to the growth rate of the area i.e. growth in production has been drop by -47% in the year 2015/016 and by -588% in 2016/017. Productivity growth rate varies from 86% to -764%. Average annual growth for productivity is -13% (decreasing) and compound annual growth rate is 2% similar to the production, AGR during 2008/09 and 2009/10 has a minimum and maximum productivity growth rate.

Table 7: Annual Growth Rate (AGR) of Area, Production, and Productivity in Sindhuli

Year	Production AGR	Area AGR	Productivity AGR	Year	Production AGR	Area AGR	Productivity AGR
1968/69	-7%	-9%	2%	1994/95	37%	1%	36%
1969/70	0%	0%	0%	1995/96	21%	2%	19%
1970/71	5%	8%	-3%	1996/97	-21%	-27%	5%
1971/72	8%	20%	-15%	1997/98	26%	8%	19%
1972/73	7%	4%	3%	1998/99	1%	7%	-7%
1973/74	7%	4%	3%	1999/00	1%	13%	-13%
1974/75	6%	4%	3%	2000/01	9%	0%	8%
1975/76	11%	7%	5%	2001/02	0%	0%	-1%
1976/77	-11%	0%	-11%	2002/03	0%	0%	0%
1977/78	18%	1%	17%	2003/04	-18%	0%	-17%
1978/79	-20%	-1%	-19%	2004/05	2%	3%	-1%
1979/80	-4%	5%	-10%	2005/06	2%	0%	2%
1980/81	9%	0%	9%	2006/07	2%	0%	1%
1981/82	4%	0%	4%	2007/08	3%	0%	3%
1982/83	21%	21%	0%	2008/09	-728%	4%	-764%
1983/84	5%	-14%	17%	2009/10	87%	6%	86%
1984/85	-10%	5%	-15%	2010/11	18%	0%	18%
1985/86	-30%	8%	-42%	2011/12	-1%	2%	-4%
1986/87	6%	10%	-4%	2012/13	0%	4%	-4%
1987/88	45%	-2%	46%	2013/14	4%	0%	4%
1988/89	1%	1%	0%	2014/15	63%	37%	41%
1989/90	1%	1%	1%	2015/16	-47%	-32%	-11%
1990/91	-25%	1%	-26%	2016/17	-588%	-581%	-1%
1991/92	-25%	1%	-26%	2017/18	4%	0%	3%
1992/93	39%	1%	39%	Average AGR	-22%	-10%	-13%
1993/94	-50%	0%	-51%	Compound AGR	1%	-1%	2%

3.4.2 Annual Growth Rate (AGR) in Nepal

In Nepal from 1968/69 to 2017/018 growth rate from 14% to -8% was observed for the area under cultivation of potatoes. The average annual growth rate for the area was found to be 3% and the compound growth rate was found to be 3.7%. In the case of production maximum annual growth rate varies from 52.50% to -109% where the average annual growth rate is 3.4% and compound annual growth rate is 4.5%. Similarly in productivity growth varies from 25% to -26% where the average annual growth rate is 2% and compound annual growth rate is 0.8%.

Table 8: Annual Growth Rate (AGR) of Area, Production, and Productivity in Nepal

Year	Area AGR	Production AGR	Productivity AGR	Year	Area AGR	Production AGR	Productivity AGR
1968/69	0%	2.00%	1%	1994/95	8%	10.70%	3%
1969/70	7%	4.90%	0%	1995/96	8%	6.60%	-1%
1970/71	6%	3.70%	-3%	1996/97	4%	9.90%	6%
1971/72	4%	6.80%	3%	1997/98	5%	-2.60%	-8%
1972/73	0%	-0.30%	-1%	1998/99	1%	11.00%	10%
1973/74	4%	3.90%	0%	1999/00	4%	7.70%	4%
1974/75	2%	1.00%	0%	2000/01	5%	10.00%	5%
1975/76	-1%	2.10%	3%	2001/02	4%	10.80%	7%
1976/77	-2%	-16.10%	-14%	2002/03	4%	3.80%	0%
1977/78	-3%	0.70%	4%	2003/04	2%	6.80%	5%
1978/79	0%	2.50%	2%	2004/05	3%	5.50%	3%
1979/80	1%	-0.10%	-1%	2005/06	3%	11.90%	10%
1980/81	-4%	0.80%	4%	2006/07	2%	-1.60%	-3%
1981/82	5%	12.60%	8%	2007/08	2%	5.40%	3%
1982/83	12%	13.90%	2%	2008/09	14%	15.20%	2%
1983/84	-1%	2.60%	3%	2009/10	2%	3.70%	2%
1984/85	10%	8.80%	-1%	2010/11	-2%	-0.40%	1%
1985/86	6%	-17.80%	-26%	2011/12	4%	3.00%	-1%
1986/87	6%	9.70%	4%	2012/13	4%	3.00%	0%
1987/88	7%	30.30%	25%	2013/14	4%	4.50%	0%
1988/89	2%	11.50%	10%	2014/15	-4%	52.50%	-4%
1989/90	2%	4.60%	3%	2015/16	1%	-109.1%	6%
1990/91	1%	9.00%	8%	2016/17	-8%	-8.30%	-1%
1991/92	1%	-0.70%	-2%	2017/18	5%	10.10%	6%
1992/93	2%	0.10%	-2%	Average AGR	3%	3.40%	2%
1993/94	3%	2.10%	-1%	Compound AGR	3.70%	4.50%	0.80%

3.5 Supplies

When we analyze the data from 2070B.S (2013A.D), we find that more amounts of potatoes came from India. It occupies 58% of the total amount. Kavre is the largest supplier of potatoes to the Kalimati market from inside the country. It contributes 19% of the share to the total amount, followed by Kathmandu, Dolakha, Sindhupalchowk, Nuwakot, and Makwanpur with 6%, 4% 3%, 2%, and 1% respectively. The amount of Indian potato is increasing every year, its compound growth rate is about 23% in the last 7 years. Every year Nepalese production is decreasing. All top producing districts have a negative Compound growth rate in 6 years except for Makwanpur and Dolakha. Among them, the growth rate of Dolakha is quite insignificant and Makwapur has a very irregular trend of supply. The compound growth rate of Kavre is -4%, similarly, Kathmandu has -7%, Dolakha has 1%, Sindupalchowk has -13%, Nuwakot has -1%, and Makwanpur has 25%.

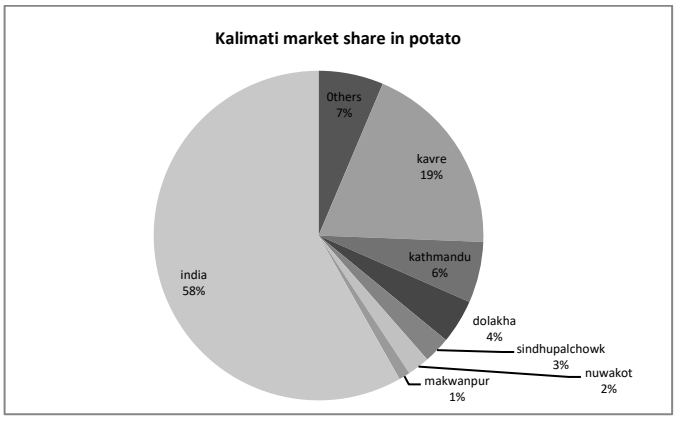

Figure 5: Pie chart for Kalimati market share

4. Conclusion

Potato is an important crop in our country but production and productivity are very low as compared to our neighboring countries. The productivity averaged over 3 years (2014/2015, 2015/2016, 2016/2017) is 14.3 Mt/ha/year and the production potential is 17 Mt/ha/year where we observe a productivity gap of almost 3 Mt/ha/year. So, Nepal is facing problems with the production of potatoes with optimum efficiency. The productivity of vegetables is in increasing trend after 1991/92 up to 2015/16. So, in the case of Nepal and Sindhuli district up to 2015, the productivity of potato was rising, the even year 2015 was the year of maximum productivity in both cases, (Sindhuli productivity=17mt/ha, overall Nepal productivity= 29mt/ha). But after 2015 productivity has to drop down in both cases by 3% and 21% in Sindhuli and Nepal respectively. There is very little difference between the average annual yield of Sindhuli and Nepal i.e of 1mt/ha. It represents a similar trend in productivity between them. The production coefficient of variation of Nepal is 93.67%, wherein the case of Sindhuli is 76.13%. The productivity coefficient of variation of Nepal is 47.14% and Sindhuli is 40.62%. The area coefficient of variation in Nepal is 51% and in Sindhuli is 37.79% so in all the cases; variability is higher in the case of the Nepalese trend. Indian imports contribute 58% of the total arrival amount of potato in Kalimati Fruits and vegetable market, while from inside country Kavre has the largest share of 19%. The average annual growth rate for the Sindhuli district was found to be negative while that for Nepal was positive. The magnitude of variability in area, production, and productivity of Nepal was found to be greater than the Sindhuli district. The coefficient of determination (R^2) which determines the effect of an area in production was found to be greater in the case of Nepalese potato trend (0.93) than Sindhuli district (0.42). Thus, the utilization of the opportunities in this sector is the boon for the successful nation.

APPENDIX

Table 9: Original data series (Area, production and productivity of potato in Sindhuli district and Nepal)

Year	Production of potato (metric ton) in Sindhuli	Potato plantation area (hectare) in Sindhuli	Productivity (mt/ha)	Potato plantation area in Nepal	Potato production in Nepal (metric ton)	Nepal Productivity (mt/ha)
1968	3660	600	6.1	43000	245000	5.70
1969	3410	550	6.2	43000	250000	5.81
1970	3410	550	6.2	46000	263000	5.72
1971	3600	600	6	49000	273000	5.57
1972	3900	750	5.2	51000	293000	5.75
1973	4200	780	5.4	51000	292000	5.73
1974	4500	810	5.6	53000	304000	5.74
1975	4800	840	5.7	54000	307000	5.69
1976	5400	900	6	53280	313509	5.88
1977	4860	900	5.4	52287	270025	5.16
1978	5950	910	6.5	50650	271870	5.37
1979	4950	900	5.5	50700	278790	5.50
1980	4750	950	5	51330	278400	5.42
1981	5220	950	5.5	49580	280540	5.66
1982	5460	950	5.7	52010	321100	6.17
1983	6900	1200	5.75	59200	372970	6.30
1984	7240	1050	6.9	58880	383080	6.51
1985	6600	1100	6	65540	420160	6.41
1986	5080	1200	4.2	69960	356720	5.10
1987	5400	1330	4.06	74310	395110	5.32
1988	9750	1300	7.5	80180	566950	7.07
1989	9820	1310	7.50	81570	640910	7.86
1990	9962	1318	7.6	83350	671810	8.06
1991	7969	1326	6.01	84280	738030	8.76
1992	6375	1334	4.8	85300	732860	8.59
1993	10530	1350	7.8	87020	733300	8.43
1994	7020	1356	5.2	89664	748913	8.35
1995	11138	1369	8.1	97634	838932	8.59
1996	14020	1402	10	106000	898350	8.48
1997	11550	1100	10.5	110850	997400	9.00
1998	15518	1193	13.0	116290	971680	8.36
1999	15637	1287	12.1	118043	1091218	9.24
2000	15875	1475	10.8	122620	1182500	9.64
2001	17400	1482	11.7	129019	1313717	10.18

2002	17365	1489	11.7	135093	1472757	10.90
2003	17400	1496	11.6	140171	1531315	10.92
2004	14750	1489	9.9	143027	1643357	11.49
2005	14990	1531	9.79	146789	1738840	11.85
2006	15230	1532	9.9	150864	1974755	13.09
2007	15470	1534	10.1	153534	1943246	12.66
2008	15950	1538	10.4	156737	2054817	13.11
2009	1926	1605	1.2	181900	2424048	13.33
2010	14550	1700	8.6	185342	2517696	13.58
2011	17700	1700	10.4	182600	2508044	13.74
2012	17500	1740	10.1	190250	2584301	13.58
2013	17560	1820	9.6	197234	2663839	13.51
2014	18200	1820	10	205725	2789012	13.56
2015	49200	2900	17.0	197037	5865914	29.77
2016	33556	2201	15.2	199971	2805582	14.03
2017	4880	323	15.1	185879	2591686	13.94
2018	5072	324	15.7	195173	2881829	14.77

Table 10: Supply amount to Kalimati Fruits and Vegetable Market

Amount of potato supply in kg by various districts						
Years	Kavre	Kathmandu	Dolakha	Makawanpur	Nuwakot	Sindupalchowk
2070	12214802	5535428	3157136			
2071	10620578	4562684	4395506		1415876	
2072	10578321	3577880	1657390		1223330	2180080
2073	9011958	2554366	1608970	899530		2700058
2074	9326690	1664026		1271450	909374	2284355
2075	9432358	1454532	2307180		1367726	2797484
2076	12210275	3492003	3371450	2021160	1643109	

REFERENCES

Alhaji, U. U., Yusuf, A. S., Edet, C. O., Oche, C. O., Agbo, E. P. 2018. Trend Analysis of Temperature in Gombe State Using Mann Kendall Trend Test. Journal of Scientific Research and Reports, 20(3), 1–9. https://doi.org/10.9734/JSRR/2018/42029

Bhandari, N. B., Aryal, M. 2014. Average Cost of Production and Gross Profit of Fruit Farming in Nepal Average Cost of Production and Gross Profit of Fruit Farming in Nepal Ministry of Agriculture Development Department of Agriculture Agribusiness Promotion and Marketing Development Dire. www.mrsmp.gov.np

FAO Perspective. 2015. World agriculture: towards 2015/2030. www.earthscan.co.uk

Gairhe, S., Gauchan, D., Timsina, K. 2017. Adoption of Improved Potato Varieties in Nepal. Journal of Nepal Agricultural Research Council, 3, 38–44. https://doi.org/10.3126/JNARC.V3I1.17274

Ghimire, D., Lamsal, G., Paudel, B., Khatri, S., Bhusal, B. 2018. Analysis of trend in area, production and yield of major vegetables of Nepal. Trends in Horticulture, 1(2). https://doi.org/10.24294/TH.V1I2.914

Gilbert, R. O. 1987. Statistical Methods for Environmental Pollution Monitoring | Wiley. https://www.wiley.com/en-us/Statistical+Methods+for+Environmental+Pollution+Monitoring-p-9780471288787

Gotame, T. P., Poudel, S., Thapa, B., Neupane, J. D. 2021. Performance evaluation of potato clones for the central Terai Region of Nepal. Journal of Agriculture and Natural Resources, 4(2), 155–166. https://doi.org/10.3126/janr.v4i2.33707

Hayes, A. 2021a. Average Annual Growth Rate (AAGR) Definition. Investopedia. https://www.investopedia.com/terms/a/aagr.asp

Hayes, A. 2021b. Average Annual Yield Definition. Investopedia. https://www.investopedia.com/terms/a/average-annual-yield.asp

Helsel, D. R., Hirsch, R. M. 1993. Statistical Methods in Water Resources. https://books.google.fr/books

Hess, A., Iyer, H., Malm, W. 2001. Linear trend analysis: A comparison of methods. Atmospheric Environment, 35(30), 5211–5222. https://doi.org/10.1016/S1352-2310(01)00342-9

KFVMDB. 2019. Kalimati Fruit and Vegetable Market Development Committee: Regulating the market in Nepalese consumer interest since 1995. https://kalimatimarket.gov.np/

Meals, D. W., Spooner, J., Dressing, S. A., Harcum, J. B. 2021. Statistical Analysis for Monotonic Trends. National Nonpoint Source Monitoring Program, 23. https://www.epa.gov/sites/production/files/2016-05/documents/tech_notes_6_dec2013_trend.pdf

MOAD. 2015. Agriculture Development Strategy (ADS) 2015 to 2035. Ministry of Agricultural Development, Part 1, 20.

MOALD. 2012. Ministry of Agriculture and Livestock Development. https://www.moald.gov.np/

MOALD. 2020. Statistical Information in Nepalese Agriculture. Ministry of Agriculture and Livestock, 290. https://nepalindata.com/resource/statistical-information-nepalese-agriculture-207374-201617/

NPC. 2019. The Fifteenth Plan Government of Nepal National Planning Commission. www.npc.gov.np

NPDP. 2016. National Potato Development Program | Other Materials. http://www.npdp.gov.np/eng/publications/general.html

Parajuli, R. K. 2005. Kavre leads nation in potato production - The Himalayan Times - Nepal's No.1 English Daily Newspaper | Nepal News, Latest Politics, Business, World, Sports, Entertainment, Travel, Life Style News. The Himalayan Times. https://thehimalayantimes.com/business/kavre-leads-nation-in-potato-production

Sen, P. K. 1968. Estimates of the Regression Coefficient Based on Kendall's Tau. Journal of the American Statistical Association, 63(324), 1379–1389. https://doi.org/10.1080/01621459.1968.10480934

Spotlight. 2014. FOOD SECURITY: Alarm Ringing | New Spotlight Magazine. https://www.spotlightnepal.com/2014/06/06/food-security-alarm-ringing/

Subedi, S., Ghimire, Y. N., Gautam, S., Poudel, H. K., Shrestha, J. 2019. Economics of potato (Solanum tuberosum L.) production in terai region of Nepal. Archives of Agriculture and Environmental Science, 4(1), 57–62. https://doi.org/10.26832/24566632.2019.040109

The Kathmandu Post. 2014. Potato, onion prices jump due to slump in supply. https://kathmandupost.com/money/2014/06/20/potato-onion-prices-jump-due-to-slump-in-supply

Timsina, K. P., Gaire, S., Ghimire, Y. N., Poudel, H. K., Devkota, D., Subedi, S., Adhikari, S. P. 2019. Returns to Potato Research Investment in Nepal. Journal of Agriculture and Natural Resources, 2(1), 1–13. https://doi.org/10.3126/JANR.V2I1.26002

Wikipedia. 2020. Agriculture in Nepal - Wikipedia. https://en.wikipedia.org/wiki/Agriculture_in_Nepal.