

Land resource management and livelihood transformation in mountain region: A case from Chandanath municipality, Mugu, Nepal

Abstract

Land resources i.e., land, water, bush and grass land and forest are important livelihood resources which have generally become a major socioeconomic issue in the mountain region of Nepal. Scientific management of available land resources have currently attracted to the national and regional as well as local attention to prepare database for exploring the potencies of land resources of livelihood transformation of remote regions attempting land use planning to use land use zones accordingly. This paper tries to provide land use database of land use planning and land use classification at the municipality level in GIS environment. The main focus is on the land use spatial endowments and planning for the paradigm shift of traditional rural lifestyle into modern land informatization development, public participation, and sustainable development by adopting evolutionary path related to ecosystem protection, climate and natural change, agricultural development, and digital land resource management. The findings of the study reveal that strengthening integration within disciplines, emphasizing on policy assessment from government level, farmers capacity development for sustainable land use and action research for proper utilization of land resources are prime focus of the day to meet the national objectives of prosperity, peace and sustainability.

Keywords: land use plan, soil nutrients, bush and grass land, high altitude farming, action research, and aromatic and medicinal herbs

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Introduction

Land resources are the bases for human civilization which are renewable in nature and provide materials, power and space for human development since the time of immemorial. During the modern period of human civilization, the world's land-use patterns have been rapidly changed due to the rapid increase of human needs with being increased science and technology. Various land use models and practices have been implemented in different spatial contexts to reasonably plan land use and allocate the limited land resources effectively.¹ Land use planning/ land zoning refers to the reasonable preparation, arrangement and allocation of future land use to enable more significant comprehensive benefits in a specific area.² Thus, land-use plan, the systematic assessment of the potential of land resource is the multi criteria evaluation of alternatives for land use aiming at sustainability, improved land management and improved economic and social conditions. Its focus to select and put into practice those land uses that could best meet the needs of the national economy and the people while safeguarding resources for the future and it has to be carried out in a series of steps and based on dialogue and a balance of interests among all parties involved.³ In the scientific of land use planning, acquisition of land data in proper way is very essential which is possible through spatial information analysis, and dynamic as well as participatory monitoring mechanism in which locals have key role. Modern spatial information technologies, such as geographic information system (GIS) environment has significant for the use of data and information in the decision-making environment since the 90s at global level.⁴ Now, GIS is being helpful tool for planners evaluating the preferences of various relevant standards and evaluation factors and the potential of different land uses. Spatial information system has further used in the field of land use planning has gradually matured and evolved in multiple directions for example

landscape planning, landscape connectivity, and management. The actual changes in land resources can be updated in full band with the accuracy of data acquisition and further strengthen land resource management. recently, the informatization development model for this application is relatively high and assessment is necessary to discover other information search methods to update the existing measures and database applications. Alemu⁵ pointed out that in developing countries like Ethiopia, agriculture-based poor economies with fast-growing populations, degradation of land resources pose a serious threat in meeting the growing demand to food production. Sustainable land management pursues to complement the often-conflicting objectives of intensified economic and social development while sustaining and intensifying the ecological and global life sustenance roles of the land resources. The sustained improvement of land management requires a better understanding of the interrelationships and coordination mechanisms in linking ecological, social, cultural, political and economic dimensions by all stakeholders from local to international levels. Therefore, more consideration should be given to the effects of sustainable land management on maximizing agricultural productivity and production.⁶ There are ample opportunities in mountain farming for the sustainable development with its small-scale character, diversification of crops, integration of forests and husbandry activities, and low carbon footprint. Mountain agriculture has evolved over the centuries in an often harsh and difficult environment. The lifestyles and beliefs of mountain communities have inspired them to seek sustenance from the land but also to conserve the natural resource base and ecosystem services vital to downstream communities both rural and urban.⁷ However, recent trends in global development have significantly reduced the resilience of mountain ecosystems. Increasing disasters of climate change, deforestation, desertification, market integration as well as changes in human values and aspirations are all taking a heavy toll on mountains and mountain development.

However, there is an increasingly aware of green quality and organic products in global level and mountain agriculture can provide high-value and high-quality products that cater to increasing market demand and generate income for local communities. This growing trend of mountain farming presents an opportunity for mountain communities to receive greater support and specific policy interventions to promote mountain livelihoods activities within the realms of agriculture, mountain orchid, forestry, pastoralism, eco-tourism and aquaculture. The Prime Minister -Agriculture modernization Project (PMAMP) of Nepal emphasizes to recognize and support the contribution of smallholder farm and nonfarm activities of mountain biophysical characteristics to food security, poverty eradication and achieving the sustainable development goals (2015-2030).⁸ To tap the potential of mountain agriculture fully, mountain communities can benefit from targeted support for strengthening the value chain from resource management planning and producing to processing and marketing. An enabling policy environment that encompasses tailored investments, business development and financial services are needed to improve mountain farmers' access to resources and enhance their capacities to generate income. Support to mountain farming and the creation of new, diversified employment, training and educational opportunities are to be prioritized in mountain development policies. Improving the livelihoods of mountain communities can check to migrate to lowlands, cities or elsewhere. The loss of traditional landowners could leave mountain areas to those who will not have the same knowledge or commitment to use the land in a sustainable way, meaning increasing risk for key ecosystem services such as water and soil management, and biodiversity conservation, which could have add-on risks that could ensure mountain environment and also the man-environment relation in the low lands.⁹

Discussion herewith related to mountain farming and livelihoods it is important to use and manage the available land resources through scientific land use planning in the active participation of local communities, local government authorities and land resource experts. Regarding this, Government of Nepal has initiated to manage land resources by maintaining accuracy and uniformity of the preparation of land resources maps at the urban and rural municipal levels under the National Land Use Act 2020. Initially, it undertaken under the Land Use Policy, 2012 which was re-directed in 2015 after the earthquake for the safe and secure settlement along with the environmental protection and ensuring of food security. The Land Use Act 2020 has directed to the Topographic Survey and Land Use Management Division (TSLUMD) to make changes on the specification to address the felt need of the nation and has designed ten land use classes to update the national level specifications for the preparation of urban and rural municipal levels land use maps, database and reports. The land Use Act 2020 also directs to mention eleven area in land use plan prepared by rural or urban municipalities.¹⁰ The main purpose of paper is to identify and classify the land utilization aspects and dimensions based on geospatial characteristics, soil quality, land capability, land suitability, and the state-of-art-of the technology to maximize the level of land resources utilization that reflect on livelihood improvement, income generation and employment in cash crops, horticulture or herbal and aromatic plant cultivation, production and marketing with sustainability of available resources in Chhayanath Rara Municipality.¹¹ This study is first attempt to rigorous analysis of nature and strengths of available resources to improve the livelihood of mountain community in Nepal. The study adopts contextual approaches to understand and contextualized social, political, economic and ecological contexts at multiple scales at micro level to examine institutional constraints, social and economic barriers, and underlying historical processes and the differential capacities and

sensitivities.¹² This approach to explore the multidimensional nature of political dimensions on resource management in the trans-Himalayan region with due consideration of environmental degradation and climatic stressors (Figure 1).

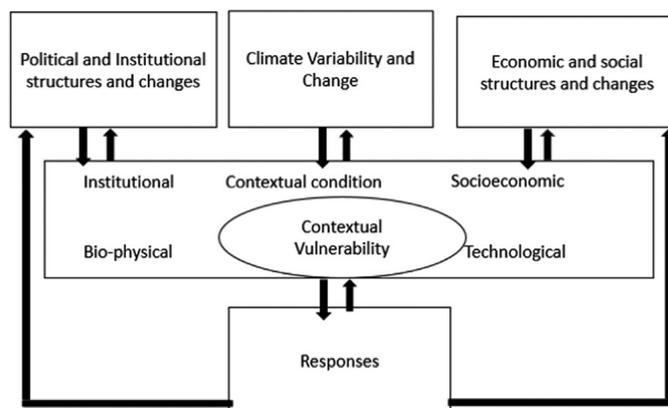


Figure 1 Contextual approach to social vulnerabilities adopted from Murphy.¹⁵

The methodology on data collection was developed through a number of consultations among multidisciplinary research team involved in land resource mapping assessment. The approach adopted for field data collection was a participatory resource assessment that considered multidimensional and contextual aspects of land resource capability and socio-economic vulnerabilities during the field inquiry. The blend of quantitative data available through secondary sources is used as much as possible with qualitative data collected to interpret resource strengths and environmental vulnerabilities in a spatial context. The study further concentrated to integrate biophysical information on climate change trends, impacts and risks with local perceptions, experiences, insights of the community to get a comprehensive understanding of multiple drivers (like population, poverty, inequality, marginalization, lack of economic and infrastructural development, market technology, urbanization, push and pull factor of migration) and conditions that determine differentiated vulnerability for the communities living in the study areas. Using multi criteria decision methods in GIS (software Arc GIS and satellite image 2020) environment, the assessment has concentrated to classify land use zones into agriculture, forest, residential, public usages, industrial corridor, special economic zone, sensitive area for national security, cultural and religious importance area, environmental and disaster sensitive area, river/stream/wetland/lake area and professional areas among the existing settlement locations. The proposed land use (zoning) has suggested to be carried out in sustainable way which could balance the environment, ecology, and economy at the municipal level and meet the national policy of sustainable land resource management and land utilization. Various thematic maps have been prepared based on the Top sheet taken in 1996 by Survey Department of Nepal.

Study area

Chhayanath Rara Municipality of Mugu district locates in mountain and high mountain region. The spatial area of the municipality comprised by covering the Rara watershed area which is covered by the high hills, hilltop and mountain range. Mountainous type of physiography of the municipality is unique in terms of geophysical, biological, hydrological and ecological characteristics. It rising gradually from the south-west to north east. Mountain topography composed of low grade metamorphic and sedimentary rocks and debris to north-east high mountain made of high grade metamorphic,

sedimentary and igneous rocks, which eroded and weathered over the last 40 million years as the Himalayas formed. The erodible nature of these conglomerates and sandstone, coupled with the steep terrain and residual red and brown silt loam soil contribute to the fragile nature of the almost geophysical characteristics of the municipality which characterized as the mountain relief features. Geographical features of municipality comprised by low land, basins, gorge, ridges, hilltops, mountain and high mountain. The spatial coverage of the municipality accounts of 48045.44575-hectare (480.45 sq km) equivalent to 25.88 percent geographical area of the Mugu district and consists of hills, ridges steep land slopes, gorges, large spans of streams. The altitude

ranges from 2000meter to 6883 meters with 4883-meter altitude variation from lowest to highest points of the municipality. The geographical extent of the municipality is from 81°58'48.75" east to 82°19'0.54" eastern longitudes and 29° 24'23.71" north to 29° 39'59.65" northern with having an area of 480.45sqkm with 30.7km north-south length and 27.02 km east-west width (Figure 2). The lithology of high Himalaya includes Tethys sediment deposits of high mountain, and formation with metamorphic shales, slates and high-grade metamorphic rocks with greenish-grey phyllites of Rani Matta and Nuwakot formation (Figure 3).

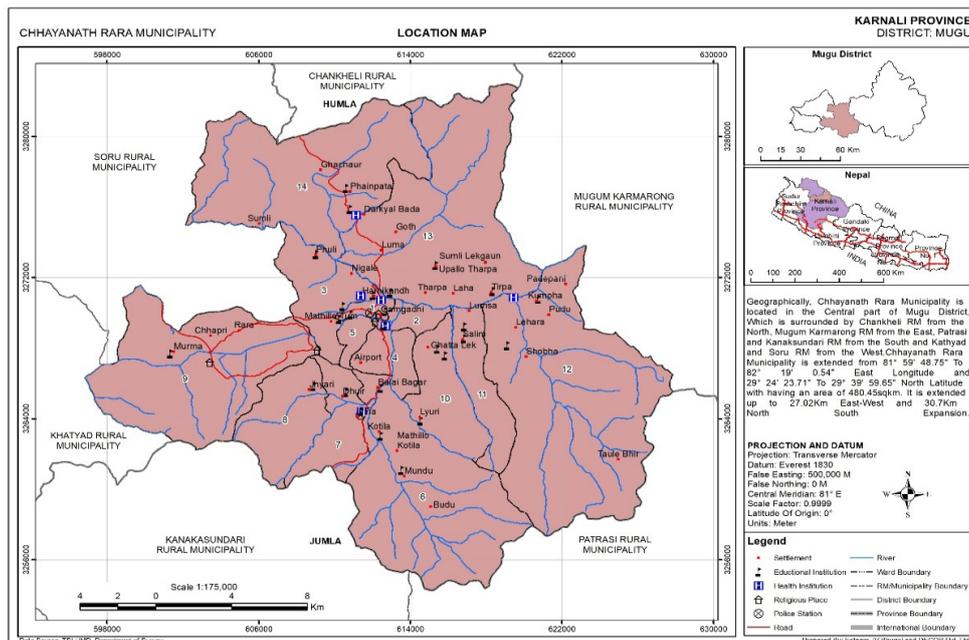


Figure 2 Location of the study area.

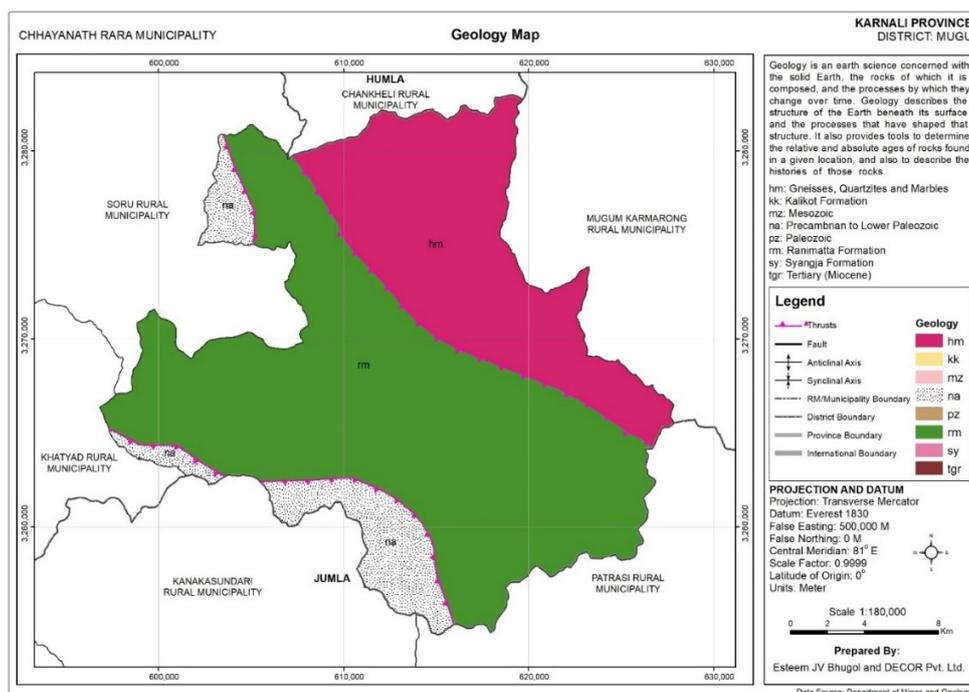


Figure 3 Geological structure of the study area.

The land system of the municipality is mountain cultivation with level terraces upland cultivation 78.90 percent and sloppy upland 21.10 percent where 80 percent land is under steeply to very steeply sloping hilly and mountainous terrain, 13.13 percent steeply to very steeply sloping mountainous terrain, and 6.87 percent moderately sloping mountainous terrain.

Soil quality

Alfisol, Entisol, Inceptisol and Mollisol, ten sub-orders, fifteen great groups and twenty-three sub-great group of soil types were identified based on the morphological, chemical and physical properties of soil acquired from the soil study by digging the soil pit and soil mapping unit level. Considering genetic horizons and soil properties, silt loam, loamy, sandy loam, silty clay types soil found at the sub group level. Based on soil taxonomy system, the Inceptisols occupied 70.02 percent followed by Mollisols 21.37 percent, Entisols 5.12 percent, Alfisols 0.33 percent and 3.16 water body. Based on soil properties such depth, genetic horizons, and fertility characteristics, organic matter on the top soil found medium to low which indicates poor nutrients in soil. Regarding the soil pH, most of the soil was acidic to slightly alkaline with highly acidic (17.23 %) followed by slightly acidic (25.54%) and medium acidic (13.50%). Majority of the soil are silty loam and around 29 percent of land is covered by Rocky Mountains area. There is very low to high level of organic matter with more proportion of land (49.21 %) under high level of organic matter. Nitrogen content ranges from very low to high level of with 25.44 percent in major proportion. Low to very high level of phosphorous content was found with the dominance of very high level of phosphorous (84.00 %) followed by high (11.53 %) and medium (0.09%) level of phosphorus. Potassium level ranges from very high to very low. Around 3.77 percent land have very high level of potassium, 8.67 percent land have high level potassium, 58.55 percent land have medium level and 26.83 percent land have low level of potassium and very few proportions of land have low level of potassium (2.92%). The quantity of nitrogen and phosphorus in soil found low to medium while the amount of potassium found medium to high. Over all the soil in the entire area of the municipality is less developed and marginally suitable for intensive agriculture and suit for crude crop farming agro forest, herbal production and forest extension. It shows that soil fertility assessment has to be the first priority of the local government to maximize the benefits from land resources (Figure 4). Land use zoning of the municipality is designating permitted uses of certain parcels of land by local governments. The local government can further designate various zones for different uses of land, such as agricultural, residential, commercial, industrial, public places, herbal conservation, and tourism infrastructure development. It is a practice of using of land based on mapped zones which separate one set of land uses from another.

Land suitability and land zoning

Suitability ratings for ten land use zones was developed using multi-criteria analysis in a GIS environment. Suitability ratings were based on land capability, present land use, socio-economic and demographic characteristics, opinions of municipal authorities, accessibility to infrastructure and services. Land capability maps developed using GIS based MCA analysis, which incorporate soil parameters, fertility, erosion susceptibility, terrain constraints and surface drainage (wetness). The potential residential and open spaces have been delineated in non-productive lands and nearby already existing residential areas. As per the Nepal Road Standard 2072 92015) a total of 62 meters width is given to highway (50m road and 6m setbacks on either sides), 32m for district and strategic roads (20m

road and 6m setback on each side of the road) and 21 meters R0W road and 3m setback on each side of the road) is given for village roads. For land allocation for residential and commercial, lands which are less suitable for cultivation were given priority. Cultivated land which are already in vicinity of residential areas were also allocated for residential since there are already different facilities like water supply electricity, communication, health, and education are already there. Medicinal and aromatic herbal plant species collection and processing enterprises development is recommended in the area, since there are number of such plant species available areas with consistent facility of electricity, water and foot trails. Most of the areas are not with sufficient irrigation facility. Small and drop irrigation system could be the cost effective for the multiple crop cultivation in a year. Public area is increased and agricultural area is decreased while zoning. This is because of allocation of agricultural, residential areas to right of way (ROW) and open spaces, similarly, new residential and commercial zone in existing agricultural area.

Hazard assessment and vulnerability

There are number of natural hazards with potential risk in future. Land slides, floods, fire and soil erosion are apparent as the main risk in the municipality. 71.27 percent area lies in the medium fire hazard zone, 23.260 percent in low hazard zone and 2.15 percent under high fire risk zone. The most of the area of the study area consists of steep hill slopes and considers as the landslides prone area where 61.81 percent area lies under low landslide risk zone whereas 28.33 percent under the medium landslide risk zone and 7.81 percent under high-risk landslide threat. More than 370 ha land area lies under the flood risk zone in which 3.07 percent under high flood risk zone whereas 15.59 percent under medium flood risk zone and 80.93 percent under low flood risk zone. The entire area of municipality lies in the low seismic risk zone having Peak Ground Acceleration (PGA) value 100 to 400 Gal.

Risk is considered one of the important factors for zoning. Residential and commercial areas are allocated on such land which are under no or low risk of landslides, flooding, river bank cutting, debris flow and fire hazard. Residential and commercial areas are not proposed within the periphery of 200m from forest area, 500m of disaster-prone zone and specified buffer distance of transmission line are adopted. Most of the agricultural areas are safe however some of the agricultural area along the river/streams bed have high risk of flooding and river bank cutting. Every year the villagers lost huge amount of property and human life due to large scale landslides in the different locations of the municipality. Geological faulty line is buffered with 1km distance for preventing the new residential site. Landslides, river bank cutting and water sheds degradation intensively deteriorated biophysical environments which created the problems of livelihood resource degradation and displacement of settlements. Land resources such as soil quality, forest thickness, and water source points continuously depleted, natural resources and natural environment both are degraded day by day and local people have faced the problems of livelihood sources. Most of the area is in high mountain and mountain region highly exposed for landslide, soil erosion and drought as the adverse effects of climate change and most of the steep hill slope and rocky in nature terrain is not suitable for cereal crop and cash crop cultivation but suitable for agro forestry, non-timber forest products, medicinal and aromatic plant cultivation and conservation.¹⁷ Agro forestry area and herbal plant species cultivation and conservation has allocated along the steep hill slope area and riverside which may control the problem of landslides, soil erosion and river bank cutting. Climate change impacts apparent particularly in the crop calendar, natural hazards like landslides, drought, and land,

water and forest resources degradation and subsequently adverse effects on livelihood of the local people in the study area.

Policy assessment for land use zoning implication

Discussion herewith indicates to use available land resources properly through government initiations and local participation to enhance the productivity of the region. So, the first and foremost step has to be focused on small irrigation facility low or river basin area to grow cereal like maize-wheat, rice-potato, millet-apple-vegetables and millet-beans-bock wheat two times in a year that may play a vital role to enhance the life standard of people in the mountain region. Government initiated agricultural pocket area under the Prime Minister Agriculture Modernization Project, apple production pocket area in Rara, Rowa, Talcha and bean production pocket area in Talcha and Karki Bada need to be promoted through mix up of modern technology and traditional wisdom. Beside the targeted pocket area development, rice-maize-millet, millet-walnut and apple-bock wheat in relatively low area, maize-potato, maize-millet, millet-bean, maize-off season vegetable and apple -millet-bock wheat production in middle range and millet-walnut, apple-bean and fodder-herbal production need to be promoted by mixing modern technology and local traditions for increasing the production and productivity of available farm and non-farm resources. For this, emphasis should be on ensuring location -specific innovative and novel practices by combining traditional practices and scientific knowledge for taking multifarious benefits from the program. There is a s high potentiality of medicinal herbal and NTFPs species production in all community forestry groups in Chhayanth Rara Municipality for example Ramda and Chulikot for Kutki, Pachanule, Yarshagumba, walnut, and other herbal plant species as well as non-timber forest products, Chankheli for Phakhanbed, Jangali Lasun, Rosi Chaur, Rara, Rigda, Pipal Pani for grass species so that local farmers have to be encouraged by providing necessary technical and financial supports from federal, province and local governments should have given first priority to use these resources to promote the livelihoods of locals adopting the principles of sustainability(18). Agro-based, medicinal and aromatic herbal plants and non-timber forest product plant species-based entrepreneurship development has to be encouraged in road head settlements. Municipal annual plan needs to prioritize grassland management for sheep farming (meat & wool), honey production, Rara Lake, Rara National Park and Murmatop) for eco-tourism and cultural tourism destinations, Maize- millet-buckwheat- potato-bean and rice-maize-vegetable-fruits (Apple &walnut) production, in middle range of the mountain and herbal plants protection, cultivation and processing in high land area, and herbal processing enterprises development near to road side area for the rapid economic development(growth), social change and ecological stability in the mountain farming community.¹⁹ Location specific greenery, agro forestry, grassland development and forest area extension and disaster risk reduction management actions need to be implemented by applying local skills and techniques in all wards. Physical infrastructure developments are to be designed and execute in such area where ecological and environmental damage could be minimized. So that environmental impact assessment needs to be conducted before extension the physical infrastructure construction works, extraction of river materials from the proposed location and for the establishment of industrial village in the proposed land zoning area. Most of the area is highly susceptible for avalanche, debris flow, rock flow and landslides hazards and various sensitive areas there are number of small settlements are located in scatter form in steep hill

slope, ridges and near the river /stream bank. Thus, the need is to implement integrated settlement development plan in safe area where easy to provide modern facilities and safe from hazards. It is therefore, government has to be developed integrated settlement development plan in proposed land use zoning save area where natural hazards are less, modern social physical facilities can be provided in low cost of development.²⁰ Being zoning criteria are subjective, it is necessary to adopt scientific guideline to develop a micro zoning wherever needed by the local government as prescribed in the Land Use Act 2020. The land resource of the municipality is highly impacted by the climate change and land, forest and water resources are deteriorating trends. Therefore, municipality should follow the scientific land use planning to extent urban area, settlements, physical infrastructures, commercial and public use by properly applying the proposed land use zoning. Land Use Act 2020 could be the most important tool to implement prescribed land use classifications, land use zones and land use development corridor. Therefore, it is essential to formulate land use implementation bylaws and guidelines at municipality level in order to implement the scientific plan of land resources development.

Development of renewable energy technologies and environmental protection are noticed as the urgent task at local level to develop a climate change adaptive capacity, and to contribute for the mitigation measures. Good practices in mountain farming over time and across the region need to be preserved and disseminated. Simultaneously, inappropriate techniques used in mountain environments can quickly lead to erosion, land degradation and even desertification. Thus, innovative techniques and traditional knowledge need to be carefully integrated into modern technology to increase and restore resilience, with the promotion of a repository of successful practices at farm level. Grassland management in public land and agro forestry practices in private land need to extended to promote the commercial livestock farming specially sheep farming for meat and wool production in the high land area of the municipality. Community forest management program needs to emphasize for NTFP, and medicinal herbal species protection, production and processing activities specially pine in Parivan of Bhadai community forest, Kutki and Chiraito in Ramda area of Tharapaka and Chulikot community forests, Pakhanbed in Chankheli community forest, jatamasi and Jnagali Lasun in Chedkhili and Mildanda community forests. Rara lake side Rara National Park and Murmatop need to be developed as the eco-tourism destination for enhancing the livelihoods of local people. Rara Lake side has high potentiality to develop as eco-tourism development through providing basic infrastructure facilities (road accessibility, eco-residential facility and well-trained guide, dissemination of local cultural and hospitality, capacity development of locals to encourage local food production, systematize horse riding services and also encourage private sector to develop the tourist sector. Local government needs to take immediate initiations for the negotiation with Rara National Park to make change policy for the extension of basic infrastructure facilities of tourism in buffer zone area as per the mitigation measures recommended by the environmental impact assessment (EIA) in order to maintain zero environmental pollution, biodiversity degradation no harm in local culture and traditions in and around the lake side, Around the lake side need is to maintain greenery and strictly control free grazing system in the adjoining area of the lake. Existing tourism activities in Rara Lake side are unorganized and not to recorded the contribution of tourism sector in municipal income generation so that there is a necessary to run tourism activities in organized form to visualize the real contribution of tourism sector in municipal resources. Establishment of community-based forest bee farming and honey production network has to be prioritized for sustainable

management of indigenous honey production. Integrated forest and watershed management efforts are required to protect and expand forests, restore wildlife for social benefits.

Conclusion

Climatic condition and soil nutrient of the study area permit to practice maize-millet- potato, maize- wheat- vegetable-bean, rice-maize- walnut cultivation, livestock farming (meat and wool) honey production and medicinal herbal and NTFP production effectively. Therefore, a comprehensive development program needs to set up to increase the productivity of these farm and non-farm production. Agricultural diversification is to be a game changer strategic steps for shifting from traditional substance rural life style into modern and competitive livelihood through implementation of agricultural pocket areas proposed in land use zoning including honey and livestock framing to increase the overall productivity of land resources. Spatial locations in the study which are relatively safe from different kinds of risks like land slides, soil erosion flood and drought and bush fire free sites need to developed for the integrated settlement development. Historical, religious, cultural and ecological sites and locations are suitable to promote for the development of tourism. Most of the fragile land features of the study area has to be intensively managed by adopting eco-friendly physical development, tourism promotion and NTFP based enterprises development activities. Protection of grasslands, forest and extension of agro-forestry including plantation in riversides and road side is also urgent to execute properly to minimize hazard risks and maximize land resource productivity. The agricultural land which is of category III/IV with moderate capability further needs to adopt terraces farming and conservation of biodiversity for livelihood improvement and ecological stability in the mountain region.

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None.

Conflicts of interest

The author declares there is no conflict of interest.

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