CEJGSD

CENTRAL EUROPEAN JOURNAL OF GEOGRAPHY AND SUSTAINABLE DEVELOPMENT

ISSN 2668-4322
ISSN-L 2668-4322 www.cejgsd.org Vol. 6, No. 2, 2024

Petroleum-Gas University of Ploiesti

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Open access international scientific journal for theory, research and practice of geography, sustainable development and related disciplines

Central European Journal of Geography and Sustainable Development (CEJGSD)
Volume 6, Issue 2, 2024

This journal is available online:
https://cejgsd.org/

ISSN 2668-4322
ISSN-L 2668-4322

DOI: 10.47246/CEJGSD

Official e-mail: office@cejgsd.org

Periodicity: Twice a year in June and December

This journal is available online: www.cejgsd.org

Instructions for authors can be found online at: https://cejgsd.org/instructions-for-authors

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Petroleum-Gas University of Ploieşti
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Tel: +40 728 858 022
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Publisher:
Ptroleum-Gas University of Ploieşti, 39 Bucharest Avenue, Ploieşti, www.upg-ploiesti.ro
Postal address: 39 Bucharest Avenue, Ploieşti 100680

Starting from 2023, CEJGSD will be published under the auspices and with the support received from Petroleum-Gas University of Ploieşti - Faculty of Economic Sciences.

December 2024
Volume 6, Issue 2

DOI: 10.47246/CEJGSD.2024.6.1
Printed in Romania

www.cejgsd.org

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ISSN 2668-4322, ISSN-L 2668-4322
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https://doi.org/10.47246/CEJGSD.2024.6.2.1

Strengthening resilience: the role of institutions in facilitating local agricultural adaptation to the impact of climate change in Tanzania

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Received: 17 July 2024; Revised: 4 November 2024; Accepted: 7 November 2024;
Published online: 11 November 2024

ABSTRACT: Building resilience in areas susceptible to climatic hazards is widely recognised as a critical strategy. This article offers valuable insights into the contribution of institutions to supporting smallholder farmers in building resilience against the effects of climate change. Data for this article was collected from Manzase and Haneti villages in Chamwino district in Dodoma region, Tanzania. The study adopted a qualitative approach and deployed key informant interviews and focus group discussions for data collection. The result showed that institutions that operate in the villages under study which include agricultural extension agencies, Non-Governmental organisations, private companies and village governments, have played such roles as providing drought-resistant seeds, disseminating seasonal weather forecast information and supporting the establishment of income diversification activities to farmers. Furthermore, the institution facilitated agroforestry farming through natural tree regeneration and ensured access to crop markets and loans for farm inputs. These roles have contributed to reducing crop loss due to drought and rainfall unreliability, enhanced household income, and allowed households access to food during drought-induced crop failure. The study also revealed that institutional linkages are crucial in comprehensively addressing challenges faced by smallholder farmers, thereby building their livelihood resilience. This paper argues that strong institutional support is essential for farmers to build resilience against climate change.

KEYWORDS: adaptation, resilience, climate change, food security, Tanzania

TO CITE THIS ARTICLE: Chetto, R., Mdemu, M., & Kihila, J. (2024). Strengthening resilience: the role of institutions in facilitating local agricultural adaptation to the impact of climate change in Tanzania. *Central European Journal of Geography and Sustainable Development*, *6*(2),5-22.
https://doi.org/10.47246/CEJGSD.2024.6.2.1

1. INTRODUCTION

Building resilience is increasingly recognised as a critical strategy in many developing regions vulnerable to natural hazards. This is particularly important because rain-fed farming and livestock keeping are the primary sources of livelihood, but are severely affected by frequent climatic hazards. Sub-Saharan Africa (SSA) is one of the most vulnerable regions to the impact of climate change (Bedeke,2023). This vulnerability is caused by several factors which include: weak institutional capacity to coordinate farmers' response to hazards, high crop sensitivity to changes in weather patterns and limited access to resources and water management technology (Mwamfupe, 2019). Projections in SSA indicate that extreme events such as drought will continue to happen frequently and the growth and development of crop pests and weeds will accelerate (Schneider et al., 2022). These climate-related effects will disrupt crop production and aggravate rural poverty in already vulnerable resource-dependent communities. Thus adaptation measures in such areas are important and in order to reduce vulnerabilities and enhance the resilience of smallholder farmers.

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In Tanzania, vulnerability to climate change impacts is caused by dependency on climate-sensitive livelihood activities such as rain-fed farming and limited financial resources to manage hazards such as droughts. From the 1980s to the 2020s, the country has experienced an increasing frequency of droughts and floods which affect different sectors, mostly farming and livestock keeping (Mabhuye, 2024). Food insecurity due to crop failure and deaths of livestock caused by severe drought have been the major results (Borhara et al., 2020).

The National Climate Change Strategy (NCCS), the Environmental Management Act of 2004 and the National Adaptation Plan of Action (NAPA) are policy frameworks for responding to climate change in Tanzania (Mwamfupe, 2019). The NCCS is a blueprint for promoting, prioritising, and implementing adaptation across various sectors nationwide. However, its success in promoting adaptation and resilience building relies on the actions of local actors in the lower levels of administration, such as local governments and other institutions, to mainstream adaptation in their development, planning and implementation (URT, 2021).

Considering the importance of local institutions in building climate change resilience, research interest in their roles has been increasing (Hovelsrud et al., 2012). The interest is motivated by the following reasons: Firstly, resilience is fundamentally a local concern since vulnerabilities are felt at this level, and the actions to fortify them are implemented at the local level (Intergovernmental Panel on Climate Change (IPCC), (2007). It is, thus, crucial to understand the local institution's roles in order to help build the resilience of vulnerable social groups such as smallholder farmers with limited resources. Secondly, local institutions are often well acquainted with the local environment and practices that have sustained the vulnerable communities for many years (Nalau et al., 2018). Thirdly, climate change adaptation and resilience building are not merely environmental questions; rather, they are challenges embedded in the community's social and economic dimensions. Understanding how local institutions navigate social and economic issues related to climate change is crucial for enhancing adaptation (Ayers, 2010). Furthermore, it is also argued that enhancing ownership of adaptation strategies and ensuring that local-level vulnerabilities are addressed requires an understanding of the role of local institutions as a crucial entry point for adaptation planning (Omukuti, 2020).

Local institutions significantly influence the livelihood activities of smallholder farmers through their roles. However, there is a lack of understanding about how these institutions contribute to the resilience of local smallholder farmers. This paper aims to bridge this gap by identifying local-level institutions that empower communities and describing their roles in climate change adaptation and resilience-building. The paper employs a qualitative approach, using information collected from interviews and focus group discussions.

The paper contributes significantly to the existing research since it sheds light on a topic largely overlooked in previous studies. By focusing on the role of institutions, the paper adds a new dimension to the existing body of research on adaptation to the impact of climate change within economically and environmentally vulnerable semi-arid areas. Previous studies have explored the contribution of livelihood strategies such as migration and tillage practices in facilitating adaptation to the effects of climate change (Afifi et al., 2013; Shemdoe et al., 2009). However, they have not delved into the role of institutions in building resilience to climate change. Understanding the role of institutions is crucial for informing policy on adaptation and resilience-building efforts at the local level. The rest of the paper is organised as follows: Section 2 is the literature review that describes concepts and how they are used in this study, followed by the empirical literature on local-level institutions' roles, and finally, the conceptual framework. Section 3 presents the methodological approaches, section 4 presents the results briefly, and Section 5 presents the discussion that interprets the results and links them with adaptation and resilience. The last section presents the conclusion and recommendations.

2. LITERATURE REVIEW

2.1. Local institutions

As opined by Uphoff & Buck (2006), local institutions are established or designed by local communities or external entities that work with the local community to organise their collective action to

achieve defined goals. These institutions may be formal entities with predefined written rules or informally organised entities composed of norms and voluntary codes of conduct that guide member interaction (Banerjee et al., 2012). Be they formal or informal institutions, their rules and enforcement mechanisms are critical in shaping how society functions. Furthermore, local Institutions can be classified as public, private, or civic depending on how they are governed and the motives for their existence (Agrawal, 2008). Public institutions typically operate under the government bureaucracy, while private institutions are individually owned and driven by profit motives. Civic ones include Non-governmental or hybrid organisations such as farmers' cooperatives (Agrawal, 2008). This paper focuses on institutions as formal organisations rather than uncodified customs or traditions. In the context of climate change, such institutions are deemed as drivers of change that also influence the adaptive capacity of communities and households (Agrawal, 2008). They are described as vehicles and enablers of livelihood resilience, reducing vulnerability and maintaining sustainable livelihoods (Smit & Wandel, 2006).

2.2. Resilience

The concept of resilience encompasses diverse interpretations. The meanings vary based on the field of study, purpose, and context. It has roots in socio-ecological theory but its usage has been adapted in many disciplines such as engineering, agriculture and climate change. Initially, resilience described the capacity of materials to return to their normal situation or equilibrium after a displacement (Norris et al., 2008). In that case, materials are considered resilient if they can be bent and bounce back rather than break when stressed (Bodin & Wiman, 2004). In the context of climate change, resilience is the ability of systems, people or organisations to absorb shocks, recover from them and maintain their functions. From these definitions: ability of material, people or organisations to “return to normal” or “recover” after being stressed has featured repeatedly. This view has also been echoed by the IPCC (2007), which defined resilience as the ability of social or ecological systems to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation and the capacity to adapt to stress and change.

Resilience in the context of climate change has been closely related to adaptation (Smit & Wandel, 2006; Nyamwanza, 2012) and is often used together with adaptation. Supporting this view, Paavola (2008) and Tompkins & Adger (2005) have argued that resilience and adaptation can interchangeably refer to the ability of actors to shield themselves and recover from adverse climate change impacts. Despite the prominent characterisation of resilience as the ability to recover and return to normal from the adverse impact of climate change, critics have argued that resilience building should not merely seek to return to basic structure or recover from stress. Instead, resilience building should create pathways for improving lives beyond pre-disruptive conditions (Dodman et al., 2012). This is especially true in most rural communities in developing countries such as Tanzania, where returning to normal or recovering from shock may still be undesirable as it may mean enduring poverty. Even before livelihood disruption by climate change impacts such as frequent droughts and rainfall variability, most rural farmers produced for subsistence and had low incomes. They could barely meet the basic needs for food and other necessities. Therefore, in exploring the role of institutions in building resilience against climate change effects, this paper adapts an approach to resilience, focusing on coping with added shocks and addressing challenges that constrain smallholder farmers' livelihoods (Dodman et al., 2012). Addressing challenges faced by rural communities such as limited access to adequate food and income, makes the households resilient and more capable of dealing with shocks, including those that emanate from the effects of climate change.

2.3. Roles of institutions in resilience building

Literature indicates that various institutions, such as agricultural extension agencies, non-governmental organisations, and private firms, have played significant roles in enhancing adaptation and building resilience against the effects of climate change. These roles include climate change risk reduction, such as disseminating weather and climate information and facilitating technology transfer by enabling

the adoption of drought-resistant seeds and innovative farming practices. Other roles include supporting income diversification activities and enhancing access to crop markets and credit.

With regard to technology, institutions have facilitated the development and adoption of improved seeds. In semi-arid areas, the common ones include drought-tolerant sorghum, millet, and groundnut seeds. Such varieties are crucial in managing frequent droughts (Shiferaw et al., 2014; Morahanye, 2020). They provide decent harvests under conditions of reduced rainfall (ibid). Some improved sorghum varieties perform better in water-stressed environments than in well-watered conditions (Mwamahonje et al., 2021), thus allowing farmers to have stable crops during drought. This scenario ensures the availability of stable food and income sources. While research institutions develop the seeds, non-governmental organisations and agricultural extension agencies, have disseminated the improved seed to farmers (Islam & Nusrey-Bray, 2017). Drought-tolerant varieties ensure farmers are resilient to drought and rainfall variability.

Institutions also catalyse farming practices crucial for climate mitigation and adaptation. Community-based organisations (CBOs) and Non-governmental organisations (NGOs) implement agroforestry practices such as agro silviculture that involve the integration of trees and shrubs on cropland. They do this by providing funds and disseminating knowledge on the practice to farmers at the local level (Bettles et al., 2021; Blanco, 2006). Agroforestry practices benefit ecosystem services, such as soil enrichment, climate mitigation through carbon storage and livelihood diversification through the sale of wood or timber. These benefits reduce vulnerability by providing alternative income and enhancing resilience to climatic hazards such as drought (Awazi, 2022).

Concerning weather and climate information, institutions such as agricultural extension agencies and Non-governmental organisations provide farmers with forecasts on meteorological parameters including temperature, precipitation and drought conditions (Maponya & Mpandeli, 2013; Ozor, 2011). This information is an essential tool for adaptation as it enables farmers to make informed decisions about crop varieties and planting dates. Kumar et al. (2020) argued that two weeks' advance information could reduce crop damage by 60 to 80 percent during harvest. However, two challenges inhibit the potential for climate information in adaptation and resilience building against the effects of climate change. The two challenges are: firstly, capacity of local institutions to produce reliable rainfall forecasts, and secondly, the challenges regarding the efficient use of climate and weather information among small-scale farmers.

To reduce dependency on traditional crops prone to drought, Institutions have facilitated the diversification of income-generating activities by introducing backyard horticultural gardens and keeping small ruminants as an alternative to traditional crops such as maize (Kuhl, 2018). Such activities provide an alternative source of income and a buffer against climate-related risks. Institutions also support farmers' access to farm implements, credit and ready-crop markets. Access to markets allows farmers to sell their crops and earn income that can be used to invest in climate-smart technologies such as drip irrigation and improved seeds. These innovations help mitigate the impact of climate change on agriculture (Agrawal, 2008). Credit from financial institutions and access to farm implements such as tools and machinery improve efficiency and overall yield, increasing income that can be invested in technologies to mitigate climate risks (Feyisa, 2017).

To effectively address the challenges of climate change, literature shows that it is critical to establish linkages between various institutions (Robinson et al., 2018). These institutions include government agencies, research organisations, non-governmental organisations, and community groups. Through collaborating and sharing resources and expertise, these institutions can work together to improve and implement climate change resilience-building strategies. The collaborative approach ensures a comprehensive response to climate change, considering diverse perspectives and leveraging the strengths of each institution (Wilby, 2020). Collaboration also helps to evade duplicate efforts and create efficient use of resources, leading to effective outcomes in building climate resilience.

2.4. Conceptual framework

The following conceptual framework (Figure 1) provides a structured approach to analysing the role of local institutions in building resilience to climate change effects. This framework was developed

based on a literature review on institutions and climate change adaptation. The components of the framework represent the themes this study sought to address. The framework has the following components: existing institutions, roles of institutions, institutional linkages and resilience building. The last component, resilience building, is a cross-cutting theme embedded in the discussions on the role of institutions and their linkages.

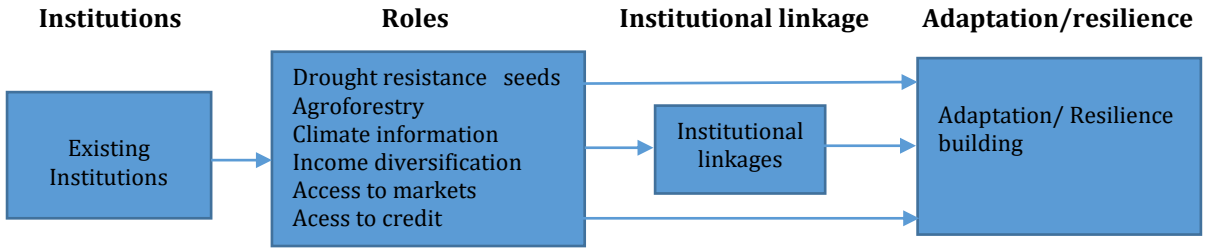

Figure 1. Conceptual framework on institutions for resilience building to climate change effects and variability.
Source: Authors construct based on review of literature.

3. RESEARCH METHODS

3.1. Study area description

This study was conducted in Chamwino district of Dodoma region in Tanzania (Figure 2). The district is situated within the semi-arid central plateau at latitude 6° 15′ South and longitude 35° 42′ East.

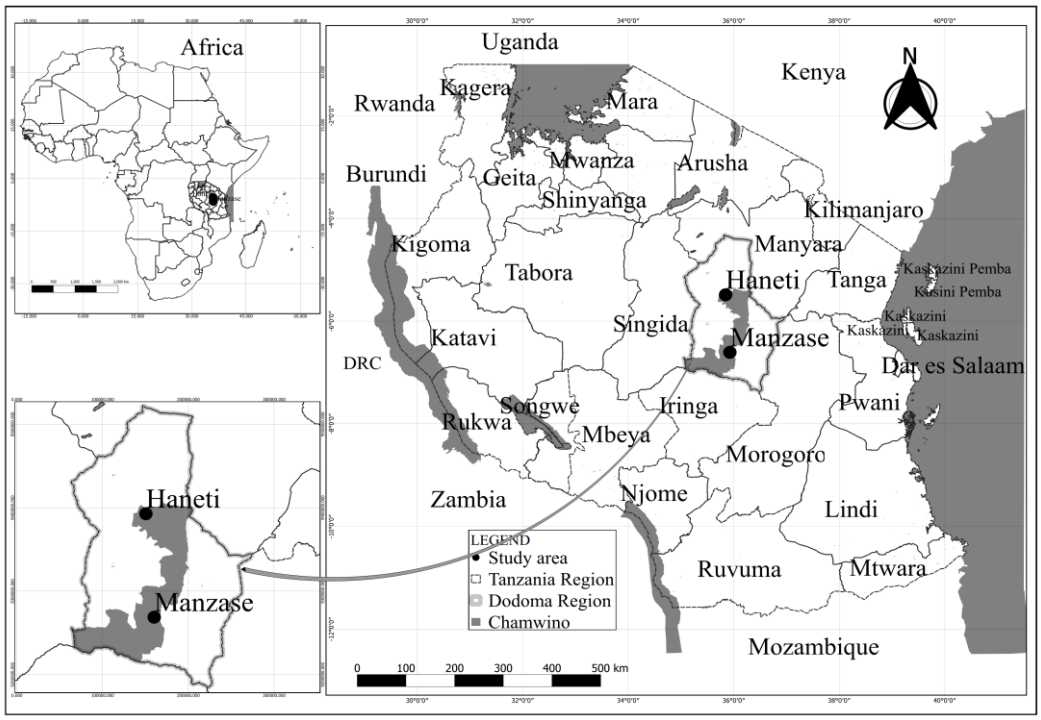

Figure 2. Study villages in the Chamwino district.
Source: Ardhi University GIS Lab (2024).

Chamwino experiences a semi-arid climate characterised by a long dry and a single wet season from late December to mid-April (Mdemu, 2021). Rainfall is scarce and unpredictable, with an annual average of 400 to 500 mm. Temperatures are relatively high, typically ranging from 20°C to 30°C, though they can rise to 35°C during peak heat periods. The district is part of the larger savanna landscape, dominated by baobab trees and dry land shrubs. A few seasonal rivers and streams flow during the rainy season but permanent rivers are scarce (Kahimba et al., 2015).

The primary economic activities for about (80%) of the district's inhabitants are smallholder rain-fed farming and livestock keeping (DED, 2020). The main food crops grown include millet, sorghum, and maize to some extent. Crops such as sunflowers and groundnuts are grown for household consumption and markets. Livestock reared include cattle, chickens, goats, and pigs. Although agriculture is the primary source of food and livelihood, the ongoing climatic-related challenges, such as frequent droughts and crop and livestock diseases, have challenged the livelihood sustainability of the district's inhabitants. Frequent droughts in the district worsen crop loss and the depletion of water resources. This situation leads to the recurring problem of food insecurity (Mdemu, 2021). Lack of sufficient food in the district is also associated with higher levels of malnutrition, as attested by a higher prevalence of stunting (44.3%) compared to the national average of 34%, (Makori et al., 2018). Other challenges facing the agriculture sector that constrain farm enterprises' productivity and profitability include unstable market for farm produce, environmental degradation, and inadequate farm implements and inputs (DED, 2020). Other economic activities apart from farming include informal trades such as petty trading in local markets and the sale of handmade products. Households also engage in other off-farm income-generating activities such as charcoal burning, local brew making, and labour selling to well-off farmers within or outside the district. Regarding water and sanitation, 61% have access to clean water, while 45% have no toilet facilities, and the literacy rate is 89% (DED, 2020).

3.2. Study design and approach

This study employed a qualitative approach to explore the role of local institutions in enhancing household resilience to the effects of climate change. Exploring facts on the roles of institutions is better done using a qualitative approach. This is because it can yield in-depth data and more nuanced information regarding the contribution of institutions in climate change adaptation and resilience building. Similar studies on institutions and climate change adaptation have also tended to use a qualitative approach (Mubaya & Mafongonya, 2017; Baudoin, 2014). This is because it captures the complexities embedded in the local area's social, cultural, and economic conditions and how such conditions affect the roles of institutions.

This research employed a multi-stage sampling technique to select the study region, district, and villages. The first step involved selecting regions most affected by drought. Dodoma is selected to represent regions that experience frequent drought (Mayaya & Kipror, 2015). Chamwino district was selected because it is a drought hotspot, characterised by frequent drought-induced crop failure and food insecurity (Mdemu, 2021; Makori et al., 2018). Study villages were also selected based on drought prevalence and food insecurity. However, drought and food insecurity information was obtained after consultation with village leaders, the district agricultural officer, and extension workers. The consultation process led to selecting two villages i.e Haneti, in the western part of the district, and Manzase, in the southern part. The study institutions were purposely selected based on information gathered during the scoping visit. The institutions were approached, and a representative familiar with the activities of the institutions in the villages was appointed to provide the information needed.

3.3. Data collection and analysis

Key informant interviews and Focus Group Discussions (FGD) were used for data collection. Respondents to the interviews were representatives of the institutions that operate in the villages. These institutions play various roles, including those contributing to enhancing adaptation and resilience in the face of climate change effects and variability. The institutions were identified after consultation with the district agricultural development officer during the scoping visit to the district in February 2023. The village leaders and farmers also confirmed the existence of the institutions during interviews and FGDs, respectively. Interview questions aimed to gather information on the roles of institutions in enhancing adaptation and resilience building, as well as their linkages with other institutions. The researcher conducted face-to-face and phone interviews with the representatives of the institutions, each lasting approximately 30 minutes. A total of 6 interviews were undertaken one with representatives of each

institution. These representatives were directly involved in project activities in the villages, making them more knowledgeable and qualified for interviews than others within the institutions.

On the other hand, the FGDs were facilitated by the researcher with the help of two assistants who made arrangements for the meeting and recorded the conversations. One of the assistants was the native speaker of the local language of the inhabitants in the study villages. This ensured that in case of a language barrier during the discussions, he could translate from the native language – *Kigogo* - to *Kiswahili*, the national language, and the lingua franca, which most participants understood. Two FGDs were conducted, one in Manzase and another in Haneti. The two FGDs were sufficient to generate the information needed since they were meant to triangulate the information collected from interviews with representatives of institutions. The FGD was composed of 9 to 10 adults and elders. These participants were considered to have the required information since they had stayed in the village for many years and were, therefore, aware of the environmental and socioeconomic conditions of the villages.

Data collected was analysed using the content analysis method. The following steps were followed to perform the analysis. Firstly, the recorded interviews and focus group discussions were transcribed to ensure that details were accurately captured. Secondly, the transcripts were verified by listening to the audio once more and making necessary corrections. Thirdly, data familiarization was conducted through re-reading the transcripts. Fourthly, codes in short phrases that emerged from the transcriptions were created. Similar codes were grouped to form themes examined for consistency with the study objective (Table 1). The table presents short phrases representing codes that emerged from interviews with representatives of institutions. These codes were combined to form broader themes presented as institutions' roles in enhancing adaptation to climate change effects. The final steps were detailed reporting on the themes.

Table 1. List of codes and themes grouping.

Codes	Themes
Use of hybrid sorghum varieties	Drought resistant seeds
Adapting fast-maturing crops	
Sunflower seeds distribution	
Keeping dairy goats	Alternative income-generating activities
Selling milk in local markets	
Vegetable production and selling	
Formation of farmer's groups	Access to markets
Direct purchase from farmers	
Crop Purchase contract	
Integration of trees with crops	Agroforestry and tree planting
Use of trees for soil conservation	
Training on tree regeneration	
Communication with banks	Access to credit
Contract farming as collateral	
Financial management training	
Sharing weather information	Weather and climate information
Education on timely planting	
Planning and preparedness	
Collaborating with NGOs	Institutional collaboration
Partnering with village government	
Engaging agricultural extension workers	

Source: Author's analysis

4. RESULTS

4.1. Existing institutions and their coordination mechanisms

Institutions that operate within the study villages to facilitate activities that build resilience to the impact of climate change were identified. Among these, two public institutions were identified: The

Agriculture Extension Agency, which falls under the Ministry of Regional Administration and Local Government, and the village government. The village extension workers represent the extension agency at the village level and are responsible for promoting and disseminating best practices and technology for farming and livestock keeping. The extension workers work closely with the Village Executive Officer (VEO) who acts as their immediate supervisor. However, extension workers receive guidelines and report to the district agricultural officer for technical aspects of extension work. The study villages have three extension workers: one in Manzase and two in Haneti. On the other hand, the village government is responsible for local governance and community development affairs and is headed by an elected chairperson. At the same time, the village executive officer (VEO) is a local government-appointed officer in charge of the village's administrative affairs and reports to the ward executive officer (WEO).

The private companies include Tanzania Breweries Limited (TBL), which implements a sorghum project in Manzase village. Three non-governmental organisations (NGOs), one in Manzase and two in Haneti (see Tables 2 and 3), were identified. These institutions (TBL, LVIA, and Farm Africa) primarily work with farmers who are organized into groups. Leaders of these groups are selected democratically from among the farmers. These institutions do not maintain permanent staff or offices in the villages. Instead, village extension workers are usually trained for specific projects, monitoring the group's activities. They report to the project officers of the respective institutions. While these institutions contribute to strengthening resilience against the impact of climate change and variability through their roles, it is important to note that their roles extend beyond the resilience-building focus. They also serve broader purposes linked to overall development and addressing challenges that smallholder farmers face, including poverty and food insecurity.

Table 2. Institutions in Manzase village.

Institution	Category
Village government	Public
Agricultural extension agency	Public
Tanzania Breweries Limited	Private
The LEAD Foundation	NGO

Source: Focus group discussion (March 2024).

Table 3. Institutions in Haneti village.

Institution	Category
Village government	Public
Agricultural extension agency	Public
Farm Africa	NGO
LVIA (Lay Volunteers International Association)	NGO

Source: Focus group discussions in Haneti (March 2024).

4.2. Institutions roles

4.2.1. Provision of drought-resistant seeds

The result shows that three institutions, Tanzania Breweries Limited (TBL), Farm Africa, and Agricultural Extension Agency, supported farmers with drought-resistant sorghum and sunflower seeds. The seed support is given as a loan to interested farmers from the TBL and Farm Africa. To ensure that farmers manage the crops properly, these institutions also provide sorghum management protocol and agricultural extension services to farmers. The seed loan agreement requires borrowers to repay in kind using part of the crops harvested or in cash after the sale of the crop. Although farmers utilise the seeds due to their drought-resistant capabilities, some are dissatisfied with the seed loan conditions, as one FGD participant narrated:

> We get drought-tolerant seeds from TBL; they are very useful because they produce high yield. However, there is one challenge: if the harvest is not good, you still have to pay back the amount of seeds you agreed upon. This is why some people hesitate to enter into a seeds borrowing agreement (FGD participant Manzase).

The village extension worker in Haneti also reported that some farmers were sceptical about the seed loan program, suspecting that the company providing the seeds had an undisclosed agenda. Despite

this challenge, the TBL representative in Manzase village noted that approximately 141 farmers out of 269 had borrowed the seeds. Meanwhile, in Haneti village, 70 farmers out of 234 received sunflower seeds from Farm Africa. The agricultural extension agency also distributes improved sunflower seeds from the Tanzania Agricultural Seeds Agency (ASA). To make them more affordable, these seeds are offered at a subsidised price of Tanzania shillings (Tsh) 3500 per kilogram, compared to market prices of Tsh 6000 per kilogram.

4.2.2. Agroforestry and tree planting

Concerning agroforestry and tree planting, the results show that The LEAD Foundation in Manzase village implements an agroforestry project called Farmer-Managed Natural Regeneration (FMNR), locally known as *kisiki hai* (Living stump). Explaining how the agroforestry project is implemented, the NGO representative narrated that:

> We have trained community-based leaders who go door to door to raise awareness of the importance of regenerating trees. We have established a farmer field school to demonstrate the steps in regenerating tree stumps. We encourage farmers to regenerate at least 20 trees per hectare of land.

In explaining the project's success, the respondent explained that about 254 households have regenerated trees in their farms, while 14,284 tree stumps have been regenerated in the villages. To ensure the survival of regenerated trees, the species chosen are native to the area thus making them suitable for the semi-arid ecological conditions. The FMNR, therefore, does not plant new trees. The project has been very successful because it is cost-effective, as hardly any expensive inputs are required. The tree stumps do not need to be irrigated; they grow relatively faster than if the trees were planted afresh and are normally ready for harvesting in one to three years. All that farmers are required to do is to prune the suckers that emerge from the tree stump and allow a few to grow into mature trees. The village governments in Manzase and Haneti encourage tree planting through the environmental committee while enforcing bylaws to prevent indiscriminate tree felling. One by-law prohibits cutting down large trees in the village's reserve land. Those caught felling such trees are fined Tanzanian shilling (Tsh) 50,000 or approximately ($20) and are required to replace each tree by planting at least one new one.

4.2.3. Weather and climate information sharing

The agricultural extension agency disseminates information on seasonal weather outlook, including rainfall onset and cessation, to farmers in both villages. Interviews with extension workers revealed that dissemination is done in village meetings. A meeting is held before the planting season, around November of every year, to communicate information on forecasted seasonal rainfall. The major challenge, however, is turnout in such meetings:

> Turnout to meetings at the beginning of the season is usually very low. To ensure we reach many farmers, we use other opportunities, such as political meetings convened by leaders such as ward councillors, to discuss issues of seasonal weather outlook and provide appropriate advice on planting dates and seeds required (Extension officer, Haneti).

However, it was reported that localised weather information for the district is often unavailable. In most cases, agricultural extension workers rely on general weather forecasts from the Tanzania Meteorological Agency (TMA) to advise farmers on which crops to grow, when to plant and what seeds to use. Farmers also use other media outlets, such as television and radio, to get information on short-term and daily weather advisories.

4.2.4. Alternative income-generating activities

The result of this study indicates that two institutions, Farm Africa and Lay Volunteers International Agency (LVIA), have supported farmers with dairy goats and horticultural seeds. Explaining the purpose of the dairy goat support, the Haneti village agricultural extension officer revealed that the project aims to provide low-income households with an alternative source of income and enhance their nutrition through milk consumption. Households are given one goat, an exotic breed that produces 1.5 to

3 litres of milk per day. He further reported that 25 households in the ward, five in each hamlet, benefited from the dairy goat project. However, the dairy project was still new, and many beneficiaries had not reaped the benefits since the goats had not yet given birth. One beneficiary, who started milking his goat, commented in the following way:

> I milk about one litre per day, which helps me sell the milk and earn a little money for household expenses. The income would be higher if the goat produced more milk (FGD participant Haneti).

Another intervention aimed at supporting households in earning a supplementary income is the LVIA horticultural project. According to the NGO representative in Haneti village, the support aims to help farmers produce African Indigenous Vegetables (AIV) through farm and backyard gardens. He further revealed that the seed support focuses on local varieties such as okra, sweet potato leaves locally known as *matembele*, black nightshade (*mnafu*), and fortified potatoes (*viazi lishe*). A total of 15 households received the seeds, and one group of producers received a solar-powered water pump to irrigate the farm gardens—however, many who grow the AIV as backyard gardens often use hand watering with buckets.

4.2.5. Enhanced access to the market

Tanzania Breweries Limited engages in contract farming with sorghum farmers in Manzase village, providing market assurance for the crop. The contract stipulates the support the TBL will provide, which includes drought-resistant seeds, agricultural extension services, and the purchase of sorghum. Regarding markets for sorghum, interviews conducted with the sorghum project field officer revealed that the market for sorghum grown under the TBL contract is guaranteed to all farmers. This point was echoed by a participant during FGD with the following statement:

> When you have a contract with TBL, you know your sorghum has a reliable market, and their price is also fair. They also buy it on time, and you do not need to wait long before you get a buyer (FGD participant Mazase).

The interview further revealed that the market price for sorghum before the commencement of the project in 2019 was about Tanzania shillings (Tshs) 250 to 300 per kilogram. However, the company bought sorghum for Tshs 550, guaranteeing steady income to farmers. To further ensure that farmers receive fair prices for their crops, the company eliminated the middlemen who often exploited farmers by purchasing sorghum at lower prices, as many farmers are typically uninformed of prevailing market prices. To achieve this, the company established sorghum purchase centres in the villages, allowing farmers to bring their crops directly.

4.2.6. Access to credit

Farmers accessed loans from banks using the contract they signed with TBL as collateral. These loans were used to hire farms for landless farmers and those wishing to cultivate more sorghum, rent tractors for cultivation, cover weeding costs and facilitate access to agricultural inputs such as pesticides and fertiliser. For the 2022 season, one farmer's group called Juhudi received a loan of Tanzanian shillings (Tsh) 30 million (USD 15000), allowing every member to get about Tsh 500,000 (USD 250). However, access to credit by farmers has not always been easy as narrated by a participant during FGD:

> Even for those in groups, sometimes getting loans from banks becomes difficult. For instance, last year, we did not get the loan we applied for because they said that some groups of farmers could not repay the loan on time, complaining that the harvest was not good (FGD participant Manzase).

The company also offers financial management training where farmers learn, how to make informed decisions about their loans and income earned after the sale of crops. They also learn record keeping and how to manage financial risks related to farming. Additionally, they are connected with wholesale agro-dealers to procure inputs as a group.

4.3. Institutional linkages

Institutions in the study villages interact with each other in their various roles. Interviews with the agricultural extension workers in Manzase and Haneti villages and the village government chairpersons

revealed that the village government has ties with all institutions operating in the villages. This is because of its role in the governance of the village affairs which requires every other institution from within or outside the village to report to the village government for clearance. The village government also provides the necessary support to facilitate institution entry and trust by the community members. On the other hand, the village agricultural extension agency handles matters related to land, agriculture, and the environment. Therefore, institutions that deal with these aspects are connected with the village extension agency.

Regarding the linkage between private companies and non-governmental organisations, it was found that the linkage mainly was in implementing their activities. The TBL, for example, collaborated with Farm Africa to implement a sorghum project. While Farm Africa dealt with sorghum production at the farm level by providing extension services, the TBL mainly focused on seed provision and the sorghum market. It was further discovered that Farm Africa implemented the project on behalf of the World Food Program (WFP) as the project's financier. As hinted earlier, the TBL also helped groups of farmers secure loans from banks through the contracts entered between them. These institutions, the village community, and individual households also maintain certain levels of linkages in their activities. The agricultural extension agency engages with the community during village general meetings and through farm visits. The representatives of the NGO also interact with households in their roles, including creating awareness of their various roles.

5. DISCUSSION

5.1. Drought-resistant seeds

This study has revealed that several institutions provide seeds with drought-resistant capabilities. It has also shown that the acceptance rate among farmers is high, indicating that they are widely used. This suggests that the seeds effectively reduce risks associated with unreliable rainfall or drought. These seeds are specifically developed for semi-arid areas that experience water-stressing conditions and are considered climate-smart crops because they can tolerate intense heat and drought (Chaturvedi et al., 2022). They feature shorter growth circles, maturing within a relatively short time of about 85 to 120 days. Farmers can sustain steady yields despite unreliable rainfall by planting drought-resistant crops, reducing crop failure and food insecurity risks.

Empirical studies by Phiri et al. (2021) and Hadebe et al. (2017) also demonstrated that these crops improve food security and income due to their flourishing ability with limited rainfall. Utilising drought-resistant seeds, therefore, constitutes an essential adaptation since using them reduces sensitivity to drought and guarantees a harvest regardless of the prevailing weather conditions in a particular season (Gitz & Meybeck, 2012; Phiri et al., 2021). Important policy frameworks for adaptation in Tanzania, such as the National Adaptation Plan of Action (NAPA) and the National Climate Change Strategy (NCCS), also promote the use of drought-tolerant seeds as an important adaptation to drought and rainfall unreliability.

Despite these benefits, some farmers were sceptical about using the seeds. Ayamaga (2018) also reported such scepticism, noting farmers' concern over the cost of acquiring these seeds and the fear of becoming dependent on seed supply from the companies instead of the traditional methods. Additionally, to reap the full benefits of improved seeds, some institutional arrangements, such as access to loans for farm inputs, remain challenging for most smallholder farmers in Africa (Beumer & Swart, 2021). This fuels the scepticism some farmers have about using the seeds.

5.2. Agroforestry and tree planting

The agroforestry farming system, as spearheaded by the LEAD Foundation, has been very successful in the village as most farmers have participated in regenerating tree stumps within their farms. Manzase village was named the second most successful in restoring degraded land into an established and sustainable landscape through the *Kisiki hai* initiative. This suggests that the system is advantageous, a reason for widest acceptance. The system offers a range of environmental benefits such as soil quality

enhancement, helping infiltrate rainwater and reducing local temperature. It also provides an opportunity for livelihood diversification through using the trees harvested for charcoal and wood for sale.

Similar benefits of agroforestry have also been reported in studies by Behnassi et al. (2021) and Arakelyan (2017), who claimed that integrating crops with trees helps diversify income, preventing soil erosion and improving livelihood through increasing farm yield. These benefits are crucial for adaptation to climate change effects such as drought. For example, through increased yield and income, a farmer can use income to maintain food security during drought-induced crop failure. Based on the affordability of managing the tree stumps, the FMNR is potentially a sustainable initiative that can restore the productivity of degraded land in semi-arid ecological zones that have also been affected by severe land degradation and soil erosion due to unsustainable farming methods.

5.3. Weather and climate information sharing

Weather and climate information that the agricultural extension agency provides is crucial in shaping short and long-term farmer adaptive actions. Based on seasonal rainfall forecasts, farmers are advised to adjust planting dates appropriately and use the seeds as recommended. This is especially critical in rainfed systems where the start of the rainy season is important to the timing of rain-fed crops. For example, soil moisture will be inadequate for seed sprouting if a farmer plants too early. If they plant too late, rainfall may wash away the seeds (Reason et al., 2005). It is crucial to deliver accurate seasonal climate forecasts to optimise timing and reduce the risk of crop loss caused by a lack of information on planting dates (Bal et al., 2021; Barihaihi & Mwanzia, 2017).

The agricultural extension agency informs farmers about weather forecast patterns in meetings and delivers information that facilitates decisions on crop choices, utilisation and planting dates. Sharing weather forecast information with farmers has also been highlighted in the Tanzania National Climate Change Strategy (NCCS) as important for climate change adaptation. However, one of the challenges is the capacity of agricultural extension workers to mobilise weather information and disseminate it to farmers. In interviews with agricultural extension workers in Haneti, the issue of a lack of district-localized climate information was raised. Nevertheless, localised weather information is generated periodically and made available on TMA electronic platforms only that the officer was unaware of.

5.4. Alternative income-generating activities

Horticulture and dairy goats provided to low-income households are an essential means by which beneficiaries can widen their livelihood options, contributing to building resilience against the effects of climate change. For example, by rearing goats and producing milk, households can earn an income that helps purchase basic needs, including food, thus reducing dependence on single farm income and spreading risks. The dairy goats in the Farm Africa project are an exotic breed reared under a low-input mixed crop system, making it a potentially sustainable venture for households. Dairy goat products, especially milk, have a niche market that can attract better prices per litre than cow milk. This ensures a good income for farmers. Dairy goats have enabled the concerned households to produce milk, sell it in the local market and earn some income while contributing to livelihood resilience.

Studies have also demonstrated that small-scale goat rearing helps improve food security through milk consumption and income generation through milk selling (Al-Atiyat, 2014). However, the full potential of the dairy goat has not been realised in Haneti village because of challenges related to feeding the dairy goats. The village agricultural extension officer reported that farmers kept the goats under a free-range system instead of zero grazing thus affecting milk production. Conversely, the horticultural project has enabled farmers to grow and sell vegetables and fortified potatoes to increase their incomes. Growing various crops, including horticultural crops, helps farmers spread the risk of extreme events such as drought. The choice of horticultural crops also considers the climatic conditions of the villages. These horticultural crops are resilient to drought and are essential for countering seasonal sources of food availability while also providing an alternative source of income for households. Fortified potatoes have been reported to be helpful in both improving food security and providing additional income for low-income households (Laurie et al., 2015).

5.5. Access to market

Farmers who receive seeds from TBL and Farm Africa have a ready market for sorghum and sunflowers. A ready market for the crops is an opportunity to offset the lack of access to a reliable market, one of the production risks that smallholder rural farmers face. The ready market offered by these institutions provides increased income through the reasonable prices that farmers receive. The TBL, for example, purchases sorghum at higher prices than the market price, allowing farmers to earn a decent income. To further enhance farmers' access to the market, the company buys directly from farmers in its crop collection centres in the village without engaging middlemen. This is another initiative to ensure farmers receive the lion's share of the final crop selling price by eliminating traders who often benefit more than farmers. This market opportunity that the TBL and Farm Africa offer is rarely accessible to small-scale farmers. Most of such opportunities are secured by large-scale farmers, and therefore, it tends to exclude small-scale poor farmers because of their lower bargaining power and lack of information (Kuhl, 2018). The higher income that farmers receive is an opportunity to improve access to food, better preserve assets in the face of shocks, increase their capacity to accumulate assets and smooth consumption during shocks (Kuhl, 2018). All of these factors contribute to household resilience.

5.6. Access to credit

Among smallholder farmers in rural areas in Tanzania, cash income is often deficient for covering the cost of fertiliser, farm tools, or improved seeds. Therefore, credit access is critical since it enables farmers to afford the inputs required to improve farm productivity. In Manzase village, the contracts that farmers entered with TBL were used as collateral for accessing loans from microfinance banks. Those who have used the credit wisely for investment in farm inputs have harvested more and earned an income that is also an important asset that can be used to purchase food in seasons when the harvest is inadequate. To ensure that loans are used wisely, the company offered training on financing management to farmers to help them make informed investment decisions, making farm enterprises profitable. Regarding credit and livelihood resilience, studies have shown that Farmers with access to credit are less vulnerable and more likely to be resilient compared to those without access (Awinda et al., 2021; Batung et al., 2023; Weldegebriel & Amphune, 2017).

5.7. Institutional linkages

This study has demonstrated that institutional collaboration is critical in addressing the challenges faced by small-scale farmers. For instance, the mandatory relations that village governments establish with the institutions operating in the villages play a crucial role in fostering acceptance and trust among community members toward external institutions. This collaboration also gives the community members confidence that their government is actively involved in interventions by external institutions. Berkhout (2012) emphasises the importance of local government in facilitating the activities of actors and institutions. However, the author notes that local government can sometimes be a constraint due to conflicting political and economic interests.

This study also shows that private companies and non-governmental organisations collaborate to address chronic problems small-scale farmers face. The institutional collaboration between TBL, Farm Africa, and financial institutions through seed provision, sorghum production protocol, guaranteed market access, and contractual arrangements that help farmers secure loans for agricultural inputs serve as exemplary cases. These collaborations leverage the expertise and resources of each institution to address farmers' challenges comprehensively. By combining agricultural extension, market access, and financial support, these partnerships create an environment that enables farmers to improve productivity and enhance income and food security, which is crucial for building farmers' adaptive capacity. This, in turn, makes them more resilient to various shocks, including those that emanate from the effects of climate change. Institutional linkages, especially in the context of climate change adaptation, are recognised as critical conduits for delivering the necessary resources for adaptive response to climate change effects (Upton, 2012; Agrawal, 2008).

Institutions' interactions with individual farmers have also been observed. However, farmers' opportunities to interact with the village's extension workers are limited since farm visits are rarely conducted for all farmers. Challenges such as lack of transportation and the inability of farmers to implement recommended practices such as using fertiliser and drought-resistant seeds due to limited financial resources further hinder these interactions. Lack of resources for farmers inhibits the uptake of agricultural extension recommendations that could potentially enhance adaptation to drought.

For NGOs and private companies, the level of interaction with individual households is higher, leading to greater success in agroforestry and seed loan projects. These institutions can reach out effectively because they are provided with means of transport and financial incentives. For example, farmers who participated in the TBL Sorghum project and the LVAIs horticultural seed project had opportunities to interact with extension field officers for advice regarding sorghum and horticultural crop production protocols. The same applies to the LEAD Foundation agroforestry initiative, where project community leaders, called champions, significantly reach out to the households in the village to raise awareness about preserving tree stumps.

6. CONCLUSIONS

Smallholder farmers who rely on rain-fed farming in the Chamwino district have encountered environmental and economic challenges. Climate change, accompanied by recurrent droughts, has led to crop failure, exacerbating food insecurity for many resource-poor households. In addition to frequent droughts, low income impedes farmers' ability to afford agricultural inputs which could enhance productivity and improve food security which in turn improves overall living conditions. In efforts to address the challenges farmers face, various institutions have supported farmers in addressing the challenges. Non-governmental organisations, private companies, and governmental institutions alike have played various roles such as facilitating access to drought-resistant seeds to reduce the risk of crop failure due to drought, promoting agroforestry farming, ensuring ready markets for sorghum and sunflower, facilitating access to loans for agricultural input and providing information on weather forecasts.

The study has also demonstrated that the linkages between institutions are crucial to comprehensively addressing farmers' challenges. Securing a reliable crop market and access to credit for farm inputs has been possible due to collaboration among institutions supporting farmers. Based on this result, this study recommends the following: firstly, farmers should reduce scepticism about using drought-resistant seeds and promote full adoption. Notably, extension agencies should create awareness of the usefulness of the seeds among farmers. Adoption of the seeds will help reduce the risk of drought-induced crop failure and improve food security. Secondly, village agricultural extension workers should be empowered to mobilise localised information on weather forecasts to suit local areas. This has to be coupled with efforts to encourage farmers to attend weather information-sharing meetings and utilise the information. Thirdly, sensitisation is needed to enable farmers to fully benefit from the dairy goat project by adhering to the required livestock management systems. While this research delivers valuable insight regarding the role of institutions in climate change adaptation, it is imperative to note that the qualitative approach and the limited sample size may hinder generalisation of findings beyond the study areas. Further research on institutions and adaptation to climate change could opt for large samples and employ quantitative methods to enhance the generalisability of results.

USE OF AI TOOLS DECLARATION

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this work. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Appendix I. Interview questions with representatives of institutions

Study Title: Institutions and adaptation to climate change effects

i. What kind of support does your institution provide to smallholder farmers for climate adaptation?
ii. What challenges or barriers does your institution face in reaching smallholder farmers with adaptation support?
iii. How do you collaborate with different institutions (government, NGOs, private sector) to support smallholder farmers' climate adaptation efforts?

Focus Group Discussion Questions

i. Identify institutions that, in one way or another, deal with roles that contribute to addressing climate change effects in this village.
ii. What kind of support does the institution provide to smallholder farmers for climate adaptation?
iii. What challenges do the institutions you mentioned face in reaching smallholder farmers with adaptation support?
iv. How do the institutions collaborate with each other to support smallholder farmers' climate adaptation efforts?

Central European Journal of Geography and Sustainable Development
ISSN 2668-4322, ISSN-L 2668-4322
2024, Volume 6, Issue 2, Pages: 23-36
https://doi.org/10.47246/CEJGSD.2024.6.2.2

Reflections on the role of healthy eating style. Insights from citrus of the South of Italy

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Received: 8 November 2024; Revised: 7 December 2024; Accepted: 11 December 2024;
Published online: 16 December 2024

ABSTRACT: As nutrition has become more of a challenge globally and sustainable eating practices receive renewed emphasis, understanding the important role of local foods can contribute to finding efficient solutions. Shedding new light on the Mediterranean diet, this research was aimed at examining citrus cultivation in Southern Italy and its vital role in developing healthy eating practices by preserving and enhancing cultural heritage. This paper contributes new insights to the literature, as it describes specific effects of locally sourced citrus fruits on nutrition and local identity, which are often overlooked in current literature. Methodologically, a qualitative analysis was conducted, introducing an overview on agricultural statistics for each of the two emblematic cases examined: the Syracuse Lemon (PGI) in Sicily and the Clementines of the Gulf of Taranto (PGI) in Apulia. The research shows that certified citrus products offer high-quality nutrition and support local identities and economies by using traditional farming practices. Findings show that growing citrus not only improves public health by encouraging people to eat local nutritious foods but also helps empower local economy and helps to the preservation of ethnic landscapes. The interdependence of gastronomy, health and ethnic heritage was highlighted in this paper, advocating for policies that strengthen small-scale producers and protect heritage crops. Research implications refer to the fact that increasing consumer awareness can strengthen both public nutritional quality and regional economic vitality. Research limitations should be acknowledged – this paper was focused on only two case studies, opening a window of opportunity for future research to incorporate a broader range of regions to further empower research findings.

KEYWORDS: Apulia, Sicily, mediterranean diet, local typical products, sustainability, food culture.

TO CITE THIS ARTICLE: Lupu, C., Ivona, A., Privitera, D., & Constantin, M. (2024). Reflections on the role of healthy eating style. Insights from citrus of the South of Italy. *Central European Journal of Geography and Sustainable Development*, *6*(2), 23–36. https://doi.org/10.47246/CEJGSD.2024.6.2.2

1. INTRODUCTION

Gastronomy was primarily associated with culinary enjoyment, or "the practice or art of choosing, cooking and eating good food" as the Oxford dictionary states. There are scholars (Md Ramli et al., 2016) that have concentrated on how food heritage has tied up with the tradition of foods prepared and consumed over an unbroken sequence of generations. Also, gastronomy is closely linked to the culture and heritage of a certain region. Hence, what local people eat, when, where, and the way they eat are all visible

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manifestations of culture. Moreover, food can be considered as the most intimate contact with the local culture as it is ingested, and the uniqueness and authenticity of local food are important markers in constructing the identity of a destination (Chatzopoulou et al. 2019; Everett & Aitchison, 2008; Stone et al., 2019; Ting et al., 2019) and important vehicles for sustainable regional development (Soare et al., 2023).

Haven-Tang & Jones (2008) recognize local food and wines as identity marks of a destination, and a source of identity formation in post-modern societies (Richards, 2002). In this context, food tourism can be an important means of strengthening a region's identity (Everett & Aitchison, 2008). Also, local governments are acknowledging the importance of gastronomic or culinary tourism and developing programs to attract tourists. Moreover, foodways are eating habits and culinary practices of people, regions, or historical periods, that symbolize different things to different people depending on the context (Counihan, 1999, p. 19). When food is designated as heritage it "takes on even greater emotional weight" (Brulotte & Di Giovine, 2014, p. 2). Of course, it is equally important that the identity of the product, its production and the place of origin are interdependent and relevant to the same extent. However, some important Italian local/traditional foods awarded with Protected Geographical Indication (PGI) labels, such as Bresaola della Valtellina, use (and the PGI protocols allow it) raw products (meat pieces) imported from other countries (Argentina namely). The attributes of typicality, traditionality, authenticy and local origin in contemporary food industry are easier than expected. For instance, if we think about the Razza Piemontese cows, whose meat represents a typical local product of the Piedmont region with many important traditional recipes transmitted from generation to generation, indeed, they are the results of a quite recent process of genetic selection which has little to do with the ancient place-based production (Colombino & Giaccaria, 2013). However, connections between taste, culture and productions are important not only to locals but also to tourists and the agricultural entrepreneurs themselves. Populations, especially in the Mediterranean area, give importance to the quality, to reputational attributes, to the geographical origin, to ethical attributes, to food safety but also the healthiness of food (Nicolosi et al., 2021).

Finding ways to increase the adoption of healthier, sustainable diet with preference to local food may be difficult but a good example is the Mediterranean diet (Schwingshackl et al., 2015). The Mediterranean diet is not only recognized by UNESCO, but it is how we share food, the culture of food, political and economic dimensions, how we educate ourselves about food to arrive at models of innovation where we aim at the care of the ecosystem and care of the community. The Mediterranean diet is healthy, but most consumers do not know the reasons for its healthfulness and that, in addition to vitamins and plant fiber, it is due to the presence of sufficient amounts of other elements such as potassium, which is important in the prevention of many diseases. The Mediterranean diet, rich in grains, legumes, vegetables, and fruits, ensures a potassium intake that is not only sufficient but higher than the standards that are now recognized as indispensable but increasingly disregarded. Not infrequently, the typical foods of the Mediterranean diet, rich in potassium such as cereals and especially fruits and vegetables, are replaced by sweets, baked goods, cheeses and cured meats with little potassium and a high sodium content that increases the urinary elimination of potassium and thus its presence within the body (Clark et al., 2018).

Italy is the home of the Mediterranean diet (D'Alessandro et al., 2019). The current Italian problem, especially among the elderly, is potassium deficiency, due to insufficient intake of potassium-rich plant foods, in combination with an excess of sodium which causes potassium depletion (Clark et al., 2018).

Foods rich in potassium are fruits and vegetables. Citrus are a significant source and not alone. They are also full of vitamins as well as C vitamins. In addition, we find on market enriched food regulated by the European Regulation (EC) No. 1925/2006, which establishes a list of allowed substances as well as their sources. These regulations are the result of a lengthy process, with the aim of regulating and harmonizing the legislation regarding fortification in Europe. The rules state that in addition to classifying the permitted limits of the nutrients to be added, a nutritional table containing the values of the supplemental nutrients must be included in the product packaging. At the turn of the 21st century, the Scientific Committee on Food began issuing guidelines to define the upper limits for the intake of vitamins and minerals in food (Efsa, 2022).

This article explores the significance of citrus production in promoting a healthy and balanced diet, emphasizing the nutritional value of traditional agricultural products and their strong connection to the identity of their territories of origin. The study focuses on two emblematic cases of citrus production in Southern Italy - clementines from Puglia and lemons from Sicily - both recognized for their certified quality. These examples, while not exhaustive, highlight the broader importance of Italy's citrus industry. The aim is to underscore the exceptional quality and health benefits of these products, demonstrating their critical role in supporting a healthy lifestyle and overall well-being.

Italy's citrus production is mainly in southern regions, with Sicily and Calabria bringing together more than 80 percent of the total. Oranges exceed 59 percent of the total supply, followed by clementines and tangerines (25%), lemons (15%), grapefruits and other citrus for the residual part (Ismea, 2023). Quality production is also increasingly on the rise: this is the case of EU-labeled certified products (EU Reg. 2081/92 and Reg. 2082/92) that represent an important segment of the Italian citrus market.

After a brief review of the literature on the importance of the Mediterranean diet and local products, the study examines the characteristics of citrus production in Italy and provides a concise historical overview of citrus fruits, tracing their journey from Asia to Europe. The analysis focuses on two case studies: lemon production in Sicily and clementine production in Apulia. Despite the inherent limitations of the analysis, the reflections presented underscore the vital role of citrus cultivation in promoting healthy lifestyles rooted in the consumption of local products.

2. THE IMPORTANCE OF MEDITERRANEAN DIET LINKED TO PLACE'S IDENTITY

The Mediterranean diet is characterized as containing large amounts of fruits, vegetables, whole grains, legumes, moderate amounts of seafood, and small amounts of other meats and using olive oil as the primary oil (Vitiello et al., 2016). The dietary analyses have consistently found that diets higher in plant-based foods are associated with reduced disease risk compared to omnivorous dietary patterns (Tilman et al., 2011). For example, shifting from a westernized dietary pattern to one that is more a Mediterranean diet reduces risk of diabetes by 7%, and of heart disease by 10%, and total mortality by 8% (Sáez-Almendros et al., 2013). Moreover, increased adoption of a combination or a mixture of Mediterranean, vegetarian, or vegan diets would reduce the risk of diabetes, cancer, heart disease, overweight and obesity, and total mortality relative to expected dietary patterns in 2050 (Springmann et al., 2016). In addition, the adoption of the Mediterranean dietary pattern by a population, based on the specific proportions and composition of foods outlined in the Mediterranean diet, can positively impact both human health and the environment. The Mediterranean diet is recognized not just as a cultural tradition but also as a model that promotes health and sustainability (Serra-Majem et al., 2012).

In recent years, new tools have been developed to "enhance and protect the legal, commercial and cultural values of foods and customs whose characteristics and reputation can be variously attributed to their origin" (Parasecoli, 2017, p. 2). These tools fall into two principal categories: place-based labels, such as PDO (Protected Designation of Origin) and the broader PGI (Protected Geographical Indication), and UNESCO's Intangible Cultural Heritage list. UNESCO first referenced intangible cultural heritage in its 1989 *Recommendation for the Safeguarding of Traditional Culture Folklore*, but food was only included in this category starting in 2010 (Clough, 2015; Di Fiore, 2018). Labels like PDO and PGI demonstrate how European agriculture policies actively preserve and promote the value of traditional, locally produced foods and wines (Silva et al., 2018).

According to Faostat data, the Mediterranean Basin accounts for about 20% of the world citrus production (and about 60% of the world fresh citrus trade). The production is mainly composed of sweet oranges and mandarins like fruits. Citrus is a major segment in the Mediterranean agricultural industry with citriculture representing a major source of income to a significant number of people. It is a source of employment at various levels of the chain, mainly during production because most of the fruit is harvested by hand and plays a role as a driving force to the economy of the entire Mediterranean region.

In Italy there are issues reflected in two paths where there is a clear reference to local and national gastronomic heritage as a closed system. Really, it is not true because globalization increases the popularity of ethnic cuisines.

The food industry involves multiple stakeholders from different sectors (Getz, 2000). These multiple stakeholders include also (food providers such as farms, farmshouse, restauranta and tourism operators) who must share a common vision to develop compositefood experiences; yet, competing interests and conflicts may interfere in its development (Alonso & Northcote, 2008; Gammack, 2006). Also, branding a food destination requires considerable negotiation among key stakeholders to define the place's identity which should emphasize the uniqueness of local food (Lai et al., 2019). Therefore, the uniqueness of local food and wine products (Haven-Tang & Jones, 2008), deeply rooted in a place (Frochot, 2003; Lin et al., 2011), can reinforce cultural differences among regions and countries (Fox, 2007). The natural landscape of territories is also considered as a unique attribute of a food (and wine) destination (Scorrano et al., 2018).

3. CITRUS IN THE LANDSCAPE OF SOUTH OF ITALY

3.1. Brief history of citrus fruits: from Asia to Europe

Citrus fruits, more than other fruit plants, have followed the history of man since the beginning. The etymology of the term citrus comes from the late Latin "acrumen", sour. The term "orange" probably comes from the Sanskrit nagaranja, meaning fruit favored by elephants, which arrived in Europe through the Arabic-Persian word *narang* or from the Latin *aurum*. The Arabs presumably discovered the bitter orange in India and from there transported it first to the Arabian Peninsula and, in parallel with their military and cultural expansion, to North Africa, Spain and Sicily around the 10th century. Another hypothesis attributes the introduction of the sweet orange, first in the gardens of Liguria and then throughout the Mediterranean, to Genoese navigators and traders, who, at the end of the 13th century, awaited the caravans coming from China and India along the coasts of the Black Sea to buy the precious goods. The apothecaries manipulated citrus fruits for the preparation of jams, medicines, and essential oils, highly prized for the perfume industry. The technique of extracting essential oils was known by the Arabs but it was the Italians who enhanced their production in perfumery. The Ligurian and Provencal Riviera established themselves from the seventeenth century as an area of production and trade of citrus fruits, both fruit and plants, In the late seventeenth century, sauces were prepared using candied flowers or fresh juice and cinnamon, and the beautiful fruit to see each other, was exhibited on the table in artistic forms (Calabrese, 2004; Camarda et al., 2013; Giarè & Giuca, 2008; Ivona & Privitera, 2023).

Without excluding the possibility of previous introductions, it seems that, through the usual Pakistani route, the bitter orange was brought to the Mediterranean by the Arabs around the middle of the 8th century. Moreover, the Arabic names of lemon and bitter orange make the first appearance in the "Nabataean agriculture book", a Syrian work of the III-IV century which, translated into Arabic in 904, also contains a brief description of the two fruits (El Faïz, 1995). The Arab works that subsequently deal with agriculture report, often in detail, the aspects related to cultivation, reproduction, properties, uses, etc. of citrus fruits in the western Mediterranean, Spain and Sicily including (Calabrese, 2004; El Faïz, 1995). The citrus fruits cultivated in these territories around the 10th century were cedar, bitter orange, and lemon, in several varieties as well as an unspecified number of intermediate forms between the three species, the lima and, probably also, the pomelo (El Faïz, 1995). Those plants, due to the suitable climate, reproduced in Liguria and from there spread to the rest of Italy, southern France and south-eastern Spain. It is very likely that they met sweet oranges in Chinese ports, cultivated in those places since time immemorial, and it can be assumed that in the first half of the 16th century they arrived in the port of Lisbon. From Portugal they passed to Spain and then to Italy. (Calabrese, 1998 and 2004; Wilkins & Hill, 2006; Langgut, 2017).

3.2. Citrus cultivation in southern Italy

Italy is one of the top ten citrus-producing countries in the world, after Brazil, China, the United States, Mexico, India, Spain, which have implemented important national development plans in the sector in recent decades, and Iran; in eighth place is Italy, followed by Nigeria and Turkey.

Overall, in Italy, the agricultural area dedicated to citrus groves is 112,033 hectares, cultivated by 49,087 companies (Gismondi, 2022). The area cultivated specifically for oranges amounts to

approximately 86,000 hectares and is slightly recovering both compared to 2022 (1.1%) and the average figure for the last three years (1.6%).

In Italy, the production of oranges in the last harvest campaign is estimated at 1.6 million tons, up 20% on an annual basis, but below the average of the last three campaigns. The current campaign is also characterized by the abundant presence of medium-small sized fruits. Domestic demand is not very dynamic, but marketing started late in 2023, due to the harvest postponed by the anomalous heat (Ismea, 2024). Data on foreign trade indicates that, between October and December 2023, imports decreased by 19% compared to the same period in 2022, against a 53% increase in average prices. In the same quarter, Italy's exports exceeded 24 thousand tons with a 29% increase on an annual basis and a 6% increase in average price lists.

Italian citrus cultivation requires certain soil and climatic characteristics typical of the southern area. The first region for production is Sicily, followed by Calabria, Apulia, Basilicata, Sardinia and Campania. In Italy, the most widely grown citrus fruit is the orange. Southern regions, such as Sicily and Calabria, are particularly renowned for producing high-quality oranges. The surface area cultivated with oranges in Italy, in 2023, amounts to approximately 86 thousand hectares and is slightly recovering compared to 2022 (1.1%) and compared to the average figure of the last three years (1.6%) (Table 1).

Table 1. Orange – production area (in hectares).

	2020	2021	2022	2023	Share 2023	2023 vs 2022	2023 vs. average of previous three years
Italy	84.162	84.243	84.773	85.733	100%	1,1%	1,6%
Sicily	55.272	55.292	55.332	56.054	65%	1,3%	1,4%
Calabria	17.749	17.764	17.764	17.799	21%	0,2%	0,2%
Apulia	3.925	3.925	4.435	4.611	5,4%	4,0%	12,6%
Basilicata	3.809	3.809	3.809	3.758	4,4%	-1,3%	-1,3%
Sardinia	1.984	2.024	2.024	2.119	2,5%	4,7%	5,4%
Other Regions	1.423	1.429	1.409	1.392	1,6%	1,2%	-2,0%

Source: Ismea, 2024.

Over the past three years, the area cultivated with orange groves in Sicily has steadily increased to the current over 56,000 hectares (the main increases are in the provinces of Catania, 500 hectares in production compared to 2022, and Agrigento, 200 hectares). Calabria follows the ranking with approximately 21% of the dedicated surfaces, showing in the last campaign a substantial stability in the growth of the cultivated surface compared to the average data of the last three years. Apulia follows with approximately 5% of the national surface invested in oranges. The Istat statistics reported by Ismea (2024) highlight a positive trend in the Apulian surfaces in production, increased by 12.6% compared to the last three years. The Apulian orange groves are located mostly in the province of Taranto.

Generally, the production of citrus fruits is practiced on rather small surfaces; the average company surface, in fact, is equal to just 2.5 hectares. Farms with agricultural area used for citrus fruits of up to 3 hectares represent 83% of total citrus farms and 27.8% of the national citrus fruit area; on the other hand, the type of company with used agricultural area between 3 and 20 hectares constitutes 15.3% of citrus farms and 43.6% of the Italian citrus area; finally, companies with utilized agricultural area greater than 20 hectares represent only 1.7% of citrus farms and 28.6% of the Italian citrus area. Such a small company size is rather disadvantageous in terms of economy of scale, ability to amortize production costs and contractual strength on the market. Furthermore, the national citrus area decreased from 172,444 hectares in 2010 to 112,033 in 2022, with drops in all regions (-34% in Basilicata), and for all the most important citrus species (-19% oranges, -9% clementines, -9% tangerines, -14% lemons). However, the decline in surface areas has been offset in recent years by an increase in production, probably linked to young plantings, varietal innovations and new forms of investment.

Italy's citrus supply consists of oranges, clementines, lemons, tangerines, grapefruits, satsuma miyagawa and other citrus fruits including bergamot, citron and chinotto, thus a rich and varied heritage of varietal and excellence linked to different territories in Sicily, Calabria, Apulia, Basilicata and Campania. In fact, they range from red-fleshed oranges, such as the *Tarocco*, *Moro* and *Sanguinello* varieties of the Catania plain, to blond-fleshed oranges such as the Anapo oval of Syracuse or the navel oranges of Ribera, from the *Ciaculli* tangerines of the province of Palermo to the clementines of the Piana di Sibari and those of Taranto, passing through the bergamot and citron crops of the Tyrrhenian and Ionian coasts of Calabria, to the oranges of the Gargano and the Amalfi lemons.

The marketing of Italian citrus fruits takes place mainly from October to April of the following calendar year; unlike the main autumn harvested fruit species (apples, pears and kiwis), citrus fruits do not undergo cold storage of the product for long periods because storage at low temperatures would affect their organoleptic quality. The citrus fruits remain on the trees until the climatic and market conditions recommend their collection. Once harvested, the product must then be quickly marketed. Most of the offer is intended for fresh consumption, but a large part of the production is given to the juice extraction industries and a more limited quantity, mainly of bergamot and small citrus fruits, is destined for the extraction of essential oils (Ismea, 2020).

3.3. Sicilian Citrus fruit: the case of the Syracuse Lemon (PGI)

Sicily is home to the red *Tarocco* and more varieties of oranges, located in the citrus groves on the slopes of the volcano Etna, which are particularly appreciated and considered distinctive from other varieties in the area for the tenderness of the pulp and the balanced, bittersweet and palatable taste, seasonality, related to the pedoclimatic conditions of ripening. Excellent production is characterized by exports to foreign markets.

Regarding the composition of the production of PGI citrus fruits, in the 2021 campaign 48% of the certified production can be attributed to red orange of Sicily (PGI). This is followed by - in strong growth – Orange of Ribera POD (15%), Syracuse Lemon PGI (13%), Lemon Interdonato Messina PGI, and recently the Lemon of Etna has been certified (Ismea, 2023).

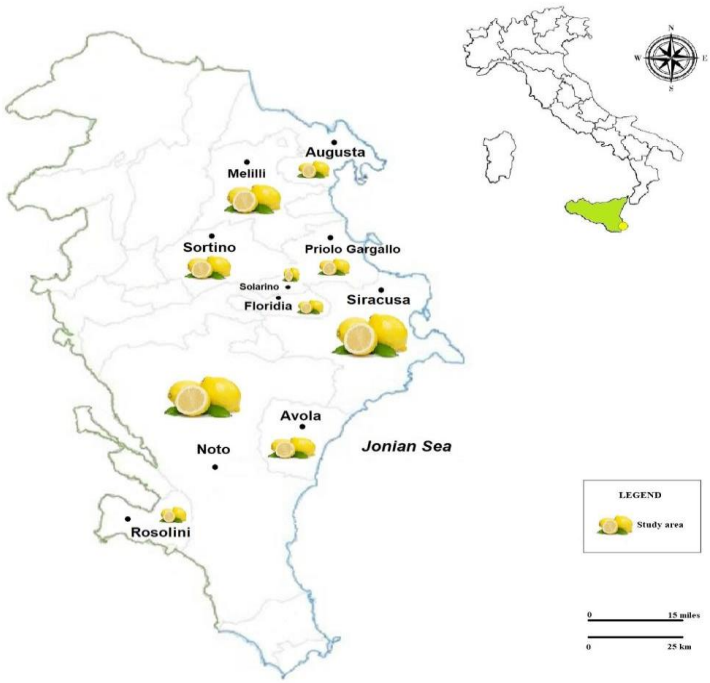

Figure 1. The production area of the Syracuse Lemon (PGI).
(The size of the lemon image is purely indicative, it does not represent the size of the phenomenon but only its location)
Source: Antonietta Ivona, Donatella Privitera (2024)

Here we highlight the Syracuse Lemon, recognized PGI in February 2011, produced between the sea and the flat hinterland and as indicated in the production specification never over 210 meters above sea level. Warm sun, humid air, alluvial and limestone-rich soil, and underground rivers make the certified lemon unique, unbeatable for juice content, very high quality of essential oils, and the high levels of vitamin C and citric acid. The fruit is advertised and recognized on the market with a nice colored brand recalling the Geographical Indication certification.

The area includes the municipalities of Syracuse, Noto, Avola, Floridia, Solarino, Priolo Gargallo, Augusta, Sortino, Rosolini and Melilli (Figure 1). Coastal strip lemon groves look eastward toward the Ionian Sea and extend along a wide area of 10 km.

Unity of climate and compactness of soil are well suited to the lemon variety reserved for the cultivar Femminello and its clones, cultivated with a traditional technique. Refreshed by the Anapo, Asinaro and Marcellino rivers, which flow down from the Iblei mountains in a westerly direction, Syracuse's lemon groves extend 50 km from north to south.

An area immersed in beauty and nature, a unique human and landscape heritage. Sicily has a historic tradition in the cultivation of citrus fruits and the respect for ancient traditions in the cultivation of these plants, handed down from generation to generation continues in the Syracuse area, giving rise to a true school of specialists in the cultivation of the Syracuse Lemon. For these reasons, the Syracuse Lemon maintains a deep connection with the environment that is evident throughout the product chain.

The reference of the companies is the Consortium for the Protection of the Syracuse Lemon (existing since 2014), which groups more than 160 companies of small, medium and large size, and about 5,800 hectares, for a production equal to more than 30 percent of the total Italian harvest (www.limone disiracusa. com). The consortium represents a protection for producers who comply with the specification and for consumers, who are guaranteed the provenance and excellent quality of a product that, like few in the world, can boast such close and long-lasting identification with its territory of origin. Syracuse can consider itself the first province for production in Italy.

Figure 2. Panoramic view of citrus fruits in eastern Sicily.
Source: Donatella Privitera (2024)

The landscape of citrus groves is characterized by a symphony and explosion of shapes and colors, catching the eye all the way to the blue sea (Figure 2).

The Mediterranean nature of the lemons is captured in the diverse ecosystems aided by farmers with an unfortunate lack of rainfall, but in manicured and specialized plantings where the concept of terroir coincides. Landscape value is represented by the presence of distinctive and qualifying elements of the rural landscape, including in combination with each other, such as: terracing, verges, bezel structures mainly made of dry-stone or rammed earth, dry-stone walls, roofing with canopies or other materials, and protective structures designed to protect a single tree. A characteristic part of the built architecture are the artifacts related to the collection and distribution of water through the methods of irrigation by submersion and run-off.

3.4. Apulian citrus fruits: the case of the Clementines of the Gulf of Taranto (PGI)

The Apulian citrus cultivation plays a role of limited importance in the regional context of the agricultural economy, although in some areas it represents a reality of extreme interest. It is almost completely localized in the province of Taranto, in the western Ionic arch called Conca d'Oro (Golden Valley). Smaller areas are also used for citrus groves on the Gargano promontory, in the northern part of the region. In this part of Apulia, particularly, the "transformation of ancient natural and rugged landscapes into a varied countryside shaped by practices derived from needs, values and ambitions, documents the identity and culture of the communities that produced it, placing itself as social construct, a real cultural landscape" (Nocco, 2021, p. 50).

Apulian citrus cultivation is a recent reality; at the beginning of the 1950s the reclamation works, and Land Reform started a process of total transformation of agriculture in the Ionian arc area. Subsequently, the environmental, climatic, pedological conditions and the availability of irrigation water favored the cultivation of citrus fruits. The acquisition of modern cultivation techniques has favored, over time, an overall improvement in Taranto's citrus cultivation to obtain excellent quality products. The pursuit of quality was an important goal for the Apulian citrus growers, who absolutely cannot compare in terms of quantity with the productions of the main citrus-growing regions such as Sicily and Calabria. Already in the 80s the technological level of the Apulian citrus farms was high regardless of their size and form of management, much more than what happened in the citrus-growing regions par excellence.

In particular, the dynamics relating to the citrus area while recording on the one hand a consistent decrease in the areas of mandarin and orange groves, on the other hand the important expansion of the cultivation of clementines which in many cases is re-grafted on the mandarin itself. Consequently, various Italian and EU legislative interventions were aimed at improving production, encouraging the reconversion of orange and mandarin groves towards the other varieties most requested by the market. The reconversion of Apulia was directed towards the common clementines which, in the Conca d'Oro area, found environmental conditions particularly favorable to cultivation.

The geographical origin of this fruit is uncertain; probably the clementines owe their name to a friar, Father ClémenteRodier, who discovered them in Algeria. Their origin is however controversial: for some authors they would be a natural hybrid found in Algeria in 1898, while for others it would be citrus fruits like the Canton mandarin, of Chinese origin. Its diffusion in the Taranto area dates to the eighteenth century, but to see a specialized production of the crop it will be necessary to wait until the twentieth century.

After the Second World War, thanks to the aforementioned Land Reform, which made it possible to make adequate water resources available to farmers, there was an expansion and specialization of citrus cultivation in the territory of the Gulf of Taranto, allowing it to assume the connotation of pre-eminent cultivation in the area. Since 2003, this fruit has been greatly enhanced with the attribution of the PGI[1] and the name Clementines of the Gulf of Taranto, with which the fruit is advertised on the market. The production area is in the province of Taranto and includes the municipalities of: Palagiano, Massafra, Ginosa, Castellaneta, Palagianello, Taranto and Statte (Figure 3) (Regione Puglia, 2022).

[1]The Protected Geographical Indication (attributed to agricultural products, foods or wines that guarantees their local origin) is also a guarantee of particular aromas and organoleptic characteristics, induced by the microclimate. In the case of clementines, the climate is characterized by mild temperatures and low humidity thanks to the presence of sea breezes.

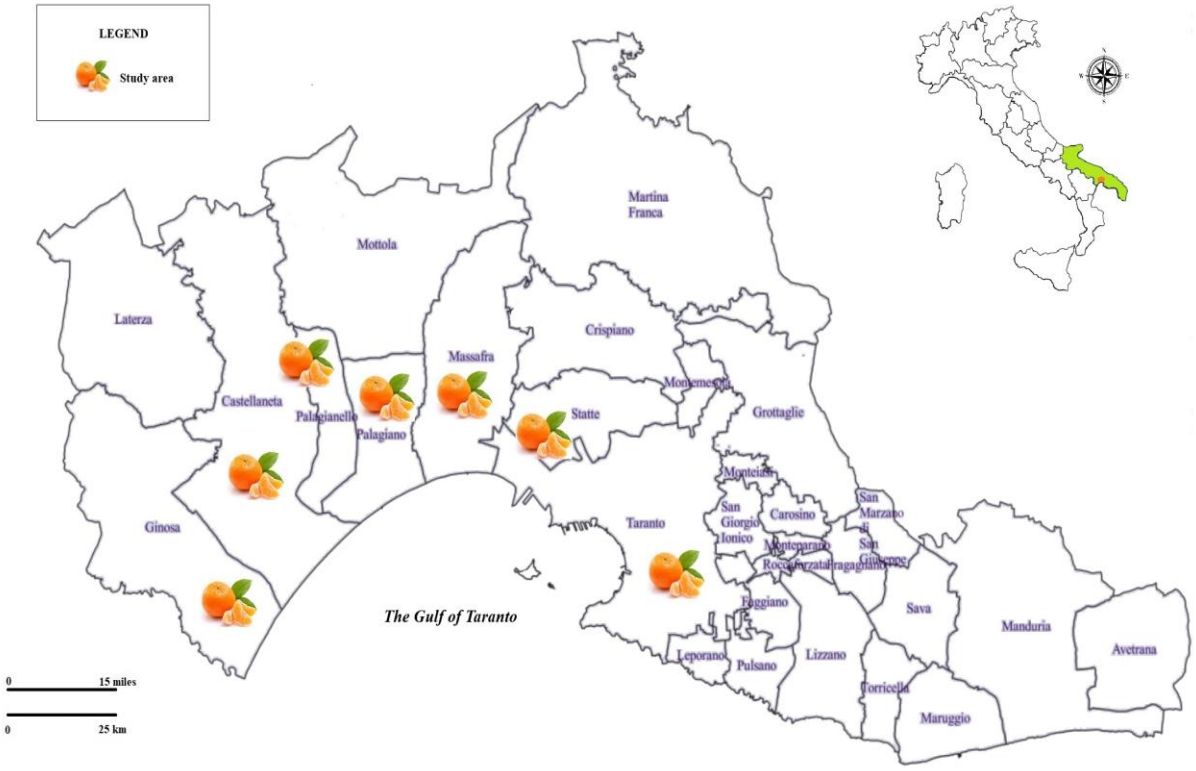

Figure 3. The production area of the Clementines of the Gulf of Taranto PGI.
(The size of the image of the clementines is purely indicative, it does not represent the size of the phenomenon but only its location)
Source: Antonietta Ivona (2024)

The taste of clementines is very similar to that of orange, with the particularity of containing a few seeds. This cross between mandarin and orange is characterized by a spheroidal shape, slightly flattened at the poles, smooth and thin skin, rich in essential oils such as linalool, alpha-pinene and limonene. Like all citrus fruits, it has a high content of vitamin C, trace elements such as calcium, iron, and magnesium, and is normally available on the markets in the months from November to March.

The cultivated varieties are different: Comune, Fedele, Precoce di Massafra and Grosso Puglia; only fruits with a minimum juice content equal to 40% of the weight are allowed for distribution. 100 grams of clementines contain approximately 5 grams of water, 0.1 of lipids, 0.9 of proteins, 1.2 of total fiber, 8.7 of sugars and carbohydrates and important quantities of sodium (4 mg), potassium (130 mg), calcium (31 mg) and phosphorus (18 mg). The fruit is seedless (presence of a maximum of 5% with seeds), packaged in containers of 3 kg up to a maximum of 25 kg. Clementines of the Gulf of Taranto are quite common on the markets in their fresh state and in the form of juices, jams, syrups and for the preparation of cosmetic products.

Citrus growers pay close attention to production methods; the soils, homogeneous and almost always flat, are fertile, deep, and well drained. This facilitates irrigation, which, practiced almost all year round, takes place by dropping or gushing, directly but away from the canopy, to avoid rotting in the collar area of the plant. Pruning, carried out every year in late spring, is aimed at supporting the balance between the vegetative and productive functions. Fertilization is based on the state of fertility of the soil and takes place every three years. Harvesting is done strictly by hand with the help of scissors, trying not to damage the fruit. The harvesting period varies according to the variety, the Municipality is the one that has the longest productive period, while the others are first fruits. The harvested fruit must be dry, with at most a few leaves (Figure 4).

Figure 4. Massafra: a field of clementines.
Source: Antonietta Ivona (2024)

There are 1,041 agricultural businesses dedicated to the production of citrus fruits in the province of Taranto, 9% of the total Ionian agri-food business, with a production of clementines, oranges and mandarins of 1.9 million quintals. In the other Apulian citrus production area, the Gargano, on the other hand, 103,000 quintals of oranges and lemons are produced, in an area at high risk of hydrogeological instability, characterized by historic citrus groves. As for the average company size, the Taranto area (2.70 hectares per farm) is among the main citrus provinces, before Catania (2.61 hectares per farm) and after Syracuse (3.25 hectares per farm). At the regional level in Apulia, the average agricultural area used with citrus fruits is equal to 1.54 hectares per farm. Overall, the annual production of citrus fruits in Apulia is 1.2 million quintals (Istat, 2024).

4. CONCLUSIONS

Southern Italy is rich in history, culture, natural landscapes of high environmental and socio-cultural interest and quality products; all these characteristics could activate virtuous processes of sustainable development. A balanced and eco-sustainable use of the territories, together with an appropriate awareness of the economic potential of local productions, would produce undoubted advantages for the entire communities that live there.

Citrus production certified with a geographical indication mark is growing year after year; despite this positive trend, they now represent a residual share of national citrus production. These are modest shares which could certainly increase considering the reduced competition from similar products and the strong territorial connotation of the productions with the EU-labeled certified brand. Also, food and gastronomy has become a motivation for traveling, and constitutes an element of identity for a territory, not only for the appreciation of the quality products but also with the exploration of the cultural and landscape heritage (Ivona & Privitera, 2023).

In many cases, however, the EU-labeled certified recognition process suffers from some negativities, such as: an insufficient analysis of the actions necessary to satisfy market demand; a frequent inadequacy of the organizational structures, which often have not been able to aggregate the sectoral economic operators (Clough, 2015). Furthermore, the often-limited dimensions of the production areas and an ineffective communication of the organoleptic and healthy qualities of the product complete a

rather opaque overview. In addition, it is necessary to consider climate change which, with drought, is limiting production, particularly in southern Italy.

The diffusion of healthy and wholesome food styles would certainly favor the whole quality agricultural sector, including certified citrus production. The benefits of human health deriving from a habitual consumption of citrus fruits are widely recognized by the international scientific community. It would be enough to leverage this element to facilitate and support the consumption of fresh citrus products, also developing new methods and opportunities for consumption. The players in the supply chain, also with cooperative initiatives, could pursue product and process innovation to increase the added value of the product (cut-out range, increase in shelf life, etc.) and to create new opportunities for consumption and ways more suitable to stimulate consumption also by young people (for example, fruit salad or juices in places of concentration such as cinemas or stadiums). Future challenges around forms of well-being will have to be faced with a more holistic vision that includes physical fitness, a healthy diet, and a long-term strategy. Really, experts have reflected the acknowledgment that gaining accessibility to a healthy and sustainable form of diet is one of the obstacles to a better future (e.g. food desert), and very few link these reflections to a reexamined understanding of sustainability and the relationship between food production and consumption (Bertella, 2020), which needs to be further enquired through academic research.

In terms of practical contributions, this study provides insights for policymakers and practitioners aiming to promote sustainable agriculture and regional development. Specially strengthening geographical indications like PDO and PGI can enhance the market value of citrus products while preserving their cultural and territorial identity, making them more competitive in local and global markets. In addition, encouraging environmentally friendly agricultural techniques observed in these case studies can contribute to sustainable farming, reduce ecological impacts, and align with green policy initiatives. Moreover, integrating citrus cultivation into culinary and agritourism experiences can diversify local economies, attract visitors, and foster an appreciation for the Mediterranean diet as part of intangible cultural heritage.

Finally, there are some limitations of this study that should be highlighted, since they may be the trigger for future research. Reflections on the subject relied on self-reported preferences, from the bibliographic review rather than observed behavior of consumers; in fact, which is tentative and doesn't provide insights from the producers nor the public policies. These limitations highlight areas where future research could refine and expand upon these findings, perhaps by including samples, using behavioral observation, or exploring additional cultural and personal factors that influence gastronomic preferences.

Acknowledgment: The authors thank the reviewers for their valuable comments. The study was performed within the project "EMPLACING FOOD. Narratives, policies and spaces in Italy. Rethinking the territorial dimensions of food, in the challenges of justice, sustainability, cultural identity and local development", Prot. 2020F5Z9CB, by Italian National Research Programme 2020.

Use of AI tools declaration: The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Author contributions: All authors contributed equally to this work. Especially, sections 1, 3.3 are attributed to Donatella Privitera; section 2 to Cristina Lupu; sections 3.1, 3.2 and 3.4 to Antonietta Ivona; section 4 to Marius Constantin. All authors read and approved the final manuscript.

Conflicts of interest: The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Central European Journal of Geography and Sustainable Development 2024, Volume 6, Issue 2, Pages: 37-49
ISSN 2668-4322, ISSN-L 2668-4322 https://doi.org/10.47246/CEJGSD.2024.6.2.3

Urban Living Labs as an innovative tool for achieving the Sustainable Development Goals? Evidence from Poland

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Received: 30 November 2024; Revised: 12 December 2024; Accepted: 16 December 2024;
Published online: 18 December 2024

ABSTRACT: The aim of the article is to analyse the activities of Urban Living Labs (ULL) in Poland from the perspective of supporting the realization of sustainable development goals at the local level. The article is based on an analysis of Internet materials (1,907 research units from social media and websites) of Polish Urban Labs on various types of activities they perform. The analysis of the materials helped to assess the way in which Sustainable Development Goals (SDGs) concepts are implemented as part of the urban innovations developed at Urban Labs. It helped to identify the most important directions of SDG implementation, as well as to propose a typology of urban labs in this regard. The main conclusions of the research concern the different strategies for concentrating ULL activities around the SDGs, as well as the emergence of three speeds of ULL in terms of their involvement in SDG implementation. The "great absentee," i.e. the undervaluing of sustainable energy topics in ULL activities in Poland, was also revealed.

KEYWORDS: Urban lab, urban living lab, living lab, sustainable development, sustainable development goals, urban development

TO CITE THIS ARTICLE: Brzeziecka, D.H., Piziak, B., & Thel, K. (2024). Urban Living Labs as an innovative tool for achieving the Sustainable Development Goals? Evidence from Poland. *Central European Journal of Geography and Sustainable Development*, *6*(2), 37–49. https://doi.org/10.47246/CEJGSD.2024.6.2.3

1. INTRODUCTION

Sustainable Development (SD) constitutes the current paradigm for global change in the urban environment (UN HABITAT, 2019). In this article, we look at the local implementation of the Sustainable Development Goals (SDGs) (United Nations General Assembly, 2015) in cities from the perspective of the innovative urban stakeholder collaboration formula of Urban (Living) Labs (ULL). As there is a plethora of terms used to describe the instrument of urban labs (urban lab, urban living lab, living lab, city lab, smart lab, etc.) and two types of names tend to be the most popular, we decided to use a cluster of words in the title, referring the concept of "lab" to both the "urban" and "living" categories (which we write about in more detail in the section: Literature review).

The aim of the article is to assess the phenomenon of ULL activity in relation to SDGs implementation. We examine which SDGs are present in their agendas, which are of the greatest and least importance. We look for a typology of ULLs in relation to the issue at hand. What distinguishes our analysis from the existing studies is that our analysis refers to a comprehensive assessment of ULL activities, and not - as is often

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the case - selected activities promoted as good practices. We sought answers to the following research questions:

- Which SDGs are implemented in the framework of ULL activities in Poland?
- Which SDGs are overlooked in the framework of ULL activities in Poland?
- Are there specific types/strategies of ULL in Poland in the context of SDG implementation?

For the purposes of this article, we adopt the widespread view in the field literature that urban (living) lab itself - as a collaborative formula - is a local innovation that can cause further growth of innovative solutions and ideas (Cosgrave, Arbuthnot & Tryfonas, 2013; Kopycinski, 2018; Scozzi, Bellantuono & Pontrandolfo, 2017). What do we mean when we discuss innovation in the context of ULL? In line with the literature, we assume that, broadly speaking, three types of activities can be considered to meet the prerequisites for innovation: introducing a new product or process (and improving it), defining and redefining the position of an organization or product/service, and defining or redefining the dominant paradigm of an organization (Mayle, 2006). When implementing this typology to ULL's activities in Poland, it is important to keep in mind that the category of "organization" covers both the structures/team of an ULL, as well as the individual groups involved in its activities. Thus, Urban labs can be seen as networks of inclusive innovation, shaped by the roles of individual stakeholders (Nystroma et al., 2014).

Innovation within the ULL formula should be understood not as a linear trajectory, but rather in terms of a collaborative network involving a web of multiple actors. The dynamics within these networks are illustrated by the quadruple helix model involving the business sector, higher education and research entities, public authorities and the society working together to generate new knowledge, solutions, technologies, products and services (Etzkowitz & Leydesdorff, 1998; Carayannis & Campbell, 2009; Arnkil et al., 2010; Schütz, Heidingsfelder & Schraudner, 2019; Cavallini et al., 2016). At the same time, we are aware of the limitations of this approach due to the deficit of analyses and research approaches that systematically measure the effectiveness of ULLs (Paskaleva & Cooper, 2021) and confirm their actual "innovation."

The quadruple helix theory with regard to the creation of innovative solutions in the city, including in the ULL formula, is further developed through the concept of the quintuple helix, as described by Carayannis et al. (2012), and with regard to social innovation in urban environments, also by Calzada (2020) and Piziak et al. (2022). The latter recognize two independent elements in the collective and simplifying category of "society," i.e. "residents" and "NGOs." It is a major distinction because of the highly important role in the creation of innovative solutions in cities both by two types of actors - individuals and social entrepreneurs (who do not identify themselves with any organization) on the one hand, and representatives of NGOs (who in many cases are the leaders of innovative projects) on the other hand.

While undertaking the study of ULLs, we noted their one specific condition, related to their focus on the quality of life and the needs of residents. "(...) in research on ULL, it is important to emphasize their role as entities responsible for implementing urban innovations, understood as new concepts, ideas and solutions that contribute to improving the quality of life for residents. Urban (living) labs have a profound impact on urban innovation by integrating citizen input and real-world testing into the innovation process. They contribute to the creation of smart cities, enhance service delivery, and improve urban living conditions. By fostering a collaborative environment, living labs help cities become more responsive to the needs of their residents, driving sustainable growth and development" (Arslan, 2022). Placing the "needs of residents" and their quality of life at the center of ULLs' activities has potential implications on how the SDGs are implemented.

2. LITERATURE REVIEW

2.1. Urban Living Lab – characteristics of the phenomenon

Although there is no uniform definition of *urban (living) lab* in the literature, its conceptual roots are shared with *living labs*. These, in turn, are defined as participatory platforms created for open innovation, which support experimentation and testing of solutions by users in real-world conditions (Voytenko et al., 2016). A similar approach is also found in publications by other authors. "Living labs are recognized as progressive platforms for fostering innovation and strengthening collaborative partnerships from bottom-

up" (Molnar et al., 2023; Priday & Pedell, 2017; Westerlund, Leminen & Habib, 2018; Compagnucci et al., 2021).

In the case of ULL, the definitions are definitely broader. Y. Voytenko et al. (2016) defines them as "a form of collective urban governance and experimentation to address the challenges of SD and the opportunities created by urbanization. Urban living labs have different goals, are initiated by different actors, and create different types of partnerships (...) Urban labs are a form of experimental governance in which urban stakeholders design, develop and test new technologies, products and services to develop innovative solutions to problems, such as those related to climate change." In a similar vein, Tukiainen et al. (2015) defined ULL as a system, constructed so that it can be used to experiment and co-create with the user the solutions of which the user will be the consumer. In addition, ULL refers to a system in which end users, together with various types of entities, including researchers, companies and public institutions, jointly research, design and approve new innovative products, services and solutions of which they are to be the intended consumers. This approach to terminological issues is also shared by Polish authors, who were the first to attempt to define the phenomenon, adapting the definition of ULL to the socio-economic conditions of Central and Eastern Europe. In a publication by M. Bień et al. (2020) ULL was defined as an instrument (organization and physical space - office and/or part of the city selected for testing selected solutions) of cooperation between city authorities and residents (including, in particular, those represented by non-governmental organizations), businesses (from local micro-enterprises to global corporations) and scientific entities (universities, scientific and research units, experts), aimed at improving the quality of life of residents through innovative solutions to identified problems (initiating, testing, implementing and evaluating projects) and generating additional value using city resources.

This definition refers to the concept of creating innovation ecosystems, which was inspired by solutions used in the ICT world at the turn of the 20th and 21st centuries (Almirall et al., 2012; Paskaleva & Cooper, 2021). It was implemented in the framework of cooperation between academic centers and the external environment (Bajgier et al., 1991), and finally transferred to urban governance. It enables incubation, promotion and testing of new ideas for urban development (McCormick & Hartmann, 2017), as well as participatory intervention in the face of emerging challenges (Sandholz, de Carvalho Turmena, Hardoy & Almansi, 2022). The key features of ULL include: 1. geographic rootedness and dependence on the local context; 2. experimentation, testing and learning; 3. participatory nature; 4. support for responsible leadership; 5. openness to evaluation and improvement (Voytenko et al., 2016).

Urban Labs can be considered a form of experimental management in which city users design, develop and test new technologies, products and services to develop innovative solutions to urban problems and challenges (Voytenko, 2016). This experimental formula assumes the ambiguity of expected results, which affects the difficulty of assessing the effectiveness and innovation of ULL. However, the failure of experiments in this situation is inherent in the project's design, and coordination of activities can be cost- and resource-intensive (Steen & Van Bueren 2017), and maintaining a balance between stakeholders - can sometimes be difficult (Leminen, Westerlund & Nystrom, 2012; Hakkarainen & Hyysalo 2013). As a result, ULL is characterized by a high "mortality" rate (Nesti, 2015). In addition, if we agree that shortcomings and failures are part of the process of learning through innovation creation (Bień, Jarczewski & Piziak, 2020), the issue of performance measurement becomes even more complicated, as it suggests that performance evaluation - more than to the assumed "hard" outcomes" - should refer to the identification of valuable and ineffective approaches (Van Geenhuizen, 2018), to the process of learning and circulation of information on innovation implementation, and to the improvement of stakeholders' knowledge, competencies and skills for collaboration around innovation generation and implementation.

2.2. Urban Living Lab and the Sustainable Development Goals

The SDGs and Agenda 2030 have a predominantly global ambition and are targeted at policymakers representing nation-states, but with broad involvement of different types of stakeholders. The SD should be rooted in local, grassroots initiatives, which often take the form of more experimental efforts. "It is in this tension between global ambition and local necessity that living labs can play a vital bridging role (...)

The role of living labs as a contributor to the SDGs is particularly relevant through its social impact process of partnerships and innovative solution development" (Molnar et al., 2023).

Over the past few years, there has been a steadily growing interest in ULLs as a tool to support the achievement of the SDGs, such as in the context of socioeconomic development (Leal Filho et al., 2022; Rodrigues and Franco, 2018), education (Purcell et al., 2019; Findler et al., 2019;), the circular economy, urban mobility, sustainable urban planning and sustainable consumption (Sierra-Pérez & López-Forniés, 2020), and climate change challenges (Leal Filho et al., 2021). According to Compagnucci et al. (2021), ULLs as collaborative platforms can promote long-term partnerships between stakeholders, thus contributing to their effectiveness in achieving collaborative goals, particularly SDG 17 - Partnerships for the goals (Leal Filho et al., 2022). They can also facilitate the testing and scaling of various tools for SD.

It is possible to identify two main ways in which ULLs can be involved in the implementation of SD ideas. First, by implementing activities that have similar goals to the SDGs (27). Second, by contributing to SDG monitoring, reporting and dissemination. Currently, it seems that the first way is dominant in ULLs - and although their activities may lead to solutions that coincide with the achievement of the SDGs, but it is difficult to assess and parameterize (Molnar, et al., 2023). Perhaps this is the reason why urban laboratories are less active in monitoring and reporting on the SDGs.

Given the technical nature of SDG reporting, it is understandable that ULLs may not have the expertise resources to directly contribute to "hard" monitoring mechanisms. However, there are also more user-friendly monitoring tools (OECD, 2020). For example, the reporting and monitoring of local implementation of the SDGs in cities is referred to by the Voluntary Local Review - VLR initiative, which is promoted by the UN to increase the importance of local efforts to implement SDG concepts (Siragusa et. al. 2022; Derner, 2022; Ruiz-Campillo & Rosas Nieva, 2022; Osman et al. 2021; Desa 2019; Andersdotter-Fabre, 2017). Although ULL's activities are sometimes shown in such reports (e.g., Hamburg), however, such mentions are found in very few such documents. It should be noted here, however, that the idea of VLR is not widespread in Poland, and according to the Online Voluntary Local Review (VLR) Lab, not a single such report has been prepared in Poland (IGES, 2024). The urban context of SDG implementation in Poland, on the other hand, is the subject of analyses prepared at the national level within the Voluntary National Review - VNR (Council of Ministers, Poland, 2023); where, however, we find no mention of the ULL phenomenon. The same is true of reporting on the subject at the European level (EU, 2023).

2.3. Selected contexts of SDG implementation at Urban Living Labs

The literature emphasizes that the practical implementation of the SDG concept is often associated with the presence of development dilemmas, which we can be considered on three levels.

1. The first level of such dilemmas is the manifestation of conflicts of interest. "While multidisciplinary urban problems often trigger transdisciplinary approaches in urban experiments, this does not necessarily lead to an integration process. Co-creation (as part of ULL's work) requires that interests and perspectives are transparent and subject to debate. If differences are not articulated openly, co-creation processes become prone to manipulation by parties (within and outside of the municipality) who want to impose their interest or perspective. Non-transparent power games are harmful for co-creation and reduce the possibility of joint learning" (Scholl, Kemp & de Kraker, 2017).

2. The second level, which can be described as temporal, refers to the timeline and addresses dilemmas in choosing short-term or long-term benefits. Long-term benefits seem easier to secure if ULL's activities are linked to a strategic vision for the city's development. It is then possible to coordinate the goals and their timeframes and how to achieve synergies of activities (Scholl, Kemp, 2016; Scholl, Kemp & de Kraker, 2017).

3. The third level of dilemmas in the context of implementing the SD concept concerns the discrepancy between individual and collective rationality. It refers to game theory and concerns the search for balance between individual and collective benefits. Individual rationality will focus on the goals of a group or organization (e.g., improving the image of the local government, CSR, solving local residents' problems, testing new products/concepts). By collective rationality, I mean adding additional criteria for individual rationality. This can manifest itself in two ways. First - as taking into account the interests of other individuals/groups/organizations, and especially certain categories of people (e.g., the most vulnerable, mar-

ginalized, dependent). Second - as a focus on maintaining or repairing social institutions deemed valuable (Dunn, 1994).

An important aspect affecting the way SDGs are implemented in ULL in the context of individual and collective rationality is the formula of organization and the nature of participation of individual partners. There are laboratories that rely on self-organization and grassroots initiative (Barbanente, Mono, 2018). There are those that form their activities as a top-down planned initiative of a single entity, such as a local government or university (Morales, Segalas & Masseck, 2023; Tercanli & Jongbloed, 2022; Kaszkur, 2020). There are also those that are formed by clustering existing initiatives (Guerra & Syed, 2024). Categories of participation - core, active, passive - of certain actors are fluid (TUC, 2022), so the determination of dominant rationales is time-varying and context-dependent.

3. RESEARCH METHODS

3.1. Scope of research

Our study concerns the functioning of ULLs in Polish cities, which does not have a long history. Urban labs in Poland began to function in an organized manner and in accordance with the generally accepted operating formula in 2019. Previously, there were attempts to implement projects using the living lab method, but their implementation usually ended once funding for these projects was over. Currently operating ULLs in Poland have diverse goals, cooperation formulas, origins of functioning, and schemes for implementing and financing activities. Even an unambiguous determination of the number of urban labs currently operating in Poland poses difficulties due to factors such as diverse nomenclature (e.g. “urban lab”, “living lab”, “smart lab”, “innovation center”, “creativity center”), ephemerality, frequent dependence on external, project-based sources of funding (Bień, Ner & Piziak, 2020). We are aware that the different criteria adopted by researchers for assessing the functioning of ULLs have an impact on their identification and classification. In light of our analysis, actively operating ULLs in Poland (as of August 2024) are presented in Table 1.

Table. 1 Active urban laboratories in Polish cities (as of October 2024).

Lp.	Nazwa of the ULL	City	Address	Seat
1.	Śląski Urban Lab	Gliwice	Marcina Strzody 8, Gliwice	Minucipality
2.	Urban Lab Rzeszów	Rzeszów	3 Maja 13, 35-030 Rzeszów	Minucipality
3.	Urban Lab	Gdynia	Gdynia al. Zwycięstwa 96/98 81-451 Gdynia	The building of Pomorski Park Naukowo-Technologiczny
4.	Urban Lab Mysłowice	Mysłowice	ul. Grunwaldzka 8, Mysłowice	Minucipality
5.	UrbanLab WGSR UW	Warszawa	Krakowskie Przedmieście 30, p. 114	Uniwersity of Warsaw
6.	SmartCity Lab	Chełm	ul. Ceramiczna 3E 22-100 Chełm	Chelm Economic Activity Center
7.	Urban Lab Toruń	Toruń	ul. Fosa Staromiejska 3, Toruń	Nicolaus Copernicus University of Toruń
8.	UrsynLab - Przedsiębiorczy Ursynów	Warszawa	al. Komisji Edukacji Narodowej 61, Warszawa	Ursynów District Office
9.	Green Lab Toruń	Toruń	ul. św. Katarzyny 5 lok. 3, Toruń	Pracownia Zrównoważonego Rozwoju (Foundation)
10.	Stalove Urban Lab	Stalowa Wola	ul. Ks. J. Popiełuszki 10, Stalowa Wola	Stalowa Wola City Hall - Municipal Public Library
11.	Campus Living Lab	Kraków	ul. prof. St. Łojasiewicza 4, Kraków	Jagiellonian University in Cracow
12.	Szarlota LAB	Rydułtowy	Ofiar Terroru 49, Rydułtowy	Minucipality

It is worth noting that the quantitative growth of such initiatives and the expansion of their reach to smaller urban centers is visible, as well as their increasing association with the category of innovation and networking of cooperation in the city. Polish Urban (Living) Labs draw on good practices and foreign in-

spiration, but the implementation of solutions is sometimes difficult due to, among other things, the still smaller involvement of Poles in participatory projects in the cities compared to Western European societies, less activity in building grassroots initiatives, frequent negative attitude of residents towards public authorities, as well as the different mentality of society in its approach to cooperation and joint problem solving. Understanding the complex operations of the socio-spatial system of urban resources, actors and governance, as well as local stakeholder dynamics, seems essential for the effective functioning of ULL (Wróbel & Wisniewska, 2021).

Another major aspect of ULLs is the importance of individual sector stakeholders in initiating and leading projects and particular activities (Piziak, Bień, Jarczewski & Ner, 2023; Arnkil, Järvensivu, Koski & Piirainen, 2010), as well as their financing. Pilot programs on the implementation of the urban laboratory instrument in Poland were introduced in two Polish cities - Rzeszów and Gdynia - thanks to the cooperation of local governments and the ministry coordinating the redistribution of EU funds in Poland, as well as a research institute that coordinated the entire implementation process from the technical side (Bień, Jarczewski, & Piziak, 2020). In European countries, in addition to public funding, one can see a significant contribution of private investors or fundraising by universities, while in Poland the main source of funding is still EU funds and local government budgets, while the private sector is often not even aware of the existence of ULLs and the initiation and support of projects implemented in them (Wróbel & Wiśniewska, 2021).

3.2. Research procedure

We used a multi-stage research procedure. The first stage consisted of determining the research sample. It was intended to include all currently (as of 2024) operating ULLs in Poland. The very identification and selection of labs and the selection of those to be analyzed posed a challenge due to the aforementioned diversity of names, goals and forms of operation. In the end, we decided to adopt a declarative criterion, supported by an assessment of the activity profile. This means that if a structure identifies itself with the ULL concept, e.g. in the form of a reference in its own name or in the way it presents itself in certain expert circles (e.g. in the media, during public appearances) as an urban laboratory, then there is a sufficient argument for us to consider it as part of the sample. Such a method has been adopted by ULL researchers before (Evans & Karvonnen, 2014).

Table 2. Sources of knowledge and number of entries about the activities of the studied ULLs in relation to the SDGs.

	Name of the ULL (initial research sample)	Source	Entries	Collected from	Collected to
1.	Śląski Urban Lab	Facebook	26	30/06/2022	26/04/2024
2.	Urban Lab Rzeszów	WWW	483	09/10/2019	10/10/2024
3.	Urban Lab Gdynia	WWW	275	30/09/2019	16/03/2024
4.	Uban Lab Mysłowice	Facebook	126	23/01/2024	18/10/2024
5.	UrbanLab WGSR UW	Facebook	168	13/06/2024	20/10/2024
6.	Smart City Lab Chełm	WWW, Facebook	46	01/03/2024	18/10/2024
7.	Urban Lab Toruń UMK		Less than 20 entries		
8.	UrsynLab - Przedsiębiorczy Ursynów	Facebook	512	17/01/2022	18/10/2024
9.	Green Lab Toruń		Less than 20 entries		
10.	Stalove Urban Lab		Less than 20 entries		
11.	Campus Living Lab	Facebook	83	30/03/2023	15/10/2024
12.	Szarlota LAB	Facebook	188	04/02/2022	24/04/2024

Source: own work

Thus, initially the research sample included 12 entities: Śląski Urban Lab, Urban Lab Rzeszów, Urban Lab Gdynia, Urban Lab Mysłowice, UrbanLab WGSR UW, SmartCity Lab Chełm, Urban Lab Toruń UMK,

UrsynLab - Przedsiębiorczy Ursynów, Green Lab Torun, Stalove Urban Lab, Campus Living Lab oraz Szarlota LAB. The range of dates of origin of the material and the sample size for each laboratory is illustrated in Table 2. The cut-off date for collecting the material was October 20, 2024.

The second stage of the research procedure consisted of netnographic analysis of the websites of selected ULLs, as a result of which 1,907 research units (entries) were collected, i.e. snapshots of websites/FB describing ULL events and activities. Materials available on the Internet, websites and profiles on social media were analyzed, hence the information under the news tab - their frequency, regularity and timeliness - was important for the evaluation of activities. By far, the most frequently used medium by ULL was Facebook, which may indicate that in communicating the activities of these institutions, direct contact with residents is important, as well as the ability to inform and invite people to events held there. We assumed that we would eventually adopt the caesura of a certain number of entries (20) as a minimum threshold. As a result, we obtained a final sample consisting of 9 ULLs: Campus Living Lab, Ursyn Lab, UrbanLab WGSR UW, Urban Lab Rzeszów, Śląski Urban Lab, Urban Lab Gdynia, Urban Lab Mysłowice, Smart City Lab Chełm, Szarlota LAB Rydułtowy.

The third stage of the research procedure involved coding the research material. Each research unit in the MaxQDA software environment was assigned from 0 to 3 SDGs (maximum 3 SDGs) related to the entries under analysis, depending on the issue of the entry. The codes were assigned to the maximum 3 SDGs that were most prominently reflected in the given entries. Coding was done based on semantic field analysis and keyword search related to SDGs. In total, 3,374 codes were assigned to 1,907 entries, resulting in an average of 1.7 codes per entry. Based on the assigned codes, a ratio was calculated - the sum of codes for a particular SDG target for a particular ULL was divided by the total sum of codes of all SDG target codes for a particular ULL. The last column titled "Total" in Table 3 indicates the calculated indicator - the sum of codes for a particular SDG goal from a particular ULL divided by the sum of all assigned codes of all SDG goal codes for a particular ULL. This allowed us to determine the level of ULL activity in Poland in relation to each SDG.

In addition, in order to deepen the conducted research, two study visits were made to ULLs in Rzeszów and Warsaw. The purpose of the visits was to qualitatively analyze the space, observe the activities carried out at ULLs, as well as to obtain, through IDI, information from those involved in the operation of ULLs about their experiences and perceptions of the issue in question.

4. RESULTS

In the context of our research, the most prominent themes when it comes to SDGs within the activities of ULLs in Poland are those related to sustainable cities and communities (SDG 11), decent work and economic growth (SDG 8) and Industry, innovation and infrastructure (SDG 9).

The data are interesting when it comes to the prevalence of interest in specific SDGs, 6 of the 17 SDGs were the focus of all ULLs surveyed. These are SDGs 4, 8, 9, 11, 16 and 17. The least interest of ULLs can be seen with SDGs 1, 2, 6, 7 and 14.

Analyzing the involvement of individual ULLs, it is possible to propose a certain typology relating to the level of focus of activity on specific SDGs.

1. one-pillar strategy - identifies ULL activities in which the dominance of one SDG is clear. This group includes 4 ULLs focused on SDG 11 - UrbanLab WGSR UW, Urban Lab Rzeszów, Urban Lab Gdynia, Urban Lab Mysłowice, as well as 2 ULLs focused on SDG 8 - Ursyn Lab and Szarlota LAB Rydułtowy.

2. two-pillar strategy - defines ULLs activities with focus on 2 SDGs. Such a strategy is represented by 2 ULLs - Śląski Urban Lab (SDG 11 and SDG 16) and Smart City Lab Chełm (SDG 9 and SDG 11).

3. dispersion strategy - defines the type of ULLs in which activities are concentrated on several SDGs, without a clear dominant. This type was represented by one ULL - Campus City Lab.

The results of our research (Figure 1) show that there are three speeds among ULLs in Poland when it comes to involvement in SDG implementation. The ULLs of the "First Speed" that are most focused on and committed to the main three selected SDGs are Smart City Lab Chełm, Szarlota LAB Rydułtowy and Śląski Urban Lab. Second speed ULLs included Urban Lan WGSR UW, Ursyn Lab - Przedsiębiorczy Ursynów and Campus Living Lab. The "Third Speed" group as far as SDGs are concerned included ULLs from Gdynia, Rzeszów and Mysłowice.

Table. 3. ULLs activity in Poland in terms of individual SDG targets.

SDG	Campus Living Lab	Ursyn Lab	Urban Lab WGSR UW	Urban Lab Rzeszów	Śląski Urban Lab	Urban Lab Gdynia	Urban Lab Mysłowice	Smart City Lab Chełm	Szarlota LAB Rydułtowy	TOTAL
1. No poverty	0%	0%	0%	0%	0%	3%	0%	0%	1%	0%
2. Zero hunger	1%	0%	1%	0%	1%	1%	0%	0%	1%	0%
3. Good health and well-being	4%	1%	3%	6%	0%	10%	11%	0%	1%	5%
4. Quality education	16%	14%	16%	14%	10%	8%	11%	11%	5%	12%
5. Gender equality	0%	1%	1%	1%	0%	1%	7%	0%	1%	1%
6. Clean water and sanitation	1%	0%	0%	1%	0%	1%	0%	0%	0%	1%
7. Affordable and clean energy	0%	0%	0%	1%	0%	0%	0%	0%	1%	1%
8. Decent work and economic growth	2%	37%	2%	6%	1%	2%	5%	3%	42%	14%
9. Industry, innovation and infrastructure	20%	11%	13%	13%	3%	6%	2%	34%	20%	13%
10. Reduced inequalities	4%	8%	2%	6%	1%	8%	12%	0%	10%	7%
11. Sustainable cities and communities	22%	9%	34%	26%	33%	30%	32%	33%	4%	23%
12. Responsible consumption and production	3%	2%	3%	2%	3%	3%	5%	0%	2%	2%
13. Climate action	3%	1%	4%	7%	1%	12%	0%	5%	1%	5%
14. Life below water	1%	0%	0%	0%	0%	1%	0%	0%	0%	0%
15. Life on land	5%	0%	4%	2%	7%	1%	0%	0%	0%	2%
16. Peace, justice, and strong institutions	1%	3%	6%	6%	26%	7%	10%	1%	4%	6%
17. Partnerships for the goals	19%	14%	13%	10%	11%	7%	5%	13%	7%	10%

Source: own work

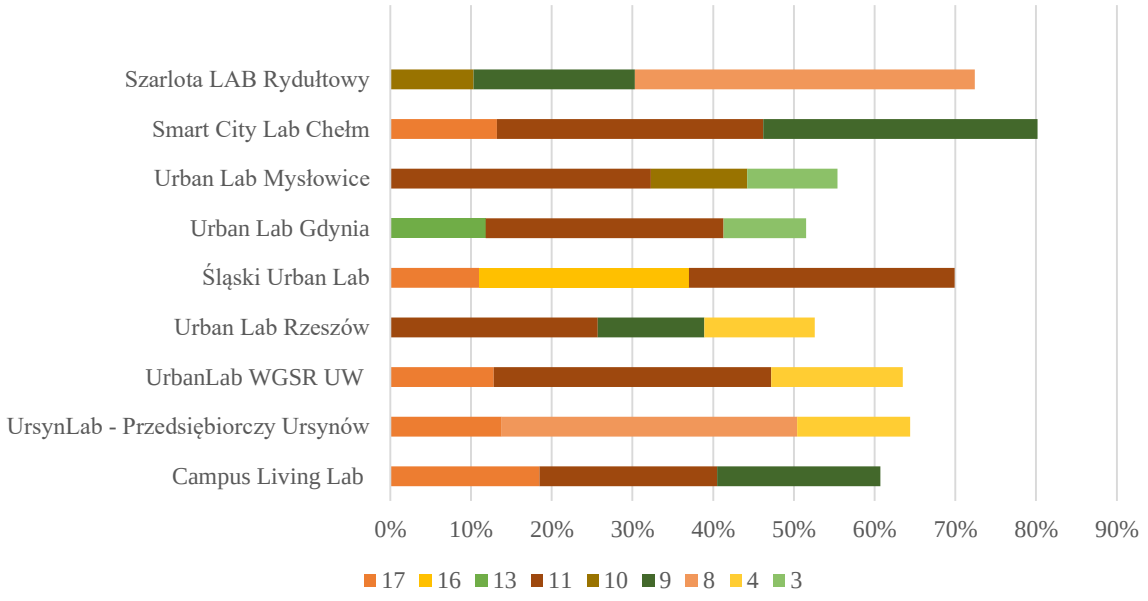

Figure 1. ULLs' involvement in SDG activities.
Source: own work

5. DISCUSSION

In this article, we sought answers to 3 research questions: 1. Which SDGs are implemented in the framework of ULLs activities in Poland? 2. Which SDGs are overlooked in the framework of ULLs activities in Poland? 3. Are there specific types/strategies of ULLs in Poland in the context of SDGs implementation?

Regarding the first research question, we have noticed a strong interest in the goals related to sustainable cities and communities (SDG 11), decent work and economic growth (SDG 8) and industry, innovation and infrastructure (SDG 9). SDG 11 is clearly related to urban development, so its presence in this list is certainly not surprising. The emphasis on economic issues may be related to the fact that the first experience of Urban lab in Poland is related to the concept of smart city. This model was the axis of the concept of the first pilot program, which became the beginning of change and the inspiration for the creation of subsequent ULLs.

In the context of the low interest in the issues of poverty, hunger, clean water and sanitation, we can look for an explanation in the fact that Poland has reached a certain level of civilization development, which makes the issues largely solved and they lose their importance. In Poland, the issue of living underwater does not seem to be the subject of public debate in wider circles, and even less so in relation to the quality of urban life, which, as we pointed out in the introduction, is the central focus of Polish ULLs. Consequently, this leads to less interest in the topic at ULL. What is most surprising to us, however, is the lack of emphasis on affordable and clean energy in the activity. This is a topic that is of strong interest of Polish local governments, widely covered by the media and affecting residents to a large extent. Strategic documents are being created in this regard, new industries are being developed, legislation is being passed, financial tools are being launched, and all this results in a high relevance of the topic in relation to local development. Some explanation may be provided here by the fact that energy issues, however, concern capital-intensive issues and projects and are the responsibility of companies operating in cities or commercial entities appropriate for this, while urban laboratories, however, deal with micro-innovations and projects on a much smaller scale implemented in cities.

As for ULLs in Poland, most of them are initiated and managed by local governments. This is a different trend than the state of the art indicates, where the initiative and involvement of universities is emphasized (Piziak, Bień, Jarczewski & Ner, 2023; Leal Filho W., 2021). In the light of our in-depth research, when we had the opportunity to speak directly with ULLs stakeholders, it became clear that although ULLs are a local government initiative, however, the local government as a single entity is not involved, but only selected organizational units. This confirms the analyses that speak of the siloed nature of public administration, which can involve dilemmas related to differing rationales for SD, and even conflicts of interest between different offices or departments. Only when engaged in innovative collaborative formulas (like ULL) can it move beyond narrow specializations and see complex problems holistically. Perhaps, at this stage, the energy issue is precisely a "victim" of the indicated siloed character of public administration, and additional efforts are needed to invite local government stakeholders to open up the field of dialogue and cooperation on this issue more.

6. CONCLUSIONS

To summarize the research conducted, we would like to point out its limitations. One type of limitation stems from the way we obtained data. We analyzed information made public on websites regarding ULLs' activities. However, using this method, it is impossible to be sure that we found information on all forms of activities that were actually carried out for the SDGs. A possible way to confirm the consistency of information from the website with the facts would be to conduct interviews with people with longer tenure in ULLs' structures. Here, however, there is a danger arising from the selectiveness of memory, as well as putting a better value and giving more importance to the types of activities in which people were directly involved.

There are several remarks worth making in the context of the very choice of ULLs as the subject of the study. The most significant conclusion regarding the ULL study procedure itself relates to a challenge we encountered early on in our research work, namely their ambiguity (in terms of naming and formula) and instability (due to the sources of financing and the managing entity). Our research shows that they have varying dynamics. Some are operating vigorously, while some seem to be currently in a dormant phase, but are not officially dissolved. ULLs do not report the end of their activities, hence it is not always clear whether what we are investigating is still an active entity or just appears "on paper." This "hibernation" may be related to the way ULLs' activities are financed in Poland and their dependence on having external grants (especially support from European funds) to carry out specific projects.

The second challenge in studying ULLs is related to their embeddedness in the map of urban institutions. In light of our analysis, one can risk the thesis that redefining the position of local government and the dominant paradigm (from governance to management) plays an important role in assessing ULL activity in Poland. As said in the introduction, the following can be considered as activity that meets the prerequisites of innovation:

introducing a new product or process, defining and redefining the position of the organization, and defining or redefining the dominant paradigm of the organization (Mayle, 2006). If we assume that ULLs as innovation networks are shaped by the roles of individual stakeholders (Nystroma et al., 2014), and that ULLs in Poland are mainly led by local governments, then it should be recognized that innovation in ULLs will face the same opportunities and constraints as innovation in local government. As the main opportunities, one can point to personnel and organizational resources, high clout and a high level of trust of target groups. On the other hand, the most important drawbacks for innovation in this context are subordination to politics and tenure (resulting, among other things, in the turnover of personnel), proceduralism, less willingness to address topics that are controversial to the public and high risk.

The agenda of issues taken up by the ULLs we surveyed does not address topics that are antagonistic to the Polish public, such as the issue of converting religious buildings into facilities with different functionality. There also seems to be little use of culture and art for activities around SD (Urban Lab Rzeszów is an exception and a good example here). All this to some extent narrows the area of potential ULLs research and thus creates a somewhat hermetic circle of interested parties from the researchers of the phenomenon. This affects the possibility of showing ULLs activities in different contexts and to different audiences. In conclusion, we would like to point out potential directions for further research.

1. Our research confirmed that ULLs are involved in the implementation of SD ideas, but have almost no contribution to SDG monitoring, reporting and dissemination. As for the key features of ULL (mentioned by Voytenko), our research shows that in Polish ULLs, geographic rootedness and dependence on the local context and participatory nature are of particular importance. The activities analyzed by us in terms of SDG indicate the multiplicity of stakeholders from different environments. This opens a potential field for further research on ULLs as elements of the network of municipal institutions.
2. Our research has resulted in the proposal of 2 typologies. One is based on ULLs' activity strategy with respect to one, two or multiple SDGs. The other typology relates to ULLs' involvement in the implementation of the SDGs, and based on this we distinguished 3 speed groups. The typologies we proposed can be used for further analysis focused on the research problem posed.
3. Our article was based on desk research. The analysis of the literature on the phenomenon of ULLs and innovative urban development management tools, as well as on approaches to local implementation of the SDGs, and a search of the websites and social media of selected ULLs was conducted. We sought information on ULLs activities in Poland from the perspective of the SDGs. Our research included a qualitative component on a limited basis, in the form of four verification interviews. It seems that this exploratory research in the next step could be supplemented by survey tools. With these, it would be possible to obtain the opinions of the participants in these events on their assessment of the connection between the activities of urban laboratories and specific SDGs. A postulate for further research is an in-depth qualitative analysis and conducting a broad panel of interviews with representatives of the ULLs community - stakeholders and beneficiaries of the activities (with the limitation related to subjectivity that we wrote about earlier).

At the same time, we would like to note that the ULL research we have undertaken in the context of achieving SDG goals is one of the few that has been carried out in such a broad sense in relation to a given country. Such publications, addressing this timely and relevant topic amidst global urbanization trends and sustainable development challenges, are still relatively few.

Acknowledgments: The authors thank the reviewers for their valuable comments.

Use of AI tools declaration: The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Author contributions: All authors contributed equally to this work. All authors read and approved the final manuscript.

Conflicts of interest: The authors declare no conflicts of interest.

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Central European Journal of Geography and Sustainable Development
ISSN 2668-4322, ISSN-L 2668-4322
2024, Volume 6, Issue 2, Pages: 50-75
https://doi.org/10.47246/CEJGSD.2024.6.2.4

Exploring Agricultural Heritage Landscapes in the Balkans: Insights from the Danube Delta and the Valley of Roses

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Received: 12 November 2024; Revised: 19 December 2024; Accepted: 21 December 2024;
Published online: 24 December 2024

ABSTRACT: Archaeology has the potential to address environmental challenges in the Anthropocene by offering valuable lessons from historical experiences. However, its application in mitigating the climate crisis and enhancing community resilience still needs to be explored. This analysis positions archaeology as a novel perspective for characterising and managing Agricultural Heritage Landscapes (AHLs)—traditional farming systems with exceptional cultural and environmental value shaped by their unique landscapes. In the Balkans, rich yet understudied landscapes and vulnerable communities practising traditional farming provide intriguing study cases. The present article focuses on the fishing traditions in Romania's Danube Delta (focusing on Letea village, Mila 23 and Crisan) and rose oil production in Bulgaria's Valley of Roses (mainly Kazanlak). Using the AHL methodology, these practices are examined, particularly emphasising their archaeological dimensions and integration within a food systems framework. This approach uncovers innovative management strategies and advocates for revising the AHL methodology to incorporate archaeological and food systems perspectives. The urgency of protecting AHLs in the Balkans is underscored, highlighting the essential role of archaeology in proposing solutions such as diversifying land use, fostering community education, and understanding the evolution of cultural traditions. Additionally, the discussion emphasises the need for robust policies and more quantitative analysis to safeguard cultural heritage and landscapes. By drawing on its rich insights into the past, archaeology can inform policies that help AHLs maintain their identity while adapting to the challenges posed by the climate crisis.

KEYWORDS: agricultural heritage, heritage landscapes, environmental archaeology, landscape management, sustainable heritage.

TO CITE THIS ARTICLE: Luca, Ş.D. (2024). Exploring Agricultural Heritage Landscapes in the Balkans: Insights from the Danube Delta and the Valley of Roses. *Central European Journal of Geography and Sustainable Development, 6*(2), 50–75. https://doi.org/10.47246/CEJGSD.2024.6.2.4

1. INTRODUCTION

The United Nations (UN) proposed 17 Sustainable Development Goals (SGD), stating that humans cannot thrive without addressing climate change (European Commission, 2021). While no past society perfectly mirrors the 'global village' experience that characterises our present societal landscape, we find striking similarities in their services, including economics and trade, social norms, food, shelter, and belief systems, which, to varying degrees, have influenced and continue to shape institutions and settlement patterns that endure today (Rick & Sandweiss, 2020). In this context, archaeology places itself at the intersection of the cultural and natural, offering the possibility of studying the dynamic of the two across time and space (Rivera-Collazo, 2022) and remains an underexplored source of inspiration for policymakers. To date, archaeology (which is mainly represented in the mainstream discourse through a culture's tangible heritage) and climate change have only been addressed together concerning Indigenous

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communities. The US Fourth National Climate Assessment points out that Indigenous communities will have their history and heritage affected by climate change (Markon et al., 2018), which, while correct, is an affirmation based on falsely defined and associated terms. Indigenous communities, archaeology, and heritage are not mutually defined, as they, while having a rich heritage, still belong to contemporary times dealing with contemporary challenges (Rockman & Hritz, 2020).

All human societies have history and heritage affected by climate change, including the development of modern socioeconomic systems that have led to a human-driven shift in climate (Hollesen et al., 2018), but also vulnerable communities, which, in Europe are represented by ethnic minorities and the ones living in the Balkans (Rovolis, 2011). Moreover, communities in Balkan countries present unique traditions, including agricultural practices (Tomova, 2003), which are excluded when discussing heritage conservation regarding food systems and agriculture, as no studies up to the writing of the present analysis appear to have covered them.

The present analysis proposes traditional agricultural landscapes as invaluable cultural and natural heritage that, if protected, could provide a multifunctional strategy to mitigate the effects of climate change and boost local resilience and economy, meaning that trade-offs are minimised. Agricultural heritage is the crystallised expression of material and immaterial culture showcasing the complex human-nature dynamics that have persisted through time and are still present, making it a way archaeology can be integrated into the climate discourse. Agricultural heritage landscapes (AHLs) are "physical space on the earth's epidermis, yet with mental and cognitive attachments to the past, present and future of spatiotemporal characters, and inextricably related to memory" (Gkoltsiou et al., 2021); this relationship to memory creates mental values interpreted as cultural heritage. Agricultural heritage systems possess outstanding universal values and require unique dynamic conservation and management strategies. Currently, initiatives striving for agricultural heritage landscape protection are in their infancy worldwide, with one of the most significant being the Globally Important Agricultural Heritage Systems (GIAHS) initiated in 2022 under the Food and Agriculture Organization (FAO) of the UN (FAO, 2022). GIAHS defines agricultural heritage systems as "outstanding landscapes of aesthetic beauty that combine agricultural biodiversity, resilient ecosystems and a valuable cultural heritage (FAO, 2022)", focusing on the human experiences in a landscape, including resilience to climate and different socio-economic forces (Gkoltsiou et al., 2021).

There are only ten designated systems in Europe and Central Asia, all of them belonging to countries situated in South and Western Europe. Nowadays, Europe has the highest percentage of residential rainfed croplands, residential villages, and residential woodlands, meaning there is a lot of potential for exploring agricultural landscapes on the entire continent (Ellis, 2021). As no site in the Balkans is included in the GIAHS list, and many of the sites that are recognised at a national level do so by separating the traditions from the landscape (Printsmann et al., 2012), the present analysis aims to reveal the importance of a few systems in the Balkans where the two combine.

Hence, the primary objective is identifying and evaluating the Balkan region's farming landscapes and agricultural heritage. Two sites were identified by scanning literature on tourism: the Danube Delta in Romania and the Rose Valley in Bulgaria. This study represents the first attempt at characterizing their natural and cultural heritage as no previous academic literature has compiled this information. While the central methodology is concerned with characterizing the landscapes in the present and planning the future, the present analysis takes a different approach by shifting the perspective to emphasize that research should appreciate the deep time dimension of traditions and inhabitations and how this approach can inform us about the future. Secondly, the foods and other derived products are investigated as additional dimensions to the existing research. The key methodological framework is based on a recent article touching on three agricultural heritage landscapes in Greece (Gkoltsiou et al., 2021). After characterizing the landscapes, the final objective of the study is to identify potential methodology improvements/future steps by addressing its limitations, such as not including the dimensions of food systems and a deeper perspective on the past. This involves emphasising archaeology's role and its potential to impact policy, representing a novel approach in the field.

2. LITERATURE REVIEW

The Balkans is the easternmost of Europe's three greatest peninsulas and usually comprises Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Kosovo, Montenegro, North Macedonia, Romania and Serbia, as all or at least a part of each of those countries is located within the peninsula. The most accepted definition follows the geographical delimitations indicated by the Danube-Sava- Kupa line, meaning the proportion of the mainland south of the three rivers is considered the Balkans (Figure 1)(Jelavich, 1993).

The present analysis deals with land use and the role land plays in constructing heritage, making the physical space of the study a central element, although the landscapes are not separated from their governing entities. Nonetheless, it is essential to acknowledge that the communities inhabiting these regions have actively shaped them and created their identities, meaning "Balkan" does not define a cultural monolith. However, common themes (reliance on agriculture for job security, understudied landscapes, lack of resources for cultural research and finances for culture conservation) (Rovolis, 2011) make the Balkans an intriguing area of European study.

Figure 1. Outline of the Balkan Peninsula, following the Danube-Sava-Kupa line, highlighting the location of the two landscapes analysed (the Danube Delta in the northeast and the Valley of Roses in the center-north of the peninsula.
Source: Made by the author using ArcGIS.

Only four Balkan countries are part of the European Union (EU) (Greece, Bulgaria, Romania, and Croatia). Others are candidates or potential candidates for EU membership (8), which impacts their mitigation strategies, resources and archaeological and conservation work. The EU contains a mosaic of heterogeneity and heritage associated with agriculture, reflected in the number of small farms (two-thirds of the 10.3 million farms were less than 5 ha in size in 2016) (Gkoltsiou et al., 2021). In 2020, the number of farms decreased (9.1 million), although the proportion of small-scale farming remained the same (Eurostat, 2022). It has been shown that these small-scale farmers are more likely to use traditional

methods and rely on their land to gain an income (Toma et al., 2021). Although agricultural landscapes can vary from cropland to wetland, they present great ecological, economic, aesthetic, recreational, and cultural value. They can provide food, pharmaceuticals, forage and fibre, as well as support genetic biodiversity, soil fertility and water purification (Gkoltsiou et al., 2021). Although named an "anathema to conservation" (Power, 2010), if carefully managed, they can help in flood control, carbon storage, waste management, and climate regulation, making them a valuable system often underappreciated (Ortiz et al., 2021).

Innovative solutions must be proposed tailored to the diverse landscapes of the Balkans (Cvijic, 1918; Tonta, 2009). In this analysis, the cultural dimension of the landscapes is considered an essential factor in their quest for sustainability, which will be analysed through time. Potential Balkan agricultural heritage landscapes would benefit from being included in conservation efforts, as more recognition and resources will be allocated. After investigating popular opinions from various countries regarding landscapes considered vital to the national identity of the people who bear a long line of traditional knowledge related to farming and crafts (Hristova, 2022), some of the most appealing sites found were the traditional fishing villages in the Danube Delta, Romania and the Rose Valley of Bulgaria.

3. RESEARCH METHODS

3.1. Presenting the Geography, History, Culture and Landscape

A literature review was conducted to offer a comprehensive overview of the sites and their agricultural heritage. For each site, keywords were chosen as follows:

- Danube Delta, heritage, traditional agriculture, landscape, fishery, fish, ancient, Histria, Halmyris.
- Rose Valley, Kazanlak rose, Damask rose oil, traditional agriculture, Rose Valley, Bulgaria.

These keywords were used to find articles relevant to the topic using SOLO (Search Oxford Libraries Online) and the Central and Eastern European Online Library. Moreover, Google Scholar was also used to find articles about the sites in the local languages. Web resources were also included, such as official websites of the UN and EU, Romanian and Bulgarian Government websites, and local NGOs. Accessing resources available remotely enabled finding elements of material culture associated with the traditions in the two sites.

3.2. Landscape Assessment

The present analysis uses the Agricultural Heritage Landscapes characterisation methods described in a recent article (Gkoltsiou et al., 2021). Hence, the methodological framework comprises geography, archaeology, landscape architecture and ecology theories. In their article, the authors use LCA, a framework published by the Countryside Agency and Scottish Natural Heritage (The Countryside Agency, 2002). LCA is a two-stage process comprising landscape characterisation and landscape assessment. While the former concerns understanding how the identity and type of landscape were created, the latter deals with landscape quality. Besides the LCA, a review of both the GIAHS criteria (FAO, 2022), focused on landscape, and the World's Heritage List (UNESCO, 2008), concentrated on the requirements for a site to be considered of universal value, was applied to the sites chosen for their analysis. These three sets of criteria were combined, and their interrelation was proposed as a new way of assessing landscapes, titled the Proposed Criteria for Acknowledgement and Conservation of AHLs (Gkoltsiou et al., 2021). The authors go further, compiling criteria for managing these sites to identify potential development areas in a section titled Proposed Criteria for Management of AHLs. The analysis applies the combined criteria to the Danube Delta and the Valley of Roses. This theoretical framework can be applied using the existing literature, as Gkoltsiou et al., 2021 did. Thus, it does not include any terrain work.

3.3. Food Systems and Products

Agriculture and production are the initial steps in a food system (Ingram & Zurek, 2018), meaning their impact goes beyond the landscape. While the primary focus of GIAHS and AHLs is to highlight the human dimension, this can only be fully achieved by considering the broader value of the landscape in the lives of the people, which could include food and other derived products (Gora, 2018), how people connect to local foods, and how food systems create work opportunities. This analysis will address

essential questions about the evolution of a food system to its current extent, the number of people who rely financially on it, and how management strategies could improve their lives.

Hence, the methodological framework of this analysis includes food and other derived products throughout history, as well as a deep time perspective of history and culture associated with the landscape (Figure 2). The integration is beneficial and crucial for a comprehensive understanding of landscape management

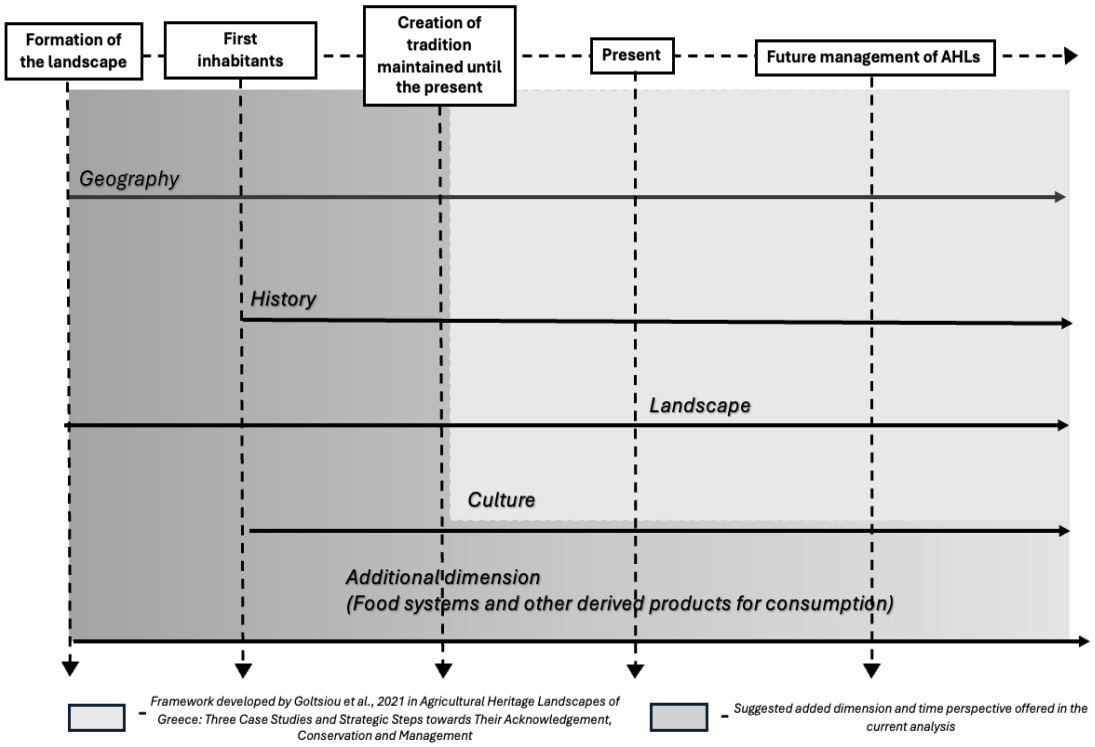

Figure 2. Diagram showcasing the expansion of the base methods.
Source: Made by the author.

4. RESULTS

4.1. The Danube Delta - Traditional Fishing Villages

The Danube Delta (Figure 3) is the second-largest wetland area in Europe and one of the continent's least populated areas in the temperate region (Romanescu, 2013). Most of the Danube Delta lies in Romania, the county of Tulcea, although a small part is found in Ukraine. It is the youngest territory of the Dobrogea region of Romania (also known as Dobruja) and marks the final stretch of the Danube's journey to the Black Sea (Figure 3, A). Tracing its origin to the end of the Würm glaciation (around 12,000 years ago), only 9% is permanently above water, with the constantly developing landscape resulting in a labyrinth of freshwater lakes, great fields of aquatic vegetation and flooded islets (Figure 3, C-E) (Péter, 2004). Much of the alluvium and major surface expansion since its formation resulted from soil erosion after anthropogenic forest clearing in the past two millennia (Giosan et al., 2012).

The Danube Delta is also part of the UNESCO World Heritage list, meaning it already fulfils the biodiversity criteria required to be considered an AHL. The Rewilding Europe initiative describes the region as economically depressed, harboring low living standards and a high percentage of rural depopulation, making it highly susceptible to unsustainable development and the loss of traditions associated with the landscape (Rewilding Europe, 2024). Although there is an effort to create new opportunities for the local communities to construct nature tourism infrastructure, traditions in the area appear to be mentioned rarely.

The Danube Delta Biosphere Reserve (DDBR) is almost entirely rural, comprising 26 villages and a town (Sulina) with around 15,000 inhabitants (Lup et al., 2017). The traditional fishing villages of the

Danube Delta are those in the Crișan commune (Caraorman, Mila 23, and Crișan), Sf. Gheorghe and Letea, although this analysis will mostly mention Letea. Mila 23 and Crisan. In the context of climate change, it is essential to acknowledge that the condition of the landscape features is declining, with the small tributary rivers being projected to face significant runoff reduction in the summer (by around 5-30%) by 2050, accompanied by an increase in droughts (Mauser et al., 2018). As a result of the rising sea level, eutrophication will increase while water quality will decrease, affecting biodiversity and agriculture (Crăciun et al., 2022). The effects of climate change on water and biodiversity are of extreme urgency in the Delta, as fishing and fish farming (to a lesser degree) are at the heart of the local economy (Damian, 2019). Moreover, deforestation and intensive agriculture in the northern part of the Delta increases erosion and, thus, water flow in the north distributary, Chilia, causing the northern part of the landscape to sink slowly (Winiwarter et al., 2013).

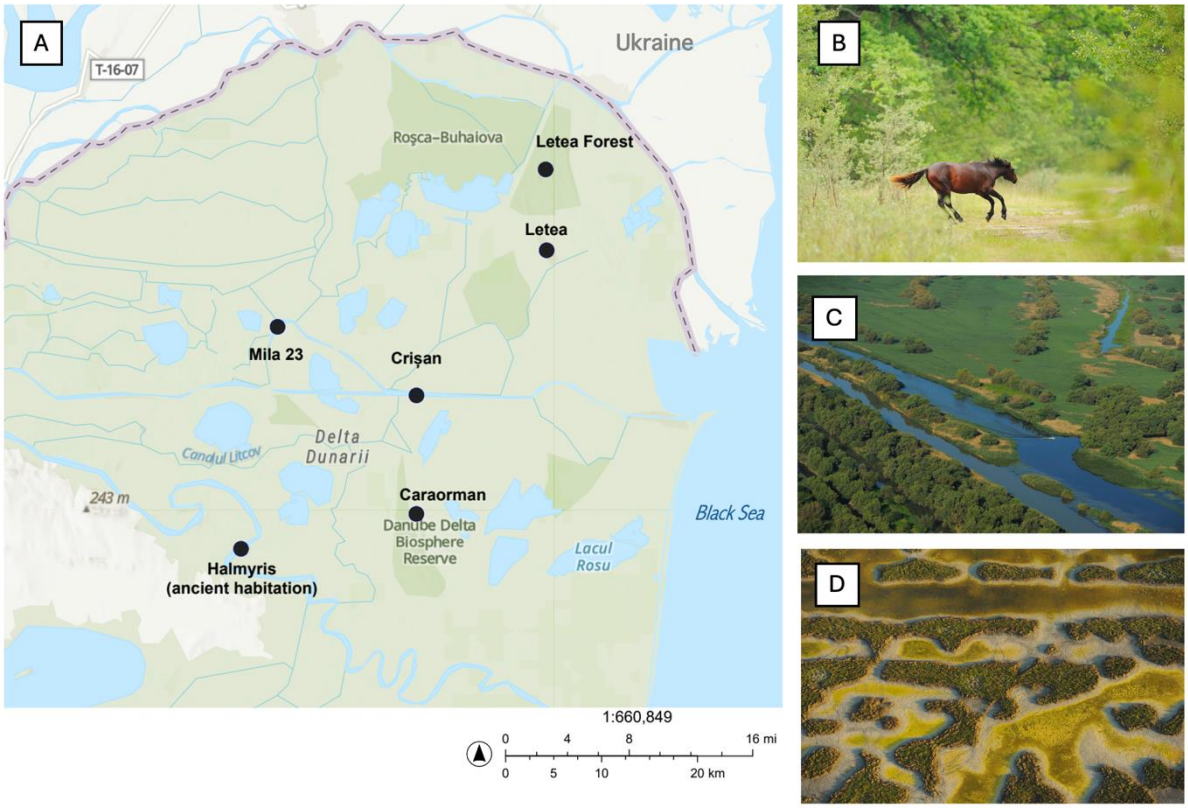

Figure 3. Overview of the Romanian Danube Delta **A**) Map of settlements mentioned in the text. **B**) Image of wild horse in Letea forest. **C-D**) Aerials of the Danube Delta Biosphere Reserve . **C**) Image of flooded islets forming in the Danube Delta. **D**) Image highlighting the formation of inland lakes and alternation with wetland vegetation.
Source: **A**) Map created by author in ArcGIS. **B-D**) Rewilding Europe, 2024.

4.1.1. History - Inhabitation, Land Use and Archaeology

As ceramic evidence suggests, villages such as Letea and Crisan have been populated since the 6th century BC, dating to the Greek period (Micu et al., 2016). After the Greek stage, there were Roman (1st century BC to 7th century AD) and Byzantine stages (7th to 14th century AD) and Turkish domination of the area (1417 to 1878 AD). During these stages, populations were dynamic and exploring natural resources on a large scale, although material culture remains regarding fishing is scarce (Micu et al., 2016). One of the most comprehensive studies on the region's environmental history focuses on the Roman settlement of Halmyris, where a complex picture of the subsistence practices of inhabitants during the 5th and 6th century AD was revealed (Stanc et al., 2023). Phytolith investigations identified strong signalling for cereal processing. The exploited animal resources varied, including mammals, fish, and molluscs. Still, the study does not go into the implications of the role fishing played in the economy,

despite the Roman inscriptions potentially referring to Halmyris as a mariner's village (vicus classicorum) (Stanc et al., 2023).

Remains such as fragmentary weights for a fishing net dating to the 10th-11th centuries, have been found in southern Dobruja (Paraschiv-Talmaţchi, 2018), giving the earliest fishing instrument recovered, although no such early tools have been identified from the Delta region. Between the 11th and 15th century AD, sturgeon harvesting became an integral activity in the Lower Danube (Hungary, Serbia, Romania), with several traditional fishing villages being established alongside the Danube close to the spawning site of sturgeons (specifically in Hungary)(Dinu, 2010). In 1878 AD, the Delta rejoined the other Romanian provinces, altering its ethnic structure and resulting in a complex mix of cultural identities, languages, and traditions.

4.1.2. Landscape – Architecture, Agriculture and Biodiversity

As most distances are covered by foot and vehicles are rare, the sand-covered country lanes give the deltaic villages a certain degree of isolation and a perspective that focuses more on the human scale than other more well-connected communities. They experience increased isolation during winter, which has led to the preservation of the vernacular architecture in the area, as seen in Letea village (Figure 4, C), an architecture inspired by the Russian populations settled in the Danube Delta (Maio, 2018).

Figure 4. Images from Letea village. **A**) Aerials of Letea, highlighting the small size of the traditional village. **B**) Lady from Letea in her garden. **C**) Vernacular architecture in Letea and an example of a garden attached to the house. **D**) Ladies in Letea use traditional hoes to weed corn.
Source: (Rewilding Europe, 2024)

Moreover, the remoteness makes the range of building materials to choose from relatively narrow, making traditional architecture blend subtly with its surroundings. One of the Deltaic people's most notable traditions is the roof thatching techniques using reed (Figure 4, A) (2). In terms of agricultural practices, the villages of the Delta present an intriguing landscape, where agricultural plots are primarily situated on the continental edge, although houses in the villages have their own gardens. Moreover, people use traditional agricultural tools such as hoes, making the plots a testament to persistent agricultural practices (Figure 4, D). Sheep, pigs, and cattle are the main animals bred in the area, and wheat, maize, sunflower, and soybeans are the main crops.

Regarding overall biodiversity, the Danube Delta is considered a protected area and included in the Natura2000 project (Anghel & Iordache, 2020; Spiliopoulou et al., 2023). Moreover, the Letea forest is home to a population of feral horses among the continent's last untamed equines (Stejskalova et al., 2019). The landscape contains endangered birds, such as the Dalmatian pelican (Pelecanus crispus)(Barboutis et al., 2021) and many species of fish (69 in 2021)(Năstase et al., 2021)with sturgeons being one of the most well-known types. Two out of the six species of sturgeons are extinct, while four are critically the highest threat category before extinction (Pekárik et al., 2019; WWF, 2019).

Romania banned sturgeon products indefinitely in 2021 (Ludwig et al., 2023) and aquaculture represents an intriguing possibility of fighting the decline of sturgeon stocks. More efforts are going into constructing sustainable aquaculture practices, the earliest recorded ones being from the 1990s (Directorate-General for Maritime Affairs and Fisheries, 2023). A general fishing ban occurs annually and can vary from 45 to 60 days between April and June, allowing the local fish population to reproduce and migrate. The DDBR is the most biodiverse section of the Danube, although it is also one of the most fragile, given the number of micro-ecosystems it encompasses (Gogaladze et al., 2022). Compared to the wider Danube basin, it becomes apparent that the is one of the least perturbed parts (Anđelković et al., 2022; Baldan et al., 2023; Csagoly et al., 2018), a unique landscape where salt and freshwater mix, with more than half of the entire number of fish species in the Danube (estimated at around 100)(Schletterer et al., 2018).

4.1.3. Culture – Traditions, Instruments and Social Initiatives

The ethnographic studies paint a dynamic life in the traditional fishing villages, emphasizing the variety of tools they used for fishing and the importance of cultivating one's garden. Thus, it can be argued that agricultural heritage in the DDBR comprises two strands: cultivation in private gardens using traditional tools and fishing heritage, although the latter has been recognized as unique to the region.

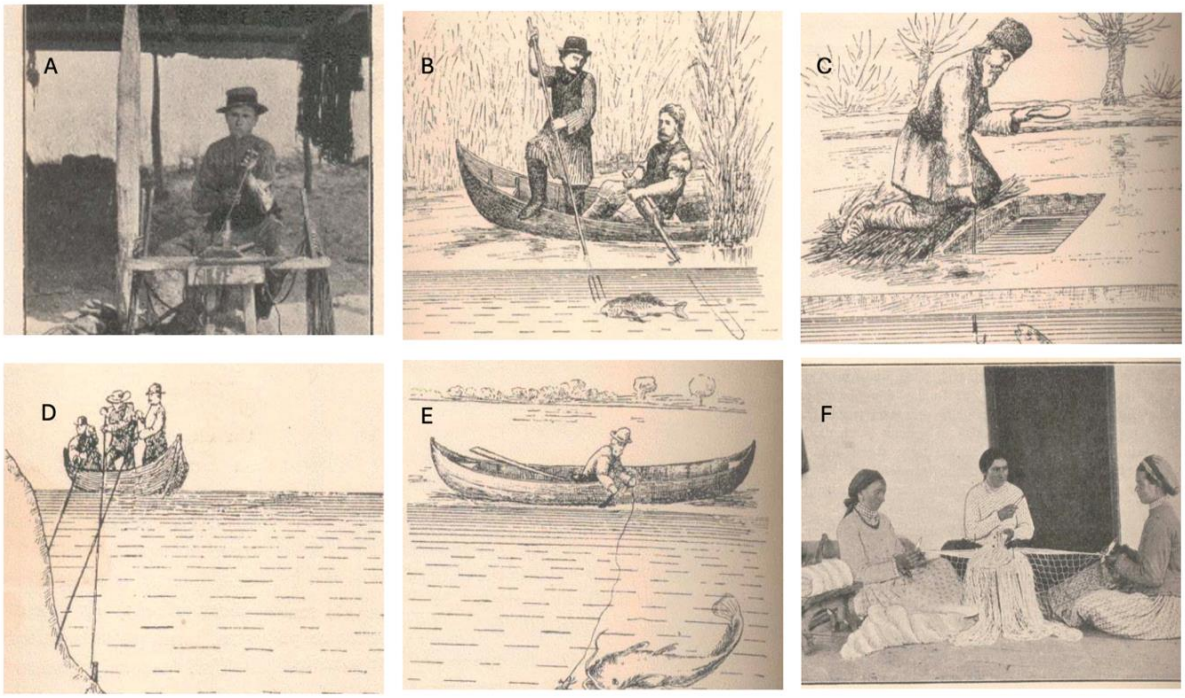

Figure 5. Examples of fishing with different tools and other related activities: **A**) Sharpening the hooks for "carmace". **B**) Fishing with an instrument called "osie". **C**) Fishing with a hook and a mirror that misleads the prey. **D**) Fishing with an instrument called "ghin". **E**) Fishing with a "clonc". **F**) Women working on a fishing net.
Source: Antipa, 1916.

Traditionally, women mainly worked in the fields and cared for the vineyards while also making and repairing fishing nets (Antipa, 1916) (Figure 5, F). Various other jobs were required to maintain fishing instruments, such as sharpening the hooks (Figure 5, A). To braid fishing nets, cotton was twisted in four

or six threads to create the braids, and women generally carried out this activity in winter (Revista de Lingvistică şi Cultură Românească, 2016). Fishing occurred primarily in inland waters, with different species being caught within specific time frames of the year and with specialised instruments. This showcases how folk ecological knowledge in the area balanced the resources exploited and the inhabitants. Fishing has left an imprint on the traditions associated with the region and shaped the cultural identity present to this day, primarily through constructing traditional fishermen's shelters and fishing tools specific to certain fish types, one example being the "carmace", now banned by law.

As fishermen used to be away from their homes for the entire season, they built shelters close to their fixed fishing spots, with some reflecting the traditional architecture of the houses (Maio, 2018). While away from the village, fishermen salted or fermented the fish to keep it fresh and met merchants to sell their catches, rarely returning home (Antipa, 1916). They would also prepare fish borscht, which is now considered a traditional dish.

Besides the efforts in the architectural sector, which aim to transform traditional fishermen's shelters into energy-efficient tourist housing that utilizes local materials and maintains the aesthetic, various other NGOs have proposed ways of rural development through the capitalization of traditions. The National Association for Rural, Ecological and Cultural Tourism (ANTREC), Tulcea Branch, has been organising from 2013 to 2018, in Crişan, the Danube Delta Fish Borscht Festival (ANTREC, 2018). This initiative celebrated traditional gastronomy and brought forward local chefs and folklore performances. ANTREC has also organised, from 2012 to 2019, the Danube Delta Pike Fishing Championship in Mila 23 and Crişan, encouraging participants to "catch, kiss, release" pike fish, hence encouraging sensible fishing practices (2019).

Another initiative that aims to bridge traditional knowledge and technology with modernity comes from the Ivan Patzaichin – Mila 23 Association. Ivan Patzaichin was a Romanian canoeist, born in Crişan commune, in the village of Mila 23, who came up with the idea to revive the traditional boat of the Danube Delta ("lotca" in Romanian) (ROWmania, 2020), after noticing the noise pollution caused by motorboats. Patzaichin observed that local workshops no longer build lotcas. Thus his association started advocating for a new boat, called the "canotca", that combines the canoe with the traditional boat, aiming for a more sustainable solution using local materials. The canotca would stand as a short-distance tourism option. This initiative spawned workshops for younger generations, teaching them to build canotcas (ROWmania, 2021). Moreover, some initiatives aim to bring back crafts, such as roof thatching with reeds, so that they can be acknowledged as intangible heritage (Maio, 2018). However, the available information did not reveal how the Covid-19 pandemic and subsequent crisis affected the intitiatives in the Delta.

4.1.4. Shortcomings and Future Perspectives

Although material evidence depicting the evolution of traditions is scarce, the perpetual use of terminology describing the fishing villages as preserving traditional agriculture and fishing techniques (ANTREC, 2018, 2019; Damian, 2019; Lup et al., 2017) reflects the status of this area as a center for agricultural heritage in the minds of its inhabitants and beyond.

One of the main shortcomings regarding the heritage built around fishing, especially the material culture element (such as instruments and boats), is the lack of research creating a timeline for its evolution. Although challenging for various reasons, including taphonomy, a general history of these traditional instruments through time could be compiled by integrating multiple lines of evidence, such as material culture alongside the Lower Danube and historical sources. Currently, museums in Tulcea County possess material culture elements that date back to the 18th century related to fishing, although earlier tools may be held in private collections. Knowing that recovering and promoting traditions about ecological knowledge help socio-ecological systems maintain social resilience when facing disruptions, as shown in other areas of Romania (Chitonu & Cîrstolovean, 2013), means that archaeology is more valuable than previously thought in this type of understudied landscape. Moreover, ethnographic sources focus on the physical description of the tools rather than their meaning and evolution (Antipa, 1916).

Fish farming and its history have yet to be studied in the DDBR. However, in recent years, the intensification of aquaculture in freshwater inland lakes in the Delta has garnered more attention. Exploring its archaeology in the region and the broader Danube would reveal how aquaculture evolved in the area and the interplay between traditional fishing and farming, which has been hinted at in ethnographies (translocation of species in freshwater lakes for increased accessibility)(Antipa, 1916).

4.2. The Rose Valley – Rose Oil Production

The Rose Valley is a region in Bulgaria, delimited north by the Balkan Mountains and south by the Sredna Gora chain, which includes cities such as Klisura, Karlovo (both part of the Plovdiv Province), and Kazanlak and Pavel Banya (situated in the Stara Zagora Province) (Baser & Arslan, 2014).

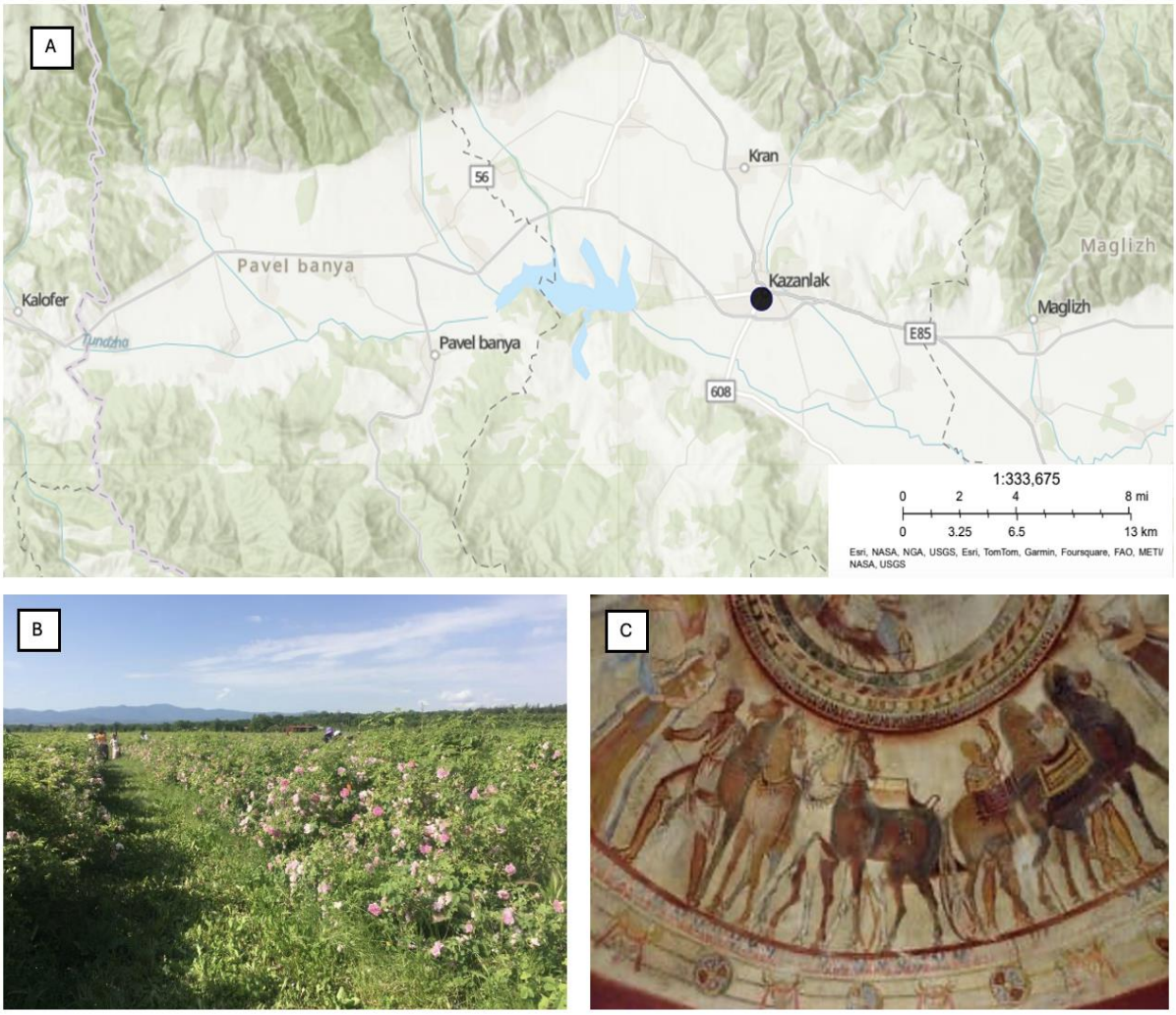

Figure 6. Map and Images of the Rose Valley, Bulgaria. **A**) Map of Tundhza Valley, showcasing the eastern location of Kazanlak. **B**) Image highlighting the aesthetic value and landscape features of Kazanlak. **C**) Image of the Tomb of Kazanlak, highlighting the rich archaeological potential of the region. Source: **A**) Map made by the author in ArcGIS online; **B-C**) Bulgaria Rose Festival. (2020).

Geologically, it consists of two river valleys, with the valley of Stryama to the west and the Tundhza to the east (Figure 6). The Rose Valley of Kazanlak stretches for about 10-12 km, spanning an area of about 1995 square kilometres, and the Kalofer Valley of Roses covers an area of about 1387 square kilometres (Shishkova et al., 2022). Although the exact geographic boundaries of the Rose Valley are hard to find, it represents a vast area in the heart of the country, known for the production of the Bulgarian oil-bearing rose – or Damask rose, or Kazanlak rose (Rosa damascena Mill. F. trigintipetala Dieck) (Shishkova et al., 2022). The region is characterised by sandy, clay-free soils suitable for growing herbs. Moreover, compared to the rest of Bulgaria, the winters are milder, as the two rivers and the mountains shield the region from atmospheric volatility (Paskova, 2018). This fluctuation in temperature causes the roses to produce more oil as a defence mechanism, which makes the area a suitable place for rose oil production (Nenov et al., 2016; Rutherford, 2022).

The Rose Valley was formed during the Quaternary Period, when the Balkan and the Sredna Gora Mountains rose, and the Fore-Balkan fields submerged (Eftimoski et al., 2017). With Europe being the faster warming continent (WMO, 2023), the effects of climate change begin to be visible in the Rose Valley,

as in 2024, the onset of rose blooming took place almost a month faster than the historical average (between the 10th and the 20th of June). Although this might not seem initially like an alarming sign of a declining landscape, it is vital to understand that this unusually warm winter followed by a warm spring, causing the early bloom, is consistent with the broader patterns associated with general climate change dynamics (Georgieva et al., 2022).

Moreover, it will not only influence the blooming time, but it can also have catastrophic effects on the activity of pollinating insects. Plant stress will increase due to exposure to inappropriate external factors, leading to decreased production quantity and quality and a decline in the overall aspect and function of the landscape (Vasileva et al., 2021). There is already a decline recorded in the production of rose oil, as in 2021, the quantity declined by 33% compared to the previous year, causing farmers to rely mainly on subsidies and state aid (Georgieva et al., 2022; Rutherford, 2022).

The present analysis focuses on the tradition of making rose oil and other rose-derived products in Kazanlak, which is among the 15 biggest industrial centres in Bulgaria, with a population of approximately 45,000 people in 2017.

4.2.1. History – Land Use, Archaeology and Settlement Pattern

Seuthopolis was a city founded in the Rose Valley in the 4th century BC, 8 km west of Kazanlak, marking the area of the present analysis as a hotspot for archaeological research (Boyadzhiev, 2020). It was the capital of the Odrysian kingdom and the preferred burial ground for nobility for centuries (Nankov, 2008, 2012), with the Thracian tombs underneath the Valley of Roses dating to the 4th century BC (Nankov, 2008). The Valley of the Thracians Rulers contains over 1500 burial mounts, among which the Kazanlak Tomb, included in the UNESCO World Heritage Sites in 1979, decorated with striking murals exemplifying Thracian burial rituals (D'Onofrio, 2022). This tomb is a window into Thracian culture (Slavova, 2022) and also the best-preserved art from the Hellenistic period on the territory of Bulgaria (UNESCO, 2024).

Agriculture in Seuthopolis was focused on farming and stockbreeding. Ploughs had iron parts, proof of high technological innovation and viticulture was a central activity, as indicated by curved knives made of iron used for pruning vines (Zyromski, 2004). There is less research on agriculture in Philippopolis and Serdica. However, the fertile land is mainly associated with viticulture (Georgieva, 2021) and cereal production (wheat, barley and oats)(Andonova-Katsarski & Stoyanova, 2023).

In the Middle Ages, the area of Kazanlak became an administrative centre for the Krun region before joining the Ottoman Empire in 1370 (Tomova, 2003). The modern city appeared in the 15th century, and it was initially a fortress serving military purposes, later developing as a city of craftsmen (Shepard, 1999). The oil-producing rose was imported from central Asia during Ottoman times, with the most accurate sources placing the date somewhere in the 17th century, quickly becoming incorporated into the local economy, with the locals taking pride in their organic farming tradition (Bruman, 1937). Rose production has been a staple since Bulgaria's liberation from the Ottomans in 1878, marking a significant stage in national history (Palairet, 1999). Moreover, the landscape is strongly connected with the area's socioeconomic systems, as it represents the source of employment for a large portion of inhabitants (above 65,000 employees in the entire Valley, although most of them are seasonal workers) (Kovacheva et al., 2010), be it through tourism or rose oil processing (Tomova, 2003).

4.2.2. Landscape – Agriculture and Biodiversity

Current agriculture in the Rose Valley is concentrated around growing roses, although other activities, such as viticulture, play an important role in the local economy. The region grows mostly black grape varieties in vineyards, with occasional fruit orchards, sunflower and cereal fields (Sobotkova & Ross, 2020). The agricultural plots containing the roses do not appear to be part of a diverse land use system but rather a monoculture, except for legumes/cereal mixtures planted between the rows to enhance the properties of the soil (Georgiev, 2016). A possible explanation for why the roses are isolated could be related to preserving particular aesthetics associated with the Rose Festivals (Hristova-Vladi, 2023).

The farmers in the region are known to increase biodiversity by leaving strips of land in the rose fields with natural vegetation. Moreover, farmers in the Rose Valley apply manure and compost mixtures to increase soil fertility and as a means of disease control, which supplements the sowing of cereal and legume mixtures between rose rows in autumn (Chalova et al., 2017). The Damask rose is not resistant to

major diseases and pests, such as black spots and powdery mildew (Kovacheva et al., 2010). While in conventional farming systems, this issue is usually controlled through chemical treatments, organic production prohibits it, and modification using gene transfer (Rusanov et al., 2009). The roses are planted in autumn, and there is an all-year-round effort to maintain the fields through fertilizing and insect and weed removal. The cultivation of the Damask rose is not unique to the Rose Valley since the rose is also grown in Iran, Turkey, France, and India, with cultivation in Persia being known since Roman times.

Although overall biodiversity research in the area has yet to be conducted, the Rose Valley is bordered by natural parks and protected areas included in the Natura2000 project (the natural reservation of Tsentralen Balkan and the riverbanks of Stryama and Tundhza)(EEA, 2024). Given the geographical proximity, some species might overlap through ecosystem connectivity, and landscape management in one environment could have tangible effects on another.

4.2.3. Culture – Traditions, Instruments and Social Initiatives

The traditional method of extracting rose oil in Bulgaria involves a labour-intensive process passed down through generations (Kovacheva et al., 2010). The rose petals are hand-picked (Figure 7) at dawn when the essential oils are at their peak concentration, usually during the Festival of Roses (Tomova, 2003), which attracts many tourists and is considered one of the most important cultural events in the country. Women and young girls would do the rose-picking, although nowadays, everyone participates in the activity (Bulgaria Rose Festival, 2020) and usually wears a flower crown during the festival (Fig. 7, C).

Kazanlak is at the center of the rose oil industry and organizes the biggest festival (Paskova, 2018). After Bulgaria became a People's Republic in 1946 (Vassilev, 2009), the festival's fame declined, although the tradition persisted in towns such as Rozino, based on local initiatives (Chalova et al., 2017). However, it is speculated that the country's then-leader, Todor Zhivkov, attended this celebration in 1957 (Hristova, 2022), which led to the festival being declared a national holiday in 1967 (Zheleva, 2019).

Figure 7. Rose picking in Kazanlak. **A-B**) Women and men are involved in the rose picking activity. **C**) Rose crowns are made to be worn on the day of the festival. **D**) Great quantities are collected during the festival.
Source: Paskova, 2018.

The Rose Festival of Kazanlak has a long history, being founded in 1903 (Hristova-Vladi, 2023). In 2024, the Festival took place on the 1st and 2nd of June in a few villages in Kazanlak and generally involves the election of a Queen of Roses in a beauty contest, followed by a parade on the main square, where folkloric performances occur. A rose-picking ritual associated with the festival involves folklore groups (kukeri) men wearing scary masks who perform and dance to celebrate rose-picking (Tomova, 2003).

Figure 8. Rose distillation through time. **A**) Zlatyo Boyadzhiev's "Rose distillation" showcases the gyulpanas close to rivers. **B**) Improved copper kazan. **C**) Modern industrial rose-distillation machinery. Source: **A)** Tomova, 2003. **B-C)** Bulgaria Rose Festival, 2020.

Following the harvest, the rose petals are transported to traditional rose distilleries and subjected to steam distillation. A clear timeline regarding the evolution of technologies emerged from the first gyulpanas (rose distilleries using an instrument called gyulap, which is a cauldron used in distillation) to the modern industrial rose distilleries (Figure 8) (Bulgaria Rose Festival, 2020, Hristova-Vladi, 2023). Initially gyulpanas were built close to rivers, and a fireplace was built for one or more cauldrons (Figure 8, A). The gyulap had four handles and consisted of two parts: the cauldron and the lid. The first cauldrons were described as bigger than the ones used in France and India, which might have influenced how the water vapour gathered. Records state that in Kazanlak in 1860, there were 1,271 gyulpanas (Bulgaria Rose Festival, 2020). With a gyulap, about 3,000-3,500 kg of rose blossoms are necessary to obtain 1 kg of rose oil (Tomova, 2003). However, the traditional gyulap was improved by the local distillers, being transformed into a "kazan" (copper cauldron), covered by a sealing lid and having a side pipe that passes through a barrel of cooling water (Figure 8, B), which helps condense the outflow (Bulgaria Rose Festival, 2020).

The European Commission approved the oil produced in Bulgaria as a new Protected Geographical Indication in 2014, meaning the product is recognized as a staple of the local culture (European Commission, 2014). While it is established that the Rose Valley has created a brand name for itself, its agricultural products are also becoming increasingly recognizable, which have been the subject of proposed branding. Besides the famous rose oil, this includes rose honey (or rose petal jam), with its distinctive color and aroma, and rose brandy or gjulovitza. Although these two products have yet to be

recognized internationally, the efforts of locals and business developers continue to advocate for acknowledging their value.

4.2.4. Shortcomings and Future Perspectives

While the roses and their cultural associations are well-researched in the area, and a clear timeline exists for the evolution of the tools and celebrations, efforts to promote and preserve the heritage appear primarily focused on expanding tourism. This community-centric approach to leveraging heritage to boost the economy presents opportunities and downfalls, particularly as it can lead to unverifiable claims and biased information. Consequently, the main shortcoming in researching the Rose Valley is the dominance of information on the festival, with other facets, such as biodiversity and alternative agricultural occupations, such as viticulture, being understudied.

Heritage in the region is presented as unidimensional, mostly related to the roses, with viticulture and other traditions dating back to the Thracians receiving insufficient attention. It's crucial to note that roses are a recent addition to the landscape, previously dominated by extensive alternative farming. The underrepresentation is a significant gap, as it overlooks a potential strategy for landscape management. Given the threat to the rose fields by climate change, alternating rose cultures with medicinal plants known in Bulgaria (such as borage, yarrow and clover) and traditional crops (grapes) might prove the right step towards sustainability, maintaining the traditions while diversifying sources of income. Clover (Trifolium spp.) is a nitrogen-fixing legume proven to enhance yields in organic crop production (Płaza et al., 2022), while borage (Borago officinalis L.) and yarrow (Achillea millefolium L.) attract a variety of pollinators and increase nutrient cycling (Griffiths-Lee et al., 2020). In this context, the potential of archaeological investigations into past land use to inform policymakers on landscape management directions that combine the cultivation of long-term species adapted to local conditions in the area with the roses is significant. This form of ecological restoration has the potential to foster biodiversity and expand the ranges of currently threatened species.

4.3. Comparing the Sites

After compiling the information gathered on the sites, the results (Table 1) indicate that both meet most of the requirements for AHLs (the Danube Delta – 15/16 and the Rose Valley – 12/16) and display proactive actions for managing their cultural heritage. Both landscapes present unique tangible and intangible heritage and provide extensive ecosystem services (cultural, provisioning and regulating). Nonetheless, they both lack documentation on current laws protecting landscape quality and recovery from natural disasters. There was no information on whether dialogue between governing bodies and local communities exists or was attempted, meaning ruling institutions have not formally considered local views. Plenty of primary quality research should be conducted on the landscapes, traditions, and interactions between the two. Research must acknowledge the differences and variations across the sites and other AHLs in terms of geography, land use, populations, and agricultural activities and be tailored to address current gaps in knowledge (in the Danube Delta manifested as a lack of ethnographic investigations and in the Rose Valley as lack of biodiversity and land use exploration). Another critical aspect of gaps in the literature regarding both sites is represented by the lack of previous academic studies analyzing the landscapes and them only being covered in tourist literature and guides. Thus, fieldwork and ethnography are essential in revealing insights about the sites.

Although the table below might indicate that the two analyzed landscapes are taking most of the necessary steps to achieve sustainability and protect their heritage, the case studies reveal that solutions should be found outside of the ten proposed management criteria. While the sites fulfill most of the requirements (Danube Delta and Rose Valley – 6/10), it becomes apparent that the critical aspect of research is missing from the existing list of factors. This might result in trade-offs, such as further eco-tourism development altering the region's balance between humans and nature. The concept of eco-tourism is challenging, as the practice appears to lack a cohesive framework, with studies pointing out their environmental impact similar to conventional tourism (Torsney & Buckley, 2023). Hence, while appearances indicate a good current grasp on management, criteria regarding solutions are somewhat superficial and based on a short-term view of sustainability.

Moreover, the base methodology presents vague criteria, such as "landscapes provide significant ecosystem services," which is insufficient, as every agricultural landscape that is to be considered in such an analysis must provide cultural and provisional services. Exploring the food and other products derived from the landscapes is the first step in narrowing the scope and aiming to find solutions for one of the key features that define the landscape (its provisioning aspect), which will be explored in the next section.

Table 1. Comparative analysis of the criteria and strategic steps for acknowledging and conserving the two landscapes.

Proposed Criteria for Acknowledgement and Conservation of AHL		**Danube Delta**	**Rose Valley**
Landscape Character	1. Aesthetically remarkable agricultural landscapes of exceptional aesthetic beauty and importance.	x	x
	2. The morphological characteristics (form, shape) of landscapes and/or seascapes and their interlinkages are characterized by long historical persistence, representative culture and a strong connection with the local socio-economic systems that produced them.	x	x
	3. Diversity of spatial structure of agricultural plots	x	-
	4. Agricultural infrastructure and settlements contribute to the spatial pattern of the landscape and illustrate a significant stage in national or global history.	-	x
Landscape Quality	5. Dynamically evolved landscapes. The process of evolution is reflected in the form and elements and features. The condition of landscape features and elements might be poor/declining/good.	x	x
	6. Landscapes shaped by unique, traditional distinctive agriculture and farming methods (in relation to the effective use of natural resources, adapted to the local environmental conditions) representative of a culture, which still contribute to the local economy.	x	x
	7. Agricultural plots part of a diverse land-use system	x	-
	8. Agricultural landscapes with significant ecosystem services	x	x
Landscape Value	9. Landscapes valued as a resource because they are rare	x	-
	10. Landscapes reflecting a particular cultural identity	x	x
	11. To be acknowledged by the public about their importance	x	x
	12. To be associated with invaluable local and traditional knowledge, ingenious adaptive technology, local traditional, cultural, spiritual, religious and social initiatives (e.g., agricultural events, festivals) and traditional management systems of natural resources.	x	x
	13. Presence of social organisations for the transfer of agricultural culture, implementation of educational activities and practices, institutions to share and transfer knowledge and technology	x	x
	14. To contain significant features of wildlife, earth science or archaeological or historic interest for in—situ conservation.	x	x
	15. Remarkable landscapes under dynamic conservation	x	-
	16. Globally significant biodiversity and genetic resources for food and agriculture and their importance for conservation	x	x
Proposed Criteria for Management of AHLs			
Landscape Aspect	17. The values of agricultural landscape heritage are retained, through a balance between people and the environment.	x	x
	18. Capable of recovering from natural disasters and changes in ecosystems of local traditional systems	-	-

	19. Mechanisms/networks that ensure that the agricultural landscape heritage is reliably inherited by future generations	x	x
Social Aspect	20. Governance through dialogue and agreement among key stakeholder	-	-
	21. Participation of various local stakeholders and development of a shared vision for the future	x	x
	22. In place initiatives to facilitate public participation	x	x
Legal Aspect	23. Laws support the maintenance of the territory potentialities and protection of landscape quality	-	-
Economic Aspect	24. Development of alternative forms of tourism (e.g., agrotourism)	x	x
	25. Brand name for the agricultural landscape and products	x	x
	26. Promotion of new business model associated with the Agricultural Heritage Landscapes	-	-

4.4. Food Systems as an Additional Dimension

4.4.1. The Danube Delta from a Food Systems Perspective

In the Danube Delta, fishing is a full-time occupation for traditional fishermen and a subsistence activity in most cases. The commercial aspect of fishing in this landscape is highly relevant, as in 2022, catches from inland waters across the country amounted to 62 tonnes (Eurofish International Organisation, 2023). While the exact numbers are lacking, it became apparent that nowadays, the fish caught in the Danube Delta is intended for internal consumption within the country, mainly by the locals and tourists (Năvodaru & Staraş, 1998). Nevertheless, a black market exists for sturgeons and caviar primarily for export, although it appears to be diminishing due to international sturgeon conservation efforts (Directorate-General for Maritime Affairs and Fisheries, 2023; WWF, 2019).

This paints the image that fishing in the Danube Delta is the initial step in a food system that is somewhat enclosed and concentrated around the Delta's geographic borders. Still, throughout history, exports and consumption on a larger scale were more prevalent. The overall fishing production fell from 6,500 tons in 1990 to 2,000 tons in 2022, and the internal fish consumption of the country fell from 96% provided by the socialist fleet catches to less than 10% share of domestic catches nowadays. The overthrow of the Communist regime (1989) and the post-socialist period ended overexploitation, with the subsequent designation of the site as a biosphere reserve initiating more conservation-focused management of the landscape (Nastase & Navodaru, 2023). However, its implementation lacked the integration of the human dimension, leaving a shortage of employment opportunities. Moreover, it can be argued that the economic crisis, low investments, and rapid deterioration of fishing gear and vessels incentivized people to leave the area, with the remaining population trying to make a living out of tourism (Damian, 2011).

Nowadays, besides the over 600 registered fishermen (Boja & Popescu, 2000), the entire population of the Delta is somewhat dependent on the fishing activity in the area and the fish foods, be it for commercial activities, sustenance, or work in the tourism sector preparing fish foods (Ivan, 2017). Thus, this food should be at the forefront of protecting the landscape and local livelihoods. Currently, there are no management strategies targeting food systems (such as sustainable waste management, which could be a great way to bridge the conservation efforts with the unemployment gap).

4.4.2. Rose-derived Products and Food Systems

The products obtained from the roses (such as rose jam, brandy, and oil) are mainly indented for export, with foreign markets in Japan, France, and the US being the leading destinations in the most recent published data (Labban & Thallaj, 2020). The organically produced oil is used in cosmetics, pharmaceutics, and medicine (Nenov et al., 2016). The demand for rose products has been increasing since the beginning of its cultivation in the area. However, the historical trends show a rise and fall in production in tandem with significant political and societal changes, such as the fall in output associated with the collapse of the Ottoman rule following the Russo-Turkish War in 1878 and the rise of the Communist Party post-World War II (Palairet, 1999). Nonetheless, whether the rose oil was intended for

the Ottoman world or the big cities of the current era, the landscape has proven to be part of a system that extends and impacts people on multiple continents, with the local farmers being a small fraction.

In 1849, Bulgaria produced 450 kg of rose oil; by 1881, production had increased to 1,450 kilograms. Data on overall production is lacking from 1941 to 1990, although various articles mention an increase in production in the 60s followed by a decrease in the last years of communism (1985-1989)(Kovacheva et al., 2010). The most recent numbers cover 1990 to 2008, showing an exponential increase in production associated with expanding rose fields (Vasileva et al., 2021). Although it suffered numerous changes, alternating between low and high production years, 2023 1,370 kg of oil were exported from Bulgaria (Hristova-Vladi, 2023), meaning the product is still in high demand. However, production is far lower than the historical peaks. Nevertheless, keeping up the numbers appears challenging as the changing climate and land degradation threats require more sustainable solutions (Yale Environment 360, 2024), including those that aim to tackle production as part of a broader system. Using rose biomass waste as antioxidant supplements and natural color stabilizers is one solution, even if it has yet to be implemented due to challenges regarding waste management investments (Shishkova et al., 2022).

While the extent of the two food systems mentioned varies, with the rose-derived products affecting a higher proportion of people involved in the middle parts of the food system (transport, storage, marketing, and processing) and a broader consumer demographic (although exact numbers are missing), it appears that the farmers are experiencing a similar degree of vulnerability in the face of climate change. In both of the analyzed scenarios, local economies and job markets depend on the landscapes, although it can be argued that local subsistence is also affected in the Delta. Nevertheless, this section underscores the urgent need for effective management strategies, the most prominent concerning waste, and highlights that the current methodology is insufficient in assessing different landscapes. Future steps should ensure local communities' livelihoods and maintain the commodities' global status, a difficult task in severe environmental changes.

5. DISCUSSION

5.1. Conserving Culture within a Landscape – Archaeology as the Link

The landscape's inhabitants are the primary actors in its protection, and its condition will primarily affect them (Fritz et al., 2019). Therefore, safeguarding and addressing their needs is critical to achieving sustainability. A dialogue among local and national stakeholders with diverse worldviews and types of knowledge must thus be initiated. A community linked by cultural heritage displays easier recovery after crises and is more socially cohesive (Granovetter, 2018). However, cultural heritage must be balanced by flexibility in the current context, with solutions built at the interface between modernity and tradition. Studies emphasize the necessity for innovation regarding fast-paced tourism, which has been regarded as an ecological threat (Luekveerawattana, 2024), with others supporting the study of heritage in formal higher education frameworks, aiming to promote the cultural inheritance and address modernization (Yan & Li, 2023).

Education for the entire community, especially regarding the history and archaeology of the landscape, traditions, and food, could be a highly accessible solution. In the Danube Delta, where most of the community is rural and lacks extensive financial resources, education programs focused on the link between landscape and heritage could encourage responsible action regarding daily activities (e.g., understanding the balance between people and environment would foster collaboration for sustainable solutions and would potentially dissuade inhabitants from partaking in illegal fishing) (Dorondel & Mitroi, 2017). Educational programs could encourage proactive community involvement in the Rose Valley, where there is higher anthropogenic input due to the mix of urban and rural populations. For instance, implementing a more diverse land use system based on the landscape existing before the roses could enhance biodiversity and increase pest resistance.

Implementing educational activities as such was proven to help locals overcome barriers and address critical issues regarding adaptive planning (Galan et al., 2023). However, more research is needed to assess how well a community in tune with its heritage can be assertive towards ruling bodies; relevant case studies in Europe have yet to be investigated through this lens. For the AHL framework to succeed and generate the impact it aspires to, it requires as much robust research into the past as it does in the

present, making archaeology, especially environmental archaeology, a valuable link between culture and landscape.

5.2. Current Policies – Inclusion of Archaeology and Heritage

Understanding modern policy dynamics is essential to contextualizing how heritage and archaeology have been incorporated into current legislation and regional development strategies. The SGDs included agricultural landscapes in Goal 2 (United Nations, 2022), advocating for protecting small-scale food producers, particularly Indigenous people, family farmers, women, and fishers, while maintaining ecosystems and genetic diversity of crops, animals, and wild species (Fritz et al., 2019). Besides the UN SGDs, various other programs target the conservation and management of landscapes, such as the Common Agricultural Policy (CAP), which is a partnership between Europe and its farmers, setting ambitious goals such as securing a worthy economic future as well as maintaining the place of agriculture in Europe's heart and ensuring climate and environmental action (Paun & Ivascu, 2021). To implement the SDGs proposed by the UN, the European Commission (EC) adopted the EU Strategy on Adaptation to Climate Change in 2021, setting out how EU countries can adapt and become climate-neutral by 2050.

The SGDs, European Green Deal, and CAP support agricultural landscapes as the path to an ecologically viable future for our planet. However, no initiative links the cultural element (traditional farming practices) to the broader ecological implications, meaning novel initiatives that combine the two must be created. The HEREIN network is another tool that helps track progress across Balkan countries (Council of Europe, 2021), revealing that financing cultural heritage preservation and more administrative capacity in conservation remains an outstanding problem. For example, the latest report for all Balkan countries shows that no registered competent government authorities or organizations have legal responsibility for landscape heritage policy and management.

In the case of the Danube Delta and Rose Valley, NGOs and various local initiatives support the propagation of traditions, and governmental support could boost their success and amplify their message (Escallón, 2020). While it shows that locals self-initiate action, it might be insufficient when facing extraordinary threats such as climate change or even the economic displacement and environmental degradation that high-influx tourism could bring (Luekveerawattana, 2024). Nevertheless, the present paper has shown that the connection to agricultural heritage, expressed through celebrations, tools, and food, plays a critical role in the lives of the locals and beyond, being a valuable aspect of world heritage yet so fragile in the current context. Complex challenges like the climate crisis require interdisciplinary solutions tailored to individual communities and landscapes, which could be better understood through the study of the past. Hence, archaeology and heritage studies can make a real-life difference if included in policy frameworks.

5.3. Limitations and Future Directions

Essential follow-up questions highlight the limitations of the current research, with the most prominent one being the methodology. Moreover, if the sites succeed in being integrated into initiatives such as the GIAHS, how would the change materialize in the landscape and local livelihoods? What is the most efficient way of translating academic thought into real-life scenarios?

While the initial methodology represents a first attempt to assess holistically a landscape and, to a certain extent, succeeds in its scope, limitations became apparent during site analysis. Firstly, subjectivity might be considered an issue when applying LCA (Terkenli et al., 2021), as landscape quality and value (aesthetic and cultural significance) could mean various things to different assessors. Secondly, methods do not account for a "time-depth" perspective regarding culture and landscapes as they evolve, missing valuable potential management strategies, which is the same with food systems.

The accuracy of the analysis relies heavily on quality data, which could be compromised by outdated, incomplete, biased sources or limited availability in different languages (Griffiths, 2018). As this article is an extensive literature review, the quality of the data available is quintessential to ensuring reliable representation. Although there is some documentation of traditions and crafts, it does appear to be limited to tourism literature and created for such purposes. In this regard, a more objective perspective could be achieved by conducting fieldwork investigations to document tourism and other activities. Moreover, the methodology is quite limited by the theoretical aspect of its framework. Fieldwork is not a

required aspect of characterizing the landscape, which could be considered a limitation due to the abovementioned gaps in literature. Thus, fieldwork and ethnographic research should become essential to a revised methodology.

Moreover, the baseline methodology does not offer a comprehensive definition of what traditional agriculture entails; for how long does a tradition have to exist before it becomes heritage? A landscape's maximum or minimum size is not appropriately defined, leading to the potential selection of evidence. Another shortcoming can arise from focusing on one type of heritage, such as fishing in the Danube Delta, despite the likely existence of multiple lines of agricultural heritage (gardening and breeding cattle). This emphasis on precision in definitions is crucial to ensuring as much objectivity as possible. Moreover, integrating and comparing other landscape assessment methods, such as the Living Landscape approach (Warnock & Griffiths, 2015), could emphasize the introduction of wildlife in inhabited regions. In addition to objectivity, this analysis is purely qualitative, with the addition of the food systems dimension aiming to offer a quantitative side. Nevertheless, incomplete datasets and a lack of pre-existing interest in compiling economic and environmental data from these specific landscapes make creating a reliable timeline difficult.

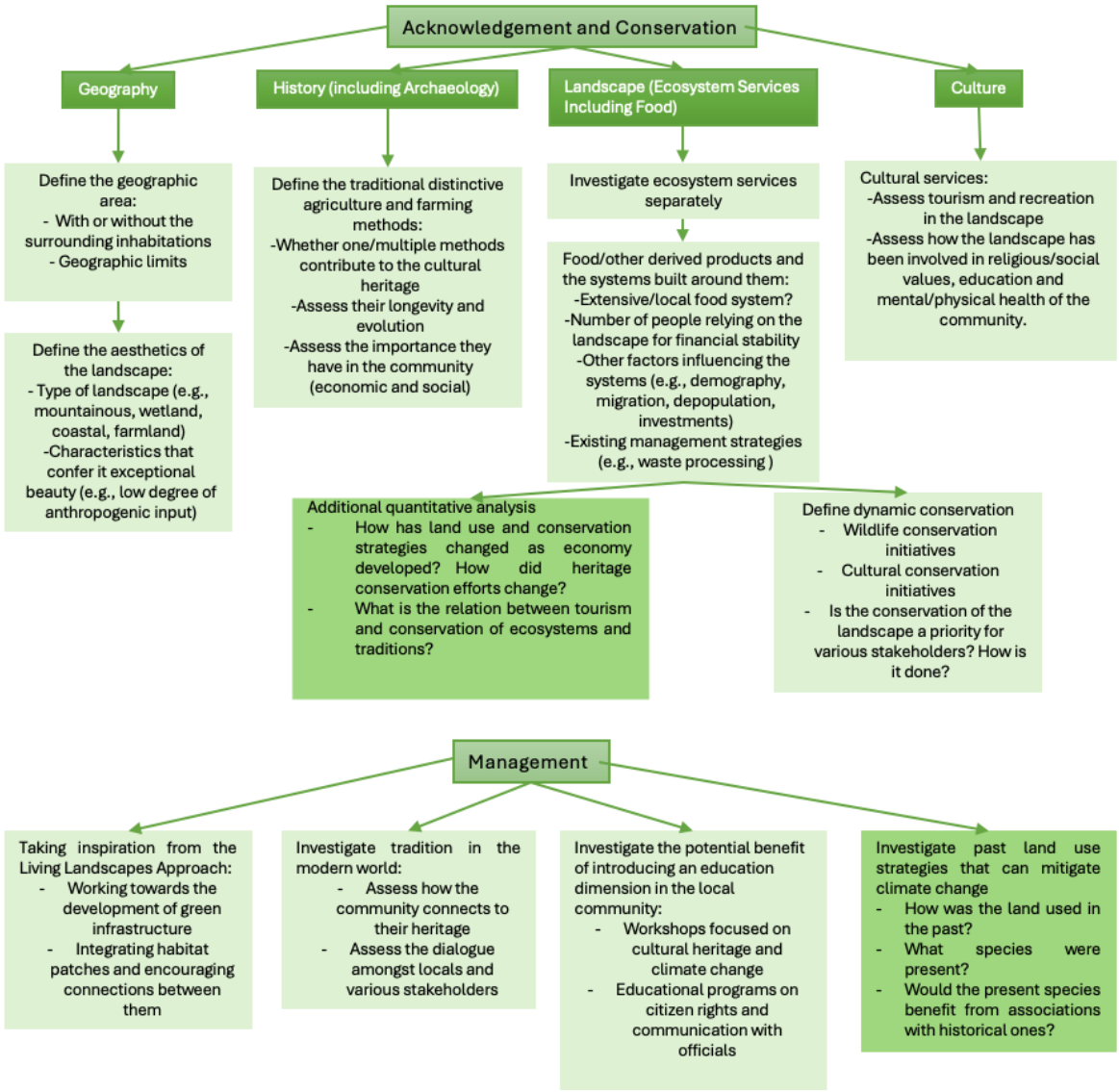

Figure 9. Proposed areas of expansion in the methodology and their associated sections (either belonging to the acknowledgment and conservation part of the framework or the management strategies proposed).
Source: Made by the author.

The literature revealed gaps in addressing essential aspects of landscape characterization. As this is the first study to reveal the history—both natural and in terms of traditions—of the concerned landscapes, its main contribution to the scientific world is revealing the gaps in knowledge that could be addressed through fieldwork and the potential limitations of the current frameworks aimed at protecting these landscapes. The major limitation of the present study is that it gave a general overview of the area but not a focused and detailed study of the different communities inhabiting the landscapes. Future research could focus on conducting more in-depth analyses and adopting a comparative approach to exploring the differences and similarities between landscapes and the practices of their respective communities, as these aspects could alter potential mitigation strategies.

Initiatives such as GIAHS do not offer financial incentives but promote intervention strategies at the global, national, and local/site levels (FAO, 2022), which crystallize into capacity-building workshops for local farmers and government bodies. This aligns with the follow-up education action proposed above. However, it offers a partial solution to the current issues, such as lack of policy, funding, or developing strategies in partnership with experts on local heritage. Nonetheless, communication between governing bodies and locals and ethnographic research could help identify where modernity must meet tradition, whether it is crystallized in modern housing retaining traditional elements or modern tools inspired by traditional ones. Given all these, a revised methodology that should address the abovementioned limitations must be created. Recommendations regarding the expansion of each section are presented in Figure 9.

6. CONCLUSIONS

The present analysis illuminates critical points concerning heritage landscape management. The case studies of the traditional fishing villages in the Danube Delta, Romania, and the tradition of oil production in the Rose Valley, Bulgaria, raise many follow-up questions that can potentially transform the trajectory of climate change mitigation and resilience, especially in rural areas. While both sites could be categorized as AHLs due to their qualities, presented in the results section, this is simply the first step toward their management. The objectives have been achieved (characterizing the landscape, including an additional dimension in the form of food systems, and highlighting the limitations of current frameworks), with the major implication being that the present study represents the first attempt at introducing archaeology into climate policy by protecting agricultural heritage. Another novelty component is that the present study is the first academic attempt at compiling the literature describing the traditions and landscapes. However, it reveals the need for ethnographic inquiry and fieldwork characterizations, as the literature presents outdated, inconsistent findings in most cases.

Recognizing and investigating invaluable landscapes and heritage in academic discourse is the first implication of this study. In the case of the Danube Delta, the heritage built around fishing requires a cohesive history, with material culture being underrepresented and ethnographic investigations focused mainly on describing the objects. On the other hand, the Valley of Roses does not present mechanisms that ensure the reliable inheritance of these traditions or investigations into the region's biodiversity and past land use. Both landscapes should have more dialogue between the governing bodies and the inhabitants and could suffer negative impacts related to high tourism levels, such as the landscape's overexploitation. Further archaeological and ethnographic inquiries could help uncover the history of cultural heritage and how modern communities connect to it. This is of utmost relevance if heritage should be included in the broader climate discourse: heritage can only be preserved if understood.

Moreover, this is the first study to advocate internationally for the conservation of agricultural heritage in the two landscapes analyzed, assessing the tangible and intangible cultural heritage associated with them. It highlights the potential positive impact on policy and rural development that applying innovative associations between culture and nature could have. It encourages the development of legislation bridging tradition and nature and for competent authorities to act, as balancing the two opens the possibility of boosting resilience and social cohesion in a changing climate. The current legislative frameworks strongly advocate for better farming and rural conditions, although most of the practical work is done by NGOs, with no competent authorities protecting heritage. A third point of extreme relevance is a novel methodology that overcomes the shortcomings of the initial one (subjectivity, vagueness, lack of multiple dimensions such as food).

Acknowledgments: The author thanks the reviewers for their valuable comments.

Use of AI tools declaration: The author declares have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflicts of interest: The author declares no conflicts of interest.

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Central European Journal of Geography and Sustainable Development
ISSN 2668-4322, ISSN-L 2668-4322
2024, Volume 6, Issue 2, Pages: 76-92
https://doi.org/10.47246/CEJGSD.2024.6.2.5

Evaluation of dams constructed on the rivers of the North Development Region of the Republic of Moldova

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Received: 30 November 2024; Revised: 20 December 2024; Accepted: 24 December 2024;
Published online: 27 December 2024

ABSTRACT: Main aim of the present research is mapping as well as general evaluation of the state of the dams built on the streams and rivers of the North Development region of the Republic of Moldova. Dams' mapping was performed form actual satellite images connected to Google Earth, using geoinformational techniques. In total 2,523 dams were identified and mapped. In comparison in official statistic the number is by 2.2 times higher. Dams' average length is about 134, ranging from 8 to 626 m. From the total number, 86% of dams' are estimated to be generally in satisfactory condition, the other 14% being partially demolished. In case of the dams' upstream part, only for 49% of them reservoirs and ponds are in good condition, those in eutrophic condition and semi-dry accumulations are of 13%, the upstream of other 30% is characterized by dry territory and 8% by wetland. Dams' density is considered very high in case of streams, the average being 0.57 dams/ river km or about 1 dam on every 1.77 km of river, and much lower on medium rivers, being only 0.15 dams/river km or one dam is constructed on almost every 7 km of river. Dams' density in the limits of river basins and districts, calculated as dam per km^2, is on average 0.25 dams/km^2. In general, the highest density is established for the southern part of NDR and the lowest – for its eastern part, values for the central part are similar to the average for the whole region, while those from the western part are slightly lower than the medium. Further studies, including those in the field, should be performed in order to improve actual dams' knowledge and finalize the development of the comprehensive database of dams. Also, dams' mapping and evaluation should be extended for the whole country which further would facilitate decision makers to identify and apply measures for river restoration.

KEYWORDS: dams, density, conditions, spatial database, Republic of Moldova

TO CITE THIS ARTICLE: Jeleapov, A. (2024). Evaluation of dams constructed on the rivers of the North Development Region of the Republic of Moldova. *Central European Journal of Geography and Sustainable Development*, *6*(2), 76-92. https://doi.org/10.47246/CEJGSD.2024.6.2.5

1. INTRODUCTION

Dams and reservoirs are hydrotechnical constructions built to provide water to the different needs of human life and activity. From various purposes of these structures, main refer to water supply, flood control, fishery, irrigation, navigation, electricity production and recreation (ICOLD RD, 2024; Altinbilek & Cakmak 2001, Binnie, 2004 etc.). Social and economical benefits are large, quality of life and financial growth of the reservoirs surrounding regions being on the rise. In conditions of climate change and due to increasing dependence on water resources, dams and reservoirs will continue to play an important role in human development and maintenance of life. Even if the costs of their construction are high, dams and reservoirs will continue to appear in all regions of the world. Global trend shows that, for the last 70 years, from 5000 large dams, built by the 60' of the last century, at present this number has increased by 12.6 times (Adamo, 2020; ICOLD, 2024).

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Despite the fact of high importance of dams and reservoirs, the negative effect of dams and reservoirs is estimated to be a great global challenge. Construction of dams on river courses has modified their connectivity either directly through the impeding effect of the structure itself, or indirectly through alterations to the hydrological, thermal, sediment regimes, as well as had lead to changes of riparian and aquatic ecosystems. (Grill et al., 2019). The impact of dams is proportional with their scale, large dams having higher impact (Brown et al., 2024), however in some circumstance, cumulative impact of small dams (which are usually outnumbered and little considered) can be significant (Spinti et al., 2023). Many reviews, made during the last decades (Pirestani et al., 2011; Khir Alla & Liu, 2021; Ledec et al., 2003; Zahng et al., 2022; Dixon et al., 1987; Lin 2011; Zang 2022), have defined and described in details the negative impacts of dams on the environment, basing on which the following groups of destructive effects of dams were estimated: physical, chemical, biological (aquatic and terrestrial ecosystem), health and human well-being, economical, social, cultural, climate, induced seismicity, hydrological and morphological. Dams' effect was also analyzed for different phases: during dam construction, reservoir impoundment and reservoir operation (Khir Alla & Liu, 2021,). As a result of evaluation of the negative effect of dams and reservoirs, many researches propose key indicators of likely environmental impacts (Ledec et al., 2003,), certain mitigation measures as well as decision making and management recommendations for decreasing the impact (Liu, 2021; Dams and Development 2000).

In order to establish a framework for the protection of surface waters and groundwater, Water Framework Directive was adopted by European Parliament and the Council (EU Directive 2000/60/EC). The Directive treats with special attention water bodies classified as heavily modified. These are the result of physical alterations caused by human activity that substantially changed their character (Art. 2 EU Directive 2000/60/EC). Guidance document no. 4 *Identification and Designation of Heavily Modified and Artificial Water Bodies* was developed in order to delineate such type of water bodies (Guidance document n.o 4 for implementation of EU Directive 2000/60/EC). Interruption of longitudinal and lateral connectivity is hydromorphological condition taken into account when establishing if a water body is heavily modified or not. Dams as well as reservoirs represent one of the main reasons of attribution to water bodies the status of heavily modified.

In the Republic of Moldova, Water Framework Directive is partially transposed in the Water Law (Legea apleor 2011). River basin management plans for two districts: the Dniester as well as the Danube-Prut and Black Sea (H.G. 814/2017; H.G. 955/2018, Proiect Nistru II), are developed and implemented for 6 years cycles. In 2024 national legislation was progressively enriched with methodologies in order to better transpose Water Framework Directive. In this regard, methodologies on the identification and designation of surface water bodies as artificial or heavily modified, on the identification of hydromorphological changes, monitoring and assessment of water bodies, on analysis of pressures and assessment of anthropogenic risks within river basin districts (H.G. 648/2024; H.G. 675/2024; H.G. 709/2024) were developed and approved. All these methodologies contain reference to hydromorphological alteration induced by dams and reservoirs. However, even if methodology on analysis of pressures and assessment of anthropogenic risks is applied for the development of river basin management plans, heavily modified water bodies as well as hydromorphological changes of water bodies still need to be evaluated using approved approaches. Even so the national management plans (H.G. 814/2017; H.G. 955/2018, Proiect Nistru II) contains measures in order to identify and eliminate the dams causing interruption of river continuity, as well as to renaturate the river courses.

Despite progressive modern technological tools, development and maintenance of world dataset on dams and reservoirs remains a challenge (Wang J., et al., 2022). Total number of dams is still unknown, although the estimations show a number of 63,000 dams higher 5 m from 166 countries, from which only two-thirds are currently georeferenced (ICOLD, 2024). Datasets on reservoirs and dams form 2011 (Lehner et al., 2011) resulted in establishment of a total number of reservoirs of 16.7 mil. with total area of 305,723 km^2 and a total storage volume of 8,069 km^3. The largest world datasets are the World Register of Dams, updated mainly by the International Commission on Large Dams (ICOLD WRD, 2024), GlObal geOreferenced Database of Dams (Mulligan et al., 2020), Global River Obstruction Database (GROD) (Yang et al., 2022), Global River Width from Landsat database (Allen & Pavelsky, 2018), United Nations Food and Agricultural Organization (FAO) AQUASTAT (AQUASTAT, 2024) and the Global Reservoir and Dam database (Lehner et al., 2011), Georeferenced global Dams And Reservoirs dataset, GeoDAR (Wang et al.,

2022), Global Dam tracker (Zhang et al., 2023). Some datasets contain rich and valuable information like reservoir purpose, storage capacity, dam height, etc.), however, essential information (like geographic coordinates) is missing or inaccessible to public. Other datasets present accurate dams location but included dams characteristics are few (Wang et al., 2022). Other datasets contain position and many dams characteristic but the total number of registered dams is still small. Nevertheless, dams and reservoirs databases continue to be improved and enriched with information.

In the Republic of Moldova, a certain database on dams can be found in the yearbooks of the Inspectorate of Environmental Protection (IPM, 2010-2019). Main parameters about dams are their and their hydrotechnical structures state, usually classified as satisfactory, damaged or absent. No data is given about dams physical parameters (lengths, height, width, etc.). Information is integrated in special tables linked to reservoirs and is updated every year. Small reservoirs and ponds, as usual, are not long lasting. Due to climate change, reduction of water resources, siltation processes, ponds became unusable in 10-15 years, transformation being to dry land or occasionally wetland. When it happens, renaturalization of rivers and streams by demolishing the dams is not often performed. Subsequently, when the reservoirs physically disappear, the dams continue to negatively influence the state of water bodies, and in some cases statistical data do not reflect them anymore in the yearbooks. A comprehensive and complete spatial database on reservoirs and dams is absent.

Present research represents a first attempt to develop such a database as well as to check the official statistic about these hydrotechnical structures. Main aim is mapping the dams built on the river streams. The objectives are identification of their spatial position using satellite images and mapping of dams situated on river with a length over 2.5 km, estimation of their general state, evaluation of upstream part state and calculation of dams' density.

2. STUDY AREA

Study area is considered the North Development Region (NDR) of the Republic of Moldova. NDR represents one of the most important regions of the country, its surface being about 10,014 km^2 or approx. 33% of the total area of the Republic of Moldova. NDR includes 11 districts (rayons): Briceni, Edineţ, Ocniţa, Donduşeni, Rîscani, Drochia, Soroca, Glodeni, Făleşti, Sîngerei, Floreşti and the municipality of Balti (Figure 1).

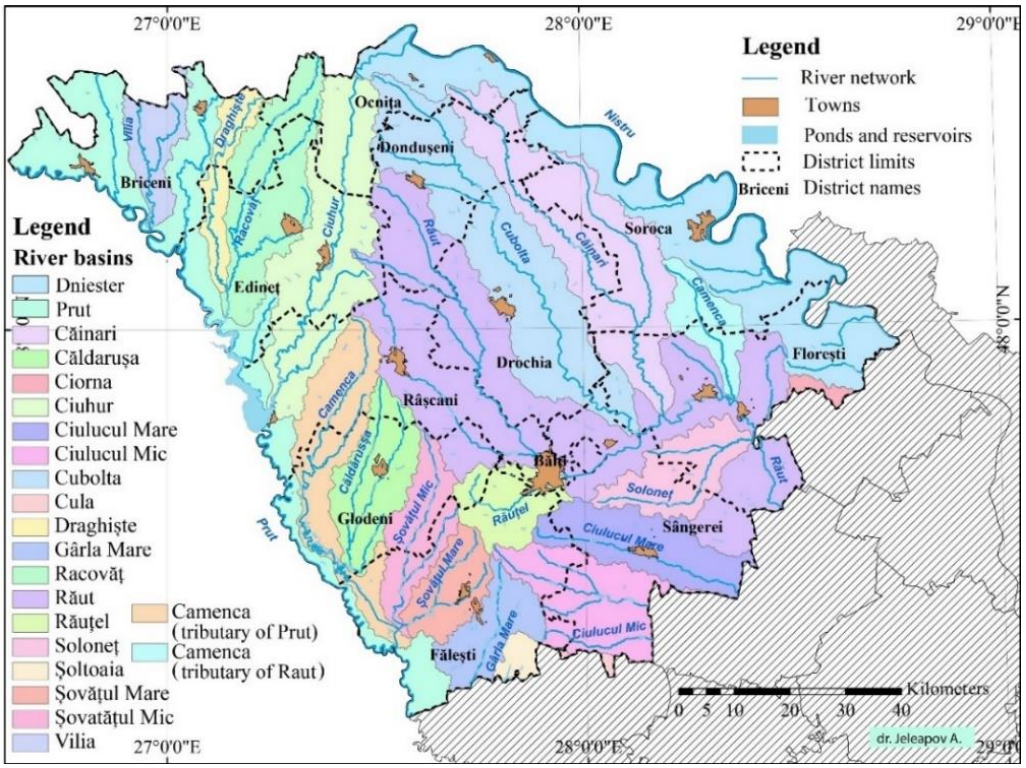


Figure 1. River network of the North Development Region of the Republic of Moldova.
Source: own work.

The total number of settlements is 572, including 20 towns. The population number is 980 ths. inhabitants of which 36.4% live in urban area and 63.6% - in the rural (Profilul socio-economic RDN, 2019).

The main rivers that pass through the NDR are the Prut and the Dniester, which are the eastern and western borders of the region. Within the limits of the study area, the length of the Dniester river is 194 km, the area of the basin – 6,087 km^2, and of the Prut river - 232 km, the area of the basin being 3,964 km^2. The main tributary of the Dniester river is the Răut, its length being 161 km, and the area of the basin - 5009 km^2 (in the limits of NDR). The most important tributaries of the Răut river are Cubolta, Căinari, Soloneț, Camenca, Răuțel etc. The main tributaries of the Prut river are Camenca, Ciuhur, Racovăț, Vilia (Figure 1). The flow direction of the large rivers as well as the rivers of the Dniester basin is from northwest to southeast, the rivers of the Prut basin flow from northeast to southwest.

In NDR, reservoirs and ponds, created on rivers and stream by damming, have different needs: fishery, recreation, irrigation, etc. For the last 10 years, general tendency shows an increasing number of reservoirs and ponds in the NDR from about 2,460 in 2010 to 2,624 in 2019, and decreasing of their surface from 20,000 ha to 16,000 ha (Burduja & Bacal, 2021), which means that reservoirs became smaller in size and bigger in number. In 2019, water accumulations constructed on rivers and streams counted 1,157 or only 44% of their total number (Burduja & Bacal, 2021).

3. MATERIALS AND METHODS

Geospatial technologies represent a modern method of assessing the state of rivers. They allow the collection of information, the assessment of the spatial position and the initial analysis of the hydromorphological elements of the rivers and the factors that determine their deterioration. The speed of spatial analysis, remote management and enabling rapid decision-making are obvious advantages of geospatial technologies, GIS, satellite imagery. Modern and world-wide used software which contains actual satellite images is Google Earth pro (Google Earth 7.3.6., 2023). It was mainly used for mapping of dams, evaluation of their general state and identification of their upstream part status. According to data from version 7.3.6. satellite images correspond to 2020 year. Final maps and statistical calculations were performed in QGIS (Quantum GIS 3.30, 2023).

The spatial database on dams was performed for rivers of the network of NDR with a length over 2.5 km. Considered river network was extracted from National geospatial data fund, geoportal.md (NGDF, 2022). The rivers were classified in 4 categories: streams (length 2.5 km - 10 km), small rivers (length 10 km - 100 km), medium rivers (length > 100 km), large rivers: Prut and Dniester (for the study these were not considered). Classification is attributed to Water Law (Legea apelor nr. 272 din 23.12.2011). As a result of dams' state analysis, these were grouped in two: satisfactory with the mean that the dams is visually undamaged and partially demolished which, as usual, are destroyed in the middle part in order to release the natural flow (Figure 5). Along with evaluation of dams' conditions, the upstream part of the dams was also analyzed. As usual, it is considered to be a water accumulation. However, the study shows that the upstream part can be classified in: reservoirs (surface over 2 ha), ponds (surface less 2 ha), eutrophic water accumulation, semi-dry water accumulation, dry land, wetland. Finally, as a result of identification and mapping of dams, their lengths as well as their density were calculated.

4. RESULTS AND DISCUSSION

4.1. Mapping the dams position

The results of spatial identification and mapping of the dams situated on rivers and streams of the North Development Region of the Republic of Moldova are shown on figures and tables below. Total number of dams is 2,523, total length is 338 km (Figure 2, Figure 3 and Table 2).

In the limits of the Dniester river basin part, 1,471 dams were identified (1,002 – on streams, 423 – on small rivers, 46 – on medium rivers), from which 1,335 dams are situated on rivers of the Răut river basin (905 – on streams, 384 – on small rivers, 46 – on medium rivers) including 242 dams in the Cubolta river basin (140 – on streams, 83 – on small rivers, 19 – on Cubolta), 204 – in the Căinari (157 – on streams, 28 – on small rivers, 19 – on Căinari), 240 – in the Ciulucul Mic (165 – on streams, 58 – on small

rivers, 8 – on Ciulucul Mic). A high number of dams is identified in the Răuţel and Soloneţ river basins, despite the fact that these are quite small. Thus, in the Răuţel basin from 98 dams, 79 are situated on streams, 7 dams on small rivers and 12 dams are on the Răuţel. In the Soloneţ basin from 97 dams, 58 are situated on streams, 18 dams on small rivers and 21 dams are on the Soloneţ.

In the limits of the Prut river basin part, 1,052 dams were mapped, including 378 dams on rivers of the Camenca rivers (213 – on streams, 140 – on small rivers, 25 – on Camenca), 229 – on Ciuhur (175 – on streams, 39 – on small rivers, 15 – on Ciuhur), 155 - on Racovăţ (76 – on streams, 59 – on small rivers, 20 – on Racovăţ). The rivers and streams from the Camenca river basin are highlighted by the highest hydromorphological alteration. Here, in the Căldăruşa basin the dams are built as follows 63 – on streams, 29 – on small rivers, 14 – on Căldăruşa, in Şovăţul Mare basin: 45 – on streams, 10 – on small rivers, 16 – on Şovăţul Mare and in Şovăţul Mic basin: 62 – on streams, 18 – on small rivers, 31 – on Şovăţul Mic.

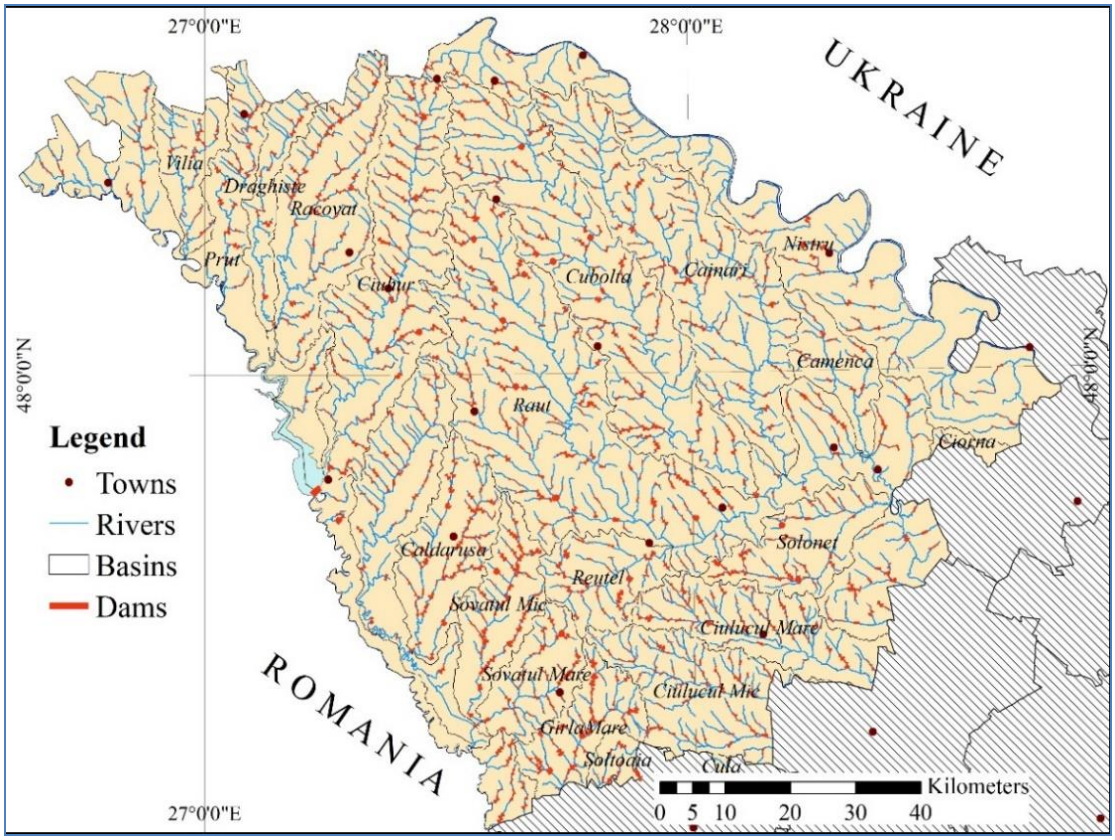
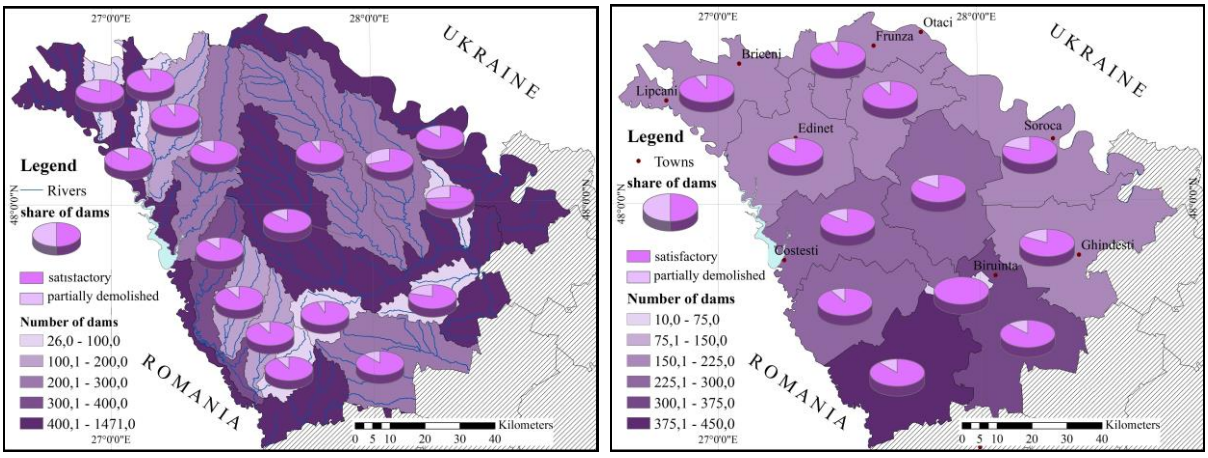


Figure 2. Spatial position of the dams situated on river streams of NDR.
Source: own work.



(a) **(b)**

Figure 3. Dams' number in the limits of river basins (**a**) and districts (**b**).
Source: own work.

The number of dams was calculated also for districts (Figure 3, Table 2). Thus, highest number of dams was estimated for Fălești – 379, Sîngerei – 326, and the lowest for Soroca – 169, Briceni – 168, Florești – 167, Dondușeni – 163. In the rest of the districts the number of dams ranges from 225 to 268. In the Balti municipality there are 10 dams.

Average length of the dams is 134 m. In the limits of the Dniester basin, this value ranges from 105 m in Răuțel basin to 164 m in the Camenca basin, in other basins it is about 123-136 m, average being 131 m (Table 1). In the Prut basin, dams' average length is higher. It ranges not much, from 126 m (Vilia basin) to 146 m (Draghișteа basin), average value being around 140 m.

In order to estimate relationships between dams, rivers, basins, correlation were built between different parameters (Figure 4). Satisfactory correlations were identified between number of dams and river length. On average, number of dams' constructed on streams (average length - 4.45 km) is 2.5 dams, on small rivers (average length - 19.5 km) is 8 dams, on medium rivers (average length - 121 km) is 18 dams. The dams' number increases with river length, however, on the medium rivers its range is 19-25 (except Raut river with inly 8 dams on the course), while the highest number of dams is observed on the rivers between 20 and 80 km, the average being 13 dams, and the range from 3 to 31 (Figure 4).

Stronger correlation was evaluated between dams length and water accumulations area. General evaluations show that ponds are dammed by up to 110 m length dams, for reservoirs with surface up to 10 ha the dams' length is from 110 – 250 m, for those of 10-30 ha, the hydrotechnical structure is of 250-400m. The dams over 400 m embank reservoirs over 30 ha. Expected strong correlation was obtained for number of dams and river basins, larger the basin - higher the number of dams. Also, high correlation was estimated between number of dams in the limits of the districts and dam density in the same areas.

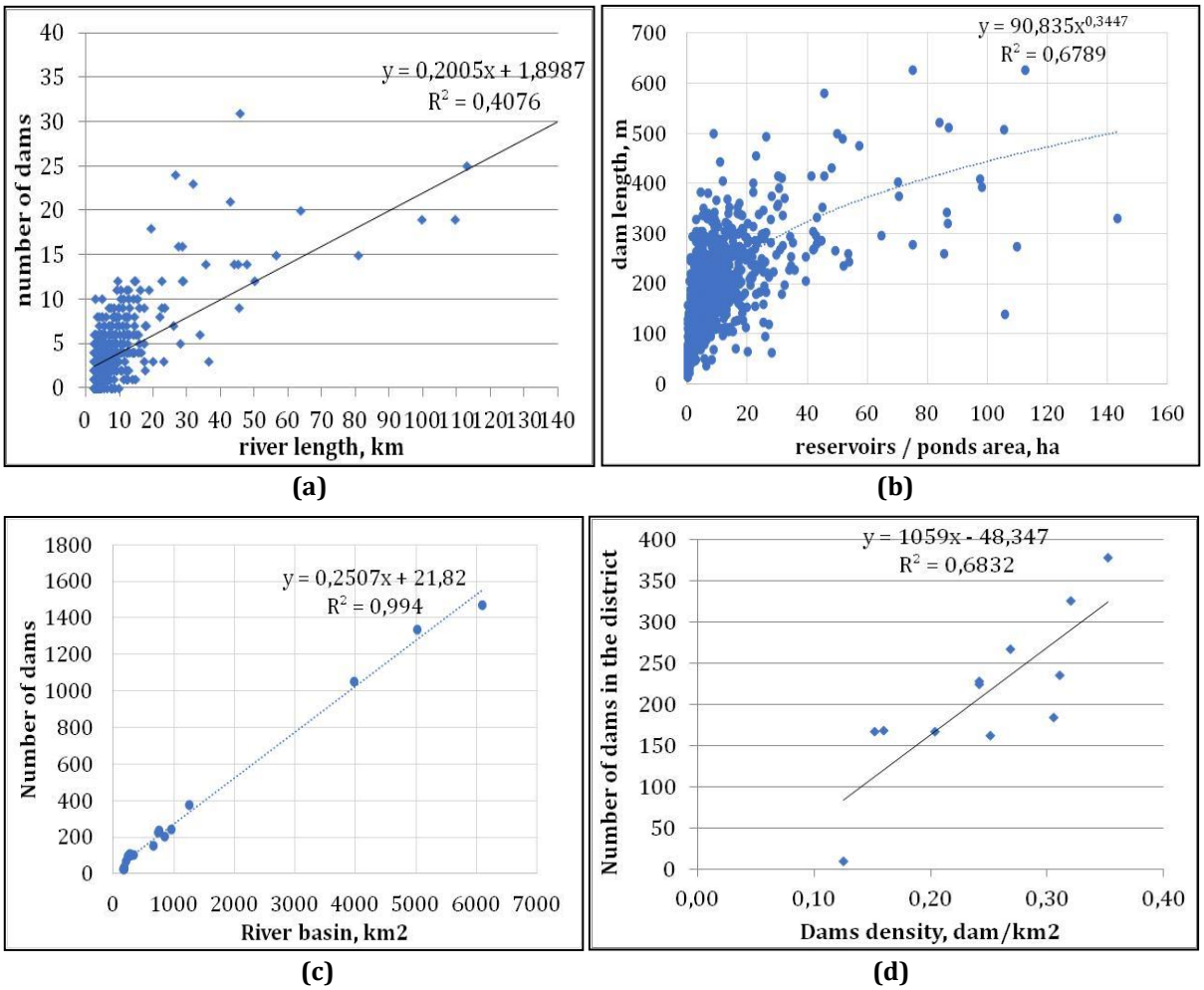


Figure 4. Correlation between: dams' number and river length (**a**); dams' length and reservoirs areas (**b**); dams' number and river basins (**c**); number of dams in the district and dams density in the district (**d**). Source: own work.

4.2. The state of the dams

Dams' condition was grouped in satisfactory – when no damages are identified as a result of visual analysis, and partially demolished – when dams breach is observed and river flows through it (Figure 5).

(a) **(b)**

Figure 5. Dam in satisfactory condition (**a**); Partially demolished dam (**b**).
Source: Google Earth, 2023.

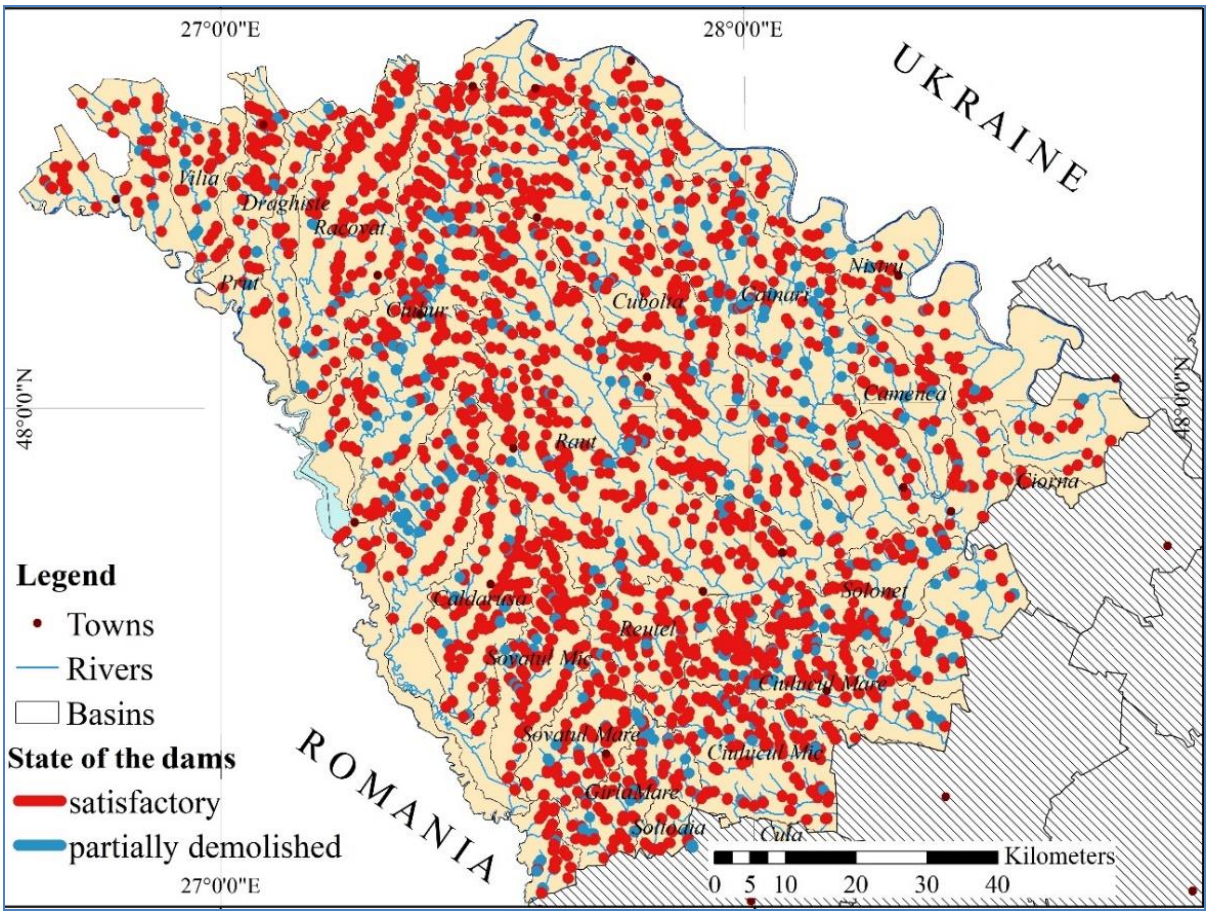


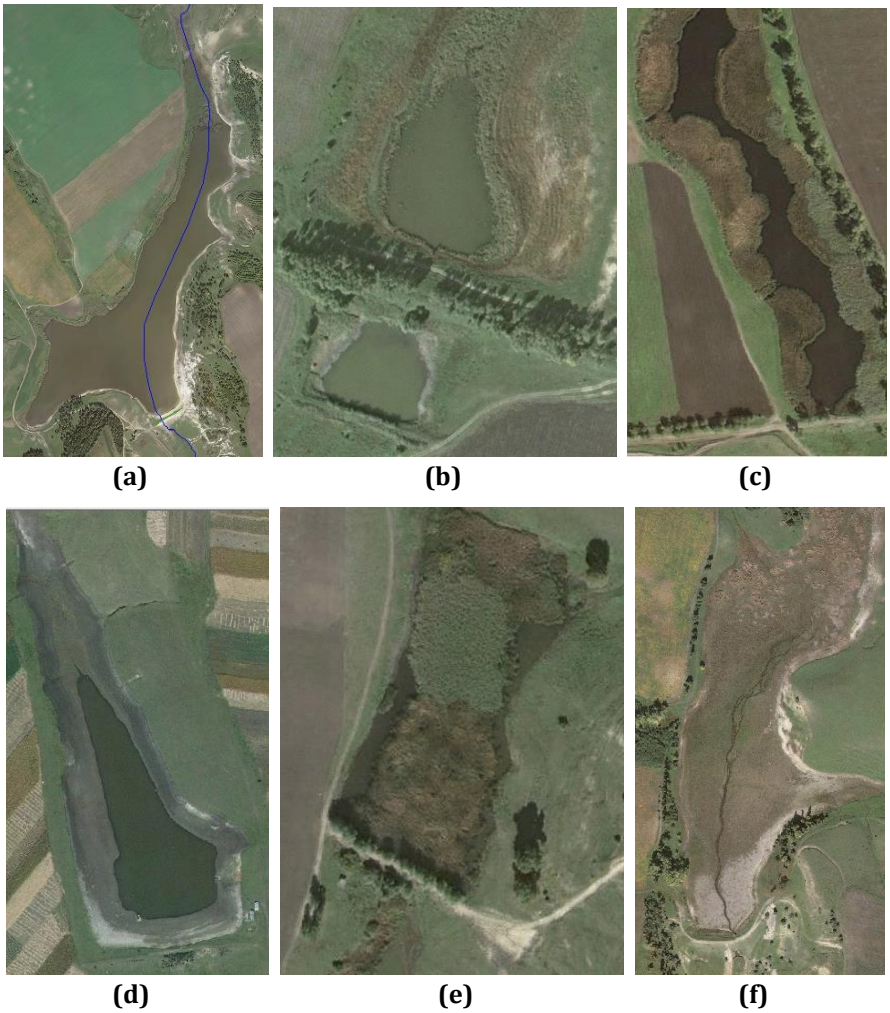
Figure 6. The state of the dams.
Source: own work.

In total from 2,523 dams, 361 dams or 14.3% have breach in the body, and 2,161 dams or 85.7 % are in satisfactory state (Table 1, Table 2, Figure 6). In the Dniester basin part from 1471 dams or 14.4 % are partially demolished. The share varies from 7% in the Răuțel river basin, 8.7 % in the Cubolta river up to 21.6% in the Soloneț basin, 26% in the Camenca (Răut), 29 % in the Căinari river basin. The number of

partially demolished dams in the Răut basin part is 201 or 15%. Classifying by the river type, about 16% of dams situated on stream are partially demolished, 10% dams on small rivers and 35% on medium rivers are of mentioned type of condition. The highest number of partially demolished dams is in the Căinari river basin. Here, these dams share is 26% on streams, 39% on small rivers, 37% on the Căinari. High share is also specific for the Camenca basin (Răut), where 28% of partially demolished dams are situated on streams, 17 % - on small rivers, 33 % - on the Camenca. In the Soloneț basin, partially demolished dams are situated on steams – 29% and on small rivers – 11%, and the river itself – 9.5%. In the Cubolta river basin, mentioned type of dams is in a number of 37% on the river itself, and only a few of them being on rivers and streams – 5-7%.

In the Prut river basin, the share of partially demolished dams is the same as in the Dniester, about 14%. It varies from about 8% in the Draghișteand Racovăț river basins, up to 19% in the Vilia basin. In the rest of the basins, the range is from 11 to 15%. By river type, 16% of these dams are situated on streams, 12% - on small rivers and 4% on medium rivers. In the Camenca river basin, the share of partially demolished dams is lower, 21.6% - on streams, 3% - on small rivers. Higher share is in Ciuhur basin, being 14% on streams, 15% on small rivers, 33% on the Ciuhur itself. The highest share is in the Vilia basin, where 13% of partially demolished dams are situated on streams, 12.5 % - on small rivers, 50 % - on Vilia.

In the districts, the highest share of partially demolished dams is in Soroca and Florești – about 20%, and the lowest share is in Ocnița and Briceni – 8-9%. In the rest of the districts this value ranges between 10% (Dondușeni) and 17% (Drochia). These dams can be the first in the list of measures for river state rehabilitation.



(a) **(b)** **(c)**

(d) **(e)** **(f)**

Figure 7. Reservoir (**a**); Ponds (**b**); Eutrophic water accumulation (**c**); Semi-dry water accumulation (**d**); Wetland (**e**); Dry terrain (**f**).
Source: Google Earth, 2023.

4.3. The state of upstream part of the dams

Along with mapping of dams, their upstream part was analyzed. It was classified in 6 classes. First two classes consist of normal water accumulations grouped in reservoirs with surface over 2 ha and ponds with surface less 2 ha. The other two classes refer to water accumulations in degraded state: one class is accumulations covered by vegetation with a small share of open water – classified as eutrophic and the other one is semi-dry accumulations which water surface occupy visible less than half of the real area. The rest two classes are represented by dry terrain and wetland developed as a result of reservoirs and ponds eutrophication. Examples of classification of dams' upstream part are shown in Figure 7.

Overall, in case of only 49% situations, in the upstream part, waters are presented by: 30% - reservoirs, 19% - ponds. The other 14% situations are characterized by accumulations in degraded state: 9% - eutrophic, and 5% - semi-dry. 30% of cases are represented by dry terrain and 8% by developed wetlands (Table 1, Table 2, Figure 8 and Figure 9).

Table 1. The state of dams situated on the river of the North Development Region.

Name of basin	River basin in the NDR limit, km²	Number of dams	Average length of the dams, m	Dam density, dam/km of river	Dam density, dam/km²	State of dams		The state of the upstream part of the dams					
						Satisfactory	Partially demolished	Reservoirs	Ponds	Eutrophic accumulations	Semi-dry	Dry land	Wetland
The Dniester river basin													
Cubolta	939	242	134	0.45	0.26	221	21	89	45	19	5	70	14
Căinari	830	204	123	0.40	0.25	145	59	30	39	12	10	101	12
Camenca	174	27	164	0.27	0.16	20	7	10	3	2	0	11	1
Soloneț	268	97	136	0.64	0.36	76	21	21	12	12	3	41	8
Răuțel	222	98	105	0.79	0.44	91	7	23	38	4	5	22	6
Ciulucul Mic*	743	240	134	0.49	0.32	205	35	53	31	17	29	90	20
Răut*	5009	1335	132	0.52	0.27	1134	201	365	232	108	71	450	109
Dniester*	6087	1471	131	0.50	0.24	1259	212	399	264	123	79	490	116
The Prut river basin													
Vilia*	172	37	126	0.40	0.22	30	7	14	6	5	1	8	3
Draghișteˆ*	156	26	146	0.30	0.17	24	2	7	9	3	0	5	2
Racovăț*	656	155	142	0.44	0.24	142	13	45	41	20	1	29	19
Ciuhur	724	229	135	0.55	0.32	193	35	91	45	22	7	51	13
Căldărușa	321	106	137	0.65	0.33	94	12	52	24	3	2	19	6
Șovățul Mic	259	111	140	0.85	0.43	99	12	39	28	10	6	24	4
Șovățul Mare	204	71	142	0.68	0.35	63	8	20	16	0	7	22	6
Camenca*	1239	378	136	0.58	0.31	327	51	142	78	23	15	91	29
Prut*	3964	1052	140	0.52	0.27	903	149	359	210	97	35	267	84

*Total, in the limits of NDR

In the Dniester basin part, the share of the mentioned classes is as follows: 27% - reservoirs, 18% - ponds, 8.4% - eutrophic, 5.4% - semi-dry accumulation, 33.3% - dry terrain and 8% - wetlands. The share of reservoirs and ponds in the basins ranges from 33.8% (14.7% reservoirs and 19.1% ponds) - in the Căinari basin, 34% (21.6% reservoirs and 12.4% ponds) - in the Soloneț basin to 62.2% (23.6% reservoirs and 38.8% ponds) - in the Răuțel basin. The share of eutrophic and semi-dry accumulations is not high. The first ranges from 4% in the Răuțel basin to 12 % in the Soloneț basin, the share in the other basins being 6-8%. The second type of degraded accumulations is lower in number. No semi-dry accumulations were identified in the Camenca basin, in the others it is 2-5%, only in the Ciulucul Mic being 12%.

Quite high share of dry lakes was identified in the basins of the Dniester river. Aprox. 1/3 of the dams' upstream part is dry in the Cubolta, Răut, 40% - in the Ciulucul Mic, Camenca, Soloneț, and even 50% in the Căinari river basin. The share of wetlands is much lower, being 4% in Camenca, 6% in the Căinari, Cubolta and Răuțel and 8% in the rest of the basins.

Table 2. The state of dams in the districts of the North Development Region.

Name of district	District area, km²	Number of dams	Dams density, dam/km²	Average length of the dams, m	State of dams		The state of the upstream part of the dams					
					Satisfactory	Partially demolished	Reservoirs	Ponds	Eutrophic accumulations	Semi-dry	Dry land	Wetland
Briceni	824	168	0.20	141	152	16	56	40	22	3	30	17
Edineț	933	225	0.24	133	192	33	76	48	37	1	49	14
Ocnița	603	184	0.31	129	170	14	81	40	7	7	33	16
Dondușeni	649	163	0.25	128	146	17	61	32	15	5	40	10
Rîscani	943	228	0.24	144	190	37	94	31	24	8	54	17
Drochia	999	268	0.27	125	222	46	65	38	22	12	112	19
Soroca	1058	169	0.16	126	133	36	27	41	15	7	71	8
Glodeni	760	236	0.31	126	209	27	92	51	17	6	46	24
Florești	1103	167	0.15	158	135	32	47	16	18	8	64	14
Fălești	1076	379	0.35	136	325	54	87	77	20	29	139	27
Sîngerei	1019	326	0.32	133	277	49	69	58	21	27	118	33
Balti	80	10	0.13	215	10	0	3	2	2	1	1	1

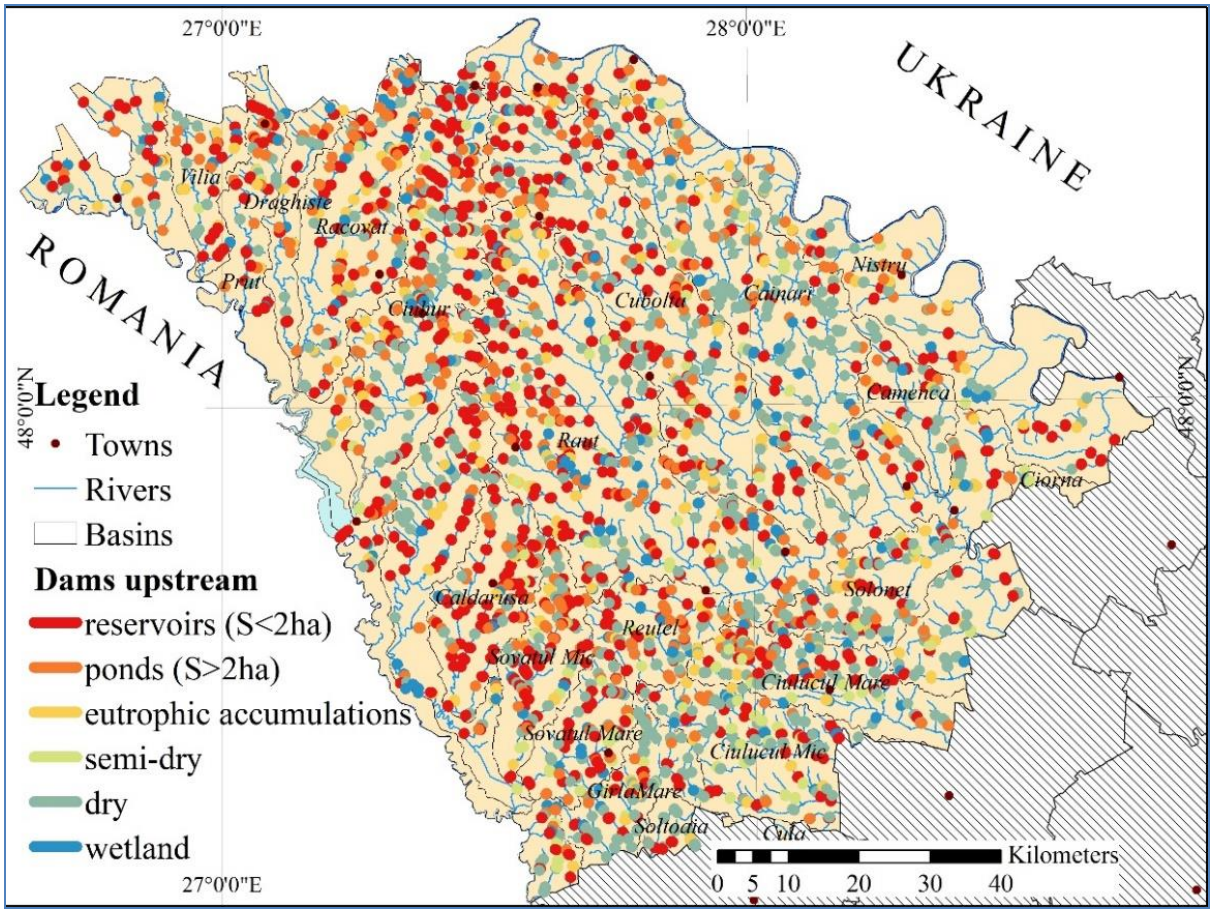


Figure 8. The state of the upstream part of the dams.
Source: own work.

In the Prut basin part, the share of the dams' upstream part is as follows: 34% - reservoirs, 20% - ponds, 9.2% – eutrophic, 3.3% - semi-dry, 25.4% - dry terrain and 8% - wetlands. The share of normal water accumulations is higher in comparison with the Dniester basin. Here, the range is 51% (28.2% reservoirs and 22.5% ponds) - in Şovăţul Mic basin to 72% (49% reservoirs and 23% ponds) - in Căldăruşa basin, in the other basins the share is 55%-60%. Eutrophic accumulations are higher in number in Vilia, Draghişte, Racovăţ – about 11-14%, and lower in Căldăruşa basin – 3%, null number is in Şovăţul Mare basin. Semi-dry accumulations are absent in the Draghişte basin and just a few in the Căldăruşa, Vilia, Ciuhur, Camenca, 2-4%, the highest number being in Şovăţul Mare basin – 10%. In the basins of the Prut the share of dry terrains is lower than in those from the Dniester river. Approximately 1/3 of the dams' upstream part is dry in the Şovăţul Mare basin, in the other basins their number in around 20%. Developed wetlands are in between 4% - Şovăţul Mic basin and 12% - Racovăţ basin, in the others the values are about 6-8%.

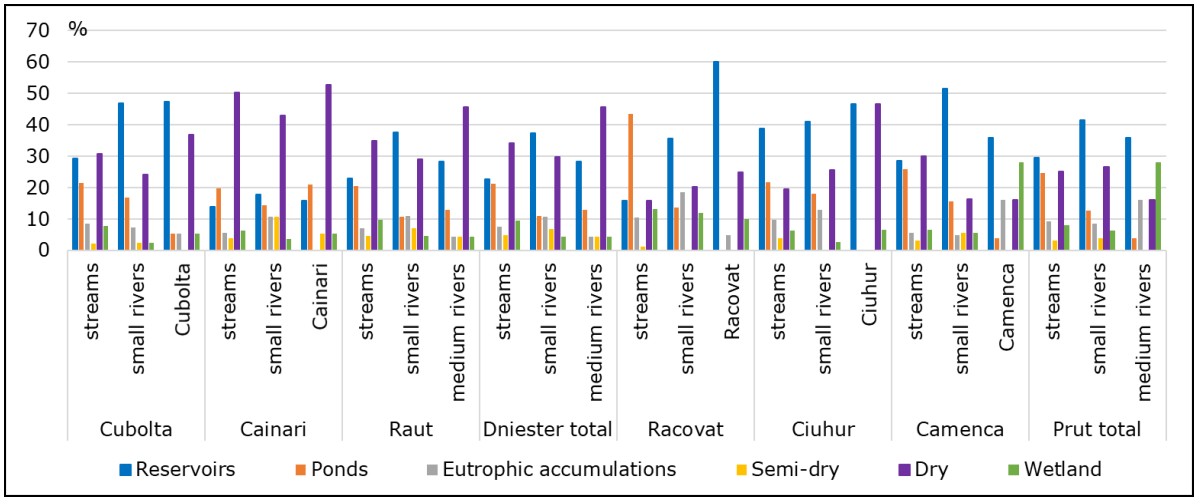
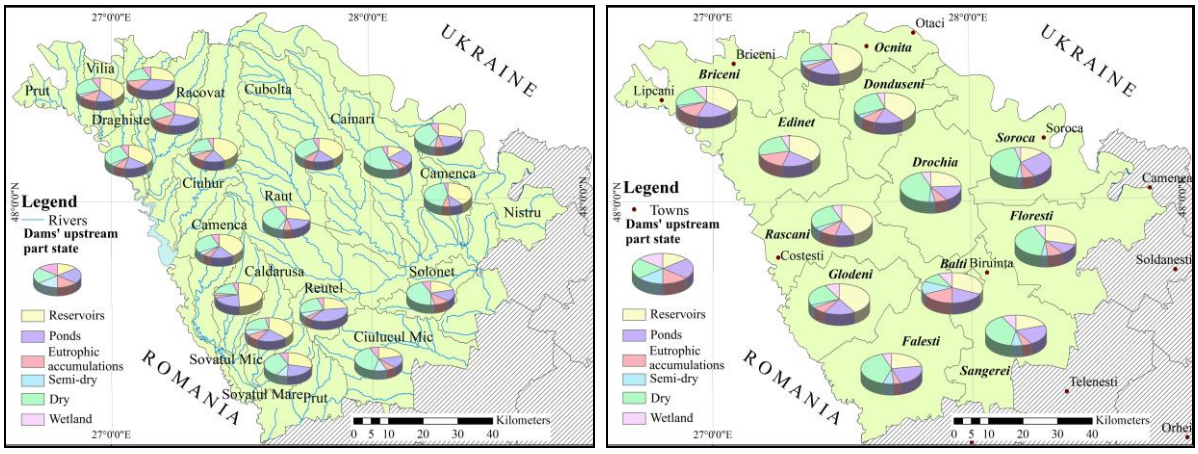


Figure 9. The state of the upstream part of the dams.
Source: own work.



(a) **(b)**

Figure 10. Dams upstream part state in the limits of river basins (**a**) and districts (**b**).
Source: own work.

The share of the dams' upstream part for considered types of rivers for the pilot basins is represented in Figure 9 and Figure 10. Main emphasized situations are reservoirs and ponds as well as dry land, less obvious are semi-dry and eutrophic accumulations and wetlands. Overall, in the Dniester basin, as well as in the Raut basin, on the streams highest share is specific for open water, reservoirs and ponds being of about the same number (aprox. 21% each) and dry land (35%). The share of wetlands is about 9.5%, twice higher than in case of other types of rivers. In case of small rivers, 1/3 of dams' upstream part is dry, while 48% is open water (from which 37% is reservoirs), and 10% eutrophic accumulations. On medium rivers, the share of reservoirs and ponds in sum is almost equal with the dry

land, the other situation are of about 4% each. In comparison with basinal averages, in the Căinari basin, in case of all types of rivers, ½ of the dams' upstream part is represented by dry land, reservoirs and ponds are of the share, about 14-20%. Number of eutrophic and semi-dry accumulations is higher on small rivers, about 10%, in case of other rivers it is twice lower. In the Cubolta river, mainly open water is emphasized as a condition of dams' upstream state. Its number is over 50% in case of streams and Cubolta itself, and over 60% on small rivers. The share of dry land is also high of about 1/3.

In the Prut river basin, the obvious condition of the upstream part of the dams is mainly open water – reservoirs. The other conditions differ from type to type and from basin to basin. Overall, in the Prut basin as well as in the Camenca basin, on the streams, reservoirs, ponds and dry land are of about ¼ each. On small rivers, reservoirs occupy ½ of cases, ponds - 14% and dry land - ¼ or 1/5. On streams and small rivers, low share is specific for eutrophic and semi-dry accumulations and wetlands. In comparison with other river types, on the Camenca river – medium river, main conditions of the upstream part of the dams are reservoirs – 36%, wetlands – 28%, eutrophic accumulations – 16% and dry land – 16%. In the other basins, the dams upstream part conditions differ. More or less comparable are the situations in case of steams and small rivers of the Racovăţ and Ciuhur basins. Thus, on streams, reservoirs and ponds summarize about 60%, however in case of Racovăţ number of ponds is about 43% and reservoirs 16%, and in case of Ciuhur this number is reversed. Share of dry land is between 15% and 25%, eutrophic accumulations occupy a lower number, of about 10% - 18%. Wetlands are present mainly on the streams and small rivers of Racovăţ, share being over 10% from the total number of the dams' upstream part conditions. In case of Ciuhur, half of situations is reservoirs and the other half is dry lands. The upstream part of the dams of the Racovăţ river is mainly reservoirs – 60%, 25% is dry land and 10% is wetland.

At the district level, as in case of basins, main types of dams' upstream conditions are reservoirs, ponds and dry land. Conventionally, the districts can be divided in two groups, the one with almost equal share of open water and dry terrain, and the second with higher dominance of ponds and reservoirs. First group contains 5 districts: Drochia, Soroca, Floreşti, Făleşti, Sîngerei, here the share of open water and dry land is about 40% each. In the other districts: Briceni, Edineţ, Ocniţa, Donduşeni, Rîscani, Drochia, Soroca, Glodeni, the share of ponds and reservoirs is about 50-60% while the value of dry land is around 20% or smaller by two or even three times than the previous one. The share of the other types of dams' upstream part is not high. Eutrophic accumulations are of about 10% (the lowest share of 4-6% is in Ocniţa, Făleşti, Sîngerei, and the highest share of 13-16% is in Briceni, Edineţ). Semi-dry accumulations are only a few, average being 4%, only 0.4% is specific for Edineţ and about 7-8% for Făleşti, Sîngerei. Share of wetland is 8%, range being from 4.7% in Soroca and 10% in Briceni, Glodeni, Sîngerei.

4.3. The dams' density

The dams' density is a good indicator for understanding which type of rivers or basins and districts are the most affected by this phenomenon and its real extend. Evaluation of dams´ density was performed for considered river types, by estimation of number of dams constructed per kilometer of river. The map of dams' density for every river can be found in the Figure 11, while the average dams' density for the river basins is represented in Figure 12. Also, dams' density was evaluated as dam per km^2 of basins or districts. The maps with this indicator are shown in Figure 14.

In the Dniester basin, the highest density of dams was identified in the Soloneţ and Răuţel basins. The dams on the streams have a density of 0.74 dams/river km (or a dam on every 1,36 km of river) in the Soloneţ and of 0.95 dams/river km (or a dam on every 1.06 km of river) in the Răuţel basin. In these basins, the dams' density on small rivers is also higher than in others. On average, in the Soloneţ, it is 0.54 dams/river km and in the Răuţel – 0.47 dams/river km or a dam on every 2 km of river. The lowest values of dams' density are in the Camenca basin, on the streams this indicator is 0.38 dams/river km (or a dam on every 2,66 km of river), and on small rivers it is 0.18 dams/river km (or a dam on every 5.66 km of river). In the other basins, Cubolta, Căinari, Ciulucul Mic, Răut and Dniester overall, the values of dams' density are more or less the same. The dams on the streams have a density of 0.5 dams/river km (or a dam on every 2 km of river). Mentioned density on small rivers ranges from 0.27 dams/river km in Căinari basin to 0.51 dams/river km in Cubolta, in other basins being about 0.4 dams/river km. Average dams' density on medium rivers is 0.17 dams/river km in Cubolta basin and 0.19 dams/river km in Căinari or a dam on every 5 km of river. Average value in the Dniester basin is 0.12 dams/medium river

km (or a dam on every 8 km of river), the lowest is on the Răut itself - 0.05 dams/ river km (or a dam on every 20 km of river).

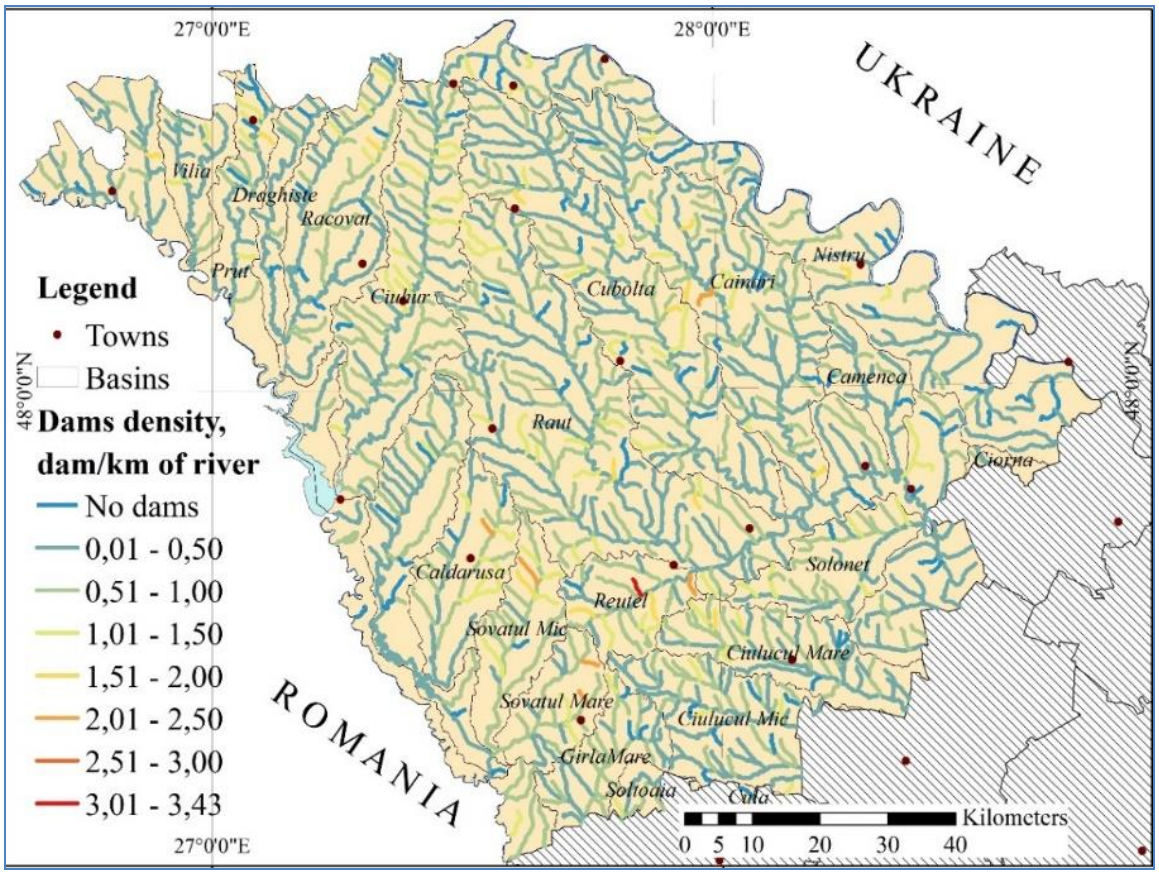


Figure 11. Density of the dams.
Source: own work.

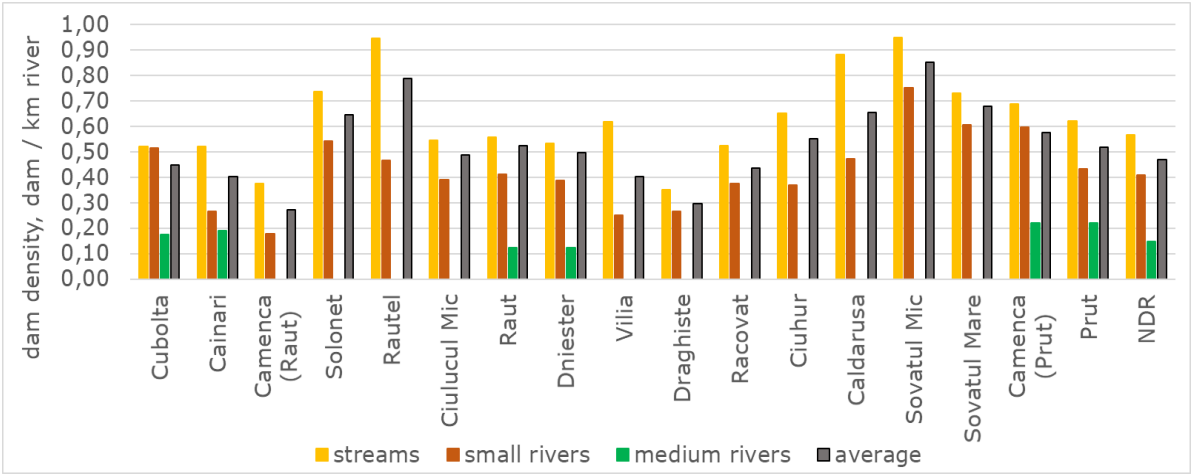
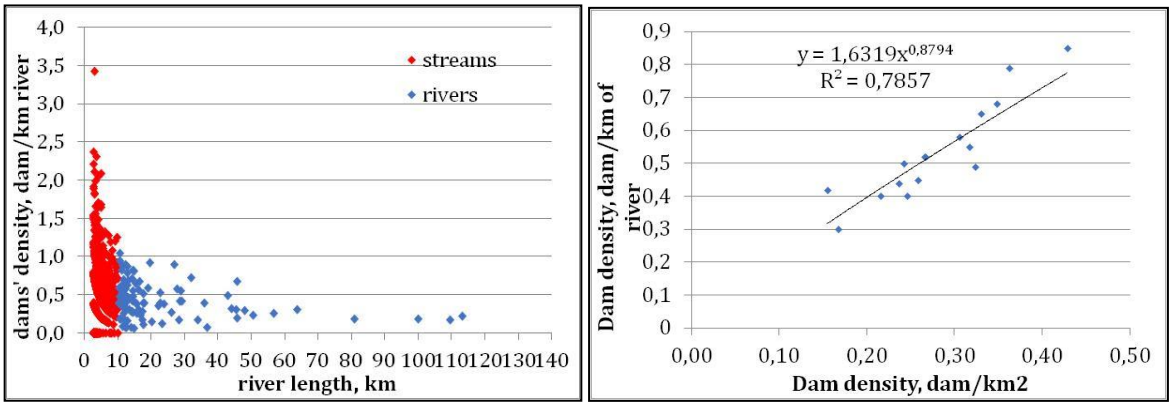


Figure 12. Average dams' density in different river basins.
Source: own work.

In the Prut basin, the dams' density on the streams and small rivers is higher than in the Dniester basin. The Camenca river with its tributaries is emphasized at the basin level. On its streams this indicator is from 0.73 dams/ river km in the Șovățul Mare (or a dam on every 1.37 km of river) to 0.95 dams/ river km in the Șovățul Mic (or a dam on every 1.05 km of river). On its small rivers, dams' density is from 0.47 dams/river km in the Căldărușa (or a dam on every 2.11 km of river) to 0.75 dams/ river km in the Șovățul Mic (or a dam on every 1.33 km of river). Dams' density on the Camenca itself is 0.22 dams/ river km or a dam on almost every 5 km of river. In the other basins, dams' density on streams is lower and is about 0.5 dams/ river km, ranging from 0.35 dams/ river km in the Draghişte to 0.65 dams/ river km in

the Vilia, Ciuhur, Prut overall. Dams' density on small rivers is about 0.3 dams/ river km varying from 0.27 dams/ river km in the Vilia and Draghişte basin to 0.37 dams/ river km in the Racovăţ and Ciuhur.

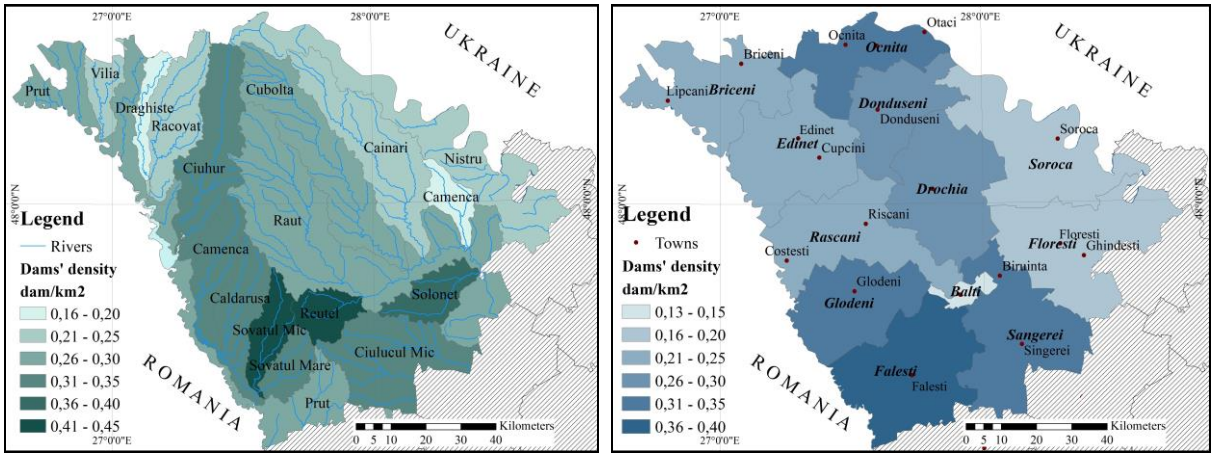
On average the density of dams is 0.47 dams/ river km, which means that on almost every 2 km of rivers a dam can be found. The value is almost the same in the Dniester and the Prut basins. However, analysis of this indicator with reference to river types shows that the highest density is specific for streams, here the average value is 0.57 dams/river km, which means that a dam is constructed on every 1.77 km of stream. In comparison, on small rivers this indicator is much lower, average is 0.41 dams/river km or one dam is found on every 2.45 km of river. The lowest dams' density is specific to medium rivers, being only 0.15 dams/river km or one dam is constructed on every 6.8 km of river. Thus, the streams are the most affected by dams' phenomenon (Figure 13).



(a) **(b)**

Figure 13. Relationship between dams' density and river length (**a**), dams' density related to river length and basin areas (**b**).
Source: own work

Dams' density in the limits of river basins and districts, calculated as dam per km², is on average 0.25 dams/km². The highest values are specific for basins Sovatul Mic, 0.43 dam/km², and Rautel, 0.44 dam/km². The parameter in the nearest basins is lower, of 0.36 dam/km² in the Solonet basin, of 0.31-0.33 dam/km² in the Ciuhur, Camenca, Caldarusa, Sovatul Mare and Ciulucul Mic basins. The lowest values are estimated for Camenca (Raut) and Draghiste – 0.16 dam/km², situate to the north and to the east of the region. The central part of the region is characterized by dams' density of 0.26 dam/km² (basins Raut, Cubolta). For the districts, the highest dams' density is established for Falesti – 0.35 dam/km², while in the Glodeni, Sangerei (situated in the south of NDR) as well as in the Ocnita (situated in the north of NDR) this indicator is 0.31 dam/km². In the east districts, the value is lower, of 0.15 dam/km² and in the west districts of about 0.2-0.24 dam/km². For the central districts of NDR, the density is average, 0.25-0.27 dam/km².



(a) **(b)**

Figure 14. Dams' density in the limits of river basins (**a**) and districts (**b**).
Source: own work.

In general, the highest density is established for the southern part of NDR and the lowest – for its eastern part, values for the central part are similar to the average for the whole region, while those from the western part are slightly lower than medium (Figure 14).

6. CONCLUSIONS

In the North Development Region of the Republic of Moldova, dams and reservoirs situated on rivers and stream is performed for fishery, recreation, irrigation. In official statistic, information about 1,157 reservoirs and their dams can be found (Burduja & Bacal, 2021), the real mapped number of dams being 2523 or at least 2.2 time higher. It should be mentioned that in many cases, if water accumulations do not represent any economic importance, they are abandoned without performing any river renaturalization activities, and are not considered anymore in official statistics. Thus, further studies, including those in the field, should be performed in order to develop a full database of dams, their state and measures as well as steps of rivers naturalization and unnecessary dams demolishing.

Average dams' length is about 134, ranging from 8 to 626 m. Ponds' dams are of by up to 110 m length, of the reservoirs with surface up to 10 ha these are from 110 to 250 m, for those of 10-30 ha, the hydrotechnical structure is of 250-400 m. The dams over 400 m embank reservoirs over 30 ha.

From total number of 2,523 dams mapped on the stream and rivers of the NDR, 86% are estimated to be generally in satisfactory condition, the other 14% being partially demolished. Analysis of the upper part of the dams' showed that only in case of 49% there are presented reservoirs and ponds in good condition, those in eutrophic condition and semi-dry accumulations are of 13%, the upstream of other 30% is characterized by dry territory and 8% by wetland.

Dams' density is considered very high in case of streams, the average being 0.57 dams/ river km or about 1 dam on every 1.77 km of river, and much lower on medium rivers, being only 0.15 dams/river km or one dam is constructed on almost every 7 km of river. Thus, real extent of the dams' impact comes to light only after a detailed mapping and analysis. Maximum human impact is attributed to streams, while medium rivers are less influenced by this phenomenon. From another point of view, water stacked in a huge number of ponds and reservoirs constructed on streams is mostly lost, and doesn't reach large rivers, thus overall water resources being significantly reduced.

Dams' density in the limits of river basins and districts, calculated as dam per km^2, is on average 0.25 dams/km^2. In general, the highest density is established for the southern part of NDR and the lowest – for its eastern part, values for the central part are similar to the average for the whole region, while those from the western part are slightly lower than the medium.

Present research is a first attempt to develop a dams' spatial database. Further studies, including those in the field, should be performed in order to improve actual studies and finalize the development of a comprehensive database of dams. Also, dams' mapping and evaluation should be extended for the whole country which further would facilitate decision makers to identify and apply measures for river restoration.

Acknowledgments: The author thanks the reviewers for their valuable comments.

Use of AI tools declaration: The author declares they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflicts of interest: The author declares no conflicts of interest.

Funding: This article is developed within the Research Project 20.80009.7007.11 "Assessment of urban and rural ecosystems stability in order to ensure sustainable development" of the Institute of Ecology and Geography, Moldova State University, the Republic of Moldova (2020-2023).

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Abstract

The abstract should be a total of about 300 words maximum. For research articles, abstracts should give a pertinent overview of the work. The abstract should contain the following elements: aim, research methods, conclusions, originality / value of the article, implications of the research (if applicable), limitations of the research (if applicable).The abstract should be a single paragraph (Cambria 10pt, Normal).

Keywords

Five to seven pertinent keywords (separated by comma) need to be added after the abstract (Cambria 10pt, Normal).

Main text

The condition of reviewing the article is to follow the guidelines.
The suggested scheme of article
Body of the paper consisting of part corresponding with steps of realization of aims of the paper should be divided into following sections: Introduction/Literature review/Research methods/Results/Discussions/Conclusions.

1. **INTRODUCTION** (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt) The introductory paragraph outlines clearly the objectives and motivation for writing the paper. The introduction should provide a context for the discussion in the body of the paper and point explicitly the purpose of the article. The checklist:

- The introduction includes the justification for the topic importance.
- The introduction section includes the aim/objective.
- The introduction section includes brief information on methods.
- The content of each section of the article is briefly described in the last paragraph of the introduction (Cambria, 10pt, Normal).

2. **LITERATURE REVIEW** (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt) The checklist:

- Is the literature review properly prepared?
- Is primary literature correctly summarized?
- The literature review shows who dealt with similar research topic before?
- The literature review shows what are the results of the prior studies?
- Did the Author position himself/herself among the previous researchers?
- Are different options/perspectives from the literature covered in the reviewed article?
- The difference with existing studies is explicitly identified and documented.
- The text includes references whenever necessary (Cambria, 10pt, Normal).

3. **RESEARCH METHODS** (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt) This section is compulsory and it should provide specific description of the methodology. The checklist:

- The research methodology section includes the description of the material selection.
- The research methodology section includes: the hypothesis (-es).
- The research methodology section includes the description of the research methods.
- The article identifies strengths and weaknesses of the methodology and its findings (Cambria, 10pt, Normal).

4. **RESULTS** (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt) The checklist:

- Are the results discussed in details?
- Is the research problem original and a kind of novelty?
- Has the Author given the appropriate interpretation of the data and references?
- Are the pieces of information used inside the paper comes from reliable sources? (Cambria, 10pt, Normal).

5. **DISCUSSION** (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt) The checklist:

- The article assesses and critiques the findings and/or the statistical analysis.
- Are the findings in the article compared to findings of other authors? (Cambria, 10pt, Normal).

6. **CONCLUSIONS** (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt) It should provide a neat summary and possible directions of future research. The checklist:

- Does this part include the general summary of the article, its results and findings?
- Does this part include implications and recommendations for practice?
- Does this part include research limitations?
- Does this part include suggestions for future research? (Cambria, 10pt, Normal).

ACKNOWLEDGMENTS: (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt). Apart from the usual acknowledgements, use this section to mention sponsoring and funding information (Cambria, 10pt, Normal).

USE OF AI TOOLS DECLARATION: (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt). The authors declare they have not used Artificial Intelligence (AI) tools in the creation of the articles (Cambria, 10pt, Normal).

AUTHOR CONTRIBUTIONS: (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt) Each author is expected to have made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; or have drafted the work or substantively revised it; and has approved the submitted version (and version substantially edited by journal staff that involves the author's contribution to the study) (Cambria, 10pt, Normal).

CONFLICTS OF INTEREST: (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt). Authors must identify and declare any personal circumstances or interest that may be perceived as influencing the representation or interpretation of reported research results. If there is no conflict of interest, please state *"The authors declare no conflict of interest."* (Cambria, 10pt, Normal).

REFERENCES (Cambria, 10pt, Bold. Spacing: Before 12pt; After 6pt. Line spacing: At least; At 13pt) The list of references should be complete and accurate. For each work shown in the list of references, there must be a reference in the text.

Beginning with Volume 5, Issue 1 / 2023, the citation of authors in the text will follow the 7th edition of the APA style (American Psychological Association), instead of the previously used Vancouver style.

Citations in the text and the list of references should follow the referencing style used by the American Psychological Association, the latest version of the APA Publication Manual (i.e., APA 7), which released in October 2019. Details concerning this referencing style can be found at **http://www.library.cornell.edu/resrch/citmanage/apa**. Authors can also use citation machine at **http://citationmachine.net/**

References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters "a", "b", "c", etc., placed after the year of publication.

In every article there should be at least 20 references and majority of references have to be from SCOPUS/Web of Science. The authors should concentrate on the references to publications for recent years.

Authors are required to complete the reference in a list of literature used with DOI (Digital Object Identifier) if it has been assigned to the publication. To search for the DOI, please visit: **http://www.crossref.org/guestquery/**

- ***In-text citations:*** The citation of authors in the text will follow the 7th edition of the APA style.

Every use of information from other sources must be cited in the text so that it is clear that external material has been used. For every in-text citation, there should be a full citation in the reference list and vice versa. In APA style, in-text citations are placed within sentences and paragraphs so that it is clear what and whose data or information is being quoted or paraphrased.

If the author is already mentioned in the main text then the year should follow the name within parentheses.

- Research by Posea (2005) and Ielenicz (2003) supports…

If the author's name is not mentioned in the main text then the surname and year should be inserted, in parentheses, after the relevant text. Multiple citations should be separated by semicolon and follow alphabetical order.

- The petrographic composition of the massif explains this type of relief (Ielenicz 2003; Posea 2005).

If three or fewer authors are cited from the same citation then all should be listed. If four or more authors are part of the citation then 'et al.' should follow the first author's name.

- (Ielenicz, Comanescu & Nedelea 2010)
- (Ielenicz et al.2008)

If multipe sources are used from the same author and the same year, then a lowercase letter, starting from 'a', should be placed after the year.

- (Ielenicz 2003a; Ielenicz 2003b)

If you are directly quoting from a work, you will need to include the author, year of publication, and page number for the reference (preceded by "p." for a single page and "pp." for a span of multiple pages, with the page numbers separated by an en dash).

You can introduce the quotation with a signal phrase that includes the author's last name followed by the date of publication in parentheses.

- According to Ielenicz (2003), "quoted text" (p. 199).
- Ielenicz (2003) found "quoted text" (pp. 199-202).

If you do not include the author's name in the text of the sentence, place the author's last name, the year of publication, and the page number in parentheses after the quotation.

- The author stated, "quoted text" (Ielenicz, 2003, p. 199), but he did not offer an explanation as to why.

Authors with the Same Last Name: To prevent confusion, use first initials with the last names.

- (D. Privitera, 2004; A.C. Privitera, 2019)

The names of groups that serve as authors (corporate authors) are usually written out each time they appear in a text reference.

- (European Environment Agency [EEA], 2018)

When appropriate, the names of some corporate authors are spelled out in the first reference and abbreviated in all subsequent citations. The general rule for abbreviating in this manner is to supply enough information in the text citation for a reader to locate its source in the Reference List without difficulty.

- (EEA, 2018)

If the name of the group first appears in the narrative, put the abbreviation, a comma, and the year for the citation in parentheses after it.

- The European Environment Agency (EEA, 2023) state that extreme weather threat makes climate change adaptation a top priority.

When a paper has no author, use the first two or three words of the paper's title (using the first few words of the reference list entry, usually the title) as your text reference, capitalizing each word. Place the title in quotation marks if it refers to an article, chapter of a book, or Web page. Italicize the title if it refers to a book, periodical, brochure, or report.

- On climate change ("Climate and Weather", 2010) …
- Guide to Hydrological Practices (2008)

Please do not include URLs in parenthetical citations.

(Cambria, 10pt, Normal).

- ***Reference list***: References follow the 7th edition of the APA style, which includes a dedicated section to the citation of electronic resources.

We strongly recommend the use of reference management software such as Mendeley or Zotero. The official APA style manual can be purchased through their website. (Cambria, 9pt, Normal, Idendation, Special: Hanging; By: 1cm; Line spacing: Single).

Triple-check your references details and their correspondence with the in-text citation. Be aware that despite doing our best to remediate possible issues, authors are responsible for the accuracy of references.

Some examples of references in APA style (7th edition) are included below.

Book with one author:

Fennell, D. (2008). *Ecotourism.* Third edition. Routledge.

Book with two authors:

Jones, R., & Shaw, B.J. (2007). *Geographies of Australian Heritages: Loving a Sunburnt Country?* Routledge. https://doi.org/10.4324/9781351157520

Book with more than two authors:

Carter, T., Harvey, D., Jones, R., & Robertson, I. (Eds.). (2019). *Creating Heritage: Unrecognised Pasts and Rejected Futures*. Routledge. https://doi.org/10.4324/9781351168526

Journal article with DOI:

Leimgruber, W. (2021). Tourism in Switzerland – How can the future be? *Research in Globalization, 3*, Article 100058. https://doi.org/10.1016/j.resglo.2021.100058

Journal article without DOI (when DOI is not available):

Ianos, I., Sirodoev, I., & Pascariu, G. (2012). Land-use conflicts and environmental policies in two post-socialist urban agglomerations: Bucharest and Chişinău. *Carpathian Journal of Earth and Environmental Sciences, 7*(4), 125–136. https://www.cjees.ro/viewTopic.php?topicId=276

Journal article with an article number or eLocator:

Ivona, A., Rinella, A., Rinella, F., Epifani, F., & Nocco, S. (2021). Resilient Rural Areas and Tourism Development Paths: A Comparison of Case Studies. *Sustainability, 13*(6), Article 3022. https://doi.org/10.3390/su13063022

Article in a magazine or newspaper:

Benabent Fernández de Córdoba, M., & Mata Olmo, R. (2007, July 13). El futuro de la geografía. *El País.* https://elpais.com/diario/2007/07/13/opinion/1184277607_850215.html

Edited book:

Yang, P. (Ed.) 2018. *Cases on Green Energy and Sustainable Development.* IGI Global.

Chapter in an edited book:

Privitera, D., Štetić, S., Baran, T., & Nedelcu, A. (2019). Food, Rural Heritage, and Tourism in the Local Economy: Case Studies in Serbia, Romania, Italy, and Turkey. In J. V. Andrei, J. Subic, A. Grubor & D. Privitera (Eds.), *Handbook of Research on Agricultural Policy, Rural Development, and Entrepreneurship in Contemporary Economies* (pp.189-219). IGI Global. DOI: 10.4018/978-1-5225-9837-4.ch010

Conference proceedings (published):

García Palomares, J. C., Gutiérrez Puebla, J., Romanillos Arroyo, G., & Salas-Olmedo, H. (2016). Patrones espaciales de concentración de turistas en Madrid a partir de datos geolocalizados de redes sociales: Panoramio y Twitter. In *Aplicaciones de las Tecnologías de la Información Geográfica (TIG) para el desarrollo económico sostenible* (pp. 131-139). Actas del XVII Congreso Nacional de Tecnologías de Información Geográfica. Málaga, June 29-30 and July 1. http://congresotig2016.uma.es/downloads/separadas/lt1/García%20Palomares.pdf

Working paper (more than twenty authors):

De Stefano, L., Urquijo Reguera, J., Acácio, V., Andreu, J., Assimacopolus, D., Bifulco, C., De Carli, A., De Paoli, L., Dias, S., Gad, F., Haro Monteagudo, D., Kampragou, E., Keller, C., Lekkas, D., Manoli, E., Massarutto, A., Miguel Ayala, L., Musolino, D., Paredes Arquiola, J., … Wolters, W. (2012). *Policy and drought responses–Case Study scale* (Technical report no. 4). DROUGHT-R&SPI project. http://www.isa.ulisboa.pt/ceabn/uploads/docs/projectos/drought/DROUGHT_TR_4.pdf

Webpage or piece of online content:

Vasile Loghin – Geographical Works. *Volcano Island. Geological, geomorphological and volcanological features*.

https://vasileloghin.files.wordpress.com/2015/02/insula-vulcano-cu-foto-final.pdf

Facebook page:

American Association of Geographers - Home [Facebook page]. Facebook. Retrieved September 19, 2022 from https://www.facebook.com/geographers

Non-English references should contain, at the end, additional explanation in which language it was written. If the article contains English summary it should be mentioned. For example:

Grahovac, M., Pivac, T. & Nedelcu, A. (2018). Značaj internet prezentacije za razvoj vinskog turizma Banata(Srpski i Rumunski Banat), *SINTEZA 2017, International Scientific Conference on Information Technology and Data Related Research.* (in Serbian with English abstract & summary)

Dinu, M. (2002). *Geografia turismului [Tourism Geography]*. Editura Didactică și Pedagogică. (in Romanian)

Language and Text

Foreign concepts, proper nouns, names of institutions etc.

If the article discusses foreign institutions or businesses, the original name should be provided in parentheses. Foreign terms and phrases should be set in italics and followed by an English translation enclosed in parentheses; for example, *griko* (the good food).

Spelling

Submissions must be made in English. Authors are welcome to use American or British spellings as long as they are used consistently throughout the whole of the submission.

- colour (UK) *vs.* color (US)

When referring to proper nouns and normal institutional titles, the official, original spelling must be used.

- World Health Organization, *NOT* World Health Organisation

Grammar

American or English grammar rules may be used as long as they are used consistently and match the spelling format (see above). For instance, you may use a serial comma or not.

- red, white, and blue *OR* red, white and blue

Authors not proficient in English should have their manuscripts checked before submission by a competent or native English speaker. Presenting your work in a well-structured manuscript and in well-written English gives it its best chance for editors and reviewers to understand it and evaluate it fairly.

Font

The font used should be commonly available and in an easily readable size. This may be changed during the typesetting process.

Underlined text should be avoided whenever possible.

The use of bold or italicised text to emphasise a point is permitted, although it should be restricted to minimal occurrences to maximise its impact.

Lists

Use bullet points to denote a list without a hierarchy or order of value. If the list indicates a specific sequence then a numbered list must be used.

Lists should be used sparingly to maximise their impact.

Acronyms and Abbreviations

Except for units' measurement, abbreviations are strongly discouraged. With abbreviations, the crucial goal is to ensure that the reader – particularly one who may not be fully familiar with the topic or context being addressed – is able to follow along. Spell out almost all acronyms on first use, indicating the acronym in parentheses immediately thereafter. Use the acronym for all subsequent references.

- Research completed by the International Geographical Union (IGU) shows …

A number of abbreviations are so common that they do not require the full text on the first instance of use. Examples of these can be found **here**.

Abbreviations should usually be in capital letters without full stops.

- USA, *NOT* U.S.A.

Common examples from Latin do not follow this rule, should be lower case and can include full stops.

- e.g., i.e., etc.

Use of footnotes/endnotes

Use endnotes rather than footnotes (we refer to these as 'Notes' in the online publication). These will appear at the end of the main text, before 'References'.

Notes should be used only where crucial, clarifying information needs to be conveyed.

Avoid using notes for the purposes of referencing; use in-text citations instead.

Symbols

Symbols are permitted within the main text and datasets as long as they are commonly in use or an explanatory definition is included on their first usage.

Hyphenation, em and en dashes

For guidelines on hyphenation, please refer to an authoritative style guide, such as The Chicago Manual of Style (16th ed.) (US English) or Oxford's New Hart's Rules (UK English). Be consistent in your style of hyphenation.

Em dashes should be used sparingly. If they are present they should denote emphasis, change of thought or interruption to the main sentence; em dashes can replace commas, parentheses, colons or semicolons.

En dashes can be used to replace 'to' when indicating a range. No space should surround the dash.

- 10–25 years *OR* pp. 10–65

Numbers

For numbers zero to nine please spell the whole words. Use figures for numbers 10 or higher. We are happy for authors to use either words or numbers to represent large whole numbers (i.e. one million or 1,000,000) as long as the usage is consistent throughout the text.

If the sentence includes a series of numbers then figures must be used in each instance.

- Thermal springs were found in the north of Bucharest at depths of 100, 175, and 230 m.

If the number appears as part of a dataset, in conjunction with a symbol or as part of a table then a figure must be used.

- This study confirmed that 7% of…

If a sentence starts with a number it must be spelt, or the sentence should be re-written so that it no longer starts with the number.

- Fifteen examples were found to exist… *RE-WRITTEN*: The result showed that 15 examples existed…

Do not use a comma for a decimal place.

- 2.56 *NOT* 2,56

For numbers that are less than one a '0' must precede the decimal point.

- 0.29 *NOT* .29

Units of measurement

Symbols following a figure to denote a unit of measurement must be taken from the latest **SI brochure**.

Formulae

Formulae must be proofed carefully by the author. Editors will not edit formulae. If special software has been used to create formulae, the way it is laid out is the way it will appear in the publication.

Tables

Tables must be created using a word processor's table function, not tabbed text.

Tables should be included in the manuscript. The final layout will place the tables as close to their first citation as possible.

All tables must be cited within the main text and numbered with Arabic numerals in consecutive order (e.g. Table 1, Table 2, etc.).

Each table must have an accompanying descriptive title. This should clearly and concisely summarise the content and/or use of the table. A short additional table legend is optional to offer a further description of the table.

The title should be above the table (font 10pt) and the source of the data below (font 10pt).

Example:

Table 1. This is a table. Tables should be placed in the main text near to the first time they are cited

Year	Number of foreign tourists (millions)	Foreign currency cashing (USD billions)	Cashing increase compared to 1950
1950	25,3	2,1	-
1990	410,4	300,4	143,0
2010	940,0	919,0	437,6
2013	1, 087,0	1, 159,0	551,9

Source: UNWTO, 2015

Tables should not include:

- Rotated text
- Images
- Vertical and Diagonal lines
- Multiple parts (e.g. 'Table 1a' and 'Table 1b'). These should either be merged into one table, or separated into 'Table 1' and 'Table 2'.

NOTE: *If there are more columns than can be fitted on a single page, then the table will be placed horizontally on the page. If it still cannot be fitted horizontally on a page, the table will be broken into two.*

Figures

All photographs, maps and graphs have to be named as Figure. The figures have to be enclosed in the text, in their order of appearance and should be numbered consecutively using Arabic numbers. The title (font10pt) has to be below the figure. All figures (photographs and maps) have to be submitted as a separate file. All graphs have to be submitted as a separate file in MS Excel format with all the data needed for making the graph. The file should be named as the number of the figure in the main text. Example: Figure 1, Figure 2, etc. If a figure has been previously published, acknowledge the original source. Example:

(a) **(b)**

Figure 1. This is a figure. Schemes follow the same formatting. If there are multiple panels, they should be listed as: (**a**) Description of what is contained in the first panel; (**b**) Description of what is contained in the second panel. Figures should be placed in the main text near to the first time they are cited. A caption on a single line should be centered.
Source: Adrian Nedelcu, 2014.

Figure 1. Sardinia. La Pelosa beach with marine abrasion forms.
Source: Adrian Nedelcu (2019).

NOTE: *All figures must be uploaded separately as supplementary files during the submission process, if possible in colour and at a resolution of at least 300dpi. Each file should not be more than 20MB. Standard formats accepted are: JPG, TIFF, GIF and PNG. For line drawings, please provide the original vector file (e.g. .ai or .eps).*

Reviewer Suggestions

During the submission process, please suggest three potential reviewers with the appropriate expertise to review the manuscript. The editors will not necessarily approach these referees. Please provide detailed contact information (address, phone, e-mail address). The proposed referees should neither be current collaborators of the co-authors nor have published with any of the co-authors of the manuscript within the last five years. Proposed reviewers should be from different institutions to the authors. You may suggest reviewers from among the authors that you frequently cite in your paper.

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CEJGSD

CENTRAL EUROPEAN JOURNAL OF GEOGRAPHY AND SUSTAINABLE DEVELOPMENT

December 2024

volume **6** issue **2**

DOI: 10.47246/CEJGSD.2024.6.2

ISSN 2668-4322
ISSN-L 2668-4322

www.cejgsd.org