

Where is Nepal in the Food System Transition?

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Authors' contributions

This work was carried out in collaboration between both authors. Author MS designed the study, performed the statistical analysis, did literature surveys and wrote the first draft of the manuscript. Author AP managed the analyses of the study and helped in discussion process. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/SAJSSE/2020/v8i430216

Editor(s):

(1) Dr. Alexandru Trifu, "Petre Andrei" University of Iasi, Romania.

Reviewers:

(1) Sudhanand Prasad Lal, Dr. Rajendra Prasad Central Agricultural University, India.

(2) Lakshmi, Management College of Commerce, India.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/58936>

Received 08 May 2020

Accepted 14 July 2020

Published 02 December 2020

Original Research Article

ABSTRACT

In Nepal, 27% of GDP is contributed by the agriculture sector with 65.56% of households depending upon agriculture for employment. However, 51.8% of households are still food insecure and 25.2% are under the poverty line. Given these facts, it is interesting to watch how the economic growth and food system will go forward, despite the paradoxical history of development-modest growth but brisk poverty reduction has already been experienced. While literature noted that the transition to a food system is rapid for developing countries, very limited analysis linking the food system to its drivers and its consequences exists in the context of Nepal. The study examined food system transition using the secondary data from different sources and analyzing it through a conceptual framework of the food system. The study showed the contemporary food security issue is disparity in food access among the peoples driven by the poverty gap. The trends and scenarios shown in results revealed that the tendencies of food system drivers are on positive sides, but the structural foundation of agriculture (land issues, labor migration, mechanization, adaptations, etc.) is not so strong. This situation has created a serious question on the transition of the food system in Nepal. For this, the policy priorities are imperative to be institutionalized at all three levels of government-federal, state and local, and need to be concerted to transform the food system.

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Keywords: Food system; food policy; food security; Nepal; food transition.

1. INTRODUCTION

Nepal is one of least developed (LDCs), land locked and disadvantaged countries with an annual GDP of USD 29.04 billion and a population of 28.08 millions in 2018 [1]. After leaving behind the decade-long armed conflict (1996-2007) and subsequent transitional period, Nepal is now on the mainstream of economic development with the vision of peaceful and prosperous Nepal. The three levels election at federal (1), provincial (7) and local levels (753), gradual implementation of constitution and ensued political stability have created the tremendous opportunities to climb Nepal toward developing countries in 2022 and the middle-income country in 2030. However, as the consequences of Covid-19 on the world economy and Nepal economy as well is unprecedented, temporarily plunging into recession [2], the problem of unemployment and food insecurity will be more likely to threaten Nepal.

On the one hand, real GDP of Nepal grew by 7.1% in FY 2019 as compared to an average of 4.1% in FY 2007-2016 driven by service and agriculture sectors with favorable monsoons [3]. Agriculture has remained the larger part of Nepal's economy (27%) as a key source of employment (69.78%) and a driver of poverty alleviation [4]. The potentiality of tapping diverse climates to produce commodities having comparative advantages especially high value crops and linking the local domestic chains to two giant economies is outstanding. Within south Asia, Nepal has medium performances in terms of poverty and malnutrition; irrespective of high dependence on agriculture economy as compared to other South Asian countries ([5]; see Table 1). On other hand, the challenges of the agriculture sector is solidified by labor outmigration, dependence over monsoons, subsistence farming and poor mechanization, contributing to steady loss of competitiveness and hurting food security severely. Moreover, the national food system is highly vulnerable to external shocks and stresses [6], as it is a salient feature of low income countries. The national food secure household is only 48.2%, while 10% are a widely insecure household [7]. The juxtaposition of these two scenarios shows the criticality of economic development and structural transformation. However, Nepal has seen the

paradoxical history of development- modest growth but brisk poverty reduction [8]. The pattern of structural transformation has also shown the peculiar characteristics-shrinking agriculture, premature stall of manufacture and greater role of services, reason being armed conflict and discontinued policy directions [9].

In such a situation, discussion among agriculture economists and development practitioners should be focused on food system dynamics within a complex interdisciplinary and multi-sectoral framework. The key concern is to link the majority of small holding farmers (52.7% holding less than 0.5 ha land) into the value chain and market system, and to sustain the food security, given the fact that 25.2% of people live below the poverty line [10]. Food security itself is the multidimensional concept and complex outcome of multiple aspects (i.e., multi-scalar and cross-sectoral), operating from household level to international level [11]. Sustainable food security is established on the foundation of balance of socio-economic welfare and ecological services. Keeping these aspects in mind, the paper is on the verse to contribute for analyzing the food system of Nepal, and hopefully provide ways forward for future direction of policies on the basis of underlying challenges and realized opportunities.

This article is thus about analysis of the food system, challenges and future direction. It is structured as follows. In part two, the methodology of the paper is discussed. Part three describes the situation of food systems, its challenges and trends. Part four shows the opportunities and future direction for sustainable food security. Finally, part five presents the conclusion and limitations.

2. METHODOLOGY

To understand the food system transformation, it is first important to analyze the drivers of food system and their expected outcomes [12,13,14]. There are ranges of drivers or exogenous variables categorized by various literatures falls under five broad categories (see., Fig. 1), though the rigorous analysis of Bene et al., [12] has listed 12 key drivers- rapid urbanization, rise in consumer income, population growth, concerns on diet and health issues, technological innovations, intensification and homogenization

Table 1. Profile of South Asia (2019)

Indicators	Unit	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Srilanka
GDP	Constant 2010 (Billion US\$)	20.96	194.15	2.36	2841.58	4.14	22.96	254.20	85.30
	Growth rate (%)	1.03	7.86	3.03	6.81	6.89	6.69	5.83	3.21
GDP per capita	Constant 2010 US\$)	563.83	1203.22	3128.00	2100.80	8033.33	817.45	1197.84	3936.45
	Growth rate (%)	-1.35	6.74	1.82	5.71	2.89	4.91	3.68	2.13
Agriculture GDP	% of GDP	NA	13.07	15.89	14.60	5.59	25.29	22.85	7.87
	Growth rate (%)	-5.00	4.19	4.36	2.92	4.81	2.79	3.94	4.76
Employment in agriculture	% of total employment	43.38	39.46	55.99	43.33	8.73	65.56	37.42	25.23
Poverty gap	At \$1.90 a day (2011 PPP) (%)	NA	2.7	0.2	4.3	0	3.1	0.5	0.1
	At \$3.20 a day (2011 PPP) (%)	NA	15.6	2.5	19.7	0.1	15.8	7.6	1.9
GINI index	Index	NA	32.4	37.4	37.8	31.3	32.8	33.5	39.8
Trade	% of GDP	NA	38.24	86.71	43.38	146.27	55.23	28.54	52.92
Infant mortality rate	Per 1,000 live births	47.9	25.1	24.8	29.9	7.4	26.7	57.2	6.4
Prevalence of stunting	% of children under five	38.2	30.8	33.5	34.7	19	36	37.6	17.3
Mortality rate under age five	Per 1,000 live births	62.3	30.2	29.7	36.6	8.6	32.2	69.3	7.4

Source: World Bank, 2020 [1]

of agriculture sector, climate change, environmental degradation, increasing accessibility to infrastructure and information, trade policies and its influences, private investments and food safety concerns. These drivers impact the three broad aspects of food system viz., food value chains, food environment and consumer behaviors, which are analyzed on this paper. Based on the trend or observed transitions in different indicators of these outputs, the paper has analyzed the food system situation in Nepal and come up with possible future directions. The secondary sources of information and data from the World Bank, FAOSTAT, national database and literature are taken for analysis. The scenarios of food balance are based on economic forecasting using Box-Jenkins ARIMA model in R software. The forecasted food balance is the difference of forecasted food production and forecasted food consumption. The food production and food consumption is forecasted using past data from 1961 to 2019, available in FAOSTAT. The data of food consumption is calculated as: Food consumption = Food imports + Food production – Food exports.

In general, an ARIMA model is characterized by the notation ARIMA (p, d, q) where p, d, q denote

orders of auto-regression (AR), integration (differencing) and moving average (MA) respectively. In ARIMA, time series is a linear function of past actual values and random shocks. A stationary ARIMA (p, q) process is defined by the equation:

$$Y_t = \alpha_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \dots + \beta_p Y_{t-p} - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (i)$$

where, Y_t is the outcome variable that will be explained in time t. $Y_{t-1}, Y_{t-2}, \dots, Y_{t-p}$ are lags of time series data Y at time lags t-1, t-2, ..., t-p, respectively. α_0 is constant or intercept. $\beta_1, \beta_2, \dots, \beta_p$ are AR coefficients. $\theta_1, \theta_2, \dots, \theta_q$ are MA coefficients. ε_t is residuals or errors in time t. $\varepsilon_1, \varepsilon_2, \dots, \varepsilon_{t-q}$ are the error term that represents the variables not explained by model. To build this model, we need to study the time series and identify p, d, and q. First we have to ensure stationarity. During this course, the appropriate value of d is determined. Next step is identification, in which the appropriate value of p and q are determined using ACF, PACF and unit root tests. Then are the estimations of the ARIMA model. To pick best models, residuals of estimated ARIMA models are checked to see if they are white noise. Finally, the process of forecasting is done.

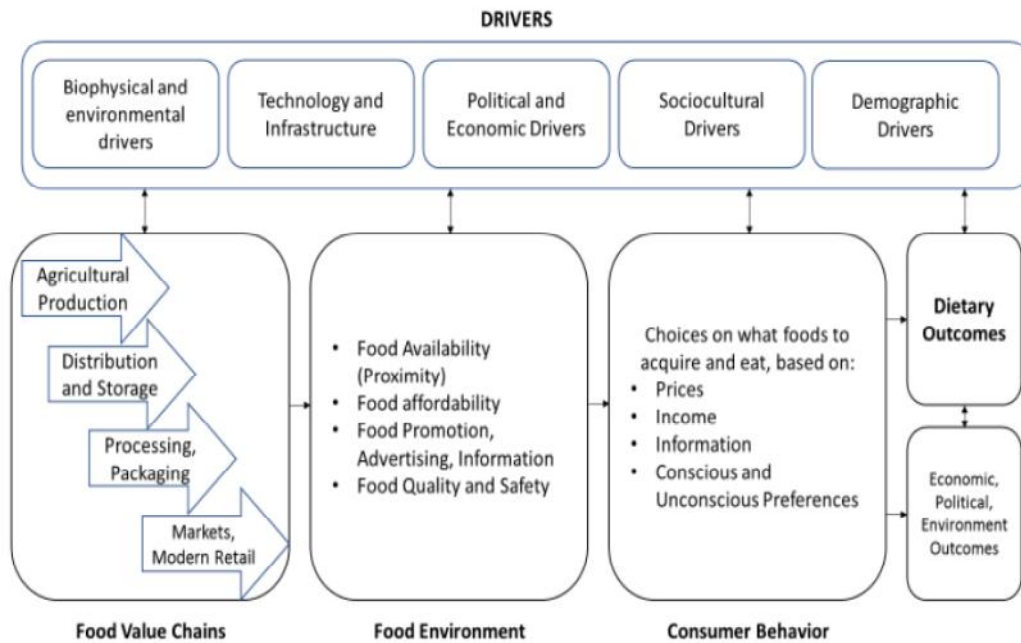


Fig. 1. Conceptual framework of food system

Source: De Brauw et al., [14]

3. RESULTS AND DISCUSSION

The criteria's for food system assessment are given below:

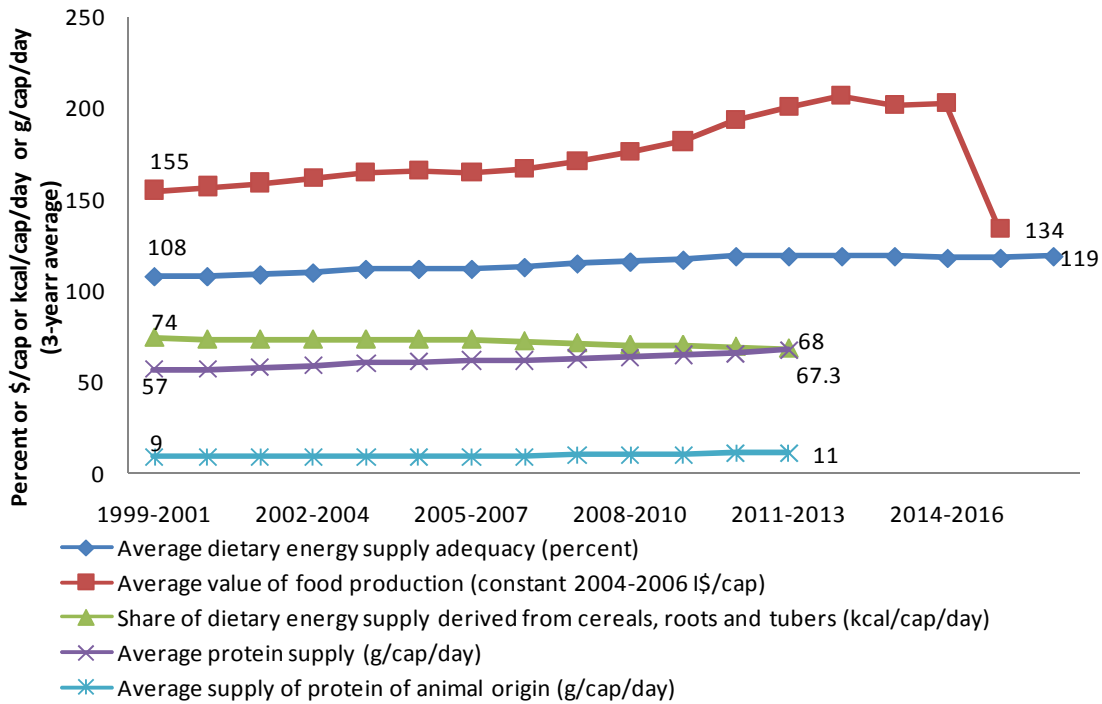
3.1 State of Art on food Security in Nepal

Food security has always remained the national priority in Nepal, however not able to progress significantly. As FAO [15] has defined food security from the perspectives of four pillars, namely availability, accessibility, utilization and stability; various anthropometric, social, economic and political measures could be used to represent these pillars. Most of the indicators of food security are oriented towards a positive direction, but at a very slow rate (see Fig. 1). The average dietary energy supply (adequacy, protein and animal protein) has been increasing in trend while the share of energy supply from cereals and tubers is decreased by 6 kcal per capita per day between 2000 and 2012. It indicated that food consumption is diversifying slowly from a cereal-dominated one to a mix of high calorie commodities [16]; but unlikely to occur in larger scale due to about 10 times higher land allocation to grain, low productivity and constant price rises [8]. The undernourished population has declined from 22% in 2000 to 8.7% in 2017, which is a significant achievement despite 1.35% of annual population growth. The status of food accessibility also shows appreciable inclination on the basis of trends of undernourishment populations (decreased by 2.7 million between 2000 and 2017) and per capita GDP (increased by \$1197 between 2000 and 2018) and severely insecure population (declined from 2.5 million in 2015 to 2.3 million in 2017). However, the per capita increasing trend in GDP has come from gains in prices, not yields [8]. The World Bank (2017) reported that with the period of 2004 to 2011, the crop income increased by 21% was contributed by increase in prices (18%), yields (5%) and land contraction (-2%). Nepal ranks 73rd out of 117 qualifying countries in the Global Hunger Index with the value of 20.8 in 2019. The index is designed on the basis of four anthropogenic indicators: child mortality, wasting, stunting and undernourishment, which are highly reflected on status of food utilization. Despite the hunger index seeming to decreasing in trend since 1998, Nepal has not yet lifted from the serious level of hunger [17].

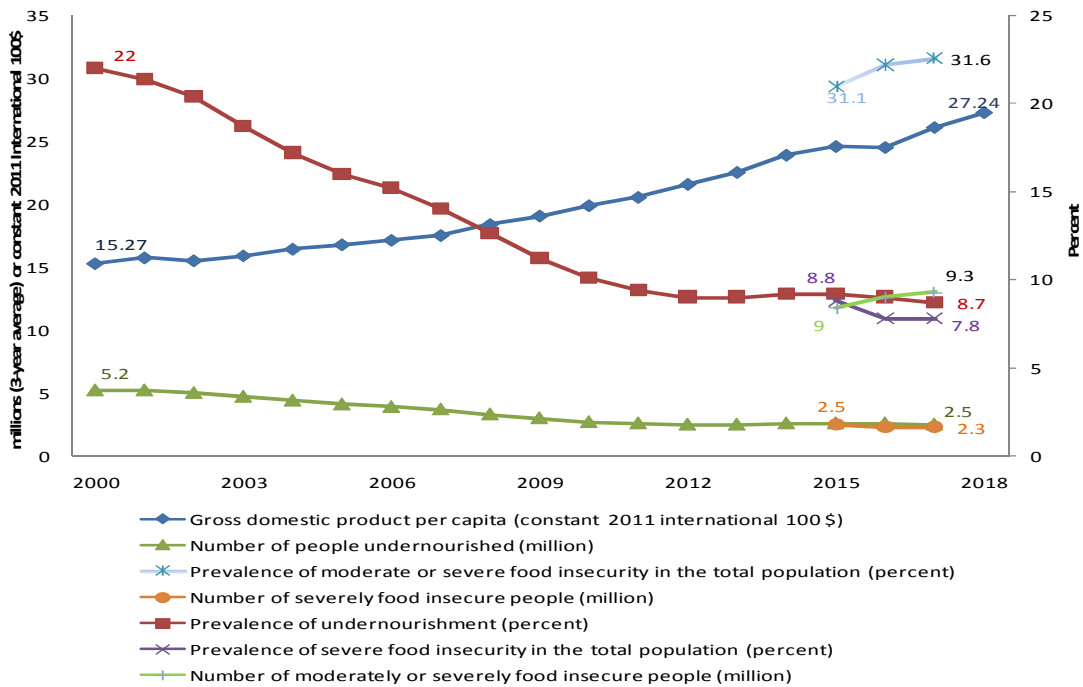
During the period 2000-2016, the political stability and violence index declined by 0.15 points. This is contributed by Comprehensive peace accord between Maoists who departed insurgency of 1996-2007, and government of Nepal at 2007, and after promulgation of constitution at 2015 [18]. The cereal import dependency ratio and value of imports in total merchandise exports have surged from 1.7% to 50.6% between 2000 and 2016, and 23% to 81% between 2000 and 2012, respectively. The per capita food supply variability is seen quite fluctuating in decreasing trends from 28 kcal per capita per day to 18 kcal per capita per day between 2000 and 2013. The value of per capita food production variability has also increased from 3.1 thousand dollars to 11.3 thousand dollars between 2000 and 2016.

3.2 Agricultural Supply and Value Chain Economics

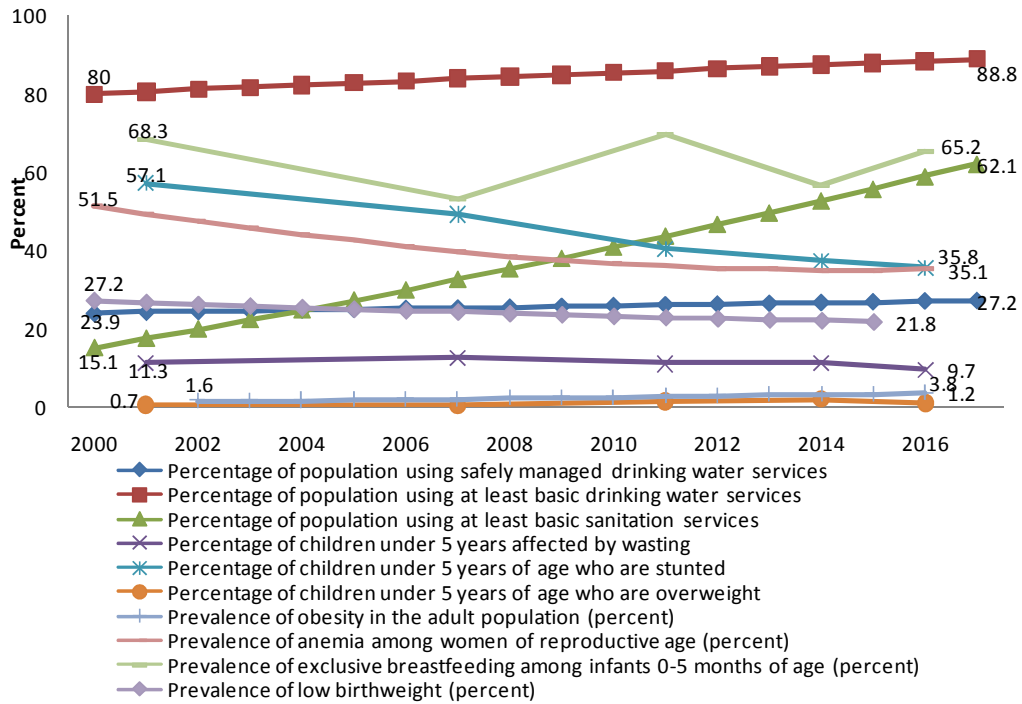
Government of Nepal has acknowledged value chain approach in its major strategic paper-Agriculture Development Strategy (ADS 2015-2030), to enhance scale economies and competitiveness through development of prioritized inclusive value chains (maize, dairy, vegetables, lentils and tea), public-private partnership and strengthening linkages [20]. Value chain approach in Nepal is mainly taken to address the uneven development and poverty reduction under the collaboration with various development partners like Agriculture Development Bank (ADB), United States Agency for International Development (USAID), International Fund for Agriculture Development (IFAD), United Nation Development Programme (UNDP), Korea International Cooperation Agency (KOICA) etc. [20,21]. The per capita consumption of food is increasing in Nepal across all food categories [16], and highly dependent on food imports (see Fig. 2), import value index (2000=100) equals 808.28 [1]. It has raised the policy question on import substitution strategy and competitiveness of domestic value chain in response to imports [22]. Most existing value chain systems in Nepal are already affected by weaker coordination, poor infrastructures and weaker governance [23,24,80]. The linkages of local chains with regional or global chains are constrained by market impediments in the form of Sanitary and Phytosanitary (SPS), non-tariff trade barriers, and an unpredictable fiscal regime.



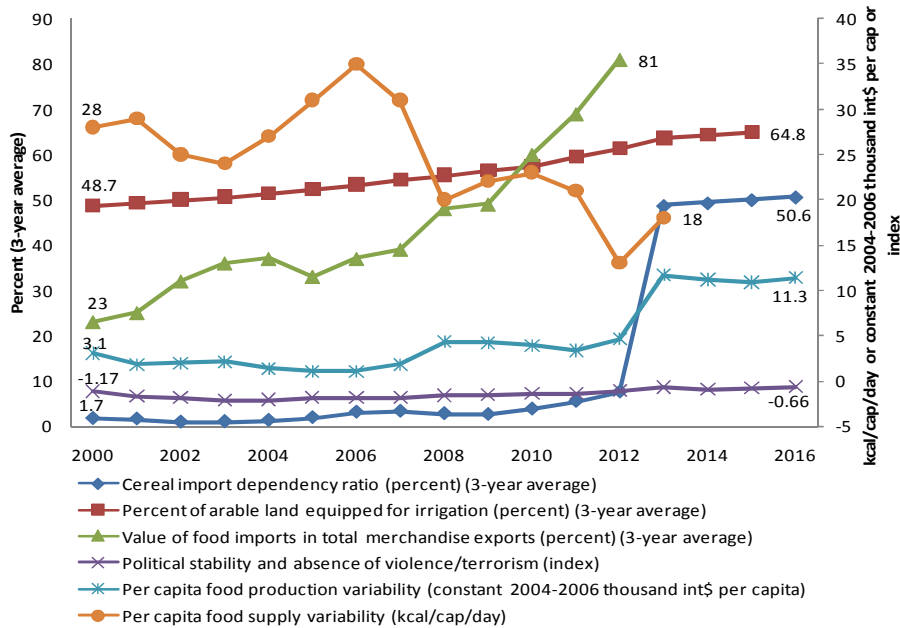
a. Status of food availability



b. Status of food accessibility



c. Status of food utilization



d. Status of food stability

Fig. 2. Situation of food security in Nepal
Source: FAO [19]

Nepal has a medium level index in logistic performance (2.5) with a road-based transportation system. Consequently, very low level of price transmission to local markets but stronger inter-temporal carryover is evident, triggered by weaker transportation, physical and institutional infrastructure, causing higher price levels and volatility in local markets especially for rice and wheat markets [25]. Food price inflation has become prominent since 2007 in Nepal, and vegetables followed by cereals, and meat and fish are major contributors of overall inflation in Nepal [26]. Sharma [26] also reported the fairly close price relation between foods, even with products having low tradability, but not in non food products. The most likely reasons could be unrecorded informal trade from the porous border of India-Nepal. One percent rise in food inflation in Nepal will push 100 thousand additional people into overall poverty and 180 thousand additional people into food poverty [27].

The trade balance of Nepal is not healthy-escalating imports and slow growth of export dominated by low value added products, which is hampering the food stability part [26]. The import-export ratio of agriculture increased with average growth rate being 8.71% between 2000 and 2017 in the agriculture sector (see Fig. 3). The agricultural trade balance has never been positive since 1986, reaching upto US\$ 1.6 billion in 2017 with an average growth rate of 18.3% per year between 2000 and 2007. The gross value added (GVA) of the agriculture sector increased from US\$ 2.1 billion to US\$ 6.8 billion between 2000 and 2017, with an average growth rate of 7.58%.

3.3 Consumption Behaviors

It is likely transition of food baskets from cereals-based to vegetables, fruits and animal products with increase in per capita income, though the trend of increasing per capita income remained stand still for a very long period due to ten years long conflict and laggard growth in successive transitional periods. The consumption of processed food has also been increased which is triggered by urbanization, increasing per capita income and trade liberalization [28]. During the period 1996 to 2011, household food expenditure and per-capita food expenditure had increased at an annual rate of 8.41% and 9.68%, respectively in nominal terms [29]. Low income rural Nepalese households exhibited the higher expenditure elasticities of food as compared to

higher income households [30]. Khanal, Baskota & Giri, [30] has shown that luxury goods like meats, dairy products and alcoholic beverages in 1996 were changed into necessary goods in 2011 while tobacco and tobacco products became inferior goods. The general perception of food consumers in Nepal is orthodox, and legally unaware. The food choice is governed by taste, physical appearance, prices and labeling of date and expiry, ignoring the qualitative aspects of labeling [31]. Local food products are more preferred to foreign and unbranded products in Nepal; however people evaluate the foreign products as superior.

Food choices and preferences are multi-determined factors, imparted by biological, economical and social contexts [32,33]. As Nepal is multi-ethnic (126 ethnic groups) country, the wide range of traditional food consumption practices and cultures varies from oily & spices to nutrient-rich are perceived as both supportive and barriers of effective diet management [34,35]. Caste system in Nepal has also been determinant of food adoption because it dictates the occupation and regulates income and finance. The low level of education and income are major reasons in Nepal to prevent accessibility of globalizing food system, especially for dalit and people of mid-western [36]. The study of Biehl et al., [37] found that the low cost food of Nepal found in all three agro-ecological zones are deficit in calcium and deficit in vitamin B-12 in hills and mountains [36]. The output price uncertainty especially of wheat and rice also tends to reduce calorie intake in rural households in Nepal, reason being to avoid cost for buying high calorie foods [38].

3.4 Resources Allocations and Care Practices

Fertilizer consumption rate in Nepal (74.08 kg/ha) is quite low as compared to South Asian countries (160.28 kg/ha) and world rate (140.55 kg/ha). In addition, the fertilizers use fluctuates in yearly basis; however, trend shows increasing pattern (see Fig. 4 and Fig. 5). The growth of fertilizer use is substantially contributed by Terai regions having relatively larger farm size. Within Fertilizer consumption rate in Nepal (74.08 kg/ha) is quite low as compared to South Asian countries (160.28 kg/ha) and world rate (140.55 kg/ha). In addition, the fertilizer use fluctuates on a yearly basis; however, the trend shows an increasing pattern (see Fig. 4 and Fig. 5). The

growth of fertilizer use is substantially contributed by Terai regions having relatively larger farm size. Within the last 10 to 20 years, Nepal has seen reductions in real chemical fertilizer price, relative to the food price [39]. Takeshima [39] found that small farmers having low assets could not get significant return from increasing

fertilizers use. Income effect of fertilizer use in the household level of Terai was up to 3 times as compared to Hills farms. Price of fertilizer in Nepal is usually influenced by Indian subsidies policies, which is exacerbated by open and porous borders with India.

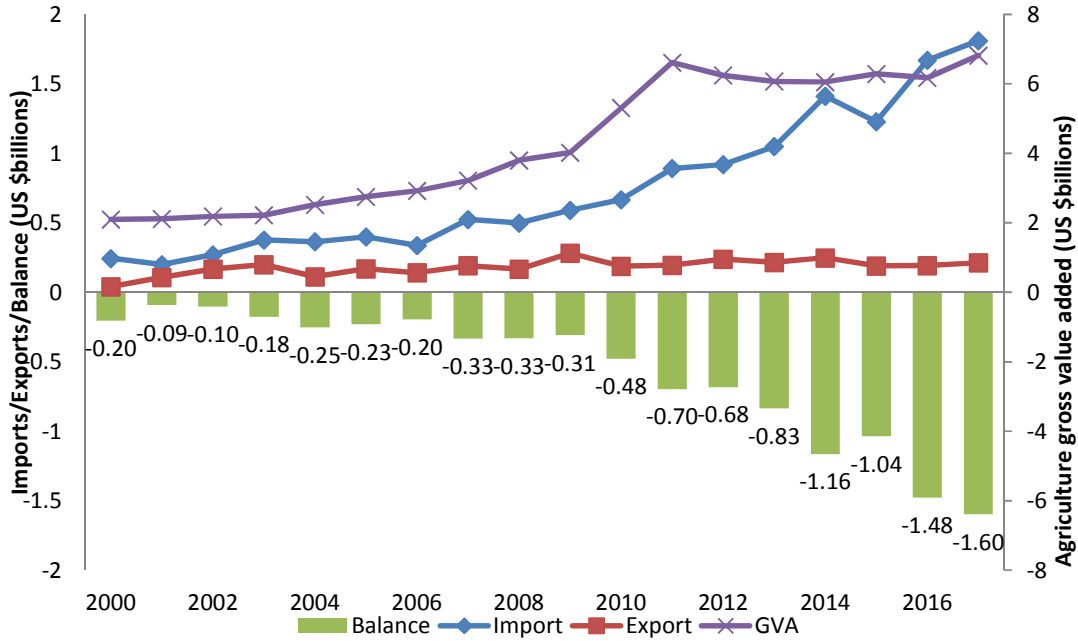


Fig. 3. Import, export, trade balance and gross value added of agriculture sector in Nepal (2000-2017)

Source: FAO [19]; World Bank, [1]

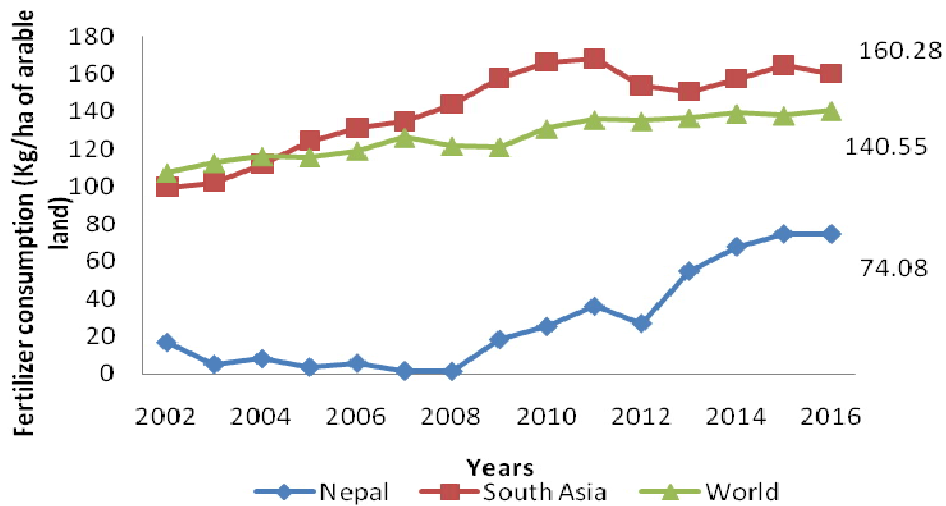


Fig. 4. Fertilizer consumption in Nepal

Source: FAO, [19]

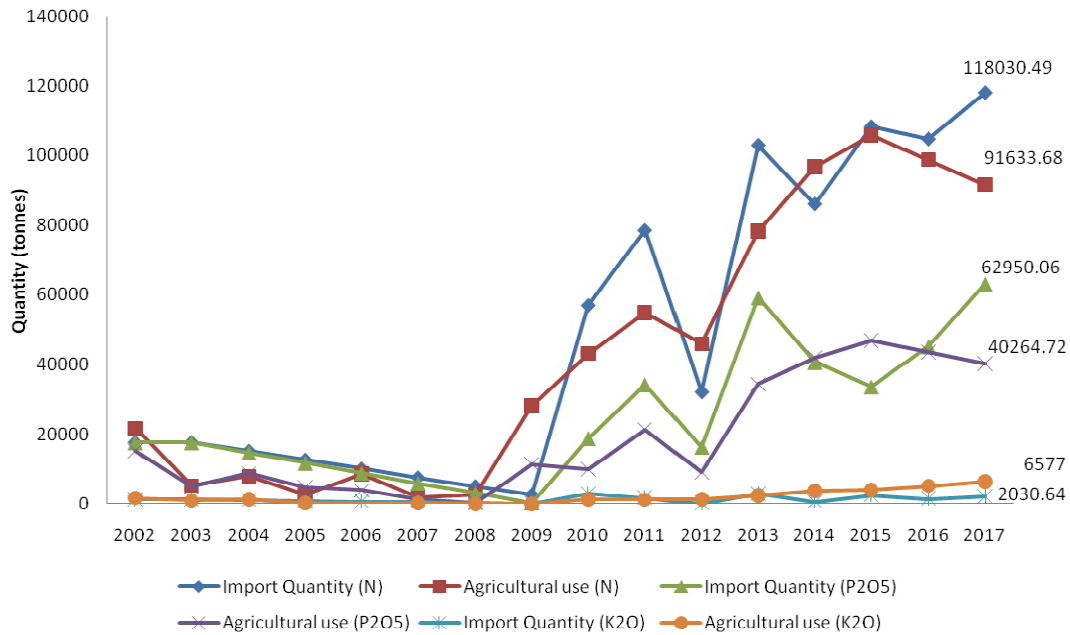


Fig. 5. Fertilizer use in Nepal
Source: FAO, [19]

The seed system of Nepal is in a primitive stage (97% farm household dependent upon informal seed system) and not sufficient to provide timely access to quality seeds and promote diversity [40]. With high likelihood informal seed sector persists even after developing commercial seed sector and seed markets due to small and marginal farmers, thin market coverage and poor infrastructures [41]. The use of farm machines shows the increasing trends between 1995 to 2010 census- tractors from 5 to 23%, threshers from 4 to 21%, pump ownership from 2 to 7% etc. [42], which have significant effects (20-30%) on increment of per capita income from agriculture. Farm mechanization enhances farm income through increasing the market participation of farmers, land productivity, labour productivity and irrigation efficiency [42], thus mechanization and commercialization are interdependent. The major challenges of insufficient resource uses are driven by an import-dependent system, price fluctuation in international markets, and inconsistent subsidy schemes [43].

3.5 Agri-environmental Challenges

Nepalese agriculture is mostly dependent in monsoon (only 27% of agricultural land access to

irrigation) and highly climate sensitive because of having lower adaptive capacity to variability [44,45,46]. The rainfall patterns show uneven distribution in different cropping seasons along with irregular and decreasing annual trends [47]. Marginal and small holder farmers (47.7%), having landholdings 0.1 to 0.5 ha, are largely affected by recurrent and severe droughts and other increasingly erratic and unpredictable climatic adversaries causing detrimental effects on food security [41,46,48]. Other effects of climate change in Nepal included increased outbreaks of insect pests, weeds and crop diseases, and decline in soil quality [49].

Spatial distributions of temperature trends in Nepal show high variations across the country, with significant rise (0.0560C/yr) in annual maximum temperature between 1975 and 2014 (DHM, 2017). The winter temperature variations tend to be higher in comparison to monsoon season ([47]; also see Fig. 6), which could result positively for maize and millets, especially in hills and mountains [46]. The climate in all of Nepal is expected to be significantly warmer and wetter in the future, except for a decrease in precipitation during the pre-monsoon season and extreme events [51]. This will affect the smallholding farmers, landless laborers and vulnerable people

disproportionately. Chalise, Naranpanawa, Bandara, & Sarker [48] predicted the climate induced productivity loss will be around 7% and price of rice, wheat and maize are expected to rise significantly by around 26%, 36%, and 44%, respectively by 2080. Decline in productivity and increasing food price induced by climate change will result in serious food security problems and the most significant factor of vulnerability in

Nepal among south Asian countries [6,52]. In terms of policy, the climate change policies, National Adaptation Programme of Action (NAPA) and Local Adaptation Plans of Action (LAPA) has not challenged the structural root causes of vulnerability rather focusing on outcome vulnerability in expense of contextual vulnerabilities [53].

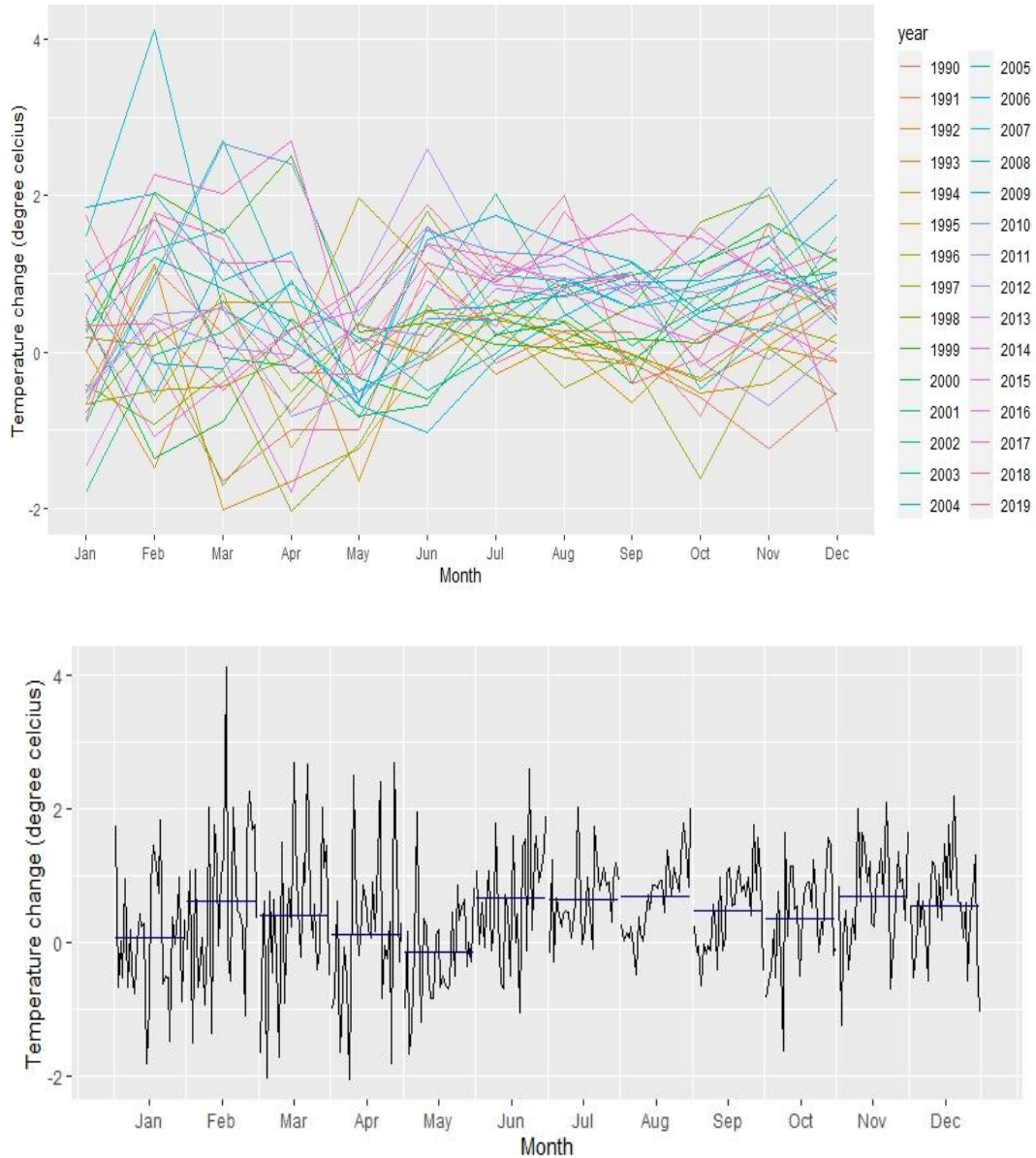


Fig. 6. Monthly temperature variations in last 30 years in Nepal

Source: FAO, [19]

3.6 Productivity and Profitability Statistics

The principal underlying causes inhibiting the growth of productivity in Nepal are low levels of technical change and technical efficiency, which is highly associated with food accessibility [8]. The reasons are subsistence farming, land fragmentations, financial constraints and limited availability of inputs. The agricultural growth rate of Nepal between 1980 and 2013 is 0.06% which is lowest among India, Bangladesh and Pakistan, despite little variation in technical and scale efficiency [54]. Anik et al., [54] argued that natural and technological factors are major drivers of TFP in south Asia while financial and diversification retards TFP growth. The productivity growth of all crops and milk has increased between 2000 and 2018, but at a modest rate (see Fig. 7).

3.7 Food Balance

The demand of food in Nepal has always been higher than its domestic production, causing too much dependency over India for food products and huge loss of revenues (see details on Sharma, [26]). Based on forecasted data, the consumption of food products (cereals, fruits, oilseeds, vegetables and pulses) will grow by higher rate, as compared to production growth (see Fig. 8). The deficit of vegetables, cereals, pulses, oilseeds and fruits to meet demand are estimated to be 1372.96 thousand MT, 1424.49 thousand MT, 680.88 thousand MT, 196.23 thousand MT, and 6614.60 thousand MT, respectively, by 2035 AD (For details, see Table 2). Despite these pessimistic trends of increasing negative food balance, stabilizing fertilizer use and irrigation facilities could result in appreciable gains in domestic production [55].

3.8 Analysis of Policy Framework in Nepal

The periodic plans from past to till now (on the verge of 15th periodic plan 2019/20 – 2023/24), food security has always been the major aspect and continuously focusing to improve food production along with poverty alleviation. The Government of Nepal had announced the Basic Need Program (BNP) for the first time in 1987 under 7th five year periodic plan (1985/86 – 1989/90) to address the food security and poverty issue. The constitution of Nepal 2015 has addressed the right to food, and food

sovereignty to each citizen in article 36, under part 3, fundamental rights and duties [56]. ADS as the major strategic plan of the agriculture sector in Nepal have clearly stated the food security in it's the vision statement as "A competitive, sustainable and inclusive agricultural sector that contributes to economic growth, improved livelihoods, and food and nutrition security" [20]. Food and nutritional security is one of the prominent vision components and long term goal of ADS, 2015-2030, for which Food and Nutritional Security Program (FANUSEP) as flagship and core program is expected to be launched. ADS has envisaged food security as a major concern for most disadvantaged rural populations including lactating and pregnant women, janajatis, dalits, and groups in disadvantaged regions such as the Karnali. The Right to Food and Food Sovereignty Act, 2018 act has made few important provisions for first time like;

- Provision of Food support identity card,
- Concessional price for food to targeted households,
- Declaration of food crisis zone,
- Formation of food council at national and provincial level, and food coordination committee at local level.

3.9 Future Directions

The political agenda of "food first", a high prioritized policy issue in the low income countries like Nepal, is actually miss-balancing the system approach of food security because of negligence towards the nutritional capabilities [57]. The food system are socio-ecological systems relied on the economic and institutional framework adopted by country, which consists of four major food areas- food security, food safety, healthy nutrition, and sustainability [58, 78]. The challenges for Nepal is off-course significant to integrate all these aspects of system because of trade-offs situation in lacking resources. However, the policy at least should integrate the possible instruments making compatible adjustments within system. The major food policy levers are pricing, consumer information, accessibility and regulations of food environment [58], which could consist of varieties of instruments contributive to food areas. In this section, we are going to discuss those instruments based on evidences and empirical findings adopted in Nepal or low incomes countries in world (shown in Table 3), which

are much likely to be suitable in context of Nepal.

Hunger and poverty are still predominantly a rural phenomenon. The food insecurity is determined more by food entitlements of household than food availability, while food entitlements are associated with socio-demographic factors. Family size, male-headed family, higher dependency ratio, and participation in community organizations are found to be significant predictors of household food security in Nepal [59]. The existing socio-economic structure of the family needs to be changed through community mobilizations, women empowerment and promoting non-farm activities [60]. The enhancement of household accessibility to food should be the first priority of policies. Wage labourers, especially landless or casually employed farm-workers are highly vulnerable to food insecurity, for those conditional cash or land transfer programs could be a better instrument to enhance the agriculture activity and food security [61]. Roka [62] argued that the changing the structure of land ownership could be contributive to food entitlements of poor farmers through commodification of subsistence, rural labour market formation, primitive accumulation and social differentiation. The small holding farmers are often net-buyers of foods. The food security of small holding farmers could be strengthened through multiple aspects: taxing unhealthy foods, subsidizing healthy foods, linking farmers through pocket production or cooperative farming, and creation of community and home gardens. Social safety nets and instruments such as fair price shops, ration cards, food coupons and school foods are appropriate for the vulnerable people [79].

The food deficit and imbalance of food demand-supply is needed to be corrected because closing the yield gap will lead to greater food security [63] for which the first production side should be prioritized. The fertilizer and farm mechanization policy should be designed considering the longer-term goal of the agriculture sector and the future of smallholder farmers [39]. This is because of adopting the volatile fertilizer policy- regulation (1973-1975 onward), de-regulation (1997 onward) and again regulation (2009) of fertilizers subsidies- have produced mixed results depending on international price and informal (or, illegal) trade with India [64]. Mechanization of small farms would enhance the smallholders' resilience,

helping to strengthen localized food systems, shorter supply chains and safer supply in COVID-19 pandemic [65]. Policy should focus on urban-rural linkages through means of road connectivity and communication to facilitate the flow of inputs and productions [66]. Lowering fertilizers price encourages the larger farms while discouraging the smallholding farmers [39]. Thus policy should adopt directions accordingly based on farm size. Insurance schemes are really helpful for smallholding farmers, thus the government should focus on increasing branch offices and more equally disseminating the concept of insurance. Patt, Suarez, & Hess [67] reported the positive correlation between understanding of insurance and its preference to purchase. Cultivation at sloppy and marginal land has increased the vulnerability of lands and decreased the crop productivity, for which conservation agriculture is a better option and should be prioritized [68]. Release and dissemination of varieties should be promoted within a very short period of time. Participatory varietal selection (PVS) and informal research and development (IRD) could be beneficial to reduce the time required for varietal testing and popularization [69]. The revision and harmonization of national seed policy (1999) is essential to ease the introduction of new varieties and strengthening the seed value chain [40]. Efficient water use is essential factors of sustainable food security.

The question of food security is not concerned with only productive capacity of Nepal, also with food distribution and sustainability [70]. Moucheraud et al., [71] noted that with increasing urbanization in Nepal, it is also equally important to motivate the urban households for urban or peri-urban agriculture in shaping diets and nutrition. With the federal systems of Nepal, the local institutions can impact livelihood of smallholder farmers through promoting value chain upgrading and market development, which has already been evident from the tea sector in Nepal [24]. The institutionalization process is crucial to upgrade the value chain continuously and make it competitive to participate and sustain in the global value chain. Pyakurel, Roy and Thapa [79] suggested two categories of policy suggestions, first short to medium term policy to encourage the private sectors in marketing infrastructures and second, long run policy to balance regional development through road connectivity.

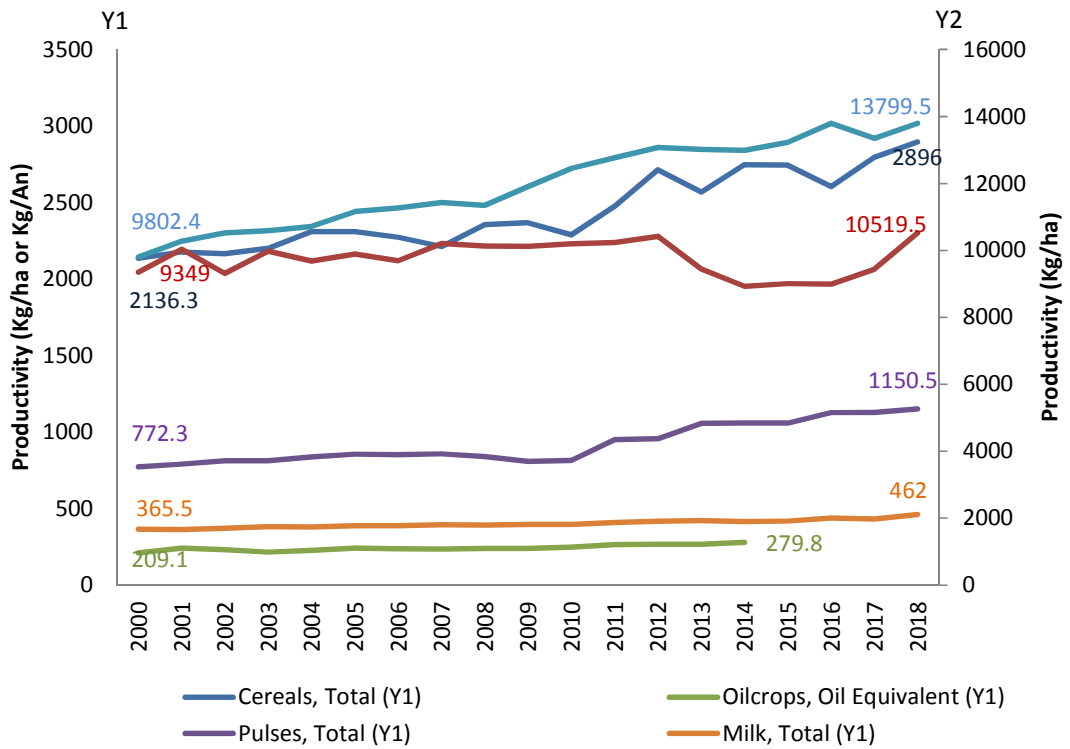


Fig. 7. Productivity of crops in Nepal
Source: FAO, [19]

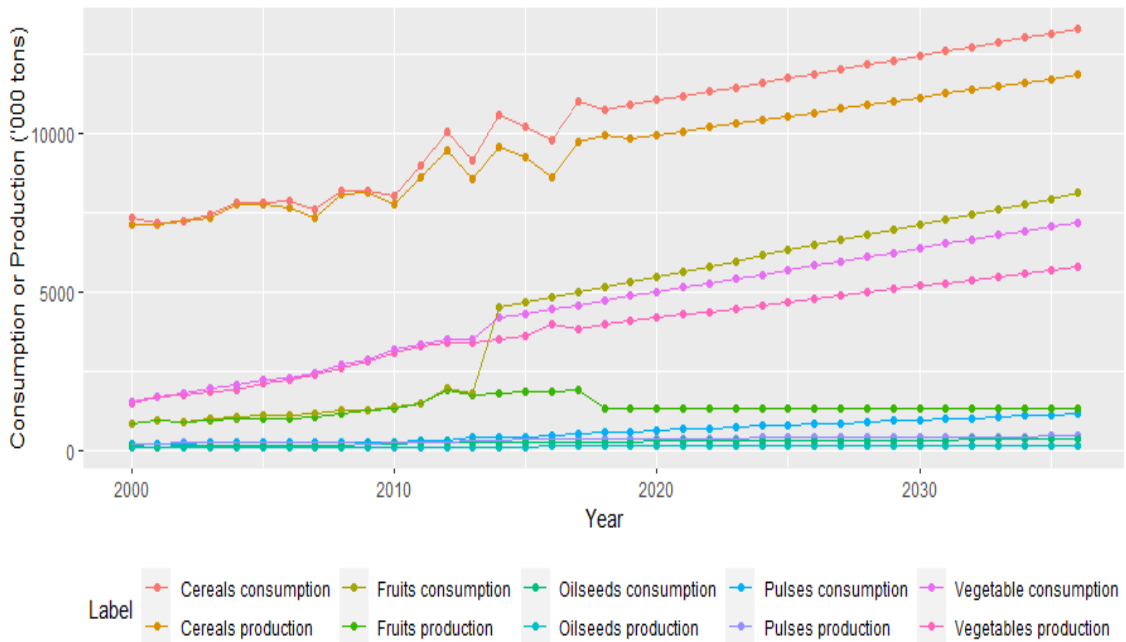


Fig. 8. Forecasted balance of crop productions in Nepal

Table 2. Forecasted food balance (MT) of different crops using ARIMA model

Year	Vegetables	Cereals	Pulses	Oilseeds	Fruits
2020	-828952.18	-1085853.63	-259043.86	-155257.17	-4149784.00
2021	-865219.33	-1108429.42	-290332.95	-157988.96	-4314105.55
2022	-901486.47	-1131005.22	-316561.84	-160720.75	-4478427.10
2023	-937753.61	-1153581.01	-345819.05	-163452.54	-4642748.64
2024	-974020.76	-1176156.81	-373015.46	-166184.33	-4807070.19
2025	-1010287.90	-1198732.60	-401497.87	-168916.12	-4971391.73
2026	-1046555.04	-1221308.40	-429129.82	-171647.91	-5135713.28
2027	-1082822.18	-1243884.19	-457302.65	-174379.70	-5300034.83
2028	-1119089.33	-1266459.99	-485122.35	-177111.49	-5464356.37
2029	-1155356.47	-1289035.78	-513168.58	-179843.28	-5628677.92
2030	-1191623.61	-1311611.58	-541067.77	-182575.07	-5792999.46
2031	-1227890.76	-1334187.37	-569061.64	-185306.86	-5957321.01
2032	-1264157.90	-1356763.17	-596994.22	-188038.65	-6121642.55
2033	-1300425.04	-1379338.96	-624966.34	-190770.44	-6285964.10
2034	-1336692.18	-1401914.76	-652912.88	-193502.23	-6450285.65
2035	-1372959.33	-1424490.55	-680875.94	-196234.02	-6614607.19

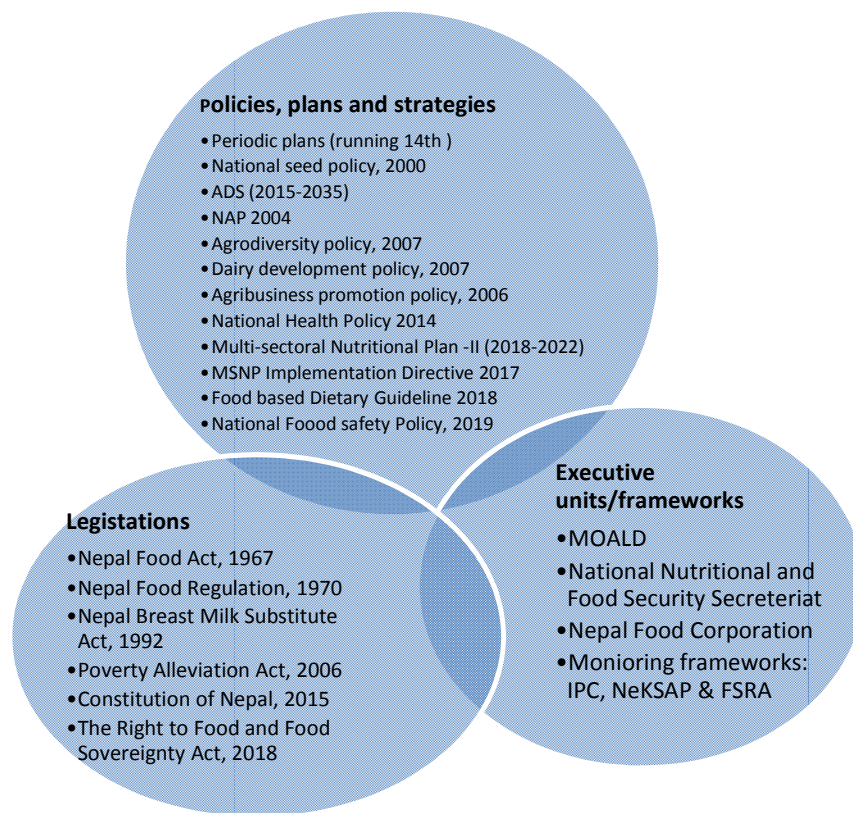


Fig. 9. Institutional and Policy framework for food security in Nepal

(ADS: Agriculture Development Strategy; NAP: Nepal Agriculture Policy; MSNP: Multi-Sectoral Nutritional Plan; MoALD: Ministry of Agriculture and Livestock Development; IPC: Integrated Phase Classification Analytical framework; NeKSAP: Nepal Food Security Monitoring System Framework; FSRA: Food Security Response Analysis framework)

Table 3. Policy priorities and instruments for sustainable food system

Food policy levers	Pricing policies	Food information and consumer policies	Food environment policies	Accessibility & availability policies
Food policy areas				
Health & Nutrition	Taxation (sin tax); Incentives to fortified food products	Nutritional labeling; Behavior-centered intervention	Nudging approach; Nutrition monitoring	Safety net (Rasan card; School feeding); Food diversification
Food safety	Incentives to IPM & organic farming	Quality standard Certification; Consumer awareness	Food handling strategies; Non-tariff barriers	Residuals' tests; Pesticide limitations
Sustainability	Green subsidies; Incentives to IPM & organic farming	Eco-labeling	Inclusiveness; Land distribution; Conservation agriculture	Institution focused; Pocket packages; Decentralized food system; Farm mechanization
Food security	Risk transfers; Price floors & ceiling; Price support	Nudging approach	Governance & coordination	Credit schemes; Income transfers; Roads and Infrastructures; Technology & innovation

Thaler & Sustein [72] suggested that nudging approach could be powerful instruments to change the behaviors of food chain actors and other economic agents towards better food habits in order to strengthen food security, though context specific experiments are necessary [73]. For instance, Bucher et al., [74] identified that the manipulation of food product order or proximity can influence food choice. The information approach- providing the information about healthy diets and food safety, caloric labeling, influences the behaviors of consumers [75,76]. Low income countries are always vulnerable, for which institutional framework should be constructed as capable to act or react as per severity of possible external shocks and calamities. Nagoda [53] argues that climate change policies of Nepal should be redefined from the political process to address contextual vulnerability arising from multiple sources viz., social, economical, political, cultural and environmental.

4. CONCLUSION AND LIMITATIONS

With available empirical evidence and literature, the food system transformation of Nepal is not going so easy. The key drivers of food systems like demographic structure, consumer concern on dietary patterns, trade policies, technological innovations and consumers' income are moving towards a positive direction. The indicators of food security also show positive inclination during the past two decades. However, the challenges of productivity gains, trade balance and agri-environment are seems to be a solid obstruction of food transformation. Besides these, the structural foundation of agriculture- land issues, labor migration, farm mechanization and adaptations- demands the interventions at policy level. The federalization of Nepal has provided opportunities to address these challenges and issues at different levels- local, state and federal, in a comprehensive way. Finally the paper comes up with policy priorities and instruments that could be adopted for a sustainable food system. However, in the short run COVID-19 pandemic has disrupted the food supply and value chain through creation of pockets of labor shortages caused by lockdown and travel ban [77], which could be addressed through decentralized food systems. The promotion of digital technologies to manage food supply, regulating food procurement and stocks, safety nets and ensuring reasonable working conditions

should be short run action plans of government [65].

The study has limitations that it is largely based on the national data, their trend analysis and supportive literature. The behaviors of economic agents and food chain actors need the experiments and field surveys, which are not the part of this study. The study of association between food sufficiency and food security in Nepal is quite unknown, which largely determines the sustainability of the food system. Thus, further research on these various dynamics of the food system are needed to get clear insights on possible future food systems of Nepal.

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DATA AVAILABILITY

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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