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Status, Prospects and Challenges for Non-Timber Forest Products Conservation in Nepal: A Critical Review

Pramod Ghimire*[1], Nabaraj Pudasaini[2], Uchita Lamichhane[3]
[1]Agriculture and Forestry University, Faculty of Forestry, Hetauda, Nepal. Email: pghimire@afu.edu.np
[2]Ministry of Industry, Tourism, Forest and Environment, Bagmati Province, Nepal. Email: nabusaini@gmail.com
[3]Agriculture and Forestry University, Faculty of Forestry, Hetauda, Nepal. Email: uniqueuchita123@gmail.com
**Corresponding author | ORCID: 0000-0002-2925-8844*

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Abstract
Non-timber forest products (NTFPs) consist of goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests. The importance of NTFPs for sustaining rural livelihoods, fostering rural poverty alleviation, enhancing biodiversity conservation, and facilitating rural economic growth is well known in Nepal. In spite of these facts, NTFPs have not received the sustained and systematic support. With the gradual rise in population, unsustainable harvesting and depletion of resources, sustainable management of NTFPs has become a challenge. Similarly, the increasing global demand of NTFPs leads to over-exploitation of these resources that further leads to dwindling and adversely affecting the biodiversity. In this context, this paper intends to explore and analyze the conservation status, prospects and challenges for efficient and sustainable management of NTFPs in the context of Nepal.

Keywords
NTFPs; Livelihood; Sustainable management; Conservation; Nepal

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Introduction

Nepal is well known for its rich biological and cultural diversities. Variability in physiographic and climatic condition has enriched the country with a high diversity of flora, fauna, ecosystems and cultural heritage. Overall, Nepal occupies about 0.1% of the global land mass in which floral diversity harbours 3.2% of the global diversity (MoFSC, 2014). The country is ranked on 25th position of global biodiversity richness and 11th among Asian countries (MoFE, 2018b). The country boasts over 11,971 flora species out of which 284 flowering plants are endemic to Nepal (MoFSC, 2014). Based on various publications related to flora of Nepal, about 5,833 species of flowering plants have been recorded by Koba *et al*. (1994), 6,500 by DoF (2004), 6,973 by MoFSC (2014), and, recently, Rajbhandari *et al*. (2017) have reported 5,309 species under 1,515 genera and 193 families. In total 7,000 species of vascular plants are found in Nepal and more than 2,000 species are regarded as producing the NTFPs, among which 1,624 species are estimated to have medicinal uses (MoFSC, 2012).

Non-timber forest products (NTFPs) are also known as minor forest products (MFPs) and non-wood forest products (NWFPs). There is no uniformity in the use of the term. FAO (1999) has defined NTFPs as all goods of biological origin as well as services derived from forests, other wooded land and trees outside forests, and excluded woods in all its form. There are many other terms that have been used for these products, such as alternative, special, and secondary – all of which emphasize that the product is subsidiary objective of forest management. It means, their production is secondary in importance and excludes woods in all its forms (Wong, 2002). In Nepal, the NTFPs are also termed as *Jaributi* (herbs) and include all biological materials and different services rendered by forest land; for example, medicinal materials, fibers, dyes, gums, fatty oils, wild edible products (vegetables, fruits, spices and condiments), agricultural implements, thatching grasses, rattan, resins, pesticides, animal bedding, veterinary medicines, green manure, ornamental plants, cosmetics, ceremonial products, tannins, charcoal, honey, food, etc., and wildlife products (e.g., bones for ritual and decoration) are grouped as NTFPs (GoN/MOFSC, 1993).

NTFPs are important component of the Nepalese economy. They are associated with socio-economic and cultural life of forest-dependent communities inhabiting in a wide range of ecological and geo-climatic conditions throughout the country (Rijal *et al*., 2019; Rai *et al*., 2019). Globally, a large proportion of rural populations depend on NTFPs for livelihoods, such as for food, nutrition, medicines, fodder, fibres, and other useful materials (Shrestha et al., 2020; Talukdar *et al.*, 2021). In the mountains of Nepal, 10-100% of households are involved in the collection of medicinal plants and other NTFPs; and in certain rural areas, this contributes up to 50% of the family income (Olsen and Larsen, 2003; Rijal *et al*., 2019; Rai *et al*., 2019; Shrestha *et al.*, 2020). In the past, NTFPs had been considered secondary in importance against the timber and were confined to local economies, as very little knowledge existed about them. In recent years, NTFPs have attracted considerable global interest. This is due to the increasing recognition of the fact that NTFPs can fulfill community needs for improving rural livelihoods, contribute to household food security and nutrition, help generate additional employment and income, offer opportunity for NTFP-based enterprises contributing to foreign exchange, and support biodiversity and other conservation objectives (Pandey *et al*., 2016; Rai *et al*., 2019). In the past few decades, with growing concern about conservation, together with rural poverty and sustainable development, researchers, as well as conservation and development organizations, made efforts to bring NTFPs at the centre of discourse (Belcher *et al*., 2005; Subedi, 2003; Banjade and Paudel, 2008). As a result, the governments of several developing countries, including Nepal, received pressure to formulate plans and policies that promoted NTFPs. Following the changing global focus, forest policies in Nepal for the last three decades have also highlighted NTFPs through various policy documents, public meetings, party manifestos and other documents. This paper aims to analyze the conservation status, prospects and challenges of NTFPs for the efficient and sustainable use in Nepalese context.

This study is based on an extensive review of government policy documents, available published and grey materials. Google Scholar and ResearchGate were the primary databases used for acquiring the literature

with keyword 'Prospects and Challenges of Non-timber forest products conservation in Nepal'. A total of 51 results from 1976 to 2019 were obtained. Finally, the literatures collected were systematically reviewed for logical discussion and conclusion.

Current Status of NTFPs in Nepal

Small, but the diverse, geography and climate of Nepal have shaped it into a unique land of NTFPs along with other natural resources. According to an estimate, over 2,000 species of plants are considered to be potentially useful, including food, nutrition and medicinal plants (MoFSC, 2012). The most known and important Nepalese NTFP-producing species, with their local names in parentheses, are *Picrorhiza kurroa* (Kutki), *Dactylorhiza hatagirea* (Panch Aule), *Nardostachys grandiflora* (Jatamasi), *Ophiocordyceps sinensis* (Yarsagumba), *Rheum australi* (Padmachal), *Morchella conica* (Guchhi Chyau), *Swertia chirayita* (Chiraito), *Rauvolfia serpentina* (Sarpagandha), *Rubia manjith* (Majitho), *Asparagus racemosus* (Kurilo), etc. The majority of NTFPs fall into two contrasting groups: high value NTFPs from high altitudes (i.e., above 2,000 m) and low value NTFPs from lower altitudes (i.e., below 2,000 m) (Amatya *et al*., 2016). For example, whole plants of Yarsagumba, roots of Kutki, and rhizomes of Panchaule fall under the high value groups of NTFPs, whereas the root of Kurilo, fruits of Ritha, bark and leaves of Tejpat, and bark, fruits and seeds of Timur fall under the low value NTFPs. In terms of distribution pattern of NTFPs, Nepal's tropical region (below 1,000 m) holds 49% of them, subtropical region (1,000-2,000 m) 54%, temperate region (2,000-3,000 m) 36%, sub-alpine region (3,000-4,000 m) 18%, and alpine region (above 4,000 m) holds 7% (Malla and Shakya, 1995). The high mountains are highly admired for high value but low volume of NTFPs, hence, fetching higher prices.

Ministry of Forest and Environment, Government of Nepal has given its priority on NTFPs development, and that is why Government of Nepal has introduced NTFPs development programme in all 75 districts of Nepal. Similarly, Government of Nepal (GoN) has categorized 237 NTFPs in 8 groups for royalty determination under the Schedule-3 of the Forest Regulation 1995 (Table 1).

Table 1: NTFPs categories according to their uses

S.N.	*Categories of NTFPs*	*Species Number*	*Percentage (%)*
1.	Root and buds species	48	20.3
2.	Bark species	25	10.5
3.	Leaves and stem species	30	12.7
4.	Flower and fur species	16	6.7
5.	Fruits and seeds species	65	27.4
6.	Entire plant species	21	8.9
7.	Gum, and resin species	8	3.4
8.	Others	24	10.1
	Total	237	100

Source: MoFSC, 2012

The GoN has also imposed restrictions on the export of 12 NTFPs species under section 77 of the Forest Act 2019 (Table 2). Other international conservation agencies, like IUCN, CITES, have also listed such plant species in their Red Data Book[1]. The IUCN has listed total 9 groups of species in four different categories (MoFSC, 2014), while the CITES has listed a number of species existing in Nepal under various CITES appendices; viz. a total of 417 species (2 species in Appendix I; 411 species in Appendix II; and 4 species in Appendix III) (MoFE, 2018a).

[1] https://www.iucnredlist.org/

Table 2: NTFPs species protected in Nepal

S.N.	*Scientific Name*	*Common Name*	*Local Name*	*IUCN Red List Status*	*CITES Appendix Status*
A. Species banned for collection, use, sale, distribution, transportation and export					
1	*Dactylorhiza hatagirea*	Salep	Pachaule		II
2	*Juglans regia*	Walnut	Okhar		
3	*Picrorhiza kurroa*	Picrorhiza	Kutki	VU	II
B. Species banned[2] for export outside the country without processing					
1	*Nardostachys grandiflora*	Spikenard	Jatamansi	VU	II
2	*Rauvolfia serpentina*	Serpentine	Sarpagandha	ED	II
3	*Cinnamomum glaucescens*	Nepali Sassafras	Sujandhakokila		
4	*Valeriana jatamansii*	Indian Valerian	Sugandhawal		
5	*Parmelia* spp.	Lichen	Jhyau		
6	*Abies spectabilis*	Himalayan Fir	Talis Patra		
7	*Taxus wallichiana*	Himalayan Yew	Lauth Salla		II
8	*Ophiocordyceps sinensis*	Chinese caterpillar fungus	Yarsagumba		
9	Rock Exudate	Shilajit	Shilajit		

Source: DoF, 2018

Similarly, the government has taken some initiation on conservation of NTFPs by prioritizing 30 major species for economic development of the country (Table 3) and 12 species have been selected for research and agrotechnology purpose (DoPR, 2009).

Table 3: NTFPs prioritized for economic development of Nepal

S.N.	*Nepali Name*	*Scientific Name*	*Distribution (m)*	*Used Part*	*Major Use*
1	Atis	*Aconitum heterophylum*	2,400-4,100	Root, tuber	Medicine
2	Bisha	*Aconitum spicatum*	3,300-4,300	Root, flower, leaf	Medicine
3	Bojo	*Acorus calamus*	200-2,300	Root	Medicine, aromatic oil
4	Kurilo	*Asparagus racemosus*	150-2,100	Root, rhizome	Medicine, food
5	Neem	*Azadirachta indica*	100-900	Entire plant	Medicine
6	Paskhanbed	*Bergenia ciliate*	1,600-3,600	Root, rhizome	Medicine

[2] Species banned for export except for processed with permission of Department of Forest and Soil Conservation (On the recommendation of the Department of Plant Resource) or the Herbs Production and Processing Company Limited (except for their own production) and the pre-approval of the Department of Forest and Soil Conservation, the following 9 items can be processed in the country for export, otherwise banned.)

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S.N.	*Nepali Name*	*Scientific Name*	*Distribution (m)*	*Used Part*	*Major Use*
7	Sugandhakokila	*Cinnamomum glaucescens*	2,000-2,500	Fruit	Medicine, aromatic oil
8	Tejpat	*Cinamomum tamala*	450-2,100	Bark, leaf	Medicine, spices
9	Yarsagumba	*Ophiocordyceps sinensis*	4,200-5,000	Whole plant	Medicine
10	Pachaule	*Dactylorhiza hatagirea*	2,800-4,000	Root, tuber	Medicine
11	Bhyakur	*Dioscorea deltoidea*	450-3,100	Root, fruit	Food
12	Dhasingre	*Gaultheria fragrantissima*	1,200-2,700	Leaf	Medicine, aromatic oil
13	Okhar	*Juglans regia*	1,200-3,000	Fruit, bark	Medicine, food, dye
14	Guchhi Chyau	*Morchella conica*	2,000-3,500	Whole plant	Food
15	Jatamansi	*Nardostachys grandiflora*	3,600-5,000	Root, rhizome	Medicine, aromatic oil
16	Kutki	*Picrorhiza kurroa*	3,600-4,800	Root, rhizome	Medicine
17	Jhyau	*Lichens*		Whole plant	Medicine, food
18	Amala	*Phyllanthus emblica*	150-1,400	Fruit	Medicine, food
19	Pipla	*Piper longum*	200-800	Leaf, stem	Medicine, spices
20	Laghu patra	*Podophyllum hexandrum*	2,400-4,500	Root	Medicine
21	Sarpagandha	*Rauvolfia serpentina*	100-1,200	Root	Medicine
22	Padmachal	*Rheum austral*	3,000-4,200	Root, stem	Medicine, food
23	Majitho	*Rubia manjith*	1,200-2,100	Root, stem	Medicine, dye
24	Rithaa	*Sapindus mukorosi*	1,000-1,400	Fruit, bark, seed	Medicine, detergent
25	Chiraeto	*Swertia chirayita*	1,500-3,000	Entire plant	Medicine
26	Jangali Sayapatri	*Tagetes minuta*	1,200-2,500	Entire plant	Medicine, aromatic oil
27	Lauth Salla	*Taxus wallichiana*	2,400-3,400	Leaf	Medicine
28	Gurjo	*Tinospora sinensis*	300-1,500	Climber	Medicine
29	Sugandhawal	*Valeriana jatamansii*	1,500-3,600	Root, rhizome	Medicine, aromatic oil
30	Timur	*Zanthoxylum Armatum*	1,100-2,500	Fruit	Medicine, spice

Source: DoPR, 2009; MoFSC, 2012

Forest Sector Policies in Promotion of NTFPs in Nepal

Several policy and legal provisions cover the NTFPs sector in Nepal. The most prominent of them are the National Forestry Plan 1976, the Master Plan for the Forestry Sector (MPFS) 1988, the Forest Act 1993, the Forest Regulation 1995, the Forest Act 2019, the Herbs and NTFPs Policy 2004, and international conventions such as the Convention on Biological Diversity (CBD) and Conventions on International Trade

of Endangered Species of Flora and Fauna (CITES). The major policies and legislations and their provisions related to NTFPs development and promotion in Nepal are highlighted below in the table 4.

Table 4: NTFPs related policies and their provisions in Nepal

Year	*Legislation/Policy*	*Features*
1976	National Forestry Plan[3]	• Shift of focus to hill forest, recognized need for improved management of NTFPs. • Identification of need of appropriate management of NTFPs
1988	Master Plan for Forestry Sector[4]	• Heavy emphasized on community forestry. Local control, separate program on NTFPs with medicinal plants as a main component. • Classified NTFPs in 7 major categories.
1992	Convention on Biological Diversity [5]	• Provides international policy framework for conservation and sustainable use of NTFPs, priority in equitable benefit sharing of benefits.
1993	Forest Act[6]	• Promotes community forestry but continue strict regulation of people's right to forest products. • Imposed restrictions on the collection sale, distribution and export of endangered and valuable NTFPs species.
1995	Forest Regulation[7]	• Detailed description of the restrictive procedures required to utilize NTFPs and Medicinal and Aromatic Plants (MAPs).
2002	Nepal Biodiversity Strategy[8]	• Provides a systematic approaches and strategies for the promotion of NTFPs priority in equitable benefit sharing and sustainable harvest.
2004	Herbs and NTFPs Policy[9]	• Promoted conservation and sustainable management of NTFPs. Improvement of harvesting, processing and marketing of NTFPs. • Local participation in NTFPs development, income and employment opportunities.
2012	NTFPs Inventory Guideline[10]	• Provides systematic approaches for inventory and assessment of NTFPs resources in the country.
2014	National Biodiversity and Action Plan[11]	• Emphasizes a systematic approach and strategy for the conservation and promotion of NTFPs. Priority is given to people's participation, equitable benefit sharing and sustainable harvest.
2019a	National Forest Policy[12]	• Emphasizes on conservation, development, management and processing of NTFPs.
2019b	Forest Act[13]	• Promotes conservation, development and sustainable management of forest resource or biological diversity. • Imposed restrictions on the collection sale, distribution and export of endangered and important NTFPs species.

[3] https://www.worldcat.org/title/nepals-national-forestry-plan-1976-2033/oclc/12952728
[4] https://lib.icimod.org/record/3656/files/MpffsnSummaryoftheprogrammes63490685MIS.pdf
[5] http://www.pngcepa.com/wp-content/uploads/2018/07/CBD-Convention.pdf
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[8] https://www.mofe.gov.np/downloadfile/4_Biodiversity_Strategy_1526380257.pdf
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[13] http://www.lawcommission.gov.np/en/wp-content/uploads/2021/03/The-Forest-Act-2019-2076.pdf

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Prospects of NTFPs in Nepal

About 7,000 vascular plant species have been reported in the country so far, out of which more than 1,600 are identified having medicinal value, of which 238 are chemically tested and 160 species are in collection and trade (Subedi, 2003; GoN, 2004; MoFSC, 2012). The Government of Nepal has kept 30 species in priority list, from which 12 are for commercial cultivation and market promotion (Subedi, 2006; DoPR, 2009). It is well established that NTFPs fulfill multiple functions in supporting human well-being. NTFPs have been a welfare or livelihood commodity for long; these are traditional sources of food and nutrition, medicine, fodder, fuel, thatch and construction materials, mulch and non-farm income (Malhotra and Bhattacharya, 2010; Pandey *et al*., 2011). About 80% of the households in rural hilly areas in the country are reported to be involved in commercial collection of NTFPs and MAPs in Nepal (NEHHPA, 2012; Rai *et al*., 2019). The Department of Forest and Forest User Groups (FUGs) collect revenue of NPR 25 million per annum from the trading of NTFPs (MoFSC, 2012). NTFPs sub-sector in Nepal contributes about 5% to the National Gross Domestic Product (GDP), and about 15% GDP is contributed by the whole forestry sector (ANSAB, 1999; MoFSC, 2009). More than 160 types of NTFP species are harvested from the wild and traded in international market, mostly to India; 95% of the NTFPs are collected from the wild and 90% are exported to India in raw form (MoFSC, 2012).

The NTFPs create high economic value and large-scale employment. NTFPs have become the major source of livelihood for farmers in the mid-hills of Nepal and continue to be in future, as there is a lack of off-farm employment opportunities (Olsen and Larsen, 2003; NEHHPA, 2012). There is always a strong potential for community forests to serve as the basis for improving the quality of life and the status of livelihoods in rural Nepal while conserving forest resources, on the other hand (Thoms, 2008). In recent years, NTFPs have attracted considerable global interest due to the increasing recognition of the fact that they can provide important community needs for improved rural livelihood (FAO, 1999; World Bank, 2006). The importance of NTFPs for sustaining rural livelihoods, furthering rural poverty alleviation, biodiversity conservation, and facilitating rural economic growth is well known. Even with good evidence of the fact, NTFPs have not received the sustained and systematic support (Luintel *et al*., 2004; Uprety *et al*., 2016; Rai *et al*., 2019). With the gradual increase in population and depletion of natural resource base, sustainable management of the NTFPs has become a challenge (Pandit, 2001; Uprety *et al*., 2016). Similarly, the increasing global demand of NTFPs leads to over-exploitation of these resources, which further leads to dwindling the biodiversity and adversely affecting the ecology. Therefore, it is very essential to educate and capacitate forest managers and forest users about the importance of NTPFs in their livelihood for sustainability of the forest resource management.

Challenges of NTFPs in Nepal

Non-Timber Forest Products (NTFPs) in Nepal are being increasingly recognized for their role in rural livelihoods, biodiversity conservation and economic values. As such they are of interest to a wide disciplinary range of researchers and government agencies seeking to promote rural livelihoods, incomes, and ecologically sustainable practices (Shackleton *et al.,* 2018). The market of NTFPs is expanding, and this is an opportunity as well as a challenge for a more sustainable, efficient and equitable management of NTFP resources. Effective management through sustainable harvesting and market driven commercialization are two contrasting aspects that are bringing challenges in development of NTFPs sector. Inventory and research on NTFPs, identifying potential species having market value, conducting value chain analyses, promotion of capacity building and technology transfer and sustainable management of NTFPs need analysis of their use patterns by communities and trends at a regional scale (Subedi, 2003; Heinen and Shrestha-Acharya, 2011; Uprety *et al*., 2016). Some of the major challenges for conservation and sustainable management of NTFP species in Nepal are discussed in the following sub-headings.

Inventory and research on NTFP species

In Nepal, need for inventory and research on NTFP species is a major issue. Various studies indicate that there is lack of inventory of NTFP resources in the country (Luintel *et al.*, 2004; Heinen and Shrestha-Acharya, 2011). Therefore, there is a ominous need for inventory of NTFPs in Nepal to find out what there is and in what quantity. What NTFP species are there, what are their ecological niche, what is their status, are they abundant or declining? Such aspects need to be assessed (Heinen and Shrestha-Acharya, 2011; Uprety *et al*., 2016). At present, all these information are scattered and there is no linkage between them. For example, in mid-west and far west Nepal, it is said that there is a trade worth millions of dollars of Yarsagumba (*Ophiocordyceps sinensis*), a rare and protected plant species in Nepal colloquially known as caterpillar fungus used as aphrodisiac and tonic in Chinese medicine, but none knows the exact volume of the available plant material. Thus, identification and inventory of NTFP species are very important for sustainable management.

Production and harvesting management

Unsustainable harvesting of NTFP species is another issue in NTFPs sector in Nepal. The management options for increasing production while making it sustainable do not exist in practice in most of the areas. The current practice of NTFP utilization involves only harvesting that is convenient to the collectors. Often, collectors do not know which species are traded. There are instances of early harvest due to competition without leaving sufficient stock for regeneration of many NTFPs. Generally, the harvesting practices are unsustainable due to a lack of sensitivity and market information (Subedi, 2003; Heinen and Shrestha-Acharya, 2011). Therefore, there is a need to consider several possible options for production management depending upon the institutional arrangements, capacity enhancement, information transformation and commercial opportunities. The key for the sustainable management is the reconciliation of biological sustainability with commercial viability. There may be several possibilities to increase the NTFPs production in a sustainable way: improving production from the wild, through domestication and improving harvesting technologies, reducing post-harvest lost, and institutionalization of management system.

Value addition

Lack of proper value addition is another challenge for NTFPs management in Nepal. The value of Nepal's NTFPs is significant, but the potential of value adding opportunities is unrealized. There is not much processing and value addition being done to NTFPs that are collected and exported to India mostly in raw form. The collected or produced NTFPs from wild or cultivated land can be sold in different forms i.e., crude raw materials, improved raw materials or processed raw materials through different marketing channels. The improved and processed raw materials generally yield higher price than crude raw material. Value addition to the raw material can not only increase employment but also can contribute to the economic development of a region or nation. Unfortunately, value addition or processing of NTFPs in Nepal has exploited and deprived the local producer or collectors due to the lack of coordination between collectors and local traders (Subedi, 2003; Heinen and Shrestha-Acharya, 2011; Chakravarty *et al*., 2015). A lack of market and marketing infrastructure, and limited access to availability of information and technology for product development and processing are hindering the value addition process. Resource based enterprise development has not been initiated in the country. Thus, there is a need for increasing the efficiency in each stage of the value chain of NTFP products. NTFPs can be processed, or value added into consumer-oriented products. Processing or value addition of NTFPs should now be promoted as an approach to local development, particularly in NTFPs rich country like Nepal. Improvement to raw materials and the processing are two major examples of value addition that can be done by local communities.

Domestication

Studies show that NTFPs can be domesticated, like other agricultural crops (Leakey and Newton, 1994; Bista and Webb, 2006; Pandit, 2008). In Nepal, NTFP producing species are almost non-domesticated. Unfortunately, many of the most often used annual and perennial NTFPs remain neglected for domestication till date. Though DoPR (2009) under the Ministry of Forest and Environment (MoFE) has prioritized 12 NTFPs for research and cultivation, domestication of NTFPs is still in slow pace and not extensive. The people are generally not very much willing to cultivate NTFPs on the cultivated land. No research has been done so far why people are unwilling to domesticate, as NTFPs have high potential in fulfilling the household needs. In Nepal, some efforts have been made by individuals and groups to domesticate some exotic as well as indigenous NTFP species. But there are several stages of scientific procedures, which need to be addressed during the domestication process, such as characterization, germplasm exploration, vegetative propagation, genetic selection, and incorporation into a sustainable land-use system (Leaky and Newton, 1994; Subedi, 2003; MoFSC, 2012). The domestication of promising, under-exploited species in private farmland, community managed forest land and leasehold forest land can contribute a lot to this sector. Agroforestry practice can also offer a flexible land use system by which NTFPs can be domesticated gradually in a way that is adapted to local conditions and practices.

Marketing and trade

Another equally important challenge associated with promotion of NTFPs in Nepal is the lack of market and marketing information. The insecure and seasonal fluctuation in market price of the products, and the difficulties in processing, were the biggest issues in NTFPs sector. The main difficulties are getting reliable information, processing technologies and access to market. Community forestry, small holders, family farmers, and producers need to be able to meet the standards of quality and sustainability as important purchasing criteria (ASEAN, 2020). A study shows that trade in NTFPs is not transparent, and traders have greater influence over the pricing mechanism (traders-oriented price). Despite the materials are of good quality, harvesters do not have much stake in pricing due to the non-transparent nature of NTFP trade. Traders do not want to share real prices and mostly work in isolation. There is a huge gap between road head traders and harvesters, and harvesters get very little of the profit (Subedi, 2003; Heinen and Shrestha-Acharya, 2011; Uprety *et al*., 2016). In Nepal, NTFPs are sold in local, urban, national, regional and international markets. There seems market for NTFPs, but existence of market does not assure the access to the market, which is quite often very difficult to get for NTFPs. Majority of high-value NTFPs are located in very remote area, the processing and marketing costs are generally high. The NTFPs produced in remote areas are sold through a long marketing channel which is inefficient and costly from the perspective of the collectors. Moreover, the current trade chain is not providing the fair share of profits to the harvesters or collectors. The support services available for processing and marketing of NTFPs are not adequate for small fair-trade businesses. In some cases, these are favourable for illegal transactions. The additional challenges faced in marketing of NTFPs are the lack of marketing infrastructure, imperfect wholesale market for NTFPs (created by limited number of wholesalers, controlled by government and the major buyers), limited access to availability of information and technology for product development, difficulties in matching market requirements by suppliers due to several uncertainties such as reduction fluctuation, decreased collection, inconsistent quality of products coming from many sources, and guaranty of collection permits. So, there is a serious need to explore and address the existing markets and marketing systems of NTFPs. Improvement in communication about markets, prices and other concerns to collectors and traders can improve the market strategy for NTFPs promotion in Nepal.

Certification

Forest certification (FC) is a concept accepted worldwide, and that advocates the reflectance of sustainable forest management (SFM) and gives assurance to forest product users (FAO, 2000). Forest certification is intended to improve forest management via market-based incentives, and it is based on the assessment of

the social, economic and environmental aspects of forest management as per the predetermined set of standards (FAO, 2000; FSC, 2015). Certification of forests is a newly introduced concept in Nepal and has formally been introduced by the Private Public Alliance (PPA) as a tool to promote sustainable forest management (SFM) and responsible business practices focusing on NTFPs (Kandel, 2007). Aiming the NTFPs, 14,086 hectares community-managed forests were certified in Bajhang and Dolakha districts under Forest Stewardship Council (FSC) certification scheme between 2004 and 2005 (FSC, 2015; Kandel, 2007). Nepal Foresters Association (NFA) and Asia Network for Sustainable Bioresources (ANSAB), supported and funded by United States Agency for International Development (USAID), are major organizations involved in initiating and promoting forest certification schemes in Nepal. Currently, the area has been expanded to more than 80 community forest user groups (CFUGs) having their 17,146 hectares forests are certified incorporating payment for ecosystem services. It is meant to ensure that 24 NTFPs including herbal products, essential oils are sustainably harvested from sustainably managed forest (Acharya and Karki, 2015; Subedi *et al*., 2015).

However, certification of forest products (especially NTFPs) requires a base of knowledge regarding the ecology, socioeconomics and legal aspects of non-timber forest products, much of which is undocumented and unknown. A common challenge in NTFPs certification is the difficulty of marrying a system driven by international scientific norms with local community practices and cultures. Chain of custody (CoC)[14] certification has not been performed yet to export the NTFPs from certified forests of Nepal. On the one hand, the barriers to achieving certification for products from forests controlled by CFUGs are high, whereas the economic return remains largely unrealized in the absence of market where sustainably produced forest products are valued (Ebrahim *et al*., 2014). Some specific factors that are hindering the certification of forest products in Nepal are:

- Inaccessibility of certification to small scale producers
- Problems in meeting quality standards developed for industrial scale forestry
- Complex chain of custody
- Lack of capacity to achieve the technical conditions necessary for certification
- Lack of market demand for NTFP products certified as environmentally friendly, or as originated from 'well managed' areas
- Lack of ecological information to be able to prove the sustainability of any given harvesting operation.

Hence, there is a need to explore and address the existing certification issues. Promoting culturally appropriate education, capacity building and training, identifying synergies between forest and fair-trade certification, and leveraging the local and regional market could scale up the forest certification programme in Nepal.

Policy perspectives

More than 1 billion people globally use or trade non-timber forest products with the majority of NTFP use and trade occurring at local and regional scales, generally invisible to researchers and policy makers (Shanley *et al.*, 2016). Among the developing countries, Nepal has been progressive in conservation and management of NTFPs for nearly four decades. The country formulated comprehensive legislation for the protection and management of natural resources (including NTFPs) and has amended conservation legislation many times to include more participatory approaches that have had many measured successes (Heinen and Shrestha-Acharya, 2011; Uprety *et al.*, 2016). The most prominent of them are Master Plan for the Forestry Sector (MPFS) 1988, Convention on Biological Diversity (CBD) 1992, the Forest Act 1993, the Forest Rules 1995, the Herbs and NTFP Development Policy 2004, the Forest Act 2019, etc. The MPFS

[14] Chain of custody certification is a mechanism, which verifies that certified material is identified or kept separate from non-certified material.

1988, which is the first comprehensive policy statement in Nepal's forestry sector, recognizes the participatory approach to forestry, but fails to appreciate the scope of the NTFPs as an important area of intervention from conservation as well as economic viewpoints. When evaluated in terms of the impact of the forest legislation on NTFPs conservation and management, the national policy objectives do not seem to be properly translated into regulations. The regulations pertaining to NTFPs are still based on restrictive policy (Ojha, 2000; Shrestha-Acharya and Heinen, 2006; Heinen and Shrestha-Acharya, 2011). Some of the major policy issues related to NTFPs that need to be addressed in the future are:

- Contradictions between the Forest Act and the Local Governance Act regarding control over NTFPs use and management;
- Ad-hoc royalty rates for NTFPs and absence of well-developed system of determining royalty;
- Ban or restriction on collection and trade of commercially valuable NTFPs that can be harvested on a non-destructive basis;
- Lengthy and costly export formalities for NTFPs trade; and
- Inappropriate control and absence of enabling environment for conservation and trade of NTFPs.

The above-listed issues suggest that the government's efforts have focused on controlling the extraction, use and trade of NTFPs, while the resourceful traders are drawing profits often exploiting the local producers or collectors in the value chain, irrespective of regulatory control (Ojha, 2000; Shrestha-Acharya and Heinen, 2006). Nepal has a separate policy for NTFPs, but there are no implementation plans or regulations formulated in accordance with the policy. However, the recent Nepal National Biodiversity Strategy and Action Plan 2014 and the Forest Policy 2019 have emphasized sustainable use and management of NTFPs and critically provide special opportunity to support livelihoods of marginalized pro-poor and women through wise use of NTFPs. Yet, the present policy formation, implementation and field reality reflect power structures and domination by certain stakeholders and interest groups (Larsen *et al.*, 2000; Uprety *et al*., 2016). Therefore, there is a need for administrative expansion and simplification of the policy that could address the current prevailing issues and the most essential would be the formulation of a separate NTFPs Management Strategy and Action Plan.

Conclusion

Non-timber forest products are the most important provisioning services the people obtain from forest ecosystems. The importance of NTFPs in rural livelihoods and forest conservation has been well recognized as they provide income generation opportunities to millions of people around the world. Nepal is well known for NTFPs. The diverse geography and climate have rendered it a unique land of over 2,000 species of plants that are considered to be potentially useful, including food, nutrition, fibres and medicinal values. NTFPs are an important part of the Nepalese economy and they are significant sources of subsistence, income and employment to the people dwelling in forests. Due to poor economy of the rural community and lack of alternative living sources, more pressure is observed on the forest resources. The lack of NTFP resources inventory, unsustainable harvesting and lack of marketing information and capacity building, and arbitrary legislative provisions were the major challenges and constraints for sustainable management of NTFP sector in Nepal. There is a need to create effective management through sustainable harvesting and market-driven commercialization by implementing adaptive policies.

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Collected the data	Yes	Yes	Yes
Contributed to data analysis & interpretation	Yes	Yes	Yes
Wrote the article/paper	Yes	Yes	Yes
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Patterns of Resource Use for Tourism Development in Mountainous Communities in Ukraine

Yaroslava Korobeinykova
Department of Tourism, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine.
Email: yaroslava.korob@gmail.com | *ORCID: 0000-0002-4882-8611*

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Abstract

The purpose of this article is to identify the problems associated with the tourism resource utilization in mountainous communities of Ukraine. Developing tourism at local level is a priority in the region of Ivano-Frankivsk, especially in the context of decentralization process in Ukraine. A survey was conducted involving the managers of hospitality establishments during the "active" tourist season from July to August 2019. Main parameters selected for this inquiry included the water consumption (in the form of drainage), solid waste disposal, and the quantum of electricity consumed. Data of water consumption (drainage), consumed electricity, and solid waste disposal in the surveyed hospitality establishments reflects proportional growth of the tourism manifesting accommodated tourists, capacity, and category of the hospitality establishments. On priority, identified problems of resource utilization encompass waste management, water supply, sewerage, energy supply and incom ing tourist flows. Quantitative forecasting of environmental load to be exerted by tourism development is necessary when planning resource utilization and livelihood systems of mountainous communities.

Keywords

Decentralization; Tourism; Hospitality; Resource utilization

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Introduction

Decentralization of the local administration system in Ukraine began in 2015 and is continuing till now. It is accompanied by the formation of local institutions and the creation of roadmaps for community development. For the mountainous territorial communities or OTGs[1] of Ukraine, the promising sectors of the economy are forestry and forest processing, tourism development, development of infrastructure, especially transport and roads, development of energy-saving eco-friendly industries, development of traditional mountain agriculture, and revival and development of traditional crafts and handicrafts. Powerful natural and historical-cultural potential in combination with preserved ethnic traditions and traditional crafts have formed the basis for the development of tourism in the Ivano-Frankivsk region of Ukraine. The region also has the highest potential for nature reserves in Ukraine. The tourism industry does not require significant investment and has a fast payback period for projects. Given the stable dynamics of the industry, the contribution of tourism to the region's economy was 12.86% in 2019. Gross value added in the field of tourism in 2019 was 8.27% according to the National Tourism Organization of Ukraine (National Tourist Organization of Ukraine, 2020a). Locally formed territorial communities (OTGs) define tourism as a priority area of economic development. As the experience of cooperation with local communities in the field of tourism shows, they require not only a better study of the recreational and tourist potential of their local community but also support many other activities. Among such activities are:

- formation of investment proposals for the development of certain types of tourism in the local community;
- development and planning of the projects for recreational park areas;
- development of the programs to promote local tourism products linking tourism services;
- creation of databases of resource potential and infrastructural components for tourism development;
- outlining projects encompassing improvement of tourist infrastructure in community areas;
- creation of excursion programs within the community areas; and
- consultations on the possibility of development of rural tourism in community areas.

Various studies on environmental aspects of the development of local communities are undertaken by the scientific community under the auspices of the United Nations Environment Program (UNEP). One set of such research emphasized the environmental impact of tourism in general (Holden, 2016; Davies and Cahill, 2000) and the environmental impact of tourism in the context of the hotel industry (Rabbany *et al*., 2013). The problem of wastes generated by tourist destinations is covered in more detail in the scientific literature. Nair and Jayakumar (2008) studied waste management in the context of rural tourism. Scientific factors influencing the quantity of the generated waste were explored by Khajuria, Yamamoto and Morioka (2010). The research conducted by Romanian specialists in the tourist destination of Bicaz-Chei is especially relevant for Ukrainian territories because of the close territorial proximity and similarity of conditions (Mihai, 2013). The researchers have elaborated tourism as a source of waste generation both in urban and rural destinations. A pertinent analysis of the impact of tourism on waste generation is performed in the article authored by Mateu-Sbert *et al*. (2013). An important study was carried out in EU countries on waste management in relation to tourism development (Ezeah, Fazakerley and Byrne, 2015). Noticeably, regional aspects of the environmental impact of tourism are covered in the publications of Peterson (2013), Bashir and Goswami (2016) and Giulietti *et al*. (2018). These studies explain the problems at some popular destinations around the world, which are currently under active development. There are only a few Ukrainian authors who cover the environmental consequences of tourism, and their articles are rather general. Ways to ensure environmental safety as part of balanced development of the tourism industry are set out in the research published by Kutsenko (2010), Prygara (2014) and Sharko (2014).

Within the Carpathian region, the main environmental impacts of tourist destinations are changes in primary landscapes, water pollution, the problem of waste management (Korobeinykova and Murava, 2013). One of

[1] OTG is an association of territorial communities of a village, settlement or city, which border on each other. Related documents are available on the link: https://zakon.rada.gov.ua/laws/show/157-19#Text

the previous publications estimate the quantity of generated waste within the Carpathian region of Ukraine. The problem of tourism resource use is further complicated by the fact that today most of the solid waste landfills in the Ivano-Frankivsk region are filled by an average of 80-90% or completely exhausted. The least equipped landfills for solid wastes are the most popular tourist communities: Yaremche City Council and Kosiv (Murava and Korobeinykova, 2016).

International experience in the conceptualization and implementation of territorial development strategies is gained with the inconsistency of Ukrainian legislation with the regulatory framework of other countries. Often, such experiences become irrelevant in particular contexts of mountainous local communities of the Ivano-Frankivsk region. A large number of publications by domestic scientists are devoted to the reform of territorial management. The most important publications in the area are by Berdanova and Vakulenko (2012), Borodina (2016), and Tkachuk, Kashevskyi and Mavko (2016). These publications highlight the general aspects and problems of local governance reform and developed methodological tools for strategic development planning for small local communities. Under the Ukrainian legislation (Cabinet of Ministers of Ukraine, 2014a), a sufficient scientific basis for the legal and financial aspects of decentralization of power in Ukraine has been developed. The issue of effective resource utilization planning in communities is unfortunately left unattended. This issue is currently weakly addressed in the development of communities in general, the development of their livelihood systems, solving environmental problems, and so on. Most of the Ukrainian research concentrates on the distribution of powers between districts, regions, and territorial communities, organizational and legal aspects of decentralization, basic concepts, principles, models, and types of decentralization, and financial implications of reforms. However, such research covers mainly the theoretical aspects of the decentralization process in Ukraine, while the practical manifestations are still left out. Unfortunately, the decentralization processes are slow, and new problems arise faster than the old ones are solved. This is a grim reality of the implementation of a state-initiated socio-economic experiment of decentralization.

The reform of the administrative-territorial system in Ukraine is a multi-stage and cumbersome process in multiple areas of livelihood and development of the society. According to the legislation of Ukraine (Cabinet of Ministers of Ukraine, 2014a), territorial communities (OTGs) have gained the right to manage land resources within their territory and to arrange cooperation between the neighbouring communities. The practical implementation of the decentralization process began only in 2015 and is still progressing very slowly. Constituted local communities have faced several problems that make their effective development impossible. Firstly, different territorial communities vary in terms of resource potential and socio-economic status. Some of them rely mainly on government allocations. On the other hand, financial decentralization has led to the accumulation of funds in local communities, which is not always rationally utilized. Secondly, the huge burden of a community support system that has not been addressed for more than thirty years has fallen on the newly formed administrative units, i.e., OTGs. Thirdly, as the governing bodies of most of the local communities need qualified managers from a variety of technical fields, remote communities lack such staff, who should not only solve urgent problems of community affairs but also work for the future projects outlining strategic directions of community development. Additionally, the implementation of strategies faces an inconsistency highlighting legislative constraints. Most of the communities do not have an information base and appropriate methodologies that will enable the successful implementation of tourism projects.

In the situation of newly constituted local communities, the question of rational planning of social and economic development in new administrative formations becomes more relevant. Mountainous local communities occupy more than 50% of the territory of the Ivano-Frankivsk region, so their successful development as independent, self-governing bodies is the key to the regional development. The past experiences of the executed projects on tourism development of the local mountainous communities in the Ivano-Frankivsk region reveal that all mountainous communities have identified tourism as a priority area for community development. However, the functions of tourism management are carried out by specialists, mainly in the cultural sphere, in some cases, and such managers were not tourism professionals (Perederko, 2021).

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Weak implementation of environmental legislation in Ukraine, low level of environmental awareness of citizens and responsible managers, and lack of comprehensive environmental management programs lead to a negative impact of tourism on the environment of tourism destinations. The poor resource management practices that are being practiced in the local communities are lacking the fundamental understanding of the problem. Moreover, improper approaches to the development of tourist infrastructure in certain regions are disrupting the local environment and social systems. Obviously, in such conditions, communities are not able to efficiently conduct tourism resource management. Community development strategies are made without considering the environmental consequences of such development of territories; and tourism, as an industry, is currently not included in the list of the industries that have a significant impact on the environment. Therefore, the development of scientific and methodological tools for the sustainable development of united territorial communities and for ensuring a balanced, environmentally friendly tourism resource is relevant today.

The ninth special session of the Governing Council of UNEP in its policy documents noted the problems of sustainable tourism development, especially in developing countries (United Nations, 2003). The main action points in policy document included the following:

a) To increase political support, transparency, and integration;
b) To engage the private sector, encouraging businesses to integrate sustainability in their policies and operations;
c) To improve water and energy efficiency, promote the use of clean energy and reduce waste;
d) To promote sustainable building and construction practices, as well as the incorporation of natural parks in urban areas;
e) To expand knowledge and build capacity;
f) To strengthen the implementation of available tools to stimulate action on the ground and the skills and resources for effective implementation; and
g) To ensure the effective participation of indigenous people and local communities in decision-making processes.

The present research is mostly fitting into the context of the action point “c” of the above-said policy document of the UNEP. This topic is especially important for the regions that are in the early stages of tourism development. The purpose of this study is to identify current problems of tourism resource use within the united mountainous territorial communities of Ukraine. The research focuses on mountainous local communities of the Ivano-Frankivsk region having decentralization and resource management in the centre.

Materials and Methods

A field survey was conducted as the main research method. A survey is the method through which data is collected from the selected group of respondents (Brannen, 2017). The survey can provide information that is not always reflected in written sources or available through natural observation. The goal of this survey was to gather data about the resources (mainly electricity and drainage) consumption, and to estimate waste generation in the study area during the active tourism season. The survey participants were the managers of hospitality establishments. Despite the limitations of this method, it was the only viable method for investigating this case.

Main parameters selected for this inquiry include the volume of water consumption (in the form of drainage), quantity of solid waste disposal, and the magnitude of electricity consumed. The excessive resource consumption by the surveyed hospitality institutions leads to serious environmental problems in mountain communities of the Ivano-Frankivsk region. The field survey was conducted during the "active" tourist season: July-August 2019. The hospitality establishments that use centralized heating systems maintain records of water use, sewerage, waste disposal, and electricity consumption. Geographically, "mountainous areas" in the Ivano-Frankivsk region were covered for this study. The hospitality establishments that had electronic communication were selected for the ease of data collection. Moreover, the hospitality

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establishments were divided into 3 categories based on the size of their services: rural estates, small hotels (up to 50 occupancies), and hotels with 50 or more occupancies having luxury facilities, health services, and pool services.

The survey contained a small number of questions that were asked in order to ensure a high number of responses. These are structured questions (see Appendix 1) about the type of facility, its capacity, the availability of health services, usage of water, and the number of customers during one month of active tourist season (July to August). The questions assessed the water consumption, sewage production, electricity consumption, and solid waste removed in hospitality establishments. The survey questions were sent to all 52 registered hospitality establishments situated in the mountain areas of the region. Out of 52 establishments contacted, 16 establishments (over 30% of all establishments) responded (6 rural estates, 5 small hotels, and 5 luxury hotels). Initially, an assumption was that hotel managers were interested in this topic in general and were ready to cooperate for environmental sustainability. A small number of hotel managers were also interested in optimizing resource consumption and the contribution of their hotel to the environment. But they did not respond as were expected to do. The low rate of responses from the respondents can be attributed to the fact that there was a fear among the respondents that the information would be disclosed and disseminated. This fear has a reason. In fact, management of resources is often done not fully legally, and fictitious records are reported to regulatory authorities.

Results and Discussion

In 2017, there were 274 establishments in Ivano-Frankivsk region, but at the time of this survey in the region, only 67 hospitality establishments were reported (Regional Department of Statistics of the Ivano-Frankivsk Region, 2020). Probably, such a sharp decrease in the numbers is due to the implementation of strict European directives and recommendations for the collection of statistics in Ukraine since 2018. The new data collection methodology does not consider the small commercial structures that are registered as special legal entities with limited turnover, which is common for most of the hotel businesses in the region. In the hotel industry of the Ivano-Frankivsk region, rural estates occupy an important place. At least 55% of hospitality establishments usually do not have any legal status in the form of commercial enterprises and are not subject to mandatory official statistical identification. The hospitality establishments are distributed in the districts of the region very unevenly and are located mostly in the traditional mountain tourist destinations. Of them, more than 60% are located in the territory of Yaremche united community. Such a high density of hospitality establishments at one location causes the problems of unsustainable resource utilization, especially when looked at from small mountain contexts.

Table 1. Tourism resource use in the Ivano-Frankivsk region during the survey period (2019)

Average values of resource and waste consumption/ types of hospitality establishments	*Volume of solid waste disposal (kg)*		*Electricity consumption (kW × h)*		*Water consumption (l)*	
	For the entire stay of the tourist	*Per day per tourist*	*For the entire stay of the tourist*	*Per day per tourist*	*For the entire stay of the tourist*	*Per day per tourist*
Rural estates	3.28	0.82	56.48	14.12	324.00	81.00
Small hotels	15.64	3.91	60.20	15.05	472.00	118.00
Hotels with recreational complexes	16.12	4.03	67.28	16.82	1044.00	261.00

On average, guests stay for 4 days in the region (National Tourist Organization of Ukraine, 2020). Using such information, average values of solid waste, electricity consumption and water consumption were estimated and are presented in Table 1.

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Tabulated data of water consumption (drainage), consumed electricity, and solid waste disposal in the surveyed hospitality establishments reflects proportional growth of the tourism manifesting accommodated tourists, capacity, and category of the hospitality establishments. Data in Table 1 is also represented in Figure 1 to 3. This consumption of said resources by tourists in surveyed hospitality establishments is higher than average consumption by the local population in the area. Similar results were also reported by Davies and Cahill (2000). Thus, the quantity of waste generated in small hotels and luxury hotels is 4.8 and 4.9 times higher, respectively, than in rural estates (Figure 1). Most likely, this is because of the minimal set of services at rural estates and practice of more efficient waste management (for example, the food waste is used for feeding the livestock). The difference between the quantity of waste generated in a luxury hotel and a small hotel is insignificant. The quantity of solid waste generated by tourists was compared with the standards of solid waste generation in different types of households. Such standards are defined by the Ministry of Housing and Communal Services of Ukraine (Ministry of Housing and Communal Services, 2010). This quantity ranges from 0.77 to 1.59 kg (average 1.2 kg) per person per day. Thus, the quantity of waste generated by tourists in all surveyed hospitality establishments is higher, and in small hotels and luxury hotels it is 3.2 and 3.4 times higher than the standards for the local residents. For luxury hotels, the permissible amount of solid waste per hotel (not per tourist) is 0.55 kg per day. From the findings of the solid waste generation in surveyed hotels, the gravity of problem can be understood when a hotel reaches significant levels of occupancy.

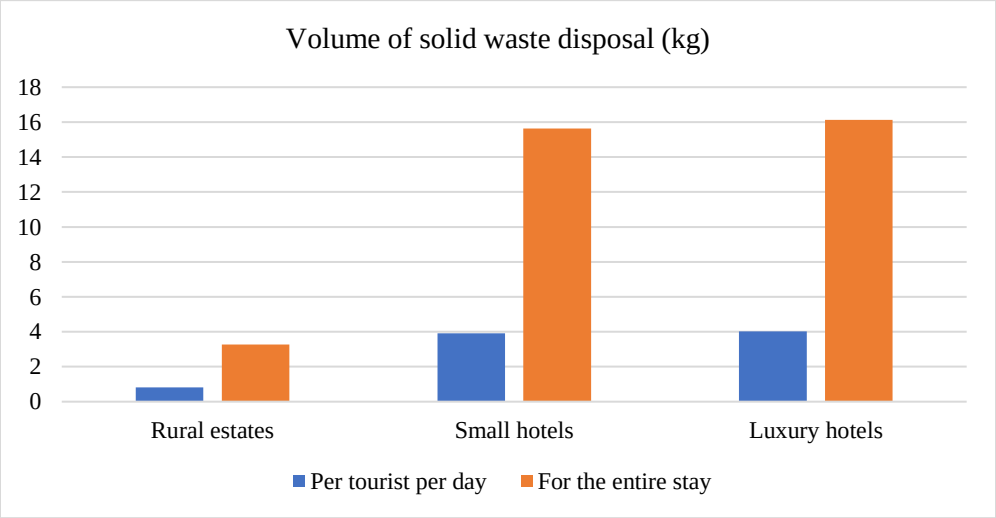

Figure 1: Illustration based on table 1 data of solid waste disposal

The amount of electricity consumed in hospitality facilities per tourist varies from 14.12 kWh in rural estates to 16.82 kWh in luxury hotels. The difference in electricity consumption is insignificant as illustrated in Figure 2. The planning of life support systems of the settlements is guided by the State building standards that outline water, electricity and gas consumption per person per month. In accordance with these standards, for a family of 4 people the rate of electricity consumption per month is 240 kWh or 2 kWh per person per day (Cabinet of Ministers of Ukraine, 2014b). Based on field data, tourists in hospitality establishments consume 7-8 times more electricity than the local residents. These results can be interpreted as the manifestation of the peculiarities of the hotels and the behaviour of tourists. To sustain a level of service, specific measures are taken in the hospitality establishments. Among those are constant lighting of corridors, halls and other public premises, illuminated signs, security, communication systems, etc. Customers usually do not practice energy saving in hotel rooms. Therefore, it is especially important for hospitality establishments to implement energy saving measures.

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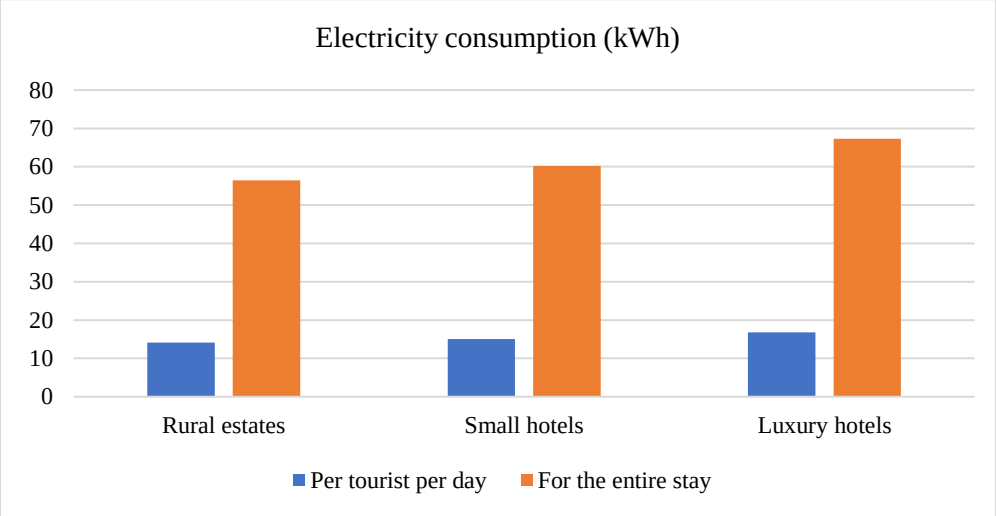

Figure 2: Illustration based on table 1 data of consumed electricity

The results of the survey on water consumption in hospitality establishments indicate that tourists consume 81 litres of water a day in rural estates, 118 litres per day in small hotels and 261 litres per day in luxury hotels (Figure 3). The 2.2-fold higher water use in luxury hotels compared to small hotels is clearly related to the additional services such as pool, and other wellness services with high water consumption. According to established governmental norms, water consumption in Ukrainian households is estimated at around 130 litres per person per day (Cabinet of Ministers of Ukraine, 2014b). The data in Figure 3 indicate that this household consumption limit is 2 times lesser than the actual water consumption in luxury hotels.

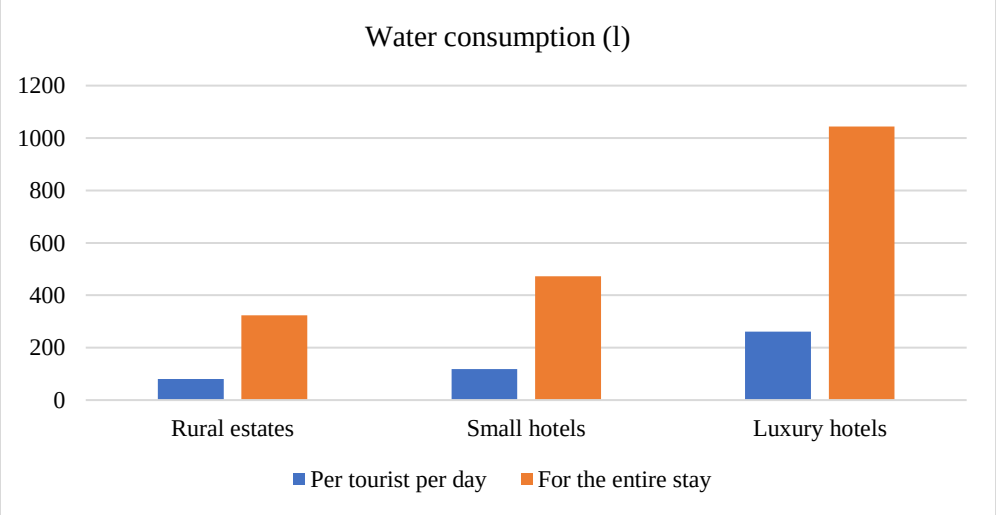

Figure 3: Illustration based on table 1 data of water consumption

The trend of tourism development in the region in recent years shows that the number of tourists grew by 25% annually from 2015 to 2018 and stabilized at 2.5 million people in 2019 (Department of External Economic Relations and Tourism of Ivano-Frankivsk Region, 2019). However, year 2020 was a failure for tourism in the region due to the COVID-19 pandemic (UNWTO, 2020; National Tourist Organization of Ukraine, 2020b). It is envisaged that after the COVID emergency, a boom of tourism in the mountain will be observed. Mountain destinations have the potential to restore health by virtue of an ecologically clean environment and healthy local food.

In some of the mountainous communities of the Ivano-Frankivsk region, the number of tourists may often exceed the local population. Statistical data on the number of tourists in some local communities is grossly missing. Such a situation complicates the process of assessing the impact of tourism on the local environment. In such circumstances, the quantification of waste generation, water consumption and wastewater discharge, and the use of electric energy can be useful in assessing the environmental impacts. Findings of this study will help planning the resource use in tourism sector and local community development. As a result, priority can be given to the projects integrating environmentally friendly technologies for waste management, wastewater treatment, and water use. Such activities can be planned while taking into account the growing number of tourists visiting the local communities.

Conclusion

The development of tourism plays an important role in the socio-economic development of local communities: new jobs are created, a high standard of living is maintained, and bases for the sustainable development of the communities are created. However, such development may be accompanied by the aggravation of environmental problems. This article analysed the main aspects of decentralization, including the function of efficient resource use at the level of local communities. Tourism resource use is invariably accompanied by exacerbation of environmental problems in the community due to excessive consumption of water resources and energy, and waste generation. The solid waste generated by tourists in hospitality establishments within the mountainous united communities were estimated. The water consumption and electricity consumption of a tourist during the stay in a hospitality establishment are also estimated. Recommendation is drawn to include the ecological components in the process of preparing strategic development plans for mountain territories.

The findings and inferences can be used to plan the livelihood systems of mountainous communities that rely on tourism development, and develop strategic plans for tourism resource use within them. In addition, the results can also be used by the managers of hotel establishments or the planners of future hotel complexes while properly preparing the infrastructural plans of accommodations for the tourists. They can reduce the consumption of resources, especially water and electricity, if use the findings of this study.

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Appendix 1: Survey questionnaire

1	Name of the establishment			
2	Address			
3	Size	Rural Estate	Hotel	
4	Number of tourist occupancy	less than 10	11 - 50	more than 50
5	Which special services are available?	yes	no	
5a	Wellness baths			
5b	Pool			
5c	Tubs with herbs			
5d	Water services not listed above			
5e	Other additional services			
6	Number of guests during July-August			
7	Resource consumption in this period			
7a	Consumed water (l)			
7b	Consumed electricity (kWh)			
7c	Solid waste disposed (kg)			

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)
This article is 100% contributed by the sole author. She conceived and designed the research or analysis, collected the data, contributed to data analysis & interpretation, wrote the article, performed critical revision of the article/paper, edited the article, and supervised and administered the field work.

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Research involving human bodies (Helsinki Declaration)
Has this research used human subjects for experimentation? No

Research involving animals (ARRIVE Checklist)
Has this research involved animal subjects for experimentation? No

Research involving Plants
During the research, the authors followed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

Research on Indigenous Peoples and/or Traditional Knowledge
Has this research involved Indigenous Peoples as participants or respondents? No

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Socio-Economic Determinants of Maize Production of Smallholder Farmers in Eastern Oromia, Ethiopia

Murad Mohammed Baker*[1], Desta Bati Nuno[2]
[1]Department of Statistics, College of Computing and Informatics, Haramaya University, Dire Dawa, Ethiopia.
Email: murt.stat@gmail.com
[2]Department of Statistics, College of Computing and Informatics, Haramaya University, Dire Dawa, Ethiopia.
Email: destabati8@gmail.com
**Corresponding author | ORCID: 0000-0002-1226-3145*

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Abstract
Agricultural sector is a mainstay of farmers' livelihoods in Ethiopia. Maize is a largest crop being grown in Ethiopia; however, currently, yield gaps are the challenges faced by the producers. This study has an objective of identifying the determinants of maize production of smallholder farmers. Data were collected from 200 farmers living in the selected kebeles (communes) of Meta district in the East Hararge zone of Oromia region, Ethiopia. The collected data was analyzed using multiple linear regression model. The result showed that the production of maize was influenced by several factors. Non-farm activity had a positive impact on the production of maize. Thus, the farmers who had money from non-farm sources utilized these additional incomes as inputs to gain more maize production. The cultivated areas of land have a positive influence on the higher yields of maize. The maize crop production of smallholder farmers was negatively affected by Development Agent's office. The study suggests that policy makers should encourage the current maize production by supplying improved seeds and fertilizers, which tend to support improving the smallholder farms.

Keywords
Livelihood diversification; Adoption; Crop cultivation; Production factors; Smallholder farmers

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Introduction

In Ethiopia, agriculture is the most important sectors that accounts for 46% of gross domestic product (GDP), 73% of employment and 80% of export values (Bukul, 2018). The agriculture sector is largely dominated by rainfed subsistence farming by the smallholder farmers who cultivate an average landholding of less than a hectare (Amsalu, 2015). Maize is among the major cereal crops produced in the world after wheat and rice (Gebre *et al*, 2019). Maize is also the most widely grown staple food crop in sub-Saharan Africa occupying more than 33 million hectares each year (Macauley and Ramadjita, 2015). It is most dominant cereal crops that the farmers adopt more than the other crops. In sub-Saharan Africa, most of the countries including Ethiopia account about 96% of the total maize production (Macauley and Ramadjita, 2015). The Food and Agricultural Organization (FAO) of the United Nations reported that the maize is commonly important for food security as a basic food for the population in Ethiopia (FAO, 2018). According to the Central Statistical Authority, on an average, the maize product was 2.6 tons per hectare between 2006 and 2017 years (CSA, 2017).

Maize is the largest and most productive crop in Ethiopia. In the year 2007-08, maize production was 4.2 million tons, 40 percent higher than teff[1] (*Eragrostis tef*), 56 percent higher than sorghum and 75 percent higher than wheat production (Rashid, Getnet and Lemma, 2010). Maize is the second most widely cultivated crop in Ethiopia and is grown under diverse agro-ecologies and socioeconomic conditions (Tsedeke *et al.*, 2017). As confirmed by the study done in Ethiopia, most of the farmers (89.5%) apply fertilizer for maize production out of which 75% of them apply inorganic fertilizers, 20.5% apply organic, and 4.5% apply both types of fertilizers (Balemi *et al.*, 2019). The study conducted by Abate *et al*. (2015) showed that the maize area covered by improved varieties in Ethiopia grew from 14% to 40% in 2004-2013, and the application rate of mineral fertilizers grew from 16 to 34 kg/ha during the same period. In Ethiopia, the maize crop production accounts for average 6.7 million tons over 2013-2015 production period (FAO, 2015). Furthermore, as confirmed by a study done in Ethiopia, in comparison to wheat and teff, maize is most important staple food to be consumed and low-priced crop (Abate *et al.*, 2015). The country assessment during 2014-15 about consumption expenditure presented that, among the key cereal crops, maize accounted for 16.7% of domestic calorie consumption compared to sorghum and wheat that accounted for 14.1% and 12.6%, respectively (Berhane *et al*., 2011).

A close look at the country's declining agricultural outputs, and, at the same time, ever-increasing population growth implores for a search of alternatives. One of the alternatives to bridge this ever-increasing gap between the two is the programs that focus mainly on the distribution of physical inputs such as fertilizer, high yielding varieties of seeds, credit supply to smallholders, and training on improved agronomic practices (Gecho and Punjabi, 2011**).** Moreover, it is important to develop the cultivated area for farming maize to ensure the food security and upholding sustainable development of agriculture (Uddin, Hossain and Hasnain, 2020).

Determining the factors affecting the maize production is important to improve the response tools related to the production of maize crop development. Even though some studies are published (Kutoya, Kebede and Yidnekachew, 2019; Yami, Meyer and Hassan, 2020; Gecho and Punjabi, 2011) concentrating on the adoption of technologies and commercial marketing of maize production, there is scarcity of studies that dispensed the determinants of maize production in the study area. Therefore, this study focuses on the influential determinants of maize production among the smallholder farmers in Eastern Ethiopia at large and in the Meta district of the Eastern Hararge zone of Oromia region in particular.

[1] *Eragrostis tef*, also known as teff, Williams lovegrass or annual bunch grass, is an annual grass, a species of lovegrass native to the Horn of Africa, notably to modern-day Ethiopia. It is cultivated for its edible seeds, also known as teff.

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Materials and Methods

Description of the study area

The study was conducted in Meta district of East Hararghe zone, Oromia region, Ethiopia. Meta district is one of the 21 districts of Eastern Hararghe zone of Oromia regional in Ethiopia. The district is classified as dearth flat, and various crop failures are a common problem usually leading to food famine. The land use of the Meta district consists of 52% arable land and 21% pasture and forest land, and the rest 27% is considered as degraded land (CSA, 2018). The major food crops in the district are sorghum, maize, barley, wheat, teff, etc. Khat *(Catha edulis)* and coffee are the main cash crops. The farming system of the district consists of crop production (7.9%), livestock production (4.1%), and mixed crop and livestock production (88.0%) (Yuya and Daba, 2018).

Sources of data and methods of data collection

The primary and secondary data were used in this study. Primary data were collected in 2019 using a semi-structured questionnaire that was managed by the trained investigators covering 200 smallholder maize farmers. Secondary data were collected from pertinent published and unpublished documents obtained from the internet, administration bureaus of the district and other available organizations.

Sampling technique and sample size determination

A two-stage sampling technique was employed to select prospective maize producer smallholder farmers. The term 'kebele' referred to a localized group of people under district in Ethiopia. In the first stage, two kebeles that potentially produce maize production were selected from district via purposive sampling methods. During the selection, kebeles that have prospective to the production of maize and accessibility to produce maize were taken into account. In the second stage, the sample size was ascertained proportionally in accordance with the population size of the farmers who produce maize. The population list of maize producer farmers from sample kebeles was consulted. Then, 200 representative farmers were randomly chosen using Yamane (1967) formula, which is as under:

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

Where *n* is the sample size, *N* is the population size (total household size), and *e is* the level of precision. The population is homogeneous in terms of maize production in the sampled kebeles. Due to the homogeneity of the population, 7% precision level was used for this study to avoid acquiring extra costs and captivating more time for collecting the same set of information on different smallholder maize producer farmers. Based on the number of the total households (9,118) in the sampling frame, the formula calculated and reached a minimum of 200 respondents to be drawn.

Method of data analysis

In order to analyse the data, the descriptive statistics and econometric model were applied. In descriptive statistics, mean, minimum, maximum, percentage and frequency were used to describe the socio-economic data and available opportunities to maize production while multiple linear regression model were applied to identify determinants of maize production among smallholder farmers in the Meta district.

Model specification

Production of maize crops owned by sampled household heads is a continuous dependent variable of the model that was measured in quintal. The appropriate econometric technique to deal with the continuous

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dependent variable is multiple linear regression model and it was the most familiar statistical model used to analyze such data. It is a general statistical technique through which one can analyze the relationship of a continuous response variable and a set of dummy/categorical/continuous explanatory variables (Alexopoulos, 2010). Multiple linear regression model is given as below:

$$MP = \beta_0 + \beta_1 AGEH + \beta_2 FSH + \beta_3 EDLH + \beta_4 NFI + \beta_5 CAL + \beta_6 DTM + \beta_7 DTDA + \beta_8 EAM + \beta_9 AFU + \beta_{10} AOFU + \beta_{11} AMI + \beta_{12} SS H + \varepsilon$$

Where $\beta_0, \beta_1, \ldots\ldots\ldots\ldots, \beta_{12}$ are the parameters and ε is a random disturbance.

Table 1: Definition and units of measurement of the variables in the multiple linear regression

Variables	Description and measurement
MP	Maize production (quintal)
AGEH	Age of household head (year)
FSH	Family size of household head (number)
EDLH	Educational level of household head (grades or number of years in school)
NFI	Non-farm income of household (dollar)
CAL	Cultivated area of land (hectare)
DTM	Distance to the market (hour)
DTDA	Distance to DA's office (hour)
EAM	Economically active members (number)
AFU	Amounts of fertilizer used (kg)
AOFU	Amounts of organic fertilizer used (kg)
AMI	Access to market information (1= if has a market information, 0 = otherwise)
SSH	Social status of household head in the community (1=if participated, 0 = otherwise)

Assumption of multiple linear regressions

Normality: The residual errors are normally distributed with mean zero and variance σ^2 can be tested by a histogram.

Homoscedasticity: Error terms have constant variance which indicates that the assumptions of homoscedasticity hold**.**

Autocorrelation: The error terms should be independent. There is no relation between successive error terms. The Durbin Watson (DW) statistic was used to test autocorrelation in the residuals from a statistical regression analysis. The Durbin-Watson statistic is always having a value between 0 and 4. Values from 0 to less than 2 indicate positive autocorrelation and values from 2 to 4 indicate negative autocorrelation.

Multicollinearity: Co-linearity, or multicollinearity, is the existence of near-linear relationships among the set of independent variables. The presence of multicollinearity was tested by the variance inflation factor, given by the formula:

$$VIF = \frac{1}{1 - R_i^2} \quad (3)$$

Where R_i^2 is coefficient of determination obtained from X_i on the other explanatory variables. If the value of VIF less than 10 (tolerance greater than 0.1), then there is no multicollinearity in the data.

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Result and Discussion

Characteristics of Socio-Economic Variables

As the results shown in Table 2, the average age of the sample respondents was 41 years with minimum age 20 years and maximum age 80 years. Similarly, the average family size of the sample households was 5, with 1 and 9 as minimum and maximum size, respectively. The average education that the farmers attended was grade 2 (Table 2). The results showed that average non-farm income of the surveyed households was USD 29.39 when the average economically active members in family were 3 members. Survey results also revealed that the average cultivated land of the households was 0.41 hectare. The average chemical fertilizers applied by the surveyed farmers was 211.19 kg, whereas the average organic manure applied by respondents was 492 kg. The mean distance between the farmer's home and the market in hours was 6.88 hours. Furthermore, the average distance between the home of household and the DA's office in hours for surveyed households was 1.62 hours (Table 2).

Table 2: Descriptive statistics for continuous variables

Variables	*Mean*	*Std. Deviation*	*Minimum*	*Maximum*
AGEH	41.59	11.58	20	80
FSH	5.82	1.66	1	9
EDLH	2.44	3.59	0	12
NFI	29.39	107.156	0	807.508
CAL	0.41	0.53	0.06	5
DTM	6.88	27.27	30	120
DTDA	1.62	13.82	2	60
EAM	3	1.01	1	6
AFU	211.19	164.08	0.00	800
AOFU	492	511	0.00	2000

AGEH = Age of Household, FSH = Family size of household, EDLH = Educational level of household, NFI = Non-farm income, CAL = Cultivated area of land, DTM = Distance to the market, DTDA = Distance to Developmental Agency's office, EAM = Economically active members, AFU = Quantity of fertilizer used, and AOFU = Quantity of organic fertilizer used.

The results in (Table 3) showed that 80% of surveyed respondents have access to market information. The access to market facilitates productivity and effectiveness of agricultural marketing amenities. 34.5% of surveyed households participated in social organizations too.

Table 3: Descriptive statistics for dummy variables

Variables	*Sample Households*	*Number*	*Percent (%)*
AMI	Yes	160	80.0
	No	40	20.0
SSH	Participated	69	34.5
	Not	131	65.5

AMI = Access to market information, SSH = Social status of household

Multiple Linear Regression Analysis for Maize Production

In order to know the determining factors that influence the production of maize crop, multiple linear regression model was employed. Firstly, the overall model adequacy was checked, then the model coefficients were analyzed. The model summary output indicated the strength of the association of the explanatory variables and the response variable. According to the model adequacy as shown in Table 4, the value of the correlation coefficient (R) was 0.85, which indicated that there was a strong association between

the maize production and other explanatory variables. The value of the coefficient of determination (R^2) was 72.25%, which indicated that 72.25% of the variation in the maize production was explained by other explanatory variables. Therefore, the model was adequate. This finding is consistent with Bukul (2018) who investigated factors affecting smallholder farmers' potato production. He found that the coefficient of determination was used to plaid the goodness of fit for the regression model. This finding is also in line with the finding of Bezawit (2011) and Mersha, Demek and Birhanu (2017).

Table 4: Model adequacy checking summary

Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*	*Durbin-Watson*
1	0.850[a]	0.7225	0.689	14.67493	2.034

Hypothesis Testing for the Model

Generally, the hypothesis testing is a technique used to test the joint effect of the explanatory variables on the response variable. ANOVA is a useful test for the ability of the model to explain any variation in the dependent variable, but it does not directly address the strength of the association between the variables. As indicated in Table 5, the overall model estimation is statistically significant, which means at least one of the parameters or coefficients of explanatory variables is different from zero.

Table 5: Overall Result of Analysis of Variance (ANOVA)

Model		*Sum of Squares*	*Df*	*Mean Square*	*F*	*Sig.*
1	Regression	82569.277	12	6880.773	32.478	0.004[b]
	Residual	39616.911	187	211.855		
	Total	41860.189	199			

As displayed in Table 6, non-farm income of the households, the cultivated area of land, distance to Developmental Agent's (DA's) office, economically active members, quantity of fertilizer used, quantity of organic manure applied and social status of household head in the community are statistically significant at 5% level of significance. This indicates that those variables are considered as important determinants that affect the maize production of farmers. The remaining explanatory variables - age of household head, family size of households, educational level of households, distance to nearest market and access of market information - were found to be not statistically significant at 5% level of significance.

Non-farm income of households has a positive and significant impact on the maize production as shown in Table 6. This is because the farmers spent additional income to buy inputs like improved seeds, chemical fertilizers and farm equipment for maize production and thus yielded more maize production compared to those who had not additional income. This finding is consistent with Bukul (2018). His finding revealed that involvement in off-farm activity had a positive impact on the potato production. Similarly, the cultivated area of land had a positive and significant effects on the farmers' production of maize in the study area. By increasing cultivation area, yields of maize production increased. This result is confirmed with the finding of Ahmed (2016). DA's office distance has a negative impact on the maize production and is significant at a 5% significance level (Table 6). The accessibility to improved agricultural information aids farmers to produce high crop diversity and to get higher production of maize crops. Similar result is reported by other researchers like Yuya and Daba (2018).

The result in Table 6 showed that the numbers of economically active members in a family have positive and significant influence on the maize production of smallholder farmers. This result matches with the findings of Yuya and Daba (2018). Moreover, quantity of fertilizer used has a positive impact on the yield of maize crop productivity. As the quantity of fertilizer increased by one kg, the quantity of maize production of smallholder farmers increased by 1.02 quintal, when other explanatory variables were kept unchanged. This result was consistent with the finding of Rao and Ketema (2016). The quantity of organic manure also has positive effect on the maize production of smallholder farmers and is statistically significant

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at 5% probability level. The result indicated that as the quantity of organic manure increased by one kg, the quantity of maize production of farmers has increased by 1.30 quintal, while keeping other explanatory variables constant. This result was consistent with Eneyew and Bekele (2012). Membership to social group was found to have a negative and significant impact on maize production of households. Thus, a communal wealth that encourages the distributing of knowledge, information, and skill concerning the worth of off- and non-farm events that benefit them to advance their income. This finding was inconsistent with the findings of Eneyew and Bekele (2012).

Table 6: Multiple regression analysis for variables predicting the production of maize crop

Variables	*Coef.*	*Std. Error*	*t-stat*	*Sig.*	*Tolerance*	*VIF*
(Constant)	1.321234	0.225640	5.855	0.838	-	-
AGEH	2.004721	0.296236	6.767	0.622	0.881	1.135
FSH	1.552358	0.382254	4.061	0.648	0.850	1.176
EDLH	2.933278	0.424568	6.908	0.000*	0.929	1.076
NFI	-0.051460	0.426235	-0.120	0.904	0.461	2.169
CAL	1.723407	0.302724	5.693	0.000*	0.942	1.062
DTM	3.852632	0.483389	7.970	0.425	0.439	1.566
DTDA	-4.452140	0.656810	-6.778	0.006*	0.885	1.131
EAM	1.291884	0.256123	5.044	0.008*	0.675	1.481
AFU	1.024562	0.385845	2.655	0.007*	0.568	1.761
AOFU	1.308254	0.267569	4.889	0.001*	0.580	1.725
AMI	-1.702520	0.426765	-3.989	0.717	0.906	1.103
SSH	2.853560	0.428231	6.663	0.000*	0.864	1.157
Number of observations		200				
F(12, 188)		32.478				
Prob>F		0.000				
R-Squared		0.7225				

AGEH = Age of household, FSH = Family size of household, EDLH = Educational level of household, NFI = Non-farm income, CAL = Cultivated area of land, DTM = Distance to the market, DTDA = Distance to Developmental Agency's office, EAM = Economically active members, AFU = Quantity of fertilizer used, AOFU = Quantity of organic fertilizer used, AMI = Access to market information, SSH = Social status of household, and * indicates significance at 5% probability level.

Model adequacy checking

Normality: The result revealed that the error terms were normally distributed approximately with mean zero and constant variance (Figure 1). This indicated that the error terms and explanatory variables were not correlated to each other. This means the models were well defined. The shape of the histogram should approximately follow the shape of the normal curve. Therefore, the assumption of normality was fulfilled. This was in line with the finding of Rao and Ketema (2016).

Homoscedasticity*:* As seen from Figure 2 of the residuals versus the fitted value (the production of maize crop), there was no relationship between the residuals and the fitted value of maize production. This indicated that there was no heteroscedasticity in the data. This means that the error term ε_i's were independently and identically distributed having a normal distribution with mean zero and constant variance σ_ε^2.

Multicollinearity*:* As indicated in Table 6, there was no serious multicollinearity problem among the explanatory variables including the model because all VIF values were less than 10 and all values of tolerances were greater than 0.1.

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Autocorrelation*:* As pointed out in Table 4, there was no autocorrelation between the error terms because the Durbin Watson statistic was 4.52, which was outside of the acceptance region (greater than 4).

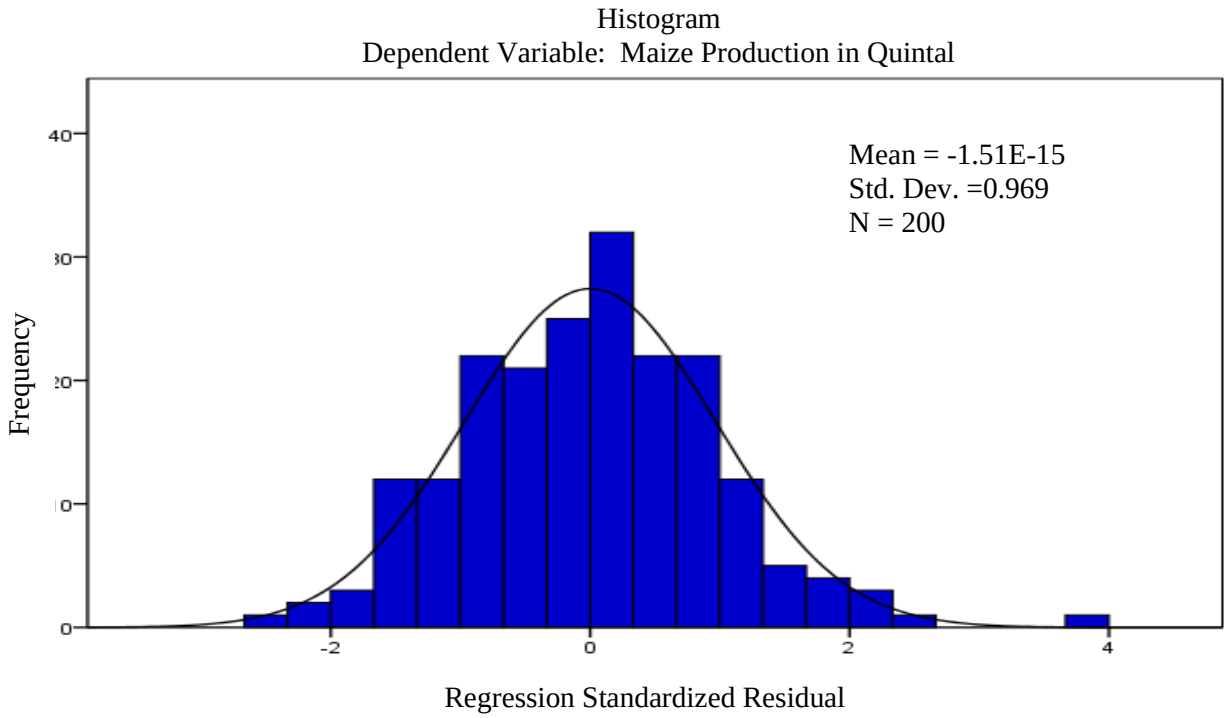

Figure 1. Histogram of residual against frequency of maize production

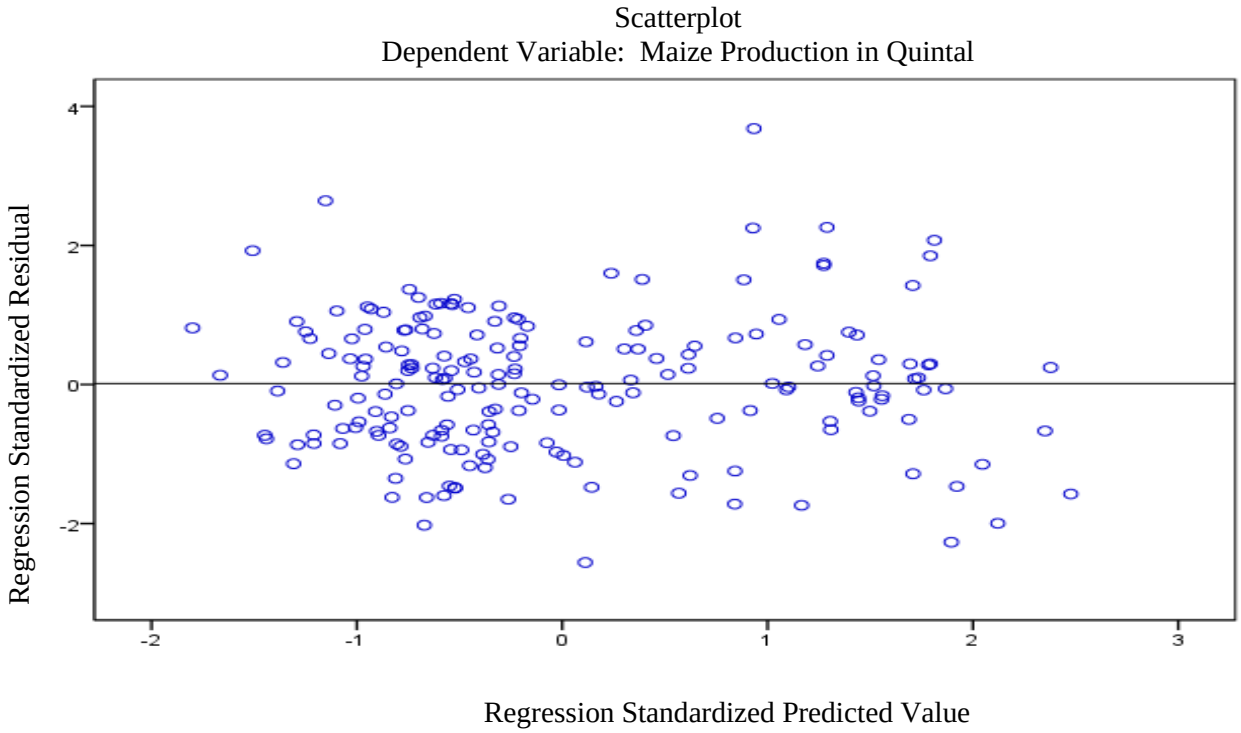

Figure 2. Scattered plot of standardized residual versus standardized predicted value

Conclusion and Recommendations

To increase the income and reduce rural poverty among smallholder farmers, agriculture needs improvement through increasing production and productivity of cereal crops. Therefore, improving the smallholder farmers' maize production is required to improve access to food and sustainable livelihoods. Therefore, this study was carried out to identify the household level determinants of maize production among smallholder farmers in the Meta district, East Hararge zone, Oromia region, Ethiopia. The result of the study showed that non-farm income of the household, the cultivated area of land, distance to DA's office, economically active members in family, quantity of fertilizer used, quantity of organic manure applied, and social status of households were important determinant of maize production among smallholder farmers. The non-farm income and cultivated area of households have positive impact on maize production. The economically active members of households have positive influence on maize production. The quantity of fertilizer used, and organic manure applied have a positive impact on the yield of maize crop productivity.

Consequently, maize productivity of smallholder farmers is fundamental in securing households' food security and reduce poverty, which in turn can ensure the wellbeing of farmer households. Therefore, government and non-government as well as other stakeholders should inspire farmers for up-to-date maize production and supply improved seeds, fertilizers and other improved technologies that support developing their farm households' prosperity.

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Collected the data	Yes	Yes
Contributed to data analysis & interpretation	Yes	Yes
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History of Agriculture of Galicia from the Second Half of 19th to First Third of 20th Centuries

Ihor Makaruk*[1], Natalia Tokar[2], Larysa Filoretova[3], Volodymyr Klapchuk[4]
[1]International Relations Department, Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine. Email: makiv45@gmail.com
[2]Department of History of Ukraine, Volodymyr Vynnychenko Central Ukrainian State Pedagogical University, Kropyvnytskyi, Ukraine. Email: vega0604@ukr.net
[3]Department of History of Ukraine, Volodymyr Vynnychenko Central Ukrainian State Pedagogical University, Kropyvnytskyi, Ukraine. Email: larisafiloretova@gmail.com
[4]Department of Hotel, Restaurant and Resort Business, Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine. Email: volodymyr_klapchuk@ukr.net
**Corresponding author | ORCID: 0000-0002-4928-4679*

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Abstract
From the second half of the 19th century until the beginning of the World War I, there was significant economic advancement in all sectors of farm management in the territory of Galicia (Halychyna), which was under the control of the Austro-Hungarian Empire during that period of history. This paper focuses on the impact of popular scientific extension, one of the key criteria for communicating the latest economic management techniques at that time. This allowed the region, which was significantly behind the other regions within the Austro-Hungarian Empire during that period, to progress economically. There was a breakthrough in methods and approaches to farm management during the studied period. The processes of mechanization, novel tillage techniques and land reclamation were introduced. Agricultural processing industry started to develop intensively. A serious consideration has been given to selective breeding of animals, which had a positive impact on the livestock rearing development. All these aspects have led to a significant improvement in the industry's performance.

Keywords
Galicia; Agriculture; Land reclamation; Farmland; Yield; Agricultural produce

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Introduction

The third division of the Polish-Lithuanian Commonwealth (Rzech Pospolita), in 1795, resulted in the annexation of the territories of west of Galicia to the Habsburg Monarchy – the lands up to Pilica (Pilitsa) and the Buh river in the north [the northern parts of the Cracow (Kraków) and Sandomierz provinces, the Lublin province, parts of the Holm land and Mazovia (Mazowsze)]. They were referred to as 'new', 'late', 'younger' or Western Galicia. In 1772, the Austrian government artificially consolidated the Ukrainian lands with parts of the Polish lands and formed the Kingdom of Galicia-Volhynia with the Grand Duchy of Kraków and the Principalities of Auschwitz and Zator as a new administrative unit of the Habsburg Monarchy (*in German*, Königreich Galizien und Lodomerien mit dem Großherzogtum Krakau und den Herzogtümern Auschwitz und Zator; *in Polish*, Królestwo Galicji i Lodomerii wraz z Wielkim Księstwem Krakowskim i Księstwem Oświęcimia i Zatoru). Lviv (Lemberg) was made the capital of the province, although the Austrian authorities initially considered Peremyshl (Przemyśl) or Jaroslav (Jarosław), closer to Vienna, as their options. By using the catchy name, the Austrian authorities were trying to underscore the so-called right of succession to the possession of the Ukrainian King Daniel dating back to the Kingdom of Galicia-Volhynia. The total area of the annexed lands was 83,000 km^2 with a population of over 2,340,000. The newly formed Kingdom of Galicia-Volhynia was one of the most densely populated provinces, encompassing 30,299 square miles and consisting of 7,980,477 citizens before World War I, of whom 4,672,050 were the Poles (58.5%) and 3,298,092 were the Ukrainians (41.3%) respectively. In Eastern Galicia, the Ukrainian population accounted for 72%, making it a majority (Nahayewsky, 1993, p.21). The Kingdom of Galicia-Volhynia was referred to as Galicia for short. It consolidated the Ukrainian ethnic lands (historical Galicia) and the lands of Malopolska. Administrative positions were held by the Polish nobles, although the majority of the population was of the Ukrainians. In addition to them, there were numerous Jewish and Armenian communities in the Kingdom. Subsequently, the Ukrainian area came to be called Eastern Galicia with its centre in Lviv, while the Polish area was referred to as Western Galicia with its centre in Cracow (Boyko, 2017).

Galicia existed in the above said status until November 1918. From November 1918 onwards, Galicia was under the administration of the West Ukrainian People's Republic (WUPR). It comprised 49 counties of Galicia, with a population of about 4 million people spread over a large territory (about 40,000 km^2). On 22 January 1919, WUPR merged with the Ukrainian People's Republic (UPR), becoming the 'Western Region of the Ukrainian People's Republic' (WRUPR). This territorial entity was dissolved on 18 July 1919 as a result of the Ukrainian-Polish war, and Galicia was divided between Poland, Romania and Czechoslovakia. On 14 March 1923, the 'Western Region of the Ukrainian People's Republic' was finally dissolved at a meeting of the Board of Ambassadors of the Entente States, whereas Eastern Galicia was granted autonomy within Poland. The political agreement between the USSR and Germany in September 1939 (Molotov-Ribbentrop Pact)[1] resulted in the annexation of Eastern Galicia, then part of Poland, to the Ukrainian Soviet Socialist Republic. In August 1991, Ukraine declared independence and seceded from the USSR. Today, Eastern Galicia is part of Ukraine (Klapchuk, 2012).

In the second half of the 19th century and before the outbreak of the World War I, there was a significant advancement in the agricultural industry in Galicia. One of the reasons for the relatively successful rise of the agricultural sector in Galicia was the development of sectoral research, the findings of which were implemented using better agricultural extension. Systemic research and scientific experiments had made it possible to carry out both arable farming and animal husbandry, advantageously. However, science without further implementation of its discoveries could not significantly affect the industry development in the region. Therefore, it is essential to examine and comprehend the scientific innovations put into practice, i.e., integration of scientific research findings into the agricultural sector of Galicia.

[1] http://historyfoundation.ru/2019/05/31/pakt/

The authors, in this paper, have identified each segment that had influenced the evolution of agricultural industry in general and definite structural units of the agrarian sphere in particular: arable farming (cereal and other crops), plant cultivation (horticultural activities) and animal husbandry (cattle breeding, horse breeding, swine breeding and sheep rearing, etc.).

Methodology

This analytical article is based on the results of a comprehensive study being carried out at the Faculty of History of the Vasyl Stefanyk Precarpathian National University, Ukraine. The overarching theme of the study was "The economic development of Galicia during the Austro-Hungarian Empire". Galicia comprises two parts – Eastern Galicia (the present-day territory of Ukraine) and Western Galicia (the present-day territory of Poland). Being a backward province of the Empire, in economic terms, it gradually began to develop successfully. This positive advancement had an integral effect on all economic realms, including agriculture.

The study of Galicia's agriculture was pursued in three countries: Ukraine, Poland and Austria. The panel of scholars visited archival facilities in Lviv, Kyiv, Cracow, Warsaw and Vienna, where they processed statistical data covering the period under study. Science-based methods were applied during the study, which made it possible to establish the facts of economic progress, in particular comparative analysis allowed to establish the dynamics of agricultural development in the different sub-disciplines of crop and livestock production. By means of a system analysis, it became possible to develop patterns that reveal the conditions for successful sustainable development of the province. This article analyzes how one of the key factors of successful agricultural development, namely scientific extension, became the driving force of change and transformation: novel approaches to farming were developed as well as new efficient methods of farming, tillage and cattle breeding were introduced. The population of the backward province responded positively to the changes, embracing them and introducing them into their day-to-day operations. Systematization has made it possible to describe the entire case study in a consistent manner on the plane of scientific inquiry.

The overwhelming majority of Galicia's residents, which was then an autonomous part of the Austro-Hungarian Empire, was involved in the agricultural sector, earning livelihood by arable farming and/or animal husbandry. To frame the research goals of this study, it was crucial to understand how agriculture was interpreted in terms of sectoral scientific achievements in that historic period. Therefore, it made the main path of this study to analyze the impact of theoretical scientific advances on human practice in the agrarian sphere via agricultural extension.

After all, the development of agriculture, in particular the use of natural resources, is part of the overall framework for studying Galicia's economic history. It will make possible to broaden the scope of the inquiry and to use the results in scientific research aiding further studies in the region within the context of the defined goals. However, a subsidiary objective of this study is to draw attention of a wide range of researchers, scholars and all concerned to the topic in question – history of the development of Galicia from the Austro-Hungarian period.

As this research included translation of literature from Polish to Ukrainian in order to understand the facts, all the translations, unless indicated otherwise, from Polish to Ukrainian or English, are done by the first author.

Review of Literature

The suggested topic is scantily studied in national academia. The subject is partially covered in the works by Klapchuk (1972), Kovalchak (1988), and Klapchuk (2015). The agricultural development was widely examined in Polish scientific information sources for both the periods under study (Rewieński, 1890; Walewski and Gieysztor, 1890; Bujak, 1908; Diamand, 1915; Dziewulski, 1918), and in the first half of the 20th century (Grochowski, 1925; Pruski, 1925; Grochowski, 1927; Przerembel, 1930). The register of

literature on issues relating to agriculture, covering a significant part of the bibliography of the period under inquiry, proved to be valuable for the study (Estreicher, 1959; Kosiek, 1962; Dybiec, 1998). In addition to scholarly publications, agricultural extension has been communicated in the dedicated journals and scientific serials such as *Rozprawy c.k. Galicyjskiego Towarzystwa Gosp.*, *Rolnik*, *Przegląd Weterynarski*, *Ogrodnictwo*, *Bartnik Postępowy*, *Głos Rolniczy*, *Przewodnik Kółek Rolniczych*, etc. It is worth noting that much of the published data in the said titles was translation of the works of the foreign academics and experts.

It is apparent from the analysis that the history of agriculture requires a meticulous and systematic examination, which will provide an opportunity to reconsider the impact of science-industry achievements on the economic development of then Galicia. Therefore, the agricultural system development in Galicia during the Austro-Hungarian period needed to be thoroughly studied.

Arable Farming and Plant Cultivation

Having comprehensively analyzed the statistical data on agricultural development in Galicia in the period under study, key findings were obtained, allowing to substantiate the focal points of this article. The status of agriculture development in Galicia at that time was definitely much poorer than the status of agricultural sector development of the individual (chiefly agrarian) European countries. In the late 19th and early 20th centuries, yields of the cereal grains in the majority of the European countries were twice as high as in Galicia (Table 1).

Table 1: Yields of staple crops in Galicia and Europe (quintals per hectare or q/ha)

States, regions	*Wheat*	*Rye*	*Barley*	*Oats*	*White potato*
Belgium	27.0	24.0	29.0	24.0	175.0
Germany	23.0	18.0	22.0	19.0	150.0
Ireland	23.0	19.0	24.0	23.0	107.0
The Netherlands	26.0	19.0	28.0	22.0	190.0
Austria	15.0	15.0	16.0	13.0	100.0
Sudetenland	17.0	15.0	17.0	18.0	110.0
Galicia	13.0	11.9	12.6	12.0	126.3

Source: Diamand (1915)

Table 1 suggests that there was only white potato farming in Galicia that was relatively competitive in the European agricultural commodities market; but yields of the cereal grains were only half of other European countries. This was also confirmed by Bujak (1917) in his study *Economic Development of Galicia (1772–1914)*. He examined the average yield of agricultural produce between 1903 and 1912, defining the scope of examination by the limits of the early 20th century (Table 2).

Table 2: Average yield of agricultural produce (q/ha) in 1903–1912

States, regions	*Wheat*	*Rye*	*White potato*	*Hay*
Galicia	11.5	10.6	113.4	30.9
Czech Republic	17.7	15.8	94.8	32.9
Germany	20.3	17.0	132.4	42.5
Poznań	20.4	16.6	143.2	38.0
Denmark	30.0	19.0	164.0	41.0

Source: Bujak (1917)

The trend of the yield changes in Galicia between 1872 and 1913 was positive and a constantly growing one (Table 3). The reason for the boost can be attributed to agricultural extension, which was constantly developing in the region. Scientific advances in the field of agriculture were of increasing interest among the parties in charge of farming operations.

Table 3: Cumulative yield index in Galicia (q/ha)

Years	*Wheat*	*Rye*	*Oats*	*Barley*	*White potato*
1872–1876	8.8	6.5	5.9	7.9	72.0
1880–1884	9.1	7.2	6.4	8.0	85.0
1884–1888	9.5	7.6	7.2	8.5	92.0
1894–1898	9.2	8.0	7.3	8.2	100.0
1901–1910	11.0	9.9	9.1	9.7	110.0
1909–1913	11.7	11.3	10.7	11.2	111.0

Source: Jezierski and Wyczański (2006)

As a consequence, the economic situation in Galicia improved significantly in the early 20th century. Bujak (1917) wrote about the issue[2] thuswise:

> "In the last few years before the war, we have been on the right track, we have undertaken extensive work on the rational organization of our economic life, and we have started to make up for our backlog and shortcomings. From a passive society, exploited by strangers from afar, we have become an active society, which has taken itself to use the wealth of its country and to satisfy its needs. If we were given an opportunity to continue along this path with all the perseverance and consistency, the gap between us and our western neighbors would undoubtedly be rapidly shrinking." (Bujak, 1917, pp.57–58)

Advancement in the cereal cultivation in Galicia took place on the cusp of the 19th and 20th centuries and was largely the result of increased inputs in the agriculture, research on enhancing yields of cereal grains and maintaining land resources efficiency. Results of this study reveal the manner in which the farmland had undergone changes in its composition, under which crops the arable land was used, and how it had positively influenced the yield improvement in Galicia of that period.

Table 4: Land resources structure during 1852–1902

Farmland type	*Area in ha*		
	1852-1866	*1889*	*1902*
Arable land	3,590,373	3,803,444	3,799,575
Grassland and vegetable gardens	922,802	986,082	984,205
Grazing	768,944	743,480	716,918
Woodland	2,113,766	2,023,724	2,020,212

Source: Pilat (1905)

The structure of land resources (Table 4) changed dynamically in favour of arable land, grassland and vegetable gardens due to reduction of grazing and woodland. This trend should have influenced the increase in agricultural production in the region. An additional point is that 13.3% of the arable land was lying fallow in Galicia in 1900 (Pilat, 1898). This contributed to improved soil fertility and more efficient farmland exploitation, as the land was resting in a loose and weed-free state, which facilitated the accumulation of sufficient moisture in it. Between 1874 and 1913 (Table 5), the area under cereal crops gradually decreased, and conversely, the area under industrial and fodder crops increased.

[2] *Weszliśmy w ostatnich latach przed wojną na dobrą drogę, podjęliśmy rozległe prace około racjonalnej organizacji naszego życia gospodarczego, zaczęliśmy odrabiać zaległości i zaniedbania nasze. Ze społeczeństwa biernego, eksploatowanego przez obcych z daleka, stawaliśmy się społeczeństwem czynnym, które samo wzięło się do zużytkowania bogactw swego kraju i do zaspokajania swoich potrzeb. Gdyby nam było danym iść dalej tą drogą z całą wytrwałością i konsekwencją, to niewątpliwie szybko zmniejszałaby się przestrzeń między nami a naszymi zachodnimi sąsiadami.*

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Table 5: Arable land distribution in Galicia (in percentage)

Years	*Cereals*	*Legumes*	*White potato*	*Fodder*	*Alios*	*Total*
1874	74.6	3.7	10.0	6.3	5.4	100
1881	71.2	4.3	11.3	7.2	6.0	100
1897	67.4	4.9	13.5	11.6	2.6	100
1913	67.7	2.5	14.8	12.2	2.8	100

Source: Jezierski and Wyczański (2006)

Decrease in cultivation of the cereal crops from 74.6% of all arable land of Galicia to 67% in the year 1913, a year before the World War I outbreak, could have had a negative impact on meeting the demands of the native population for food. Table 6 summarizes the dynamic pattern in the farmland structure in Galicia from 1900 till 1911.

Table 6: Dynamic pattern in the farmland structure in Galicia

Farmland	*Area in ha*			
	1900	*% of all used areas*	*1911*	*% of all used areas*
Arable land	3,799,879	48.41	3,806,619	48.50
Grassland	875,045	11.15	873,615	11.10
Grazing	716,848	9.13	738,604	9.41
Woodland	2,021,230	25.75	2,015,528	25.70

Source: Pilat (1900); Kryukov (1915)

At that time, most of the farmers were employing obsolete cultivation methods coupled with inadequate tools. Thus, in order to alter the situation and raise yields, it was essential to provide extension education to agricultural producers. It consisted of encouraging the use of modern equipment and the application of advanced management methods in farming systems. Jan Feliks Sikorski, in his seminal work *Mechanical Soil Tillage*, made an in-depth analysis of advantageous methods of tilling (Sikorski, 1898). The introduction of mechanization in all agricultural activities had greatly changed labour-intensive processes and, thus, had a positive impact on the efficiency of labour outcomes.

Table 7: Farming machinery and equipment in 1902

Size of farms (ha)	*Machinery (pcs)*	*Number of farms possessing machinery and equipment*									
		Fertilizer drills	*Grain drills*	*Forage harvesters*	*Reapers*	*Potato harvesters*	*Chaffcutters*	*Centrifuges*	*Shot casting plants*	*Milk houses*	*Flour mills*
<2	35,533	1	3	0	10	12	32,163	10	2,829	139	1,544
2-5	114,009	2	16	2	24	60	108,000	23	3,865	582	11,069
5-10	82,164	0	15	1	24	50	77,556	38	2,609	1,586	16,243
10-20	24,821	1	15	2	9	35	23,158	28	1,054	2,632	9,309
20-100	6,594	6	137	74	30	45	6,209	28	406	2,774	3,758
>100	3,801	276	2,138	1,211	606	406	3,598	213	859	3,300	3,069
Total	266,922	286	2,324	1,290	703	608	250,684	340	11,622	11,013	44,992

Source: Bujak (1908)

The maximum number of machinery and equipment was assigned to large farms that made handsome profits from their operations, whilst small family-operated farms possessed only the most necessary equipment. There were only three steam-driven ploughs and 12 mechanical drills in Galicia at that time (Bujak, 1908). The important constituents of yield improvement program were not only the mechanization processes, but also the research on soils, application of manures and fertilizers, introduction of crop rotation, as well as the new methods of land tilling, drainage of marshy fields, and use of melioration (Bujak, 1908; Biernacki, 1913). The drainage system along with irrigation of agricultural lands was given scientific credence (Krzyżanowski, 1879). It made it possible to exploit land plots that had previously been considered unfit for cereal crops cultivation. Commenced in 1876, active land improvement measures were enacted with the purpose of intensifying agriculture in the region. Certain areas of fecund soil were drained and irrigated, and the government significantly financed such interventions. Thus, during the 1876–1892 timeframe, the funds allocated to reclamation works increased 230-fold, amounting to PLN 1,607,370 (Pilat, 1898). Selection of cereal crops was another significant trend in the development of the sophisticated techniques in agriculture. The scientists worked on it in the Agrarian Academy in Dubliany (Mazurkiewicz, 1913), where experiments on different grain varieties were conducted in the field. The cultivation of wheat, barley, rye and oats was subject to in-depth analysis and research, especially to understand when to sow the crops and when to harvest.

White potato was used as a food item as well as the raw material for alcohol, starch and other derivatives' production. Significant areas of land were allotted to white potato cultivation as the yield was quite high in Eastern Galicia (Table 8). Farmers involved in white potato cultivation, and white beet farms were developed for the processing industry, namely alcohol manufacturing.

Table 8: White potato yields through 1909 to 1913

Province	*Area in thousand ha*	*Gross output in thousand quintals*	*Crop yield in q/ha*
Lviv	159,200	19,258.8	121
Stanislaviv	108,500	9,764.1	90
Ternopil	142,200	17,778.7	125
Galicia	409,900	46,801.6	112

Source: Khraplyvyi (1936)

Traditionally, small farms were not engaged in the cultivation of white beet, this was done by large and high-capacity farms. The relevant information on white beet growing (the results of tests, methods of planting and care, winter storage, and seed multiplication) was disclosed to the public (Żeleński, 1894; Turnau, 1903; Kosiński, 1906).

Table 9: White beet yields in Eastern Galicia during 1884–1906

Crop plant	*1884–1893*	*1896–1905*	*1906*	
	Crop yield in q/ha	*Crop yield in q/ha*	*Crop yield in q/ha*	*Gross output in thousand quintals*
White beet	165.1	205.4	212.0	1,107

Source: Bujak (1908)

Analysis of the results is presented in Table 9 that reveals that white beet yield increased rapidly, although most of the output was processed to produce alcohol rather than sugar (Dąbrowski, 1992). Researchers and scholars who were engaged in legume crop studies attributed a great significance to the clover cultivation. Most of academic papers highlighted soil tillage, the improved varieties, seed quality, nurturing, harvesting, drying and threshing (Czaykowski, 1902; Antoniewicz, 1905a; Wiśniewski, 1916). As the data in Table 10 shows, clover was planted to produce hay and seeds alike. Consequently, different seeding techniques, crop husbandry and post-harvest processing were employed. The demand for hay and seeds was obviously different and dependent on the exigencies. That is why the average annual area under clover cultivation for

hay was much larger than that for seed production.

Table 10: Clover crops and harvesting (1889–1898)

Clover	*Area in ha*			*Crop yield in quintal*	
	Total	*% to farmland*	*% to arable land*	*Gross output*	*per ha*
For hay	258,832	7.93	6.81	8,741,295	33.77
For seeds	15,339	5.93	0.4	23,853	1.56

Source: Pilat (1900)

Table 11: Areas and crop yields in 1899

Clover	*Western Galicia*			*Eastern Galicia*		
	Area in ha	*%*	*Crop yield in q/ha*	*Area in ha*	*%*	*Crop yield in q/ha*
For hay	141,256	48.4	43.5	150,670	51.6	30.9

Source: Klapchuk (2015)

The areas used under the cultivation of clover for hay increased from the annual average of 258,832 ha in 1889–1898 (see Table 10) to 291,926 ha in 1899 (see Table 11). There was also a noticeable difference in yields between Western Galicia and Eastern Galicia. The scholars who wrote on clover issues emphasized that clover was a perfect forage plant for animals, and its usage fertilized soil with nutritive substances (Zabłocki, 1902). Quite profound knowledge of clover was presented in Bronisław Janowski's work, who offered advanced methods of growing clover blends and thoroughly described the cultivation practices, harvesting and processing of the finished produce (Janowski, 1908).

Cultivation of flax for the fibres was prominently featured as an industrial crop (Jarosiński, 1916). Several fundamental works of that period contributed to the agricultural extension in Galicia. It is worth noting Władysław Noskowski's work, an agronomist and a teacher at the Agrarian School in Dubliany, where he turned attention of agricultural producers to the number of flax sub-varieties, their sowing features, how to raise them, how to use fertilizers, how to undertake measures against diseases and pests, and the latest methods of harvesting (Noskowski, 1872). Wojciech Chłopiński's *Cultivation and Processing of Flax* (Chłopiński, 1907) was commissioned by the Galicia Economic Society in Lviv, and it accelerated profound interest of the farmers in flax cultivation. Wojciech Chłopiński studied flax farming systematically and put high emphasis on this branch of farming systems. Additionally, he had other significant and popular publications relating to flax (Chłopiński, 1913; Chłopiński, 1917).

Table 12: Flax crops and harvesting during the period of 1889-1898

Crop plant	*Area in ha*			*Crop yield in q*	
	Total	*% to farmland*	*% to arable land*	*Gross output*	*per ha*
Flax	25,280	0.78	0.67	83,798	3.31

Source: Pilat (1900)

Table 13: Areas and crop yields in 1899

Crop plant	*Western Galicia*			*Eastern Galicia*		
	Area in ha	*%*	*Crop yield in q/ha*	*Area in ha*	*%*	*Crop yield in q/ha*
Flax	11,542	48.8	3.2	12,088	51.2	3.7

Source: Klapchuk (2015)

While comparing the data in Table 12 and Table 13, it is noticed that the areas used for flax cultivation in 1899 decreased as compared to the annual average for 1889–1898. However, more consideration was given to flax cultivation in Eastern Galicia than in Western Galicia; the yield in Eastern Galicia was higher.

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During the study period, horticulture was observed enhancing in the region. It was further developed and improved by researchers, scholars, scientists and extension workers (Table 14). The published works contained detailed instructions on how to plant gardens, to nurture them in order to have sufficient yield, and to select the varieties; a large number of such studies were published both in Western Galicia (Giżycki, 1845; Konkolewski, 1847; Kozubowski, 1868; Czepiński and Langie, 1868–1869; Mieroszowska, 1890; Brzeziński, 1897) and in Eastern Galicia (Giżycki, 1845; Kisielewski, 1869, Schmidt, 1878; Boberski, 1880; Roehring, 1881; Pierożyński, 1882; Ćwikliński, 1882; Oleskow, 1885).

Table 14: Fruit tree species in Galicia

Region	*Proportion of fruit tree species in percentage*								
	Apple trees	*Pear trees*	*Plum trees*	*Cherry trees*	*Sweet cherry trees*	*Apricot trees*	*Peach trees*	*Mulberry trees*	*Nut trees*
Galicia	58.4	11.1	17.0	7.1	4.3	2.2	0.1	0.1	3.3

Source: Klapchuk (2015)

In publications related to horticultural development, necessity of organizing fruit trade by establishing agencies for purchase and distribution of the horticultural produce was highlighted (Gniewosz, 1908). The total area under gardening in Galicia was reported 71,100 ha in the year 1936. More than 6.1 million plants or 129 plants per ha of fruit trees were planted in Galicia at that time (Table 15).

Table 15: Gardens in Galicia

Region	*Number of trees*	*Number of trees per ha*	*Fruit harvesting*	
			quintal	*kg per capita*
Galicia	6,122,123	129	1,300,129	26.4

Source: Khraplyvyi (1936)

Compared to the publications on the cultivation of horticultural crops, the number of published materials on fruit bush growing was much less. The reason was that this type of horticulture was underdeveloped in the region; some attention in the educational books was given to currant bushes. It was argued that this type of horticulture needed more attention of local farmers, as its produce is delicious and healthy (Tabeau, 1901; Morawski, 1902a, 1902b). Popular science journals also featured articles on the cultivation and crop husbandry of gooseberry bushes (Trzebiński, 1904; Namysłowski, 1907; Chmielewski, 1912; Namysłowski, 1913), raspberry bushes (Tabeau, 1901), and viticulture (Kośnierski, 1881; Brzeziński, 1904; Zając, 1911), occasionally.

Hayfields and grazing were an essential source of natural fodder for livestock. There were 562,000 ha under hayfields in Galicia. Such fields were divided into low-lying (55.2%), fieldgrowing (42.7%) and reclaimed (2.1%) lands. Crop productivity level of hayfields was high in Galicia (Table 16). Low-lying hayfields yielded 58.5% of all hay, which was put in storage in Galicia, fieldgrowing was 36.5%, and reclaimed lands yielded 5% only.

The farms of Galicia occupied 211,284 ha of agricultural land for grazing (Khraplyvyi, 1936). The highest value was assigned to mountain pasture grounds, which existed in unpopulated mountain highlands. The similar processes were also exhibited in the works of researchers and scholars who, in due course, analyzed in the historical aspects the processes that took place before the World War I (Styś, 1936; Wykrętowicz, 1968; Michalewicz, 1993; Spyra, 1994; Kramarz, 2002; Kargol, 2010; Wnęk, 2010; Broński, 2012).

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Table 16: Hay harvesting (thousand quintals)

Region	*Low-lying*			*Field growing*			*Reclaimed*			*Total*
	First cut	*Second cut aftermath*	*Total*	*First cut*	*Second cut aftermath*	*Total*	*First cut*	*Second cut aftermath*	*Total*	
Galicia	4594.6	1373.1	5967.7	3049.2	683.4	3732.6	370.1	134.7	504.8	10,206

Source: Klapchuk (2015)

Reinforcing the same processes in terms of the current study, Franciszek Bujak's quotation[3] is pertinent here:

> "Modern farmers set up distilleries and grow potatoes instead of grain, which they sell in the form of spirits and possibly ready-to-use vodkas; they set up sugar mills to grow beets; they set up breweries to bring in better out on barley; they process the wheat into flour and bran in their own mills and make bread in their own bakeries; they keep the gardens from which fruit and vegetables are processed into tinned food and other preserves." (Bujak, 1917, p. 289)

Livestock Husbandry

Animal husbandry was regarded as an important branch of agriculture. Similarly, to plant cultivation, it required new and effective approaches in farm management practices. The sectoral research headed into this direction. The research was able to educate the consumers and shared the results of research by means of scholarly literature and educational books. The published papers during the study period tried to cover all major specialities of animal husbandry: horse breeding (Sanguszko, 1839; Rozwadowski, 1866; Kretowicz, 1884; Szybalski, 1887; Ryx, 1888; Zygmuntowicz, 1901; Dąbrowski, 1903), cattle breeding (Puchalski, 1871; Skrzyński, 1883; Dzianott, 1886; Malsburg, 1894), poultry farming (Bojanowski, 1901a, 1901b, 1901c; Bętkowska, 1903; Czaykowski, 1903; Mańkowski, 1905; Neumanówna, 1913), pig breeding (Czaykowski, 1901; Antoniewicz, 1905b; Masior, 1913), sheep rearing (Pawlikowski, 1840; Wodzicki, 1853; Stanowski, 1884), apiculture (Lubieniecki, 1859; Macieszkiewicz, 1886) and veterinary medicine (Wierzejski, 1881; Szpilman, 1887; Kwieciński, 1887; Seifman, 1887; Prus, 1895). Full attention was given to breeding, which enabled a qualitative improvement of the livestock units. In the second half of the 19th century, there was a general tendency to increase livestock units in Galicia, excluding the bouts of blight or murrain (Klapchuk, 2015).

Table 17: Dynamic pattern of livestock units in Galicia

Year	*Horses*	*Cattle*	*Mules, Donkeys*	*Sheep*	*Goats*	*Pigs*	*Beehives*
1851	530,554	1,434,826	741	955,908	221,000	675,000	0
1857	612,222	2,325,650	2,081	810,831	41,803	683,567	0
1869	695,610	2,070,572	1,891	966,763	35,824	734,572	257,493
1880	735,262	2,242,861	1,011	609,253	13,225	674,302	295,686
1890	765,570	2,448,006	1,203	630,994	21,095	784,500	261,047
Austria, 1890	1,548,197	8,643,936	57,952	3,186,787	1,035,832	3,549,700	920,640
% Galicia, 1890	49.45	28.32	2.08	19.80	2.04	22.10	28.35

Source: Pilat (1900)

[3] *Rolnicy nowocześni zakładają gorzelnie i zamiast zboża uprawiają ziemniaki, a te sprzedają w formie spirytusu, a ewentualnie gotowych do konsumpcji wódek; zakładają cukrownie, aby uprawiać buraki; zakładają browary, aby lepiej spieniężyć jęczmień; pszenicę przerabiają na mąkę i otręby we własnych młynach, a nawet mąkę na chleb we własnych piekarniach; utrzymują ogrody, z których owoce i jarzyny przerabiają na konserwy i inne przetwory.*

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In general, during the period under study (see Table 17), a sharp fall in the livestock numbers of sheep, goats, pigs, mules and donkeys was observed, whereas the number of horses and cattle was constantly growing. Galicia was home to almost half of the horses, a third of cattle and beehives at that time. As of 1910, there were more than 5.5 million heads of major livestock in Galicia.

Table 18: Livestock numbers in Galicia from 1900 to 1910

Livestock species	*1900*	*1910*	*Increase (+) or Decrease (-)*
Horses	869,138	905,272	+4.2%
Cattle	2,718,545	2,505,079	-8.5%
Pigs	1,254,909	1,835,464	+46.2%
Sheep	437,697	358,953	-18.0%
Goats	17,952	19,164	+6.8%
Mules and donkeys	962	481	-50.0%

Source: Pilat (1911)

When examining the data in Table 18, one may well notice that the number of cattle, sheep, mules and donkeys decreased during the study period, which was caused by various diseases and murrain, whilst the same period saw an increase in the number of pigs, horses and goats. The primary animal that contributed to agricultural activities of the region was horse. This is evidenced by the relevant statistics in Table 19.

Table 19: Number of horse units in Galicia

Years	*Size in thousand animal units*	*Density in animal units / km^2*	*Density in animal units / per 1000 capita*
1830	478	6.2	115
1870	696	8.9	128
1882	735	9.4	123
1900	865	11.0	119
1912	906	11.5	113

Source: Jezierski and Wyczański (2006)

The horse population data discloses that their population size steadily increased for 80 years. This population increase of horses facilitated the development of agriculture in the region. Antoni Barański was a great authority in this field of agricultural research. In his studies (Barański, 1883; Barański, 1890), he described equine species with maintenance of their health, nutrition, husbandry, breeding and proper housing. He proved that oats were the best feedstuff for horses. As part of his scientific work, he studied domestic cattle breeds, colour inheritance in cattle, inherited diseases in horses, history of veterinary medicine, animal care, livestock breeding and veterinary legislation (Millak, 1957).

Another significant livestock were the cattle. In Galicia, as in other regions of the Empire, cattle belonged to the category of animals frequently bred in local farms. Most of the farmers were convinced that a cattle breeding was far more profitable than arable farming, and its added benefit was the large quantity of manure being produced. Accordingly, at the beginning of 1911, there were 2,505,012 cattle units in Galicia (Kryukov, 1915), including 1,491,548 cows (63.5%), 58,686 pedigree bulls (2.3%), 54,324 bulls for slaughter (2.2%), and 800,545 calves of both sexes (32.0%). Table 20 displays the cattle population and density during the 1830–1912 timeframe.

Analysis reveals that the cattle population declined by 8.5% in Galicia during 1900–1911. In the late 19th and early 20th centuries, the science-education literature informed much on livestock grazing, husbandry and animal care (Pająk, 1870; Popiel, 1882; Adametz, 1898; Turnau, 1901; Antoniewicz, 1902; Górniak, 1903). The knowledge of operating the farms where cattle were raised was constantly changing and increasing, having a positive impact on livestock farming development. Different works were published on

fodder preparations and methods of cattle feeding (Ludkiewicz, 1910), on calf rearing (Sandoz, 1913), on cattle feeding habit with green forage (Włodek, 1913), on sheep, pigs, and cattle breeding (Klecki, 1916). The local population of Galicia consumed only 50% of meat produced during the study period (Klapchuk, 2015). Meat product surplus was supplied to other regions of the Empire or exported abroad.

Table 20: Cattle population in Galicia

Years	*Size in thousand animal units*	*Density in animal units / km²*	*Density in animal units per 1000 capita*
1830	1,468	19.0	358
1870	2,072	26.8	380
1882	2,243	29.0	376
1900	2,715	35.1	371
1912	2,503	32.4	312

Source: Jezierski and Wyczański (2006)

Another important element of animal husbandry in Galicia during the study period was sheep rearing, which required due attention, as their population was constantly declining. In 1880, there were 609,000 sheep in Galicia, and before 1910 the number of sheep decreased by almost twice (i.e., –359,000). The importance of sheep rearing can be confirmed by the fact that 61,365 rural and urban farms were engaged in sheep rearing in Galicia comprising 12.9% of all farms. Thus, there were 3.8 sheep per Galician farm at that time (Klapchuk, 2015). The largest sheep stock, about 50% of the total number in Galicia, was in the Stanislaviv province.

Table 21: Sheep stock in Galicia

Years	*Size in thousand animal units*	*Density in animal units / km²*	*Density in animal units per 1000 capita*
1830	751	10	181
1843	1,367	18	207
1869	967	12	178
1890	631	8	95
1910	378	5	47

Source: Jezierski and Wyczański (2006)

This was due to the existence of large areas of high-altitude mountain pastures (over 18 thousand ha), which made sheep grazing possible with minimal costs for their upkeep.

Table 22: Sheep stock in Galicia in 1910

Province	*Size in animal units*
Lviv	70,573
Stanislaviv	148,662
Ternopil	89,903
Galicia	309,138

Source: Klapchuk (2015)

The authors of research studying sheep rearing advocated for the breeding of these animals. The published material contained the guidelines advising how to raise lambs and mature sheep, how to arrange their feed and housing (Pawlikowski, 1840; Wodzicki, 1853; Stanowski, 1884; Łaszczyński, 1891). However, the number of these research papers was insufficient in comparison to the studies on horses or cattle. There were also not enough papers on pig farming. Despite this, pig farming was vibrant in Galicia. In 1900, there were 1,294 pig units, and their number increased to 1,835 units in 1910 within the region (Kryukov, 1915).

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Table 23: Dynamic pattern of pig population in Galicia

Years	*Size in thousand animal units*	*Density in animal units / km²*	*Density in animal units per 1000 capita*
1870	735	9.4	135
1890	785	10.0	119
1900	1,254	16.0	169
1912	1,834	23.4	229

Source: Jezierski and Wyczański (2006)

Over the period of 1870–1912, the pig number increased by a factor of 2.5 (Table 23), while the number of animal unit per capita increased by a factor of 1.7 only. This was affected by the various pig diseases during the study period. Resultantly, 100,000 pigs were compulsorily slaughtered due to epizooty[4] between 1899 and 1906. For these reasons, important academic papers came into light on effective pig feeding, breeding, prevention of diseases, propagation, piglets raising, husbandry (Czaykowski, 1901; Antoniewicz, 1905b; Masior, 1913).

Another vital component of animal husbandry was poultry farming. During the period of study, a significant rise in the fowl population took place (Table 24). The number of hens had almost doubled, while the number of other domestic fowls increased by 2.5 times. Poultry farming in Galicia was developed mainly in small peasant farms. Poultry products worth 31.8 million kronen[5] were exported from Galicia annually (Kryukov, 1915).

Table 24: Number of poultry in Galicia (1900–1910)

Poultry species	*Number of units*		*Population increase*	
	1900	*1910*	*Units*	*Percentage*
Hens	6,878,377	10,301,255	3,422,878	49.8
Geese	457,939	566,671	108,732	23.7
Ducks	285,319	384,533	99,214	34.8
Other fowl	133,252	234,271	101,019	75.8
Total	7,756,787	11,488,640	3,731,843	48.1

Source: Pilat (1911)

Evidently, with the increasing demand of animal proteins in Galicia region, researchers on animal husbandry advocated the necessity to develop poultry farming. The research articles on this topic rose in number at the turn of the 19th and 20th centuries (Bojanowski, 1901a, 1901b, 1901c; Stasieniewiczowa, 1902; Mańkowski, 1905; Kukura, 1906; Misiewicz, 1912a). The publications recommended the development of domestic fowl breeding on small farms. In their works, both the academicians and practitioners of poultry farming had proved that this type of management was as essential as horse and cattle breeding (Misiewicz, 1912b). They had also considered for geese farming and fattening, and proper handling of their feathers (Bętkowska, 1903).

Findings and Conclusion

One of the primary objectives of this study was to put Galicia in the public eye. This subject was poorly studied previously in Ukraine, as it was covered mainly in Poland and countries belonging to erstwhile Austro-Hungarian Empire. Thus, the development of agricultural knowledge in Galicia is witnessed by a large number of relevant publications. It should be noted that an awareness was fostered about the need to overhaul obsolete and inefficient farming practices with the help of scientific inputs.

[4] An epizootic disease affecting many animals at the same time, or an epidemic amongst animals.
[5] A former Austrian monetary unit.

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Based on the above analysis, it is argued that a significant number of scholars, researchers, and reformers, who were engaged in regional development of farming practices, believed that agriculture would have been more successfully developed than the manufacturing industry in the Galician region (Wnęk, 2015). The results of the major crop growth yields during the interval between 1901–1911 are summarized in Table 25.

Table 25: Gross output of staple crops

1901-1910		*1911*	
Gross output in quintal	*Crop yield in q/ha*	*Gross output in q*	*Crop yield in q/ha*
Rye			
6,180,353	9.8	8,312,636	11.9
Barley			
3,331,236	9.6	4,295,597	12.6
Oats			
6,195,941	9.5	8,428,168	12.0
Maize			
910,245	11.4	719,291	11.5

Source: Kryukov (1915)

This was made possible by communicating and adopting both the latest techniques in agriculture and new methods of work organization in the industry. The problems that did not allow gaining high yields were revealed. The scientific approach to soil structure and nutrition, and introduction of effective mechanization, fertilizer or manure application, land reclamation, etc. was developed. A clear-cut breakthrough in crop cultivation was the development of the new crop varieties, which enabled a significant yield enhancement. An unequivocal achievement during the study period was the development of animal husbandry in Galicia. Such fundamental developments in agricultural productivity are attributed to the contributions made by scientific and academic research and extension.

Table 26: Livestock density in the top ten European livestock breeding countries

Country, land	*Livestock density per km²*				*Density per 100 inhabitants*			
	Horses	*Cattle*	*Pigs*	*Sheep*	*Horses*	*Cattle*	*Pigs*	*Sheep*
Austria	6.0	30.5	21.4	8.2	6.3	32.0	22.5	8.5
England	6.9	37.5	11.3	99.4	5.2	28.2	8.5	74.9
Belgium	8.5	63.0	37.9	8.0	3.8	27.7	16.6	3.5
Galicia	11.5	31.9	23.3	4.5	11.2	31.2	22.8	4.4
Denmark	13.7	57.5	37.6	18.6	20.6	86.6	56.6	28.0
Spain	1.0	4.7	4.8	29.9	2.6	12.1	12.4	77.5
Italy	3.3	21.6	8.7	38.9	2.9	19.0	7.7	34.3
Germany	8.0	38.1	41.0	14.2	6.6	31.7	34.1	11.8
France	6.0	26.6	13.6	32.3	8.2	36.4	18.6	44.2
Sweden	1.3	6.0	2.0	2.2	11.3	53.1	17.9	19.8

Source: Pilat (1911)

In terms of livestock density per km^2 and per 100 inhabitants, as is evident from Table 26, Galicia ranked among the top six countries in Europe during the study period. Another important accomplishment of agricultural extension was that the correct perspectives of agricultural science gradually instilled in agricultural readers while changing their beliefs that profound change in agronomic practices and economic comprehension of farming practices would significantly improve their economic situation and increase the productivity of farmworkers. The literature underscored that the work of farmers was a unique and demanding occupation, which was aimed at obtaining high agricultural productivity – a source of income for people not only in Galicia but also throughout Europe.

Considering the discussion above, it is witnessed that a substantial advancement in the development of agriculture was registered in Galicia during the Austro-Hungarian era. All this would have been impossible without the meticulous work of agricultural scientists, who relentlessly and doggedly promoted innovative concepts of working on land. The data that has been discussed and analyzed in this paper will be further developed into doctoral research aimed at unveiling the features of the natural resources development and use across the economic history of Galicia Kingdom. This will enable this innovative topic to be addressed not only on the domestic plane but will also help broader section of academics and specialists interested in the subject to tart up their concepts and perspectives.

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Conceived and designed the research or analysis	Yes	Yes	Yes	Yes
Collected the data	Yes	Yes	Yes	Yes
Contributed to data analysis & interpretation	Yes	Yes	Yes	Yes
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Water Scarcity, Seasonal Variation and Social Conflict in Mountain Regions of Bangladesh

Sheeladitya Chakma[1], Md. Nuralam Hossain*[2], Md. Kamrul Islam[3], Md. Mohitul Hossain[4], Md. Nazirul Islam Sarker[5]

[1]School of Earth and Environmental Sciences, University of Queensland, Brisbane, Australia.
Email: chakma@uqconnect.edu.au
[2]School of Environment and Ecology, Chongqing University, Chongqing, China. Email: nuralam@cqu.edu.cn
[3]USAID-Supported Nature and Life Project, Community Development Center (CODEC), Cox's Bazar, Bangladesh.
Email: kamrul.forestry@gmail.com
[4]School of Biological Sciences, University of Western Australia, Perth, Australia. Email: mohitulh@yahoo.com
[5]School of Political Science and Public Administration, Neijiang Normal University, Neijiang, China.
Email: sarker.scu@yahoo.com
**Corresponding Author* | *ORCID: 0000-0003-0029-9367*

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Abstract

The study intends to assess water scarcity, seasonal variations, and social conflicts through a cross sectional study based on people's perceptions. A well-structured questionnaire coupled with an interview schedule was used for data collection from the 60 households living in the mountainous two villages at Waga union of Kaptai Upazila under Rangamati District, Bangladesh. The study employed a multi-stage random sampling technique. The analysis reveals that 90% of respondents in Sapchari Monpara village mostly rely on spring for water, while 83% of respondents in Debotachari village depend on tube-wells. The study also shows that 80% of the respondents have experienced water scarcity in domestic use, while 90% of respondents have reported short duration of the rainy season causes water scarcity. More than 80% of respondents believe that shifting cultivation in upland catchments causes water quality degradation in the study villages. Most of the respondents obtain water easily in a monsoon at Sapchari Monpara, while others get from tube-wells and traditional wells in all seasons. About (87%) of respondents mention that forest conservation around the water sources can increase water availability.

Keywords

Water shortage; People's perception; Water harvesting; Catchment area

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Introduction

Water is a valuable natural resource, vital for life, development, environments, and ecosystems (Sivakumar, 2011; Loucks and Beek, 2017). Water is essential for the growth, development, and survival of plants, animals, and human societies (Sivakumar, 2011). The availability of freshwater resources is essential for any development and quality of life, especially in mountainous areas (Tampakis, Manolas, and Matoli, 2011; UNEP, 2009). However, due to increased human activities, population growth, and industrialization, this precious resource is under heavy demand and threat (Abu-Zeid and Shiklomanov, 2003; Hafizur, Hossain and Rumainul, 2017). A rising scarcity of freshwater in comparison to human needs is now evident in many parts of the world (Postel, 2000; Rajat, Jagjit, and Harpreet, 2019). Several parts of the world face water shortages and water commoditization. But how this is perceived is problematic, and its consequences in the form of policy responses become critical (Fougner, 2008; Boelee *et al.*, 2017).

Today, inadequate water availability and quality have become a significant challenge to human livelihoods, food security, and natural ecosystems (Luijten, Knapp and Jones, 2001; Krishna, 2011). In many parts of the world, overexploitation of freshwater for agriculture, industry, and urban activities threatens the health of aquatic ecosystems and their life support systems (Krishna, 2011; Covich, 1993; Postel and Carpenter, 1997). The current water consumption rate will only worsen the situation (Gobarah *et al*., 2015). It is estimated that two-thirds of the world's population may experience severe water shortage by 2025 (Luijten, Knapp and Jones, 2001; Gobarah *et al*., 2015; Seckler, Barker and Amarasinghe, 1999). In the coming decades, water experts predict that more than half of the world's population will suffer acute water scarcity by 2050 (Gobarah *et al*., 2015). People in developing countries are predominantly at risk in areas experiencing rapid population growth and limited means of managing water resources (Luijten, Knapp and Jones, 2001). Therefore, for appropriate management and planning of water resources, watershed management is crucial. Watersheds have been extensively recognized as suitable biophysical or socioeconomic units for water resources management (Brooks *et al*., 2003; Lal, 2000; Luijten, Knapp and Jones, 2001), and streams in a watershed are the primary water source for domestic and agricultural practice in hilly rural areas (Luijten, Knapp and Jones, 2001).

There are many discussions on the water crisis worldwide (Daniel and Eelco, 2017). The developing countries, where much of the world population lives, face severe water scarcity and freshwater crisis (Sivakumar, 2011). Therefore, population growth, industrialization, urbanization, water pollution, deforestation, and water demand have also played a significant role in water scarcity (Fougner, 2008; Daniel and Eelco, 2017). An estimation suggests that 1.2 billion people do not have access to safe and affordable drinking water for their household use (Daniel and Eelco, 2017; WHO, 2003). According to the UN and UNICEF, most of the rural populations of 900 million live on less than a dollar per day without access to safe drinking water for their livelihoods (Rijsberman, 2006; FAO, 2006), and 2.6 billion populations are without proper sanitation facilities (UNICEF, 2019; UN, 2010). Lack of access to freshwater has significant impacts on the well-being of the population. It is estimated that lack of access to safe drinking water and inadequate sanitation and hygiene will cost the lives of 2.18 million people and have massive health consequences from diarrheal diseases (Khan, Rahim and Salam, 2003). Besides, extreme water shortage affects 400 million people today and 4 billion people by 2050 (Pruss *et al*., 2002; Biswas *et al*., 2012).

Rangamati district is the Southeastern part of Bangladesh under the Chittagong division, and the topography has a hilly slope and a moderate slope to the valley (Kamrul, Jashimuddin and Hossain, 2017). However, most of the local population, who are Indigenous communities, in the Rangamati district of Bangladesh is also suffering from water scarcity for six years (Miah *et al*., 2012). Many people even live with less income and suffer from other deprivations such as limited access to and low quality of social services, including water access (Dhali, 2008; Rasul, 2007; Thapa and Rasul, 2006). The overexploitation of natural resources, deforestation, and soil erosion may lead to water scarcity in the hilly areas (Verner, 2010). Further, removal of vegetation may affect the rainfall producing convection circulation in a local area and reduces precipitation in soil (Eriksen, 2001). The seasonal variations in rainfall and accelerated runoff may reduce

the soil precipitation, affecting the underground water levels height resulting a shortage of surface and sub-surface water supplies (Miah *et al*., 2012; Biswas and Vacik, 2008). This can be detected through low water levels of rivers, reservoirs, swamps, lakes, and basins (UNESCO, 2006). Shifting cultivation is the principal land uses activity, with soil degradation often not taken into account in land management, enhancing the rate of soil erosion (Gafur *et al*., 2003; Biswas *et al*., 2012). As a result, the upland watersheds have seriously affected the lowland environment, particularly water quality degradation (Karmakar *et al*., 2011; Biswas *et al*., 2012).

Water management is a vital issue due to increasing demand and rising conflict between alternative uses. Furthermore, the availability of freshwater is very seasonal, depending on the monsoon's presence. Moreover, the population growth and global climate change could potentially bring additional difficulties in future planning and water management. Given these observations, previous studies assumed that there will not be enough freshwater to sustain all lives and ecosystems globally and that there will be water scarcity and crisis (Sivakumar, 2011; Chowdhury, 2010). The previous studies have assessed increasing water scarcity and analyzed improvement opportunities in rural areas of the Chittagong Hill Tracts in Bangladesh (Malley *et al*., 2009; Biswas *et al*., 2012). However, limited research has been conducted on this issue in the hilly catchment areas in the Rangamati district. Therefore, a well understanding situation is necessary for proper management of water resources management in the hilly catchment area. However, it is also important to understand the water management challenges in terms of water's role in exploring the types and nature of socio-economic aspects affecting people's livelihoods. Thus, the study has been undertaken to assess the water scarcity, seasonal variations, and social conflicts through a cross-sectional survey based on people's perceptions of the study area.

Methodology

Description of the study area

The study was carried out in the mountainous two villages, Sapchari Monpara and Debotachari of Kaptai Upazila in the Rangamati District of Bangladesh. The study area lies between 22°21' and 22°35' north latitudes and in between 92°05' and 92°18' east longitude (BBS, 2009). The Kaptai Upazila is part of the Rangamati District of Chittagong Division, which is 259 km^2 (Kamrul, Jashimudin and Hossain, 2017; RHDC, 2011). The study villages topography has a hilly slope and a moderate slope to the valley (Table 1). The sources of drinking water are tube-well (23%), tap water (43%), pond (2.6%), and others (31%) (RHDC, 2011). These two villages were chosen for this study as most of the population is indigenous and has been suffering from water scarcity for six years (Miah *et al*., 2012). The study areas experienced severe environmental degradation due to shift cultivation; deforestation due to stone collection (Eriksen, 2001).

The water bodies, main rivers are Karnafuli and Kaptai lake. The Kaptai Hydroelectric Power Station, the only hydroelectric power plant in Bangladesh, is located here. This region has a tropical monsoon weather, and the annual temperature varies from 10˚C to 35˚C. The mean minimum temperature of 24˚C is experienced from December to January, and a maximum temperature of 34˚C is experienced from March to May (BMD, 2011). The annual rainfall varies from 2,200 mm to 3,000 mm, roughly 80% of rain takes place in May to September, which creates severe soil erosion on the prevailing steep slopes, and the rest of the months of the year remain nearly dry (Miah *et al*., 2012). Landforms of Rangamati are mainly composed of high hills and medium hills (Miah *et al*., 2012). The elevation of hills influences local rainfall and temperature. The soil physical and chemical characteristics also changed with an elevation of hills and, consequently, determine the crop suitability (Biswas *et al*., 2012).

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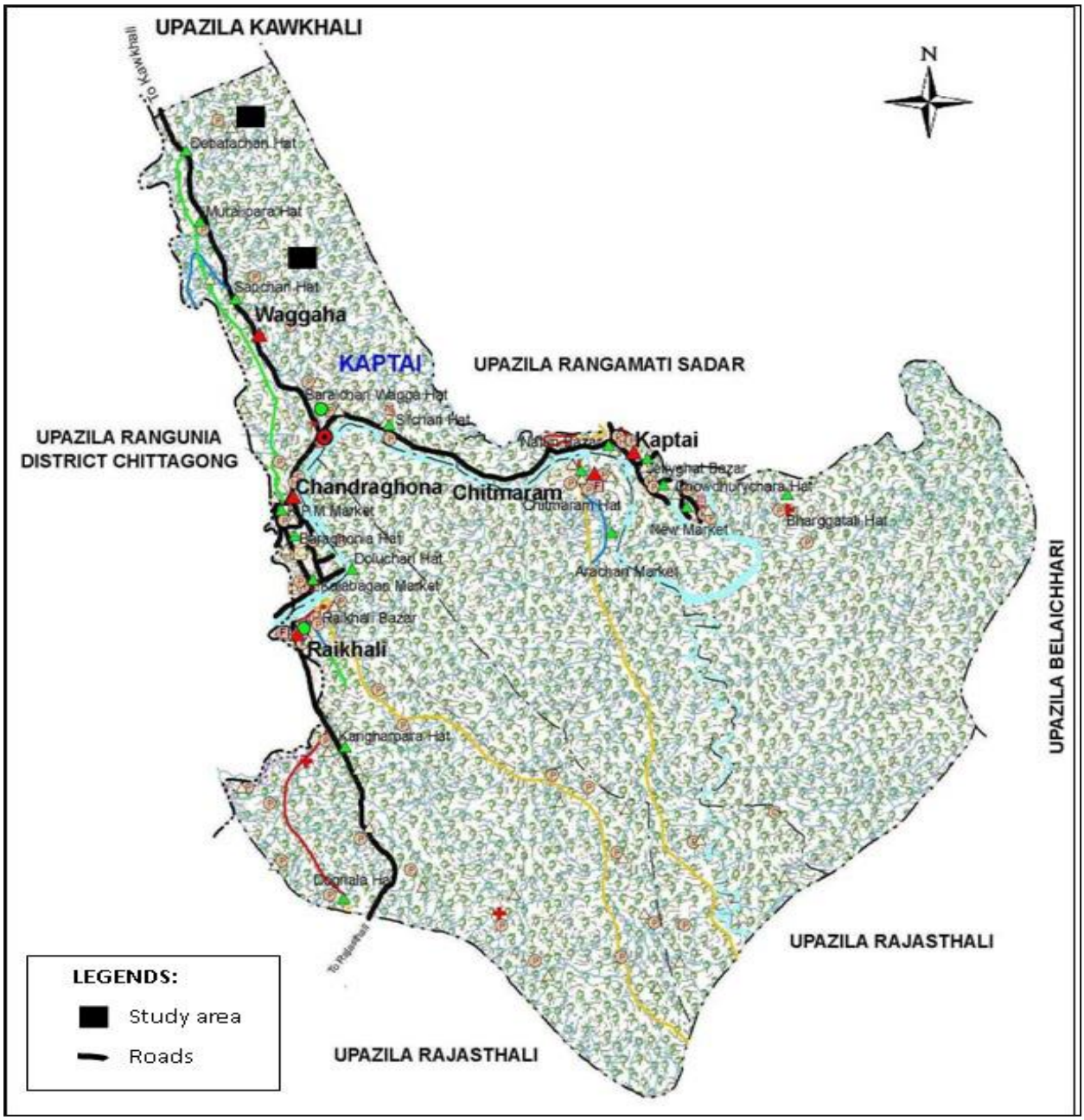

Figure 1: Location of the study area

Sampling methods

The population of the study area comprises both males and females in rural households of Indigenous communities. A multistage sampling procedure was employed to assemble primary data. Firstly, one (1) union was purposively selected from the five unions of Kaptai Upazila. Secondly, two (2) villages, namely Sapchari Monpara and Debotachari (Figure 1), were randomly selected from the union. Thirdly, thirty (30) respondents, including male and female, were randomly selected from rural households from each of the villages. Thus a total sample size of 60 respondents was selected for the survey. In Debotachari village, the rate of household sampling was 63% and Sapchari Monpara village the household sampling rate was75%. This study has been conducted at Waga union of Kaptai Upazila under Rangamati District, Bangladesh from January to March, and June to August, 2018.

Research tools

A range of research tools was used to collect information. A semi-structured questionnaire coupled with personal interview was used to elicit information from the respondents. The respondents were selected randomly for the interview. Five focus group discussions (FGDs) were arranged with the older people of the villages at familiar places where local people usually gather and sit. Total 30 people were randomly chosen for FGD session. Key questions were asked based on study objectives such as water shortage, seasonal variation, social challenges, and its solution. This approach helped reduce personal prejudice and verify the common knowledge among the villagers (Muhammed *et al*., 2013). Three key informant interviews (KIIs) were conducted with various sectoral specialists, leaders, and professionals to obtain the accurate information about the reasons, trends, and water scarcity. After completing data gathering, data were coded and tabulated into an excel sheet (Excel 2016), and statistical analysis was carried out by SPSS version 22. Data were carefully cleaned and validated to increase reliability. However, data were analyzed using both descriptive statistics and mean score and graphical representation by Microsoft Vision 2016.

Measurement of major indicators

Based on the people's perception, the water scarcity of the mountain households has assessed households' access to water sources, water use pattern, the extent of water scarcity, duration, quantity, and quality. A seasonal variation also affects water availability and creates challenges for mountain households. It has assessed by measuring the household's access to water in the different seasons to stream, spring, tubewells, and traditional well. Similarly, social conflicts have been measured by assessing gender involvement in fetching water, social challenges, and opinions to improve water availability. A number of context specific sub-indicators have been selected from existing literature (Biswas *et al*., 2012), results from FGDs, and key informant interviews. The nature of water shortage may be a social construct or the result of altered supply patterns stemming from climate change (FAO, 2007; Hossain *et al*., 2019; Sarker *et al*., 2020). In Kaptai, villagers experience a water shortage in two dimensions: the available amount for use and its suitability for human consumption. FGDs and household surveys analyzed the causes and processes of these two aspects of water scarcity.

Results

Water scarcity

Water plays an essential role in various aspects of people's livelihoods. Access to an adequate water supply can regulate a wide range of tangible and intangible activities such as better health, time savings, expenditure savings, empowerment, community capacity, food security, productivity, income, etc. Previous study found that the poorest people in the Bushbuckridge district (South Africa) obtained 17-33% of their annual income through small scale productive activities, with water being a critical input (Moriarty, Butterworth and Koppen, 2004). From this study, it is very apparent that only 20% of respondents of Debotachari used stream as an essential source of water. The number of respondents from Debotachari used tube-well and traditional well as their primary water source, which is 83% and 40%, respectively (Table 1).

In contrast, the majority of the residents of Sapchari Monpara were entirely dependent on stream (87%) and spring water (90%) (Table 1). Observation shows that the respondents' choice of water sources varied due to the geographical location of villages. Sapchari Monpara village is situated in a hilly area, so it is challenging to construct tube-wells up there. Nevertheless, the other village Debotachari is located in the valley, which has created an opportunity for the villagers to access tube-wells and traditional wells as their essential water sources for their livelihood (Figure 2).

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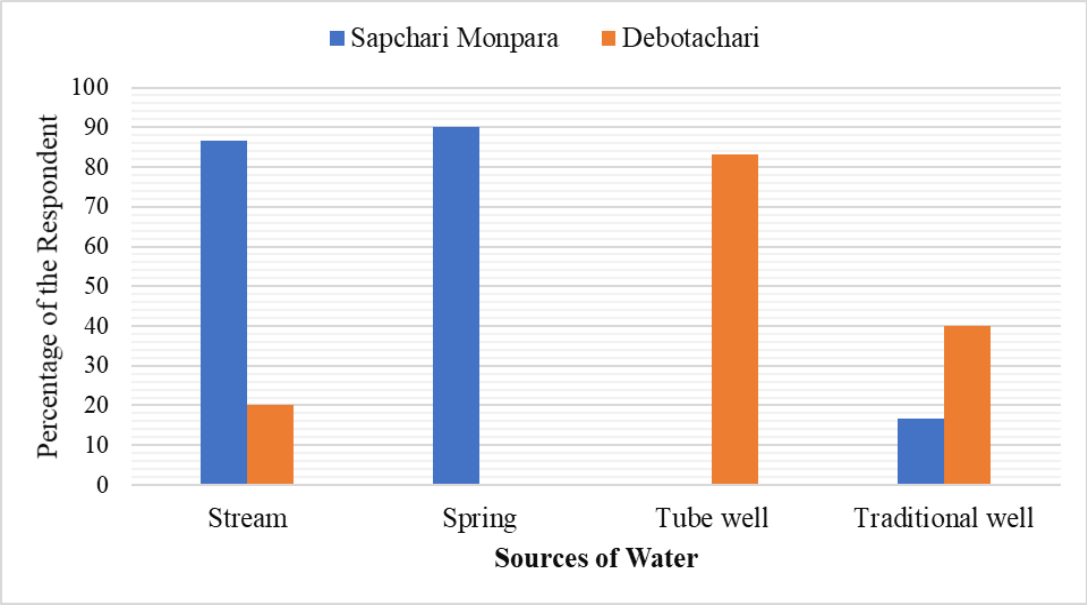

Figure 2: Sources of water

However, water sources impact on livelihoods is not always clear or equally distributed (Sivakumar, 2011). Previous study has found that a village in South Africa can better access better water supplies and is therefore in a better position to derive the maximum benefit from the water (Hope, Dixon and Maltitz, 2003). Thus, it is usually evident that improving water supply is likely to positively impact many aspects of people's livelihoods.

Table 1: Household perceptions on the important water sources in Kaptai

Responses	*Percentage of the respondents (%)*	
	Sapchari Monpara	*Debotachari*
*Important water sources (N=30) **	*100*	*100*
Stream	86.7	20
Spring	90	-
Tube-well	-	83.3
Traditional well	16.7	40

*More than one response was recorded; - No response was recorded.

The people of Sapchari Monpara are reliant on rain, streams, and springs for water (Table 2). It is only because of the non-availability of the tube-wells and traditional wells due to the village's geophysical location. In contrast, residents of Debotachari depended on tube-wells and conventional wells for water (Table 2). However, all the residents of Sapchari Monpara used spring water for drinking purposes, whereas 80% and 47% of respondents of Debotachari drink water from a tube-well and a traditional well, respectively. Besides, the stream water is used very wisely in both villages, as the general groups of villagers used it entirely for domestic use (100%), and the other groups of villagers used it both in household consumption[1] (73%) and irrigation (93%). However, Sapchari Monpara villagers do not use water for irrigation purposes as they are dependent on shifting agriculture and entirely rely on rainwater for irrigation. Moreover, a few respondents from both villages harvest rainwater for drinking purposes; the percentage was 10% in Sapchari Monpara and only 3% in Debotachari.

[1] Water uses (cooking, sanitation, cleaning and washing) besides drinking.

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Table 2: Water sources used for different purposes in Kaptai

Responses	*Percentage of the respondents (%)*					
	Sapchari Monpara			*Debotachari*		
*Water use purposes (N=30) **	*Drinking*	*Domestic*	*Irrigation*	*Drinking*	*Domestic*	*Irrigation*
Stream	26.7	100	-	-	73.3	93.3
Spring	100	10	-	-	-	-
Rainwater	46.7	-	-	6.7	30	-
Traditional well	16.7	-	-	46.7	36.7	-
Tube-well	-	-	-	80	63.3	-

*More than one response was recorded; - No response was recorded.

Water scarcity and its extent

The FAO identified water scarcity as the point at which all consumers overall impact affects the supply of water under existing institutional mechanisms to such an extent that all sectors demand, including the environment, are not completely satisfied (FAO, 2007). This survey found that 73% and 80% of the respondents belonging to Sapchari Monpara and Debotachari villages, respectively, have been facing water scarcity for more than 6 years (Figure 3). This means that most of the respondents of the study area are experiencing water shortages. These findings highlight water scarcity severity as a social problem (water conflicts, waterborne diseases, and poor sanitation) faced by the communities in the study area (Figure 5). From the study, it was apparent that only 10% of respondents of both villages are facing water scarcity for 2-4 years. Whereas 10% of respondents of Debotachari said that the problem of water scarcity existed for less than 2 years, and 17% of respondents have admitted it remain for 4-6 years. Therefore, most of the respondents of Sapchari Monpara and Debotachari mentioned facing water scarcity problems for more than 6 years by 73% and 80%, respectively (Figure 3). The FGD analyses reveal that Sapchari Monpara and Debotachari respondents are getting less water from the streams and springs in recent years. They perceive that due to the destruction of forests in the upland hills, the water shortage has existed. Besides, the stone collection from the stream for business purpose and forest destruction in catchments decrease the water infiltration capacity of soil in the catchment, while the stone collection from streams helps the water flow smoothly.

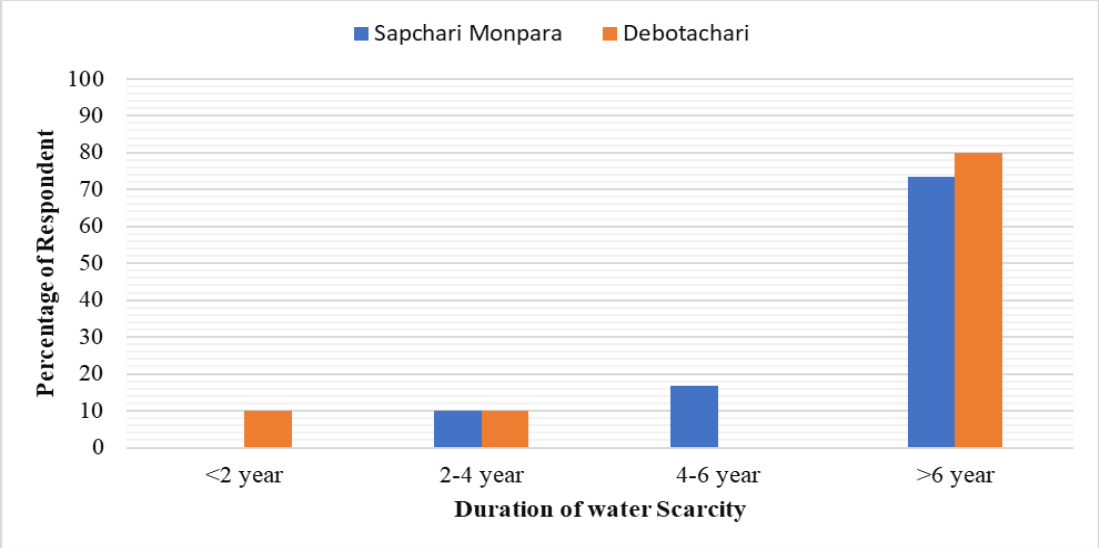

Figure 3: Household perceptions on the duration of experiencing water scarcity in Kaptai

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Decline in water quantity and quality

Water scarcity is mostly related to the water supply needed for various purposes. This fact becomes even more apparent as both the villages have poor water supply due to the low availability of water. The reasons for this low availability of water are the uneven distribution of rainfall, increased water demand, and the removal of vegetation from upland catchment areas (Biswas *et al*., 2012). According to the analysis, both villages' respondents agreed that the increased water demand and deforestation have contributed to water scarcity, which is 80% and 60%, respectively. A number of respondents of Sapchari Monpara perceived that decreased rainfall duration and amount are the causes of water shortage, which is 90% and 83%, respectively (Table 3). Considering people's perception, the Debotachari respondents have reported water misuse due to poor quality, leading to social water shortage. Besides, 30% of respondents have revealed that sedimentation in the natural water sources is responsible for water quality degradation. In contrast, 17% reported that watering livestock in the streams is another cause of water quality degradation (Table 3).

Table 3: Household perceptions about the causes of water scarcity in Kaptai

Perceived causes of water scarcity[*]	*Percentage of the respondent (%)*	
	Sapchari Monpara	*Debotachari*
A decline in the quantity of water supply		
Decreased rainfall duration	90	23
Declined rainfall amount	83	43
Increased water demand	73	80
Deforestation	80	60
Degradation of quality of human use		
Sedimentation in the natural water sources	-	30
Watering livestock in the stream	-	17

*More than one response per respondent was recorded.

Activities degrading water quality

Agricultural activities, which are considered an important way of life in rural areas, cause environmental quality degradation and subsequently impair water quality. 83% of respondents from Sapchari Monpara and 90% of respondents from Debotachari attributed the shifting cultivation in upland watersheds responsible for harm water quality. However, 40% of respondents in Sapchari Monpara and 50% of respondents in Debotachari have said that the low conservation measures in the upland catchment are causing the degradation of water quality in the stream (Table 4). 17% of respondents of Debotachari believe that watering the livestock may degrade the water quality. Furthermore, 40% of people revealed that natural sediment and debris accumulation in the stream might impair the water quality.

Table 4: Household perceptions for human activities for water quality degradation in Kaptai

*Anthropogenic activities degrading the water quality**	*Percentage of the respondent (%)*	
	Sapchari Monpara	*Debotachari*
Low conservation measures in upland catchments	40	50
Shifting cultivation in upland catchments	83	90
Watering livestock in the stream	-	17
Sediment load and accumulation of debris	13	40

*More than one response was recorded.

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Seasonal variation of water availability in stream

The availability of water in different water sources varies with seasons. 83% of the respondents in Sapchari Monpara have given their response the water is more available in monsoon season, whereas in Debotachari, 73% respondents have reported the water is more available in monsoon. However, 67% of the respondents also have reported that water becomes less available during summer in Sapchari Monpara and in Debotachari at winter (Table 5). 10% of respondents have said that water is not available in winter in Sapchari Monpara, while 33% respondents of Debotachari articulated the same. In Debotachari, 27% of respondents have reported that water is available in monsoon, whereas in Sapchari Monpara, 17% of respondents indicated that water is available both in winter and monsoon season.

Table 5: Seasonal variation of water availability in the stream in Kaptai

Categories	*Percentage of the respondents (%)*					
	Sapchari Monpara			*Debotachari*		
	Winter	*Summer*	*Monsoon*	*Winter*	*Summer*	*Monsoon*
More available	-	-	83	-	-	73
Available	17	13	17	-	-	27
Less available	73	67	-	67	17	-
Not available	10	20	-	33	83	-

Seasonal variation of water availability in spring

The study has found that only residents of Sapchari Monpara had access to spring water. 80% of the respondents in Sapchari Monpara have reported that water is more available in the monsoon season. In contrast, 93% of the respondents opined that water is less available in winter season. Further, 80% of the respondents of Sapchari Monpara have given their opinion water is less available in summer season (Table 6).

Table 6: Seasonal variation of water availability in spring in Kaptai

Categories	*Percentage of the respondents (%)*					
	Sapchari Monpara			*Debotachari*		
	Winter	*Summer*	*Monsoon*	*Winter*	*Summer*	*Monsoon*
More available	-	-	80	-	-	-
Available	7	20	20	-	-	-
Less available	93	80	-	-	-	-
Not available	-	-	-	-	-	-

Seasonal variation of water availability in tube well

It is evident from the result that tube-well is the primary water source for residents of Debotachari (Table 7). Water remains available in tube-wells throughout the year in Debotachari, but the availability level varies significantly according to seasons. 67% of respondents in Debotachari village have revealed that water is more available during the monsoon. 23% respondents of Debotachari village have reported that water is available throughout the year. Besides, 47% of the respondents in Debotachari village have said water is less available in summer season (Table 7).

Table 7: Seasonal variation of water availability in tube-well in Kaptai

Categories	Percentage of the respondents (%)					
	Sapchari Monpara			Debotachari		
	Winter	Summer	Monsoon	Winter	Summer	Monsoon
More available	-	-	-	47	20	67
Available	-	-	-	23	23	23
Less available	-	-	-	30	47	10
Not available	-	-	-	-	10	-

Seasonal variation of water availability in a traditional well

In different seasons, water availability in conventional wells varies in Kaptai Upazila. In Debotachari, 33% and 20% of respondents, respectively, said that water is available in winter, and monsoon seasons. In contrast, there were no traditional wells in Sapchari Monpara village. However, 57% of respondents in this village said that water is less available during winter, and 53% of the respondents said that water is less available during summer. More than 70% of respondents from Sapchari Monpara stated that water is unavailable in traditional wells during monsoon (Table 8).

Table 8: Seasonal variation of water availability in traditional well in Kaptai

Categories	*Percentage of the respondents (%)*					
	Sapchari Monpara			*Debotachari*		
	Winter	*Summer*	*Monsoon*	*Winter*	*Summer*	*Monsoon*
More available	-	-	-	-	-	-
Available	-	-	-	33	20	10
Less available	-	-	-	57	53	17
Not available	-	-	-	10	27	73

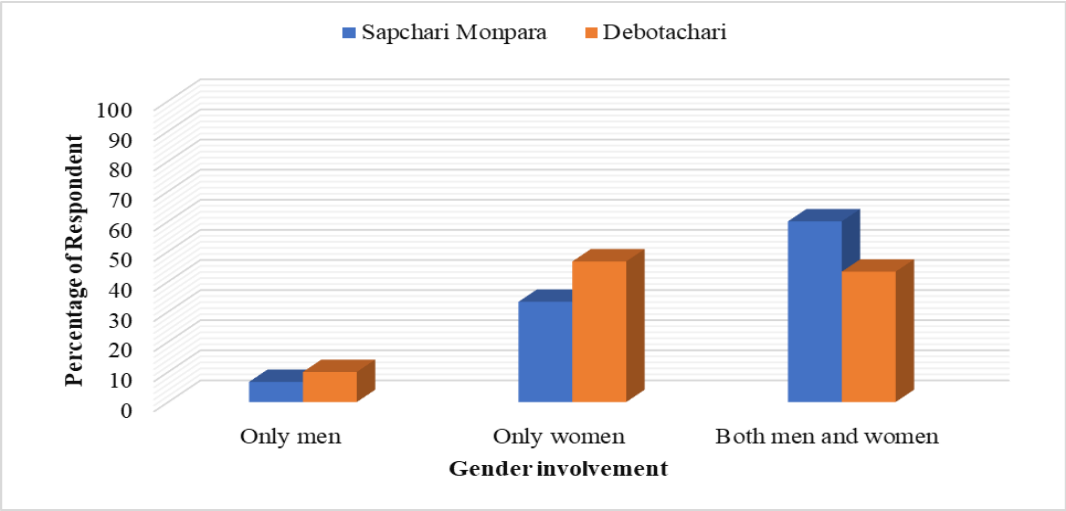

Figure 4: Gender involvement in fetching water in Kaptai

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Social Conflicts

Gender involvement in fetching water

In most of the developing countries, women and girls are ritually responsible for managing the household water supply and sanitation (UNICEF, 2008). As key persons at the household level, women are more interested in improving water and sanitation services and sustaining facilities. Survey in both the villages showed a higher percentage of women than men participating in fetching water. Only 6% and 10% of men were engaged in bringing water in Sapchari Monpara and Debotachari villages, respectively. Men do not even go frequently for water fetching in the village of Sapchari Monpara. In contrast, the proportion of women in Debotachari and Sapchari Monpara who fetch water was 47% and 33%, respectively. Thus, even though the percentage of women in fetching water was higher in Debotachari than in Sapchari Monpara, when both men and women were combined, the total percentage of both men and women in bringing water became higher in Sapchari Monpara than Debotachari (Figure 4). Therefore, the study assumed that women were more involved than men in fetching water both individually and together with men in the study area.

Social Problems due to water scarcity

Based on the respondent's opinions and FGD analyses, it was found that water scarcity leads to various social problems like conflicts in households, waterborne diseases, and poor sanitation, etc. The people of Sapchari Monpara rely on the spring for drinking water and the stream for domestic purpose. They have better water access in monsoon season, and less access in spring and dry season (winter and summer). In contrast, the respondents of Debotachari village get water from tube-wells and traditional wells in all seasons. However, the stream supplies less water in the first days of the winter season and completely dry out for the rest of the winter, and continues until the end of monsoon. Consequently, the people have to spend more time to collect water, which creates conflicts between them during collection and bathing. Water scarcity also creates conflicts within family members due to cooking delays, water unavailable for domestic use, and improper sanitation. These challenges further develop waterborne diseases like diarrhea, dysentery, cholera, etc. (Figure 5).

Opinions for improving water availability

Most of the respondents (87% in Sapchari Monpara and 77% in Debotachari) believed that forest conservation around the water sources increased water availability (Table 9). However, 53% of respondents of Sapchari Monpara and 63% of respondents of Debotachari believed that constructing a dam in the stream would make water more available. 50% of Sapchari Monpara respondents have also reported that water is harvested in the rainy season to make water more accessible. Besides, 40% of respondents in Debotachari have reported digging boreholes and wells may improve water availability. The Chittagong Hill Tracts based NGO, Hill Flower, implements a community-based forest resources conservation project in Sapchari Monpara village and improving rural livelihoods and strengthening their capacities and awareness about the environment. Another local NGO, Green Hill, implemented a drinking water supply project in Debotachari village that resolves the water scarcity.

Table 9: Household perceptions for improving water availability in Kaptai

Opinions for improving water availability[*]	*Percentage of the respondents (%)*	
	Sapchari Monpara	*Debotachari*
Conserving the forests around the source	86.67	76.67
Water harvesting in the rainy season	50	20
Constructing a dam in the stream	53	67
Digging boreholes and well	17	40

*More than one response was recorded.

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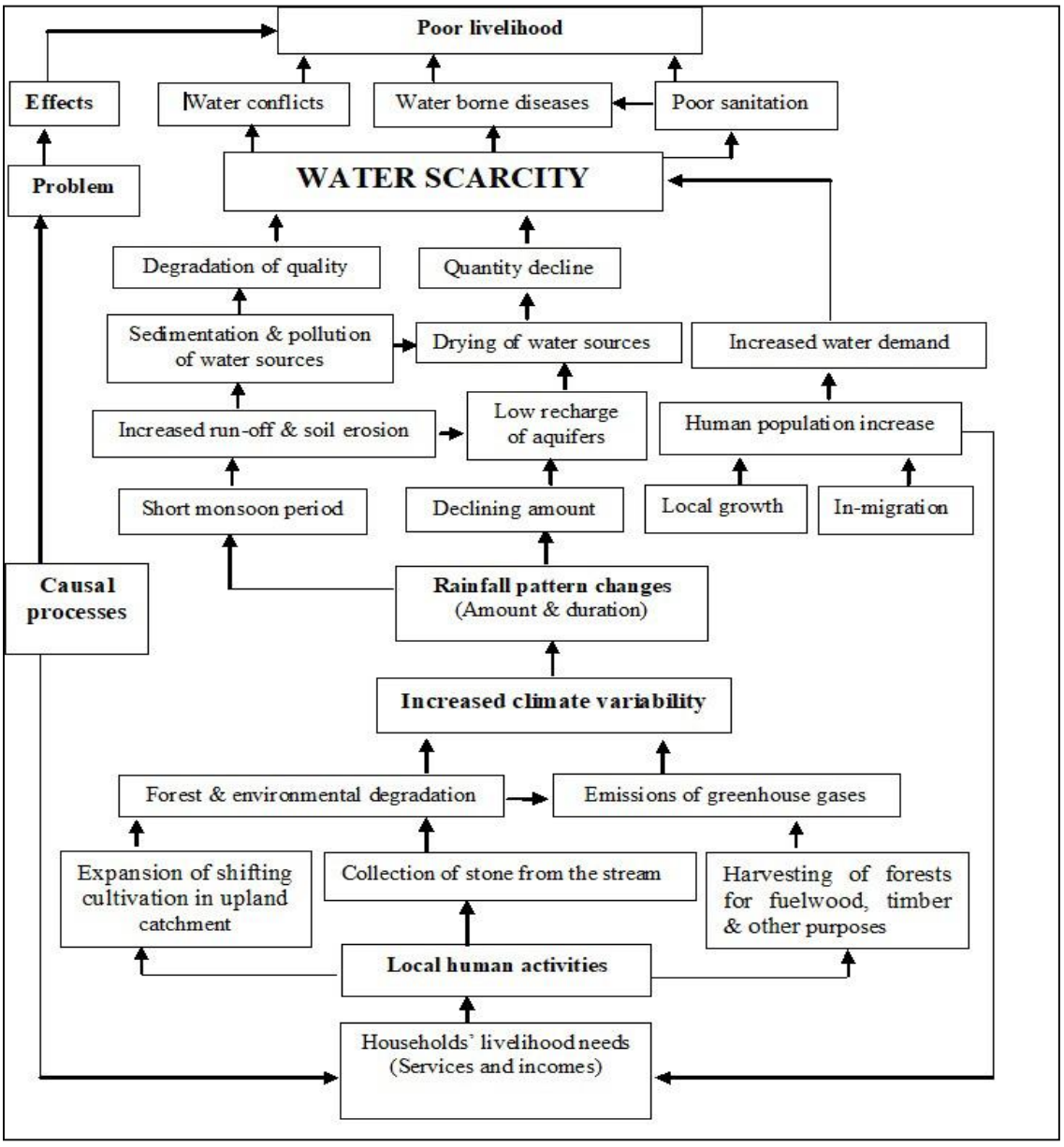

Figure 5: Cause-effects link model of water scarcity to the environment in Kaptai

Discussion

Generally, Chittagong Hill Tracts' weather has been characterized by rainfall (2,200-3,000 mm/year) (LGED, 2011). Nevertheless, during the FGDs, it was reported that the climate variability had increased in the Chittagong Hill Tracts region. Firstly, a notable increase of frequencies in precipitation deficiency, short heavy storms, and change in its timing were reported by respondents. Most of the households in the study areas associated with the increasing precipitation variability patterns faced water scarcity. This can be viewed from the perspective of rising hydrological changes, manifested by declines in surface and underground water supplies from springs, streams, traditional wells, and tube-wells. The rural livelihood activities based on natural resources (fuel and timber wood collection, edible fruits, and vegetable) keep pressure on forests, land, and water resources for agricultural production, which are degrading the environment. Previous authors reported that the degradation of forest and water resources are important

sinks of Green House Gases (GHGs), and these degradations may alter the physical properties of the environment (Malley *et al*., 2009). Droughts and seasonal variations in rainfall may reduce the soil precipitation, affecting the height of the under-groundwater levels. In this study, the respondents reported that water scarcity is associated with a shortage of rainfall. Besides, heavy storms result in runoff and soil erosion, reducing rainwater infiltration to recharge groundwater aquifers (Eriksen, 2001). Water sources, water availability and seasonal variation, water management, water scarcity duration, and social problems exist due to water scarcity. Reid and Alam (2016) have discussed ecosystems-based adaptation (EbA) emphasizes the importance of the multiple social, economic, and cultural benefits of ecosystems and their services to local communities. Healthy ecosystems provide drinking water, living space, shelter, food, raw materials, genetic materials, disaster prevention, a source of natural resources, and many other ecosystem services on which people depend (GIZ, 2019). This study supports these claims because the natural resources and ecosystem services at the hilly area offer various household benefits and livelihoods that contribute to community adaptive capacity and resilience.

The natural sediment loads come from mountain landslides that contribute to water pollution and can deteriorate water quality (Reid and Alam, 2016). Polluted water is not suitable for human consumption because pathogens and germs may be harmful to human health. Moreover, an increasing population may directly create pressure on water resources and increasing water demand needs (Rijsberman, 2006). The study shows that water shortages lead to several social risks: firstly, the risk of conflicts over the scarce water resource among the rural community; secondly, the risk of waterborne diseases (diarrhea, dysentery, cholera, etc.); and thirdly, the risk of diseases associated with inadequate sanitary and hygiene system. Most of the respondents suffer diarrhea and dysentery every year, which have been revealed in FGDs due to poor sanitation. Besides, the source of water is polluted by natural sediment from the Hilly catchment area. WHO also found similar results in their study that people experienced different waterborne diseases due to polluted water (WHO, 2003). Thus, the present study confirmed that the study villages are considerably facing water scarcity. Households have been found dependent on stream, spring, and tube-well for water as their livelihood support, and these water sources could not provide available water in the dry season. The increased demand for water, forest degradation, and reduced rainfall volume, water quantity, and quality are the prime reasons for the water shortage in the two villages (Malley *et al*., 2009). Besides, stone collection from streams for business purposes and fuelwood collection to meet the demand of brickfields further accelerated water scarcity. Shifting cultivation in the upland catchment, reduced conservation measures, and excessive water use for agriculture was also associated with water quality degradation. Consequently, the respondents have experienced poor livelihood, water conflicts, waterborne diseases, and poor sanitation. Flash flood is considered one of the significant natural hazards that directly and indirectly alter people's lives and livelihood by damaging agricultural production and ecosystems, increasing water pollution, and disrupting communication networks and neighboring economies (Abedin and Khatun, 2019).

Conclusion

Water is an essential for human survival and civilization. People of the mountain areas have limited access to modern life, and water availability. The present study focuses on the water scarcity, seasonal variations, and social conflicts in mountain areas. A number of indicators like people's perception of water scarcity, seasonal water availability, and their impact on social cohesiveness have been assessed. The study reveals that respondents mostly rely on stream (86.7%) and spring (90%) for water. The analysis also shows that 80% of respondents in Debotachari village have experienced water scarcity in domestic use for more than 6 years. More than 80% of respondents opined that shifting cultivation in upland catchments causes water quality degradation. 83% of respondents mentioned that water was more available in a monsoon in Sapchari Monpara village. The respondents of Debotachari village get water from tube-wells and traditional wells in all seasons, while in Sapchari Monpara village, the people rely on the spring for drinking and stream for domestic purposes. The study shows that the women participating in fetching water is higher than men in both the villages. Besides, women are bound to spend more time to collect water, which creates conflicts during water collection, bathing, cooking, water unavailability, and domestic use. About (86.67%)

respondents in Sapchari Monpara village agree that forest conservation around the water sources increases water availability. The study will be helpful to the mountainous region for sustainable water conservation.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3	Author 4	Author 5
Conceived and designed the research or analysis	Yes	No	Yes	Yes	No
Collected the data	Yes	No	Yes	No	No
Contributed to data analysis & interpretation	Yes	Yes	No	Yes	No
Wrote the article/paper	Yes	Yes	No	No	No
Critical revision of the article/paper	No	Yes	No	Yes	No
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Spatial Distribution Patterns of the Hydro-Ecosystems' Quality Indicators in the Ukrainian Carpathians

Liudmyla Mykolayivna Arkhypova[1]*, Marta Vasylivna Korchemlyuk[2], Oleh Mykolayovych Mandryk[3], Valery Grygorovych Omelchenko[4], Yuliya Stanislavivna Stakhmych[5]

[1]Department of Tourism, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano Frankivsk, Ukraine. Email: konsevich@ukr.net

[2]The Laboratory of the Analytical Control and Monitoring, Carpathian National Nature Park, Yaremche, Ukraine. Email: martakor@yahoo.com

[3]Department of Ecology, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano Frankivsk, Ukraine. Email: mandryk68@gmail.com

[4]Department of General, Engineering Geology and Hydrogeology, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano Frankivsk, Ukraine. Email: ovgeo@ukr.net

[5]Department of Philology and Translation, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano Frankivsk, Ukraine. Email: julia.stakhmych@gmail.com

**Corresponding author | ORCID: 0000-0002-8725-6943*

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Abstract

This study is devoted to the two major hydro-ecosystems of the Carpathian region in Ukraine, the Dniester and Danube Rivers. For the first time, the patterns of changes in the ecosystems' quality parameters were established by means of developing functional dependences among the ecological standard values of the composite quality indicators of natural waters and the river length and terrain altitude. Using the statistical processing of the data, the quality monitoring of the upper reaches of Dniester and Danube ecosystems in the Ukrainian Carpathians was conducted for the period from 2001 to 2019. The data on the Composite Potential Quality Indicators standard values was gathered for the heights of the Carpathian region: at 50 m interval for the altitude up to 1,000 m, and at 100 m interval for more than 1,000 m altitude. The acquired dependencies can be used as the territorial background standard values of the ecological indicators of basin ecosystems. It will help to scientifically substantiate the ecologically safe values of the anthropogenic pressure.

Keywords

Hydro-ecosystems; Integrated water quality; Functional dependences

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Introduction

According to the Ukrainian environmental legislation[1] (Law of 2017), environmental quality assessment, including water resources, is carried out to set the maximum permissible levels of various environmental indicators. It guarantees the environmental safety to the population and ensures natural resource management, genetic conservation and sustainable development.

The Ukrainian Carpathians comprise the basins of four major rivers (Mandryk *et al*., 2017) that are grouped into two regional hydro-ecosystems (Figure 1): Dniester (right-bank tributaries in the territories of Lviv and Ivano-Frankivsk oblasts) and the Danube rivers. Later includes the Prut river within the territories of Ivano-Frankivsk and Chernivtsi oblasts, together with the Siret tributary in Chernivtsi oblast and the Tysa tributary in Transcarpathian oblast. These waterways are of international importance, as their basins are located within several countries. The Prut and the Siret rivers flow through Ukraine, Romania and Moldova; the Tysa river crosses through Romania, Hungary and Slovakia; the Dnister river flows through Moldova (Kinash *et al*., 2019). For the reason of cross-boundary water flows, this investigation and modeling of the upstream quality of international water flows becomes an important task (Odnorih *et al*., 2020).

The watershed of the Ukrainian Carpathians covers about 28,000 watercourses, most of which are small ones with a total length of more than 50,000 km. The river network density averages 1-1.5 km per km^2 (Prykhodko *et al*., 2020). Due to the mountainous terrain of the Carpathian ranges, the basin areas are small. Small rivers (up to 10 km long) dominate and account for almost 98% of all watercourses (Khilchevskyi, Kurylo and Sherstyuk, 2018). There are 457 rivers over 10 km in length. In the Prut river basin, all rivers, except for the main river, are classified as small (Karpinski *et al*. 2018). There are seven rivers having100 to 300 km length in the basins of the Dniester, Tysa and Siret rivers. The total area of river surface basins in the Carpathians exceeds 37,500 km^2 (Mandryk *et al*., 2020).

The purpose of the study is to establish the background values of the qualitative parameters of the hydro-ecosystems of the Ukrainian Carpathians and to determine the ecological standards of the components of natural waters within the study area. To achieve this, the general and individual patterns of their spatial distribution based on statistical processing of data from the results of hydro-chemical observations has been studied, using data from the state network for monitoring the quality of water bodies for the period 2001-2019.

Methodology

To undertake the study, following research methods were used. First was an analysis of environmental information on hydro-ecosystems and its processing; and second was the statistical and mathematical analysis using Microsoft Excel and TableCurve 2D software (Stevens, Springer and Ledbetter, 2011).

One of the complex criteria used to assess water quality in Ukraine is the Water Pollution Index (WPI). The WPI is a composite quantitative assessment of water quality by a set of key indicators and types of water use (Singh, Yadav and Yadava, 2016). This integral index is calculated by the following formula:

$$WPI = \sum(C/MPC)/n, \quad (1)$$

where MPC is maximum permissible concentration (value) of the indicator;
C is actual concentration (value) of the indicator; and
n is number of indicators.

[1] https://zakon.rada.gov.ua/laws/main/en/t1

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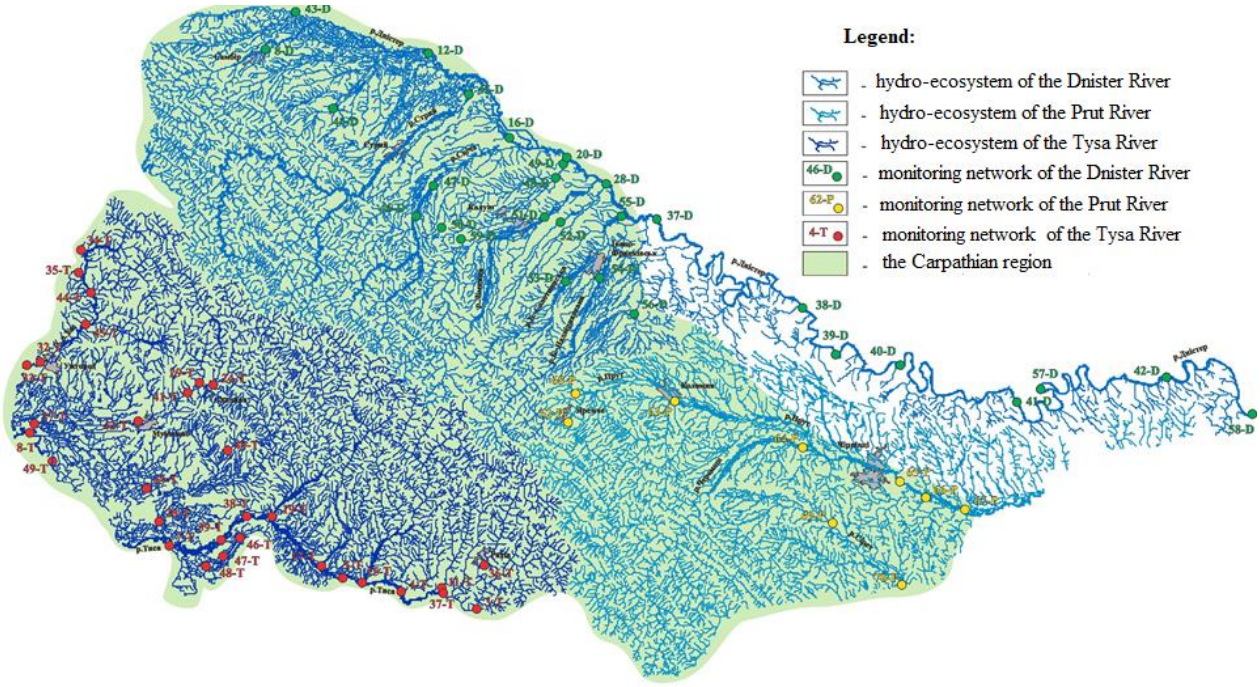

Figure 1: State monitoring network of water bodies of the Carpathian region of Ukraine

For surface waters, the number of indicators used to calculate the WPI should not be less than 5 regardless of whether they exceed the MPC or not. But they must include the dissolved oxygen (DO) and biological oxygen demand for 5 days (BOD_5) (Shmandiy *et al*., 2017). The advantages of this index are the ease of calculation, data accessibility and availability. That is why it is most often used in the State Water Resources Agency of Ukraine (the central executive body, which implements the state policy in the field of water management development) to assess river pollution.

Despite popular usage of WPI, the WPI does not sufficiently assess clean rivers. In the classification, there is quality class 1 (very clean water) having WPI < 0.2, and class 2 (clean water) having WPI from 0.2 to 1 (Government of Ukraine, 2018). It is believed that the Water Pollution Index is not flexible and sufficient to assess the degree of self-purification of rivers, the dynamics of changes in the ecological potential depending on the height and width of the terrain, water content of rivers, dynamics of changes in the anthropogenic load, and so on.

Considering the above-explained limitations of WPI, the Composite Potential Quality Indicator (CPQI) (Arkhypova *et al*., 2019) was used to determine natural regularities in this article. The CPQI is obtained by adding the coefficients of indicator reserves (relative reserve capacity) if the actual value is less than the permissible value, and by subtracting if the actual value is greater than the allowablepermissible value. The product is divided by the number of values used. The excess of the permissible value on the actual value shows the coefficient of stock (potential, reserve capacity) of the hydroecosystem. Moreover, the excess of the actual value over the permissible value shows the stock deficit ratio (relative reserve shortage).

The outcome is divided by the number of indicators used.

$$CPQI = \frac{1}{n}\sum_{i=1}^{n} x_i;\ x_i = \begin{cases} \frac{QS_i}{C_i}, if\ \frac{QS_i}{C_i} > 1 \\ -\frac{C_i}{QS_i}, if\ \frac{QS_i}{C_i} < 1 \end{cases}, \quad (2)$$

where QS_i is the water quality standard for the i^{th} indicator–limit values of water status indicators that meet the requirements of different types of water use;
C_i is actual value of water quality for the i^{th} indicator;
n is the number of indicators.

The water samples for physicochemical studies were taken at least 4 times a year (in different hydrological seasons) in accordance with the procedure prescribed by the normative document KND 211.1.1.106-2003 (Zasidko *et al*., 2019). The following indicators were used to calculate the WPI: NH_4^+ (MPC – 0.5 mg/dm^3), NO_2^- (MPC – 0.08 mg/dm^3), NO_3^- (MPC – 40.0 mg/dm^3), BOD_5 (MPC – not more than 3 mg/dm^3), dissolved oxygen (MPC – not less than 6 mg O/dm^3).

This research used a statistical model based on the mathematical processing of the statistical dataset. The data included hydro-chemical analyses of surface waters conducted by the certified laboratories of the Dniester Basin Authority and the Analytical Control Department of the Carpathian National Nature Park. Each numerical result, corresponding to a specific monitoring section, is an integrated value of over 50 values, as the samples were taken every year, four times a year. The existing hydro-chemical monitoring database was processed by the method of determining the geometric mean:

$$F(x) = \ln x, \quad (3)$$

The geometric mean reflects the arithmetic mean of the logarithms of individual values. However, at the same time, the effect of the extreme values on the mean is greatly reduced, which is often observed in the variation series of monitoring the quality of natural waters (Singh, Yadav and Yadava, 2016).

TableCurve 2D was used to obtain linear functional dependences and regression equations for statistical series of observations. Functional dependence equation, equation coefficients, and calculated statistics parameters are represented in the description above the dependences curve. TableCurve 2D uses four goodness-of-fit statistics.

In the following descriptions, *SSM* is the sum of squares of the mean; *SSE* – the sum of squares of errors (residuals); n is the total number of data values; m is the number of coefficients in the model; *DOF* is the degree of freedom (Krešić and Stevanović, 2010).

$$DOF = n\text{-}m, \quad (4)$$

where r^2 coefficient of determination (r squared):

$$r^2 = 1 - SSE/SSM. \quad (5)$$

Degree-of-freedom adjusted coefficient of determination:

$$DOF\ r^2 = (1 - SSE*(n\text{-}1))/(SSM*(DOF\text{-}1)). \quad (6)$$

Calculated standard errors:

$$StdErr = sqrt(SSE/DOF). \quad (7)$$

F-statistics:

$$F\text{-}stat = ((SSM\text{-}SSE)/(m\text{-}1))/(SSE/DOF). \quad (8)$$

The dependence between data sets will be closer if the r^2 values approach 1.0 (0 is the total lack of correlation), the standard error decreases to zero, and the F-statistics goes to infinity. For the upper reaches of the tributaries of the Danube ecosystem, the ecological monitoring database was processed using formula (1). The WPI calculations gave long-term values sets of the composite quality indicator, which reveals certain patterns of spatial distribution. In hydrometeorological calculations, the concept of standard value (as the long-term annual average of the indicator value) is used. For the long-term annual average of WPI values (8 monitoring sections at different altitudes), dependence curves and functional linear regression equations were obtained that can be the basis for determining the WPI standard value.

Results

The general and individual regularities of spatial distribution of water quality indicators on the basis of statistical processing of data of readings of the hydro-chemical observations were analyzed, using data of the state network for monitoring of quality of water objects for the period 2001-2019 (Figure 2). An example of calculating the Water Pollution Index is shown in Figure 2, and an example of calculation of the CPQI is depicted in Figure 3.

Research results of the Prut River Water Pollution Index (2001-2019)											
Water sampling location	Year	NH_4^+, mg/l	NO_2^-, mg/l	NO_3^-, mg / l	Cl^-,mg/l	SO_4^{2-}, mg/l	Dissolved oxygen, mg / l	BOD_5, mg / l	Dissolved oxygen normative	BOD_5 normative	Water pollution index
Hoverla (I)	2001.	0,00	0,001	2,6	10,3	19,0	9,5	1,5	6	3	0,20
	2002.	0,00	0,001	2,7	5,4	22,0	10,4	1,9	6	3	0,22
	2003.	0,0005	0,012	3,9	19,0	23,0	10,6	2,0	6	3	0,25
	2004.	0,001	0,010	3,4	20	25,0	10,3	2,2	6	3	0,26
	2005.	0,00	0,000	4,2	16,6	24,3	10,4	2,1	6	3	0,24
	2006.	0,00	0,001	3,6	12,6	23,0	10,1	2,0	6	3	0,23
	2007.	0,00	0,001	3,1	6,1	16,3	9,00	2,2	6	3	0,24
	2008.	0,00	0,000	7,8	9,0	20,4	9,3	2,7	6	2	0,35
	2009.	0,00	0,000	2,4	8,8	14,5	10,1	1,6	6	3	0,19
	2010.	0,01	0,003	1,6	5,3	18,0	9,67	1,5	6	3	0,20
	2011.	0,01	0,000	3,1	5,3	24,7	8,47	1,1	6	3	0,21
	2012.	0,00	0,000	2,3	7,5	29,0	10,88	1,3	6	3	0,20
	2013.	0,00	0,000	2,8	8,1	26,5	9,25	1,9	6	3	0,23
	2014.	0,00	0,000	2,2	9,8	19,2	8,2	2,4	6	3	0,26
	2015.	0,01	0,000	8,4	12,0	20,0	11	2,0	6	3	0,24
	2016.	0,004	0,0005	2,6	10,5	22,0	9,2	1,7	6	3	0,22
	2017.	0,005	0,0005	2,8	6,0	23,0	10,3	2,0	6	3	0,22
	2018.	0,005	0,008	4,0	19,6	23,0	10,6	2,0	6	3	0,25
	2019.	0,001	0,01	3,6	20,8	25,0	10,3	2,2	6	3	0,26

Figure 2: Example of the Water Pollution Index calculation with monitoring data processing

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AI	AJ	AK
	Results of hydrochemical measurements of surface water samples in Ivano-Frankivsk region																																
Location of samp	Date of sampling	Temperature, degre	smell, grade	Color, degrees	Transparency	Total Suspended solids	pH	Alkalinity, mg-	Salt content, mg / l	Ca^{2+}, mg / l	Mg^{2+}, mg / l	K+ Na, mg/l	Fe, mg/l	NH_4^+, mg/l	NO_2^-, mg/l	NO_3^-, mg / l	Hardness, mg-eq / l	Cl^- ,mg/l	SO_4^{2-}, mg/l	Cu, mg/l	Dissolved oxygen, mg /	BOD_5, mg / l	COD ,mg / l	PO_4^{3-}, mg / l	Petroleum products,	Phenols , mg / l	Mn, mg / l	Bicarbonates , mg / l	Synthetic surfactants, mg/l	Cr tot. , mg/l	Cs-137, pKi / l	Sr-90, pKi / l	**CPQI**
														Dniester river basin																			
															Dniester river																		
v. Sivka-Voinyl	01.03.2011	0	1	12	30	18	7,5	4,2	471	89	17	19	0,36	0,49	0,044	2,9	5,6	28	65	0,0	11,7	2,2	14	0,43	0,0	0,0	0,0	256	0,01	0,0	1,28	0,18	0,74189
//-//-//-//-	17.05.2011	16	1	9	28	35	7,6	3,2	362	51	7,9	41	0,22	0,13	0,086	4,3	3,2	23	47	0,0	9,3	2,2	11	0,21	0,0	0,0	0,0	195	0,02	0,0	1,12	0,17	0,90371
//-//-//-//-	20.07.2011	24	1	10	20	33	7,6	3,1	326	56	7,3	18	0,26	0,3	0,063	4,9	3,7	21	34	0,0	8,8	2	10	0,19	0,0	0,0	0,0	189	0,02	0,0	1,14	0,14	0,83126
//-//-//-//-	01.11.2011	5	1	9,8	28	13	7,6	3,6	459	77	14	28	0,3	0,46	0,06	4,4	5,1	35	78	0,0	9,7	1,7	7	0,100	0,0	0,0	0,0	220	0	0,0	1,03	0,15	0,70995
t. Halych	01.02.2011	0	1	8,5	20	15	7,8	2,6	309	60	7,3	26	0,2	0,19	0,018	1,1	3,6	28	59	0,0	12,3	2,3	13	0,021	0,0	0,0	0,0	159	0,01	0,0	1,05	0,2	2,03063
//-//-//-//-	06.04.2011	7	1	8,4	24	14	7,7	2	242	40	6,7	26	0,35	0,17	0,01	2,3	2,5	18	51	0,0	10,9	2,2	11	0,077	0,0	0,0	0,0	122	0,02	0,0	1,12	0,18	2,01119
//-//-//-//-	02.08.2011	21	1	24	22	18	7,6	1,6	218	38	6,1	13	0,52	0,37	0,03	1,7	2,4	14	44	0,0	9,2	2,3	13	0,043	0,0	0,0	0,0	98	0,01	0,0	1,21	0,14	1,9659
//-//-//-//-	11.10.2011	8	1	2	22	13	7,9	2,6	303	58	7,9	14	0,18	0,29	0,036	1,9	3,5	14	51	0,0	9,5	2,2	11	0,063	0,0	0,0	0,0	158	0,031	0,0	1,33	0,15	2,24334
v. Dovge	01.02.2011	0	1	12	20	16	7,9	3,2	367	72	8,5	30	0,22	0,41	0,05	1,7	4,3	30	69	0,0	12,1	2,5	15	0,047	0,0	0,0	0,0	195	0,013	0,0			0,94146
//-//-//-//-	06.04.2011	8	1	10	22	17	8	3,1	378	62	9,7	29	0,46	0,19	0,043	3,9	4	28	60	0,0	11,4	2,4	13	0,27	0,0	0,0	0,0	189	0,008	0,0			0,6716
//-//-//-//-	02.08.2011	23	1	28	17	23	7,5	2,1	271	44	6,1	24	0,62	0,51	0,077	3,7	2,7	18	51	0,0	9,4	2,1	12	0,26	0,0	0,0	0,0	128	0,007	0,0			0,77198
	11.10.2011	8	1	12,8	20	15	7,9	3,7	420	74	6,1	35	0,20	0,47	0,034	3,5	4,2	21	62	0,0	10,4	2,1	10,5	0,11	0,0	0,0	0,0	226	0,05	0,0			0,63443
v. Ustechko	09.02.2011	3	1	4,9	23	20	7,9	3,9	447	100	12	12	0,18	0,24	0,056	7,6	5,5	28	62	0,0	12	2,5	20	0,097	0,0	0,0	0,0	238	0	0,0			0,6327
//-//-//-//-	14.06.2011	26	1	5,9	28	25	7,9	2,7	328	55	17	15	0,2	0,1	0,07	4,6	4,2	28	63	0,0	10	2,6	24	0,11	0,0	0,0	0,0	165	0	0,0			1,06772
//-//-//-//-	06.09.2011	18	1	4,7	22	11	7,8	3	306	55	12	14	0,1	0,6	0,024	2,9	3,8	14	46	0,0	10,6	2,3	16	0,050	0,0	0,0	0,0	183	0	0,0			1,78989
	22.11.2011	2	1	5,4	30	7	7,9	4	438	93	6,7	17	0,17	0,34	0,025	7,2	5,2	35	43	0,0	10,6	2,7	22	0,100	0,0	0,0	0,0	244	0,02	0,0			0,2354
															Svicha river																		
v. Hoshiv	10.03.2011	0	1	6,0	30	4	7,2	1,4	165	24	7,2	12	0,12	0,65	0,010	2,1	1,8	5,3	35	0,0	11,3	1,4	6,8	0,024	0,0	0,0	0,0	85	0	0,0	1,12	0,14	4,46737
//-//-//-//-	05.05.11.	6	1	3	30	2	7,4	1,1	140	18	6,1	11	0,24	0,37	0,011	2,1	1,4	5	28	0,0	10,6	1,6	7,2	0,14	0,0	0,0	0,0	67	0	0,0	1,13	0,15	4,61604
//-//-//-//-	12.07.2011	15	1	16	20	11	7,4	0,9	115	20	4,2	6	0,52	0,48	0,046	2,3	1,4	5,3	28	0,0	8,5	1,6	7	0,210	0,0	0,0	0,0	55	0	0,0	1,15	0,15	3,33537
//-//-//-//-	08.11.2011	6	1	1,1	30	2	7,5	1,6	176	26	6,1	13	0,12	0,27	0,001	1,5	1,8	7,1	25	0,0	9,8	1,6	7	0,0	0,0	0,0	0,0	98	0	0,0	1,3	0,15	7,96583
v. Mizhrichchya	10.03.2011	0	1	7,8	30	5	7,2	1,6	182	30	6,1	33	0,63	0,79	0,030	3,3	2	14	63	0,0	12	1,6	7,8	0,01	0,0	0,0	0,0	97	0	0,0		0,12	1,84598
//-//-//-//-	05.05.11.	6	1	7,2	28	5	7,2	1,2	156	21	6,1	13	0,4	0,61	0,015	2,8	1,5	7	31	0,0	10,6	1,8	7,6	0,170	0,0	0,0	0,0	73	0,002	0,0			3,08519
//-//-//-//-	12.07.2011	15	1	22	17	14	7,5	1	148	20	4,2	15	0,68	0,61	0,056	2,8	1,5	8,8	31	0,0	8,4	1,8	7,8	0,250	0,0	0,0	0,0	61	0	0,0			1,91652
//-//-//-//-	08.11.2011	5	1	6,2	30	2	7,3	1,8	205	28	7,3	17	0,32	0,62	0,001	0,96	2,0	8,8	30	0,0	9,6	1,7	7,2	0,052	0,0	0,0	0,0	110	0	0,0			7,28983
															Sivka river																		
v. Voinyliv	01.03.2011	1	1	11	30	15	7,3	2,2	1361	48	63	357	0,4	0,23	0,024	5,0	7,6	514	249	0,0	11,8	2,1	13	0,06	0,0	0,0	0,0	134	0,04	0,0			-0,66574
//-//-//-//-	17.05.2011	14	1	15	24	40	7,8	2,1	1328	43	48	374	0,57	0,15	0,110	4,2	6	510	215	0,0	10	2,8	17	0,17	0,0	0,0	0,0	128	0,08	0,0			-0,8019
//-//-//-//-	20.07.2011	27	1	16	16	31	8,2	2,0	1186	45	51	352	0,1	0,54	0,021	5,5	6,5	500	216	0,0	9,8	2,7	17	0,06	0,0	0,0	0,0	122	0,08	0,0			-0,72661
//-//-//-//-	01.11.2011	5	1	13	26	36	7,6	2,2	1189	54	48	308	0,46	0,52	0,08	5,5	6,9	474	170	0,0	9,7	1,8	7,2	0,068	0,0	0,0	0,0	134	0,03	0,0			-0,738
Mouth	01.03.2011	0	1	11	30	13	7,6	2,1	1219	50	61	305	0,36	0,28	0,02	5,9	7,4	450	232	0,0	12	2	13	0,11	0,0	0,0	0,0	128	0,06	0,0	1,37	0,2	-0,57502

Figure 3: Example of calculation of CPQI by the monitoring data processing

The pollution level and state of the hydro-ecosystem are assessed based on the value of the Water Pollution Index or the Composite Potential Quality Indicator (Table 1).

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Table 1: Numerical criteria for the aquatic ecosystem state assessment based on the values of composite quality indicators

Water pollution level	*WPI value*	*Water quality class*	*Aquatic ecosystem state*	*CPQI value*
Very clean	<0.2	1	buffer state (ecological balance area)	>5
Clean	0.2-0.1	2	optimal state	3-5
Low pollution	1.0-2.0	3	adaptation tension	1-3
Medium pollution	2.0-4.0	4	pessimum zone	-1<CPQI<1
High pollution	4.0-6.0	5	critical state	-3<CPQI<-1
Very high pollution	6.0-10.0	6	crisis state	-3 <CPQI<-5
Extreme pollution	>10.0	7	catastrophic state (ecological disaster area)	<-5

On the basis of the results shown in Table 1, the analysis was performed for different hydrological seasons and monitoring sections. The average annual values were calculated, and the data obtained for the period of 2001-2019 were summarized. It is observed that the water quality at altitudes above 500 m in the Ukrainian Carpathians generally meets the reference conditions.

The long-term monitoring results of surface waters in mountain areas, the beds of which are located at altitudes above 500 m, show that the water belongs to the quality classes “clean”, “fairly clean”, “good” or “very good”. The discharge of sewage water from mountain settlements diffuses pollution in 99% of the cases.

For the upper reaches of the tributaries of the Danube ecosystem, the functional dependences among the changes in the composite quality indicator of surface water ecosystems and the river length and terrain altitude were obtained (Figures 4, 5). The obtained curve (Figure 4) of the dependence between the Water Pollution Index standard value and the terrain altitude for the Prut river passes through the centre of the cluster of observation points, the curves describing the 95% confidence interval are nearby. Thus, there is a close functional dependence between these properties. The coefficient of determination ($D=r^2=0.82$) shows that 90% of the variance in Y is due to the variance in X. The actual quality state of the Danube ecosystem in Ukraine to the altitude of 700 m is the optimal state, and below this level is the state of adaptation tension.

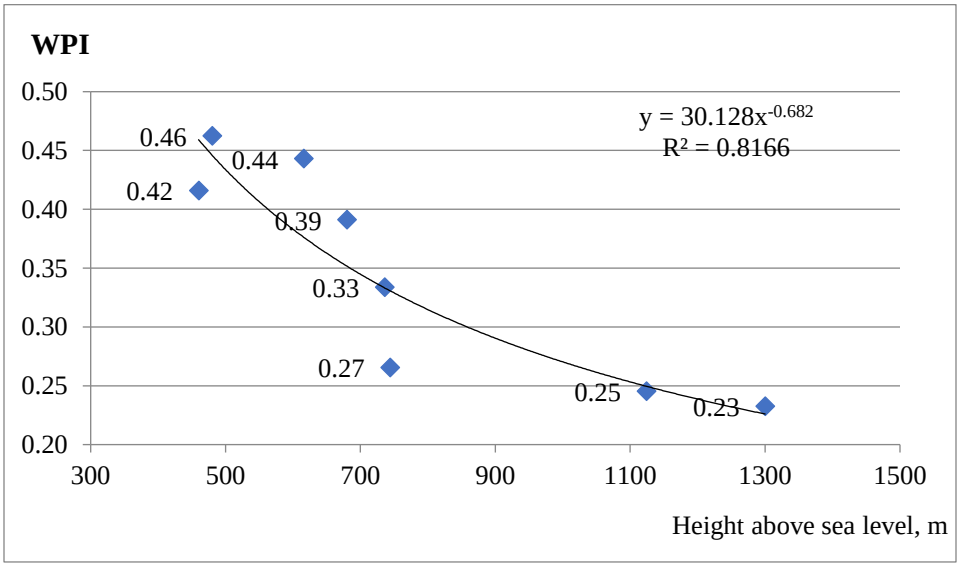

Figure 4: Functional dependence between the change in the Water Pollution Index of the Danube ecosystem and the terrain altitude in the Ukrainian Carpathians

The significance of the coefficient ($r^2=0.82$) was estimated using the F-distribution quantiles tables and the tables of coefficient significance. The latter have two entries – the number of degrees of freedom, which is equal to the number of observations minus 2; the significance level is accepted at 5%. The critical coefficient value was found after determining the significance level and the number of degrees of freedom. In this case, the value of the coefficient $r^2=0.82$ was greater than the table critical value $r^2=0.707$ (for sample volume 11 and significance level p=0.05) (Mandryk *et al.*, 2020). That is, the null hypothesis of no correlation between the properties was rejected. The hypothesis that there is a significant correlation between the properties was accepted.

Therefore, for the first time, the functional dependence between the change in the long-term annual average of the Water Pollution Index in the Danube ecosystem in the Ukrainian Carpathians and the altitude is represented. It is expressed by the following significant regression equation:

$$WPI = 30.128 \cdot H^{0,682}, \quad (9)$$

where H is the absolute height of the terrain, m

Despite the continuous diffusion of pollution, which was observed in the Danube ecosystem (even with the values of WPI<1), a close relationship between the composite Water Pollution Index and the length of the river from its source is evident (Figure 5).

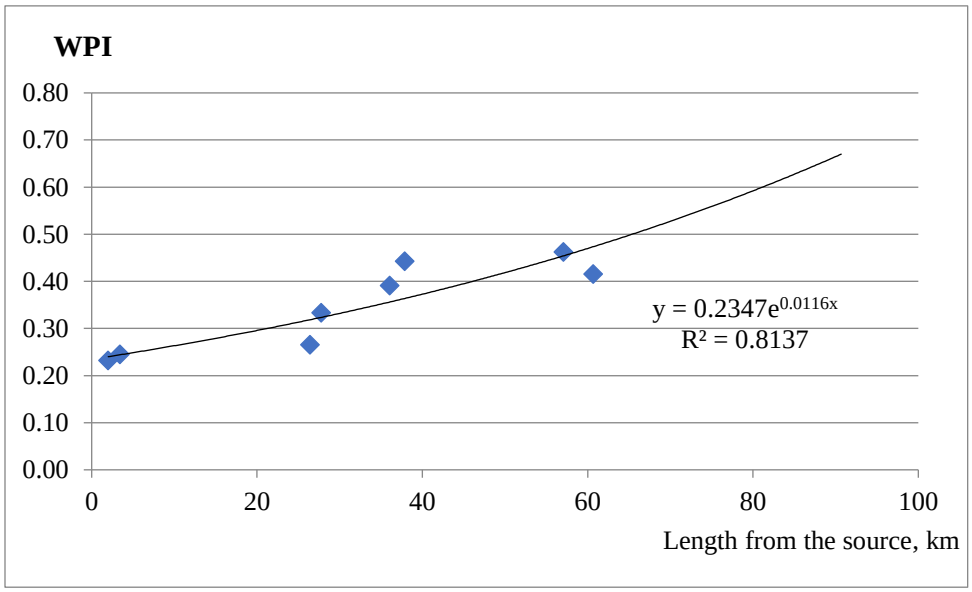

Figure 5: Functional dependence between the quality standard value of the water bodies of the Prut ecosystem and their length from the source

F-test or F-statistics is calculated using the software. The information on the distribution of this value allows to check the statistical significance of the regression model based on the value of the coefficient of determination. In fact, these tests test the hypothesis that the true coefficient of determination is equal to zero. The critical values of F-test were looked up in standard tables. The proposed hypothesis (on the existence of close dependence) is rejected if the table value of *Fstat* is greater than the calculated one and it is accepted as true if *Fstat* is less than the calculated one. In all the cases considered, the proposed hypothesis was accepted as true if the significance level was assumed to be 1%. In this case, *Fstat=56.88 (calculated)>Fstat=5.99* (table value) (Toms and Lesperance, 2003). Thus, the correlation between the properties is not accidental, it is significant.

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Therefore, as a result, for the first time the linear functional dependence between the change in the Water Pollution Index of the Danube ecosystem and the length of the river in the Carpathian National Nature Park was found. It is described by the following significant regression equation:

$$WPI=0.235\cdot e^{0.0116L}, \quad (10)$$

where L is the length of the watercourse from its source to the monitoring section, km.

In the conservation areas located in the upper reaches of the Danube ecosystem in the Ukrainian Carpathians, the Carpathian National Nature Park and the Carpathian Biosphere Reserve, the maximum permissible load on the Danube ecosystem should be the one when the WPI does not exceed the natural background value (long-term annual average standard), calculated in accordance with the dependences described above. These functional models for the monitoring assessment of the anthropogenic load on conservation areas should be used.

To process the monitoring base of the second large Dniester hydro-ecosystem, the Composite Potential Quality Indicator (2) was used, and the close regression functional dependence between the hydro-ecosystem quality standard (long-term annual average) of the whole Dniester basin in the Carpathian region and the terrain altitude was obtained (Figure 6).

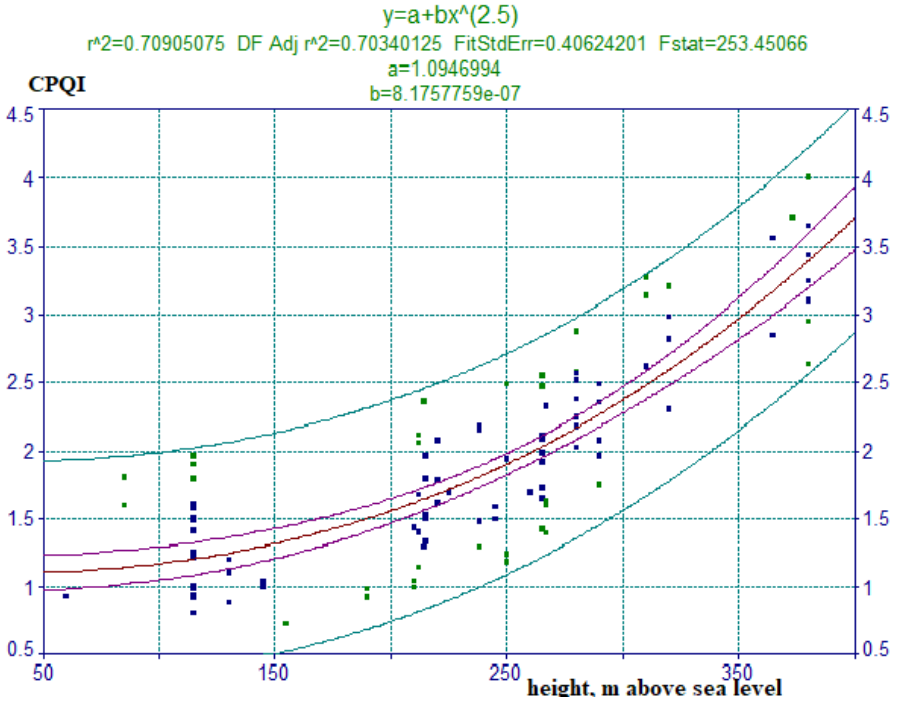

Figure 6: Functional dependence between the water quality standard of the Dniester ecosystem and terrain altitude

The calculated CPQI is a relative value that depends on the level of anthropogenic load. Even though the Dniester ecosystem is constantly polluted at most observation points (even with positive CPQI values), the close dependence between the Composite Potential Quality Indicator and the altitude is evident and is described by the curvilinear regression equation:

$$CPQI=1.095+8.18H^{2.5} \quad (11)$$

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In this case, *Fstat=253.4 (calculated)>Fstat=3.94* (table value). Thus, the correlation between the properties is not accidental, it is significant.

The functional dependence obtained for the Dniester ecosystem in the Ukrainian Carpathians by interpolation, i.e., by means of the mathematical justification for the unknown values of the dynamic series of phenomena based on the established relationship between the CPQI standard and the altitude, was approximated by a continuous linear function (Figure 7):

$$CPQI = 1.002 + 2.705H^{2.5} \quad (12)$$

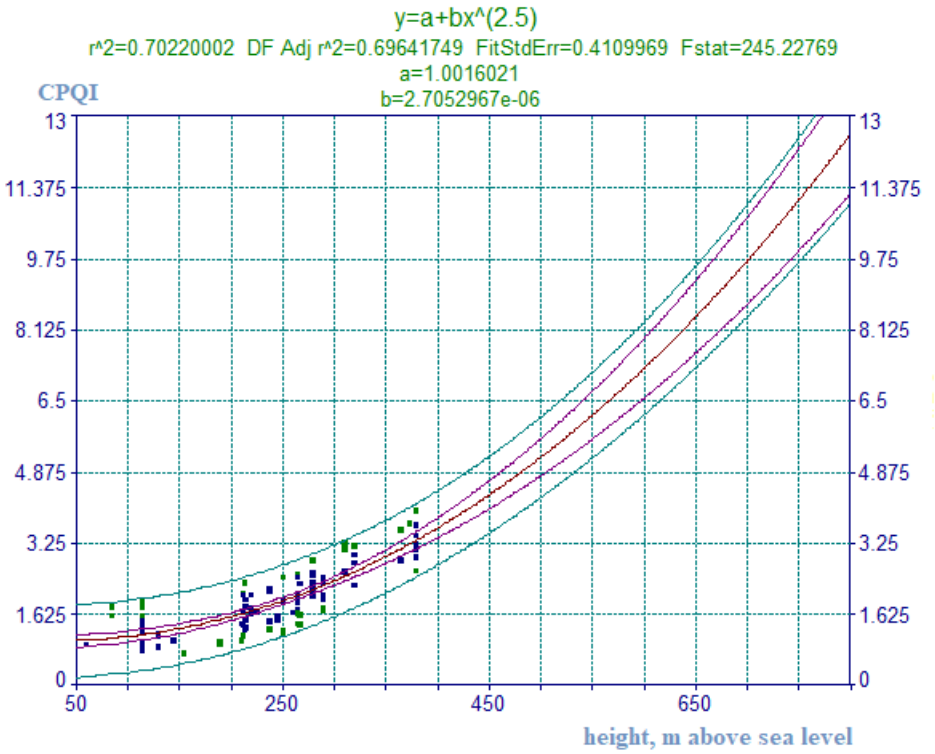

Figure 7: Approximated functional dependence between the quality standard value of the water bodies of the Dniester ecosystem in the Carpathian region and the terrain altitude

Thus, based on the acquired dependence, it is proposed to define the Composite Potential Quality Indicator standard value as a property of natural and technogenic safety at any point of the Dniester river ecosystem in the Carpathian region.

Undoubtedly, the CPQI standard values at absolute altitudes below 300 m were influenced by the existing technogenic load on the ecosystem. The surface water quality monitoring point on the Tysmenytsia river is located in the town of Drohobych and is aimed to control the influence of sewage water from the towns of Truskavets and Boryslav. In Rozvadiv village, water quality of the Dniester ecosystem is monitored due to the impact of industrial wastewater from the town of Drohobych, and in Zhuravno village it was due to the impact of the sewage waters from the town of Khodoriv (Malovanyy *et al*., 2019).

To determine the standard of the qualitative component of ecological safety of hydro-ecosystems of the Ukrainian Carpathians, it is proposed to use the Table 2. In the table, the norm of CPQI (for the natural state of hydro-ecosystems) could be estimated using the value of the height sample location. Up to an altitude of 1,000 m above sea level, water quality can be determined at every 50 m distance, and at an altitude above 1000 m it should be measured at every 100 m distance.

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Table 2: Standard values of the Composite Potential Quality Indicator for different absolute heights of the hydro-ecosystems of the Dniester, Prut, Siret and Tysa rivers

Absolute height, m	*Hydro-ecosystem*		
	Dnister	*Prut and Siret*	*Tysa*
1	2	3	4
50	1.03	-	2.50
100	1.13	0.21	4.24
150	1.31	0.52	4.91
200	1.57	0.84	5.34
250	1.94	1.18	5.64
300	2.39	1.53	5.84
350	2.94	1.89	6.02
400	3.60	2.26	6.14
450	4.35	2.63	6.25
500	5.21	3.01	6.34
550	6.17	3.40	6.43
600	7.23	3.79	6.50
650	8.41	4.18	6.57
700	9.69	4.58	6.64
750	11.08	4.98	6.68
800	12.58	5.38	6.73
850	14.19	5.79	6.76
900	-	6.21	6.81
950	-	6.62	6.85
1000	-	7.04	6.90
1100	-	7.88	-
1200	-	8.73	-
1300	-	9.59	-
1500	-	11.34	-
1600	-	12.23	-
1700	-	13.12	-
1800	-	14.01	-
1900	-	14.92	-
2000	-	15.82	-

Discussion

Water quality assessment is a time-consuming process because it is based on the comparison of the average concentrations observed at the water quality monitoring points keeping in view the standards for each ingredient (Staśko and Buczyński, 2018).

Following the principle of natural water unity, formulated by (Eigen and Schuster, 2012), the current system of water quality (drinking, waste, surface and underground waters) should be based on the classification built upon the indicators and the composition and properties (physical, chemical, biological) of water. It can

be collectively used to solve a wide range of problems associated with different types of management, utilization and protection of water resources. The system should meet simultaneously the ecological, hygienic and technological requirements (Zubaidah, Karnaningroem and Slamet, 2019). At present, there exists no such system. Hence, it was a complex multidisciplinary task (Water Framework Directive 2000/60/EC[2]).

Difficulties arise when it becomes inevitable to analyze the trend of water quality over several years, in different parts of a water body, or to compare the water quality of different water bodies contaminated by variety of pollutants, or to identify the trend of water quality over time (Strzelczyk and Steinhoff-Wrześniewska, 2020). Thus, a need to develop a methodology for integrated water quality assessment arises (European Union, 2017).

This study focusing two major hydro-ecosystems of the Carpathian region, the Dniester and Danube rivers, used a methodology of integrating natural water quality assessment with the functional dependencies between quality indicators and altitudes. It is established that the relation is logical: with the increasing altitude, the level of anthropogenic load decreases, and the quality of natural waters improves. It has been observed that the Ukrainian Carpathians are low mountains, quite populated. In small settlements, there is no centralized water supply and sewage treatment. As a tourist region, the Ivano-Frankivsk oblast has the population of 1.4 million and is visited by more than 2 million tourists annually. A big ski resort, "Bukovel", is situated in the area (Kinash *et al*., 2019). Both the high-density population and the influx of tourists add to the pollution load of watercourses in the region.

Based on the above findings, it can be inferred that the self-purification of natural waters eliminates diffused pollution in the waters flowing through mountainous part of the Ukrainian Carpathians. The comparison of method (2) with the method (1) leads to the following conclusions. The methodology (2) is more flexible, which evaluates the buffering capacity and allows the use of a simple prioritization method; that is, certain regions or areas of ecosystems that meet certain environmental quality standards can be considered as reference having no further anthropogenic pressure, while other areas of hydro-ecosystems can be ranked and evaluated using the mathematical symbols and values of CPQI.

Finally, this method is proved to be effective in assessing the level of anthropogenic load on water bodies. The obtained dependencies can be used as territorial background standards for the ecological assessment of the basin ecosystems. This study proves to be important to justify and improve the Ukrainian water monitoring methodologies that are required to be adapted to EU laws.

Conclusions

For the first time, the patterns of changes in the ecosystems' quality parameters established by means of developing functional dependences among the ecological standard values of the composite quality indicators of natural waters and the river length and terrain altitude. It is performed by using the statistical processing of the data of quality monitoring of the upper reaches of Dniester and Danube ecosystems in the Ukrainian Carpathians for the period from 2001 to 2019. The obtained dependencies can be used in the form of the territorial background standard values of ecological indicators of basin ecosystems. It will help substantiate scientifically the permissible levels of the anthropogenic pressure e.g., pollution load.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3	Author 4	Author 5
Conceived and designed the research or analysis	Yes	Yes	No	No	No
Collected the data	Yes	Yes	Yes	Yes	No
Contributed to data analysis & interpretation	Yes	Yes	No	No	Yes
Wrote the article/paper	Yes	Yes	Yes	Yes	Yes
Critical revision of the article/paper	Yes	Yes	Yes	No	Yes
Editing of the article/paper	Yes	Yes	No	No	Yes
Supervision	Yes	No	Yes	Yes	No
Project Administration	No	No	Yes	Yes	No
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M – 00204 | Research Article

Role of Non-Timber Forest Products in National Economy: A Case of Jajarkot District, Nepal

Rakshya Lamichhane[1], Deepak Gautam[2], Mahamad Sayab Miya*[3], Hom Bahadur Chhetri[4], Sachin Timilsina[5]

[1]Division Forest Office, Jajarkot, Nepal, Email: rakshyalamichhane123@gmail.com
[2]School of Ecology and Nature Conservation, Beijing Forestry University, Beijing, China.
Email: deepakgautamiof@gmail.com
[3]Institute of Forestry, Tribhuvan University, Pokhara Campus, Pokhara, Nepal. Email: sayabmiya13@gmail.com
[4]Institute of Forestry, Tribhuvan University, Pokhara Campus, Pokhara, Nepal.
Email: chhetrihombahadur@gmail.com
[5]Institute of Forestry, Tribhuvan University, Pokhara Campus, Pokhara, Nepal. Email: sachintimilsina66@gmail.com
**Corresponding author | ORCID: 0000-0002-1675-593X*

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Abstract

Non-timber forest products are the major source of income for mountainous countries like Nepal. This article attempts to explore a case of traded non-timber forest products (NTFPs) in Jajarkot district and its contribution to the economy. Collection of medicinal and aromatic plants (MAPs) and resin tapping are some of the major sources of employment for a large number of rural people. 53 different types of NTFPs are traded from the Jajarkot district. Local people collect these NTFPs from the forest and export them within and outside the district mainly to India and China. Jajarkot district on average exported 1,590,681.72 kg NTFPs worth NRs. 3,819,271.6 (equivalent to USD 32,081.88) from the year 2015 to 2020 to the national economy through royalty. NRs. 2,246,719.4 (equivalent to USD 18,872.44) per year came from MAPs and NRs. 1,572,552.2 (equivalent to USD 13,209.4) from resin during the years 2015 to 2020. If this district could produce all the commonly available NTFPs in a large scale, then there would be a high possibility of transforming the current unviable economy into a practical and vibrant economy. A proper inventory, identification and sustainable harvesting, are essential to promote and conserve these NTFPs.

Keywords

Karnali province; MAPs; NTFPs; Resin; Sustainable harvesting

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Introduction

Nepal is rich in biodiversity, both flora and fauna, at the ecosystem, species, and genetic level. Nepal ranks 10th in terms of the richest flowering plant diversity in Asia and 31st in the world (Bhuju *et al.*, 2007). Nepal harbours 3.2% of the world's total flora, i.e., 11,971 species (GoN/MoFSC, 2014), but its diverse topographic and climatic variations ranging from tropical to the alpine tundra of high altitude Himalayas offer a variety of high-value non-timber forest products (NTFPs) throughout the country. Government of Nepal has categorized NTFPs into eight different categories: fruits and seeds (65), roots and rhizomes (48), leaves/stems (30), barks (25), whole plants (21), flower and fur (hair) (16), gum, resin and lac (8), and others (24), especially for collecting royalty (GoN/MoFSC, 1995). 12 species are prioritized for commercial cultivation and market promotion (Shrestha and Das, 2008 cited in Kunwar, Ansari, and Luintel, 2009).

NTFPs are all forest products other than timber and firewood such as leaves, shoots, juice, barks, flowers, cotton, tannin, gum, resin, fruits, seeds, and roots (Ahenkan and Boon, 2010). The main habitat of NTFPs is forest land. NTFPs are increasingly growing popular with national and international markets as they are important ingredients of several herbal cosmetics, herbal tea, food, medicines, etc. (Banjade and Paudel, 2008). The use and development of NTFPs is identified as one with the most important possible solutions to sustainable management of forests and uplifting the local economy (Wiersum and Ros-Tonen, 2005; Mukul *et al*., 2010; Kar and Jacobson, 2012). They have the potential for livelihood support, poverty alleviation, biodiversity conservation, and economic growth of rural communities worldwide (Angelsen *et al.*, 2014; Shackleton and Pullanikkatil, 2018; Reta, Girum and Mekonnen, 2020). NTFPs are subsistence as well as the main source of income; they have cultural and ritual values in traditional forest communities (Angelsen and Wunder, 2003; Sahoo *et al*., 2020).

There are more than 700 plant species that have medicinal value, of which 238 are in active use and 100 are in trade (Shrestha, Shrestha, and Shah, 2020). Trading of NTFPs started with the harvesting of lichen in the 1980s and other NTFPs have been rapidly identified and commercialized thereafter (Bista and Webb, 2006). A 1995 survey of producers, traders, and processors of NTFPs operating from the eastern border of the country to the mid-western town of Nepalgunj showed that a total of 100 entrepreneurs handled 42,000 tons of over 100 different NTFP items, equal to USD 26 million (Subedi, 1997). It was found that about 90% of total NTFPs exported to India annually from Nepal (Edwards, 1996).

Various studies show that the NTFPs sub-sector in Nepal contributes 5% of national GDP out of the 15% contribution from the forestry sector (Pyakurel and Baniya, 2011). Nepal is estimated to export around 33,000 metric tons of medicinal and aromatic plants (MAPs) products with an annual revenue amounting around USD 19-60 million (MoFSC, 2009). The export value increased from USD 27.49 million in 2005 to USD 60.09 million in 2014. Nepal on average exported 13,230 metric tons MAPs products worth USD 39.34 million per year (Kalauni and Joshi, 2018) to more than 50 countries. Over 90% of the NTFPs are traded to India in crude forms without value adding processes, which provide lesser benefits to the local and national economy (ANSAB and EWW, 2000). Nepal, however, lacks the technical, financial, and guaranteed market capabilities for processed NTFPs. ANSAB (Asia Network for Sustainable Agriculture and Bioresources) has reported that around 189,000 people work in the NTFPs sub-sector (MSFP, 2014), drawing between 15 and 50% of their household income (Karki and Bhattarai, 2012; MSFP, 2014).

In Nepal, the growing middle class and lifestyle changes also impact the trade in and prospects of NTFPs. Analysis of the royalty contribution of various forest products during the fiscal year 2015-16 illustrates that royalty from forest products estimated NRs. 930,606,243.39 (equivalent to USD 7,817,092.44). About 70% of the royalty was from only timber and only 6.56% was from NTFPs. The remaining 22% was from the royalty paid by community forest and private forests. Among NTFPs, the contribution of medicinal plants was only 3% (DOF, 2017). A large number of people, mainly in the hilly regions of western Nepal, are engage in collection of MAPs for their livelihood. About 215 Plant species are used for the treatment of 139 types of diseases by major ethnic groups in hilly districts of Nepal (Miya, Timilsina and Chhetri, 2020).

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Herbs are highly used for traditional medicine followed by trees, shrubs, climbers, and grasses (Kandel *et al.*, 2020). Therefore, if NTFPs are promoted well, this sector can contribute immensely to uplifting the socio-economic status of local people.

Different laws, regulations, plans, and policies formulated by the Government of Nepal have also encouraged the development NTFPs sector. However, implementation of those plans and policies have not been effective (Schippmann, Leaman and Cunningham, 2006). A proper investment in NTFPs can create employment opportunities for local people reducing the youth migration to cities and foreign countries for jobs (Karki and Bhattarai, 2012). Thousands of rural people are involved in NTFPs collection and enterprises in different regions of the country. However, very little study has been conducted about contribution of NTFPs to the local and national economy. As far as Jajarkot district is considered, Manandhar (1995) has documented 60 medicinal plants with their local uses. The present study aims to explore traded NTFPs from the district and their contribution to the economy. The study will help to identify and prioritize potential NTFPs for uplifting local economy in the district.

Study Area

Geographically, Jajarkot is a higher mountainous district located in the Karnali Province of Nepal. It lies on 28 37' 22" N to 29 06'22" N latitude and 81 49'22" E to 82 34'86" E longitude with elevation ranging from 610 m to 5,412 m from the sea level. Naturally, the Jajarkot district is divided into three zones: i). high mountain, ii). mountain, and iii). riverine flat land. Out of the total area of 2,230 km^2, the maximum area is covered with forestland (55.9%), followed by agricultural land (15.8%), rangeland (11.8%), shrubland (11.7%), and other lands (4.8%). According to DFO/Jajarkot (2020), the forest of Jajarkot can be divided into the following types (based on climate):

a) Sub-tropical (1,000 m to 1,500 m): Major tree species are *Shorea robusta* (Sal), *Pinus roxburghii* (Khote Sallo), *Terminalia tomentosa* (Asna), *Adina cordifolia* (Karma), *Toona ciliata* (Tooni), *Alnus nepalensis* (Uttis), *Acacia catechu* (Khaer), and major NTFP species are *Zanthoxylum armatum* (Timur), *Swertia chirayita* (Chiraito), *Terminalia chebula* (Harro), *Terminalia bellirica (*Barro), *Phyllanthus emblica* (Amala), *Bergenia ciliata* (Pakhanbed), *Urtica dioica* (Sisnoo), *Persea spp.* (Kaulo), *Sapindus mukorossi* (Rittha), *Cinnamomum tamala* (Tejpat), etc.

b) Temperate (1,500 m to 2,500 m) : Major tree species are *Pinus wallichiana* (Gobre Salla), *Quercus leucotrichophora* (Banjh), *Quercus semicordata* (Khasru), *Tsuga dumosa* (Thingure Salla), *Taxus baccata* (Lauth Salla), and NTFP species are *Valeriana jatamansi* (Sugandawal), *Nardostachys grandiflora* (Jatamansi), *Allium wallichii* (Banlasun), *Paris polyphylla* (Satuwa), *Ipomea* spp. (Kala dana), *Lycopodium* spp. (Jhyau), etc.

c) Alpine forest (above 2,500 m): Major tree species are *Pinus wallichiana* (Gobre salla), *Tsuga dumosa* (Thingure Salla), *Rhododendron arboreum* (Laliguras), *Betula utilis* (Bhojpatra) and *Cedrus deodara* (Debdar), etc.

Methodology

Online portals like Google Scholar and ResearchGate were primarily used to collect data (Gautam *et al.*, 2020). The data regarding the quantity of the MAPs collection and revenue generation from the forest of Jajarkot district was retrieved from the documents obtained from the Division Forest Office, Jajarkot. Project reports, annual reports of government of different dates were also cited to collect more information on medicinal and aromatic plants of Nepal. Collected data from various sources were analyzed and represented in tables and graphs with the help of Microsoft Excel.

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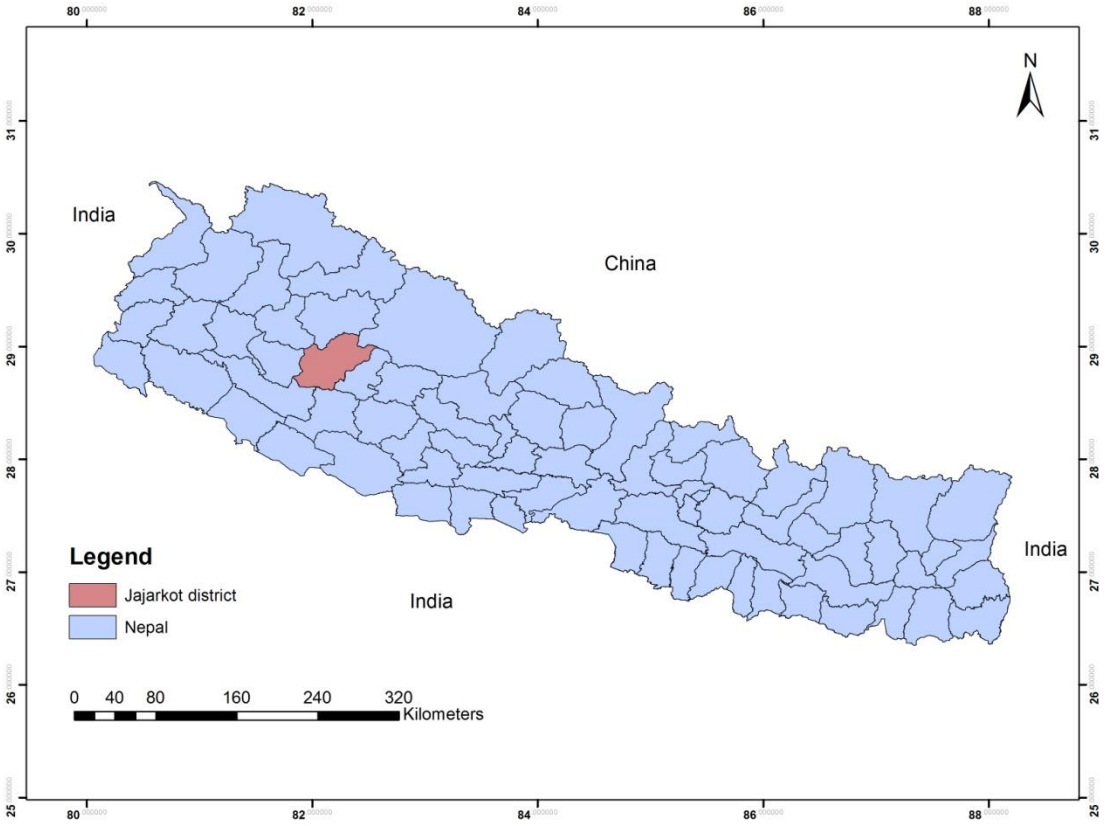

Figure 1: Map of Study Area showing Jajarkot district, Nepal

Results and Discussion

NTFPs in Jajarkot district

From the analysis it was reported that a total of 53 types of NTFP species were traded from Jajarkot district (DFO/Jajarkot, 2020). These NTFPs belong to 42 families, of which Lauraceae family represent the maximum numbers of species. Alliaceae, Asparagaceae, Asteraceae, Combretaceae, Rutaceae and Urticaceae families represent two species each, while the rest of the families represent only one species each. Two NTFPs were animal products (local name: Maha and Main) and one is a mineral extract (Silajit) (Table 1).

Table 1: List of NTFPs that are traded from Jajarkot district

S.N.	*Local Name*	*Scientific Name*	*Common Name*	*Family*
1.	Allo	*Girardinia diversifolia*	Himalayan Nettle	Urticaceae
2.	Amala	*Phyllanthus emblica*	Indian Gooseberry	Phyllanthaceae
3.	Attis	*Aconitum heterophyllum*	Indian Ateesh	Ranunculaceae
4.	Ban Lasun	*Allium wallichii*	Himalayan Onion	Alliaceae
5.	Ban Pyaj	*Allium spp.*	Wild Onion	Alliaceae
6.	Barro	*Termanalia bellerica*	Bedda Nut	Combretaceae
7.	Bel	*Aegle marmelos*	Stone Apple	Rutaceae
8.	Bhojpatra	*Betula utilis*	Himalayan Birch	Betulaceae
9.	Bhringraj	*Eclipta prostate*	False Daisy	Asteraceae
10.	Bhutkesh	*Selinum tenuifolium*	Fern-leaf Milk Parsley	Apiaceae
11.	Bishphej	*Polypodium vulgare*	Wall Fern	Polypodiaceae
12.	Bojo	*Acorus calamus*	Sweet Flag	Acoraceae

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S.N.	*Local Name*	*Scientific Name*	*Common Name*	*Family*
13.	Chiraitho	*Swertia chirayita*	Chiraito	Gentianaceae
14.	Chiuri	*Diploknema butyracea*	Indian Butter Tree	Sapotaceae
15.	Chutro	*Berberis spp.*	Indian Berberry	Berberidaceae
16.	Dhatelo	*Prinsepia utilis*	Himalayan Cherry Prinsepia	Rosaceae
17.	Dhupi	*Juniperus spp.*	Juniper	Cupressaceae
18.	Gucchi Chyau	*Morchella spp.*	Morel	Morchellaceae
19.	Gurjo	*Tinospora sinensis*	Chinese Tinospora	Menispermaceae
20.	Gurmar	Gymnema sylvestre	Gurmar	Apocynaceae
21.	Harro	*Terminalia chebula*	Chebulic Myrobalan	Combretaceae
22.	Jatamansi	*Nardostachys grandiflora*	Spikenard	Caprifoliaceae
23.	Jhyau	*Lycopodium spp.*	Lichen	Lycopodiaceae
24.	Kachur	*Curcuma zedoaria*	Zedoary	Zingiberaceae
25.	Kakarsinghi	*Pistacia integerrima*	Kakkar	Anacardiaceae
26.	Kala Dana	*Ipomea* spp.	Morning Glory	Convolvulaceae
27.	Kalikath	*Myrsine semiserrata*	Blueberry Myrtle	Myrsinaceae
28.	Kamraj	*Helminthostachys zeylanica*	Flowering Fern	Ophioglossaceae
29.	Kaulo	*Persea* spp.	Fragnant Bay Tree	Lauraceae
30.	Khote Salla	*Pinus roxburghii*	Chir Pine	Pinaceae
31.	Kurilo	*Asparagus* spp.	Asparagus	Asparagaceae
32.	Kutki	*Picrorhiza kurroa*	Kutki	Pentaginaceae
33.	Loktha	*Daphne bholua*	Nepali Paper Plant	Thymelaeaceae
34.	Maha	-	Bee Honey	-
35.	Main	-	Bee Wax	-
36.	Majitho	*Rubia manjith*	Indian Madder	Rubiaceae
37.	Panchaule	*Dactylorhiza hatagirea*	Marsh Orchid	Orchidaceae
38.	Padamchal	*Rheum austral*	Himalayan Rhubarb	Polygonaceae
39.	Pakhanbed	*Bergenia ciliate*	Hair Bergenia	Saxifragaceae
40.	Pani Amala	*Nephrolepis Cordifolia*	Fishbone Fern	Nephrolepidaceae
41.	Rato Chyau	*Ganoderma lucidum*	Reishi Mushroom	Ganodermataceae
42.	Rittha	*Sapindus mukorossi*	Chinese Soapberry	Sapindaceae
43.	Sajiwan	*Jatropha curcus*	Physic Nut	Euphorbiaceae
44.	Satuwa	*Paris polyphylla*	Himalayan Paris	Melanthiaceae
45.	Setakchini	*Polygonatum spp.*	Solomon's Seal	Asparagaceae
46.	Silajit	*Asphaltum*	Mineral Pitch	-
47.	Sisnu	*Urtica dioica*	Stinging Nettle	Urticaceae
48.	Somalata	*Ephedra gerardiana*	Gerard Joint Fir	Ephedraceae
49.	Sugandhakokila	*Cinnamomum glaucescens*	Cinnamon Berry	Lauraceae
50.	Sugandawal	*Valeriana jatamansi*	Indian Valerian	Valerianaceae
51.	Tejpat	*Cinnamomum tamala*	Indian Bay Leaf	Lauraceae
52.	Timur	*Zanthoxylum armatum*	Prickly Ash	Rutaceae
53.	Titepate	*Artemisia vulgaris*	Common Mugwort	Asteraceae

Source: DFO/Jajarkot (2020)

Trading Scenario of NTFPs

In the fiscal year 2019-20, a total of 444,665 kg of MAPs was traded contributing a total of NRs. 3,620,500 (equivalent to USD 30,412) royalty to nation economy. Comparing the revenue of fiscal year 2019-20 with total revenue collected from MAPs in the fiscal year 2016-17 in the country (NRs. 32,914,092.40), it shows

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that Jajarkot district covers about 11% of total revenue collected from MAPs all over Nepal (DOF, 2017). Among different MAPs, the maximum traded species was Timur (*Zanthoxylum armatum*) that covered 28% of total traded MAPs. Whereas Setakchini (*Polygonatum* spp.) was the second most traded species (13%) and Pasanbed (*Bergenia ciliata*) was the third most traded species (11%) (Figure 2).

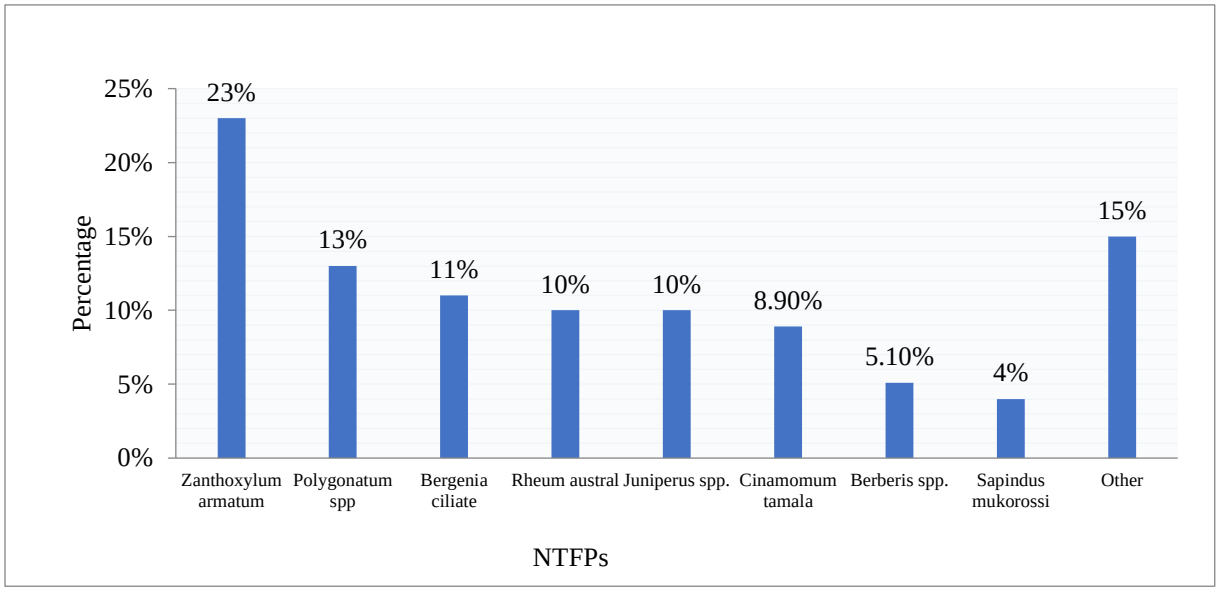

Figure 2: Percentage of the traded species in fiscal year 2019-20

Figure 3 shows the trade scenario of three most exported NTFPs i.e., Timur, Setakchini and Pasanbed from fiscal year 2015-16 to 2019-20. From this figure, we can conclude that the trade pattern of these NTFP species is increasing. For the sustainable management of these NTFPs, sustainable harvesting is required.

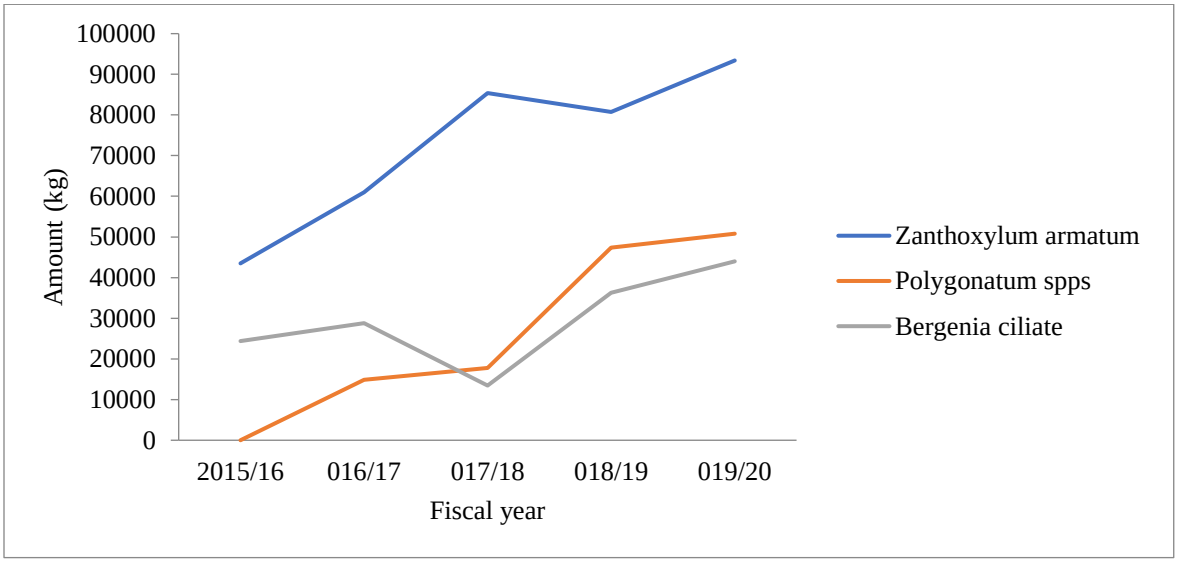

Figure 3: Traded pattern of three most exported MAPs.

Trading Rate of NTFPs (MAPs)

In the fiscal year 2015-16, the amount of the NTFPs collected from national forests was 94,029 kg which provided revenue of NRs.1,463,981 (equivalent to USD 12,297.44) to the government. While in the year,

2019-20, the amount of collection increased to 444,665 kg and revenue generated was NRs. 3,620,500 (equivalent to USD 30,412.2) (Figure 4 and Figure 5). From this, we can conclude that the trading rate of NTFPs per year from Jajarkot is increasing. Increased rate of harvesting and trading may lead to loss of such valuable NTFPs in the area. NTFPs could be threatened due to unsustainable harvesting, habitat loss, deforestation, over-grazing, and lack of marketing (Uprety *et al.*, 2010; Uprety *et al.*, 2016). So, it is important to explore the distribution pattern of NTFPs in the district, harvest and trade valuable NTFPs sustainably, launch effective strategies and programs for the conservation, identification and sustainable use of NTFPs. Uprety *et al.* (2016) have suggested an integrated approach to promote sustainable use of NTFPs along with contribution to livelihood improvement and income generation for local people.

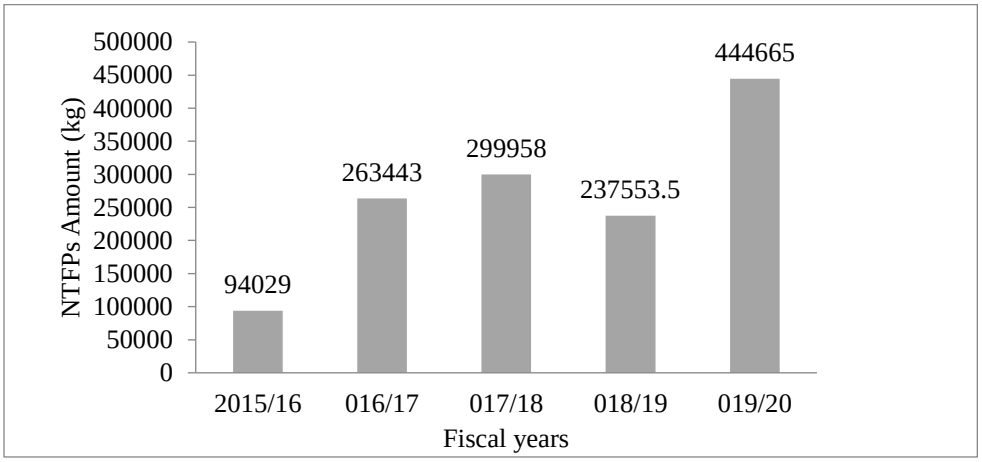

Figure 4: Trading rate of MAPs from Jajarkot

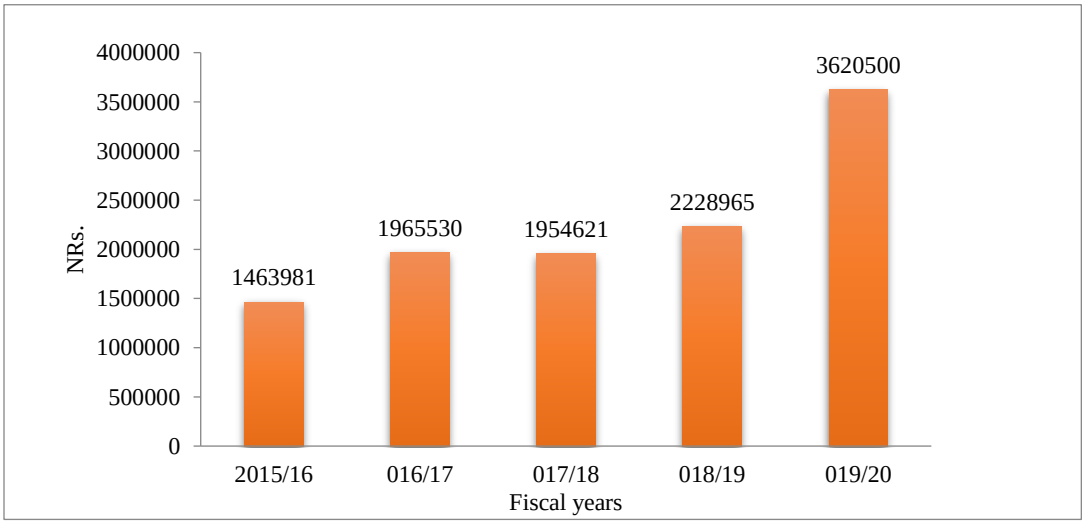

Figure 5: Royalty from MAPs from 2015-16 to 2019-20

Harvesting and Trading of Resin

During the fiscal year 2015-16 to 2019-20, a total of 1,322,752 kg resin was collected per year from community forests. It means that at least 293,945 trees have been tapped per year. A single Chirpine tree yields approximately 4.5 kg of resin annually (MSFP, 2007). It has also enhanced employment opportunities for local people, especially for poor and excluded groups. The amount of resin extraction is decreasing year by year (Figure 6). The reason behind decreasing the extraction of resin is the decreasing market value of rosin and turpentine in the Indian market.

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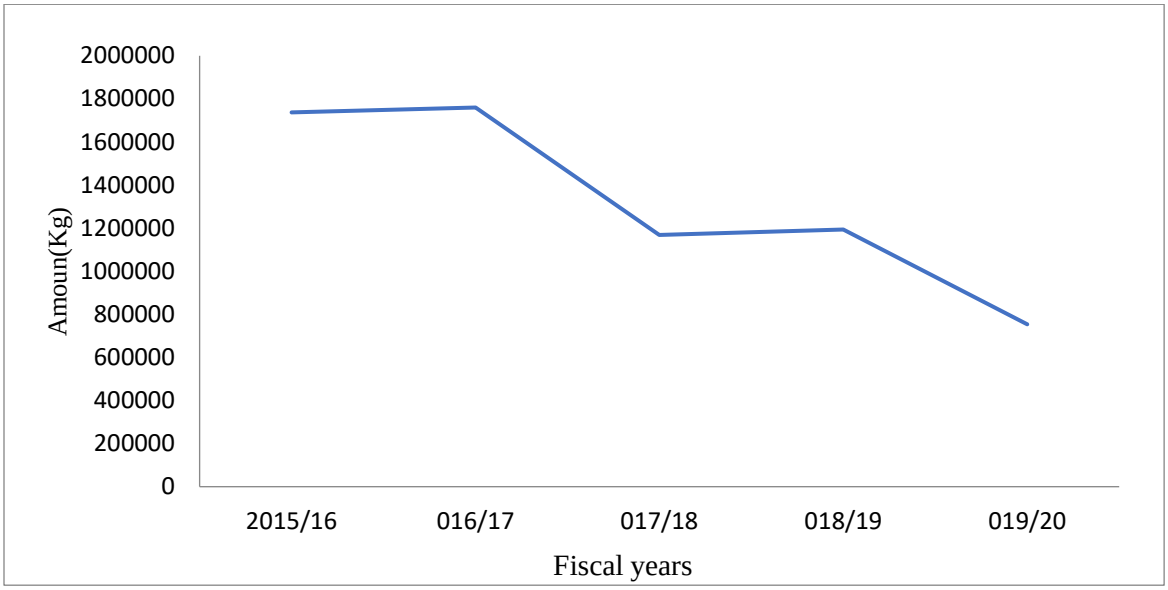

Figure 6: Harvesting pattern of Resin during fiscal year 2015-16 to 2019-20

In this district, eight resin companies are involved in Chirpine resin extraction from more than 100 community forests (DFO/Jajarkot, 2020). In the fiscal year 2019-20, a total of 753,615.6 kg resin was collected from community forests that generated NRs. 9,043,387.1 (equivalent to USD 75,964.45) to community forest user groups (CFUGs) and NRs. 1,175,640.323 (equivalent to USD 9875.4) royalty to the government. By analyzing data of last five fiscal year (2015-16 to 2019-20), it is discovered that average NRs. 12,096,555.5 (equivalent to USD 101,611.06) revenue was created to community forest user groups per year and NRs. 1,572,552.2 (equivalent to USD 13,209.44) per year to the Government of Nepal from the resin (Table 2).

Table 2: Revenue collected from resin since fiscal year 2015-16 to 2019-20

S.N.	*Fiscal year*	*Revenue to CFUGs (NRs.)*	*Revenue to Government (NRs.)*
1.	2015-16	13,902,838	1,807,368.94
2.	2016-17	14,079,170.40	1,830,292.15
3.	2017-18	9,352,758.40	1,215,858.59
4.	2018-19	14,104,623.60	1,833,601.07
5.	2019-20	9,043,387.10	1,175,640.32
	Average	12,096,555.50	1,572,552.20

(CFUG= community forest user group)

Conclusion

Jajarkot district, on an average, exported 1,590,681.72 kg NTFPs worth NRs. 3,819,271.6 (equivalent to USD 32,081.88) to nation economy per year, whereas NRs. 2,246,719.4 (equivalent to USD 18,872.44) per year came from only MAPs and NRs. 1,572,552.2 (equivalent to USD 13,209.4) from resin. *Zanthoxylum armatum* (Timur), *Polygonatum* spp. (Setak chini), *Bergenia ciliata* (Pasanbed), *Sapindus mukorossi* (Rittha), *Phyllanthus emblica* (Amala), *Cinnamomum tamala* (Dalchini), *Polypodium vulgare* (Bisphej) and resin of *Pinus roxburghi* (Chirpine) were the most traded NTFPs from Jajarkot. These NTFPs are valuable in terms of medicinal use and essential oils extraction. NTFPs collection and trade are providing the employment opportunity to the people to uplift their income. Due to lack of proper knowledge about NTFPs, unscientific collection, and illegal trading of NTFPs, many species of NTFPs are being in danger of

extinction. Creating a proper inventory and developing their sustainable harvesting protocol are the current need for conserving and sustaining these highly valuable NTFP species.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3	Author 4	Author 5
Conceived and designed the research or analysis	Yes	Yes	No	Yes	No
Collected the data	Yes	Yes	No	No	Yes
Contributed to data analysis & interpretation	Yes	Yes	No	Yes	Yes
Wrote the article/paper	Yes	Yes	Yes	Yes	Yes
Critical revision of the article/paper	Yes	Yes	Yes	No	Yes
Editing of the article/paper	Yes	No	Yes	No	No
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Project Administration	No	No	Yes	Yes	No
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Socio-Demographic Factors influencing the Sustainable Development of Carpathian Euroregion: Case of Tourism Development

Volodymyr Humeniuk[1], Nataliia Kaziuka*[2], Yevheniia Sheketa [3]
[1]Tourism Department, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine. Email: grc@ukr.net
[2]Tourism Department, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine. Email: natalinki@ukr.net
[3]Finance, Banking and Insurance Department, Ivano-Frankivsk College of Lviv National Agrarian University, Ivano-Frankivsk, Ukraine. Email: sheketa-evgenija@ukr.net
**Corresponding author | ORCID: 0000-0001-9440-7431*

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Abstract
In this article, a number of demographic factors influencing the processes of sustainable economic development in particular context of tourism in the Carpathian Euroregion have been analyzed. It is generally articulated that tourism is one of the priority economic activities recommended for this region. The socio-demographic changes can be a driving force for creating and solving existing and future socio-economic problems. A comparative analysis of socio-demographic indicators such as birth rate, mortality, median age of population, average life expectancy, migration processes, etc. has been carried out for five countries constituting the Carpathian Euroregion. It is observed that demographic trends have become persistently negative with long-term consequences, they are manifested in low life expectancy, high mortality, rapidly ageing population. The public policy in Carpathian Euroregion should be aimed at enhancing social development, reviving the family and serving the interests of people. It is impossible to solve these problems without overcoming poverty, income growth, improving the welfare of the entire population and reforming the labour market.
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Keywords
Tourism; Socio-demographic factors; Birth rate; Mortality rate; Migration

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Introduction

The strategy of sustainable economic development of the Carpathian Euroregion should concentrate on productive forces, economic structure, specialization and location of production keeping in view the contemporary situations. It must be consistent with the available resources and replenishment potential of the environment of all constituent territories in the Carpathian Euroregion. The examination of demographic changes can make it possible to integrate such tenets while evolving a sustainable economic development strategy for the Carpathian Euroregion in the future. Favourably, the socio-demographic component significantly affects the regional development through organizational, economic-innovative, socio-environmental and information levers. Identifying and integrating the demographic processes specific to the region can be a driving force for solving a number of socio-economic and environmental problems. It will also contribute to the development of the region in terms of resource-saving and innovative and high-tech productions. However, extent and use of available resources, resource limitations, flow of capital investment, orientation of economic and organizational progress should be consistent not only with the existing but also future needs of the populations residing in constituent territories of the Carpathian Euroregion.

The development of tourism is linked to the sustainable regional development, elimination of infrastructure restrictions, spatially balanced production and social infrastructure, environmental security, and competitive economy in mountain areas. In context of Carpathian Euroregion, tourism is entrusted as one of the promising areas for sustainable development. This region has a unique natural, historical and cultural heritage, recreational and resource potential; and it is characterized by a favourable economic, geographical and geopolitical combinations as along with relatively high environmental security.

When the service sector is becoming dominant, tourism plays a key role in international social activities, as it contributes to comprehensive sustainable economic development, employment and poverty reduction. Tourism plays a significant role in GDP shaping, creating additional jobs and employment, and improving foreign trade. Acting as a catalyst for socio-economic development, tourism has a significant impact on key areas of the region, e.g., transport, communications, infrastructure, construction, agriculture, consumer goods production, etc. Therefore, the transformation of socio-demographic indicators affects the development of tourism as one of the main components of sustainable economic development of the Carpathian Euroregion. Thus, the analytical study on socio-demographic characteristics coupled with the development of recommendations for their improvement has laid the foundation for this article.

Social and demographic factors, the influence of which is multifaceted, cause a permanent impact on the development of tourism. This directly concerns the quantitative and structural characteristics of the population, including the population size, its distribution in separate regions, the sex-age structure (with the allocation of the working-age population), marital status, family composition (increase in the number of working women and change in income per family, increase in the proportion of single people, tendencies to later marriage and family formation, increase in the number of childless couples in the population, decrease in immigration restrictions, increase of paid business trips and more flexible working hours, increase of people's awareness of their tourism opportunities), etc. These indicators, to some extent, affect the structure of leisure time of the population, which creates objective social and demographic conditions for tourism development. Currently, quite often there are inconsistencies between the structure of leisure and economic opportunities of the population. There is a situation in which part of the population who has free time cannot use tourist services. In turn, representatives of commercial structures, that have the material means to organize recreation using travel agencies, often cannot afford even a short-term absence. Socio-demographic factors affect tourism processes through changes and tourist flows. For example, the increase in potential tourists directly depends on population growth. However, even as the population grows, different growth rates in different countries can significantly affect both incoming and outgoing tourist flows. Changes in the age structure of the population also affect the functioning of tourist processes.

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Issues of tourism development can be dealt not only by studying the needs of existing and potential customers, but also by assessing demographic trends in the world. For instance, the decline in population reproduction in some countries is accompanied by an increase in the number of elderly tourists. This trend is associated with falling birth rates and increasing life expectancy. Companies in the tourism industry must take this situation into account, as the needs of older people are very different from those of young people. Young people prefer not to stay in the same place, but to travel around the country or countries, visiting different places. The increase in birth rates, in turn, leads to an increase in the number of tourists with young children. Thus, the demographic factors affect developing the array of this service and are crucial for the tourism industry.

Demographic characteristics, along with cultural and ethnic models, economic development of adjacent territories and extent of barrier functions of state borders, influence the processes of cross-border cooperation. In addition, to neutralize the effect of negative demographic changes and their potential impact on regional labour markets, it is the intensification of cross-border cooperation that can enhance the development and implementation of new and innovative regional strategies. The most important issue in the context of identifying resources to improve the efficiency of cross-border regions through the route of improving the foreign economic relations formed over a period of time revolves around sustained spatial structures fostering the coordination and synchronization of development programs on both sides of the border, which, in turn, leads to convergence of regions in cross-border space (Artyomov, 2012).

In recent years, the importance of social indicators in economics has been rising remarkably, especially in context of tourism. Such indicators may be the householders' behaviours, their social status, age and other demographic indicators. These behaviourial and social indicators have profound effect on the macro-economic variables, such as saving and consumption (Doker, Turkmen and Selcuk, 2016). Socio-economic development of the regions is impossible without solving demographic problems, developing and implementing an effective policy in the demography arena. The works of many scientists are devoted to the study of the impact of demographic trends on economic development (Gasparenienea and Remeikienea, 2016). Docquier *et al.* (2019) explore demographic trends and human development; Strulik (1999) studies the development of demography and economic cycles; Hallett *et al.* (2019) research sustainable fiscal strategies under changing demographics; and Volodymyr Gumeniuk explores the impact of demographic factors on the financial stability of tourism enterprises (Gumeniuk, 2015). O'Sullivan (2020) argues that stabilization of the population is needed to ensure stable economic development of the state. It can be a factor in reducing resource consumption and will help equalize incomes. Kitao and Mikoshiba (2020) find that a rise in the labour supply of females and the elderly of both genders in an extensive margin and in labour productivity can significantly mitigate effects of demographic aging on the macroeconomy and reduce fiscal pressures, despite their negative effects on equilibrium wages during the transition. Their study suggests that a combination of policies that remove obstacles hindering labour supply and enhance a more efficient allocation of male and female workers of all age groups will be critical to keep government deficit under control by raising income across the nation.

Referring above contexts, it is important to take into account, in a consistent manner, the demographic factors and regional development in context of tourism. The analysis of changes in socio-demographic processes allows to establish a coherence and linkages. Thus, demographic processes play a role in the changes that are clearly taking place in the global tourism scenario.

Methodology

The methodology of analytical research in this article involves the use of general and special research methods. Synthesis and generalization methods of analysis were used to present the results of the study clearly and consistently. Historical and logical methods were applied to analyze the scientific opinion of other researchers. Methods of economic, statistical, and comparative analysis with detailing and systematization were employed to process the main statistical indicators and assessing their dynamics.

Mathematical modeling was used to forecast the values of population of the Carpathian Euroregion. Lastly, graphics and tabular form have been used for visual representation of statistical data and supporting certain theoretical and practical aspects.

Results and Discussion

Europe is currently experiencing an unprecedented process of reterritorialization in the context of European Union integration: central to this process is the implementation of various cross-border cooperation schemes, commonly known as Euroregion (Popescu, 2008). Furthermore, Euroregion is a form of cross-border cooperation between territorial communities or local authorities of border regions of two or more States that have a common border. Euroregion aims at coordinating joint efforts addressing various spheres of life and national and international laws to tackle problematic issues. This operates in the interests of the people who inhabit cross-border territories.

Establishing the Euroregion, Europe is gradually leaving behind the principle of regionalization at the level of political and national boundaries and focusing primarily on economic and sustainable ecological development. This creates a unique space for primarily cross-border areas of neighbouring States, which often differ in terms of development from the core parts of the country.

The Carpathian Euroregion

The Carpathian Euroregion comprises 19 administrative units of five countries from Central and Eastern Europe: Poland, Slovakia, Hungary, Ukraine and Romania. Its total area is about 160,000 km^2 or over 60,000 $miles^2$. It is inhabited by over 15 million people. The Carpathian Euroregion is designed to bring together the people who inhabit the region of the Carpathian Mountains and to facilitate their cooperation in the fields of science, culture, education, trade, tourism and economy (Carpathian Euroregion, 2021).

The goals of the Carpathian Euroregion are defined as: “promoting a cooperation in the economic, social, scientific, environmental, educational, cultural spheres and sports, lobbying and implementing cross-border projects, and cooperating with national institutions and organizations” (Khiminets, 2012). Intended outcomes for the Carpathian Euroregion are: establishing an effective functioning model of the Carpathian Euroregion agreed upon by all the participating nations - Poland, Slovakia, Hungary, Romania and Ukraine; fostering sustainable partnerships and information flow between authorities, local governments, NGOs (non-governmental organizations) and expert groups in the border regions; developing CBC (cross border cooperation programme) initiatives that have strategic importance for cross-border cooperation in the context of sustainable development (Regional Development Association for the Carpathian Euroregion, 2021).

The Carpathian Euroregion can be characterized by both strengths and weaknesses. Strong aspects include the activities undertaken within a single ecosystem (in Western Europe, there is a positive experience of solving common issues by Euroregions, which also operate within ecosystems such as the Baltic or Alpine); the presence of a common border with European Union, which facilitates the implementation of EU-funded joint projects; the possibility of financing cross-border projects under joint EU programs; availability of common technical infrastructure within the Carpathian Euroregion; common cultural heritage; favourable, relatively clean environment in the territory of the Euroregion; the presence of the Carpathian Biosphere Reserve, the largest in Europe, in the Ukrainian, Polish and Slovak parts of the Carpathian Euroregion (Carpathian Horizon, 2013).

As for the weaknesses of the Carpathian Euroregion, it has large territorial scale of the association covering 19 regions of five States, the distance between the centres of which sometimes reaches 500 km, which complicates multilateral contacts within the association. It must also be mentioned that member States need additional coordination within the Euroregion (i.e., coordination of decisions at the national level, etc.). Competences of the national parties, derived by different systems of administrative-territorial organization

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in the five States cause the problem of defining similar administrative units with the same powers, especially at the local level, within which cooperation could develop. On top of all, there is lack of common sources of funding for the entire Carpathian Euroregion, especially within the framework of EU cooperation programs.

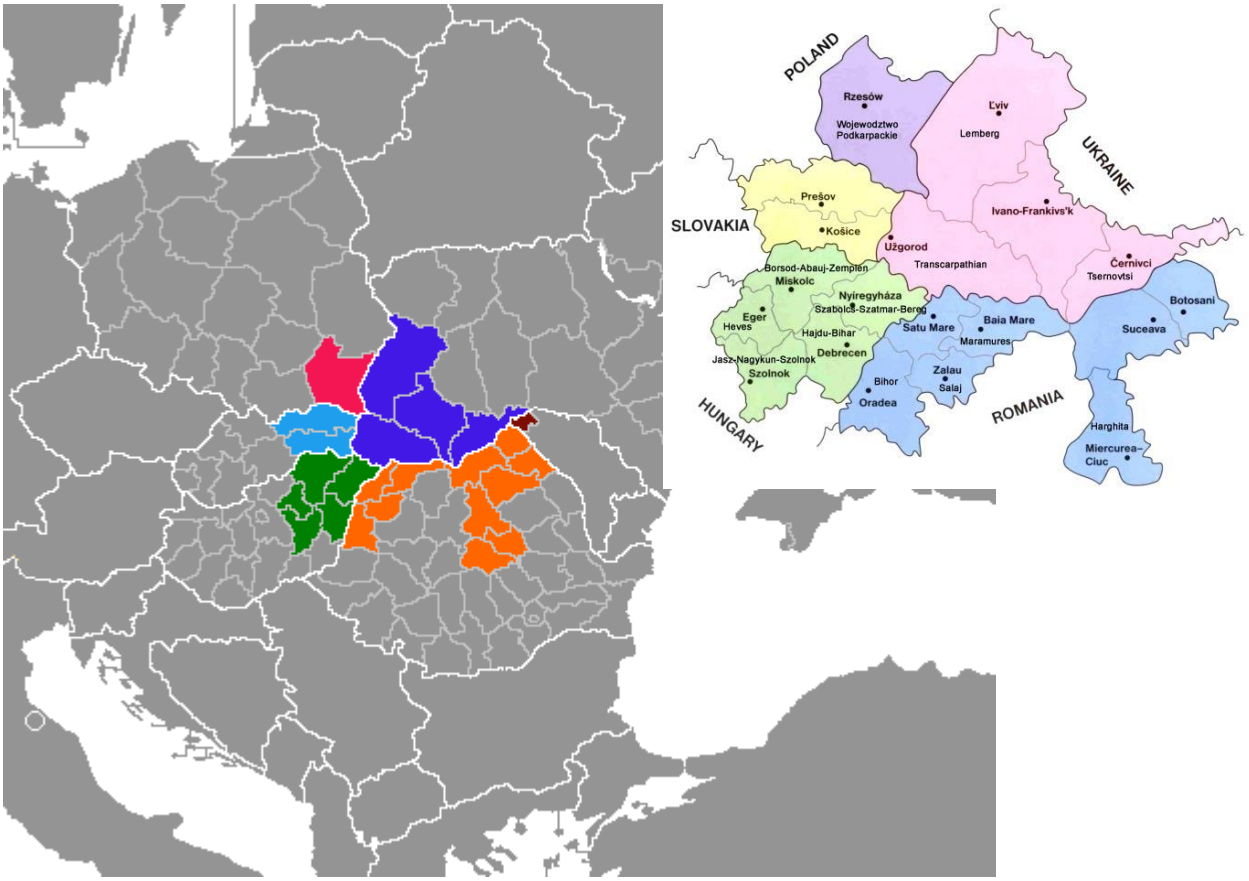

Figure 1: The Carpathian Euroregion on the map of Europe

It is worth noting that in connection with the accession of a number of neighbouring European countries to the EU changed the conditions and procedures for European Commission funding of cross-border programs in Slovakia, Hungary, Romania and Poland. It puts several new requirements for cross-border regional EU financial resources aimed at strengthening cross-border cooperation on the eastern borders of this association (Artyomov, 2012). Improving the quality of human capital in the region is also a priority for the common interests of the Carpathian Euroregion. To increase the competitiveness of the region, it is essential to integrate the preservation of historical and cultural heritage, development of tourism by building transport, information and social infrastructure of the Ukrainian Carpathians.

The Influence of Demographic Factors on Regional Development

Changes in the population and scale of production, combined with irrational consumption patterns, are placing an increasingly heavy burden on the life-sustaining potential of our planet. These interacting processes affect the exploitation of the atmosphere, land, water, energy and other resources. Without proper regulation of this activity, fast-growing cities face serious environmental problems: the growing number and expansion of urban boundaries force them to pay more attention to the activities of local governments and regional development management. A key element of this complex interconnection system is the human factor, which should be duly taken into account in the development and implementation of a comprehensive

policy for sustainable development. Such policies should consider the links between demographic trends and factors, resource use, technology diffusion and sustainable development.

Demographic policy must also consider the role that people play in addressing environmental and sustainable development issues. In this context, it is advisable to raise the awareness of policymakers at all levels on this issue and to provide them with more accurate information, which should form the basis of their national and international policies, while expanding their capacity to assess such information qualitatively. The population of an area influences key components of social division of labour in the regional and State labour markets. The decrease in the population causes an increase in the qualitative characteristics of the labour force. A decrease in its mobility in terms of labour capacity, while reducing production in various sectors of the economy, is a result of the lack of labour shortages. Even when the financial situation of the companies improves with extended investments in human capital, the negative demographic trends, in particular the decrease of the workers population, will lead to intensified competition among companies for attracting and retaining the workforce (Ozolina-Ozolaa and Gaile-Sarkane, 2017).

In relation to declining workforce, the ageing population affects the overall scenario. Ageing population increases not only because of better quality of life, but also because of high mortality of the working population, low birth rate and share of younger age groups in the total population. Besides, in developed countries, modern technologies fighting against mortality prove more effective, significantly increasing the healthy life of older peoples (Emerson and Knabb, 2020).

The ageing of the population and resulting reduction of labour supply require a remedy aiming at increasing the economic activity of citizens of older age groups, developing effective mechanisms to stimulate the production. Moreover, ageing coupled with emigration is one of the most important demographic problem in rural areas. The phenomenon of ageing is getting worse every year in Euroregion causing considerable decrease in availability of the workforce (Sytnyk *et al.*, 2020). Thus, reducing number of employed population due to the demographic changes, and emigration processes are limiting factors for economic and social growth. As a result, labour may become one of the scarcest resources. D'Albis, Boubtane and Coulibaly (2021) have analyzed the effects of demographic variables on the labour income share by distinguishing between natural increase and migration. They showed empirically that these two variables have opposite effects on the economy: natural increase reduces per capita total income and the labour income share, whereas migration increases per capita total income and labour income share.

The migration trends show that the region faces the same problems as most developed countries face. The lack of an effective migration policy increases illegal labour migration, employment in the shadow economy, and, as a result, crime, social spending in the absence of adequate income, and non-payment of taxes. Ukraine is characterized by a number of factors that exacerbate migration processes. Such factors include the imperfection of Ukrainian legislation. First, it is the inadequacy of migration and labour legislation vis-à-vis realities of the modern labour market. Second, the existence of shadow employment attracts the increased demand for low-paid, socially vulnerable categories of workers.

Among other factors are the imperfection of the mechanism for coordinating the actions of the authorities in the development and implementation of migration policy in Ukraine, and the management of migration flows. Managing the migration flows and the reduction of mortality can solve the problems of restoring demographic potential in the short and medium term. At the same time, the issue of decreasing birth rate should be addressed through a range of measures having social and economic nature. Joanna Tyrowicz and Velde (2018) studied problem of labour force reallocation. They showed that changes in the demand for labour were accommodated mostly through demographic flows, with a smaller role left for job transitions. The speed of changing the ownership structure in the economy has driven exits to retirement, in particular the early exits.

First, the stability of the overall socio-economic situation and the strengthening of the systems of social, political and economic guarantees, including the expansion of real access to quality education and health care, are crucial. Noticeably, public policy in Carpathian Euroregion creates incentives for the participation of all stakeholders in executing the appropriate actions. Thus, a significant number of enterprises under the ambit of framework of social programs can implement measures related to maternity support (assistance to preschool children, to health and recreation of children, and to mothers, education, etc.). Virtually, all reforms in the social sphere of Ukraine in the recent years have contributed to increased availability and quality of health services, education and social security – trying to improve the demographic situation.

Next, social policy reform should be carried out considering the need to address demographic problems. To this end, a demographic examination of the decisions made in this region should be conducted. Thus, negative demographic processes, which have led to an increase in the burden on the working population, are accompanied by increased pressure on the health care and social security system. Such processes exacerbate the problem of paying pensions and social benefits while restraining their growth. The existing problems in the field of health care for workers and the increase in the birth rate are increasingly calling for reforming the system of compulsory social insurance.

Meanwhile, the unprecedented increase in international migration flows has placed immigration issues at the forefront of media coverage and political debates of destination countries. This debate often focuses on the potential negative consequences of immigration in context of labour market prospects for the native population or of its negative effect on the public accounts (Mestres, Casasnovas and Castelló, 2021). Bairoliya and Miller (2020) developed a dynamic general equilibrium model to analyze the impact of social insurance policy and demographic changes on rural-urban migration. Their quantitative analyses indicate that different social insurance programs not only have differential effects on net migration flows but also on the age and income distribution of migrants.

The level of scientific and technological development, the degree of professional and practical training, and the development of qualitative characteristics of labour potential depend on changes in demographic characteristics. However, a growing population is not a guarantee of socio-economic progress. A significant role is played by the personal interest of citizens in the development of economic processes, the degree of professional skills, the presence of incentives from government agencies, economic and political freedom of labour force to choose a profession, and appropriate wages. The labour activity of the population also depends on the demographic situation, in addition to such important indicators such as gender and age structure of the population, marital status, level of professional training. It should be noted that demographic policy is more dependent on women, requiring greater choice of place and working conditions, appropriate length of the working day, and reduced period of employment.

Birth Rate in Relation to Labour Resources

The study of demographic processes is impossible without an assessment of births and deaths because these phenomena are the basis for the restoration of labour resources. Analysis of the impact of demographic trends on the development of the region should begin with the birth rate, because this indicator is closely related to socio-economic changes in modern conditions caused by production fall, dwarfing wages, degrading living standards, inflation, housing problems, especially, if we are talking about young people. Analysis reveals a decrease in the population of the Carpathian Euroregion (Figure 2) by 5,001,824 people. It is the largest decrease (that took place in Ukraine) by 3,865,400 people when compared to 2010. These processes can be explained by a steady downward trend in the birth rate – a decrease by 196,031 people in the region as a whole from 2010 to 2019 (Figure 3). Noticeably, there is also a decrease in mortality by 138,042 people (Figure 4).

To increase the birth rate, it is advisable to provide material conditions for the reproduction of the population, increase the general welfare of society, overcome the trend of impoverishment of the nation and

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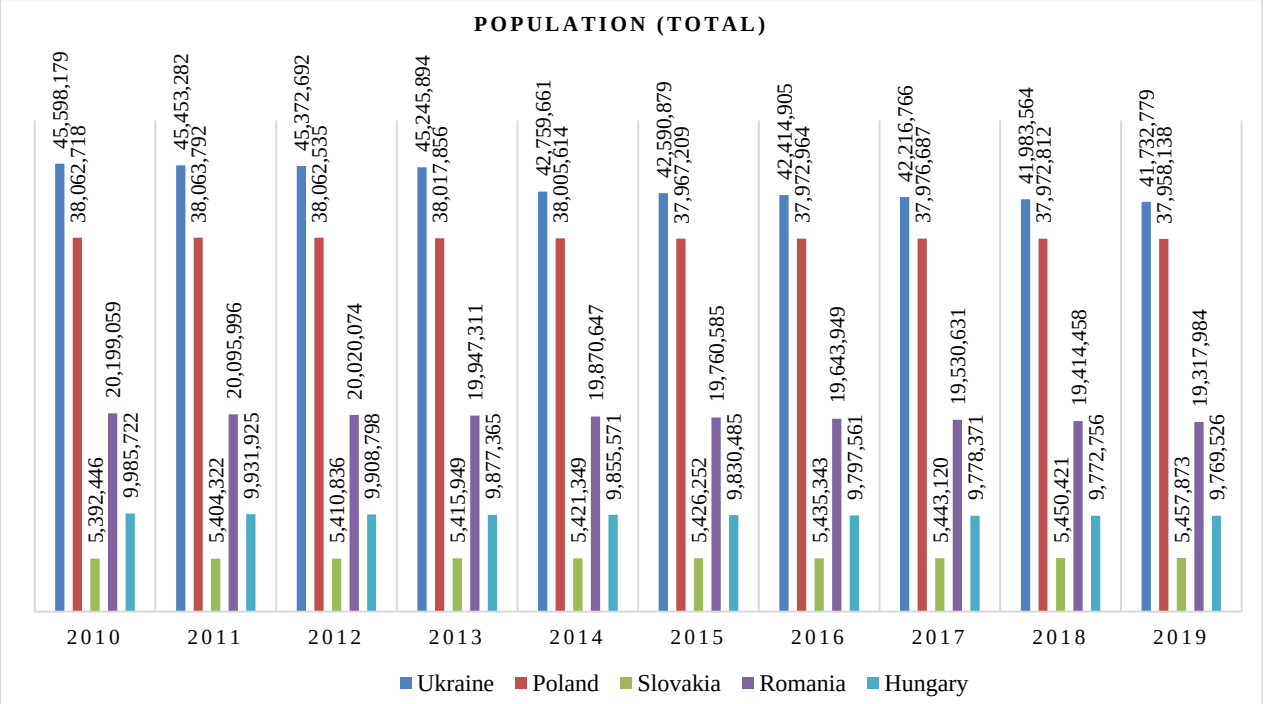
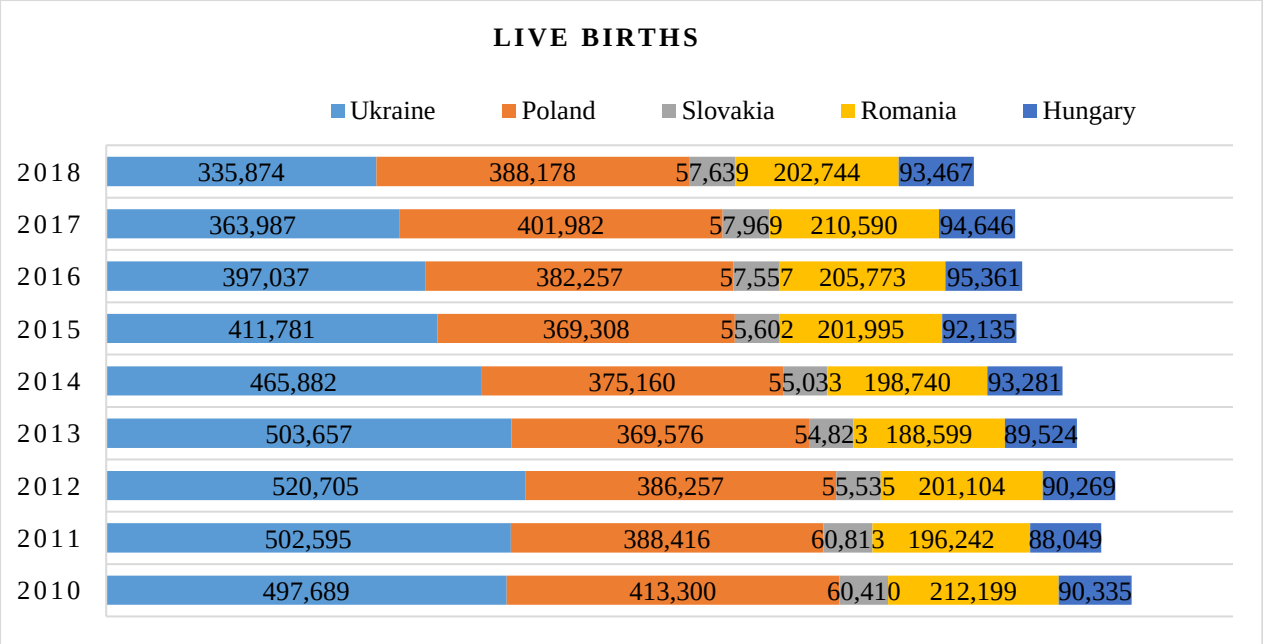
increase its income. The birth rate can also be increased by providing material incentives for the birth and upbringing of children, and in particular the payments should be made not after the birth of a child, but with the beginning of pregnancy – to ensure healthy development of fetus (Beluzo *et al.*, 2020).



*Prepared by the authors based on the Eurostat data: https://ec.europa.eu/eurostat

Figure 2: Total population by countries of the Carpathian Euroregion*



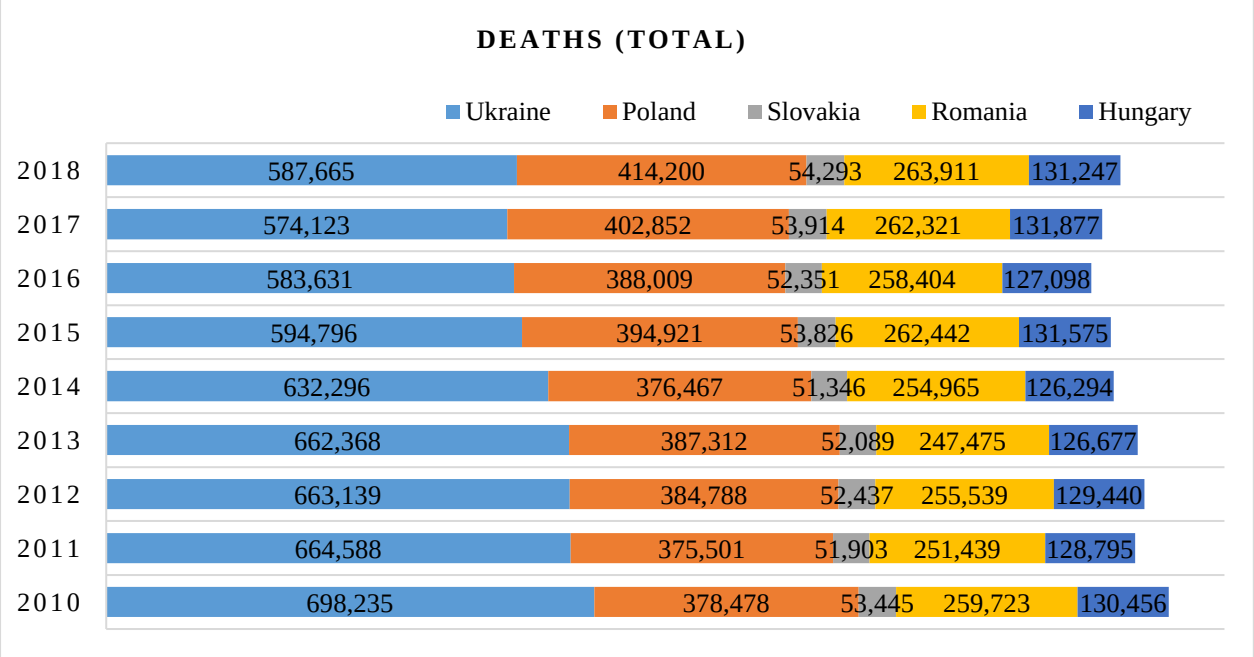
*Prepared by the authors based on the Eurostat data: https://ec.europa.eu/eurostat

Figure 3: Live births by countries of the Carpathian Euroregion*

Thus, it can be observed a narrowing demographic base of potential labour restoration due to low birth rates, high mortality rates and deteriorating age structure. Such processes in the long run will have a negative impact on the economic development of the Carpathian Euroregion.

Mortality Rate

The next factor influencing the employment, development of labour potential, gender composition and age structure is the mortality rate, which retrospectively depends on socio-economic development, health care, social welfare and environmental conditions. Thus, during the analyzed period, the reduction of overall mortality rate in the countries of the Carpathian Euroregion occurred only in Ukraine (by 110,570 people); while in the other countries there was an increase in mortality rate from 2010 to 2019 (Figure 4). Nevertheless, comparing the overall mortality rates with the birth rates in the Carpathian Euroregion, it is noted that the mortality rate significantly exceeds the birth rate. At the same time, the birth rate is declining faster than the mortality rate.



* Prepared by the authors based on the Eurostat data: https://ec.europa.eu/eurostat

Figure 4: Total deaths by countries of the Carpathian Euroregion*

The high mortality rate of the working population is associated not only with the insufficient health care and medical care, but is also the result of social and political factors. Currently, bottleneck is the development and implementation of comprehensive programs aimed at reducing mortality, especially in working age. In this situation, the priority is to develop a set of measures aimed at achieving this goal. These should be the measures in the field of general medicine, preventive medicine, occupational injury reduction, and enhancing employers' motivation to ensure safe occupational conditions. In addition, measures should also include improving the system of compulsory social insurance against accidents at work and occupational diseases, measures to prevent and combat alcoholism, drug addiction and social evils.

Mortality is an indicator reflecting the level of material and spiritual life of a person, his/her life, nutrition, environment, level of health care, and socio-economic development of the country. Therefore, without creating an effective mechanism for the functioning of such processes, it is impossible to reduce mortality in the region. To reduce mortality, it is advisable to implement multiple measures to improve the material

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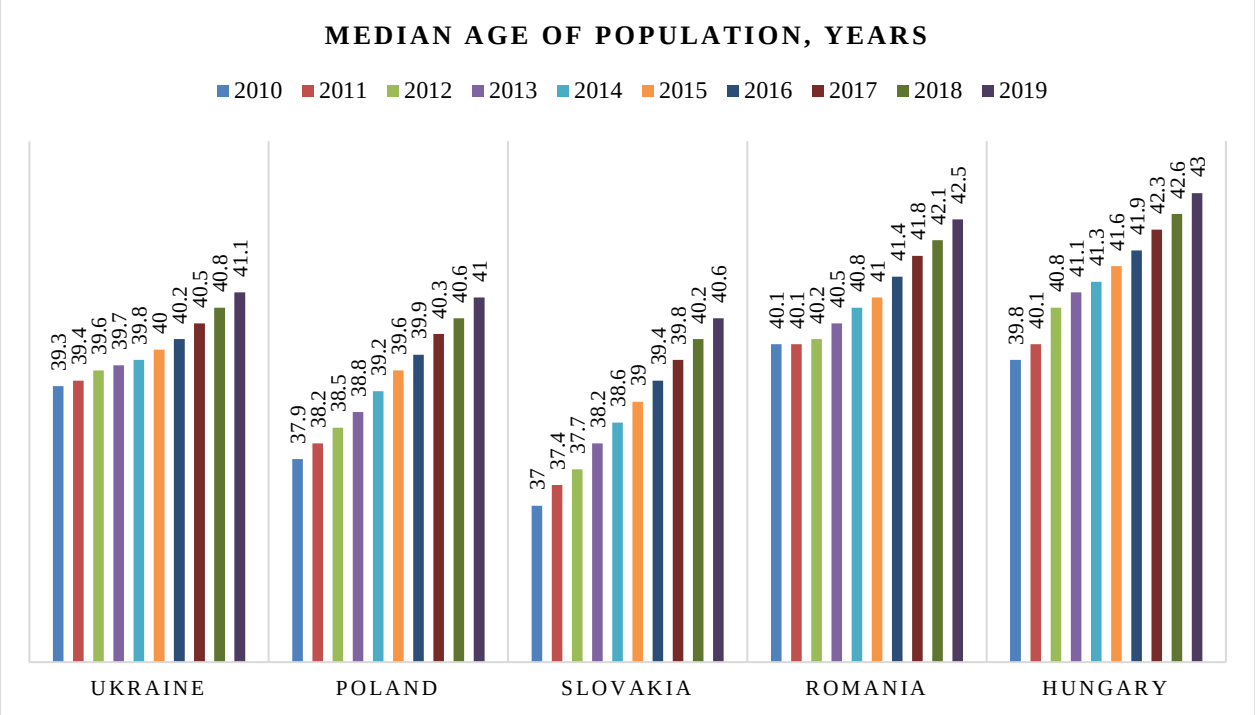
conditions of the population, to improve living environmental conditions, to reduce stress, and to overcome negative social evils such as alcoholism and drug addiction.

Estimation of the general population ageing is effective for determining the dependence of employment on demographic variables. The real physical ability to work reflects the relationship of conditions and factors in which an individual lives and works. Cooley and Henriksen (2018) in their paper argue that changing demographics, in particular aging populations combined with increased life expectancy, may be part of the explanation as to why we observe falling productivity growth.



* Prepared by the authors based on the Eurostat data: https://ec.europa.eu/eurostat

Figure 5: Median age of population by countries of the Carpathian Euroregion*

Statistical data reflects that the average age of the population of the Carpathian Euroregion is increasing (Figure 5), which is not always associated with an increase in life expectancy (Figure 6) but mainly with a decrease in fertility. At the same time, the dynamics of mortality contributed, rather, to a decrease in middle age due to reduced mortality in younger age groups and growth in middle and older age. It is observed that the decline in the proportion of the population in younger age groups has led to a corresponding increase in the proportion of older people.

Thus, to improve the demographic situation, it is necessary to implement programs to increase the welfare of the population, reform the education system, use health insurance, increase wages, and improve the general living conditions of people. Concerning migration processes, it is effective to implement employment expansion policies and create new jobs that will correspond to the existing structure of the workforce and the magnitude of professional training.

Conclusively, the following changes can be observed in the demographic structure of the Euroregion's population: ageing population (declining birth rate causes an increase in the share of older people, and the number of younger age groups, in particular from 15 to 24 years, is steadily declining); increased number of working women, increase of women's desire to make a career (this leads to late marriage, postponement of childbirth, and increase in the number of childless married couples); and increased singles (in large cities they

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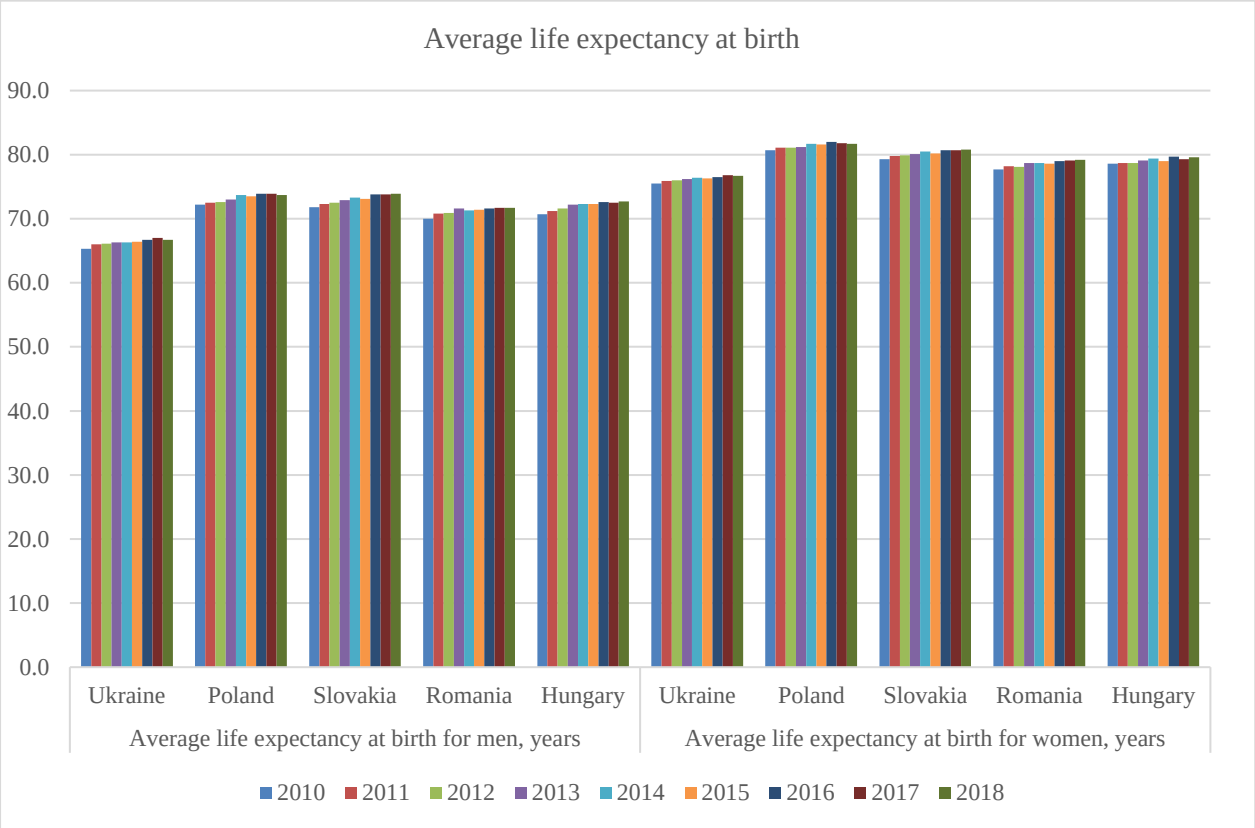
can be up to half of the total population). Thus, the processes of population reproduction are influenced by the socio-economic laws. Besides, other factors that have ambiguous influences on births and deaths, such as political, psychological, historical, and cultural, can be singled out. These factors, in turn, also cause significant differentiation in the demographic processes of different regions comprising rural or urban settlements altogether.



* Prepared by the authors based on the Eurostat data: https://ec.europa.eu/eurostat

Figure 6: Average life expectancy at birth by countries of the Carpathian Euroregion*

Effects of Migration on Euroregion's Economy

In modern circumstances, the structure of employment is also significantly influenced by migration trends, which depend on many socio-economic processes associated with both economic transformations taking place in the country and changes in social and industrial relations. The demographic situation has an impact on the structure of employment through the mechanical and natural movement of the population. Thus, an important indicator reflecting the demographic trends of the region is the magnitude of labour migration. When migration is not always considered a positive phenomenon, it facilitates the exchange of labour, skills and abilities. It also reflects negative processes: dissatisfaction with work, wages, working conditions, difficult economic or environmental situation in the country or region. External migration causes the loss of skilled labour, intellectual richness, and labour potential of the region.

Besides, the departure of citizens abroad threatens to be leaching of the domestic labour force, the deteriorating demographic situation within the country, the shortage of qualified personnel in enterprises, and so on. However, from alternative point of view, it is the labour migration that provides the highest level of social adaptation to the living standards of developed European countries, that allows them to gain experience in the market and business environment of EU countries. These social processes of adaptation are incomparable in importance with that acquired during cross-border trade and other forms of foreign

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economic activity within cross-border regions. It also provides the accumulation of sufficient financial resources that can be effectively used for investment in Ukraine (Mikula, 2013).

Table 1: Migration indicators by countries of the Carpathian Euroregion*

Year	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*Change from 2009*
Emigration (Males)											
Poland	115,188	109,991	133,744	140,586	137,775	140,515	148,879	133,162	120,564	105,386	-9,802
Slovakia	953	844	751	778	1,088	1,442	1,554	1,535	1,365	1,280	327
Romania	105,778	85,663	87,389	70,163	65,303	87,356	104,700	100,533	122,791	118,803	13,025
Hungary	6,034	7,333	8,193	12,831	19,679	23,342	23,685	21,689	22,062	27,291	21,257
Emigration (Females)											
Poland	114,132	108,135	132,054	135,017	138,671	127,784	109,958	103,279	97,928	84,408	-29,724
Slovakia	1,026	1,045	1,112	1,225	1,682	2,202	2,316	2,266	2,101	2,018	992
Romania	140,848	112,322	108,162	100,023	96,452	85,515	90,018	107,045	119,402	112,858	-27,990
Hungary	4,449	6,032	6,907	10,049	15,012	18,871	19,540	18,200	17,767	20,887	16,438
Total											
Ukraine	629,372	667,316	652,301	664,382	644,029	519,914	519,045	246,188	430,290	610,687	-18,685
Poland	229,320	218,126	265,798	275,603	276,446	268,299	258,837	236,441	218,492	189,794	-39 526
Slovakia	1,979	1,889	1,863	2,003	2,770	3,644	3,870	3,801	3,466	3,298	1,319
Romania	246,626	197,985	195,551	170,186	161,755	172,871	194,718	207,578	242,193	231,661	-14,965
Hungary	10,483	13,365	15,100	22,880	34,691	42,213	43,225	39,889	39,829	48,178	37,695
Immigration (Males)											
Poland	130,381	101,648	95,739	128,318	128,486	125,641	125,535	121,428	117,960	123,699	-6,682
Slovakia	3,970	3,247	3,013	3,218	2,967	3,109	4,102	4,422	3,911	3,946	-24
Romania	79,398	85,486	83,931	94,047	84,790	70,841	73,670	79,387	101,036	98,271	18,873
Hungary	15,739	14,290	15,404	18,630	21,899	30,835	33,151	30,121	38,903	48,922	33,183
Immigration (Females)											
Poland	58,785	53,483	61,320	89,228	91,825	96,634	92,612	86,874	91,393	90,384	31,599
Slovakia	2,376	2,025	1,816	2,201	2,182	2,248	2,895	3,264	3,277	3,307	931
Romania	56,446	64,399	63,754	73,219	68,856	65,194	59,125	58,068	76,399	74,307	17,861
Hungary	12,155	11,229	12,614	15,072	17,069	23,746	25,193	23,497	29,167	34,015	21,860
Total											
Ukraine	642,819	683,449	669,397	726,226	675,942	542,506	533,278	256,808	442,287	629,276	-13,543
Poland	189,166	155 131	157,059	217,546	220,311	222,275	218,147	208,302	209,353	214,083	24,917
Slovakia	6,346	5,272	4,829	5,419	5,149	5,357	6,997	7,686	7,188	7,253	907
Romania	135,844	149 885	147,685	167,266	153,646	136,035	132,795	137,455	177,435	172,578	36,734
Hungary	27,894	25,519	28,018	33,702	38,968	54,581	58,344	53,618	68,070	82,937	55,043
Mmigration balance											
Ukraine	13,447	16,133	17,096	61,844	31,913	22,592	14,233	10,620	11,997	18,589	5,142
Poland	-40,154	-62,995	-108,739	-58,057	-56,135	-46,024	-40,690	-28,139	-9,139	24,289	64,443
Slovakia	4,367	3,383	2,966	3,416	2,379	1,713	3,127	3,885	3,722	3,955	-412
Romania	-110,782	-48,100	-47,866	-2,920	-8,109	-36,836	-61,923	-70,123	-64,758	-59,083	51,699
Hungary	17,411	12,154	12,918	10,822	4,277	12,368	15,119	13,729	28,241	34,759	17,348

* Calculated by the authors based on the Eurostat data: https://ec.europa.eu/eurostat

Labour emigration is dominating among the migration processes that affect changes in the structure of employment, apart from internal migration (relocating from rural areas to urban areas). That is mostly illegal emigration, aimed at going abroad in search of more earnings and self-interest, aspirations, hopes. This situation is associated with reduced employment, lower production, rising inflation and declining incomes. Immigrants are also affected most by the global crisis caused by COVID-19. These factors not only negatively affect the economic situation in the region, but also the demographic situation of the population. Young specialists and the specialists who are forced to work abroad (mostly not in their specialty) are losing their qualification skills and are withdrawn from production.

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Case of Tourism in Context of Demographic Factors and Sustainable Development

Mankind's desire for economic and technological development is largely ensured by the irrational and destructive exploitation of natural resources and the environment. The result is a large-scale global environmental crisis, and the contradictions between economic and environmental systems have reached alarming levels. This has led most developed countries to think about what should be done to achieve sustainable development. To accomplish the sustainable development, States need to cultivate a new qualitative society that does not endanger the lives of future generations, and in which everyone has everything necessary for development and lives in harmony with the environment.

Notably, tourism, based on the globalization priorities of the sustainable development, plays a major role in the social and transformational processes of the world economy. The range of functions performed by tourism allows to use it as an effective tool to stimulate socio-economic growth at the macro and meso levels of management. The functions of tourism are primarily manifested in the territories of specific regions, and the possibilities of its development are determined by the conditions of the regions. Therefore, the consideration of tourism as a tool of socio-economic development is especially relevant from the standpoint of the regional approach.

The principal way to implement the strategy of sustainable development in the Carpathian Euroregion is to develop an appropriate methodology taking into account all components of sustainable development and the mechanism of their implementation. The development of tourism is a priority in the implementation of the framework of sustainable development, as it is in the plane of state economic, social and environmental policy of these countries. The development of tourism in the context of sustainable development should be formed and maintained at the regional level, and its provision should be carried out vertically i.e., from a specific administrative-territorial unit to the national and world levels. To position and promote tourism services in the region, it is necessary to identify the resource security of the territory, balance the economic, social and environmental interests of local development policy actors, as well as carefully analyze the situation in the leading sectors of the economy. For the countries of the Carpathian Euroregion, the sphere of tourism is an important and strategic direction of the State policy implementation, considering the available natural resources and recreational potential at suitable geographical locations of these countries.

On the one hand the tourism industry is a factor of globalization, whereas on the other hand, it develops under the influence of many other factors such as information technologies, social differentiation of society, climate characteristics, etc. All components of the society can be stimulating or inhibiting factors in the development of tourism; their number, relationship and intensity of impact depend on the hierarchical level of the tourism market and its focus. The study of socio-cultural factors that affect the development of tourism enables not only to predict its development but also to explore the relationship and, accordingly, the impact of tourism on the development of society, in general, and social component, in particular.

The demographic situation refers to external factors influencing the tourism business. External (exogenous) factors influence tourism through demographic and social change. These factors include age of the population, number of working women and change in income per family, proportion of single people, tendencies to late marriage and family formation, number of childless couples in the population, immigration restrictions, paid business trips and more flexible working hours, and people's awareness of their tourism opportunities.

The size and location of the population directly determines the volume of the consumer tourism sector. Thus, the growth of population in the world as a whole and its individual regions directly determine the number of tourists. Demographic factors such as the growth of the world's population, its uneven density and concentration in large cities (urbanization) lead to an increase in tourism potential, increased tourist flows. Moreover, age, sex, marriage and family structure of the population are significant factors in the development of the tourism industry. It means that there is a clear trend that tourist mobility depends on the

age, gender and marital status of the population. For example, persons aged 18-30 are most inclined to active form of tourism. Similarly, unmarried people are significantly more mobile than married people, and women are more interested in tourism than men. Likewise, increase in life expectancy and changes in the demographic movement made it possible for older people, who have financial means, to adopt tourism. Hence, socio-demographic changes are directly linked to the sustainable development of the region in particular context of tourism.

Conclusions

In recent years, the demographic problems come first if we talk about socio-economic development of a region. Currently, the fall of the certain demographic characteristics of a population is an obvious fact. Demographic trends have become persistently negative with long-term consequences. They are manifested in low life expectancy, high mortality (especially of working age), rapidly ageing population, and so on. As a result, the current demographic situation reduces the pace and quality of economic growth and complicates the transition to intensive forms of economic development. This trend may provoke shortage of labour and poor quality of labour productivity, limit wage growth, and, consequently, reduce the income of the working population. One of the most worrying trends in demographic change is the high mortality rate, especially of people of working age (especially males). Since the demographic factors play crucial role in providing the region with labour resources, the public policy in Carpathian Euroregion should be aimed at enhancing social development, reviving the family and serving the interests of people. It is impossible to solve these problems without overcoming poverty, income growth, improving the welfare of the entire population and reforming the labour market. These are the reasons of migration processes and uncongenial behavior of the individuals. Additionally, solution of demographic problems should be based not on quantitative but on qualitative parameters, and the main efforts should be aimed at resolving issues related to population reproduction, social protection, environmental situation, healthy lifestyle, access to quality medical education and sociocultural development.

Demographic factors, together with socio-economic, material and technical and political are dynamic factors of the development. Various socio-demographic groups of the population tend to give priority to certain types of tourism. The processes happening in the demographic environment determine the flow of tourists when more and more people have a desire and opportunity to travel. Features of development and interaction of the tourism components, on the one hand, depend on several factors including natural, cultural, demographic, social, economic, etc., whereas, on the other hand, they affect the regional development and its individual components.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*
Conceived and designed the research or analysis	Yes	Yes	No
Collected the data	No	Yes	No
Contributed to data analysis & interpretation	Yes	Yes	Yes
Wrote the article/paper	Yes	Yes	Yes
Critical revision of the article/paper	Yes	No	No
Editing of the article/paper	No	Yes	Yes
Supervision	Yes	Yes	Yes
Project Administration	Yes	Yes	No
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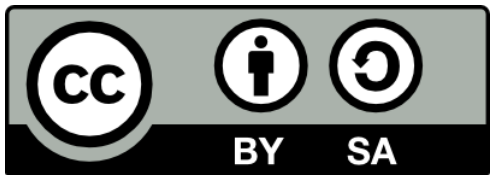

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