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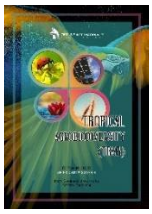
Tropical Agrobiodiversity (TRAB)

DOI: http://doi.org/10.26480/trab.01.2025.01.06

ISSN: 2716-7046 (Online)
CODEN: TARGCA



RESEARCH ARTICLE

REHABILITATION OF AGRO BIODIVERSITY IN KARNALI RIVER BASIN OF NEPAL

Janak Pant, Prava Dawadi

Department of Agronomy, Agriculture and Forestry University, Bhansi-18, Bheemdatt, Kanchapur, Nepal.
****Corresponding Author Email: Janakpant500@gmail.com***

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ARTICLE DETAILS

Article History:

Received 17 October 2024
Revised 21 November 2024
Accepted 29 December 2024
Available online 23 January 2025

ABSTRACT

Loss of biodiversity has been one of the major challenges of Karnali river basin. So, an experiment and discussion were conducted to determine various methods in rehabilitating agricultural biodiversity in Mugu and Jumla districts of Karnali basin from January 2021 to January 2024. Randomized Complete Block Design (RCBD) method was used to make comparison between indigenous versus modern method of seed conservation, climate smart versus modern method of farming, water resources in soil: cement tank versus cement tank, compost manuring versus chemical fertilizer, crop diversification versus single cropping, improved shed versus non-improved shed and use of traps versus chemical pesticides. Focus Group Discussion (FGD) was carried to determine information in local seed promotion (seed bank, seed treatment). Eco-farming (Ecosystem balancing, Perma-garden), socio-ecological management, agro-biodiversity promotions, and policy interventions. Indigenous or climate smart farming methods or seed conservation, application of internal resources such as composts, promotion of local seed through seed banks or seed treatment, socio-ecological biodiversity management including promotional intervention of agricultural biodiversity and strengthening government policies have found viable and effective method to rehabilitate agricultural biodiversity in Karnali river basin of Nepal.

KEYWORDS

Agro-biodiversity, Climate, Chemical, Eco-farming, Mini-plots, Seed banks

1. INTRODUCTION

Agro- biodiversity is a component of biodiversity which is the combination of life forms and their interactions with one another, and with the physical environment which has made the earth habitable for humans. Biodiversity in agricultural ecosystems provides for our food and the means to produce it. The variety of plants and animals that constitute the food we eat are obvious parts of agricultural biodiversity (Jarvis et al., 2007). Crops and livestock that we grow and rear to consume ourselves and sell surplus are the true agrio-biodiversity. It is only recently through the Convention on Biological Diversity that the world recognized the importance and significant contributions of agro-biodiversity in the functions of agro-ecosystems. In the international policy arena, agricultural biodiversity was addressed for the first time in a comprehensive manner by the conference of parties of the CBD (Convention of Biological Diversity) in 1996 (Jarvis et al., 2007).

The CBD program of work on agricultural biodiversity, which was subsequently developed and adopted in 2000, recognizes the multiple dimensions of agricultural biodiversity and the range of goods and services provided. Nepal is mountainous agricultural country, where crop cultivation ranges from 60 m (in Kechana Kalan, Jhapa where rice is grown) to 4700 m (in Khumbu, Solukhumbu where potato is grown) altitude. Small-scale farmers in Nepal since time immemorial have nurtured and maintained diverse agrobiodiversity resources for their immediate food needs and survival. Several types of crop varieties and animal breeds are domesticated, selected, maintained, and conserved over generation by farmers in different ecological regions, farming systems and social contexts. It is estimated that more than 90% of the seed required in Nepal are met through this type of informal seed system (Baniya et al., 2003; Gauchan et al., 2003; ADB/MoF 2010). Karnali is rich in agricultural biodiversity. Jumli Marshi rice (*Oryza sativa* variety japonica) is an indigenous and important cold tolerant summer field crop in Jumla (Paudel, 2011; Acharya, 2019). Numerous agriculture biodiversity prevails in remote and inaccessible parts of river basin.

Rapid loss of agrobiodiversity is now occurring worldwide, as an indirect result of population growth in the developing world and the high per capita consumption of natural resources in the industrialized world, affecting the production of food, fuel, and fiber and many ecological services such as those supporting water supplies, health, and wildlife habitat. Most (75%) of the world's poor people live in rural landscapes and will be especially vulnerable to these changes (WRI, 2005). Changes in land use and agricultural intensification have been two of the most important drivers of biodiversity loss in both natural and agricultural productions systems (MA, 2005). Human induced activities majorly contribute in agro-biodiversity loss. Trend of loss and threats in such resources have increasing day by day.

Reliance on biodiversity-based agriculture and ecological intensification requires investing in the five key livelihood resources: human, social, natural, physical, and financial assets (Scoones, 1998). Successful organic farm management has used the environmental knowledge of insects to recruit them as allies in terms of maintaining and preventing their natural resource base and reducing the chances of them becoming harmful (Culliney and Pimentel, 1986). Application and reintegration of local resources such as botanical pesticides, farmyard manure, green mulching, technology have tremendous impact to improve loosed agro-biodiversity. Many organisms in the soil rely on the organic matter. A rich supply of diverse source of organic matter generally supports presence of wider spectra of organisms (Gomiero et al., 2011). Selection of suitable plant varieties and animal breeds increases and promotes biodiversity.

According to a study, the use of a suitable variety increases the yield by 10-

Quick Response Code	Access this article online	
	Website: www.trab.org.my	**DOI:** 10.26480/trab.01.2025.01.06

Cite the Article: Janak Pant, Prava Dawadi (2025). Rehabilitation Of Agro Biodiversity In Karnali River Basin Of Nepal . *Tropical Agrobiodiversity, 6(1):01-06.*

35%. Another more important feature of manure is that they influence the texture of the soil and enrich it with organic matter (Mazid and Khan, 2015; Darwish et al., 1995). Timely utilization of manure and livestock by-product increase health of crop and consumer maintaining degraded ecosystem. Ex situ conservation is another technique of conserving all levels of biodiversity outside their natural habitats through various techniques such as zoos, aquariums, botanical gardens, and gene banks (Borokini et al., 2010). It plays a key role in communicating problems, raising awareness, and gaining broad public and political support for conservation and breeding activities of endangered species. several stakeholders are actively working on biodiversity conservation through ex situ conservation strategies through the establishment of gene banks, botanical gardens, and zoos (Zegeye, 2016).

However, for rehabilitating agricultural biodiversity a comprehensive study is necessary. The exploitation and loss of agricultural biodiversity have been one of the major challenges in Karnali river basin. In this study various climate resilient techniques to promote local seed, eco-farming, socio-ecological richness, management of natural resources, plant protection & government policy opportunities with promotional interventions were assessed to identify level of effectiveness in rehabilitating ago-biodiversity.

2. Materials and Methods

To determine effective methods of rehabilitating agricultural biodiversity field experiments and discussion were carried out in Mugu and Jumla district from January 2021 to January 2024.

2.1 Research design

Randomized Complete Block Design (RCBD) method was used to make comparison between various methods of farming for three years. Focus Group Discussion (FGD) was carried to determine different aspects of agriculture biodiversity.

2.2 Data and information collection methods

2.2.1 Experimental field

This includes comparison between indigenous vs. modern method of seed conservation, climate smart vs. modern method of farming, water resources in soil: cement tank vs. cement tank, compost manuring vs. chemical fertilize, crop diversification vs. single cropping, improved shed vs. non-improved shed and use of traps vs. chemical pesticides.

2.2.2 Discussion

Both primary and secondary sources were used to generate information in local seed promotion (seed bank, seed treatment), Eco-farming (Ecosystem balancing, Perma-garden), socio-ecological management, agro-biodiversity promotions, and policy interventions.

2.3 Research and analysis process

2.3.1 Conduction of field experiments

Small & uniform size fields were prepared, and each two mini plots were used to compare the research attributes. Process started with (land preparation) clearing, plowing, manuring, sowing, weeding, irrigation and to the harvesting. Each two mini plots prepared to contrast indigenous vs. modern method of seed conservation, climate smart vs. modern method of farming, water resources in soil: cement tank vs. cement tank, compost manuring vs. chemical fertilizer, crop diversification vs. single cropping, improved shed vs. non-improved shed and use of traps vs. chemical pesticides.

Seeds were produced and conserved in farmers own home in indigenous method for next season while produced seeds sold in near market and bought seeds for next season for sowing or planting in modern method where production was compared in both methods in next year. In climate smart farming various local inputs such as ash, cows' urine (fertigation), green manuring, legume as boarder cropping, etc. were applied to grow vegetable crops while chemical pesticides, vitamins and chemical fertilizer were applied as a part of modern farming system. After the third year of cultivation production in both the mini plots were assessed with previous years.

Crop production in the field of water harvested by soil: cement tank and concrete tank were compared in two mini-plots. The comparison continued for three years. Homemade manures were applied in one plot to compare with sole chemical fertilizer applied in the next plot in compost manuring vs. chemical fertilizer attributes.

The contrast continued for three progressive years. Similarly, relay cropping was carried in one mini plot while the next plot land remained fallow for only next season, i.e., second year (later the soil was tested in both field), and production of vegetable was compared in third year in both the mini plot. Types of sheds (livestock) were assessed in terms of crop productivity. Finally, yellow sticky traps were used around one mini-plot of cabbage while insecticide was applied in another mini plot to compare the production.

2.3.2 Primary and secondary data

Prepared questionnaires were asked to farmer groups regarding local seed promotion status & consequences (seed bank, seed treatment), ecological farming status (Ecosystem balancing, Perma-garden), socio-ecological management (conservation of agrobiodiversity, belief and social connectivity, and applications), promotional interventions of agro-biodiversity through fair, exhibitions, local market, cultural shifts, exposure and exchange visits (with their importance and practices) and policy interventions of government bodies. Secondary information collected from literature, government leaflets and books, internet, etc.

2.4 Statistical Analysis

The primary and secondary data collected from the field was first coded and entered in SPSS data sheet and analysis was done by using computer software packages; Statistical Package for Social Science (SPSS) version 21. Means & frequency distribution analysis were also carried.

3. Results and Discussions

3.1 Indigenous vs. Modern method of seed conservation

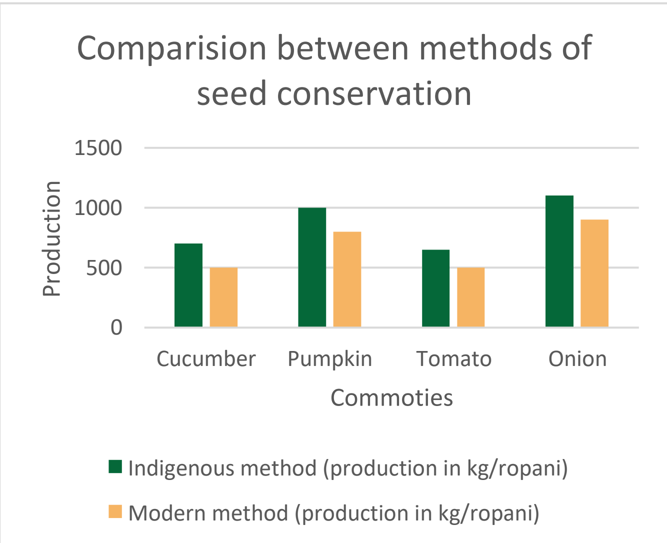

Figure 1: Comparison between methods of seed conservation

It was observed that production of onion was highest with 1100 kg ropani^{-1} through indigenous method of seed conservation followed by 900 kg ropani^{-1} in onion through modern method of seed conservation. Pumpkin, cumber & tomato produced 1000 kg ropani^{-1}, 700 kg ropani^{-1} & 650 kg ropani^{-1} through indigenous method of seed conservation followed by 800 kg ropani^{-1} in pumpkin and uniform of 500 kg ropani^{-1} in cumber & tomato through modern method of seed conservation (Figure 1). Men and women have great knowledge in seed, and their local conservation, and was revealed great quality and yield of seeds from conserved than purchased from market (Kothari, 2003).

3.2 Climate smart vs. modern method offarming

Table 1: Climate smart vs. modern method of farming

	Tomato (First year)	**Onion (First Year)**	**Tomato (Second year)**	**Onion (Second Year)**	**Tomato (Third year)**	**Onion (Third Year)**
Climate smart method (production in kg ropani^{-1})	500	900	450	890	500	920
Modern method (production in kg ropani^{-1})	600	1100	550	950	400	750

It was observed that production of tomato & onion in first year through the application of climate smart technique was 500 kg ropani^{-1} & 900 kg ropani^{-1} in comparison with 600 kg ropani^{-1} & 1100 kg ropani^{-1} produced from same commodities in same year through modern method of farming. Similarly, in second year the production of tomato and onion from climate smart method observed as 450 kg ropani^{-1} & 890 kg ropani^{-1} in comparison with 550 kg ropani^{-1} & 950 kg ropani^{-1} for same commodities in the same year through modern method of farming. Finally in third year of cultivation the production through climate smart method in tomato and onion observed as 500 kg ropani^{-1} & 920 kg ropani^{-1} in comparison of 400 kg ropani^{-1} & 750 in same commodities and year through modern method of farming respectively (Table 1).

Different studies have suggested cows' urine (fertigation), green manuring, legume as boarder cropping, etc. when applied as a resources of climate smart techniques to grow crops have almost constant production in each progressive years while chemical pesticides, vitamins and chemical fertilizer applied as a source of modern technique of farming have resulted gradual decline of production. The productive inputs increase crop productivity directly in initial time, while the damage control agent indirectly & later enhancing low crop yield by reducing the losses to pests (Lichtenber and Zilberman, 1986; Lansink and Carpentire, 2001).

3.3 Water from soil: cement tank vs. cement or concrete tank

Table 2: Differences in production with application of water from social:cement tank vs. cement tank

	Tomato (First year)	Onion (First Year)	Tomato (Second year)	Onion (Second Year)	Tomato (Third year)	Onion (Third Year)
Water from soil:cement tank (production in kg/ropani)	400	850	420	830	445	870
Water from cement or concrete tank (production in kg/ropani)	400	800	380	720	350	667

The production in tomato and onion noticed 400 kg ropani^{-1} & 850 kg ropani^{-1} in first year, 420 kg ropani^{-1} & 830 kg ropani^{-1} in second year, and 445 kg ropani^{-1} & 870 kg ropani^{-1} in third year through the application of irrigation from soil:cement tank remaining other inputs constant. Similarly, the production of tomato and onion noticed 400 kg ropani^{-1} & 800 kg ropani^{-1} in first year, 380 kg ropani^{-1} & 720 kg ropani^{-1} in second year, and 350 kg ropani^{-1} & 667 kg ropani^{-1} in third year through the

application of irrigation from cement or concrete tank remaining other inputs constant (Table 2). The study agrees with various past research that external inputs slowly and gradually impact or decline crop production and soil productivity.

3.4 Compost manuring vs. chemicalfertilizer

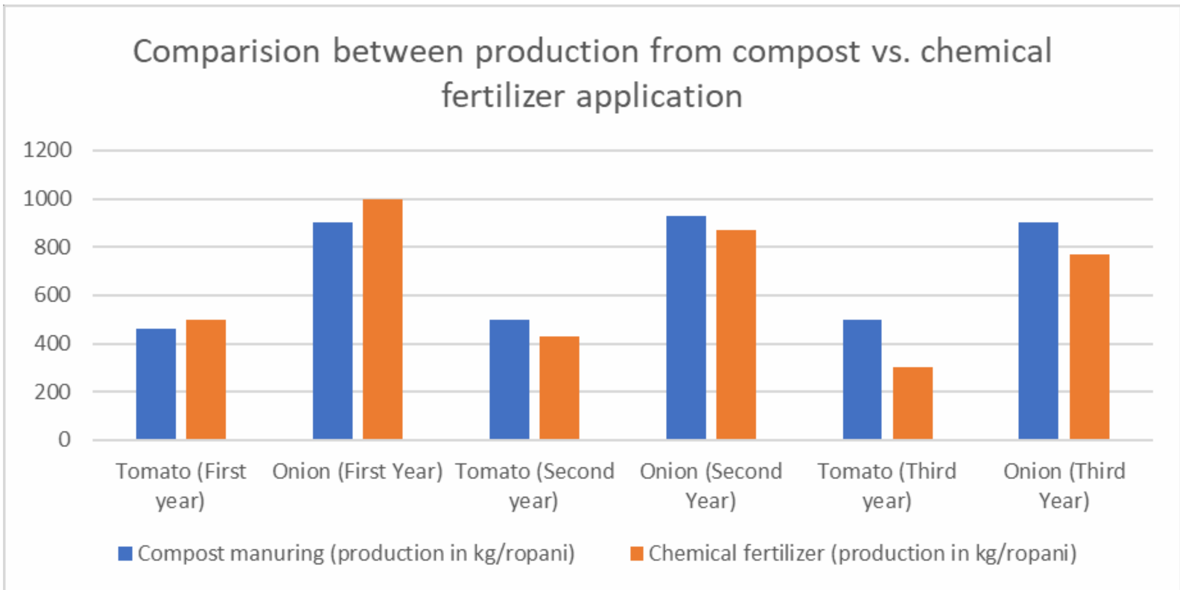

Figure 2: Production with application of compost vs. chemical fertilizer

From the study it was assessed that the production in compost manuring (remaining other factors constant) mini plot for tomato and onion were 460 kg ropani^{-1} & 900 kg ropani^{-1} in first year, 496 kg ropani^{-1} & 930 kg ropani^{-1} in second year, and 500 kg ropani^{-1} & 900 kg ropani^{-1} in third year. Similarly, the production in mini plot of chemical fertilizer application was assessed 500 kg ropani^{-1} & 1000 kg ropani^{-1} in first year, 430 kg ropani^{-1} & 870 kg ropani^{-1} in second year, and 300 kg ropani^{-1} & 770 kg ropani^{-1} in third year for the same commodities remaining other factors constant (Figure 2). The results coincide with numerous past studies.

It was observed that production of tomato & onion in first year through

3.5 Crop diversificationvs. single cropping

Table 3: Crop diversification vs. single cropping

	Tomato (First year)	Onion (First Year)	Tomato (Third year)	Onion (Third Year)	Soil test in average (inorganic nitrogen content, mg-1 kg)
Diversified cropping (production in kg ropani-1)	500	925	500	900	10
Single cropping or fallow land (production in kg ropani-1)	500	1000	320	790	6

In the diversified crop field, the production was identified as 500 kg ropani^{-1} & 925 kg ropani^{-1} for tomato and onion in the first year followed by 500 k kg ropani^{-1} & 1000 k kg ropani^{-1} for same commodities in the same year through single cropping mini plot. In third year, the production of tomato & onion was identified as 500 kg ropani^{-1} & 900 kg ropani^{-1} through diversified or relay cropping method which was followed by 320 kg ropani^{-1} & 790 kg ropani^{-1} from the same commodities in the same year through fallow land in second year. The laboratory test of soil revealed average inorganic nitrogen content as 10 mg^{-1} kg in diversified crop field followed by 6 mg^{-1} kg in fallow land mini plot field (Table 3). Fallow duration and the ratio between cropping and fallow period strongly influence soil properties, crop yields and sustainability of cropping (Szott et al., 1999; Samake et al., 2005; Diekmann et al., 2007). The gap between cropping duration results declines in production and soil arability.

3.6 Improved shed vs. non-improved shed

It was observed that the production of vegetables such as onion, tomato, potato, and green leafy vegetables through the application of manure and local fertilizer from improved shed was influential compared with non-improved shed of livestock.

3.7 Traps vs. chemical pesticides

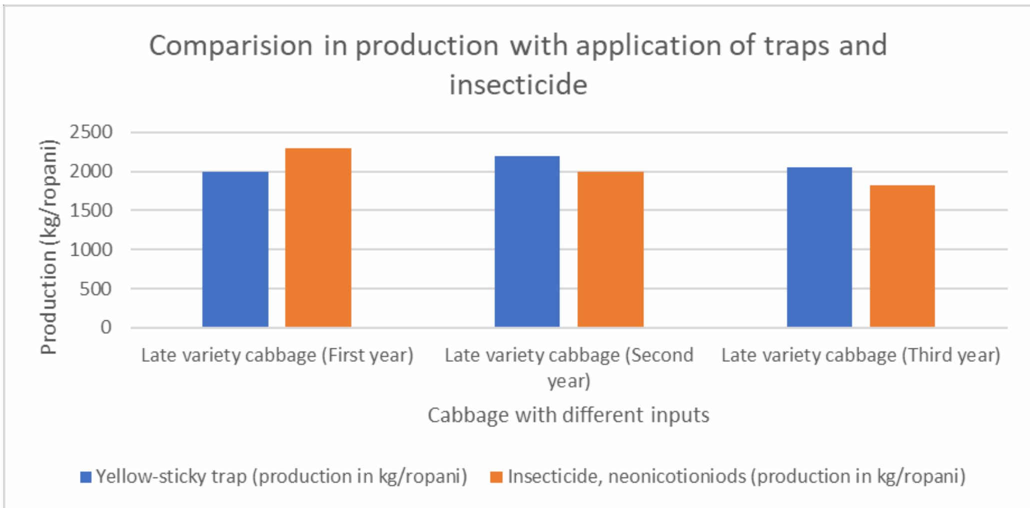

Figure 3: Traps vs. chemical pesticides

It was observed that the production of cabbage (early variety) in first, second and third year with application of yellow sticky trap were 200 kg ropani^{-1}, 2200 kg ropani^{-1} & 2050 kg ropani^{-1}. Similarly, with the application of neonicotinoids as insecticide was found the production of cabbage equals to 2300 kg ropani^{-1}, 2000 kg ropani^{-1} & 1820 kg ropani^{-1} in first, second and third year of field experiment. Such studies were supported by much past research (Figure 3).

3.8 Local seed promotion methods (seed banks and seed treatments)

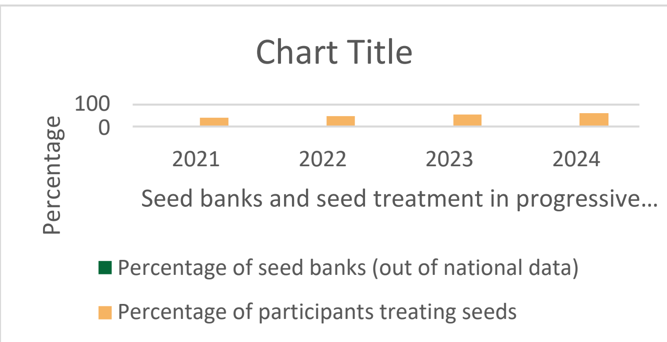

Figure 4: Local seed promotion

From the FGD it was determined that percentage of seeds banks decreased from 4 to 1 from 2021 to 2024. It was also identified that percentage of participants increased from 40 (out of 25) to 70 (out of 25) from 2021 to 2024 in treating and conserving their seeds (Figure 4).

3.9 Ecological farming status (Ecosystem balancing, Perma-garden)

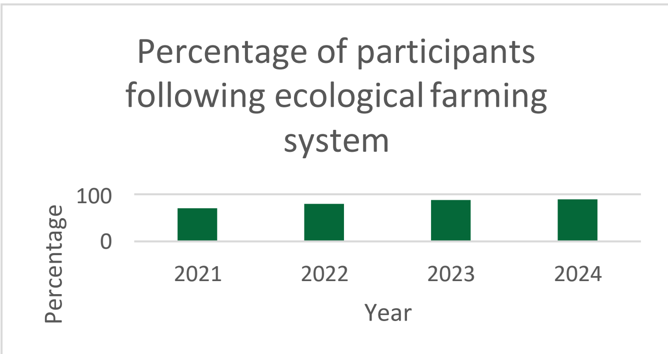

Figure 5: Status of Ecological farming

The trend of participants following ecological farming system was observed increasing from 70% (out of 25) to 89% (out of 25) dated 2021 to 2024 (Figure 5). The data suggest that there is an increase in organically

& eco-farming cultivable land in 2012 by 0.5 percent, and around 1.9 million producers are engaged in the organic farming world wise (Willer and Lernoud, 2014).

3.10 Socio-ecological management (conservation of agrobiodiversity, belief and social connectivity, and applications)

It was found that almost all the participants have cultural and religious connectivity with agricultural biodiversity. The local people believe, worship, and co-share their valuable time within the complex community system. The trust has helped to manage and conserve existing agricultural biodiversity with increased bonding and inter-relationship amongst the community people. An investigation reflected few factors (attitudes; values; environmental concern) which influence local people and farmers to adopt and rely on agricultural biodiversity (Lokhorst et al., 2011). Local people have great connectivity with local resources of agricultural biodiversity and lead towards sustainable system.

3.11 Promotional interventions of agro-biodiversity through fair, exhibitions, local market, cultural shifts, exposure & exchange visits, and policy interventions of government bodies.

Through the rigorous discussion with local people, it was identified that promotion of agro-biodiversity has influenced them to follow the principles and practices of agrobiodiversity. Almost all the participants convinced in importance of exhibitions, fair, etc. to contribute agro-biodiversity management and rehabilitation. In addition, almost 50% respondents shared that they are unaware in policy interventions of government bodies regarding agricultural biodiversity. Such activities are in line with numerous past studies to rehabilitate the agro-biodiversity. The study and assessment clearly show that indigenous or climate smart farming methods or seed conservation, application of internal resources such as composts, diversified cropping, managed shed and non-pesticidal insect control methods, promotion of local seed through seed banks or seed treatment, socio-ecological biodiversity management including promotional intervention of agricultural biodiversity and strengthening government policies are effective methods to rehabilitate agricultural biodiversity in Karnali river basin.

3. Conclusion

Loss of agricultural biodiversity has been one of the great challenges in the region. This has a tremendous & ultimate impact in crop productivity and food system. An experiment and discussion were conducted to determine effective methods of rehabilitating agro-biodiversity in Karnali river basin of Mugu and Jumla district from January 2021 to January 2024. Randomized Complete Block Design (RCBD) method was used to make comparisons between various methods of farming. Focus Group Discussion (FGD) was carried out to determine different aspects of agriculture biodiversity. Small & uniform size fields were prepared, and each two mini plots were used to compare the research attributes. Each two mini plots prepared to contrast indigenous vs. modern method of seed conservation, climate smart vs. modern method of farming, water resources in soil: cement tank vs. cement tank, compost manuring vs. chemical fertilizer, crop diversification vs. single cropping, improved shed vs. non-improved shed and use of traps vs. chemical pesticides. Farmer groups were surveyed to generate information on local seed promotion (seed bank, seed treatment), Eco-farming (Ecosystem balancing, Perma-garden), socio-ecological management, agro-biodiversity promotions, and policy interventions. The conventional methods were found positive and result oriented. Indigenous or climate smart farming methods or seed conservation, application of internal resources such as composts, promotion of local seed through seed banks or seed treatment, socio-ecological biodiversity management including promotional intervention of agricultural biodiversity and strengthening government policies have found effective methods to rehabilitate agricultural biodiversity in Karnali river basin of Nepal.

Acknowledgements

I would like to express my sincere gratitude to my supervisor, Asst. Prof. Suraj Karki for his insightful support, invaluable guidance & supervisions. I always keep in mind that kind support I got from the staffs of municipalities, and farmer groups of Karnali Province. I think this entire work was impossible without support of my family. I am indebted to my parents for all kind of desired supports. Lastly, I must express my thanks to all known and unknown helping hands from stakeholder team, and all others respected persons.

Funding source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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