

Research Article

Prospect and potentiality of finger millet in Nepal: Nutritional security and trade perspective

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ABSTRACT

Millet is an important food crop for ensuring food and nutrition security of smallholder farmers and marginalized communities in the hill and mountain of Nepal. The main objectives of the study were to assess prospects and potentiality of millet by analysing the area, production, productivity, and trade for the year 2009-2019. The study used a combination of exploratory survey and secondary data for assessing the production system, compound growth rate, coefficient of variation (CV), instability index (IIN), and trade specialization index. The results of the study are compiled and the synthesis of the analysis is presented in both tabular and graphic forms. Growth rate analysis showed that the area of millet is declining but the import value, production, and yield were increasing at the rate of 14.62, 0.47, and 0.73 percent per annum respectively. Import and export values and quantity showed higher CV as well as IIN while area, production, and yield showed lower values. The trade specialization index was found as -0.992, which indicates that millet is in the introduction phase. Out of the total millets area, 78% of the area lies in the hill, 19% in the mountain, and only 3% in the terai. The highest area and production can be observed in Bagmati province while the least was observed in province no two. The study implies that there is a need to increase production and productivity to reduce increasing imports and make the country self-reliant in millet production with increased investment in research and development and adequate support from national policies and programs.

Keywords: millets, production system, smallholders, nutrition security, trade

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INTRODUCTION

Millet is an important group of small-seeded cereal crops and is a member of the grass family. Among the millets, finger millet is the most important crop in Nepal in terms of area and production followed by proso millet and foxtail millet. Besides, Sorghum, barnyard millet, pearl millet, little millet, and kodo millet are also grown in different parts of the country (Ghimire *et al.*, 2017). Among millet groups, finger millet is the most important crop and the fourth important cereal crop after rice, maize, wheat in Nepal. It is planted in the area of 263,261 ha in 2018/19 with average productivity of 1.19 t/ha in 2019 (MoALD, 2019) which was 1.10 t/ha a decade ago in 2008/09 (MoALD, 2009). Recent official data of the Ministry of Agriculture and Livestock Development (MoALD, 2018/19) show that finger millet is grown

in 70 districts except in 2 districts of high mountains (Manang and Mustang) and 4 districts of Terai namely, Kapilbastu, Banke, Bardiyaa and Kanchanpur. High diversity of finger millet exists in the mid hills of Nepal. Out of 15 species reported in the world, three of them namely *Elusine coracana*, *E. indica* and *E. aegyptica* are found in Nepal (Kandel *et al.*, 2019a). In the climate change scenario, there is scope for increasing finger millet growing areas due to its adaptability and suitability for low, marginal lands and also for harsh weather conditions (Kandel *et al.*, 2019b). The major production districts of Nepal for this crop are Khotang, Sindhupalchok, Baglung, Syangja, Kaski, Gorkha, and Sindhuli and are considered very important crop for food and nutrition security in both mid-hill and mountain (Ghimire *et al.*, 2017). Finger millet is the number one crop in Humla and Mugu districts whereas it is the second important crop in Jumla, Khotang, and Sindhupalchok in terms of area and production. Baglung district of Gandaki Province has the largest area and production under finger millet in Nepal. The highest productivity of finger millet is found in Udaypur (1.97 mt/ha) followed by Panchthar (1.97 mt/ha) and Okhaldhunga districts (1.97 mt/ha). Province 1 has the highest productivity of finger millet (1.35 mt/ha).

Nepal is considered a secondary center of millet diversity with diverse types of varieties grown by smallholder farmers across different altitudes, farming systems, and locations in Nepal. It is cultivated up to 3100 msl above sea level in Humla at Burounse village near Simikot, probably at the highest altitude in the world (Baniya *et al.*, 1992; Ghimire *et al.*, 2017; 2020). Millet crop is a C4 crop with high photosynthetic efficiency, nutrient-dense, locally available, and climate resilience with high adaptation to drought and other biotic and abiotic stresses. Despite it is underutilized minor crops in the country, it has the potentials for improving the nutrition and health security of the growing urban and global population in the changing climate and other natural environments (Ghimire *et al.*, 2020; Gauchan *et al.*, 2020). Indeed, the millet of Nepal harbours globally important unique gene pools of nutrition, cold, drought, and pest tolerance that are important for food and nutrition security of the smallholder farmers and marginalized mountain communities in the face of changing climate (UNEP GEF, 2013; Ghimire *et al.*, 2018; Gauchan *et al.*, 2019). The crop is grown under defacto organic conditions and it is meeting multiple livelihood securities (food, fodder, nutrition, livelihood, and ecological) of smallholder mountain farmers. This crop is gluten-free, nutrient-dense containing rich micronutrients, dietary fibers, rare amino acids, vitamins, and account for higher protein, calcium, and iron as compared to major food staples such as rice, wheat, and potato (DFTQC, 2012; Gauchan, 2019). It is also considered as “Future Smart Food” considering its great value for nutrition, local adaptation, climate resilience, and risk diversification (Li and Siddique 2018, Ghimire *et al.*, 2018; Joshi *et al.*, 2019; Gauchan *et al.*, 2019). In Nepal, the GEF UNEP Local Crop Project has named it as one of the Himalayan Superfoods (www.himalayancrops.org). Five years of food import data of Nepal showed that the import value has increased from NPRs. 44.43 billion in 2009-10 to NPRs. 127.51 billion in 2013-14 (Gairhe *et al.*, 2018). Even though there is increased productivity of millet over a period, Nepal has spent NRs 180.10 million to import millet in 2019 (TEPC, 2019).

Farmer preferred variety improvement by participatory method, promoting an agronomic package of practice, creating market incentives to enhance domestic production, and integration of in public school are the policy options to uplift the finger millets in Nepal (LIBIRD, 2016). There is still a social taboo in its consumption by the elite groups in the rural and urban areas of Nepal. As a result, its research, development is limited and there is a declining area in the last 3 decades (1991-2011) as per the national census of agriculture in Nepal (CBS, 2012; Gauchan, 2019). Since finger millet is considered a minor and neglected crop, a very limited study has been done on studying its production system, productivity, and

trade dynamics in Nepal. Therefore, this study aims to understand its prospects and potentiality by assessing its production system, production and requirement gaps, dynamics of its production and imports growths, and trade in Nepal.

MATERIALS AND METHODS

Data Sources

Data on area, production, and yield of millet were collected from Statistical Information of Nepalese Agriculture of the Ministry of Agricultural and Livestock Development (MoALD). The import and export data were collected from the Trade and Export Promotion Centre of the Ministry of Industry, Commerce, and Supplies (MoICS). Source seed production data were collected from the Monitoring and Evaluation (M&E) Division of Nepal Agricultural Research Council (NARC). The analyses of the data were done by using 11 years of data from 2009 to 2019 on area, production, yield, import, and export of Millets. The study used some specific analytical tools for assessing the area, production, import, and export growth rate, as well as production and requirement gap and trade specialization index, are used which are outlined in this section. The simple descriptive statistics and specific assessment techniques for compound growth rate and other techniques are presented in both tabular and graphic forms.

Compound Growth Rate (g) Analysis

Growth of any variable indicates its past performance and is frequently used in economic studies to see the trend of a particular variable over a time period. Gairhe *et al.* (2018) also used growth rate while analyzing the dynamics of major cereals productivity in Nepal. The exponential growth function was used to estimate the growth in the area, production, yield, value, and quantity of millet import and export in Nepal, which is given below:

$$Y_t = ab^t u_t \dots\dots\dots (1)$$

Where,

Y_t : Dependent variable for which growth rate was estimated

a: Intercept

b: Coefficient of regression (1+g)

t: Years which takes values, 1, 2,, n

u_t : Disturbance term for the year t

For the estimation purpose, the equation was transformed into log-linear form and the ordinary least square (OLS) technique was used for estimation. The compound growth rate (g) in percentage was then computed from the relationship:

$$g = \{ \text{Antilog of } (\ln b) - 1 \} \times 100$$

Regression coefficient significance was tested by using the student's' test.

Coefficient of Variation

To find out the variation in any time-series data, a simple analytical technique like the coefficient of variation is useful (Gairhe, 2011; Gairhe *et al.*, 2018). It is estimated as follows:

$$CV = (SD / \text{Mean}) \times 100$$

Where SD = Standard Deviation

Instability Index

To study the fluctuation or instability in any time series data, a simple analytical technique instability index is very much useful. It is estimated as follows:

- i. Parameter of a log-linear trend line is estimated for the variable (Y_t) to which instability is to be estimated
- ii. If the parameter that is estimated is statistically significant, then the instability index (IIN) is defined as
$$IIN = CV \times (1-r^2)^{0.5}$$
Where, CV = Coefficient of Variation
 r^2 = Coefficient of Determination
 $CV = (SD/ \text{Mean}) \times 100$ Where SD = Standard Deviation
- iii. If the estimated parameter is not significant in the regression equation, then the CV itself is the instability index.

Production and Requirement Gap

Requirement = Production + Import - Export

Trade Specialization Index

Trade Specialization Index (TSI) is used to calculate the competitive position of millet in Nepal. The formula used is as follows:

$$TSI = \frac{Nx - Nm}{Nx + Nm}$$

Where,

TSI is Trade Specialization Index,

N_x is the value of millet exports from Nepal

N_m is the value of millet imports to Nepal

The value of this index has a range between -1 to + 1. If the value is between 0 to 1, then the millet has strong competitiveness as an exporter. Instead, competitiveness is weak or inclined as the importer, if the value is below 0 to -1.

TSI can be used to identify the position of the competitiveness of a commodity in trade and divided into the following phases: (1) Phase introduction, in this phase, the value index is -1.00 to -0.50; (2) Phase import substitution, which is the index value between -0.51 to 0.00; (3) Stage growth, is the value from 0.01 to 0.80; (4) Phase Maturity, is the range 0.81 to 1.00.

RESULTS AND DISCUSSION

Production System and Usage in Food Culture

Finger millet is cultivated by smallholder farmers in all most all districts from the east to far-western regions of hill and mountain ranging from 500 msl to 3100 msl in different agro-ecologies, and farming system, though it is grown in a small area in some parts of Terai below 500 msl (Baniya *et al.*, 1992; Ghimire *et al.*, 2017; 2020). It is mainly grown in rain-fed conditions in the uplands as a sole crop or relay cropping with maize. Farmers have maintained diverse traditional varieties of millet over a generation by cultivating, selecting, community sharing, and conserving them based on their unique preferences for adaptation, yields, livelihood, and cultural use. These include extra short duration variety such as Tinmase (grown in 3 months) to open finger types (Nangre) and close and compact type (mudke) to samdi kodo (white grained delicious finger millet variety). The major production domain, important

varieties, and farmer preferred traits of finger millet with a diverse use of food culture and farmer preferred attributes are briefly presented in Table 1.

The crop has multipurpose use from its use in main meals (*Dhindo*), flat chhappati roti to different type's modern food recipes such as pancake, multigrain breads, biscuits, cakes, selroti to very useful livestock feeds. Finger millet has usage in diverse food culture and livelihood of smallholder farmers in the hill and mountain. Finger millet flour is commonly used for making *dhindo*, *roti*, and grain is used for making high quality traditionally fermented liquors called *Jhand* or *chhyang*, *tumba* and preparing distilled liquor called *raksi*. The straw is used as an important livestock feed in the hill and mountain during dry lean season. Recently finger millet is being used in modern food culture as a nutritious multigrain bread, cakes, cookies, nimkin, momo etc. There is increasing use of this crop in the daily life of the Nepalese people (Ghimire *et al.*, 2018).

Table 1: Production domains, important varieties, preferred traits and usage in food culture

Production domains	Important Varieties	Farmer Preferred Traits	Usage in food culture
Middle Mountain of far-west to the east including a high mountain of Karnali Province cultivated in rainfed uplands without use of external inputs (chemical fertilizer and pesticides).	1. Jhype, 2. Mudke 3. Chulthe 4. Dalle 5. Lampate 6. Lurke 7. Chhatre 8. Batule 9. Rato kodo 10. Seto kodo 11. Dudhe 12. Lopre 13. Nangre 14. Tauke 15. Tinmase 16. Paudere	-High yield -Early maturity -Disease tolerance -Pest tolerant -Drought tolerance -Ease in processing -Cooking quality -Stay green nature of straw	-Dhindo (thick porridge) - Chhapati/ flat Roti -Haluwa, sweets -Millet Soup (Khole) -Home-made Liquor (Jhand, Tomba, Rakshi) -Modern food dishes (multigrain bread, pancake, biscuits, nimkin, momo, cakes, selroti) - Straw as livestock feed

Source: Authors adaptation from various sources (Ghimire *et al.*, 2017; 2020; Joshi *et al.*, 2017)

Area, Production, and Productivity

Area, production, and yield of millet from 2009 to 2019 is shown in figure 1. The production and yield showed an increasing trend while the area showed a decreasing trend. To date, only five finger millet varieties have been released by the government of Nepal (SQCC, 2019) and their productivity ranges from 2.4 to 3.3 t/ha. However average productivity is far below the potential productivity. The study by Luitel *et al.* (2020) predicted significant shrinkage of existing suitable finger millet areas with an increase in temperatures. Similarly, Zomer *et al.* (2014) stated that climatic factors like drought, rise in maximum temperature, increasing erratic pattern of rainfall, and the shift of bioclimatic zones in different elevations in Nepal may play a role in the decline of a suitable area of finger millet. Labour constraint and processing difficulty were the reasons for the farmers' declining interest in finger millet cultivation in Nepal (Devkota *et al.*, 2016; Ghimire *et al.*, 2017; Gauchan, 2019).

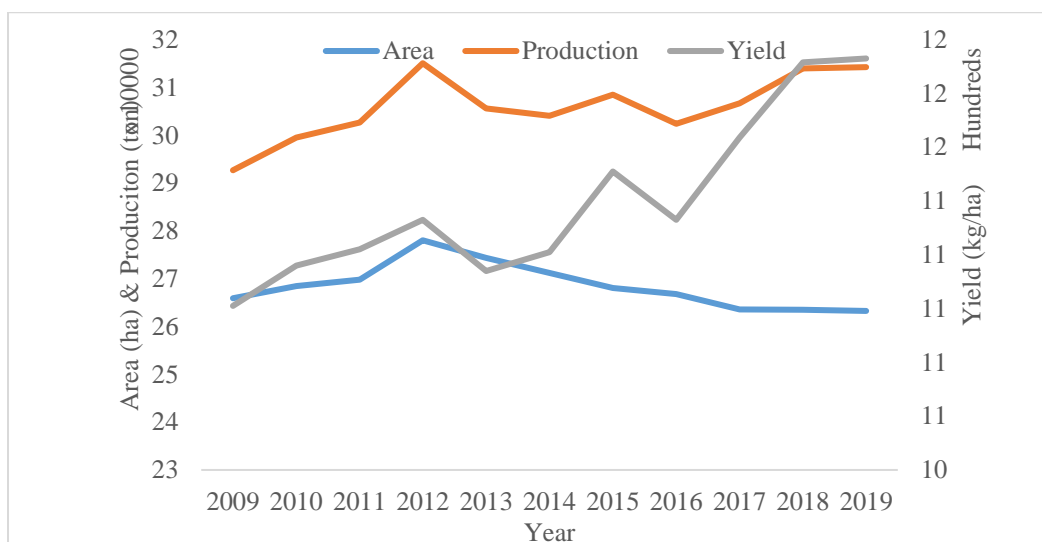


Figure 1: Area, production, and productivity of millet in Nepal

As evident from the above figure 1 and recent data (MoALD, 2019), the yield of finger millet is very low hovering around 1 mt/ ha as compared to about 3 mt /ha for major cereals like rice, maize, and wheat. Hence, there are high prospects for increasing production and productivity of this crop by the use of improved varieties, production technologies, and management practices.

Millet area based on agro-ecology in Nepal is shown in figure 2. Among the different agro-ecology, the hill of Nepal covered 78 % followed by the mountain 19% and only 3% in terai region. Western hill occupied the highest area followed by eastern hill and least in the far-western hill. The highest area was observed in the central mountain followed by eastern mountain and no area in the western mountain. The highest area was occupied in eastern terai followed by central terai and least on mid-western terai (MoALMC, 2017). According to Ghimire *et al.* (2020), 77% of millet produced in the hill and 20 % from mountain districts.

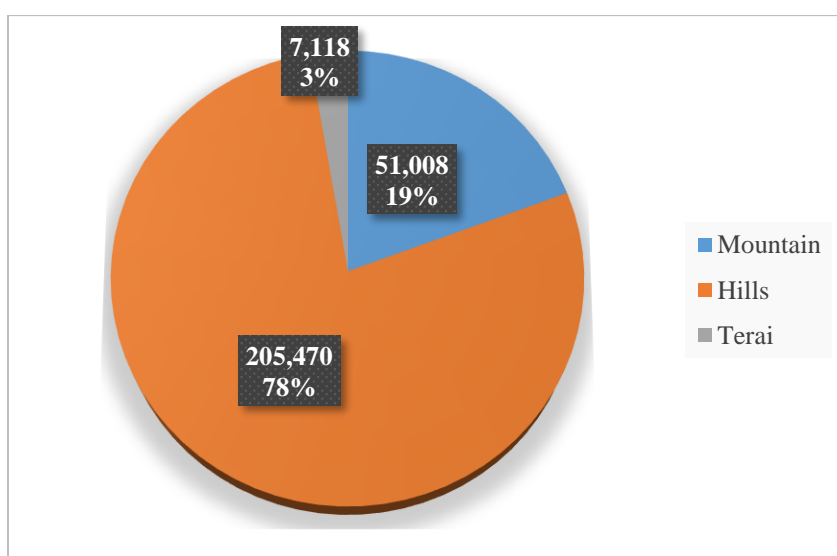


Figure 2: Area of millet in 2017 based on agro-ecology in Nepal

Province wise area and production of millet are shown in figure 3. The highest area and production can be observed in Bagmati province while the least was observed in province no two.

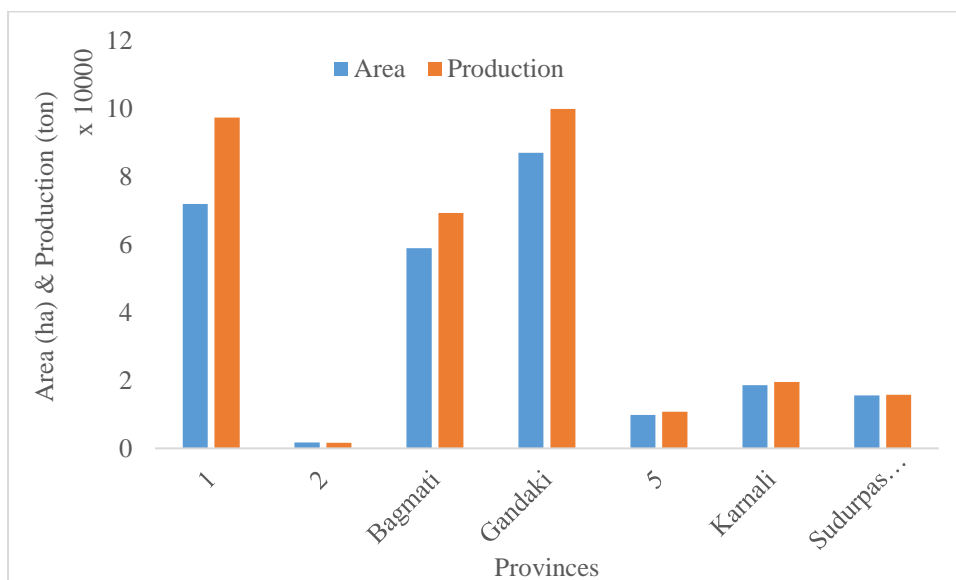


Figure 3: Province wise average area and production of millet in Nepal

Production and Requirement

Production and requirements of millet in Nepal are illustrated in figure 4. In all the years, the requirement is higher than production. An average of 14,402-ton millet is required in addition to edible millet grain production in Nepal. Despite such importance, production and consumption are decreasing as a result of, inter alia, the expanding availability of more profitable crops, and a lack of awareness regarding its nutritional qualities by urban consumers, and limited R&D dedicated to this crop (Pallante *et al.*, 2016). One of the declining production and productivity is also due to low financial return finger millet as compared to many cash crops such as coffee which has 3.3 times higher return than for millet production in Nepal (GoN, 2017).

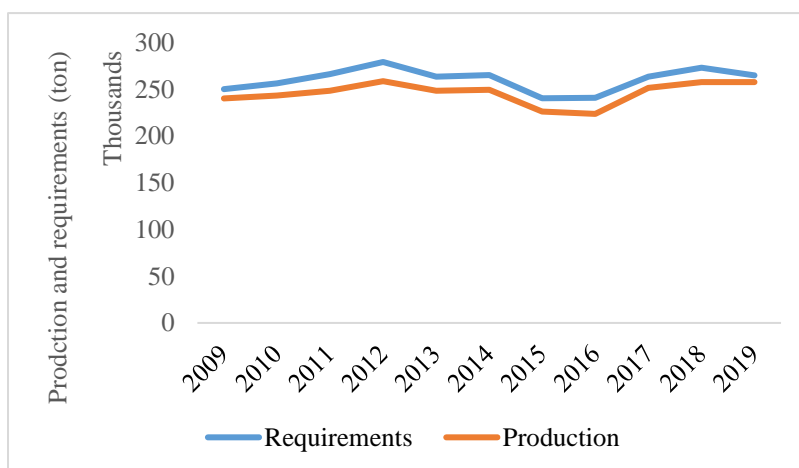


Figure 4: Production and requirements of millet in Nepal

Import and Export

Millet import quantity and value are shown in figure 5. Millet value and quantity showed sharp increasing trend up-to 2012-13 and thereafter quantity started declining some years while increase slightly in some years but the value of import continue to increase gradually which later declined after 2016. There was high variability after 2014 (Figure 5). The finger millet import is imported mainly from India for liquor purposes without any linkage in the domestic value chain (Gauchan *et al.*, 2019).



Figure 5: Import of millet in Nepal

Millet export quantity and value are shown in Figure 6. Millet value and quantity showed a sharp increasing trend up-to 2014 and thereafter showed a declining trend. The decrease in the export of millet is associated with the decrease in import of millet in Nepal. It can be assumed that the millet export has reduced to home consumption and that leads to a decrease in import also. However, scientific information to validate this is to be investigated in the future.

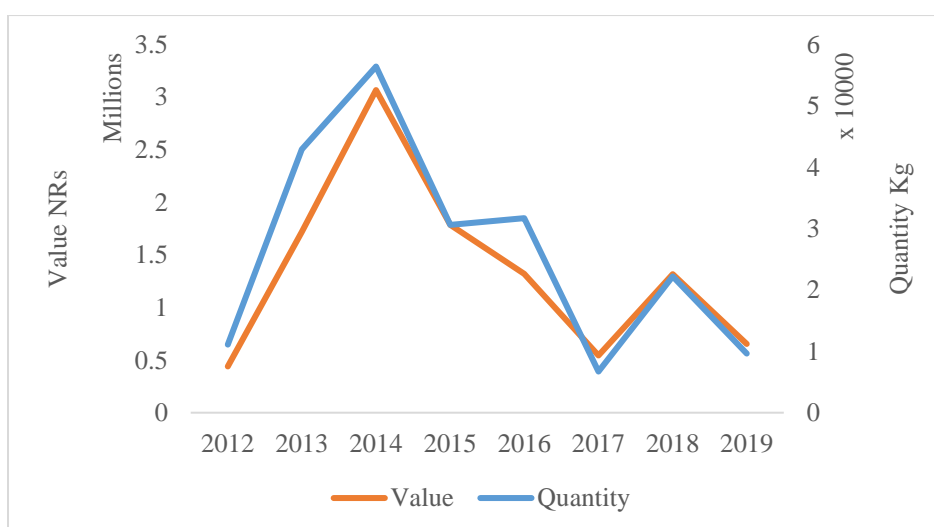


Figure 6: Export of millet in Nepal

The study revealed that millet import value and millet production in Nepal are increasing at the rate of 14.62 and 0.47 percent per annum respectively and significant at 5 percent level of

significance (table 2). The growth rate of yield was 0.73 and significant at 1 percent level of significance. Other variables such as the quantity of import, area, export quantity, export value, and source seed production growth rate are not significant.

Table 2: Compound growth rate of millet area, production, yield, source seed production, import & export quantity and value in Nepal from 2009 to 2019

Particulars	Intercept	CGR	R ²	P-value
Area (ha)	12.52	-0.27	0.27	0.101
Production (ton)	12.60	0.47*	0.47	0.020
Yield (Kg/ha)	6.99	0.73**	0.80	0.000
Source seed (ton)+	0.69	3.15	0.11	0.414
Import Quantity (Kg)	16.58	-2.21	0.06	0.461
Import Value (NRs)	18.45	14.62*	0.46	0.022
Export Quantity (Kg)+	10.52	-11.89	0.16	0.320
Export Value (NRs)+	14.15	-4.70	0.03	0.677

Note: * and ** denotes significance at 5 and 1 percent level of significance respectively. + indicates data from 2012 to 2019

The coefficient of variation and instability index of finger millet is illustrated in table 3. The result showed that the highest CV was observed in export quantity followed by an export value, import value, import quantity, and source seed production. Least was observed in area, production, and yield. The highest instability index was observed in export value followed by an export quantity, import value, import quantity, and source seed production. A lower index was observed in yield, area, and production respectively.

Table 3: Coefficient of variation and instability index of area, production, yield, source seed production, import and export of millets in Nepal from 2009 to 2019

Particulars	CV	IIN
Area (ha)	1.75	1.49
Production (ton)	2.23	1.62
Yield (Kg/ha)	2.74	1.22
Source seed (ton)+	21.50	20.24
Import Quantity (Kg)	26.16	25.34
Import Value (NRs)	49.55	36.38
Export Quantity (Kg)+	66.18	60.53
Export Value (NRs)+	63.82	62.83

Note: + indicates data from 2012 to 2019

Table 4: Trade specialization index of millet from 2012 to 2019

S.N.	Year	TSI
1	2012	-0.996
2	2013	-0.989
3	2014	-0.985
4	2015	-0.991
5	2016	-0.994
6	2017	-0.997
7	2018	-0.994
8	2019	-0.993
Total		-7.939
Average		-0.992

The trade specialization index (TSI) of millet in Nepal from 2012 to 2019 is shown in table 4. The average value of TSI was found as -0.992 which indicates the strong negative value of the

index between the range of 0 to -1 so that the millet has very weak competitiveness or inclined as an importer. TSI can also be used to identify the competitive position of a commodity in trade. Since the index value lies between -1 to -0.50, millet is in the introduction phase. There are still high prospects by putting increasing efforts to promote trade of millet by increasing production, productivity for its commercialization by creating nutrition and health value of the products.

CONCLUSION

Finger millet is an important food crop for smallholder poor and vulnerable farmers in the hill and mountain of Nepal. About three-fourth area of finger millet is in the hill indicating important crops for food and nutrition security of the hill farmers. Despite this, the area of millet is declining with stagnant in production and yield. But the import value is increasing rapidly with 14 % per annum in the last decade. This indicates that current production has not been able to meet the increasing demand for millet products in the country. Presently the country has a higher CV and IIN in imports and exports indicating a high fluctuation in the imports and exports of millet in the country. The trade specialization index found as -0.992 indicates millet is in the introduction phase. This indicates that there is still a high prospect by putting increasing efforts to promote trade of millet by increasing production, productivity for its commercialization by creating nutrition and health value of the products. Considering the low productivity of the crop hovering around 1 mt as compared to an average of 3 mt per hectare for major cereals like rice, maize, and wheat, there are high prospects for increasing production and productivity of this crop by the use of improved varieties, production technologies and management practices. Hence, there is an urgent need to increase productivity with increasing investment in research and development to reduce increasing imports and make the country self-reliant in millet production. Moreover, because of their high nutrition value and ability to grow in low input marginal hill slopes and rain-fed terraces, millet can be potential crops for improving food and nutrition security of smallholder farmers in the hill and the mountain in the future. This will, however, require increased priority and policy support for promoting this crop in the rain-fed marginal lands of hill and mountain.

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Authors' Contributions

S Gairhe design the research work and collected data and drafted a manuscript. D Gauchan and KP Timsina elaborated the sections and provided inputs, critical feedback and comments. The final form of the manuscript was approved by all authors through rigorous review.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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