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Policy Briefs

Can Tractor Driven Farm Mechanization Solve Rural Farm Mechanization objectives?

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Summary

At present, due to high pace of out migration of youth and working age population from rural areas for foreign employment, Nepal is started to face shortage of labor in many sectors, basically in agriculture sector. In addition, the daily wage rate of unskilled labor has also risen up more in Nepal than in the many of the northern states of India (Bihar and Uttar Pradesh), as a result there is higher pace of immigration of labor forces from northern Indian states to Nepal. The ongoing trend of young individuals seeking employment abroad is increasing at an alarming pace in Nepal in the recent years. In fact, the out migration of youth from rural Nepal is regarded as a major underlying cause for the increased-on labor wage in Nepal, and in turn, increasing demand for agricultural mechanization and other labor-saving technologies in agriculture and other sectors. The average size of agricultural land holdings is 0.55 hectares and in fragmented blocks. As a result, single ownership of tractors and machinery on small farms is often not economically viable. However, by using rental services of agricultural related equipment's, even small farmers can take advantage of agricultural mechanization. At present, this trend is particularly evident in tractor related services (largely for ploughing, threshing and irrigation related activities) and is gradually extending to other agricultural machinery. Due to ineffective rental servicing and custom hiring provisions, costly machinery imported from other countries is experiencing notable under-utilization. This inefficiency not only impacts economic resources but also raises concerns about its sustainability. It is therefore the need of creating conducive environment to promote rental market services for its efficient use of the large and costly farm implements. Government of Nepal need to envisage the establishments of professionally run Rental service centers/ Custom Hiring Centers (CHCs) in different places of the country in order to facilitate easy availability of tractors and other hi-tech equipment's for farmers on rental basis. Faced with these circumstances, it is widely suggested that Nepal government needs to embrace and encourage adoption of labor-saving technology to engage youth populations in agriculture sector.

Policy Messages

- Bringing Agricultural Mechanization Promotion Policy 2014 (AMPP) in action
- Formulation of guidelines for facilitating guidelines for rental services of machineries
- Promoting Tractor usage in farm and off-farm sector
- Tariff review for Spare Parts of Machineries used in agriculture sector
- Provision of machineries testing centers and advisory committee for importing the efficient Agri-machineries
- Provision of Training to youths from local workshops on repair and maintenance of Agri machineries
- Provision of insurance of Agri-machineries and for Agri-machineries operators
- The need for a database system in terms Agri-machineries working in municipality level

Introduction

Mechanization in Agricultural Practices in Nepal is often colloquially referred to as 'Tractorization' that primarily focused on ploughing in place of Ox. Tractors serve as essential machinery, playing a key role in tillage, transporting irrigation pumps, threshers, and facilitating the transportation of agricultural goods. They contribute to time efficiency for farmers and ease in transportation. These machines are indispensable tools for farmers engaged in a diverse range of agricultural activities for modernization of agriculture sector. The utilization of tractors leads to an increase in cropping intensity, emphasizing the importance of maximizing production from a single plot of land.

In total, 150,000 tractors are registered in Nepal. Most of those tractors are used for transportation purposes in the hills, mountains, and Terai. It is estimated that about one-third of those tractors are used for agricultural purposes in Terai (Shrestha, 2022). The jump in the sale of power tillers was due to the emerging private sector in import and sales of Chinese power tiller in Nepal and the government subsidy after the agricultural mechanization promotion policy 2014. Tractor use in the Terai has grown at relatively fast rates, and power tillers in Hills for ploughing fields has seen with significant growths. Furthermore, the import of agricultural machineries is going up in recent years (figure 1).

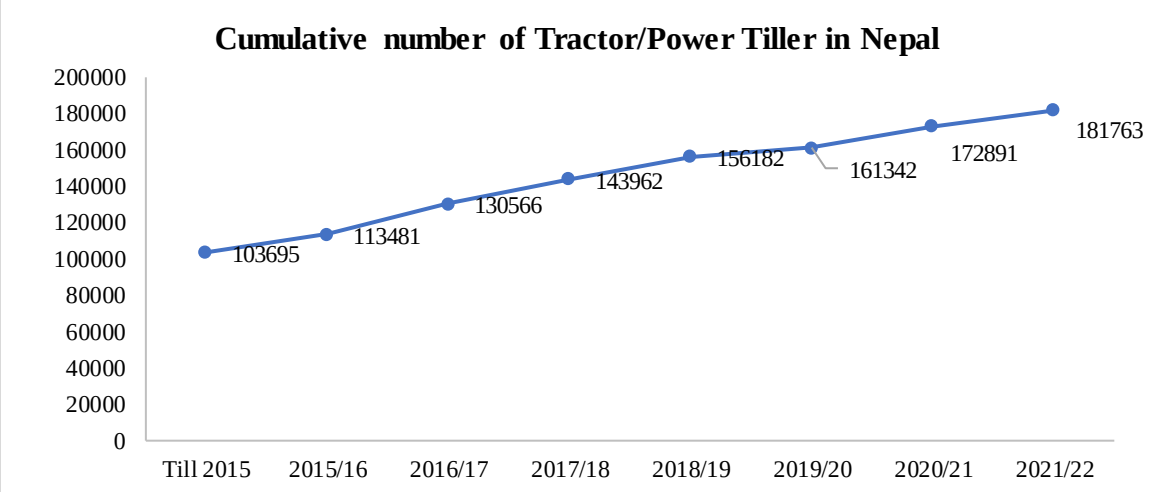

Figure 1: Tractor and Power Tillers in Nepal since 1990 to 2022
Source: Ministry of Physical Infrastructure and Transport, 2022 (cited in MoF, 2022).

As farming methods have evolved, the energy sources employed in agriculture have undergone a gradual transition from human muscle power to animal power and eventually to machine power. The share draft animals (basically Ox) have come down Significantly in 20 years period. The study findings show the escalating decreasing of Ox holding HHs for ploughing purpose (figure 2), which is also highly correlated with youth migration to abroad and urban places.

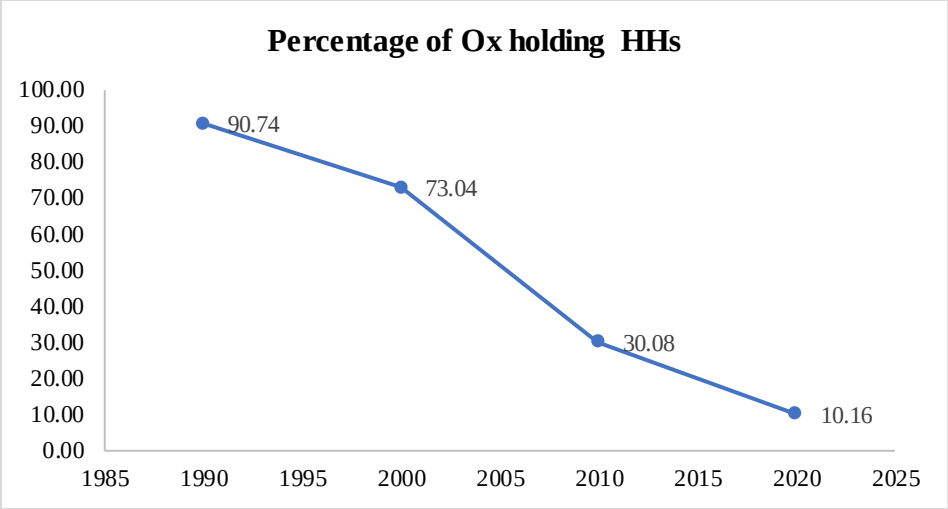

Figure 2: Ox holdings HHs in sampling areas at different time frame
Source: Based on study sites calculation (2023).

The interesting structural transformation is taking place in rural Nepal in the last decades, facilitate by wide spread of tractors for land preparation. Tractors have replaced Ox for ploughing, largely in places with better access to rural roads and infrastructure. Young people are most interested to use machineries rather than Ox holdings, since Ox holding for sole ploughing purpose is costlier. In few places of Mid hills, the local government has been providing financial benefits in their annual program to the households engaged in 'Ox keeping' as there due to in-accessibility of mini tiller and for cultural reasons i.e. bull fighting (observed in few municipalities of *Nuwakot*). This provision of financial support and subsidies to poorer households in rural areas benefits those who use oxen for manure and crop cultivation, particularly for maize sowing in plough lines, and for traditional turmeric and tuber cultivation.

Photo 1: Use of Oxen in traditional agriculture (maize sowing)

Similarly, the prevalence of Ox keeping in the Households in Terai areas tends to rise at the time when there is an increase in petroleum product prices and fuel shortage (observed in *Saptari* during October, 2022). In an average, only 5% of land areas in Terai have no access to tractor for ploughing as these needs Ox keeping with attention. This approach reflects a blend of both mechanized and traditional system. Rising on-farm rural wage due to labor shortage and draft animal shortage are the primary drivers of mini-tiller/tractor adoption. Similarly, improved road access and proximity to markets have likely increased access to tillers/tractors, threshers, fuel supplies, mechanics, and spare parts. Additionally, government subsidies for purchasing mini-tillers and tractors have further enhanced this access compared to the use of oxen. These heterogeneity shows the adoption of tractors and mini tillers in different parts of countries but with different rates.

Objective of the study

The objective of the policy brief is to discuss the pivotal role of agricultural machinery to small farmers to boost crop production, improve quality, timeliness and efficiency of agriculture operations. The specific objectives of the study are:

- To explore opportunities and challenges in rental services of tractors to mechanize the agriculture sector.
- To review the status of mis-utilization and underutilization of imported farm machineries.

Scope and method of analysis

The study focuses on exploring opportunities and challenges in rental services of tractors to mechanize the agriculture sector with some promising policy recommendations. In addition to, it highlighted the importance of rental services for promotion of agro-machinery uses in Nepal. Field observation was carried out from six districts *(Terathum, Saptari, Mahotari, Sindhuli, Nuwakot, Rasuwa).* Focus Group Discussions with farmers, farmer groups and Cooperative members were conducted in those districts. In addition to, quantitative and qualitative information were obtained from Key Informants Interviews (KIIs) with Tractor owners, Tractor operators and old aged farmers using recall method. Literature review of relevant empirical findings, desk review from relevant policies, 15th plan, ADS, and Economic survey were considered during the study period.

Policy Analysis

Agricultural mechanization has grown in Nepal at steadily pace in the past two decades although the actual pace of mechanization varied considerably across agro-ecological regions of the country, as well as the types and mode of uses of the farm machinery. The following section discusses the existing policies in this regard.

Past policies, such as the Land Act (1964) and the National Civil Code (1853, 1962, 2017), focused on land rights and inheritance rather than on the commercial use of agricultural land and productivity improvement. Similarly, Nepalese labor policy has not adequately recognized the value of agricultural labor and its welfare aspects, such as drudgery reduction, and the Transport Policy (2002) lacks specific provisions for mechanization.

The Agricultural Mechanization Promotion Policy 2014, introduced by the Nepal government, aims to address this historical gap by targeting the enhancement of mechanization efficiency, thereby working towards the reduction of food production costs (Ministry of Agricultural Development, 2014). Similarly, fifteen plan (2019/20-2023/24) advised mechanization in agriculture sector in order to attract the youth, so that agriculture will be transformed into a technology-friendly, mechanized, professional, highly rewarding, and dignified occupation (GoN, 2019). The effort can be viewed with some sense of optimism, but result was far below the expectation. It is due to lack of proper guiding policy as the legal framework specially the AMPP, ADS came into practice before the promulgation of the current Constitution of Nepal. Now the jurisdiction related to agriculture come down mainly to the local bodies. Many provisions need to be amended for effective implementations.

Prime-Minister Agriculture Modernization Project (PMAMP) is the biggest agricultural promotion initiation for 10 years period (2016 to 2025) for modernizing the agriculture sector still in operation within 16 districts of country. PMAMP aimed at modernizing the agricultural sector by adopting mechanized methods that can significantly reduce costs in agricultural operations. However, various efforts have been going into promoting mechanization by PMAMP and these efforts have resulted in a significant increase in the availability of farm power per unit area of 1.4 kw/ha compared to 0.8kw/ha of Nepal.

Mechanization in Agriculture sector basically contribute to SDGs targets by 2030 – SDG_1 – no poverty (Target 1.1: eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day) & SDG_2 – zero hunger (Target 2.3: double the agricultural productivity and incomes of small-scale food producers). In this various policy are in support of Mechanization that can significantly enhance farm productivity by making agricultural operations more efficient and timelier, leading to increased crop yields and higher incomes for small-scale food producers.

Despite these limitations, the adoption of agricultural mechanization in Nepal is increasing due to liberal import policies, better connectivity, and labor shortages from youth migration. However, there is a pressing need for policies delineating the responsibilities of the three tiers of government in accordance with the constitutional arrangement. Similarly, there is an urgent requirement for formulating comprehensive guidelines and procedures for the effective implementation of policies to maximize the utilization of machinery in the agricultural sector.

Rental market services and Mechanization

Commercial farming is next to impossible at least without the use of machine for timely operation of agricultural activities. Mechanization helps not only to reduce operational time and women drudgery, but also saves labor and energy. This reduces the cultivation cost creating conducive environment for the competitive market price of the produced agricultural commodities. Literature have shown strong-positive correlation between farm power availability and agricultural productivity. At a same time, even small and marginal farmers need farm machineries in operations like land preparation and harvesting and for them individual ownership of such machineries is uneconomical.

The extent of adoption of a farm machinery depends upon several factors such as labor markets, cropping pattern, agrarian structure (land holding, rural infrastructure), level of farm intensification, access to market, etc. However, through rental market services, even smallholding farmers are being able to use costly machineries (tractor and harvesters) and get their benefits (Bhattarai, 2016). So, to get rid of self-ownership, provision of rental market services is possible. In this background, here is quite popular saying "Why to trouble in owning the own entire ship when you can simply enjoy the voyage?"

The effective use of agricultural mechanization is essential for timely field operations, higher productivity, reduction in production cost, and reducing manual labor on farms. Unfortunately, this aspect often gets overlooked. Hence, formalizing the rental market for Agri-mechanization services, ranging from tractors/mini-tillers to harvesters/thresher's, is imperative to fully reap the benefits. For these formulating guidelines and implementation of model programs for facilitating rental market services in agriculture sector for sustaining agricultural growth is an urgent need. Through the development of rental market services, along with improving machinery availability and addressing skill gaps, farmers can elevate productivity, reduce costs, and drive forward the overall development of the agricultural sector. Rental service market centers can even drive a workable model of land pooling initiatives, facilitating collective use of agricultural machinery and promoting resource-sharing among farmers, thereby enhancing the efficiency and affordability of mechanized farming practices.

Photo 2: Land pooling for conserving agricultural productivity in *Nuwakot, Tarkeshowr* rural municipality[1].

This effort will not only bring about the development of additional employment avenues within the community but also drive-up productivity level in agriculture sector through technological shift.

Effectiveness of Rental service market and limitations

Larger equipment such as tractors/other farm mechanization tools, combine harvesters, Threshers are also available in the small and medium size towns. These also make it possible for the small farmers to access the services of relatively costly equipment on per hour basis without a need to own. In hilly regions, small machineries are common such as mini tillers and two-wheel tractors. The 12 to 19 horsepower two-wheel tractors are appropriate on farms near roads whereas light-weighted 5- to 9-horsepower mini-tillers are appropriate in the hill geographies (Paudel et al. 2023). However, with convenient access to road transportation, tractors are rapidly ascending from plains to hilly areas at an increased pace, especially following the structural transformation of the country. The combination of mini tillers and 4WT can be advantageous, even in hilly areas with plain surfaces, promoting efficiency and saving time. Despite the growths in the adoptions of tractors in Nepal, the evidence is still scarce regarding the determinants and various agricultural production practices (Takeshima & Bhattarai, 2019).

In Hilly areas, limited options are available for Tractor 4WT (25 to 50 HP) due to rugged topography and abundant terrace in the field. Most available options in Hill areas are Mini-Tiller 5 to 9 HP for up-hills, and Rotavator tiller 12 to 19 HP and Tractor 4 WT for river irrigated agriculture fields. In Terai areas, large use of machineries is in application such as reaper-harvesters, threshers, shellers and combine harvesters and still lack of efficient usage of these machineries.

[1] Original photo and machines used will be provided later.

Table 1: Rental cost of Mini-Tillers and Tractors for ploughing

Machineries types	Region	Average rental Cost of ploughing	Average time (hours) to plough 1 hectare land	Average rental cost (NPR) of ploughing by OX	Average time (hours) taken to plough
Mini-Tiller 5-9HP	Hill	NPR 1000/hr	4 hours	20,000	16
Rotavator tiller 12-19 HP	Hill	NPR 12000/hr	3 hours		
Tractor -4WT (25-50 HP)	Hill	NPR 3500/hr	1 hour		
Tractor -4WT (25-50HP)	Terai	NPR 1500-2300/hr	45 minutes	NA	12 hours

Source: Author's calculation based on field survey (2023).

The table 1 compares different types of machinery and oxen (OX) for ploughing land in various regions, focusing on their rental costs and the time required to plough one hectare of land. Using oxen for ploughing is significantly more time-consuming and expensive compared to mechanical options.

Photo 3: Paddy field preparation using 4WT in hilly areas by multi-use tractor

Photo 4: Tractor attached Thresher for Wheat harvesting

Working Modalities

Two types of models are currently existing in many places besides Government owned Custom Hiring Centers in 16 districts of Nepal. The two model are primarily working Private owned Machineries and Co-operatives owned machineries. While comparing the performance of co-operative and private owned rental provisions, both models have their own issues and challenges. Ultimately, the goal remains the same regardless of the model: to enhance the performance of machinery. These challenges can be addressed through the development of policies, enabling provisions, and guidelines addressing problems of tractor operators, training, insurance and working modality. The guideline needs to be developed under the involvement of concerned stakeholders.

Table 2: Model of CHCs for promoting Agricultural mechanization in India

Model of CHCs	Description
Individual Farmer Lending	In this model, an individual farmer establishes the center, assumes ownership, and manages its financial activities.
Farmers Group/Self-Help Groups (SHGs)/Co-operative Purchased Machinery	A group of farmers collectively purchases machinery and registers the CHC as a society. Group members assume roles such as financial manager, supervisor, and manager.
Traders Implemented	Traders, alongside selling machinery, lend some of the machineries to the CHC to generate additional profit.
Individual Entrepreneur Operated	An individual entrepreneur establishes and solely operates the center.

NGO/s Operated	A group of NGOs or a single NGO establishes the center to provide services to farmers.

Source: Adapted from Priyanka & Rohith (2022).

While providing guidelines focusing on Tractor/Mini-tillers, it opens up opportunities to utilize modern and heavy equipment. Agri-mechanization offers numerous advantages, including the use of large and modern machinery such as potato harvesters and combine harvesters. Additionally, it facilitates adaptation to climate change and variability issues through the implementation of zero-tillage machinery, timely harvest, and minimizing losses. Overall, these initiatives aim to transform agriculture into a more organized and manageable endeavor, making it appealing for the younger generation rather than a burden for the older generation in the current context.

Box 1: Custom Hiring center in Karnataka, India

To overcome the problems and to achieve mechanization in the Indian farms custom hiring centers (CHC) play a pivotal role in introducing high technology agricultural machinery even to small farmers with the objective to boost crop production, improve quality, timeliness and efficiency of agriculture operations. One example of the spread and successful emergence of custom hiring centers is based on **private companies that can provide rental services and maintain their equipment are allowed to start centers directly or through their dealers.** However, it is difficult for centers to be profitable that mainly hire out tractors and implements on account of their low hiring rates (about INR 500 to INR 800 per hour – $7 to $11/hr, depending on type of operation) as the many tractors in the state drive these rates down (Justice et al.,2021 pp:28).

Government subsidy mechanism for Mechanization

Agricultural mechanization falls under the jurisdiction of three tiers of government, yet there exists inconsistency in the distribution of tools and machinery across these governmental levels. Ensuring uniformity in programs and preventing duplication of activities is imperative.

After transition to federalism in 2015, Local level government has been intervening in agriculture mechanization through subsidizing mini-tillers and tractors in their Municipalities. Financial interventions in the form of subsidy (50% to 75% of capital cost) have been made farm machinery to reach to farmers. Municipalities facilitate the subsidies for tractor but oversees the promotion of rental market system. The increased distribution of subsidized mini tillers and tractors has widened access to these agricultural machines. To enhance efficient utilization, it is crucial to address the limited availability of repair and maintenance service centers, particularly in the context of promoting rental market services. This challenge is exacerbated by a shortage of adequately trained human resources in the maintenance sector. By enhancing the effectiveness of the local government's delivery mechanism and implementing proper maintenance protocols, issues related to mis-utilization and underutilization of agri-machineries can be minimized.

The local government's pivotal role in facilitating mechanization includes subsidizing mini tillers and tractors, yet predominantly benefits medium and large landholders, overlooking smallholders. Municipalities need to extend the subsidy to ensure equal opportunities by offering subsidy through farmers group/cooperatives. Subsidy distribution must prioritize fairness, perhaps through a lottery-based system. Local service providers need to be trained and, granting them with a subsidized machinery service.

Box 2: Experience of Hari Krishna Devkota, Chairperson, *Kalika* Municipality (2023), *Rauswa*

"In the hills of rural communities today, the cost of a pair of oxen has soared to double (about NPR 1,00,000) that of a subsidized mini-tiller cost (about NPR 50,0000). Yet, the practicality of relying on oxen for land plowing only 2-3 months a year has led to a scarcity in their availability. With the ever-growing demand for mini-tillers, driven by the efficiency and accessibility of fossil fuels, we urge households to unite and establish registered groups in municipality to implement rental services. In our municipality alone, we've already deployed more than 50 tractors till 2022, alongside comprehensive repair and maintenance training programs in recent years realizing the mis-utilization and underutilization of the equipment. Looking ahead, we're need to establish a rental service center that can register tractors, threshers, irrigation pumps along with repair and maintenance facilities. However, there is lack of guidelines and feasibility study of subsidy based agri-equipments and reliable rental servicing model to implement for longer period. It supports to enhance production and attract

Mis-utilization and under-utilization of Agri-equipment

Tractors imported for farm works in particular are using on a massive scale to transport their products other than agriculture products like sand, boulders, construction sector and in brick industry to carry construction materials to market. Similarly, inefficient use of agricultural equipment, coupled with inadequate servicing and repair-maintenance provisions, often leads to these tools being abandoned. The lack of ownership within farmers' groups and insufficient monitoring further shortens the lifespan of this equipment.

Photo 5: Neglected Thresher: A Reminder of Importance of Maintenance

It is imperative for country like Nepal for Agricultural mechanization's sole reliance on fossil fuels as a potential challenge (Justice et al., 2021). So, it is advisable to establish machinery testing center to check and recommend fuel efficient and long working hour tractors and other agri-machineries.

Photo 6: Servicing needed Tractor

By developing data base can, a systematic maintenance, repairing and counselling center can be maintained with wise-use of resources. Today, motorcycles are widely used for transportation, leading to the establishment of repair centers in many municipalities. These centers offer opportunities for training youths in agricultural equipment maintenance. NARC like entities should conduct feasibility studies of related Agri-machineries to identify cost-effective energy solutions and repair maintenance accessibility aligned with specific farm production goals.

Conclusion

Increasing cost of cultivation led to the realization that mechanization of farm operations is one of the effective ways to tackle with small holders' hardship. However, dominance of small farm and old-aged farmers, it is not possible and practicable for small farmers to own farm machinery. This has led to a new phenomenon of rental services of farm machinery and equipment. Due to existing ineffective rental services or custom hiring provisions, there has been a noted under-utilization of costly machines. To overcome, Government of Nepal need to visualize the establishments of professionally run Rental service centers/ Custom Hiring Centers (CHCs) in different places in order to facilitate easy availability of tractors and other hi-tech equipment's for farmers on rental basis.

Rental Service Center/Custom Hiring Centers can offer mechanical services at subsidized rates, providing labors that can help them carry out agricultural operations more efficiently and on schedule. This is crucial, because during peak agricultural season, farmers find it difficult to complete agricultural operations on time due to acute labor scarcity. By improving machinery availability and addressing the skill gap, farmers can enhance their productivity, reduce costs, and ultimately contribute to the overall development of the agricultural sector. Innovations in mechanization (in the form of smaller or scalable machinery) enabled small farms to substitute capital for labor amid rising wages. All this are useful in efficient use of machineries and longevity of machineries. Mechanization in Nepal has several constraints and limitations like high initial cost which often prohibits individual ownership especially amongst small, marginal and medium farm holders in addition to it, lack of knowledge in the aspects of operation, maintenance and repair of equipment often restricts the use of farm machinery and lack of space for shelter also constraints the use of machinery. Mechanization of agriculture will help in increasing the productivity and reduce the cost of cultivation and also enable the farmer to complete farming operations in time. It is recommended to increase subsidies to purchase agricultural machinery, research and promote machinery suitable for cash crops, increase the level of socialized agricultural services, and improve the ability of farmers to apply novel agricultural machinery and tools so as to increase their operating profits.

Policy implications (Recommendations)

- **Establishing a regulatory framework to ensure fair practices and quality service in the rental market.** To expedite the mechanization of small farms in Nepal for increased productivity and profitability, there's a critical need to promote rental service markets and competitive custom hire services. Governments should develop policies to strengthen these services, including operational guidelines for Rental Services/Custom Hiring Centers (CHCs), while also exploring financial instruments (soft loan, collateral free loan) and leveraging partial subsidies for purchases of Agriculture Machineries to operate Rental service center.
- **Bringing Agricultural Mechanization Policy, 2014 in action.** Research and extension of scale appropriate machineries, subsidy in agricultural machineries, training and demonstration of machineries, tax exemption in spare parts and raw materials, rental fixation of Machineries, Organization management and human resource development. The policy needs to be revisited through feasibility study of rental market service center in hill areas and Custom Hiring Centers in plain areas. The subsidy needs to be provided to scale appropriate machineries in a registered farmers group as promoting the rental services.
- **Creating an enabling environment for the domestic manufacturing of spare parts is recommended to overcome this challenge**. In order to mitigate the risk of technology import failures, it is imperative to address the lack of testing, quality control, and demonstration facilities for imported equipment. the need of establishing of Testing Institute for quality control, training and registration of machineries. For this, PMAMP can facilitate at least one Central Farm Machinery Testing and Training Institute for recommending the machineries to import into the country.
- **The absence of a conducive business environment is compounded by steep import taxes of 15% on spare parts and attachments, along with a 13% Value Added Tax (VAT) on such imports.** In contrast, tractors and power tillers enjoy a more favorable scenario with a low import tax (1%) and exemption from VAT. This need to be reviewed and revised. Policy options for zero tariff /nominal tariff need to be reviewed for encouraging investing private industries for maintenance and local manufacturing of spare parts and reducing the tariff for spare parts.
- **Lack of database of machineries registered and operated in farm level, spare parts availability, availability of technical human resources for operation and maintenance of Agri machineries**. Furthermore, lack of database on foreign returnee youths with the skill in using technology and capacity in investing in commercial agriculture and created a demand for appropriate mechanization technologies. The record system should be conducted. It is essential to establish a systematic record-keeping system to address these gaps.
- **An evaluation study is needed to assess the Rental market Services, focusing on factors like location, transportation costs, and time-schedule for agricultural crops growth.** Additionally, the study should determine the necessary machinery on

a ward or municipality level. Likewise, it is recommended to reassess restrictions on tractors by promoting tractors in off-farm related production, marketing and transportation related to agriculture sector.

- **Local governments, in collaboration with cooperatives, need to conduct training and workshops,** and also proper adaptation of tractor technology as per local needs, to enhance the capacity of farmers in the effective utilization and maintenance of agricultural machinery. Subsidies should target efficient machinery tailored to specific locations, ensuring widespread utilization by a larger number of users.
- **Repair and maintenance of machineries is major constraint in rural Nepal**. For this purpose, motorcycle workshop centers need be supported by involving the technician youths for repairing agricultural equipment's. Local artisans (black smiths) need to provided training to be able to repair and maintenance the agricultural equipment. This approach will address the parts shortage problem in better way through training the local youths with improved knowledge and skills.
- **Rental service centers can drive an innovative model including land pooling initiatives,** facilitating collective use of agricultural machinery and promoting resource-sharing among farmers, thereby enhancing the efficiency and affordability of mechanized farming practices.
- **Wage discrimination persists among women and men farmers**. Still, women in rural settings encounter social and cultural barriers to using machines and hiring services, and marginalized women may face financial challenges in accessing machinery services. This situation can be transformed by offering training facilities specifically for women. Addressing these issues through targeted training and support can bring about positive change in Gender role. Prioritizing occupational health, and provision of health insurance for machine operators, is essential to transform agriculture into decent job.

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Capitalizing Land Use, Land Use Change and Forestry (LULUCF) for Climate Mitigation: Opportunities and Challenges in Nepal

Sanjeeb Bhattarai (*may include others after stakeholder consultations)

Introduction

Anthropogenic greenhouse gas (GHG) emissions are the main forces behind change in modern climate. Fossil fuel consumption for industries, automobiles, electricity, and heat; as well as agriculture, forestry, and land uses (AFOLU) sectors have been identified as major sources of GHG emissions. The land supports many ecosystem services on which human existence, well-being, and livelihood ultimately depend. Yet over-exploitation of land resources has been reported as driving considerable and unprecedented rates of biodiversity loss, and wider environmental degradation. AFOLU sector accounts for almost a quarter of anthropogenic GHG emissions globally, and is unique due to its capacity to mitigate climate change through emission reductions, as well as enhance removals (IPCC 2019, IPBES 2019). Among the subsectors within AFOLU, forests, and other land uses, also known as land use change and forestry (LULUCF), have been considered as a potential for its climate mitigation services to offset emissions from other sectors.

Despite negligible contribution to greenhouse gas (GHG) emissions at the global scale, Nepal has been actively performing activities related to climate change management ever since it became a Party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1994. As part of its commitment to ambitious climate change mitigation, Nepal adopted a Long-Term Strategy for Net Zero Emissions (LTS) in 2021, which aspires to achieve sustainable net-zero CO_2 emissions by 2045 (GoN, 2021). As Nepal has also set a target to graduate to a middle-income country status from the Least Developed Country (LDC) by 2030, it is expected to increase its emissions while accelerating development in the near future. According to Nepal's LTS document, the total carbon dioxide (CO_2) emissions of the country was 23 $mMtCO_2$ in 2019, which is expected to rise to 34 $mMtCO_2$ in 2030 and to 79 $mMtCO_2$ in 2050 (Figure 1). It is hence challenging to strike a balance between development imperatives and net-zero CO_2 emissions targets.

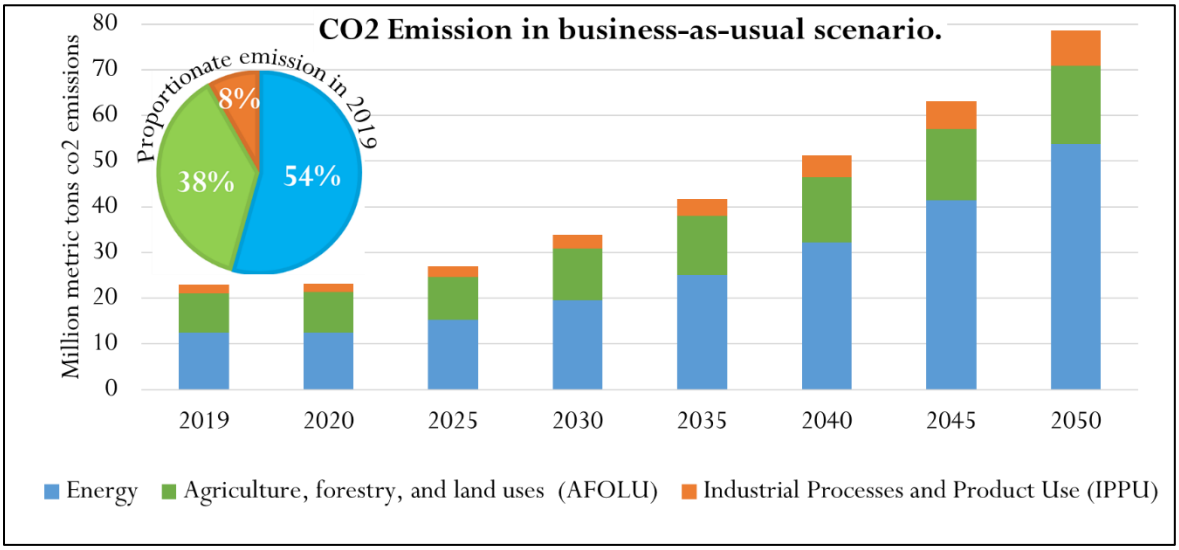

Figure 1: Present and predicted greenhouse gas emissions (in terms of CO2 equivalent) from major sectors in Nepal (GoN 2021).

In addition to LULUCF management and intervention activities outlined in regular periodic plans and policies, the Government of Nepal (GoN) has voluntarily committed to different interventions and estimated GHG removals from such interventions at different international forums such as UNFCCC. These interventions are targeted at reducing deforestation and forest degradation, enhancing forest conditions, and in maintaining or increasing areas under forest or vegetation for carbon enhancement. Nepal has developed AFOLU supportive policy and institutional arrangements and has implemented multilateral and bilateral forest-based carbon emission reduction initiatives.

Nepal's LULUCF is further crucial may be due to 1. Nepal has 45% forest area of this total land area. 2. Nepal's NDC includes AFOLU as a major approach to CC mitigation. 3. Nepal's aspiration can be met through its pioneer community-based land management including Community Forestry.

The diverse nature of LULUCF sub-sector, its linkage with wider societal, economic and environmental aspects demands coordinated interventions to fully realize its role as sink to atmospheric GHG. However, limited knowledge is developed in this regard. This policy paper aims to assess and compare the mitigation benefits of the targeted packages of interventions in the LULUCF sub-sector. The intervention packages are represented by the business-as-usual (BAU), Realistic, and Optimistic scenarios.

Methodology

The analysis is based on two steps, first estimation of land use, land cover, and their changes; followed by scenarios analysis. The analysis of land use, land cover, and their changes was carried out between 2000 and 2019 using the data from the Forest Research

and Training Centre (FRTC) (FRTC, 2022). The BAU, Realistic, and Optimistic scenarios represent packages of interventions in policy documents and their extrapolation. The scenarios were developed from 2025 to 2050 in five-year intervals. The data and information from the following plans, policies, and project documents, and their extrapolation, were incorporated for developing scenarios:

- The revised Forest Reference Level (FRL) submitted by Government of Nepal to the UNFCCC (MoFSC, 2017)
- The Second Nationally Determined Contribution (NDC) (GoN, 2020)
- Nepal's Forestry Sector Strategy (MoFSC, 2016)
- Nepal's 15th Plan (NPC, 2020)
- The World Bank's Emission Reduction (ER) targets[2]

The collected data and information from nationally authorized sources were insufficient for estimating emissions and removals. The data calibrated by Hansen et al. (2013) for 2010 according to FRTC (2022) and projected up to 2050 under BAU. The data of Giglio et al. (2021) was used for forest fire trend and prediction data. In the cases of data gaps, IPCC Tier 1 default values were used (IPCC 2019).

Based on the compiled data, the BAU scenario included the continuation of past activities, and the Realistic scenario considered the realization of targeted emission reduction and mitigation interventions proposed in the plan, policy, and project documents. Finally, the Optimistic scenario hypothetically extrapolated the targets of the Realistic scenario. The scenario analysis was based on the interventions in reviewed documents (Figure 2), detail of each intervention in all scenarios are presented in

Abbreviations

AFOLU	Agriculture, forestry, and land uses
BAU	Business-as-usual
CO2	Carbon dioxide
ER	Emission reduction
ERP	Emission reduction program
FRL	Forest reference level
FRTC	Forest Research and Training Centre
GHG	Greenhouse gas
GoN	Government of Nepal
LDC	Least developed country
LTS	Long-term strategy for net zero emissions
LULUCF	Land use, land use change and forestry

[2] A Sustainable Forest Management-Based Emission Reduction Program in the Terai Arc Landscape (TAL ERP), Nepal Forests for Prosperity Project (FFPP), Building a Resilient Churia Region in Nepal (BRCRN), Improving Climate Resilience of Vulnerable Communities and Ecosystems in the Gandaki River Basin (ICR GRB), LEAF Coalition

MoFE	Ministry of Forest and Environment
NDC	Nationally determined contribution
PES	Payment for ecosystem services
SFM	Sustainable forest management
tCO2e	Tons of carbon equivalent
UNFCCC	United Nations Framework Convention on Climate Change

Annex *1*.

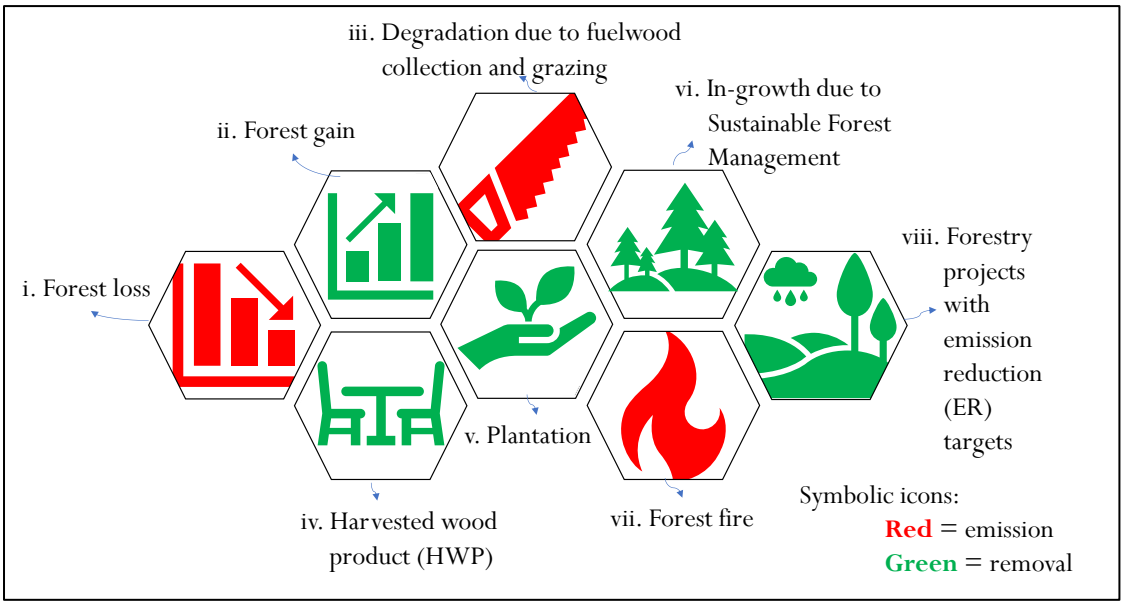

Figure 2 Activities and interventions considered for scenarios forthe forestry sector (also see

Abbreviations

AFOLU	Agriculture, forestry, and land uses
BAU	Business-as-usual
CO2	Carbon dioxide
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Annex 1 for details).

Findings

Pattern of land use and land cover[3] changes

Occupying 41.69% of Nepal's area, forest dominates land cover, followed by other land uses[4] (34.10%) and cropland (24.21%) (FRTC 2022). Moreover, there have been 2.10% decrease in cropland, 1.70% increase in forest, and 0.40% increase in other land cover

[3] Land use documents how people are using the land such as agriculture or settlement, whereas land cover indicates the physical land type such as forest or open water.

[4] Other land cover category includes grassland, snow, bare rock, other wooded land, glacier, riverbed, built-up, waterbody, and bare soil (FRTC, 2022).

between 2000 and 2019 (Figure 3).

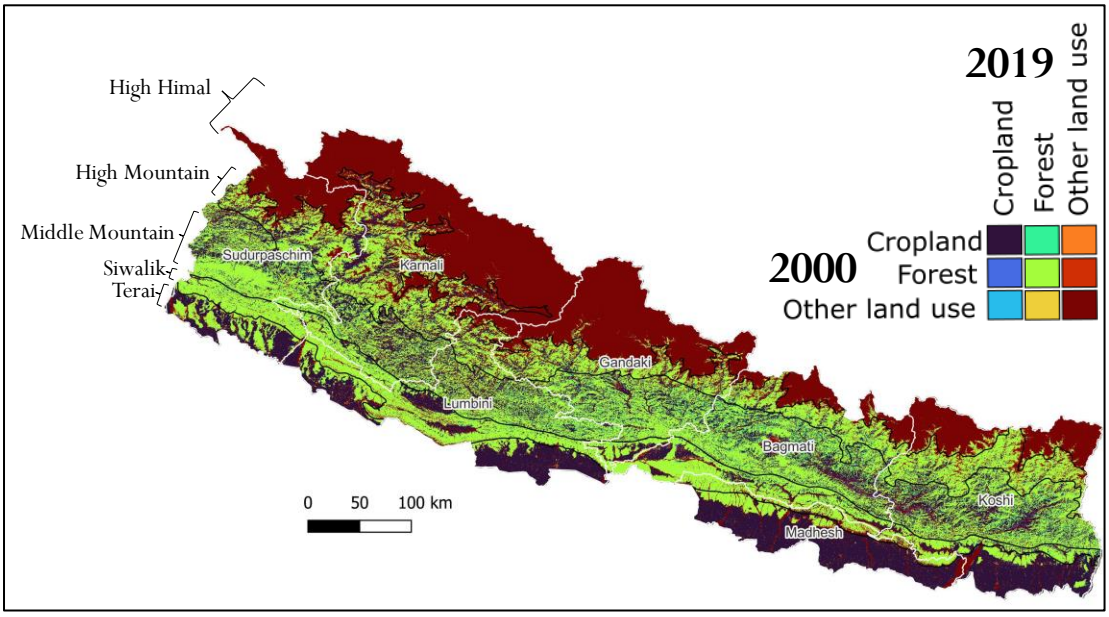

Figure 3. Land cover change between 2000 and 2019 (Data source: FRTC). White polygons indicate seven provincial boundaries, whereas black polygons separate five physiographic regions.

Net transition of 252,420 ha from cropland to forest and 58,033 ha from cropland to other land uses were observed as the two most prominent land cover conversions between 2000 and 2019 at the national level (Table 3).

Table 3: Land cover change matrix between 2000 and 2019 in Nepal

		2019 (ha)			
		Cropland	**Forest**	**Other land uses**	**Total**
2000 (ha.)	**Cropland**	3,420,253	370,805	100,441	3,891,499
	Forest	118,385	5,589,552	207,581	5,915,518
	Other land uses	42,408	206,409	4,737,176	4,985,993
	Total	3,581,046	6,166,766	5,045,198	14,793,010

Physiographic region-wise, Middle Mountain experienced the highest gain in 249,348 ha forest with the losses of cropland (233,550 ha) and other land uses (15,798 ha), whereas High Mountain experienced the overall gain in 36,158 ha of other land uses in loss of forest (26,478 ha) and cropland (9,679 ha) (Figure 4).

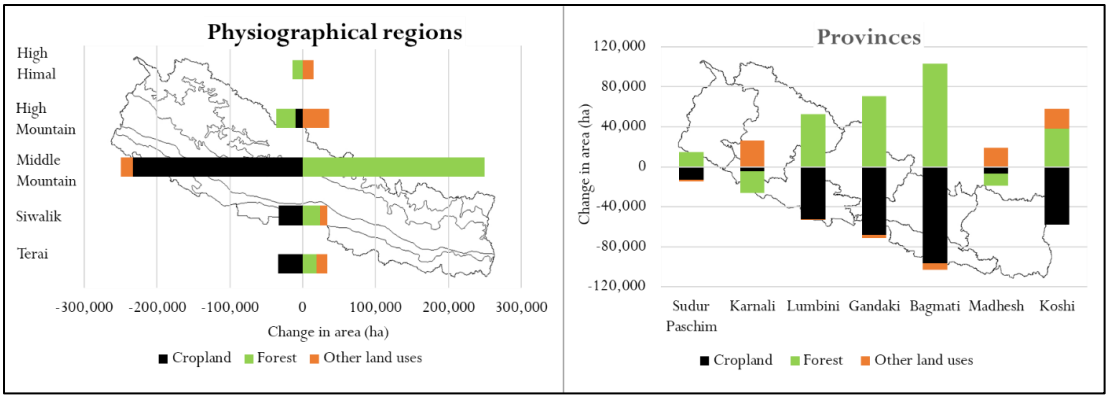

Figure 4: Sub-national level changes in the land cover area between 2000 and 2019

At the provincial level, except Madhesh and Karnali, all provinces show net forest gain between 2000 and 2019. Moreover, Bagmati, Gandaki, Lumbini, and Sudur Pashchim provinces show similar trends of gaining forest at the expense of cropland and other land uses. Among all the provincial level changes, and in terms of area, the largest gain was observed in forest (102,905 ha) in Bagmati at the expense of cropland (96,494 ha) and other land uses (6,411 ha).

The land cover change patterns among different cover types at sub-national levels (physiographic and provincial) between 2000 and 2019 were diverse except for cropland, which was found to be declining consistently in all cases.

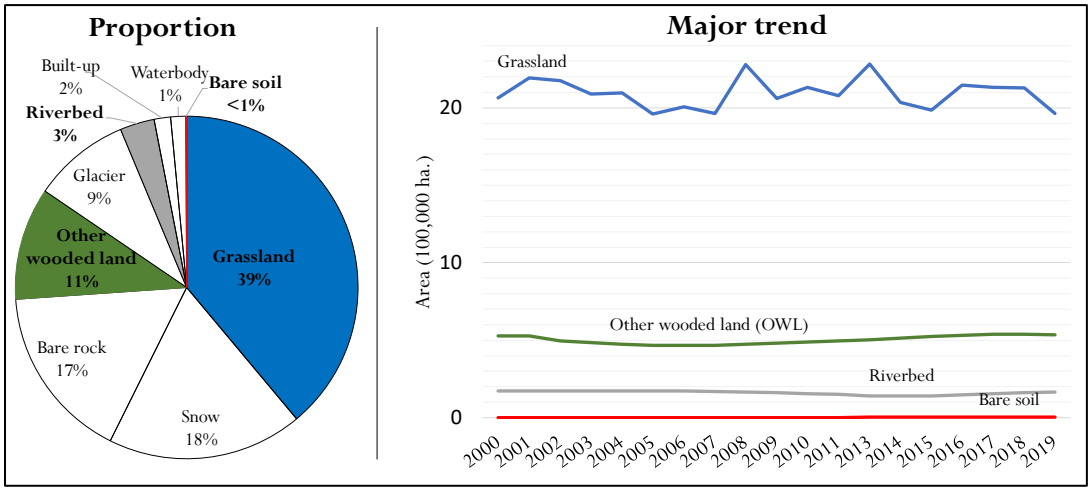

Figure 5. Proportion and trend of coverage by different categories within other land uses (FRTC 2022)

Note: The proportionate is calculated considering other land uses as 100% in 2019, coloured land uses are identified as land used that have considerable mitigation and adaptation potential.

The proportion and trend of land use categories under the land uses shows about 2,724,406 ha of land cover categories (bare soil, riverbed, other wooded lands, and grassland)

available for enhancement of vegetation and forest cover, hence potential for interventions targeted for CO2 mitigation (Figure 5).

Greenhouse gas emission, removal, and scenarios

Monitoring and analysing data from 2000 to 2010, MoFSC (2017) estimated national-level annual carbon equivalent emission and removals from forested areas by four major activities. Accordingly, the greenhouse gas emissions in terms of metric tons of carbon equivalent (tCO_2e/year) per year at the national level were 917,743 by deforestation, 341,000 by fuelwood collection, and 1,767,273 by unsustainable grazing. The removal was estimated to be 150,110 tCO_2e/year by afforestation. Finally, the net emission from forested areas at the national level, calculated by subtracting removals by afforestation from the total emissions from both deforestation and degradation, is estimated to be 2,875,906 tCO_2e/year (MoFSC, 2017).

Under the BAU, the trend line of cumulative net emissions appears to be nearly linear in the positive direction, implying that carbon emissions will increase in the same trend over the estimated period (i.e., until 2050). (Figure 6). However, the trend in forest area under the BAU appears to be in reverse and moderate until 2030 and steep then after, implying that the forest area in Nepal will decrease smoothly until 2030, and rapidly thereafter as a result of current forest management activities considered under BAU.

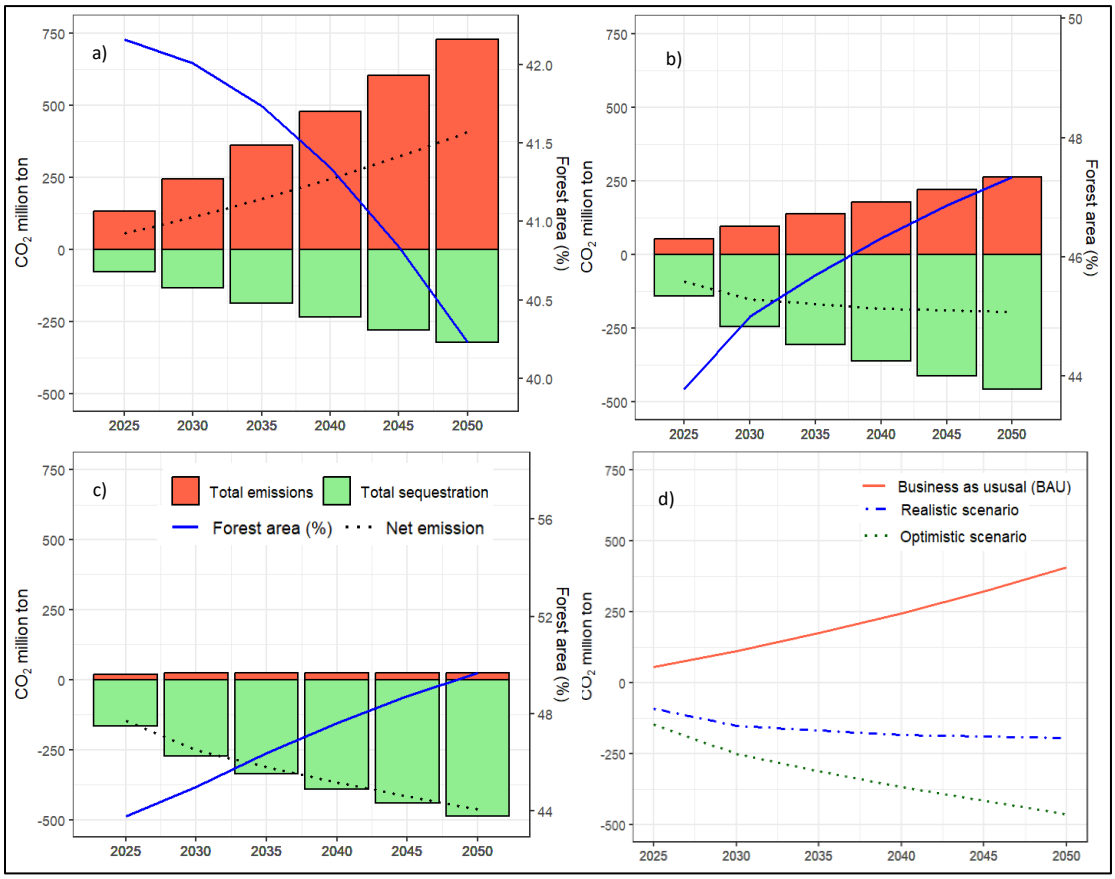

Figure 6. Five-yearly cumulative summary of total emissions, sequestration, and forest area percentage under a) BAU, b) Realistic and c) Optimistic scenarios; and d) comparison of their net emissions.

Under the Realistic scenario, the net emission appears to be negative throughout the analysis period due to a significant reduction in emissions and an increase in removals. The goal of achieving 45 percent forest cover by 2030 significantly increases forest cover and appears to be the most notable driver for removal by 2030. By the end of 2050, the forest area increased to 47.3 percent of the national land coverage, owing primarily to the plantation.

The Optimistic scenario mostly results in removals, and hence limited emissions. The trend follows almost that of the Realistic scenario i.e. steep removals by 2030 (contributed by the target to meet 45% forest cover) and gradual decline afterward, but still net removal.

When the net emissions trends for the three scenarios were compared, it is clear that Realistic and Optimistic have nearly identical trends. In-growth removal due to sustainable forest management (SFM) - to meet the target of 75 percent forest in the Terai, Inner Terai, the middle hills and mountains under SFM, zero forest loss, and low levels of degradation and forest fire in the Optimistic scenario contributed to its enhanced removals compared to Realistic scenario.

Opportunities and challenges of GHG mitigation in other land uses

It is estimated that an average of 37% of arable land is abandoned in Nepal (Paudel et al. 2014; Ojha et al. 2017). The abandoned land can also be seen as an opportunity for ecological restoration. Forest regeneration on abandoned fields enhances carbon removals. Restoring degraded forests and other wooded land through the promotion of natural regeneration or the use of secondary succession on croplands improves ecosystem services by rehabilitating and re-naturalizing land. In addition, the abandonment of farmland may assist in the restoration of soil fertility and will contribute to the provision of ecosystem services through the sequestration of soil organic carbon and the improvement of soil health. The risks of climate hazards such as floods, fire, drought, landslide erosion, and mudslides have impacted land degradation and land productivity (UNFCCC, 2007). Thus, the impact of climate change on crops compounded with the land abandonment issues is detrimental to food security issues in Nepal and requires immediate action. Conversion of abandoned agricultural land into an agroforestry system could be one of the best options, because of the higher potential of agroforestry for annual returns with a single investment under labour shortage circumstances (Amatya et al. 2018). The GoN is also promoting agroforestry in the country, for example by formulation of the Nepal national agroforestry

policy in 2019, which emphasizes the promotion of the agroforestry program by realizing its multiple benefits and sustainability for the dominant mountain environment in Nepal.

Payment for ecosystem services (PES) is already in practice in Nepal (Bhatta 2014). So far, a few PES-like projects have already been tested at a pilot scale financed by donors, based on their success, the policies have already been adopted in the forestry sector by the GoN. However, due to large-scale financing needs for implementation and sustainability in other sectors, there are challenges in broader implementation, hence the permanence of the impacts from such projects. The development and adoption of integrated policies related to PES will incentivise landholders to put their land under sustainable use practices such as fallow to agroforestry. It will not have a mitigation advantage, but wider ecological, economic, and societal benefits.

With the trend of depopulation and increase in vegetation and forest cover, there is an increasing trend of human-wildlife conflict in sparsely populated located at remote areas (Baral 2021), which needs to be duly considered.

The whole process of monitoring, reporting, and verifying (MRV) carbon mitigation programs and projects needs standard, accurate, and timely data guided by internally approved materials and methods. This needs investment in infrastructure and skilled human resource. Though new tools and techniques are emerging to make the process more affordable (e.g. integration of geospatial analysis), Nepal needs investment in regard to preparation. Particularly the mechanism of regularly collecting data and making them available publicly through a repository at the national nodal body needs to be immediately implemented.

Almost half of the forest in Nepal is managed by some form of community participation. Most of these communities are dominated by indigenous populations, who have been utilizing forests for various purposes. Hence ensuring rights the rights of the local and indigenous peoples (IPs) for their traditional use of forest and environmental products and services must also be considered for any GHG mitigation intervention in the LULUCF sub-sector.

Recommendations

- Nepal's immediate future challenge is to graduate to a middle-income country status from the LDC and to achieve nationally determined contribution (NDC) targets in the LULUCF sub-sector - both by 2030. This will necessitate an integrated approach to economic development, as well as to increase forest area while also addressing the drivers of deforestation and forest degradation.
- Recent trends of land abandonment, particularly due to outmigration in hilly areas, and conversion of croplands into forest and other land uses have created serious

social, economic, and ecological implications. There is a steady pattern of increase in forested areas in most parts of Nepal.

- The findings suggest that by 2050, Nepal will have transformed its LULUCF sub-sector from a net emitter in BAU (406.94 mtCO2e) to a net remover in Realistic (-193.95 mtCO2e) and Optimistic (-462.75 mtCO2e) scenarios. Maintaining 45% of forest land, and linking LULUCF-based mitigation and removal not only contribute to offsets from other sectors, but also benefit local communities who are the actors of LULUCF.
- Though Nepal has already been applying projects with (or received commitments for some) financial support to implement interventions under Realistic scenarios in the form of ERPs, there is still a significant financial gap in realising the outlined interventions in Realistic and Optimistic scenarios.
- There is an immediate need for enhancing the capacity of the national nodal body (e.g. MoFE) to regularly collect, process, update, store, and produce all relevant data for analysis at national and sub-national levels.
- It is challenging to strike a balance between net-zero emissions and graduating from the least developing sectors. The LULUCF sub-sector can play a pivotal role in terms of mitigating emissions from other sectors such as construction and industries, which have limited options for reducing their emissions. Other sectors can finance the LULUCF sub-sector for implementing mitigation interventions, and claim emission credit to achieve their sectorial net-zero emissions. Hence, policies such as payments for ecosystem services (PES) need urgent attention for further elaboration and wider implementation.

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Abbreviations

AFOLU	Agriculture, forestry, and land uses
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ERP	Emission reduction program
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LTS	Long-term strategy for net zero emissions
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MoFE	Ministry of Forest and Environment
NDC	Nationally determined contribution
PES	Payment for ecosystem services
SFM	Sustainable forest management
tCO_2e	Tons of carbon equivalent
UNFCCC	United Nations Framework Convention on Climate Change

Annex 1: Activities and assumptions for scenario analysis

Activities	*Business-as-usual (BAU)*	*Realistic scenario*	*Optimistic scenario*
i. Forest loss	Data: Hansen et al. (2013) calibrated for 2010 according to FRTC (2022) and projected up to 2050; Method: Gain/loss using emission/sequestration values from FRL. Unit removal rate due to gain modified for 2020 to 2050 accordingly.	Half of BAU	By 2030, no loss
ii. Forest gain		25% of plantation and additional to meet 45% target by 2030	As in Realistic Scenario
iii. Degradation due to unsuitable fuelwood harvesting		Half of BAU, deduct area under sustainable forest management	By 2030, no degradation, deduct area under sustainable forest management by then
iv. Harvested wood product	Data: Extrapolation of available national data Invalid source specified. and their extrapolation; Method: IPCC Tier 1 method using default values	Data: Proposed extraction data in recent five-year plan (NPC, 2020) and their extrapolation; Method: As in BAU	As in Realistic Scenario

v. Plantation	Forest gain due to plantation is considered to be included in FRL. However, available national data on the plantation (Paudyal, 2018; MoFE, 2020) and their extrapolation are used to calculate additional under Realistic Scenario	Data: ERP targets. proposed data on the plantation in the recent five-year plan (NPC, 2020) and their extrapolation. 25% of increased plantation area in WEM compared to BAU; Method: IPCC Tier 1 method using default values	As in Realistic Scenario
vi. In-growth due to Sustainable Forest Management	Existing forest area under Scientific Forest Management (SFM)	As per existing ERPs	By 2030, 50% of Terai and Inner-Terai forests, and 25% of middle hills and mountain forests (GoN, 2020)
vii. Forest fire	Period: 2000-2020; Data: Analysis of global data (Giglio, Justice, Boschetti, & Roy, 2021) and their extrapolation; Method: IPCC Tier 1 method using default values	Half of BAU	By 2030, 25% due to Projects for Forest Fire Prevention and Control
viii. Forestry projects with emission reduction targets	None	TAL ERP, FFPP, BRCRN. ICR GRB, LEAF Coalition	As in Realistic Scenario

How to Tackle Current Dairy Crisis in Nepal?

Jyoti Dhungana[*5]

Summary

The dairy sector is a vital source of income, employment, and nutrition security for the average household in Nepal. However, farmers and dairy sector traders struggle to sell dairy products in markets. In this context, this policy brief highlights some of these discourses in the dairy sector and provides alternate policies and recommendations to revive the dairy sector as a vibrant industry. There is a glutting of over 5,000 tons of powdered milk, over 8,000 tons of butter, and over 1,400 tons of cheese in the warehouses of major dairy industries in the country. These industries have failed to sell their products in domestic and international markets due to various inter-twined factors and sector policy failures in the country in the last few years. This scale of stockpiles of finished dairy products at the dairy industries' warehouse has resulted in delayed payments to the smallholder farmers, with a pending amount of over 6 billion by the end of March 2024. The dairy sector is facing a series of challenges and the threat of a collapsing point now if these pending overdue amounts are not paid to the farmers on time. Besides, the Nepalese dairy sectors have faced constraints, such as high milk production costs, poor quality milk, prevalence of animal diseases, and limited export opportunities, making it less competitive globally. The regulatory framework for quality compliance, control of contagious diseases like Foot and Mouth Disease (FMD), and milk supply systems are weak. Based on the policy analysis and findings, recommendations have been suggested to policy makers for their urgent actions.

Photo 1: Dumping the milk on street to protest against the delay in milk payment, Chitwan , 20 Feb 2024

Policy Recommendations

- Milk price system needs to be rationalized
- Declare Foot and Mouth Disease zone is essential
- Illegal import into the domestic market should be discouraged
- Milk quality standard needs to be enforced tightly
- Strict enforcement of milk quality standard is necessary
- Cost-reduction technology should be promoted
- Proactive engagement of farmers' federation for dairy farmers, is required

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Introduction

The dairy sector plays a multi-dimensional role in reducing poverty and enhancing economic prosperity through income generation. The dairy sector in Nepal contributes 63% and 9% to livestock Gross Domestic Product (GDP) and agriculture GDP, respectively (MoF, 2023). In addition, it provides nutritional value to families and creates opportunities for cash flow from urban to rural areas. Skim Milk Powder (SMP), butter, ghee, cheese, dog chew, and buttermilk are the main exportable dairy products in Nepal.

Over the past decade, milk production in Nepal has gradually increased from 1.68 million tons in 2012/13 to 2.57 million tons in 2021/22) (MoALD, 2023). The annual average production of SMP stands at 414,478 tons, followed by butter and ghee at 24,470 tons and 38,867 tons, respectively (FAOSTAT, 2023). The Agriculture Development Strategy (ADS, 2015-2035) has identified dairy as the second most important commodity in agriculture value chain of Nepal. The National Dairy Development Policy (2021) aims to increase milk production through breed improvement, better veterinary services, improved fodder/forage, and insurance services. The Industrial Enterprises Act (2020) and National Action Plan on Trade Deficit Reduction (2023/24 to 2028/29) are additional measures to reduce imports and promote exportable products of industries.

Despite these efforts, current unsold stock of dairy products such as: SMP, Ghee and cheese in dairy industry remains a big problem. This issue remains unresolved due to the inability to sell dairy products in the domestic and international markets as well. Thus, this policy brief specifically examines those challenges and offers practical recommendations for improvement. Thereby, we can foster a thriving dairy industry in Nepal that benefits farmers, consumers, and the overall economy.

Current issue of dairy sector

Farmers across the country are increasingly worried about milk sales. Dairies seem reluctant to collect milk from farmers, causing delays in payment for over seven months. The total amount paid to farmers nationwide has exceeded six billion. Meanwhile, the dairy industry is tackling excess dairy products, including SMP, butter, ghee, and cheese. According to the National Dairy Development Board, more than 5,000 tons of powdered milk, 8,000 tons of butter, and 1,400 tons of cheese are in stock across the country.

Photo 2: Store of cheese at Lucky dairy in Ilam

Photo 3: Storage of powder milk in Chitwan

This problem is primarily caused by decreased local milk demand due to economic crisis and trade barriers in international markets. Moreover, private dairies and industries operate under capacity (45% utilization), and heavily use of imported feed leads to increased milk production costs. The high trade deficit results from limited capacity to export in the international market. There is inadequate quality compliance with low-quality milk, informal marketing, high disease prevalence, and high cost of milk production, leading to unmet criteria set by the World Trade Organization (WTO), resulting in low exports.

Why dairy sector is important?

Milk is a highly nutritious food that is rich in vitamins and minerals. It has the potential to generate income for both rural and urban areas through product diversification and value addition. Around 500,000 farming households in the country produce milk, and the dairy industry is comprised of five large-scale (>50,000 L/day), 30 medium-scale (10,000-50,000 L/day), and 600 small-scale (<10,000 L/day) industries (NDDB, 2021). However, growing trend in milk production could lead to an oversupply in the future. On the other hand, dairy products can replace imports, saving billions of rupees and promoting self-sufficiency. Therefore, it is crucial to make more efforts to address the current challenges in the Nepalese dairy sector.

Analysis and findings

Milk Production Trend

Over the past decade, there has been a consistent increase in the production of milk and dairy products, as shown in Figure 1. As of 2021/22, milk production has reached 2.57 million tons, and dairy products have reached 0.52 million tons (MoALD, 2023). The availability of milk per capita has also increased from 62 kg in 2015/16 to 85 kg in 2021/22 (MoF, 2023), which is close to the recommended amount of 92 kg as advised by the Food and Agriculture Organization (FAO). With such a positive growth rate, it is evident that the country will become self-sufficient in milk within a few years.

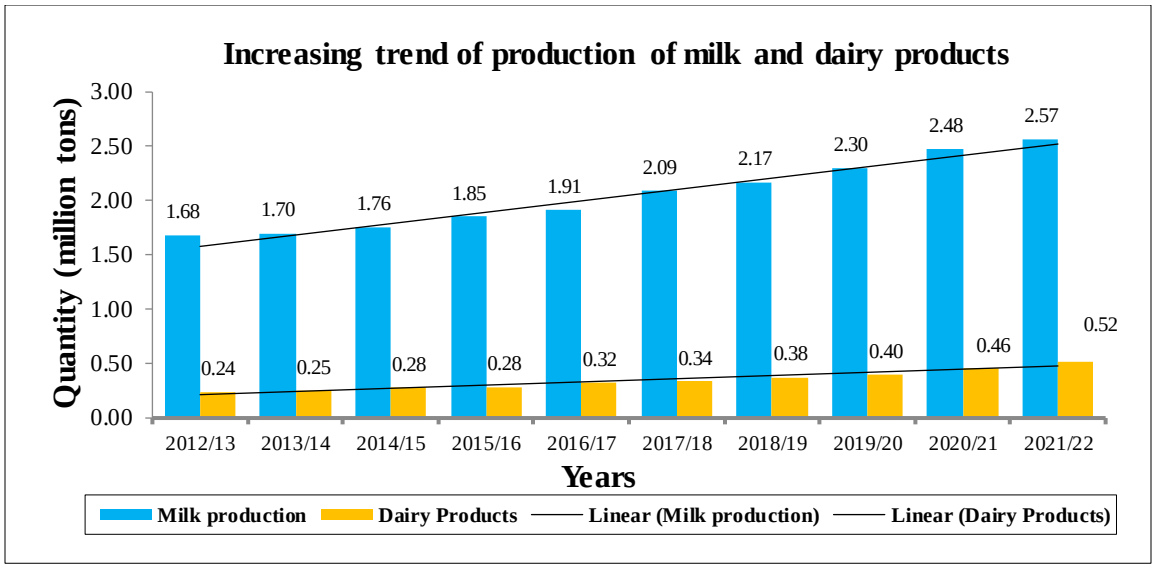

Figure 7: Trend of production of milk and dairy products (10 years period) (Source: MoALD, 2023).

Milk Trade Situation

The import of dairy products gradually decreased from 7,572 tons in 2018/19 to 2,897 tons in 2020/21 and then increased to 4,035 tons in 2022/23 (Department of Customs, 2023) (Figure 2). Similarly, milk product exports dropped significantly from 242 tons in 2018/19 to 56 tons in 2021/22 (Department of Customs, 2023). This decline in exports and imports is attributed to the lockdown during the COVID-19 pandemic. The main reason for the decline in exports and imports is due to the lockdown in the COVID-19 pandemic period and the import ban by the Government of Nepal. Besides, the dairy industry continued to collect milk, resulting in a surplus of dairy products. However, the informal milk trade near the border areas has continued to import dairy products in large quantities.

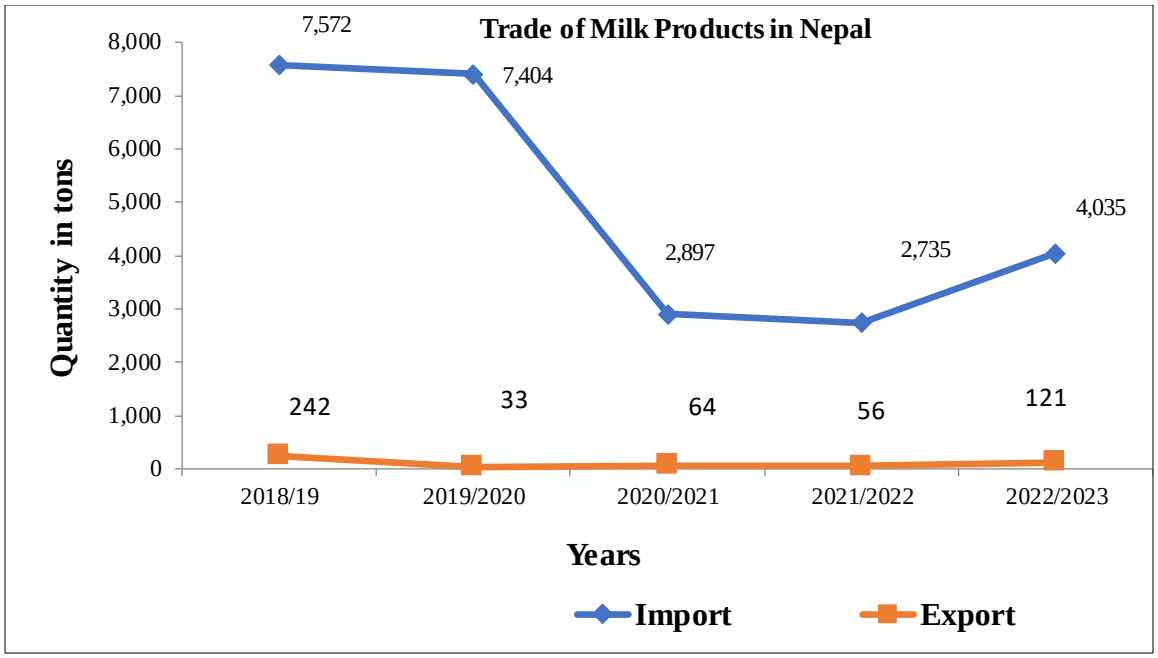

Figure 8: Trend of export and import of dairy products in five years period
Source: Statistical data of Custom Department, 2023).

Key Factors of Current Dairy Issues

The dairy sector is facing challenges, including high production cost, sub-standard milk quality, the widespread occurrence of animal diseases, and limited prospects for exporting dairy products. These factors result in delays in payment to farmers, economic loss, and low efficiency, leading to low trade in dairy products, as shown in Figure 3. Additionally, there are weak regulatory and institutional mechanisms for ensuring quality compliance, controlling infectious diseases such as Foot-and-Mouth disease (FMD), and managing supply systems.

High cost of milk production

Table 1 indicates that only 45% of the capacity of dairy industry is being utilized, while the remaining 55% still needs to be fulfilled, resulting in high production costs.

Table 4: Operating processing capacity of dairy industries in Nepal

SN	Dairy Industry	Capacity per day (L)	Utilization (L)	Efficiency %
1	Kamdhenu Dairy, Tarahara	50,000	30,000	60
2	Chitwan Milk Limited, Chitwan	150,000	95,000	63
3	Ritika Dairy, Morang	24,000	12,000	50
4	Gorus Dairy, Morang	16,000	7,500	47
5	NMC Dairy, Jhapa	24,000	8,000	33
6	Sivam Dairy, Biratnagar	16,000	5,000	31
7	Suryodaya dairy,Morang	16,000	5,000	31
	Average	**42,286**	**23,214**	**45**

Source: Based on personal interview, 2023.

This under-capacity is due to a higher number of private dairies and limited product diversification that fail to meet needs and preferences of consumers. Nepali milk producers are unable to compete with heavily subsidized Indian farmers in terms of price. India has a competitive advantage in milk production due to its large-scale production and mechanization. As a result, the final price of Nepalese milk is Rs 8/L higher than that of Indian milk, leading to informal imports from the border side.

Further, only feed costs share 60% of the total cost of milk production. In Nepal, almost 95% of the feed is imported from India. Forage and feed availability, as well as their production at the local level, play a crucial role in reducing the milk price. Moreover, the existing price control mechanisms have failed to encourage farmers to commercialize their farming practices, as there is no difference in the price of milk sales between lean and flush seasons.

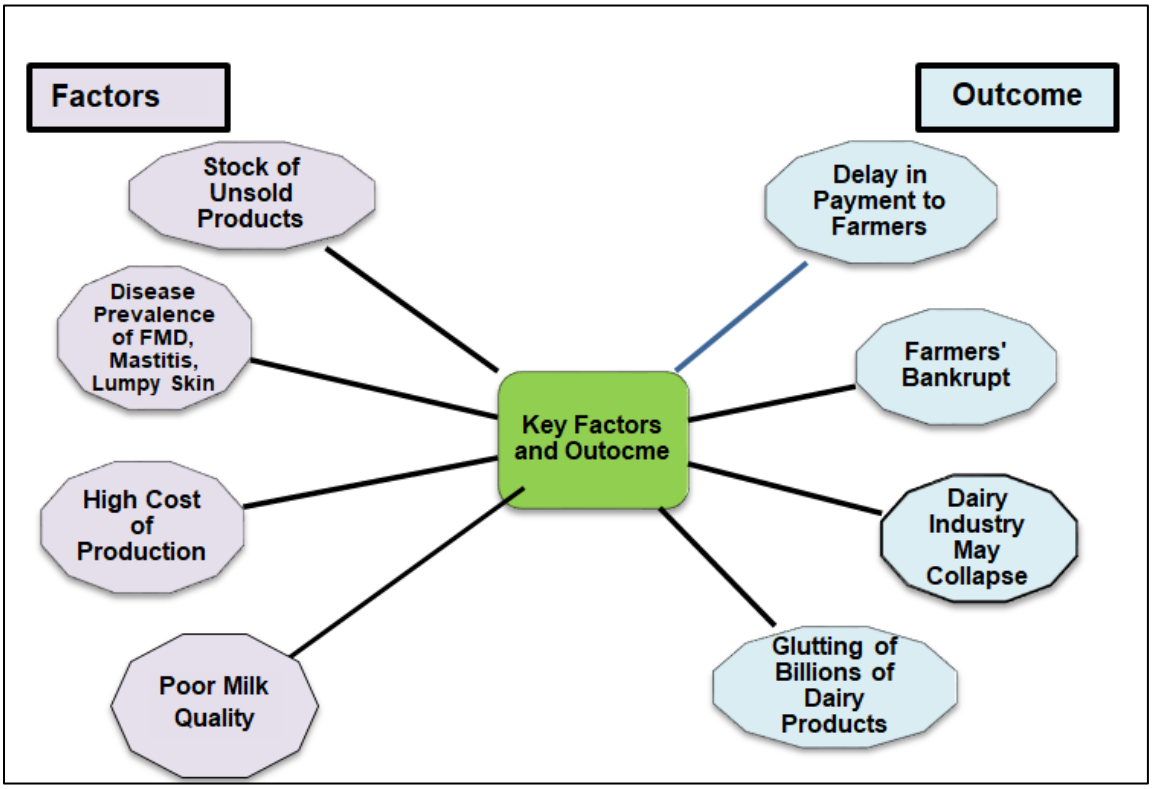

Figure 3: Graphical illustration of Factors and outcome affecting of current dairy issue

Quality and safety measures

Farmers still rely on traditional animal husbandry practices. The protocols are in place to inspect and test finished dairy products; however, the regulation of raw milk is still limited. The prevalence of adulteration in milk is a significant concern. The study found that 33.3% and 48.3% of the samples tested had been mixed with sugar and soda, respectively (Parajuli et al., 2023). This harmful practice poses significant risks to human health and undermines the potential benefits of milk. The informal milk marketing accounts for more than 65% of

total milk marketing. Additionally, Nepali exporters face hurdles related to Sanitary and Phyto-sanitary (SPS) measures when exporting goods to international markets. However, establishing Good Husbandry Practices (GHPs) and safety standards can address these issues, ensuring public health and boosting international trade.

Disease prevalence

The Government of Nepal has mandated the declaration of FMD free zone in the Dairy Development Policy. However, this has yet to be implemented. The WTO restricts the trading of animals and animal products from endemic areas. The movement of animals, particularly during festival seasons, illegal trading at the border, limited knowledge about the disease among farmers, and inadequate quarantine measures contribute to the frequent outbreaks of FMD. Sub-clinical and clinical mastitis disease caused an estimated economic loss of 8,320 and 4,430 million Nepalese rupees, respectively (Kharel et al., 2023). Recent data from Nepal reveals that 47,649 cattle have died due to lumpy skin disease (MoALD, 2023), which can be attributed to poor farm management, unhygienic practices, and insufficient veterinary services.

Dairy product export

Trade from Nepal is too dependent in India, accounting for over two-thirds of exports and imports. In particular, different types of export promotion schemes undertaken by the central government were deemed non-compliant with international trade. To overcome this issue, the supply can be enhanced through increasing consumption of milk by using the mass media campaigns. Moreover, simplifying the process of obtaining export authorization and initiating international food certification for the industry would be beneficial. The dairy product diversification and making some government-to-government (G2G) deals with other dairy-deficit regions or countries could reduce the dependence on the Indian market.

Policy recommendations

To address these problems following urgent policy options are suggested:

Rationalize the milk price system: The current milk pricing system needs to be re-evaluated and adjusted to align with the supply and demand of milk in the country. There is a growing concern that the pricing decisions are not based on market forces, as they do not account for variations in production levels between lean and flush seasons. Also, the price is generally fixed for farmers rather than for dairy products traders and intermediaries.

FMD free zone declaration: The declaration of FMD zones should be based on scientific and trade-friendly criteria to enable Nepalese dairy products to be exported to the global market. A task force team should be deployed with a clear action plan and vaccination program to ensure proper control of FMD. Both dairy producers and exporters have urged the development of FMD-free milk production districts. Similarly, the quarantine measures and the free movement of animals should be restricted.

Improve the milk quality and hygiene: Public concerns regarding milk quality and informal marketing can be addressed by implementing strict regulations to the entire milk production process, from raw milk to product diversification. Adopting standard operating procedures SPS measures and GHPs should be mandated to ensure compliance and safety. It is essential to have a reward and punishment system and to license market intermediaries to regulate formal milk marketing. Adulteration of dairy products with any chemical should be strictly prohibited, and violations should be penalized under existing regulations.

Promote the cost reduction technologies: It is essential to prioritize the development of policies that effectively disseminate milk cost reduction technologies and ensure the continuation of fodder/forage programs alongside the maize and soybean mission program. Additionally, providing incentives and fostering a favorable business environment is necessary for the domestic dairy and feed industry. Furthermore, the illegal import of milk and dairy products into the domestic market needs to be discouraged.

Proactive engagement of farmers' federation: The Dairy Farmer Federation has a vital role in advocating for the interests of smallholder dairy farmers by proactively engaging with federal and provincial policymakers. They can collaborate with various organizations to address the challenges of dairy farmers and provide suggestions to policymakers regarding policy changes that may benefit the dairy sector.

Conclusion

The policy brief assessed the current critical constraints in the dairy sector, including unsold dairy products and delayed payment to milk farmers for the past seven months. Dairy-related policies are unable to address milk quality, safety, and cost issues. Nevertheless, there is an opportunity to sell milk and its products in national and international markets. Improving milk quality products increases milk consumption in domestic markets, and product diversification may help address the current issue. Further, exploring and studying the possibility of supplying milk products in milk-deficit countries can promote milk exports

Acknowledgement

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Can subsidy be effective in strengthening the seed system in Nepal?

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Summary

This policy brief analyzes subsidies as an important tool for strengthening the seed system in Nepal. The coverage of the improved rice varieties in Nepal is low. To meet the increasing demand for seed, the private seed producer group has to be strengthened and incentivized. Though the government has made huge investments in subsidy-efficient targeting, categorization of the farmers has not been done. Nepal is expending huge investment in importing seeds and still this can still be predicted to go higher. Access to quality seed and the parental lines for hybrid production is limited. In this context, this paper has recommended some corrective measures to overcome this situation. The voucher system of input-based subsidy distribution, the public-private partnership model of seed production, categorization and identification of the real seed entrepreneur farmers, the provision of a soft loan for the entrepreneur farmers, and increasing the availability of parental lines for the seed companies, are some of the ways to improve the existing situation.

Recommendation

- Piloting voucher system in the distribution of input-based subsidy.
- Provision of the Soft Loan Scheme for the seed entrepreneur farmer instead of giving direct subsidy to them.
- Categorization and identification of the real seed entrepreneur farmer. Moreover, there is a necessity of the one-door policy for providing subsidies.
- Public-private partnership and incentivizing the private sector. Incentivizing Agro-vet and other input supplier to make domestic production competitive.
- The national seed system should be strengthened to provide the foundation seeds to the seed entrepreneur, including the parental lines for hybrid production. The Community Seed Bank scheme needs to be promoted and incentivized.

Introduction

The population is increasing at a rate of 0.93%. Food production is increasing now at a higher rate than the current population growth rate of less than one percent and cannot meet the growing population demand. Food and nutritional security are directly linked to seed security. Quality seeds with improved variety can contribute 15-20% of the increment in productivity. Sowing good-quality seeds leads to lower seed rates, better emergence, uniformity, and vigorous early growth, which increases the yield up to 20% (IRRI, 2019). It is estimated that 80% of the seed in Nepal is derived from the informal seed system in Nepal (SQCC, 2023). The seed replacement rate (SRR) in rice is 26%, while that of whole cereals is 20%.

The seed producer and the entrepreneurs usually take economic factors into consideration Different studies have shown that seeds incur only about 4–8% of the total cost of production. The market sale margin (benefits) was lower for domestic inbred varieties (Rs 4-5/kg), while for imported hybrid varieties, margin was relatively high with average of Rs 18-42/kg (Gauchan et al., 2016). Because of this, agro-vets are willing to sell imported varieties rather than national ones. This is one of the reasons for the lower coverage of the improved varieties. To promote the nationally developed varieties, the private sector needs to be encouraged and supported. The seed industry needs to be profitable and competitive to be sustainable. Thus, it needs motivation and some kind of trigger for support and initiation. The low access to the availability of the parental lines for the production of hybrids has been reported by the seed entrepreneur farmers and concerned stakeholders. Nepal has rich sources of local crops which has high potential in terms of production, and stress tolerance. Those traits can be used for the production of hybrids and needs to be conserved at the local level by the community.

The government sector alone cannot produce the required quantity of seeds. There is always an opportunity to increase the domestic production of quality seeds through a public-private partnership. The functional coordination between the public and private sectors needs to be strengthened. In this regard, incentives and subsidies can be useful tools for seed security. The government subsidy program and the supporting activities can provide an assured market with less effort and cost. The subsidy management guidelines, 2078 defines subsidy as the financial aid, physical infrastructure, agriculture input, equipment provided to the farmers, farmer groups, cooperatives, and agribusiness centers that aid in production, processing, value addition, marketing, infrastructure development, diversification, commercialization, modernization, industrialization, and poverty alleviation. Subsidy reduces the cost of production and increases the consumer welfare. Globally, input-based subsidies, output-based subsidies, and voucher systems have been adopted in different countries. Various study has proved output-based subsidy to be effective in increasing the income of the farmers. Limited study has been carried out with respect to the seed system and type of subsidies in Nepal. It is difficult to measure the

scattered production across the country for subsidy distribution. Hence, Output based subsidy are difficult to implement in Nepal. Huge bureaucratic wastes and leakage are documented in case of input-based subsidy. Voucher system for input-based subsidy distribution is mostly adopted in most of the developing countries. It also reduces the biases in distribution of subsidy. Study done in Malawi and other developing countries showed that voucher system in input-based subsidy can control the irregularities to a greater extent. In this context, the objective of this policy brief will provide recommendation for strengthening the rice seed system with good subsidy policy options. This brief will provide the answer to the questions whether subsidies are effective in strengthening the seed system in Nepal.

Scope and Methodology

The study is limited and is confined within the seed system of cereals, particularly rice seeds. It is primarily based on secondary information and various literature reviews, personal communication expert consultation and interaction with the authorized personnel of MoALD. The perception of the entrepreneur, farmer and expert was taken with the Google form and presented with a pie diagram. Discussion with the seed production and research Centre was also done.

Policy Analysis

Demand and supply of the cereal seeds

The demand for quality seeds is higher than their supply. The demand, supply, and scope of seed production in Nepal are presented in the table below. The table shows that there is a high scope of seed production for cereals in the country.

Table 1. Demand and Supply of the cereal seeds

Crop	Area	Required seed quantity (MT)	Required seed to achieve 25% SRR (MT)	Domestic Production (MT)	Scope of Production (MT)
Paddy	1,458,915	67,252	16,813	16,400	413
Maize	957,650	23,941	5,985	1,025	4,965
Wheat	707,505	84,479	21,119	17,522	3,598
Cereals	*3,124,070*	*175,672*	*43,918*	*34,947*	*8,976*
Lentil	212,876	8,515	2,128	455	1,673
Mustard	258,141	2,581	645	330	315

Adapted from SQCC, 2020.

Import of the seeds of various crops

In order to meet the demand for high-yielding varieties of different crops, Nepal imports a huge quantity of seeds from India and other countries each year. The data shows the import of cereals has increased over the years. Imports of paddy seeds have been found to increase over the last few years, which indicates a growing demand for rice varieties in Nepal. Because of the open and porous border with India, a large volume of seeds of unreleased and unregistered crop varieties, both open-pollinated and hybrid, are freely traded in Nepal through a huge network of agro-vets, and mechanisms to control this kind of transaction have not been developed till date. The graph below shows the value of the import of cereal seeds (in MT) for last five years.

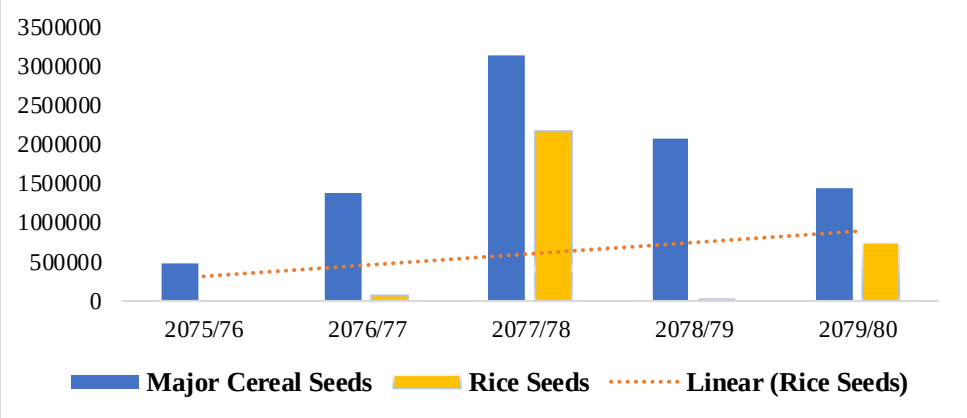

Figure 1: Import value of the cereal seeds and rice seeds
Source: Department of customs.

Allocation of subsidy in Nepal

Up until the year 2070/71, the responsibility of providing seed subsidies was given to the then-National Seed Company Limited (NSCL). This responsibility was handed to the provincial government, local government, Centre for Crop Development and Agrobiodiversity Conservation (CCDABC), and Seed Quality Control Center after the promulgation of the new constitution in 2015. Table 2 describes the quantity of seeds that was provided subsidy and their value.

Table 2. Quantity of Seeds provided in subsidy by NSCL

Description	2068/69	2069/70	2070/71	2070/71
Sales (Mt)	579	10	6,550	7,862
Subsidy (NRs)	6,530,000	475,000	111,073,000	155,379,000
Subsidy (%)	25-40	100	15-35	30-35

Adapted from Bista et al., 2017.

According to the CCDABC, in the year 2077, the quantity of seeds provided in subsidy was 8.4 mt, which is equal to the amount of Rs 1,87,770. In the year 2078, the subsidy was for 26.906 mt of wheat seeds with a value of Rs 672650 and for 79.5 mt of seeds with a value equal to NPR 1,703,545. The periodic plans in Nepal, Agriculture Perspective Plan, National Agricultural Policy 2004, Agriculture Development Strategy (ADS), Prime Minister Agricultural Modernization Project (PMAMP) have envisaged policies regarding subsidies in agriculture. Due to the absence of a one-door policy in providing subsidies, issues like duplication of beneficiaries and wrong targeting, waste of the subsidy, and poor documentation have been reported. The lack of identification a categorization of the farmers in terms of the land-holding, types of commodities has made the seed system more ambagious.

Box 1: Case of the Success of the Voucher System in Malawi

Success case of the Voucher system: Farm Input Subsidy Program in Malawi

Farm input subsidy program (FISP) is one of the most expenditure items in Malawi. The FISP was implemented between the 2004/05 and 2019/20 agricultural seasons. The country's 2004-2005 Farm Input Subsidy Program (FISP) was born in the wake of a major drought in Malawi. The goal of FISP was to enhance the food sufficiency by increasing the access to and use of improved agricultural inputs, thereby boosting the income of the resource poor farmers. FISP distributed seeds and fertilizer to approximately 50 percent of the population. The FISP was administered through a voucher or coupons that enable farmers to buy fertilizer, hybrid seeds, pesticides and insecticides etc. Metanalysis of this program as an experiment showed the increase in the adoption, productivity and Farm income of the recipient farmers. The national level data during the FISP period showed a positive and statistically significant impact on maize production. It is reported that the increase in production of maize due to the intervention of the program was between 10-20% which in-turn increases the GDP of the country. The increase in the production of the Receipt of the FISP vouchers was associated with the increase in the fertilizer use and land expansion. The study done in Malawi showed that farmers receiving coupons for the improved seeds allocate 45% more of their land in comparison who did not receive. There seems to be a double advantage of increase in the yield and the adoption of the drought tolerant varieties.

Experiences of the Seed Producer

Bimal Agro-farm and Research Center in *Bharatpur-6 Chitwan* district, is one of the better-known seed producers, especially for rice and maize. Mr. Tirtha Subedi owns this center and produces the rice seeds commercially on about 3 hectares of land every year. A discussion was held with Mr. Subedi. "For wide dissemination of the improved varieties local agrovet and the private sector, seed companies need to be subsidized and incentivized," Subedi said. He further added, in his own words, "For various reasons, it is difficult to get the required parental lines of the hybrid variety." In his view, a soft loan is far better than giving subsidies.

Perception on the appropriateness of the current subsidy policy

The experts and the farmers were asked about their perceptions of the current flat subsidy system prevailing in Nepal (Figure 2). Almost 90% of the experts and 76% of the farmers responded that the current flat subsidy policy is inappropriate.

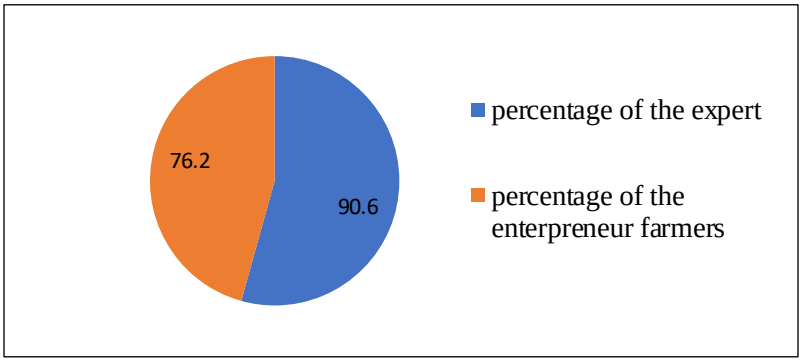

Figure 2: Perception on the appropriateness of the current subsidy policy

Recommendations

Piloting voucher system in the distribution of subsidy : ADS have proposed the use of the voucher system in the distribution of input like fertilizers, seeds. The practice providing the subsidy through voucher system is worldwide. This minimizes the exploitation of the subsidy in the wrong way. The implementation of the voucher system has already been late in Nepal. So, piloting of the voucher system is urgent for increasing the effectiveness of the subsidy program.

Provision of the soft loan scheme: For commercial farmers, a soft loan is more feasible. A loan that equals the amount of subsidy is more beneficial to the farmers than a direct form of subsidy. A study done by Lamichhane et al. in 2020 with entrepreneurs, farmers, and experts showed that there is a need for financial support in the form of soft loans.

Categorization and identification of the farmers: Identification of such farmers is necessary to prevent the leakage of the subsidy. Similarly, categorization of the farmer is a must for the distribution of subsidies, which can be done on the basis of the size of the land holding and the type of crop. The subsidy requirement differs with the size of land holdings and types of crops.

Public-Private Partnership (PPP): The PPP model has been proven to be a successful model to increase the adoption of the varieties by increasing seed production in the required quantity. Past studies have shown the wide dissemination of the *Srijana* variety of tomato and many other cereals and vegetables through this model. The variety developed by the NARC can be successfully multiplied by the private sector and disseminated. The provision

of subsidies to the private sector involved in the seed production of rice varieties is of utmost importance to effectively utilize the assigned subsidy expenditure.

Access to the source seeds and the parental lines: Parental lines of the varieties are crucial for the development of the hybrid seeds. The parental lines are unavailable most of the time. The national seed system should be strengthened in such a way to produce the required quantity of seeds and ensure fair distribution of these lines to the seed company. The balance sheet should be prepared in an effective and realistic way, as far as possible.

Promoting and incentivizing the community seed bank: It is a type of gene bank where seeds of different crop varieties and rare plant species are stored for future use. A community seed bank may also identify, test, preserve, and multiply high-yielding varieties that are suitable to the local agro-climatic situation. Furthermore, the production of the local hybrids should be emphasized. The producer should be supported to enhance these varieties through different kinds of incentive schemes.

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Small Farms – Big Risks: Can Agricultural Insurance Bridge this Gap for Nepali Farmers?

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Summary

Despite significant growth in Nepal's agricultural insurance program, adoption rate is lowest among Asian countries. Key challenges include farmers' affordability and a lack of products suited to specific farmer needs. Several factors influence demand and supply in this market, with farmers' risk perception, affordability, and vulnerability playing a crucial role on the demand side, while product characteristics and transaction mechanisms on the supply side. Interestingly, while livestock insurance dominates the market, claims paid for crops are increasing faster, suggesting a potential discrepancy in risk exposure between the sectors. Challenges like moral hazard, adverse selection, and limited access to reinsurance further complicate the market. To create a more inclusive and sustainable system, interventions aimed at bridging the gap between demand and supply are essential. This will ultimately enhance the resilience of Nepal's farming communities and mitigate the impact of agricultural risks on their livelihoods and food security.

Key Recommendations

Conduct comprehensive research: *Understand farmers' risk profile and willingness to pay through in-depth studies to inform product and policy design.*

Develop diverse and flexible products: *Tailor insurance products to commodity specific risk profile, local farming contexts, and exploring index-based insurance where suitable.*

Provide subsidies to resource-constrained farmers: Address affordability concerns by categorizing farmers based on risk profile, affordability, and willingness to pay, and then offering subsidies specifically to those who are resource-constrained, with a plan to gradually withdraw the subsidies over time.

Implement extensive awareness campaigns: *Educate farmers through targeted campaigns explaining insurance benefits and simplifying access to available products.*

Strengthen agricultural extension services: *Enhance their capacity to disseminate information, facilitate insurance access, and support farmers during the claims process.*

Nepalese Farming Context and Risk Profile

Nepal's agricultural sector, characterized by small landholdings with approximately 87% of farmers owning less than one hectare and an average landholding size of just 0.54 hectares (Figure 1), is exposed to numerous risks, particularly those posed by climate change. While the carbon fertilization effect might offer some benefits up to a 2.5°C rise, agricultural production is still expected to decrease by 5% by 2080 and 17% thereafter. About 90% of the crop losses in Nepal are attributed to hydro-meteorological hazards such as droughts and floods. These events have had a significant economic impact, with an estimated toll of 288 million USD between 1983 and 2005. Given the dominance of smallholders and resource-poor farmers, Nepali farmers cannot manage these substantial risks on their own, highlighting the need for external support. Disaster relief payments, while crucial, often become a significant economic burden for the government. In this context, low-premium agricultural insurance programs are emerging as a cost-effective and proactive solution across Asia. These programs offer a safety net for resource-constrained farmers, helping them mitigate risks and ensure long-term sustainability.

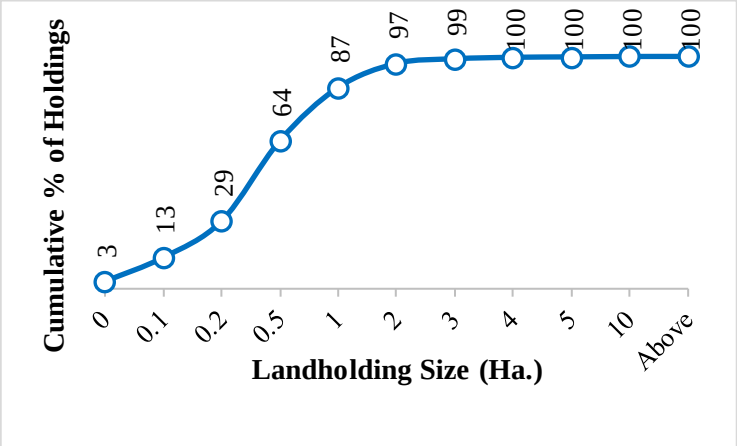

Figure 9: Landholding distribution in Nepal

Agricultural Insurance Programs in Nepal

The history of agricultural insurance in Nepal began in 1987 when the Central Bank and the Deposit Insurance and Credit Guarantee Corporation jointly introduced a livestock insurance program (Figure 2). This program aimed to protect loans provided by commercial banks to small farmers for purchasing livestock. Simultaneously,

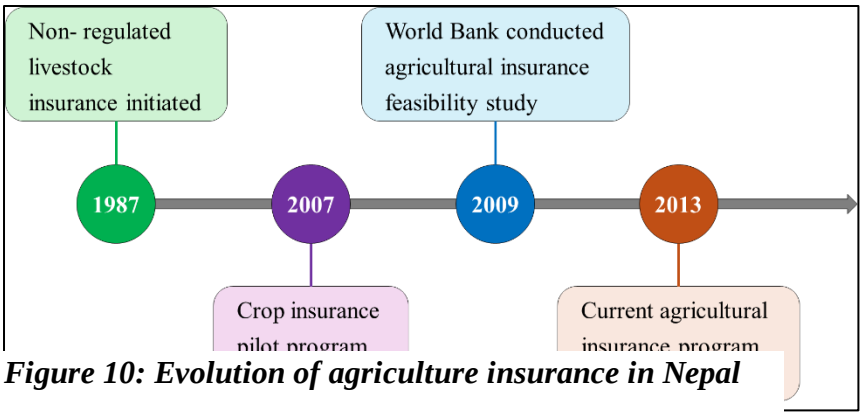

Figure 10: Evolution of agriculture insurance in Nepal

organizations like Small Farmer Cooperative Limited, Community Livestock Development Program, and Centre for Self-Help Development also initiated livestock insurance. Building on the demand for agricultural risk management tools identified in these early initiatives, the Department of Agriculture launched crop insurance pilot programs in 2007. Further, an agricultural insurance feasibility study conducted by the World Bank in 2009 facilitated the enactment of the Agricultural Insurance Directives by the Ministry of Agriculture and Livestock Development (MoALD) in 2013. These directives enabled the implementation of subsidized livestock and crop insurance products in Nepal. To encourage farmer participation, MoALD initially provided a 50% subsidy on insurance premiums, which has since been increased to 80%. In some cases, provincial governments provide additional subsidies, bringing the total subsidy on insurance premiums to 100%.

Figure 3 depicts the substantial growth of Nepal's agricultural insurance program over the past decade. The sum insured has surged from 54.88 million NPR in 2013 to 50,035.47 million NPR in 2023, representing a remarkable 911.78-fold increase. However, this growth is skewed towards the livestock sector. Over the past six years, livestock insurance has consistently accounted for 64% to 93% of the total sum insured.

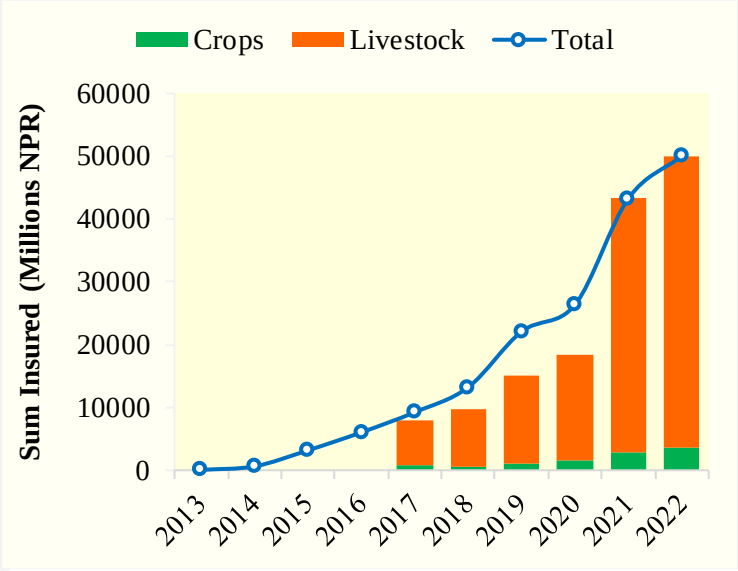

Figure 11: Growth of agricultural insurance (MoALD, 2023)

Figure 4 illustrates the growth of insurance claims paid to farmers over the last decade. While indemnification has seen significant growth, its growth pattern deviates from that of the sum insured, with claims paid in the crops sector exhibiting a faster rise compared to the livestock sector. This trend contradicts the dominant share of livestock in the total sum insured, as discussed earlier. Despite the above discussed increase in agricultural insurance, the adoption of agricultural insurance in Nepal is lowest among the Asian countries (Bhushan et al., 2016). The low agriculture insurance adoption rate is mainly due to farmers' affordability challenges and a mismatch between existing insurance products and farmers' needs (Ghimire et al., 2016; Budhathoki et al., 2019). To address these barriers, a multi-pronged approach is recommended, including extensive research, diversified product options, awareness campaigns, sustained subsidies, alternative financing mechanisms, and capacity building of agricultural extension workers.

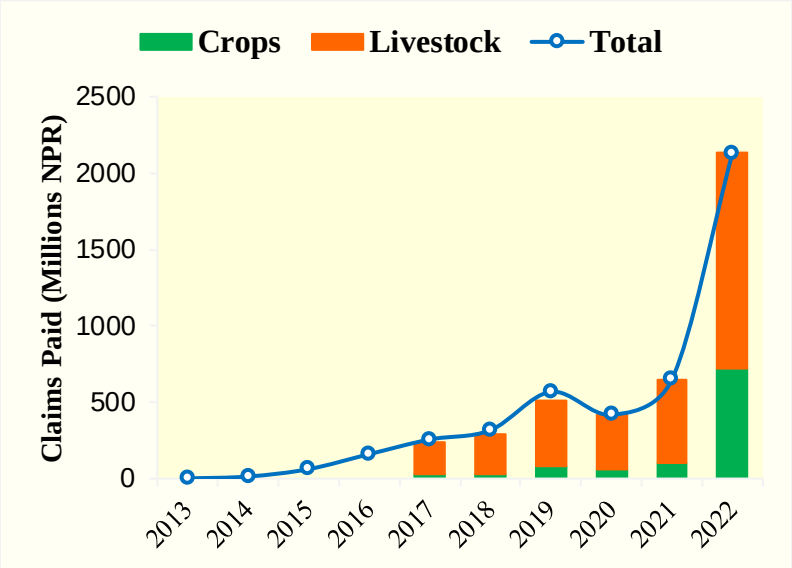

Figure 12: Growth of insurance indemnification (MoALD, 2023)

Risk Exposure

Despite the significant growth in both the sum insured and claims paid for agricultural insurance over the past decade, a critical difference in risk exposure between crops and livestock sectors is evident. This is reflected in the consistently higher ratio of claims paid to sum insured in the crops sector compared to livestock (Figure 5). This discrepancy is potentially due to higher vulnerability of crops to weather-related hazards, variations in claim settlement processes, and lower awareness of crop insurance in farmers. The existing loss-based insurance is more suitable to livestock than crops because payouts are based on animal death rather than yield loss. Further investigation into these potential factors is crucial to fully understand the observed discrepancy and develop more effective interventions.

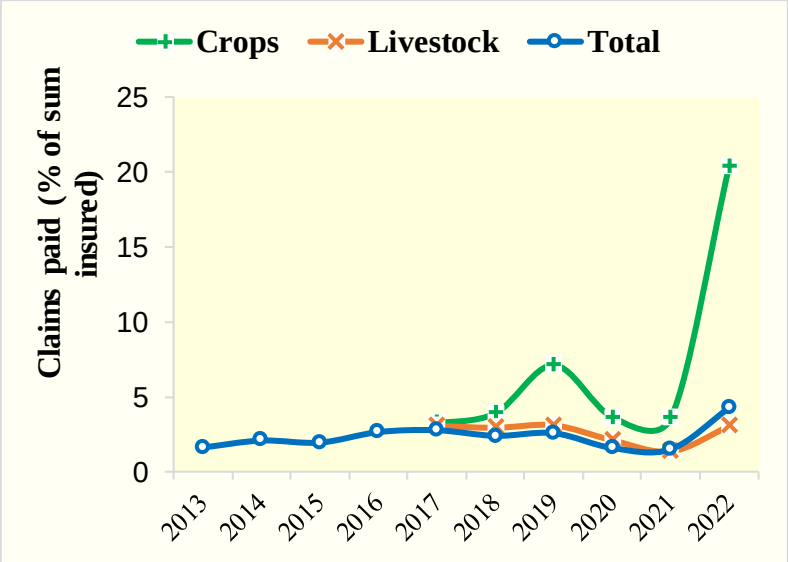

Figure 13: Claims paid as percent of sum insured (MoALD, 2023)

Insurability of Agricultural Risks

The selection of a risk management strategy depends on the probability of a hazard occurring and the potential negative consequences associated with it. Risks characterized by low probability, but high impacts are ideally insurable risks (Figure 6). However, the majority of farming risks fall into the category of high frequency but low impact, making them less suitable for risk transfer strategies. In such scenarios, farmers' willingness to pay for insurance is considerably lower than the actuarially fair premium. Consequently, significant subsidies are necessary for insurance markets to accommodate these high probability, low impact risks. Further, most climatic risks in agriculture are covariate which means that a hazard affects a large number of farms simultaneously. This covariate nature of farming risks reduces suitability of insurance resulting in insurance companies' unwillingness to insure such risks.

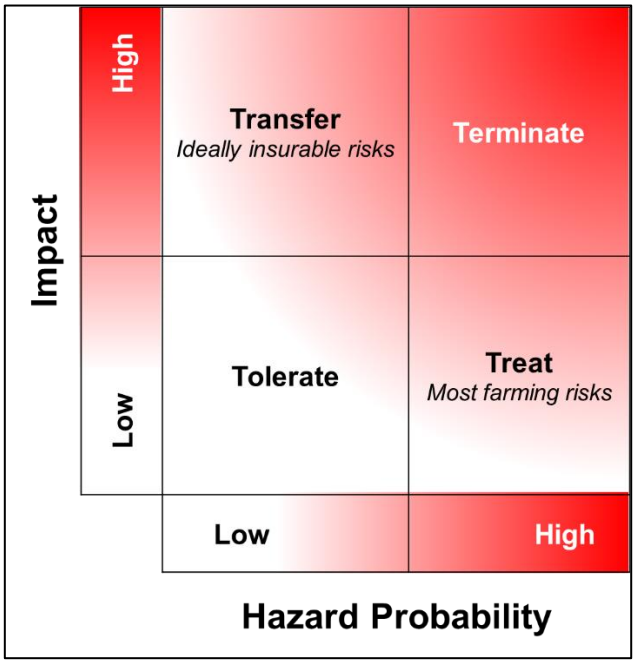

Figure 14: Four Ts Strategy of Risk Management (Adapted from Rejda and McNamara 2014)

Agriculture Insurance Market

Analyzing the key factors determining the demand for insurance by farmers and the supply of products by insurance companies is necessary for improving the efficiency of agriculture insurance market. As shown in figure 7, farmers' demand for agriculture insurance is driven by their personal characteristics and the nature of risks they face. Their risk perception indicates how they evaluate the likelihood and potential impact of the risk. Risk attitude indicates their tolerance for risk and willingness to invest in mitigation measures like insurance. Similarly, affordability indicates their ability to pay for insurance premiums, often a significant hurdle for smallholder farmers.

Furthermore, risk characteristics play a pivotal role in shaping the demand for agriculture insurance. The risk characteristics include hazards prevalence indicating the likelihood of specific events like floods or droughts occurring in their region, exposure to hazards indicating the proximity and potential impact of these events on their farms and crops, and

vulnerability indicating their capacity to absorb financial losses caused by such events. It's crucial to note that risk characteristics directly influence risk perception, highlighting the interconnectedness of these factors. For instance, a farmer frequently experiencing crop losses due to droughts will likely have a higher risk perception and increased demand for insurance covering such events.

The supply of the agriculture insurance product is influenced by the characteristics of the products and the transaction mechanisms involved. Key product characteristics include risk coverage level indicating the scope of risks covered by the insurance policy (e.g., hail damage, drought, market price fluctuations), loss estimation methods indicating how the insurance company assesses and calculates potential losses, deductible the amount the farmer bears before the insurance company starts paying claims and premium price which is the cost of the insurance policy.

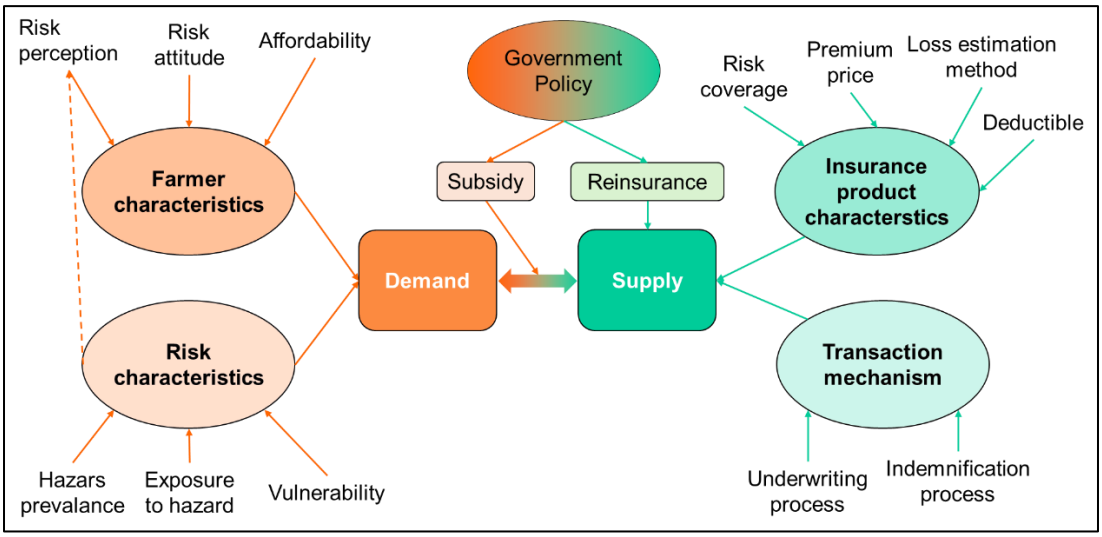

Figure 15: Factors determining demand and supply in agriculture insurance market

Additionally, transaction mechanisms play a crucial role in determining supply. These include an insurance underwriting process which involves the assessment of a farmer's risk profile and eligibility for insurance and specifying indemnification process specifying the procedures for claim settlement and payout after a covered event.

The gap between demand and supply creates a critical barrier to access for Nepali farmers. This is where government policy plays a pivotal role in closing the gap and fostering a more inclusive and accessible agricultural insurance market. Two key government policy interventions include subsidies which reduce the premium burden for farmers, making insurance more affordable and reinsurance support providing insurance companies with financial protection against large claims, encouraging them to participate in the agricultural sector despite the inherent risks. By understanding these key demand-side and supply-side factors, policymakers can design effective interventions that address the specific needs of Nepali farmers and the challenges faced by insurance companies.

Agricultural Insurance products

The insurance market offers a variety of agricultural insurance products. We focus on two major crop insurance products: loss-based insurance (LBI) and weather-index insurance (WII). While certain variants of LBI are available in Nepal, there is growing governmental interest in introducing WII due to its perceived practical advantages. LBI, a conventional insurance form, involves the insurer paying a specified indemnity to the policyholder based on the evaluation of actual yield loss. Multi-peril crop insurance (MPCI) and named-peril crop insurance (NPCI) are prevalent LBI products in the Asia-Pacific region, providing comprehensive loss protection against climatic, natural, and biological adversities (FAO, 2011). However, challenges such as moral hazards, adverse selection, and the systemic nature of weather-related risks limit the adoption of LBI (Diersen et al., 2015). High operational costs resulting from individual loss verification further impede its economic viability, especially in the smallholder farming context.

In contrast, WII has gained increased attention as a more practical alternative to LBI for addressing weather-related farming risks in developing nations. WII operates by establishing an index derived from one or multiple weather variables, indicating indemnification or production loss. Rainfall-index insurance (RII) is a prevalent form of WII, suitable for addressing drought risks. WII offers several advantages over LBI, including a straightforward contract, minimal operational costs, swift indemnification without loss verification, and the absence of information asymmetry and moral hazard concerns. The simplicity of WII makes it a more practical and cost-effective choice.

The benefits of WII are, however, accompanied by 'basis risks' arising from the imperfect correlation between the index and actual yield loss at the farm level. Basis risk refers to the disparity between the indemnity suggested by the index model and the actual yield loss. Two types of basis risk, namely production basis risk and geographical or spatial basis risk, are associated with WII. Careful design adjustments to the index, increased weather station density index, and the implementation of insurance portfolios tailored for distinct locations are some of the strategies to address basis risks in WII.

Addressing Moral Hazards and Adverse Selection

Moral hazard and adverse selection are two major issues that challenge the functioning and viability of the agricultural insurance market.

Moral hazard refers to the individuals' tendencies to take greater risks or act less carefully because they are protected by insurance. In the agricultural insurance market, moral hazard can occur if farmers, knowing they have insurance coverage, do not take sufficient precautions to protect their crops from risks, such as pests, diseases, or natural disasters. This can lead to higher insurance claims and increased costs for insurance providers. Insurers can mitigate moral hazard by setting deductibles or co-payments which encourage farmers to take preventive measures and reduce risky behavior.

Adverse selection occurs when insurance buyers have more information about their risk level than the insurance company. In the context of agricultural insurance, adverse selection can happen if only high-risk farmers purchase insurance, while low-risk farmers do not. This can lead to an imbalance in the insurance market, with a higher likelihood of claims, which can result in higher premiums for everyone. To address adverse selection, insurers can use risk assessment tools and adjust premiums based on the risk profile of individual farmers. Government subsidies or reinsurance can also help mitigate the impact of adverse selection by stabilizing the insurance market and reducing the financial burden on insurers.

A bonus-malus premium system can be used in insurance markets to address both moral hazards and adverse selection. This system adjusts the premium paid by policyholders based on their claims history. Policyholders who have made no claims or few claims receive a bonus, which reduces their premium. On the other hand, policyholders who have made many claims pay a higher premium, known as a malus. This system incentivizes policyholders to take preventive measures to avoid claims and helps insurers manage the risk of adverse selection by pricing policies more accurately based on individual risk profiles.

Government's Role in Agricultural Insurance Market

A prevalent characteristic of agricultural insurance markets globally is substantial public intervention through premium subsidies. Due to the relatively price-inelastic demand for agricultural insurance, these subsidies are deemed essential to encourage farmer participation. Recent years have witnessed significant transformations, including the shift of publicly funded insurance programs into public–private partnerships (PPPs) and the rise of index-based insurance products, particularly suited to smallholder farmers. In the PPP model of the agricultural insurance market, farmers act as buyers, private companies serve as suppliers, and the government assumes the roles of premium subsidy provider and re-insurance protection provider. Understanding buyers' preferences and willingness to pay (WTP) for insurance products is crucial for both insurance companies and the government to decide premium rates and subsidy level.

Information asymmetry and the challenge of monitoring farmer behaviors lead to adverse selection and moral hazard in the insurance market. To address this, the government can support the generation of information on weather patterns, insect prevalence, and disease outbreaks through research. Additionally, facilitating the sharing of information between farmers and insurers helps overcome information asymmetry. The government's extension network can offer technical assistance to farmers and monitor their behaviors, thereby reducing moral hazard.

Insurance companies in developing countries face limited access to international re-insurance markets. Furthermore, international re-insurance companies show less interest in

collaborating with insurance providers in developing countries that often cater to small businesses. The government can play a crucial role in assisting insurance companies in accessing the international re-insurance market. Overcoming market and regulatory obstacles is essential to attract insurance and re-insurance companies to participate in the agricultural insurance market.

The challenges of obtaining high-quality weather data and establishing sophisticated infrastructure are crucial for developing and implementing WII in developing countries. Governments, donors, and international agencies can facilitate the development of the WII system by establishing a regulatory framework, assessing demand, generating and managing required data, training insurance providers, educating farmers, funding pilot programs for insurance products, and providing a level of re-insurance support. Additionally, the government can contribute to raising farmers' risk awareness and educating them about the concept and benefits of farm insurance, which ultimately leads to increased insurance adoption.

Conclusion

Nepalese agriculture, being vulnerable to multifaceted risks, necessitates a comprehensive risk management approach. The complex web of uncertainties, including weather-related hazards, market fluctuations, institutional changes, and personal risks, poses a significant threat to farm profitability, potentially pushing smallholders into poverty traps. Effective risk management is crucial not only for stabilizing farmers' income and enhancing creditworthiness but also for encouraging the adoption of high-return innovations and ensuring the overall well-being of the farming community. Although a wide range of risk management options are available, agricultural insurance, particularly loss-based insurance and weather-index insurance are two most popular market-based solutions, with weather-index insurance gaining increasing attention as a practical alternative.

Despite a substantial growth in Nepali agriculture insurance market, the adoption rate is still lowest among Asian countries, mainly due to a mismatch between insurance products and farmers' needs, and limited understanding of demand-side issues. Farmers' risk perceptions and varying degrees of risk aversion contribute to the complexity of insurance demand. Understanding these aspects becomes crucial for policymakers, insurance providers, and agricultural extension programs to design interventions more effectively. A strategic and multifaceted approach is necessary which involves extensive research to understand farmers' preferences and willingness to pay, diversified and flexible product options, comprehensive awareness campaigns, sustained subsidies, and alternative financing mechanisms. By aligning products with farmers' preferences, addressing affordability concerns, and enhancing awareness, countries like Nepal can move beyond mere provision and create a robust and inclusive agricultural insurance system. Moreover, building the capacity of agricultural extension services and promoting collaboration with insurance providers are essential for efficient service delivery. Such a system not only

protects farmers from risks but also contributes to increased agricultural productivity, improved livelihoods, and enhanced food security.

Recommendations

The following action points are recommended for supporting the development of holistic farming risk management system in Nepal:

Comprehensive Research and Risk Assessment: Conduct comprehensive and continuous research involving in-depth surveys, choice experiments, and focus groups across geographically diverse regions and crops. This research should aim to accurately understand farmers' preferences for insurance features, willingness to pay, and the factors influencing their decisions.

Tailored Product Design: Utilize research findings to inform the design of agricultural insurance products. Develop diverse and flexible options that cover different crops, adjust insurance periods to local planting cycles, and introduce index-based insurance where suitable. Tailoring products to match farmers' needs and preferences is crucial for enhancing adoption rates.

Awareness Campaigns and Education: Implement extensive awareness campaigns and educational programs targeted at rural communities. These initiatives should explain the value proposition of insurance, simplify the navigation of the system, and increase awareness of available products and their benefits.

Sustainable Premium Subsidies: Sustain and potentially expand premium subsidies provided by the government. Affordability is a critical barrier to adoption, and ongoing subsidies can make insurance more accessible for resource-constrained farmers.

Alternative Financing Mechanisms: Explore alternative financing mechanisms such as micro-insurance and partnerships with rural credit institutions. These mechanisms can enhance accessibility for farmers who face financial constraints.

Agricultural Extension Services and Local Organizations: Strengthen agricultural extension services and local organizations like cooperatives to play a pivotal role in disseminating information, facilitating access to insurance, and supporting farmers during the claims process. Building their capacity and fostering collaboration with insurance providers is essential for efficient service delivery.

Government Support for International Re-insurance Market: Assist insurance companies in accessing the international re-insurance market. Overcoming market and regulatory obstacles is crucial to attracting insurance and re-insurance companies to participate in the agricultural insurance market.

Continued Monitoring and Evaluation: Implement a robust monitoring and evaluation system to assess the effectiveness of implemented strategies. Regularly review adoption rates, claim payouts, and farmers' satisfaction to identify areas for improvement and refine

interventions accordingly.

By implementing these recommendations, policymakers, insurance providers, and other stakeholders can work collaboratively to create a resilient and inclusive agricultural insurance system that aligns with farmers' needs, fosters risk management, and contributes to the overall development of the agricultural sector.

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Can increase in milling efficiency save Nepal's 50 billion NPR of rice import?

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Summary

Rice import is galloping in the country and the self-dependency ratio is decreasing in recent years. The import quantity and value were increasing at the rate of 24 and 38 percent per annum respectively, while production is hovering below 2 percent per annum. Nepal's present milling recovery rate is around 55-60 percent which requires about 7.0 million tons of paddy (4.0 million tons of milled rice) and has the possibility to increase up to 72 to 73 percent with the use of modern and efficient milling technologies.

The current focus on increase in rice production through increase in area, productivity (yield), and reducing yield gap at farmers' fields, requires considerable investment in irrigation, improved varieties and other technologies, input supply (fertilizer) and time than improvement in processing of rice. So, investment on modern, cost-effective milling and drying, commercialization and extension of recently released rice varieties, awareness on post-harvest operation, and capacity development of high throughput milling for steamed, parboiled, and polished rice is the alternative strategy to achieve rice self-sufficiency in Nepal and save a huge sum of money spent on rice import. Further, the consumer preferences for brown, steamed, parboiled, and polished rice need to be investigated.

Policy Recommendations

- Investment on modern, cost-effective milling and drying technologies needed for which an enabling policy environment is needed.
- Commercialization and extension of recently released rice varieties that have high milling recovery.
- For adoption and promotion of modern rice mills, increased investment and skill of rice mill operator's need to be upgraded and awareness on post-harvest operations need to be disseminated.
- Capacity development of millers and traders for steamed, parboiled, and polished rice with packaging and branding.

Introduction

Rice consumption demand is increasing every year due to inadequate domestic production, preferences to fine rice, increased road access in hills and mountain areas and increased income level (Gairhe et al., 2021). Further, the galloping trend of rice (Figure 1) is mainly influenced by increased per capita income, insufficient domestic production in comparison to the population growth and preference of fine rice (Timsina et al., 2023). Rice import quantity and value were increasing at the rate of 24.48 and 38.11 percent per annum, respectively, while production growth was 2% per annum (Gairhe et al., 2021). The self-sufficiency ratio of rice is decreasing, and the import dependency ratio is increasing in recent years (Figure 2).

Choudhary et al (2022) estimated the total annual demand of milled rice in Nepal of 4.08 million tons (6.56 million tons of paddy) against a production of 3.25 million tons milled rice (5.2 million tons paddy) in 2017. Our field survey estimated the milling recovery of 55-60% and requires 6.89 million tons of paddy (4.134 million tons of milled rice) to be self-sufficient in rice. Based on the milling recovery efficiency of 60%, Timsina et al., 2023 estimated the demand for edible rice is estimated to be 4.270 to 4.818 million metric tons in 2030 and 4.784 to 6.238 million metric tons by 2050.

The policy makers, planners and professionals in Nepal have increasingly emphasized increasing rice production by increasing spring rice area, yield improvement and reduction in the yield gap. Recently, the government of Nepal planned to increase spring rice area 250 thousand hectares, cover 35 percent of rice area by fine varieties, increase the productivity of summer rice to 5 ton/ha, and planned to produce additional 2 million tons of rice to make rice self-reliant. However, the result has not been achieved so far. To be self-reliant in rice production in Nepal, to a great extent, increasing productivity that supports higher milling recovery of rice grains might be a complementary strategy (Timsina et al., 2023). Similarly, improvement in milling is better than increase in rice area and productivity through production technologies which requires considerable time than improvement in milling of rice. So, improving rice milling recovery is an alternative strategy to achieve self-sufficiency in Nepal. Rice recovery percent depends on use of proper variety,

post-harvest handling, drying technologies and type of milling and storage time. The adoption of modern rice mills may outturn 70 percent recovery by decreasing the husk, rice bran and brokens (Joshi et al., 2020).

A recent study by Joshi et al. (2020) has indicated the superior performance of modern rice mills as compared to that of traditional obsolete rice mills. So, this study focused on:

- Do improvements in milling and associated technologies in rice help to reduce imports and improve rice self-sufficiency in Nepal?
- What are the potential options and feasibility of adoption and improvement of modern rice mills and associated technologies in Nepal?

Methods and Scope of Coverage

This study is based on the literature review and the use of available official data combined with key informant interviews and consultation with experts. We estimated the Import dependency ratio from 1991 to 2022, and scenario analysis to estimate the possibility of becoming self-sufficient in rice by increasing milling recovery and use of associated technologies in rice. KII was done at *Tanahun, Parsa, Banke* districts with farmers and rice millers to know the farmers perception on rice quality and milling recovery by production ecology, varieties, harvesting and threshing, drying, storage and milling. Similarly, a case study was done with the Arju Rice Mill.

Policy Analysis

Recently, Nepal imported rice worth NPR 50 billion (Figure 1) and the import dependency ratio is increasing (Figure 2). Achieving self-sufficiency in rice is very crucial in Nepal not only for food security but also to save a huge sum of money that can be used for important work. Considering its importance, the government of Nepal declared to be self-sufficient in rice (Budget speech of FY 2021/2022, section 108) in next five years. In addition, the Nepal government planned to produce additional 2 million tons of rice to be self-reliant by increasing spring rice area to 250 thousand hectares, cover 35 percent of rice area by fine varieties, and increase summer rice productivity

to 5 ton/ha in the fifteenth five-year plan. However, the country has not achieved or is in line to achieve rice self-sufficiency in Nepal.

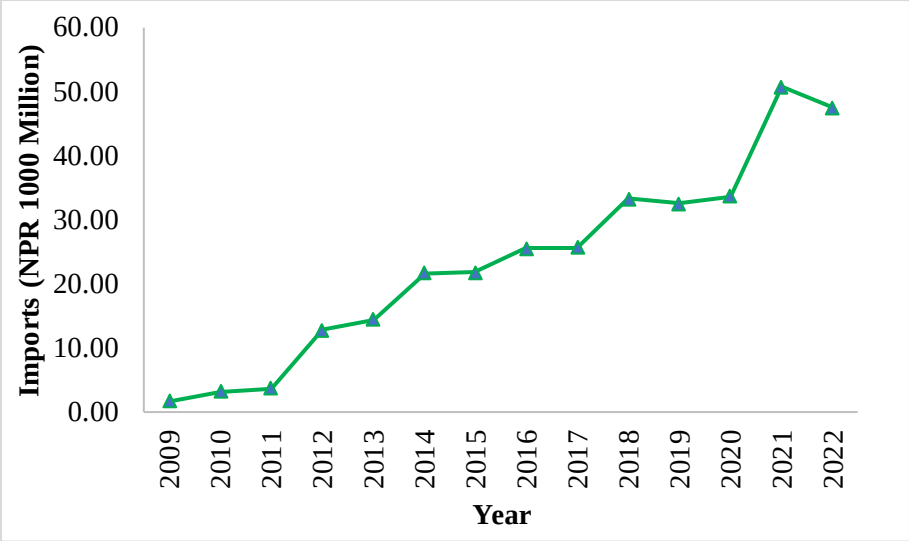

Figure 16: Import of rice from 2009 to 2022 in Nepal

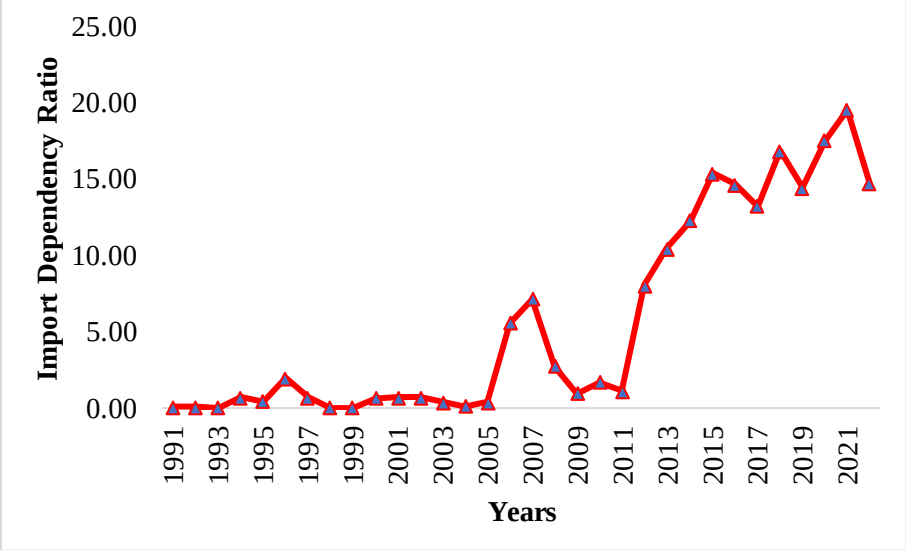

Figure 17: Import dependency ratio of rice from 1991 to 2022 in Nepal

Reducing the yield gap is one of the important ways to achieve self-sufficiency in rice. Study suggests 2.57 mt ha^{-1} of exploitable yield gap and 4.85 mt ha^{-1} of total yield gap. Adoption of good agronomic practices such as healthy seedlings, use of high-yielding hybrid or modern rice varieties, timely planting, recommended fertilizer rates, supplemental irrigation, and timely weed management make it possible to gain rice yield up to 1.86 mt ha^{-1}. However, it requires considerable time.

Alternatively, rice self-sufficiency can be achieved by improvement in milling. Most of the rice millers in Nepal have processing machines suited for coarse rice varieties and milling recovery of fine rice varieties in existing mills is poor (Choudhary et al., 2022). Fine rice has better taste quality and has a 50 to 100 percent premium price in market and high demand in the Nepalese market whereas coarse rice has high milling recovery. Adoption of high throughput parboiling and steamed rice processing technology is one of the easiest ways to improve rice milling percentage which increases milling recovery up to 72 to 73 percent mainly by decreasing the proportion of broken rice and bran considerably (Joshi et al., 2020).

Over-milling as well as under-milling, both options are undesirable whereas moderate milling preserves the flavor as well as increases sensory quality. Embryo-retaining rice germinated brown rice and parboiled rice have been recognized as novel products. Extreme milling results in an increase in broken rice, leading to the rapid release and dissipation of fragrances. Conversely, light milling leads to a coarse mouth feel.

The production system of rice plays an important role for grain quality as well as milling recovery. The low recovery may be due to rice variety, low level of irrigation, inappropriate post-harvest handling, inadequate drying, unsuitable storage, milling, lack of skilled manpower for milling, and lack of advanced type of mills. The lowland area with adequate irrigation facility helps for better quality rice grain as well as higher (>50%) rice recovery while milling. However, the upland area with limited irrigation or rain-fed system results in lower milling recovery. The irrigated rice has a thin husk as compared to rain-fed or un-irrigated rice or *Ghaiya* rice. So, increase in year-round irrigation is vital for the quality of rice grain as well as rice recovery.

The study revealed that the milling recovery of Nepalese older and traditional rice varieties ranges from 40 to 60% which is very low. In the case of Terai, the local varieties (improved ones) have less milling recovery with more broken rice due to a lack of proper drying when the farmers use combine harvesters. Similarly, the milling recovery of fine rice is lower as compared to coarse rice varieties. Recently released rice varieties with high milling recovery are presented in Table 1. These varieties developed and released by

the government of Nepal have higher milling recovery as compared to older varieties. However, some of the very old varieties such as IR8 and IR24 are still grown and milled in Nepal. Only 6 rice varieties out of 31 were new varieties that were released after 2010 (Joshi et al., 2020). So, innovation in extension of newly developed rice varieties is instrumental for improving overall rice grain quality as well as milling recovery.

Table 1: Recently released rice varieties with milling recovery percentage

S.N.	Name	Milling Recovery %
1	Khumal-12	69.7
2	Khumal-14	69.2
3	Khumal Basmati-16	71.90
4	Hardinath-6	72.8
5	Gangasagar-1	69.8
6	Gangasagar-2	71.2
7	Hardinath-4	67.85
8	Ghaiya-3	71.9

Source: Author collection, 2024.

Harvesting on time is also crucial for greater grain quality and milling recovery. If rice is harvested after full physiological maturity, it results in better quality and milling recovery. If harvested green, the unfilled grain will be high, which makes poor quality and less milling recovery. If dried more, shattering and shredding will result in higher post-harvest loss. Paddy threshing is carried out irrespective of the variety, fine varieties produce more broken rice if threshed with high-speed threshers. So, the awareness program and training regarding post-harvest handling of rice should be given to the commercial rice growers.

Drying also affects the quality of rice grain and milling recovery. If sun drying and milling is done on the same day, the percentage of broken rice will be more and if sun drying and milling is done on another day, the percentage of broken rice will be less. Similarly, while drying, if the paddy is stirred frequently, the broken percentage will be less and higher milling recovery. Farmers perceived that storage of rice also played an important role for milling recovery. If the paddy is stored in *Earthen Vessel* or *Bamboo Bhakari* the quality of grain remains good however if stored in Metal bin the quality of grain becomes lower due to sweating and decreased milling recovery.

Significant losses occur during drying, cleaning and storage. Harvesting time and moisture content in the rice affect recovery percent. Immature harvesting, uneven drying and improper setting of threshing machines reduce the recovery.

Traditional sun drying methods are very common in Nepal to reduce moisture content. Sun drying normally reduces the rice grain moisture from 25 % to 10-11 percent within five to six sunny days. Sun drying is more labor intensive and risk prone in changing weather conditions and temperature control is not possible and grain can easily overheat causing cracked grains which leads to low milling quality. Study revealed that electric dryers and solar dryers are vital for improving losses during drying and improving milling efficiency.

Farmers in the village usually go for conventional rice mills where they get milled rice that is mixed with bran and husk. After cleaning the milled rice, bran and husk are fed to livestock. Modern rice mills separate rice bran, husk, and milled rice by different outlets. The current productivity of paddy in Nepal is 3.98 ton/ha with 5,724,234 ton production (MoALD, 2024). Improvement in milling recovery and projection to increase milled rice in Nepal is shown in Table 2**.** The result of the scenario analysis revealed that at present the production of paddy in Nepal is 5.72 million tons which produces about 3.43 million tons of milled rice. If we improve the milling recovery to 65 percent, the present paddy produces 3.720 million tons of milled rice which is also vital to save a huge sum of money that is being used for rice import. Similarly, if we improve the milling recovery to 70 percent, the present paddy produces 4.006 million tons of milled rice which is nearly self-sufficient in Nepal. So, we can save up to 572,423 ton of paddy (372,075 tons of milled rice) from the present production.

Table 2: Projection of milled rice with improvement in milling recovery

Paddy production (ton)	Milling recovery %	Milled rice (ton)
5,724,234	0.55	3,148,329
5,724,234	0.60	3,434,540
5,724,234	0.65	3,720,752
5,724,234	0.70	4,006,964

Source: Author calculation, 2024.

The stocking investment is high and there is no warehouse receipt financing for rice millers. Rice mills are classified under the service industries whereas they are not classified under agro and forest-based enterprises. If they were classified under agro and forest-based, they would enjoy the privileges of nationally prioritized industries. The modern mills cost about NPR 500 million (50 crore), due to the lack of finance, millers are unable to upgrade their mills. As the rice mills are categorized as service industries, they do not get soft loan facilities from the banks. It is said that huge amount of paddy from Nepal is taken to India for milling every year and back to Nepal after milling from advanced mills. Choudhary et al (2022) revealed that most of the rice millers in Nepal are reluctant to invest in capital equipment to increase the processing of fine rice. So, the Government of Nepal can focus its subsidy to invest in processing machines for fine rice milling.

The operator's skill is also an important parameter for improving rice recovery and decrease in percentage of broken rice. Higher milling recovery is possible

Arju Rice Mill

Arju Rice mill, which has a Buhler processing unit, is located at *Belbari 9, Dangihat-Morang.* It has 4 MT/hour milling capacity along with steam and parboiling facilities and can be increased to 6 MT/hour by adding some processing units. The mill has an established drying facility for 600 MT/day (250 MT spring rice and 350 MT of normal rice) and milling recovery of 65 percent. However, the milling efficiency depends on variety, moisture content, drying duration and process, harvest condition etc.

The mill has a special drying unit which brings the spring rice moisture from 24-25 percent to 13 percent. The problem of harvesting and drying for spring rice due to the rainy season was solved by this mill to some extent and by developing ownership with the farmers.

Ramdhan, Ranjit, Sona Masuli, Chaite-5, Hardinath-6 are main varieties promoted by the mill and Bahuguni-1 is also under consideration for promotion. The mill is giving equal priority to promote spring rice in the area and has a target to produce 3000 *bigha* (1 *bigha* = 6772.63 m^2)in the main season and 1500 *bigha* in the spring season. Similarly, the mill is also planning to increase the production of long grain in the long run.

A major challenge encountered by a private company is to disseminate technology to introduce new varieties to the farmers. So, support of technical services is crucial, and harvesters are not fully utilized throughout the year.

with skillful operators. So, the proper training and capacity building of the rice mill operators is salient for the increase in grain quality of rice. The case study of Arju rice mill is given below:

Recommendations

The following recommendations are vital for improving rice milling recovery in Nepal:

- Introducing and research investment on modern, appropriate, cost-effective milling and drying technologies are vital for the improvement of the rice processing industry in Nepal for which an enabling policy environment is needed.
- Commercialization and extension of recently released rice varieties and development of varieties that are preferred by farmers and processors along with high milling recovery.
- Awareness on proper post-harvest operation needs to be given and the rice mill operator's skill should be upgraded for the adoption and promotion of modern rice mills.
- Capacity development for high throughput milling for steamed, parboiled and polished rice including the development of skilled workforce in packaging and branding is important (Joshi et al., 2020).
- Moderate milling is desirable as it retains the flavor profile while improving the sensory quality.
- The year-round irrigated area needs to be increased for the sustainable increase in rice productivity as well as grain quality.

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How to Increase Profitability and Transform Small-Scale Aquaculture?

Thaneshwar Bhandari, Dr. Devendra Gauchan, Tek Bahadur Gurung, Dr. Yam Bahadur Thapa, Dr. Hari Krishna Panta

Summary

In general, aquaculture growth and productivity in Nepal is encouraging in line with the global trends. Small-scale aquaculture (SSA) plays a vital role in providing food, nutrition, income, and livelihood to over 0.4 million Nepalese households. However, SSA faces many challenges in its transformation into business farms. This policy brief aims to assess profitable typologies of small-scale aquaculture, their productive and profitability in relation to different policies implementation; to assess profitability of fish species and assess import policies influence on SSAs prices and supply chains. To achieve these objectives, explorative surveys have been performed along with analyzing secondary data and reviewing policies and practices with wide range of stakeholders. To date, about 34683 farms are accounted under SSA with yield below 5.5 Mt/ha, in general. Sub-groups within SSA such as subsistence and small farms accounting for eight in ten farms and contribute 70% to fish production. Among total aquaculture farming types, nine in ten growers are engaged in pond-fish farming. Profitability analysis shows that top-five fish species are rainbow trout, tilapia, grass carp, Rohu and Bhakur. Likewise, low customs tariff rates and informal import further disrupts prices and supply chains for SSA. Policies and practices most improve collaboratively across three-tire governments to integrate SSA into efficient commercial operations. This entails deploying high-density technologies, enhancing fish feed and fish seed supply systems, free or low land rent of private land or easy leasing process of water bodies, cheaper electricity cost, thereby enhancing productivity and competitiveness. Additionally, the Department of Customs should review tariff rates of raw to end products and eliminate informally traded fishery-related products to support SSA's commercialization.

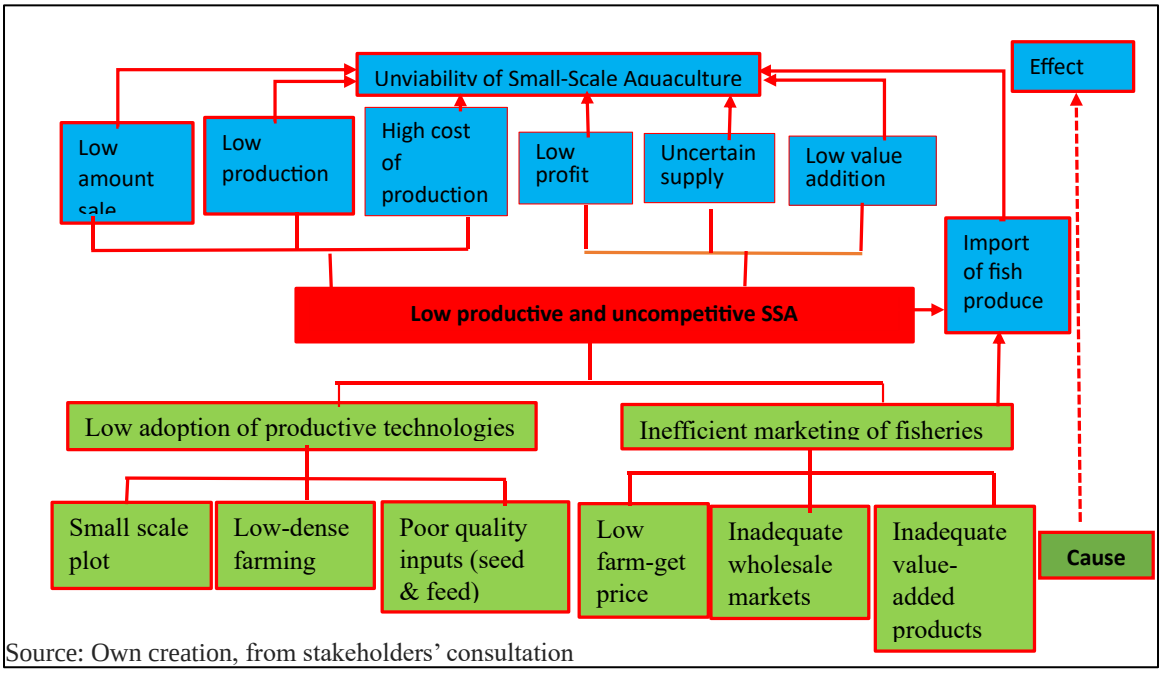
Policy recommendations

- Governments at all levels are need to develop time-specific policies, its regulations and directives, review these periodically and align them with annual plans and budget for SSA;
- A Directive must formulate to graduate SSA into business farms by including value-chain-based production inputs and post-production related subsidies, incentives and grants;
- All local governments need to establish fishery market centers for production inputs and products with sufficient market infrastructure, pricing and recording systems;
- Department of Customs is strongly suggested to review existing tariff rates of raw to end-products importable and ban informally traded production inputs and fishery products.

Introduction

Aquaculture as an art of fish cultivation is known to be started from China (Fan Li), practicing for over 2,500 years (Solve and Davy, 2010). It has become one of the fastest-growing sub-sectors in global food production, playing a key role in the blue revolution (FAO, 2023). In Nepal, the planned development of aquaculture began in 1980, and still remains predominantly Small-Scale Aquaculture (SSA) (Gurung et al., 2010; CBS, 2018). It is primarily operated by rural families, involving smallholder communities using low-input technologies (De et al., 2021). The size of small-scale aquaculture can range from a kitchen pond to a pond area of less than 0.25 hectares (DFS, 2011). Over time, two-third kitchen-pond growers have upgraded to small-scale operations and organized into 'fish production group'. A third of total farms have expanded to semi-large and large-scale operations, have merged into primary cooperatives, firms or companies[6].

In general, total aquacultural growth in area expansion, production and productivity is encouraging over latest decades (CFPPC, 2023). However, key challenges facing SSA include policies that prioritize productivity and profitability (bottom-up approach) and strengthening formal trade (top-down approach). Figure 1 shows a conceptual model of core issue of SSA, depicting cause and effect relationships.



Source: Own creation, from stakeholders' consultation

Figure 1: A conceptual model showing problems and the causes and effects of SSA in Nepal

[6] Taken from KII with fishery Dev. Officers.

Short explanation of bottom-up causes is:

- Small-scale plot means gross pond size below 0.5 ha land;
- Low-dense farming is rearing under number fingerlings or untapping farming potentials;
- Poor quality inputs mean inferior fish seed, feed qualities and other production inputs;
- Meaning of low farm-get price is receiving inadequate price by farmers after selling varieties of fish;
- Inadequate wholesale markets mean low number of market centers for selling fish products;
- Inadequate value-added products mean only selling raw form of products at farm level.

Specific objectives of this policy brief are:

a) **To assess typologies of small-scale aquaculture, their productive and profitability in relation to different policies implementation;**
b) **To assess SSA's profitability situation of selected fish species;**
c) **To evaluate impact of import policies and practices on SSAs' prices and supply chains.**

This policy brief covers methodology used in its preparation, explains scope of its preparation, review available policies, analyze the typology of SSA, assess profitability of fish species, examine trade policy barriers and practices and recommend potential transformations areas for graduating SSA into business farms.

Methods and scope of coverage

Various methods were used to formulate this policy brief. Initially, data and information were gathered from both primary and secondary sources. The primary surveys were done including small-scale fish producers and fishing communities in five districts mainly in *Chitwan, Bara, Rupandehi, Kaski* and *Nuwakot*. The exploratory surveys were also conducted through focus group discussions and key informant interviews with fishery value chain actors and service providers. Additionally, some cases described in the box are collected from model farms. The study analyzed trends from secondary sources, which are obtained from published reports or e-resources from the relevant agencies.

The SSA covers 35,000 households across rural Terai, Hill and Mountain districts who are farming carp, trout, catfish, tilapia or local species in fish-pond, cage culture, raceway, paddy-fish and swamp areas. It plays a crucial role in food systems of these households, contributing availability, access, utilization and stability pillars of food security. Since 70% of total fishery products are sourced from SSA, the transformation of this sub-sector is essential for improving diets and nutrition and commercialize their fish-keeping skills.

While fishery items are income-elastic, fresh and live items are roughly two times cheaper than mutton and local chicken, and considerably lower in price compared to buffalo meat and pork. Fish can substitute red meat sources and is known for its easy digestion properties. Therefore, the scope of this policy brief extends throughout the country and partly covers South Asia small-scale context.

Policy Analysis

Policy assessments for small-scale aquaculture (SSA)

The Government of Nepal (GoN) has specific policies for aquaculture and fisheries education, research, and extension including the Aquatic Animal Protection Act 1960, Livestock and Fishery Promotion Program Implementation Procedure (FPIP) 2021, and National Fishery Development Policy (NFDP) 2022. Additionally, there are broad-based policies supporting SSA are: National Agriculture Development Policy 2004, Agri-business policy 2006, Agriculture Perspective Plan, Agriculture Development Strategies (ADS), Development Plans and Programs, Agriculture, Livestock and Herbal Insurance Directives 2022, Nepal Trade Integrated Strategies (NTIS), as well as Integrated Custom Duties in accordance with bilaterial and multilateral trade policies. Because of these policies, not single ministry is responsible to SSA. Policy Research Institute (PRI) identified that implementation of agricultural policies depends on 38 Acts, over 24 policies of 12 ministries[7].

Despite the implementation of specific and broad-based policies since 1980, about 83% of total aquaculture farms remains small-scale in nature. In other words, eight out of every ten farms are small-scale fish producers among 2561 pond-farming operations (CBS, 2018). For instance, close to 60%, another one fourth (25%) of total aquaculture farms fall into substance, small-scale categories, respectively (Table1). The remaining proportions, primarily located in Terai districts, are semi-large and large farms.

[7] Discussion with Dr Bishnu Upreti, former Executive Director of Policy Research Institute on dated 15th April 2024.

Table 1: Aquaculture farm size (%) in different geography

Geographical area	Subsistence (0.0-0.167)	Small-scale (0.167 - 0.5)	Semi-commercial (0.5 -1 ha)	Commercial (>1 ha)	Total
Mountain	6.8	0	0.7	0.04	7.5
Hill	18.7	1.4	0.4	0.4	20.9
Terai	32.01	23.6	8.9	7.2	71.7
Total	57.47	25.0	10.0	7.6	100
Average (ha)	0.057	0.28	0.63	4.82	0.53

Source: Authors categorization based on survey data of Central Bureau of Statistics (2016).
Note: N= 2561.

The targeting, coverage, regularity in funding provided to SSA through past policies were inadequate. Some donor-funded projects only supported competitive sub-projects by offering a matching grant of 50% capital investment. Since 2015/16, fishery super zone, zone, block and pockets have been initiated under the Prime Minister Agriculture Modernization Project (PMAMP) to commercialize SSA, with a total investment of NPR 642.53 million to date. About 65% growers still lie under SSA in PMAMP working areas (PMAMP, 2023)[8].

National Fishery Development Policy (NFDP) has been in effect since 12th September 2022, with four objectives focusing on both aquaculture and capture fishery. Sub-policies and strategies lack specific target and timelines, and related legal structure, directive, standards, procedure, and regulations are yet to be formulated. These gaps have led to issues in declaring aquaculture areas, leasing or renting public land or water bodies, and graduating these small farm owners into commercial ones. Expanding area of varied land rates for small-scale growers is posing a significant policy challenge in an increased land demand for aquacultural, agricultural and non-farming needs.

Are typologies of small-scale aquaculture productive and profitable?

Farming typologies of approximately 35000 SSA are pond-fish, raceway culture, cage or pen culture, enclosure, swamp area, and paddy farms (Table 2). Among these methods, pond-fish farming is the heavily subsidized by the government resources and per hectare support is NPR 0.3 to 0.5 million for new excavation. Ministry has no specific norms for supporting other farming-types. Most SSA rear 5 to 8 types of fish species and the yield per unit of inputs (technical efficiency) is over 70%. On average, each pond yields 1.55 metric tons of fish from an area of about 2916 M^2 (or 5.83 *ropani*), equivalent to 0.53 kg

[8] Discussion with project Director and Monitoring Specialist, PMAMP, Khumaltar

/$m^{2.}$ Our estimate shows 70% production from these SSA out of 87380 Mt aquaculture production. They raise and sell various fish species, but dominantly carp species are popular. Productivity varies significantly among these types (Pandit et al., 2021; Shrestha, et al., 2022). Unlike high initial cost is, the income potential is superior to raceway culture of rainbow trout, especially in cold water areas (Gurung, 2023). The maximum profit per kilogram is NPR 100 for carp and other species, and NPR 500 for trout in a year of raising.[9]

Table 2: Area, production and productivity of varied aqua types

Types of farming	**Total area (ha)**	**Fish production (MT)**	**Productivity (Kg/ha)**	**Profit (NRs) per kg at farm-get**	**SSA households*** **
Pond fish culture (ha)	14,542	77,320	5319	120	29,208
Raceway culture (ha)*	5	747	1,49,400	300	300
Cage culture (M^3)**	73,803	313	4.3 kg/m3	150	250
Enclosed culture (ha)***	40	53	1325	200	150
Swamp area (ha)****	3,550	8,930	2,515	300	4,200
Paddy-cum-fish (ha)*****	49	17	347	120	175
Total	**18,186**	**87,380**			**34683§**

Source: MoALD 2023 for FY 2021/22.
§*Estimated with the stakeholders.*

Short information about types of farming is mentioned as follows:

*Raceway is farming rainbow trout species in hill and mountain districts by using cold water sources. Most successful example is Gandaki trout farming, Pokhara
** Small-scale growers farm carp (Bighead, Silver) or local species (*Katla* and *Vakur*) in lakes and rivers in special sized cages without feeding artificially. Successful example is *Rupa* and *Begnas* cage farming.
*** Fish rearing takes place in closed or semi-closed structures by holding water such as bio-floc, recirculating aquaculture system-RAS) or breeding purposes of specific fish breeds. Best example is enclosed farm in *Marshyandi* hydroelectricity dams or bio-floc farms in Chitwan.

[9] Field discussion in with producers of *Rupandehi, Bara and Nuwakot*.

****Farming or fishing is done in low land areas such as river, natural ponds or lake sides by small-scale growers;
***** Farming of selected fish species within rainy or spring season paddy growing farms. Both fish and paddy are grown in low land areas by building minimum structures.

Species-specific profit analysis for small-scale farmers

Profits are net benefit earning per kilogram of fish sale. The cost of production (CoP) included variable cost and fixed cost incurred by the small-scale growers. They use low external materials in comparison to commercial farms and their cost range was NPR 114 to 603 and farm-get prices were NPR 206 to 915 for a kilogram production and sale (Table 3).

Table 3: Fish-species specific production cost, farm-get price and profitability

Indicators/Species	Rainbow trout	Tilapia	Grass carp	Rohu	Bhakur	Common carp	Silver carp	Mrigal (Nainai)	Bighead carp
Cost of production Rs/kg)	603	170	114	175	207	168	114	172	154
Farm get price (NPR/Kg)	915	350	265	290	320	265	206	260	231
Profit (NPR)	312	178	151	115	113	97	92	88	77
Rank in net profit	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**

Source: Field survey 2024.

Table 3 shows that rainbow trout, tilapia, grass carp, Rohu and Bhakur are top five profitable species. It means exotic carp species such as grass carp, common carp, silver carp and bighead are low profitable in comparison to monoculture farming (rainbow trout), mono-sex farming (Tilapia). Production subsidy is estimated to be NPR 50/kg of fish for all types of farmers. Profitability of SSA is associated with amount of farm-get price receiving. These prices are set by 1681 wholesale and retail markets based on monopolistic market concept[10]. Community-owned markets offer higher farm-get prices but have poor coverage in Nepal in comparison to private-owned fish markets. The prices set at wholesale market determines farm-get prices and ultimately the profitability of farmers. The lack of a government-set minimum support price leads to a 30-50% price gap between farm-get and retail prices. Also, price gap is also associated with postharvest losses during transportation of live and fresh forms and border price references.

[10] Large number of small sellers, selling differentiated but close substitute fishery products, having different selling costs.

Import policies influence to small-scale aquaculture

Import tariffs for production inputs and fishery outputs, fall under more than 400 Harmonized System (HS) codes and set by the Department of Customs (DoC), are among the lowest in South Asia[11] and have minimal tariff variations for production inputs, primary products, and processed items (Annex 2).

Table 4: Official value (NPR in billion) of imported production inputs and key produces in last five years

SN	Types of products	2019-20	2020-21	2021-22	2022-23	2023-24
1	Fish feed & supplement	2.4	1.9	2	2.64	2.84
2	Hormones and chemicals	0.02	0.02	0.05	0.03	0.035
3	Equipment and industrial machineries	1.99	1.84	1.59	2.15	1.28
4	Fresh, chilled or frozen fish produces	1.89	1.77	1.69	1.35	1.03
5	Preserve, extract products (Mt)	0.08	0.07	0.067	0.11	0.102
6	Total import	6.38	5.6	5.397	6.28	5.287
7	Import revenues of import value (%)	11.34	12.18	13.55	9.95	11.34

Source: Dept. of Customs (2024), National Animal Feed and Livestock Quality Management Laboratory, 2024.

Import value shows a mixed trend between FY 2019-20 and 2023-24 (Table 4). Fish feed and supplements import was increased in line with the expansion of aquaculture area. SSA also uses importable tools, equipment and industrial machinery items to rear and postharvest operations. Surprisingly high machinery value imported in FY 2022/23 because of post-COVID high demand pressure. On the other hand, a decline in volume is observed for fresh, marine, and preserved fishery products, which could be attributed to an import substitution policy of the Government of Nepal. Trade policies have significantly impacted small-scale growers and their backward and forward linkage actors. Firstly, they are negatively affecting domestic feed manufacturers, hatcheries and transporters. For example, demand of imported fish feed continues to grow despite surplus domestic supply because of low price and high standards. Second, Nepal is earning 10-12% import revenue out of total import value, but that value can be increased if more protection measures imposed. Last fiscal year's revenue collection stands at NPR 624 million, maintaining a similar trend over the past four years despite a declining import value (DoC, 2024). Competition between local and imported products has created excessive pressure to sell fish at reduced farm-get prices. Third, the DoC issues licenses and permits for importable foods without considering country's need and standards, leading to competition within the homogenous products. For example, importing only marine and shellfish products would

[11] Customs duty for Bangladesh is 25% and other countries like India, Pakistan, Sri Lanka have also higher tariff rates and tight non-tariff measures than in Nepal.

not directly compete with SSA's products. Fourth, small-scale growers often face problems and competition with informally imported production materials and aqua products. Fifth, governments' trade subsidies, incentives, duty exemption policy for cold chain infrastructures have not effectively benefitting SSA.

Recommendations

The following specific and non-specific to SSA are proposed as recommendations to transform aquaculture. SSA.

Update policies, incorporate policies to annual plan and budgeting: Governments at all levels need to formulate Act, Regulation, or Procedures of National Fishery Development Policy and align with the annual plans and budget expenditures to overcome ambiguous state in beneficiaries' identification, targeting and impact assessment. Laws, acts, polices related to underlying ministries should be revised and remove any ambiguities.

Formulate a Directives to graduate SSA: A Directive should be formulated to graduate SSA into business farms by including value-chain-based production inputs and post-production related subsidies, incentives and grants. Some policy provisions are: rent and tax subsidy for private land leasing, easy leasing of swamp areas or water-bodies, declare aquaculture production area, assurance of year-round high quality fish seed and feed, free electricity supply for aquacultural farm mechanization. These support programs can be interlinked by building digital software.

Promote profitable and climate resilient technologies: Nepalese fisheries research program must test, develop, or adapt high-productive and climate resilient technologies related to stocking of advance fingerlings, feed and supplements, profitable species farming, and parasite and disease managements.

Implement regular extension program and project's program from a same door: It is highly recommended to align extension program and projects supported program from a same door in an equity basis. For example, Extension programs of seven provinces, 753 local units, Federal program such as Prime Minister Agriculture Modernization Program (PMAMP) should implement fishery related Super Zones, Zones, Blocks and Pocket program from a same floor. That office should link other program such as fishery insurance, electricity subsidy, subsidized loan facility, aqua farms link road construction, irrigation, land leasing processes in a more sustainable manner.

Establish fishery markets in every feasible local government unit with infrastructure support: All municipality as well as feasible rural municipalities should establish SSA-led community, private or joint-managed markets to reach out live, chilled or frozen products to the consumers. These markets should be supported by cold chambers, duty-

free transportation facility for to cut down postharvest losses and tied with subsidized loan facilities, side by side.

Fix prices of each product and keep records in every terminal market: Wholesale market committees of major terminal markets need to enhance their pricing and record-keeping systems for all species sold daily. Because of setting prices for four groups - Rohu, pangas, Chadi and Mahoor makes it difficult to compare the prices and volume of individual species produced by the SSA.

Rethink protection measures and ban informal trade: The customs office of Ministry of Finance needs modification of tariff rates for raw, finished, processed and industrial products. Informal import of production inputs and produces should restrict and bring these into record keeping system.

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Annex 1: Case study of small-scale pond-fish farmer Ms. Manju Khanal

Ms. Manju Khanal owns a 0.13 ha (four *Kattha*) carp farm in *Siyari-5, Siddhapur Chhapia, Rupandehi* where she has been growing fish for10 years. She stocks 1200 fingerlings of six types in three different months: Grass carp in June, Common, Silver, Rohu in May, and Bighead and Naini in July, based on fingerlings availability. She purchases fry from the government hatchery, *Thutepipal* and feeds them regularly by byproducts of chicken and fish selling leftovers plus mixture of oil cake, rice bran and mill residues. The grass carp fish is feed with the perennial and seasonal forage sources. Her per day feed cost for 5- kg amount is NPR 200 to 250. She treats ponds regularly for fish lice, tail rot disease, incurring a treatment cost of about NPR 2,200 per year.

His husband, formerly employed in Qatar, is engaged now in fresh house business. The couple rear, catch, stock, cut and sold these products from their farm-get and would earn extra NPR 90-100 rupees for a kilogram of sale. This is the best example of small-scale aquaculture how small-scale investment also supports to earn a monthly profit NPR 45000 to 50,000, and maintain moderate livelihood.

Source: Case study interview (photo to be included).

Annex 2: Best success example of aqua entrepreneur who is following high-density fish farming

Images of Mr. Bharat Yadav and his IPRS technology.

Bharat Kumar Yadav is a young entrepreneur and the owner of Sambhunath Fish Firm in Sambhunath Municipality-4 *Sakura*, *Saptari*. Initially involved in brick manufacturing business, he transitioned to fish farming a decade ago with a startup farm size of 4 ha, which has now expanded to 9.3 ha with a investment of 12.5 million. He is now stood as the biggest aquaculture entrepreneur in Madhesh Province. Although he faced challenges in the first three years, his profitability began onwards from fourth years after implementing ideas from training and exposure opportunities from local DADO office. Since 2019, he has been establishing hatchery services. He sold 4 million fish seeds last year to four adjoining districts. He yields and sells 20 Mt fish from his farm-get with 100-120 kg of fish per day plus fulfills extra demand of party or local festivals. Most recently, he has installed In-Pond Recirculatory System (IPRS) in one of his 17 ponds using local materials, which has doubled productivity from 3.3 to 6.7 metric tons in his half-hectare area. Mr. Bharat Kumar Yadav has received 4.5 million grants and 20 plus awards from local to central governments. He plans to adopt IPRS in all his ponds in the near future.

Note: This may be not appropriate to SSA.

Annex 3: Per kilogram tariff rates (in %) for fishery related raw inputs and end products

Name of input & fishery products	Custom duty for SAARC	Custom duty for other country	Excise duty	Agriculture Dev. tax	Advance income tax	VAT	Remarks
Raw sources & prepared fish feed	5	10	5	0	1.5	0	
Machines and equipment	9	10	5	9	1.5	13	
Live fishes	9	10		9	5		
Chilled or frozen finfish	9	10		9			
Chilled or frozen marine finfish	6	10		5	5		
Tuna skipjack (Atlantic, pacific)	6	10		5	1.5	13	
Tilapia and catfish species	9	10		9	5		
Frozen fish fillets	6	10		5	1.5	13	
Dried, salted finfish products	9	10				13	
Chilled, frozen, dried Shellfish, Mollusca, shrimps, prawn	6	10				13	
Manufactured industrial products	6	10				13	
Readymade food-fish products	7.25	15	15			13	

Source: Department of Customs, (2024).

Enhancing Nepal's vegetable sector: strategies for import substitutions and export promotions

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Ministry of Agriculture and Livestock Development (MoALD), Bagmati Province

Introduction

The vegetable sector holds significant potential to reduce poverty and improve the livelihood and current status of poor dietary diversity and nutrition insecurity. Cultivation of vegetables yields superior returns in contrast to cereals and fits to the farming system of small and marginal farmers with the prospect of scaling up and gradual commercialization.(Pamuk et al., 2021; Thapa, 2021). It also creates opportunities for women to earn income, contributing to household food and nutrition security thereby fostering empowerment and promoting gender equality (Balayar & Mazur, 2022).

It is one of the highly prioritized sectors as indicated by its 2nd prioritization in Agricultural Development Strategy(ADS). Its growth and commercialization over the past two decades is remarkable as demonstrated by about 5% annual growth rate from 1995 to 2015 and an estimated 30-50% commercialization (MOALD, 2016). It is also included as one of the promising sectors for export in Nepal Trade Integration Strategy(NTIS)2023.

Despite the vegetable sector's growth and commercialization remarkable over the past two decades and its current contribution to the AGDP (13.4%) comparable to rice (13.6%) from comparatively low cultivated area (289 thousand ha, 11.46% of total agricultural land) vs rice (1450 thousand ha, 57.53% of total agricultural Land) (MOALD, 2023.), the import is still high and export low and stagnant which is of great concern for national economy whose primary goal is attaining trade balance by building capacity for commercialization and competitiveness. The contribution to the AGDP increased by over 6% if potato is also counted, which is also considered vegetable in Nepal.

Vegetable production in Nepal is small-scale and unorganized. Farmers cultivate many vegetables at once instead of specializing in a few commodities. Low productivity, unorganized and inefficient supply chain, unpredictable fluctuation of price, poor post-harvest management, easy import of cheap Indian vegetables, and hurdles in export are the problems of vegetable farming.

Scope and method of analysis

The vegetable trade of Nepal with particular emphasis on import substitution and export promotion is the focus of this study. Key informant interviews with the market managers, quarantine officers, and traders; secondary data analysis of the production and trade statistics; and literature reviews were done to prepare this policy brief.

Status of the vegetable sector in Nepal

Over the past two decades, both production and yield of the vegetable has been increased with yield reaching 14.33 Mt/ha in the year 2021/22 (MOALD, 2022). However, the yield is lower than that of China (24.66 Mt/ha) and India (16.66 Mt/ha) but surpasses that of Bangladesh (9.22 Mt/ha) and Sri Lanka (11.45 Mt/ha) (CASA, 2020).

In terms of production, the leading vegetable crops in decreasing order are cauliflower, cabbage, tomato, radish, broadleaf mustard and onions. The top 24 vegetables by production and yield are depicted in Figure 1, covering 88% of the total vegetable production.

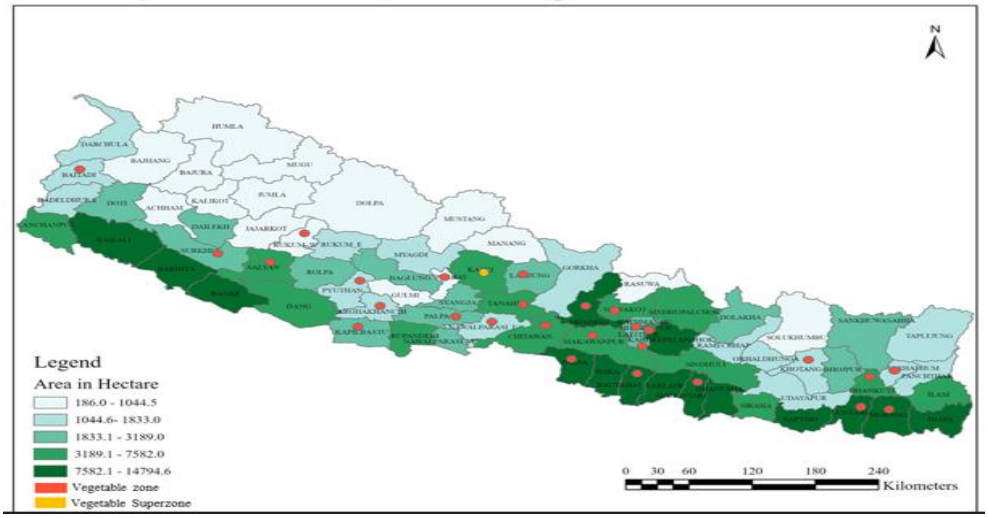


Figure 1: Distribution of vegetable production
Sources: (MOALD, 2023.)and (PMAMP, 2022).

Tomatoes have the highest yield at 18.4 MT/, followed by cabbage, chayote, cauliflower, and bottle gourd. The tomato yield is slightly better than in India (ADB, 2019), which could be due to the dominance of the protected structure in tomato production in the Mid hill area and the favorable agro climate. The study conducted by Subedi et al., (2023) found an overall productivity of 191 Mt/year of the vegetable produced in the protected structure and it is economically best to produce under the temporary structure followed by the semi-permanent and permanent structure.

Terai region (<600 m) leads in vegetable production with about 55% contribution in the vegetable area followed by Mid-hill (600-1500m) with 40% contribution. Rest is contributed by high hill (>1500 m) (Pamuk et al., 2021). Terai Zone mainly produces vegetables from the month of November to May. But from May to November, the high temperature coupled with the inundation of the land by flood restricts vegetable production there. So the vegetable from the Mid hill and High hill dominates in the summer and rainy seasons and the vegetables from Terai dominate during the winter and spring seasons in

the major market of Nepal. The average price of vegetables during the summer and rainy seasons is generally higher than in the winter and spring seasons.

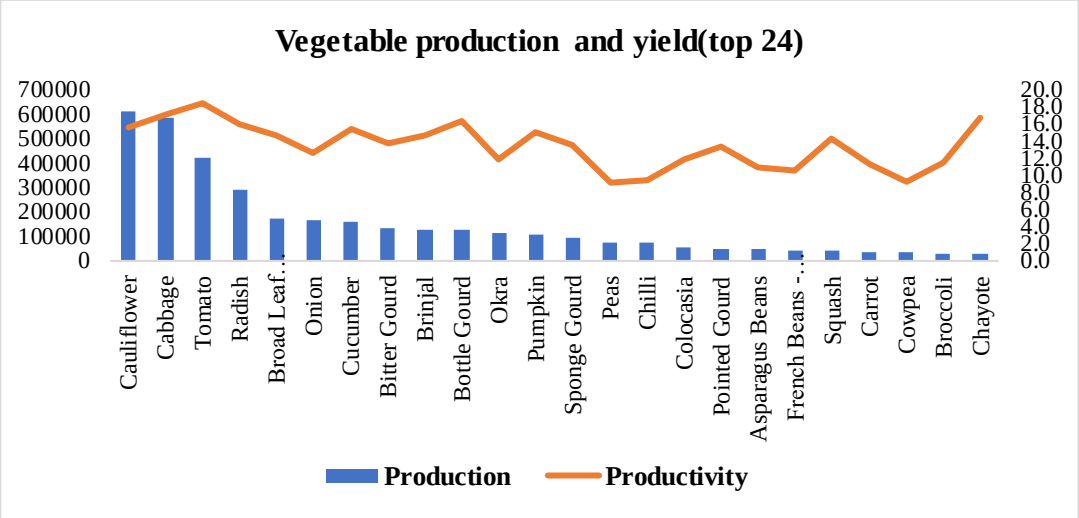


Figure 2: Production and yield of vegetables in Nepal
Source: (MOALD, 2023).

Import and export of vegetable

A total of NRP 17,780 million of vegetables have been imported into Nepal in FY 2022/23, out of which, potato, onion, garlic, and tomato include 44.6%, 38.5%, 7.0%, and 3.43% respectively. Other major fresh vegetable imports include tomato (NRP 610 million), mushroom (NRP 186 million), green legumes (NRP 132 million), and cucurbits (NRP 126 million). Almost all of the vegetable imported in Nepal comes from India except garlic.

Since, about 90% of the import of vegetables includes potatoes, onion, and garlic, the import substitution of them is crucial. The Import substitution strategies of these three vegetables is presented in the following box.

The export to India is mainly composed of cabbage from eastern Nepal from June to September. Though some informal exports of tomatoes are reported in the summer and rainy season, no formal export exists due to not being listed in the Plant Quarantine Order

Import substituting strategies of the Potato, Onion, and Garlic

Potato

Potato is produced in 198 thousand hectares with production and yield of 3,410 thousand Mt and 17.2 Mt/ha respectively. Its contribution to AGDP is about 6.3%. The yield of potatoes in Nepal is the lowest among the South Asian countries. Its yield is about one-third compared to highly productive countries like Belgium and Netherlands and about 25% lower than the world average (ADB, 2019; Soare & Chiurciu, 2021).

The increment of yield by only 2 Mt/ha which is about an 11% increment from the current yield can sufficiently substitute the existing import of about 3.10 Lakh Mt in terms of quantity. Making high-yielding seeds accessible and affordable, mechanization in planting and harvesting, investment in irrigation facilities, and easy availability of judicious application of chemical fertilizers and plant protection chemicals can boost yield. To make potatoes available all season and reduce post-harvest loss, assessment of the existing cold storage facilities, developing necessary facilities, and linking these to the major production and market center through appropriate government support are needed. Equally crucial is policy interventions to counter Indian potatoes easily penetrating domestic markets through strengthening quarantine measures.

Onion

Almost 100% of the onion marketed through the major wholesale market is imported. About 192 thousand Mt onion worth of about NRP 7000 million is imported in FY 2022/23. The imports mainly occur from India but also from China in the Indian export ban. The domestic production of 166 thousand Mt in about 13 thousand areas (MOALD, 2023) is scattered and mainly limited to household consumption and selling in the local market.

Despite having a favorable agro climate, the high cost of production, scarcity of good cultivars and quality seeds, ineffective program implementation modalities, and poor storage facilities had caused the failure of the onion promotion program in the past and less attention was given to the import substitution agenda. The huge value of imports and unpredictable fluctuation of the domestic price calls for a substitution strategy. The interventions needed for import substitutions are; the production of the seed domestically or developing a strategic partnership with foreign companies to ensure enough quality seed supply of desirable varieties; promotion of three-season onion production technology throughout the country, development of required cold storage facilities and capacitating farmers and traders about the post-harvest management requirement of onion.

Garlic

Cultivation of garlic is practiced subsistent in all regions of Nepal. Its current cultivation is limited to only about 10 thousand ha producing about 75 thousand Mt. In the fiscal year 2022/23, Nepal imported about 10 thousand Mt of fresh garlic or garlic products worth NRP 1250 million. About 90% of the Garlic traded in Nepal comes from China.

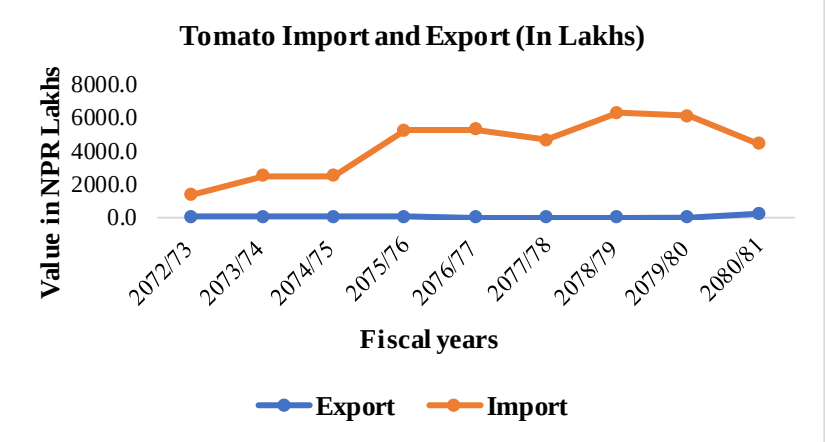
of India. Tomato, especially rainy season tomato is considered having comparative

advantages but the realization of it is limited. The details of tomato are presented in the

Case of Tomato

Tomato is cultivated in about 23 thousand ha producing 423 thousand Mt with a yield of 18.45 Mt/ha. In FY 2021/22 (MoALD, 2023). In the same year, about 48 thousand tons of tomatoes worth more than NRP 600 million were imported through formal channels from India. Its cultivation is highly profitable with net profit per hectare of more than 2nd class officer earns in annual salary in a protected structure and half the amount in open condition.

Tomato import to India is restricted due to not listing it in the Plant Quarantine order of India. However, Nepali summer season tomatoes informally go to India. When there was a crisis of tomatoes in the Indian market, in the rainy season of 2023, the Indian authority lifted the restriction in import ban temporarily, which made the export of 1769 Mt of worth NPR 3.35 Crore in the three months of June, July and August. Just before the ease of tomato export to India, Nepali farmers were protesting by throwing tomato in the road due to the lack of the market. The temporary import ease expired after October 31 and no single tomato has been exported through the formal channels after that.



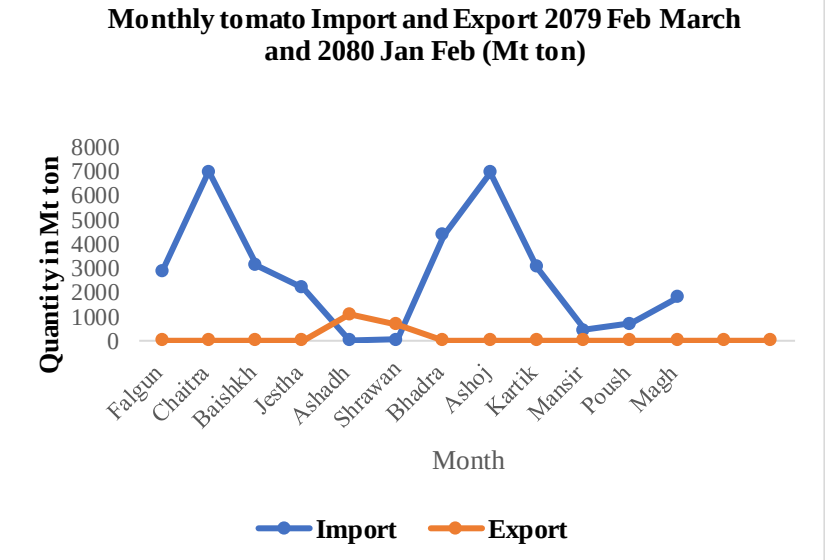


Figure 3: Monthly and yearly trade pattern of Tomato
Sources: DoC, 2016-2022. https://www.customs.gov.np/page/statistics

following box.

India is the primary export destination for vegetable Export from Nepal. Import to India demands the inclusion of vegetables in their Plant Quarantine Order and phytosanitary certificates declaring vegetables free from quarantine pests. Only cruciferous vegetables and radishes from Nepal are listed in the plant quarantine order of India.

The Gulf country is also emerging as an export destination of Nepali vegetables due to low tariff rate and high demand. Vegetables, mainly Capsicum and Asparagus, worth 1.898 Crore, have been exported to these countries in the fiscal year 2022/23. Thapa, 2021 pointed out that Bangladesh could be a Potential export destination for Nepali vegetables if the negotiation on a high tariff rate (25%) is done.

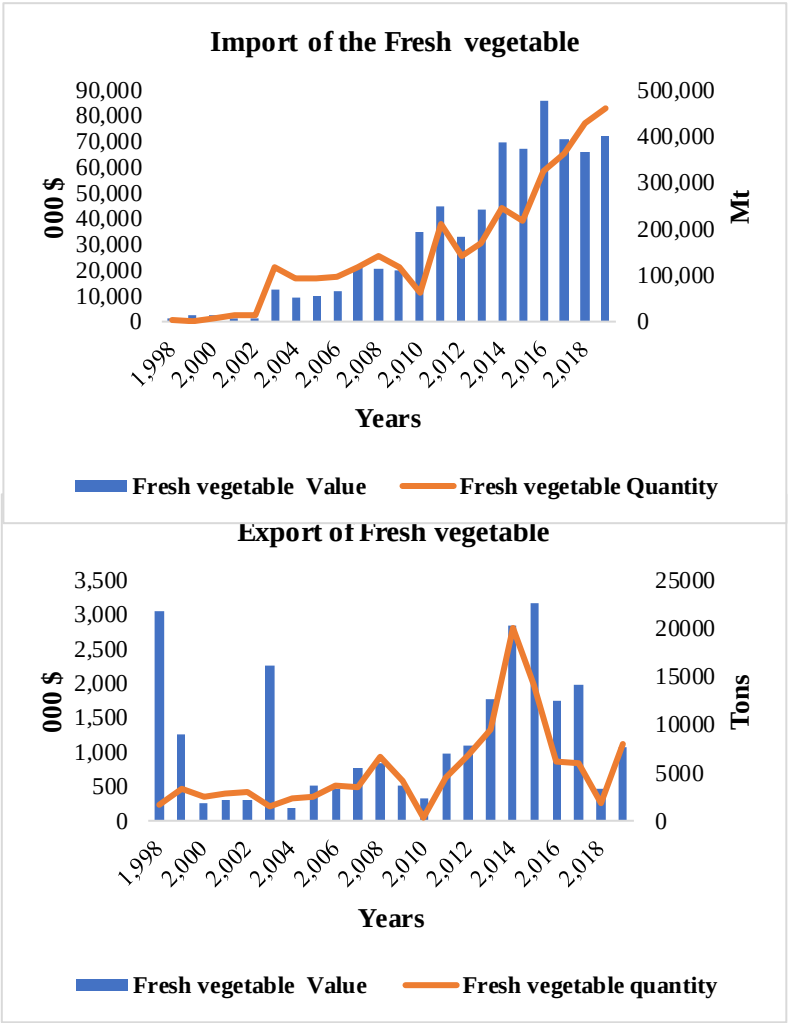


Figure 4: Trend of the vegetable import and export in Nepal
Source: BACI database.

Table 1: Structure of vegetables import and export

SN	Vegetable import In FY 2079/80		Vegetable export in FY 2079/80	
	Vegetable type	**Value millions (NRP)**	**Vegetable type**	**Value in millions (NRP)**
1	Potato	7,933	Cabbage	145
2	Onion	6,868	Dried/chilled vegetable	31
3	Garlic	1,246	Mushroom	19
4	Tomato	611	Tomatoes	15
5	Frozen vegetable	527	Other	37
6	Mushroom	186		
7	Fresh legume	132		
8	Cucurbits	126		
9	Dried vegetable/mushroom	112		
10	Root crop	29		
11	Cole and salad crop	17		
	Total	**17,789**		**248**

Sources: (NFTS, 2023).

Strategies of import substitutions and export promotion

Potato, onion, and garlic are the products we should focus exclusively on import substitution because the export promotion of this commodity in the short run is not possible due to low competitive capacity. Tomato needs import substitution strategies in the main season and export promotion strategies.

Table 2: Groupings of vegetables for trade strategies

SN	Import Substitution Group	Export promotion group
1	Potato	Cabbage
2	Onion	Cauliflower
3	Garlic	Radish
4	Main season tomato	Rainy season tomato
5	Pumpkin	Capsicum
6	Bitter gourd	Asparagus**
7	Okra	
8	Green legumes	

Source: Author's estimation.

Driving up of yield

The primary costs associated with vegetable production are labor and inputs. Labor costs typically account for about 50% to 55% of the overall expenses. Reducing it is challenging. The competition with higher-wage, off-farm employment further complicates this issue. Addressing these challenges involves increasing labor productivity and lowering labor costs. Low labor productivity is a driver of poverty, reduced food production and greater dependence on imported food (Cock et al., 2022). Technological interventions like mechanization in tillage, planting, and harvesting, innovative weed control like herbicides and plastic mulching, and fertigation reduce labor costs and increase yield. But care should be given to make those tools and techniques friendlier to the scale of operation of the farmers to avoid economic loss from underutilizing such tools.

The major inputs involved in vegetable production are seeds, manures, fertilizers, plant protection chemicals, and irrigation.

Although the cost of the seed is relatively low (around 5 %) for most of the vegetables, the quality is of prime importance. The majority (85%) of vegetable producers obtain seed from private sources and they prefer hybrid over open-pollinated varieties. Given the dearth of domestically produced hybrid varieties (only three variety of tomato and cucumber), most of the seeds used by the farmers are imported (Timsina & Shivakoti, 2018), which presents the price factor beyond the nation's control. Innovative solutions to these challenges should be explored to address these challenges.

Other production inputs used in agriculture are fertilizer and manures. Due to fertilizer supply all over the country being subsidized by the government and no private sector supplying it, the concern is availability rather than price. Ensuring the availability of fertilizers in response to farmers' demands and promoting their judicious use holds the potential to enhance productivity. Locally produced manures, primarily sourced from livestock, play a pivotal role not only in boosting production but also in maintaining soil health and promoting sustainable agricultural practices. Enhancing the decomposition by using effective microorganisms, and enhancing quality by mixing biofertilizers like *Trichoderma, Azotobacter, Azospirillium, Phospabacteria,* etc. can improve both soil and plant health. Capacitating farmers about the composting of the locally available biomass helps reduce dependency on external inputs and promotes sustainability in production.

The reliance on imported plant protection chemicals is considerably high. Embracing an integrated pest management approach, with the promotion of locally producible botanical and biological pest control products promotes food safety, sustainability as well as more value addition to the economy.

Irrigation stands as a critical input in vegetable farming, given that only 39% of agricultural land currently has year-round irrigation facilities (NSO, 2023). The availability of

irrigation facilities for smallholder farmers is even more limited, presenting a significant challenge in vegetable farming. The lack of irrigation poses a substantial obstacle to the productivity and success of small-scale vegetable cultivation (Rai et al., 2019). Dependency on the seasonal rainfall and lack of modern irrigation technology is a problem for vegetable farmers (Pamuk et al., 2021). Drip irrigation coupled with fertilization application, is known for producing more crops per drop, improving productivity, and has the potential to reduce labor costs associated with irrigation. However, even if farmers use drip irrigation, they often lack awareness about the application of fertilizers through the drip irrigation system. Developing a user-friendly protocol for fertigation based on readily and economically available sources and providing training to farmers about its use can significantly enhance yield and reduce production costs.

One of the drivers of enhancing productivity is enhancing production efficiency. This is crucial for positioning the sector competitively, especially compared to major trading partners like India. Shrestha et al., 2016 found Nepalese small-scale vegetable farms operating inefficiently and suggested changing the scale of operation, efficient use of inputs, and plantation of better return-giving commodities. According to that study, a 75% cost reduction in vegetable farming is possible by operating their farms at full technical and allocative efficiency without reducing production. Farms that operate efficiently are those utilizing improved seeds, with high participation of women, and having access to credit and markets.

Improve value chain efficiency

The Nepalese fruit and vegetable value chain is characterized by fragmentation, involving numerous unorganized actors, with limited credit, inputs information flow up and down the chain causing poor relationships, high transaction costs, and high post-harvest loss. The value chain is seasonal and there is a disconnect between farmers and market actors. Farmers' margins typically range between 40-50% of the consumer price. Farmers are producing first and seeking market later. Price instability by seasonality of production and imported products is high. (Pamuk et al., 2021).

The dysfunctional vegetable value chain in Nepal is attributed to poor and inadequate market-led post-harvest infrastructure, price setting mechanism not transparent due to oligopolistic practices by large-scale traders and wholesalers, poor market intelligence system, and market information not easily accessible and alternative marketing channels lack transparency, with limited involvement of farmers or consumer groups. The traders benefit more from selling Indian vegetables due to the facility of credit sale and the low prices than trading domestic vegetables. These challenges along with a lack of synergies among traders, low economies of scale, high transportation costs, substantial postharvest losses, and significant seasonal and spatial price fluctuations cause high marketing costs (ADB, 2019).

Enhancing the efficiency of the value chain by addressing these issues includes custom-tailored development of major markets based on the needs by equipping it with required post-harvest management facilities like cold storage, grading, and processing and linking them with production centers through necessary facilities like cold chain and collection center. It also includes promotion and incentivization of contract farming and cooperative marketing that link local production areas to high-value domestic and foreign markets, and capacity building of the farmers in post-harvest management targeted to high-value markets. In addition to this, the development of a robust market intelligence system that tracks the volume of supply and demand and price dynamics on a commodity basis and makes this information easily accessible to farmers and traders is needed.

Organize smallholder farmers

NSO, 2023 reports that 47.9% of farming households in Nepal grow vegetables. Among them, 81% are smallholders cultivating less than 0.5 ha of land. With small landholdings, farmers face proportionately more barriers to increasing production due to the difficulty of reaching modern technology and machinery and attaining economies of scale (Pamuk et al., 2021). Large farm sizes often exhibit greater efficiency in both the production and marketing of vegetables. However, the engagement of smallholder farmers in vegetable farming and the challenge of consolidating land due to individual ownership call for the organization of these smallholders. By organizing them, there is an opportunity to achieve economies of scale due to synergy in production, marketing, supplying quality inputs, and providing technical services. Good examples of smallholder farmers benefitting by organizing through cooperative vegetable marketing exist in the country. Marketing through agricultural cooperatives greatly reduces the cost of marketing as compared to private marketing as evident in the practices of cooperative marketing in Chitwan district (Poudel et al., 2015).The approaches to organizing smallholder farmers to enhance competitiveness may differ based on the context, type of commodity they produce, and target market for their produce. So a separate dedicated wing providing business development services should be built in every vegetable development program to identify, pilot, and institutional development of farmer's organizations based on the local context and need.

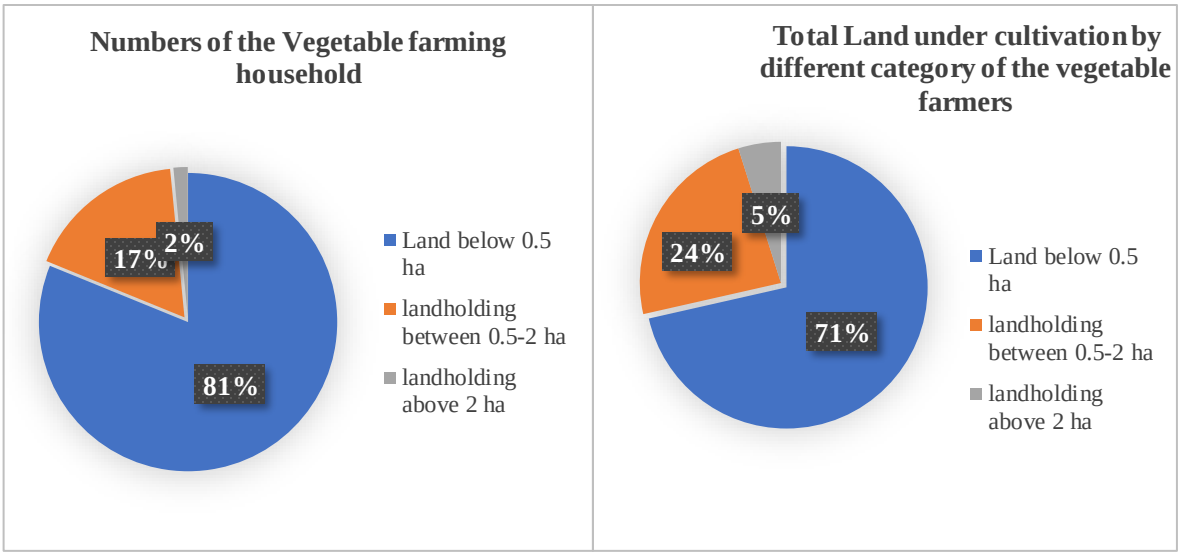


Figure 5: Landholding of vegetable producers
Source: NSO, 2022.

Trade facilitation

Realizing comparative advantages of the vegetable sector involves exploitation of the potential of export. It needs to identify potential markets and commodities, comply with the quarantine requirements of the importing country, and establish linkage of the trader of the importing country with domestic producers and traders. It also requires the development of necessary infrastructure like cold chain maintenance facilities in major customs points which is lacking in crucial requiring places like The Tribhuvan International Airport, a major export point to the Middle East. Capacity building of the local traders in export through providing opportunities to them to study and observe the potential export market is also important to promote export.

To mitigate market disruptions caused by the influx of inexpensive Indian vegetables, a review of the Nepal-India trade treaty allowing unrestricted entry of cheap Indian vegetables should be considered. Specifically, including vegetables in the sensitive list would help prevent duty-free unrestricted access to Indian products, thus safeguarding the domestic market (SWATEE, 2017). To counter the import of low-quality products, it is imperative to strengthen our quarantine measures focusing on pesticide residue analysis and pest risk analysis. Trade diplomacy to facilitate uplifting non-trade barriers to export is also crucial.

Improve Food safety and quarantine

It is argued that developing countries must adopt a strategic approach to navigate the opportunities and challenges arising from high-value agricultural and food markets, especially in the face of evolving food safety standards. This entails anticipating the actions of trading partners and taking proactive measures in response (Henson & Jaffee, 2006). It suggests three strategies of exit, loyalty, and voice of which exit strategy involves

anticipating standards, leaving a particular market or market segment, and making other commercial shifts. Loyalty strategy concerns anticipating standards and complying ahead of time. Voice strategy revolves around participating in standard creation and negotiating before the standards are applied. A distinct absence of such a strategy is evident in Nepal. Producers and traders exhibit a considerable lack of awareness regarding quarantine, phytosanitary, and food safety issues, and the government infrastructure related to food safety and phytosanitary measures is deemed untrustworthy. Enforcement and regulation are notably deficient. Our food safety standards face minimal respect, with India not to mention other developed markets. (Thapa, 2021).

Awareness of this issue is on the rise, and there is a formulation of the food safety standard, however, the enforcement is poor. Establishing reliable and trusted markets and communication channels with consumers to ensure food is safe is a daunting challenge.(Pamuk et al., 2021). To overcome this problem, Nepal needs to upgrade and enforce SPS and food safety standards to comply with international standards, or at least to the standards of the countries it targets for export by enhancing the capacity of the SPS lab so that our phytosanitary and food safety certificates are trustworthy to the importing countries. The national plant protection organization should prioritize regular surveys/ surveillance and pest risk analysis of the identified exportable commodity. In addition, Nepalese farmers must adopt good farming and manufacturing practices, to comply with quality standards in export markets, so that their products are suitable for export (CASA, 2020). Awareness and capacity building of the farmers and traders regarding quarantine pests, pesticide residue, safe food production, and rigorous quality control by the concerned authority is crucial for gaining trust from the market.

Recommendations

To substitute imports and increase exports of the vegetable the following recommendations are made:

- Government and Developmental partners should promote cost-reducing and productivity-enhancing technologies like a low-cost greenhouse, mechanized planting and harvesting, plastic mulching, chemical weed control, fertigation, and high-quality seeds that fit in the farming system of the smallholder farmers and specific needs of selected vegetables.
- Improve Value chin efficiency through customized development of major markets based on the local needs by equipping them with required post-harvest management facilities like cold storage, grading, and processing and linking them with production centers through necessary facilities like cold chain and collection centers. Promotion and incentivization of contract farming and cooperative marketing that link local production areas to high-value domestic and foreign markets and capacity building of the farmers and related value chain actors in post-harvest management and trade is also needed to make the value chain efficient.
- Organize farmers: Inbuilt separate and dedicated business development services in every vegetable development program to identify, pilot, and institutional

development of smallholder farmer's organizations based on the local context and need.

- Trade facilitation: First, develop the capacity of the local traders in export by providing opportunities for them to study and observe the potential export market. Second, Revisiting the Nepal-India trade treaty to review the provision of free entry of Indian vegetables. Third, alleviate hurdles to the export of potential vegetables through the involvement of national plant quarantine authority and trade diplomacy. Fourth, Cargo holding facilities with cold chains should be developed in the needed in the custom places like international airports.
- Regular study of food safety and quarantine requirements of the target market and strengthening SPS facility, quarantine measures, and promoting safe vegetable production to comply with these markets. Prioritize regular surveys and surveillance and pest risk analysis of the commodity target for export.

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How to Best Utilize Agrobiodiversity in High Mountains of Nepal?

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Summary

High mountain agrobiodiversity is exposed to higher risk of threats along with climate change and human activities, and the declining agrobiodiversity has substantial impacts on the livelihood of mountain people. Increasing road networks at rural settlements have increased the availability of goods and services from the nearby markets, thereby contributing to the shifting of traditional agricultural practices and loss of agrobiodiversity. In this policy paper we have analyzed the drivers of agrobiodiversity decline in High Mountains of Nepal taking case studies of *Manang* district in central Nepal. It is recommended that conservation financing system is required to be adapted and promoted to capacitate socio-economic livelihood benefit and for the conservation of high mountain agrobiodiversity for their sustainable use. The existing national policy framework and market provisions are inadequate for safeguarding indigenous agrobiodiversity resources in high mountains; hence an effective conservation financing system must be adopted particularly focusing on high mountain regions of Nepal where agriculture production is very low to sustain livelihood of local people. Mountain ecosystems are of global concern in terms of biodiversity conservation and ecosystem functioning; hence mountain communities should be encouraged for preserving local agrobiodiversity through efficient conservation financing mechanism that could be developed from collaborative efforts of local government bodies, conservation partners and tourism enterprises.

Recommendations

Urgent interventions are required to conserve, expand, value addition and use of agrobiodiversity in high mountain regions of Nepal which are exposed to high risks of agriculture land abandonment and rapid loss of agrobiodiversity.

1. It is essential for documenting and registration of agrobiodiversity and related traditional knowledge in the high mountain regions.
2. Mountain people should be made aware of the existing policy framework for agrobiodiversity conservation to recognize and conserve them before they disappear.
3. We should encourage mountain people for the conservation of agrobiodiversity (both *in situ* and *ex situ*) through conservation financing mechanism including ecotourism, technological development and by providing incentives for agriculture sustainability in high mountain landscapes.

Introduction

Mountains cover about 22% (32 million km^2) of the global land surface and accommodate about 1,010 million people (67% rural), and most of them (63%) are in developing countries. It is estimated that 40% of mountain people are vulnerable to food insecurity (FAO, 2019). Globally, only three crops, namely, wheat, rice, and maize, account for more than half of the dietary energy supply for humans, and the production diversity is declining rapidly (Adhikari et al., 2017; Mannar et al., 2020). In Nepal, the decline in agrobiodiversity is high, with the gradual disappearance of and traditional nutritious food crops such as buckwheat, barley, millets, sorghum, oat, and beans from our food systems (Adhikari et al., 2017).

Agrobiodiversity holds significant importance within the broader spectrum of biodiversity, particularly in Nepal, where it is categorized into six primary components: crops, forages, livestock, aquatic life, insects, and microorganisms. These components are further classified into four sub-components, encompassing domesticated, semi-domesticated, wild relatives, and wild-edible categories. Agrobiodiversity has been very important as their insurance against pests, diseases, and climatic changes and as a coping mechanism in extreme conditions (Bahadur et al., 2016). They form an integral part of our food systems and maintain crop diversity, crop habitat diversity, and the assemblage of varieties of crops and livestock breeds (Negi et al., 2012). It is therefore highly important to improve diversity in agriculture with the revival of traditional food crops to improve both agricultural and environmental sustainability. The national data from Nepal showed that only a slight decline in the share of traditional crops, but there has been significant decline of agrobiodiversity in the country's high-altitude mountain districts (e.g., *Humla* and *Jumla*), (Gautam et al., 2019), and such decline has also been reported from high mountain regions including *Dolpa, Mustang, Manag, Gorkha, Dhading, Rasuwa, Shankhuwasabha, Taplejung* districts of Nepal. However, the causes and consequences about loss of agricultural crop diversity due to climatic and anthropogenic activities are not well explored in mountain settlements of Nepal. As IPCC (2007) indicated the warming temperatures greater than 1.5 ^{0}C could put 20-30% of species at a higher risk of extinction, and this risk is persistent in agrobiodiversity throughout Nepal.

The biodiversity in Nepal is extensive, encompassing a reported total of 24,300 biological species (Figure 1). Of these, 28% (6,618 species) are agricultural, excluding 27 exotic ornamental fish species. Agricultural fauna exhibits greater species richness (3,785 species) compared to agricultural flora (2,833 species). The insect component leads with the highest number of agricultural species (3,500), followed by the crop component (1,026 species) and the microorganism component (800 species). The livestock component has the lowest species richness among the six components of agrobiodiversity.

Agricultural land is very important in Nepal as more than 60 percent people directly get their livelihood from agriculture. And agricultural activities in harsh climatic zones are highly critical in high mountain landscapes such as *Manang*, where 6-10 persons per hectare land ratio in 1981 was increased to more than 10 persons per hectare by 2001 (Subedi, 2003). However, studies in recent years found decreasing pressure on agricultural land due to switching off from agricultural activities to trade, tourism, and other livelihood options. And this resulted in widespread migration and agricultural land abandonment in the valley, thereby the loss in local verities of agricultural crops.

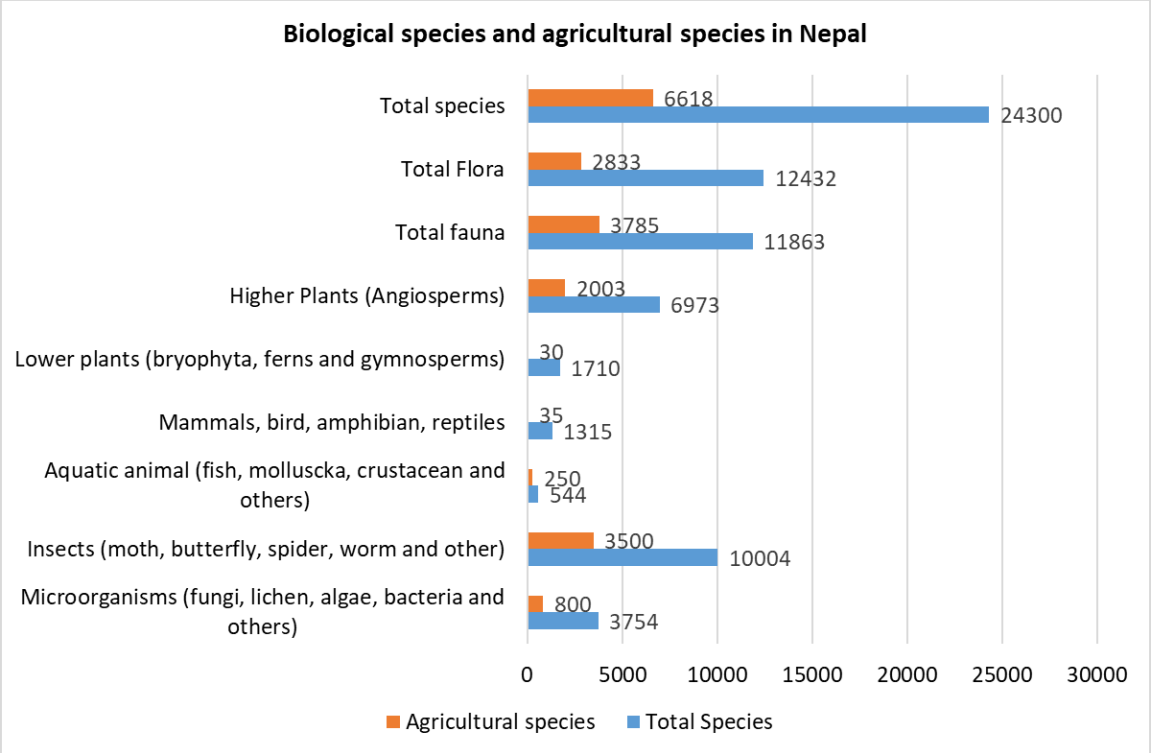

Figure 1: Biological species and agricultural species in Nepal

Scope of Assessment: A case study at *Manang* (Agrobiodiversity richness and drivers of change)

Altogether 72 respondents were interviewed regarding their livelihood options and agrobiodiversity practice in *Naar* (16) with low tourism activities, *Nagwal and Khangsar* (26) with moderate tourism activities and *Humde* and *Upper Manang* (30) with higher tourism activities in *Manang*. Field inventory data showed altogether 51 different species of agrobiodiversity species in the study area. The maximum number of species were recorded at *Manang* village (51), followed by *Nagwal/Khangsar* (38) and the least number of species at Nar (28) (Figure 2). Among different components of agrobiodiversity, vegetable crops were the richest whereas the minimum diversity was found for main crops and aquatic animals. The total number of species under agrobiodiversity is very poor in the

mountain settlements of *Manang* which forms less than 1% of total agricultural species (60/6618), and this scenario is apparently the same in high mountains of whole Nepal. And there are both natural as well as anthropogenic drivers of agrobiodiversity recognized in *Manang* including five natural and 11 anthropogenic drivers (Figure 3) as a representative driver of agrobiodiversity for high mountains of Nepal.

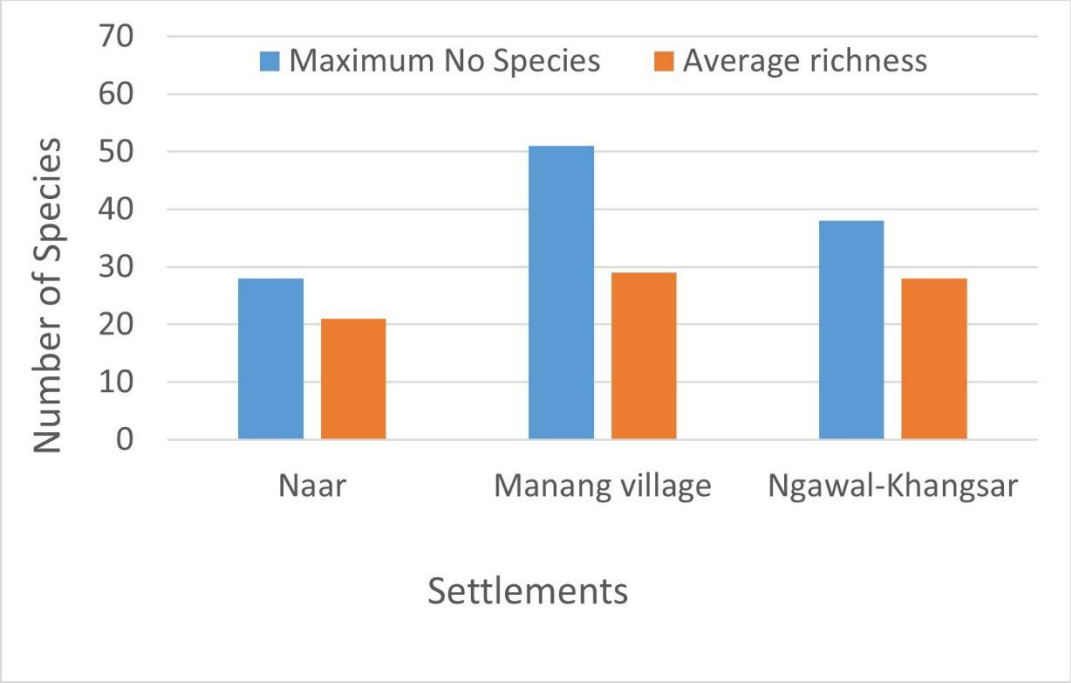

Figure 2: Agrobiodiversity richness in different settlements of *Manang*

Land Use Change

According to FRTC (2019) forest occupies 6.5 million hectares which is equivalent to 44.47% of total area of Nepal. Beside Forest, Other land and Cropland occupy 28.68% and 21.88% of total land area in Nepal respectively (Figure 2,3). The general decline of cropland in the last two decades has created substantial impact to Agrobiodiversity resources in Nepal. However, cropland area decrease is very low in high mountain areas of Nepal including *Manang* district in comparison to middle mountains and Tarai in Nepal (for high mountain region of Nepal total cropland is decreased from 456,703 ha (2000) to 447,024 ha (2019) (FRTC, 2019) (Figure 3).

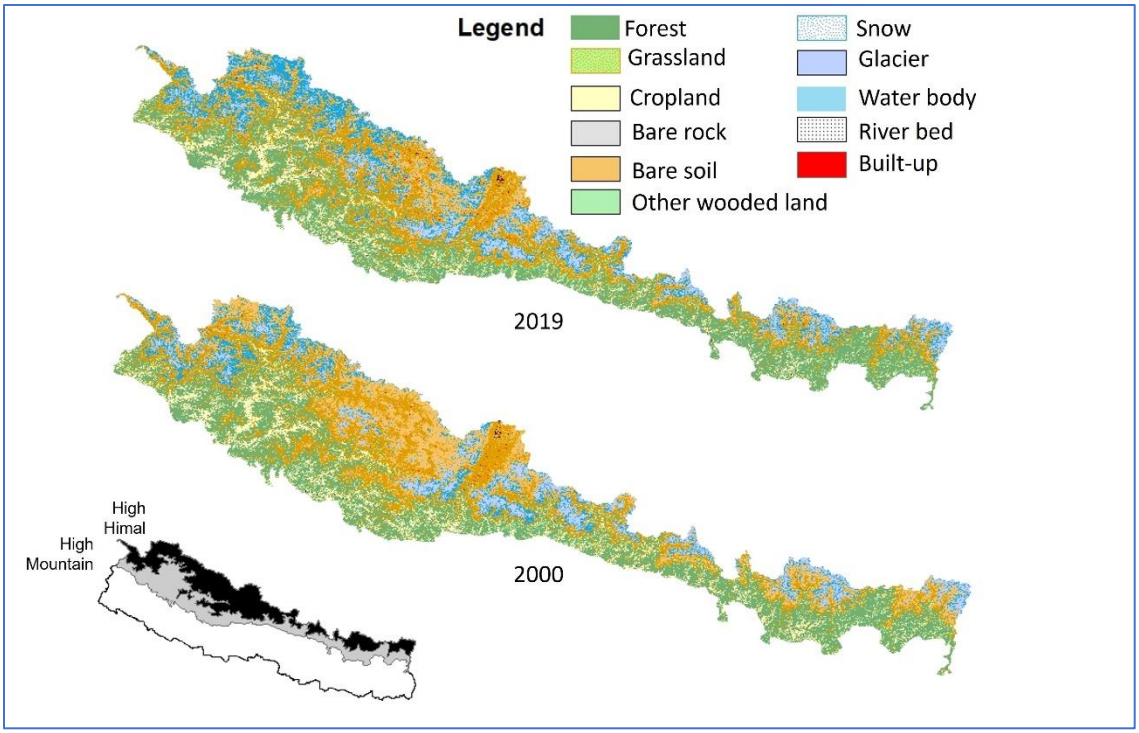

Figure 4: Land cover of High Mountain and High *Himal* physiographic regions in 2000 and 2019.
Source: FRTC, 2019.

The local people mentioned that loss of agrobiodiversity in the study area is also due to climate change however, we have observed that the local farmers are able to grow cauliflower, carrot, cabbage, chilli, tomato, coriander, spinach, and cucumber due to increasing temperature trends in the region. The farmers also experienced improved size of apple and vegetable crops as well as upward elevation shifting of crops including maize, apple, and others in *Manang*. Additionally, the local farmers have substantially used plastic tunnels to grow vegetables successfully which also saved vegetables from frost damage. One of the underlying causes of loss of crop diversity is due to increasing incidences of extreme climate events in the mountain settlements. These extreme events include hailstorm, drought episodes, untimely snowfall, and rainfall instead of snowfall, which severely affect crop yield and crop cycle, and there is policy gap to address this emerging climate crisis.

We have also identified the social and economic drivers for agrobiodiversity richness. *Manang* is well known for high outmigration, with population decline and less people to work in farmland. There is a general trend of agriculture land abandonment causing agrobiodiversity to decline. The livelihood options such as involvement in tourism, herb collection and trade, infrastructure development projects, agriculture as well as non-agriculture labors are also responsible for the decline in agrobiodiversity. Interestingly, the case study showed richer agrobiodiversity in the region with diverse livelihood options

(Upper Manang) than the region with higher dependency in agriculture (*Ngawal/Khangsar* and *Naar village)*. Further it is also highlighted that *Naar* village lies above 4,000 m altitude and has low outcome from agriculture thereby showing low richness in agrobiodiversity.

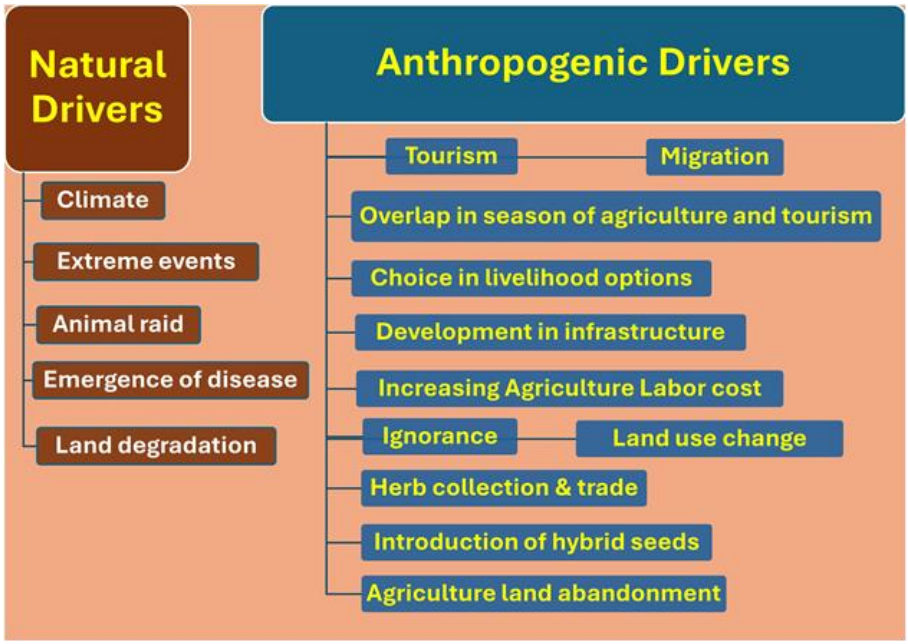

Figure 3 Drivers of changing agrobiodiversity in Manang

In case of *Manang*, overlapping in the peak season of tourism and agriculture has created labor shortage to work in farmland, as a driver of agriculture sustainability in *Manang*. The labor shortage coupled with outmigration of males and undergoing feminization and diversification on livelihood options have led to the abandonment of local crops in Nepal (Bhattarai et al., 2015). For instance, local people in *Manang* are gradually shifting from cultivation of Karu (naked barley) to cultivating wheat which is less labor intense. However, the local people in upper *Manang* are still able to manage agriculture as well as tourism which showed rich agrobiodiversity in comparison to *Ngawal/Khangsar* and *Naar village.*

Local Knowledge on Agrobiodiversity

Agricultural Genetic Resources (AGRs) in the mountainous regions of *Manang* district are relatively poor because of both climatic and topographic extremes. Despite most mountain people still relying on agriculture for their livelihood, their knowledge is relatively poor in terms of components of agrobiodiversity. Our results indicated that people of *Naar Valley* showed less knowledge regarding the importance of components of agrobiodiversity in comparison to the people of *Ngawal/Khangsar* and *Upper Manang*. It is mainly related to agrobiodiversity richness, climate suitability as well as education level of local people.

	Components of Agrobiodiversity	Naar	Ngawal	Manang
Main components	Crop	5	5	5
	Forage Crop	3.5	4	5
	Livestock	5	5	5
	Agricultural Insects (Value Insects)	3	3.5	4.5
	Agro-microbes (mushroom, soil microbes, pathogene)	2	3	4
	Aquatic Agricultural Resources (Aquatic fish, frog, wild lice)	1	2	3
Sub components	Domesticated plant/animal	2	2.5	2.5
	Semi-domesticated plants/animals	1.5	1.5	2
	Wild Relatives	1	1	0.5
	Wild Edible fruits	0.5	1.5	1.5
	Total Score	**24.5**	**29**	**33**

Figure 4: Public awareness on components of agrobiodiversity[12]

Analysis of policy framework to conserve agrobiodiversity in mountain landscapes in Nepal

The Agrobiodiversity Policy 2063 (2007 AD) was designed with the objectives of identifying, conserving, maintaining, developing, and sustainably using agrobiodiversity and traditional knowledge. It aims to establish farmers' rights in agriculture genetic materials/resources and traditional knowledge, ensure fair and equitable distribution of these resources, and manage them to balance the ecosystem in line with climate resilience, reducing the impacts of climate change. To comply with various international obligations as contracting parties of the CBD (Convention on Biological Diversity) and ITPGRfA (International Treaty on Plant Genetic Resources for Food and Agriculture), the Agrobiodiversity Policy 2063 (2007 AD) underwent amendments in 2071 (2014 AD). Additionally, an Implementation Strategy and Action Plan (ImISAP) for ITPGRfA mLS (Multilateral System) was developed in 2017, covering the period from 2018 to 2025. This strategy guides activities such as exploration and collection, conservation, documentation, exchange of materials, non-germplasm-based technology transfer, resource utilization, capacity building, germplasm export and import, and the monitoring of germplasm flows.

The conservation of AGRs in mountain settlements like *Manang* is highly challenging because of limited options of diversifying agricultural products due to extreme climate conditions of the regions. Only the keyways of conserving AGRs are to promote local indigenous crops and livestock by proving possible subsidy through well designed conservation financing to local people. This is to compensate high invest and low return from agriculture, and to sustain livelihood in high mountains which is the key for mountain biodiversity including human existence. The maximum integration of local agricultural products in expanding tourism services could enhance conservation of the agrobiodiversity

[12] Semi quantied cores; major =*5, sub components score =*5.

in the region. And for this it is highly important to make local people aware of the importance of different components and sub-components of agrobiodiversity.

Nepal, despite being rich in agrobiodiversity, has faced a serious challenge as native genetic resources have not been given sufficient attention in research, education, and development. This neglect has led to genetic erosion, posing a threat to the diversity of native agricultural resources. One critical challenge is halting the ongoing genetic erosion to preserve the unique characteristics of native genetic resources (Joshi et al., 2020). Efforts are needed to enhance the competitiveness of native Agricultural Genetic Resources (AGRs) and reduce the current heavy dependence, which stands at 95-100%, on foreign germplasm (Joshi et al 2017).

To conserve agrobiodiversity in mountain regions, there is a need to replace foreign agricultural products and germplasm with those derived from native AGRs. This involves identifying globally potential native AGRs and promoting them in international markets. Additionally, it is essential to develop site-specific products to cater to diverse agricultural environments. This involves policies that favor diversity-rich agricultural products and strains. Moreover, efforts should be made to accelerate the evolutionary population to capture diversity from a wide range of agricultural areas. Studies indicated that the introduction of exotic species and their varieties has substantially decreased the agrobiodiversity in Nepal, and this trend is taking its toll. With the commercialization of agriculture, there is an increasing trend of monoculture and hybrid varieties that are continuously replacing local and diverse landraces (Joshi et al., 2020). For instance, there is increasing trend of replacing native agricultural plants with hybrid varieties since 1995, these introduction accounts for more than 620% in tomato, 123% in Cauliflower, 260% in carrot, 447% in brinjal, 146% in Okra and 100% in cabbage.

Crop raids by wild animals have been reported by more than 90% of respondents in Manang; which lies within the Annapurna Conservation Area, where killing of wild animal is forbidden and illegal. Hence instead of threatening/killing the wild animals the local farmers are gradually shifting from agriculture to other means of livelihood.

The local people would ideally seek direct as well as indirect incentives from the government to conserve their agrobiodiversity resources. Although there has been some support for providing vegetable seeds from the local government, they are inadequate. And people do not fully rely on these seed sources for their subsistence and manage seeds on their own. This clearly indicated that the policy measures are inadequate for the conservation of native agrobiodiversity resources. It is emphasized that the local farmers should be made aware of the importance of their indigenous biological resources and need supports at policy level to support them conserve agrobiodiversity while diversifying their

livelihood options and improve their life in such remote locations with harsh environmental conditions.

Conclusion

Agrobiodiversity is declining globally, and mountain settlements of Nepal are not an exception. Despite of less changes in agricultural land in comparison to lowland and mid hills of Nepal, the agrobiodiversity of high mountain regions is not getting proper attention. The case study in *Manang* concluded that the region is relatively poor in agrobiodiversity with new livelihood options other than agrobiodiversity, and there is natural as well as anthropogenic drivers of decline in agrobiodiversity. Agriculture is high mountain regions is highly costly mainly due to extreme climate, hence people are deviating from agriculture to other means of livelihood, even though the community existence is highly dependent on local agrobiodiversity. The local level of knowledge regarding agrobiodiversity and its components is relatively poor among mountain people, hence it is highly essential to make conservation finance mechanism that would support in conservation of agrobiodiversity in high mountains of Nepal. The local people are less aware of agrobiodiversity components and their timely conservation (*in-situ, ex-situ*) to ensure agriculture sustainability. We emphasize that the drivers of change in agrobiodiversity is fundamentally the same in different parts of high mountain regions of Nepal, and the conservation initiatives should be immediately adopted to secure the loss of agrobiodiversity resources.

Policy Implications (Recommendations)

The Agrobiodiversity Policy 2063 (2007 AD) must be fully adopted for the effective conservation of agrobiodiversity. It is found that agrobiodiversity is maintained in high mountain regions through traditional agriculture, and it should be improved along with modern agriculture practice using irrigation, fertilizers, improved seeds, polyhouses etc.

There are some incentives from the level of local municipal and conservation partners like ACAP (Annapurna Conservation Area Project) for the promotion of sustainable agriculture, although it is not adequate for conserving indigenous agrobiodiversity.

New tools such as livestock insurance, compensation for crop against animal raid and increasing attraction towards local food (domestic tourists)

We should encourage mountain people for the conservation of agrobiodiversity through technological development and increasing incentives for agriculture sustainability through participatory approaches, particularly regarding low-cost farming, storage of food, product diversification, intercropping, cross cropping as well as market chain promotion, weather forecast, etc.

The wildlife loss compensation guideline 2080 (GoN), looks quite indifferent to high mountain agriculture and livestock (We strongly recommend for its revision because high

mountain people certainly need more incentives against human wildlife conflict mainly for wildlife depredation and crop raid as they have limited livelihood options in the region). There is a huge potential of harvesting high value medicinal plants such as ***Jimbu*** (*Allium hypsistum*), ***Ban lasun*** (*Allium nepalense*), ***Guchhi chyau*** (*Morchela esculenta*), Chiraito (*Swertia chirata*), etc., which are relatively at low risk to wild animals.

An efficient and handy conservation finance mechanism must be developed to promote agrobiodiversity conservation in high mountains of Nepal. This could be the collaborative funding from stakeholders including federal, provincial, and local governments, conservation partners (WWF, IUCN) and tourism entrepreneurs, as a direct subsidy to farmers because agrobiodiversity and human existence at high mountain areas are highly critical for all the stakeholders.

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[13] Agreed and will complete within June End (Advisor/ Mentor: Dr. Devendra Gauchan and Dr. Madhusudan Bhattarai)
[14] Agreed and will complete within June End (Advisor/ Mentor: Dr. Devendra Gauchan and Dr. Madhusudan Bhattarai)
[15] Probably complete within June End (Advisor/ Mentor: Dr. Devendra Gauchan and Dr. Madhusudan Bhattarai)
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