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OLIVE PRODUCTION ON CULTIVATED TERRACES IN NORTHERN ISTRIA

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ABSTRACT

Cultivated terraces in northern Istria are an important element of the cultural landscape that enables several ecosystem services. Open green space is changing due to urban sprawl, soil sealing, and land abandonment. Olive growing is the only agricultural land use category that has increased in the past two decades. This study evaluates the various ecosystem services provided by terraced landscape under olive production in northern Istria. Terraced landscapes are multifunctional; they work against land degradation and preserve soil water for climate change adaptation and mitigation. Furthermore, terraced landscapes, particularly in distant areas, are disconnected from the more populated areas directly connected to the coast, and they face land abandonment, poor maintenance, and overgrowing issues. However, positive change is increasing in terraced areas used for olive orchards. This is in part due to the demand for Slovenian olive oil. Furthermore, the value of terraced landscapes with olive orchards and their part in the preservation of biodiversity is recognized in other sectors. As a cultivated cultural landscape element, olive orchards on terraces play important roles in tourism and provide much needed added value for tourist farms.

Keywords: cultivated terraces, northern Istria, ecosystem services, soil erosion, land degradation

COLTIVAZZIONE DEL ULIVO SUI TERRENI TERRAZZATI NELL'AREA DELL'ISTRIA SETTENTRIONALE

SINTESI

I terreni terrazzati nel nord dell'Istria sono un elemento importante e caratteristico del paesaggio culturale, che consente di offrire numerosi servizi ecosistemici. Le aree verdi sono soggetto di cambiamenti dovuti all'abbandono della coltivazione, espansione dell'urbanizzazione e costruzioni di infrastrutture. Gli uliveti sono l'unica categoria del uso agricolo, la cui superficie è aumentata negli ultimi venti anni. L'articolo tratta vari servizi ecosistemici di paesaggi terrazzati con alberi di ulivo nell'area dell'Istria settentrionale. I terreni terrazzati mantengono un valore multiruolo, nella lotta contro il degrado del suolo e per il miglioramento del bilancio idrico del suolo. Questo da un'importanza per gli adattamenti ai cambiamenti climatici. Inoltre, i terreni terrazzati che non si trovano nel entroterra e sono distanti dalle aree più densamente popolate, sono sottoposti a una scarsa manutenzione e abbandonamento. Tuttavia, c'è una tendenza positiva nella crescita degli oliveti terrazzati. Sicuramente a questo ha contribuito la forte crescita della domanda di olio d'oliva sloveno. Inoltre, il valore del paesaggio terrazzato con oliveti è sempre più riconosciuto anche in altri settori e nella conservazione della biodiversità. Come paesaggio culturale, gli uliveti sulle terrazze svolgono un ruolo importante nel turismo e forniscono un valore aggiunto, tanto necessario, per le fattorie turistiche.

Parole chiave: terrazzamenti coltivati, Istria settentrionale, servizi ecosistemici, erosione del suolo, degrado del territorio

INTRODUCTION

Land terracing has introduced specific human-induced geomorphic processes that are often the most effective soil erosion and landscape changing processes acting at the field and hill-slope scales (Borselli et al., 2006; Cots-Folch et al., 2006), conserving soil and water and thus enabling more intensive crop production in sloped areas (Landi, 1989). Among all anthropogenic geomorphological features, agricultural terraces on steep land have the largest relief-modifying impact, equally affecting soil, climatic, hydrologic, and biogeographic conditions. Terraces are the predominant elements of landscapes in many parts of the world (Csorba, 2010). The reshaping of the earth's surface began almost at the same time as the rise of agricultural civilizations (Wei et al., 2016), as humans adapted sloped areas by creating different types of terraces in different sloping conditions in order to improve water balance and tillage conditions and reduce soil erosion. In the Mediterranean area, terraces spread to the drier regions with the development of agriculture practices (Price, Nixon, 2005). To this day, agricultural terraces remain one of the most distinctive elements of the cultural landscape of Mediterranean hilly environments (Loumou, Giourga, 2003), used for almond, hazelnut, and olive trees as well as vineyards (Cots-Folch et al., 2006). Until the end of the nineteenth century, terraces with stone embankments were a characteristic feature of the landscape of northern Istria. The terraces were created and maintained manually (Likar, 2017). Most of the historical terraces are of the bench type, with stone walls that are threatened by land abandonment, as stone wall terraces require a large amount of labor, since they were built and are maintained by hand (Cots-Folch et al., 2006; Likar, 2017).

Cultivated terraces are man-made spatial phenomena that are influenced by various dynamic processes. After they are built, terraces are subject to the constant influence of natural forces and the effects of human activities (Likar, 2017). The main factors influencing changes in terraced landscapes (de Graaff et al., 2010) are: (a) Agronomic measures, such as revegetation using suitable tree species, implementation of irrigation, planting of cover crops, mulching, more effective fertilization, and pest control. (b) Physical environmental measures, including corridors for wildfire protection, afforestation, and a wide range of erosion control measures (e.g., the preservation of terraces, vegetative strips). (c) Policy measures: agri-environmental measures, different types of financial support (e.g., for purchasing abandoned orchards), public rural facilities, infrastructure development (e.g., access roads), measures to improve marketing and prices, and activities to promote tourism.

Terraces are either preserved through regular maintenance – agricultural land use, improvements in their construction – or demolished due to land abandonment or urbanization (Ažman Momirski and Kladnik, 2009; di Petro, Blasi, 2002; Stanchi et al., 2012; Sluis et al., 2014; Likar, 2017; Brunori et al., 2018). In the case of terrace construction, implementation of low cost terracing is complex and can be problematic. While slopes experiencing severe human disturbances (e.g., overgrazing and deforestation) can generally become more stable after terracing, the negative effects of terracing may occur in poorly-designed or poorly-managed terraces. The maintenance of terraces is costly and eventually unaffordable for many farmers (Likar, 2017). Identifying suitable technology for the remediation of a degraded area through terracing is important (Gao et al., 2018; Stanchi et al., 2012; Ažman Momirski, Berčič, 2016), as the lack of environmental legislation adapted to local conditions can have negative policy impacts (Golobič, Lestan, 2016). In some areas terraces can mischaracterize historical and architectural heritage sites (e.g., the UNESCO World Heritage Douro Wine Region in Portugal, Valle Junior et al., 2014). The maintenance and reconstruction of agricultural terraces is an important task in landscape conservation, particularly at World Heritage sites (Csorba, 2010; Valle Junior et al., 2014), but the application of suitable technology and approaches is necessary (Loeper et al., 2016), and the costs cannot be placed on the land users alone; they have to be considered within a broader context of the ecosystem services that terraced landscapes provide.

After World War II, terraces with less expensive grass-covered embankments instead of stone walls were built (Likar, 2017), which is a practice supported by EU policies (Sierra de Lujar, 1995; Clots-Folch et al., 2006; Martínez Casasnovas et al., 2010; Mili et al., 2013), as well as Slovenian agricultural policy (Rural Development Program RDP 2007–2013, RDP 2014–2020).

Though prior works have considered terraces as a landscape characteristic of northern Istria (Titl, 1965; Stritar, 1990), there has been a clear shift in interest in the Slovenian research community. There have been two peak periods of publishing about Slovenia's terraced landscapes: the first one in 2007 and 2008 and the second one in 2015 and 2016 (Ažman Momirski, 2019). Descriptions of the cultural importance of terraced landscapes in Gorizia Hills (Ažman Momirski, 2008a, 2008b), followed by an illustrative review of terraced landscapes in Slovenia by Ažman Momirski, Kladnik, 2009, lay ground for further exploration of this element of cultural landscapes. In a nationwide study, Berčič, 2016, and Kladnik et al., 2016 evaluated the basic characteristics of terraces and their transforming processes. Ažman Momirski, Berčič, 2016, explored the distribution and occurrence of terraces in Slovenian municipalities. They noted substantial discrepancies between the international active participation of Slovenian researchers and the applied knowledge and skills transferred into local spatial planning programs and actions. The results showed

Table 1: Selected evaluated divisions of ecosystem services with examples according to MAE, 2005, and CICES (Haines-Young, Potschin, 2013).

ES division	Description	Examples of evaluated processes and indicators	
Provisioning	Products people obtain from ecosystems, such as food, fuel, fibre, fresh water (nutrition, materials and energy)	Olives & products; Wild berries, fruits, mushrooms; Game, honey harvested from wild populations; Wood, timber, flowers; Genetic material (DNA) from wild plants; Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies; Wood fuel, straw, for burning and energy production	Podgornik et al., 2017, 2018 Golobič, Lestan, 2016 Lestan et al., 2016
Regulation & Maintenance	The benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, and water purification.	Protection against erosion, landslides and gravity flow (vegetation cover protecting/stabilizing terrestrial ecosystems; Capacity of maintaining baseline flows for water supply and discharge; e.g. fostering groundwater; Recharge by appropriate land coverage that captures effective rainfall; includes drought and water scarcity aspects; Filtration and storage, accumulation of pollutants in land and soil; Visual screening of transport corridors e.g. by trees; Green infrastructure to reduce noise and smells; Natural or planted vegetation that serves as shelter belts; Pollination by bees and other insects; seed dispersal by insects, birds and other animals; Maintenance of bio-geochemical conditions of soils including fertility, nutrient storage, or soil structure; includes biological, chemical, physical weathering and pedogenesis; Modifying temperature, humidity, wind fields; maintenance of rural and urban climate and air quality	Ceglar et al., 2008 Prus et al., 2015 Likar, 2017 Prus et al., 2015 Ažman Momirski 2014, 2015a, Guštin, 2016, Likar, 2017 Prus et al., 2015, Vidic et al., 2015 Pogačar et al., 2018
Cultural	The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.	Walking, hiking, climbing, boating, bird watching; Historic records, cultural heritage e.g. preserved in soils; Ex-situ viewing and experiencing of natural world through different media; Sense of place, artistic representations of nature; Enjoyment provided by wild species, wilderness, ecosystems, terraced landscapes; Willingness to preserve plants, animals, ecosystems, landscapes for the experience and use of future generations; moral or ethical perspective or belief	Ažman Momirski, 2015b, Ažman Momirski, Berčič, 2016, Guštin, 2016, Likar, 2017, Faganel, Trnavčič, 2012 Likar, 2017

that the abandonment of terraced landscapes leads to degradation processes, such as soil erosion and slope instability in the form of landslides. An informative summary of current national and international research on terraced landscapes is provided by Kladnik et al. 2017.

Terraces were created with the rise of agricultural civilization to provide stable space for agricultural production (Price, Nixon, 2005). Their main function is soil conservation, which they accomplish by reducing slope on cultivated land and allowing water run-off from the higher side of the terrace to spread out and infiltrate on the flat part. However, terraced landscapes provide a full spectrum of ecosystem services and the full scope of the processes and functions of terraces in improved ecosystem services needs to be explored (Wei et al., 2016). In this article we review, explore, and identify the main functions of terraced landscapes planted with olive orchards in the three main sections of ecosystem services (Common International Classification of Ecosystem Services, CICES (Haynes-Young, Potschin, 2013): provisioning, regulation and maintenance, and cultural services for northern Istria.

METHODS AND MATERIALS

Ecosystem services are the benefits people derive from the ecosystems they are part of. In order to enable people to move more easily between classifications of ecosystem services and to understand more clearly how data and information are being measured and analyzed, CICES has been developed (Haines-Young, Potschin, 2013). This article is a literature review of recent scientific publications related to olive production on cultivated terraces in Slovenia and the related ecosystem services. Based on the review results, we evaluate current conditions in the olive production of northern Istria, showing the relationships between different studies and the values of the ecosystem services of cultivated terraces. All three main divisions of ecosystem services have been evaluated: provisioning, regulation and maintenance, and cultural. For each of the main divisions, a group of ecosystem services, classes, and class types has been identified (Table 1), with examples related to terraced landscapes in Slovenian Istria. For regulation and maintenance we separately evaluate climate change mitigation and biodiversity services.

The working hypothesis of this study was that terraced landscapes provide ecosystem services in all three divisions and several (sub)categories. These services benefit not only people in the agricultural sector, but also groups of people in other areas. The focus research question was: do terraced landscapes with olive orchards provide ecosystem services in more than the agricultural sector? The premise is that while more than one sector benefits from terraced landscapes with olive orchards, the cost and duty of maintenance for terraced landscapes falls solely on individuals active in agricultural sector. In other words, the benefit is distributed over multiple sectors, but the cost is borne by just one sector. The time framework of the study was the evaluation of the current state of the ecosystem services that existing terraced landscapes planted with olive orchards provide for people in various sectors. The methods employed in the research were: (i) review of the literature on the ecosystem services of terraced landscapes, (ii) analyses of the data on terraced landscape areas and olive orchards in coastal regions, (iii) evaluation of in situ literature data on terraced landscapes with olive orchards and assessment of the ecosystem services listed in Table 1, and (iv) projection of literature-identified ecosystem services of terraced landscapes with olive orchards in the coastal region of northern Istria in Slovenia.

Natural conditions of northern Istria for provisioning services

The Slovenian Coast is predominantly abrasive, with steep and crumbling cliffs of marl and sandstone in different phases of development. Weathering is the main erosion factor, with occasional landslides and toppling; wave erosion occurs during extreme storm events. There is also accumulative coast with fertile plains developed on fine sediments deposited mainly by the Soča river, and, to a smaller extent, by the rivers Rižana, Badaševica and Dragonja (Stritar, 1990; Prus et al., 2015). On these alluvial plains. alluvial soils, eutric, developed; these enable intensive agricultural production. Some of these areas are used for salt pans. In addition, hypogleyic eutric soil developed in some alluvial plain areas. In hilly areas with terraces, deeply cultivated eutric soils, eutric brown soils typic and calcaric on flysch developed. Due to the dynamic and hilly terrain, the land has been transformed into a terraced landscape suitable for cultivation in settlements' functional rural area and into the terraced land of clustered settlements (Stritar, 1990; Likar, 2017). Terraces have been in use for vegetable and fruit production, as well as olive orchards and vineyards, and still are today. For the whole coastal area of northern Istria, intensive urbanization is becoming a predominant feature, as new urban settlements, harbor activities, tourism, and industries develop. Urbanization and soil sealing is problematic statewide. According to a rough estimate, approximately 3000 m^2 of arable land (i.e., arable fields, meadows, and orchards) per capita are needed for sufficient food production for the Slovenian population in given ecological conditions (Vidic et al., 2015). Slovenia, with less than 900 m^2 per capita (Lisec et al., 2014), is already below this value. The loss of the potential for the production of strategic quantities of food, especially because of the increasingly frequent occurrences of extreme weather phenomena, suggests that food self-supply may become an important issue in the near future (Vidic et al., 2015).

Olives are the second most cultivated fruit species (after apple tree) on Slovenian soil and provide for 64 % of domestic olive oil production (Ministry for Agriculture, Forestry and Food, MAFF, 2017). According to one land use evaluation, there are approximately 2,293 ha of olive orchards in Slovenia (MAFF, 2017). All olive orchards bigger than 0.1 ha should be registered in public databases at (MAFF, 2017), yet there are documented discrepancies between the situation in the field and the public databases (Ažman Momirski, 2017). In 2013 there were 6,461 olive orchards, about 200 less than were registered, and the total area in 2013 was 1,967 ha. Current data for 2017 from the registry of agricultural husbandries is shown in Table 1. As shown in Table 2, registered olive orchards cover 1,297.4 ha, of which 823.1 ha or 63.4 % are terraced olive orchards. The reasons for the discrepancy between the information in the public database of agricultural land use data on (MAFF, 2017), and the registry of agricultural husbandries has been discussed by (Ažman Momirski, 2017). Land use is considered a two-dimensional tool, which does not recognize elevation differences

Table 2: Municipalities of three regions in Slovenia, Slovenian Istria, Vipava Valley and Gorizia Hills, their areas (ha), the area of olive orchards (ha), the area of terraced olive orchards (ha), and the share of terraced orchards (%) according to the registry of agricultural husbandries (MAFF) in 2017.

	Municipality	Municipality area (ha)	Olive orchards (ha)	Terraced olive orchards (ha)	Share of terraced orchards (%)
Coastal area of Slovenian Istria 400 km2 45°27'59'' - 45°34'34''	Izola	2856.1	234.8	154.9	66.0
	Koper	30332.3	571.5	312.0	54.6
	Piran	4345.0	314.3	246.2	78.3
	Ankaran	804.9	28.1	13.2	47.1
Vipava Valley 310 km2 45°52'32'' - 45°57'48''	Vipava	10740.7	2.0	1.8	86.1
	Šempeter-Vrtojba	1495.0	3.5	2.2	60.8
	Renče-Vogrsko	2946.8	4.6	3.6	77.4
	Nova Gorica	27949.1	41.6	29.7	71.3
	Sežana	21740.1	0.8	0.1	15.8
	Kanal	14653.1	0.1	0.0	0.0
	Ajdovščina	24523.4	26.9	12.9	48.0
	Komen	10271.7	1.7	0.2	11.9
	Miren-Kostanjevica	6278.4	6.6	2.1	32.2
Gorizia Hills 83 km2 45°58'30'' - 46°01'25''	Brda	7196.6	60.9	44.2	72.6
Total		166133.2	1297.4	823.1	63.4
Total area of olive orchards on coastal region (ha)			**1120.6**	**713.2**	
Total share of olive orchards on coastal region (%)			86.4	86.6	

and terraced slopes (Ažman Momirski, 2017). In some cases, existing terraces are omitted from the inventory because landowners do not report them; in other cases, land that is not terraced is erroneously reported as terraced by landowners. Consequently, the official data on vineyards, orchards, and olive orchards on terraces and the actual terraced slopes with such land use may differ significantly (Ažman Momirski, 2017).

The coastal municipalities of Koper, Izola, Piran, and Ankaran encompass 88.5 % of Slovenian olive orchards (1148.7 ha), and their orchards are mostly on terraces (62.3 % or 726.4 ha) (Table 2). The biggest area of olive orchards is in the municipality of Koper (571.5 ha); 54.6 % of Koper's orchards are terraced, which is the lowest share of olive orchards on terraces of the three municipalities with the biggest areas of olive orchards. The size of the individual plots remains small, as is typical in the Slovenian agricultural landscape (Likar, 2017), which is highly fragmented (Lisec et al., 2014). Records for 2017 for 2,726 registered farmers with olive orchards show that the average size of individual areas with olive orchards (graphical units of agricultural land use) is 0.47 ha. The biggest olive orchard covers 9.17 ha and is located in the northern hills of Dragonja valley. Farmers register olive yield and olive oil production on 844.11 ha of olive orchards.

The olive orchards of Slovenia are in the most northerly region where olives are cultivated, and they are frequently exposed to frost (Meze, 1959). Terraced landscapes used for olive production can be found on the coastal area of Trieste Bay and in lower hills up to 250 m a.s.l.; rarely, olives are cultivated in areas up to 300 m a.s.l. It has been speculated that olive cultivation expanded in the mid-18th century, when the first

Figure 1: An olive orchard in Padna, where some individual olive trees are more than 300 years old (Photo: I. Vrhovnik, 2011).

Figure 2: An olive orchard in Beneši, Ankaran (Photo: M. Podgornik, 2009), where olive trees were planted around 1990 on terrace plateaus with grass slopes between 10 and 20%.

taxes on olive oil were recorded (Meze, 1959). Olive production took several step backs in more recent recorded history (Meze, 1959), due both to environmental factors (frequent exposure to frost) and market conditions (competition with wine growing). Both of these factors affect cultivation in Gorizia Hills, where, in spite of the region's 20 km air distance from the Adriatic Sea, there are only 44.2 ha of terraced olive orchards and 60.9 ha of olive orchards in total (Table 1). According to the Slovenian Association of Olive Growers, in 1985 olive orchards covered ca 400 ha total. This number corresponds to the area estimate before World War II, if a planting density of 200 – 300 trees per ha is used; namely, there were an estimated 300,000 trees in northern Istria prior to the 1929 frost damage and 120,000 after, and between 50,000 to 60,000 after World War II.

The technology and approaches for creating terraces inside settlements and in the landscape in Slovenian Istria are well described by Ažman Momirski, Berčič, 2016 and Likar, 2017. The following figures describe some typical olive orchards found in northern Istria and the Vipava Valley (Figures 1–5). The oldest olive orchards on terraces can be found on the hills around the village of Padna (Figure 1), where some trees are more than 300 years old. These areas have supplied the coastal cities of Piran and Portorož with fruits and vegetables.

This kind of highly fragmented land structure with small orchards allows only extensive olive growing. This increases olive oil production costs immensely. Due to the slope height (in some cases up to 3 m), harvesting is very difficult. In addition, trees in Istria are traditionally Y shaped, which results in lower yields per area. Maintaining terraces is costly due to the high slopes that need regular grass mowing performed either manually or with specially adjusted machinery. The olive tree crown has to be open, tree spacing is 6m x 7m (Figures 2 and 5), and trees with such dimensions need manual harvesting. Though the recommended form for olive tree cultivation is open vase, with a higher density of trees (4–5 m x 3–5 m, or higher if the form is spindle bush, Štampar and Jakopič, 2017), the natural conditions of Slovenian Istria – namely the shape and size of the terraces – do not permit this approach. Experiments with higher planting density resulted in the replanting of the olive trees due to poor machinery access and lighting. The estimated production costs are 12 € per liter of olive oil. As discussed at the beginning of this section, there are no areas suitable for intensive olive production like, e.g., orchards in Spain, where olive trees are planted 4 m x 1.5 m (Egea et al., 2017) and costs are ca. 2 € per liter.

Slovenian olive oil commands relatively high prices on the market; however, there is an increasing supply of cheaper, imported olive oil. The only way for olive growers to remain competitive is to focus on the high quality of Slovenian olive oil.

Regularly maintained and mulched inter-row spaces in terraced olive orchards are grounds for subsidies according to the RDP 2014–2020. Furthermore, if a new olive orchard is planted, grass cover has to be planted immediately in order to decrease soil erosion (RDP 2014–2020). Modern era olive orchards enable machine tillage, but they are more prone to degradation in case of abandonment or poor maintenance.

Preserved stone walls ("suhozidi" in Slovenian) are terraces of high quality construction. Most were built of stones removed from the fields (Ažman Momirski, Kladnik, 2009). The dimensions of the terraces and tree spacing prevent the use of machinery, so these terraces have to be manually maintained. Renovation is costly and manual labor intensive. Terraces of this type are typical in the cultural landscape of the Slovenian coastal region (Ažman Momirski, Kladnik, 2009; Likar, 2017). These orchards are situated predominantly on the land of the Farmland and Forest Fund of the Republic of Slovenia (Figures 3 and 4).

Figure 3: An olive orchard in Dekani (Photo: M. Podgornik, 2009), where olive trees were planted on a plateau of the stone wall terrace in 2000.

Regulating ecosystem services

The A major focus of prior literature is the role of terraces in regulation and maintenance functions in the mediation of flows in the hydrological cycle and water flow maintenance, which enables soil conservation by reducing soil erosion (e.g. García-Ruiz et al., 2011; Tarolli et al., 2014). The control of surface water runoff is invaluable for the prevention of soil erosion and landslides. Cultivated terraces prevail up to gentle-medium slope land, while uncultivated and wooded areas dominated terraces on steep slopes (García-Ruiz et al., 2013). In this context, poly-cultural olive orchards proved to be a cropping system particularly resilient to global change, irrespective of land slope. Terraced systems and extensive poly-cultural olive orchards play a role in the preservation of ecosystem integrity, landscape quality, and soil functionality, and, therefore, environmental sustainability (García-Ruiz et al., 2013).

The climate in northern Istria is Sub-Mediterranean. The average annual temperature and precipitation rate for the period 1971-2000 were 12.8 °C and 931.2 mm, respectively (Slovenian environment agency, 2014). Traditionally, olive orchards in Slovenian Istria were the most northern point where olives were grown (Meze, 1959) under rain-fed conditions (Podgornik et al., 2017). Frost is historically documented and still a regular occurrence (Figure 6). Frost exposure in the northern areas, such as Gorizia Hills (Meze, 1959), and wind erosion in the Vipava Valley put the natural conditions at the limit for olive growing in the two Coastal regions, which is reflected in the areas under olive orchards (Table 2). The soils of northern Istria are fertile, however, and the limiting factor is often the lack of water during the growing season (Vidic et al., 2015). Due to the increased occurrence and intensity of agricultural droughts in humid Mediterranean regions, monitored irrigation is becoming an increasingly inevitable element of agricultural practice (Podgornik et al., 2017). As a further result of these droughts, in recent years, Slovenian olive growers and producers have faced obstacles to achieving consistent yields and quality of olive oil due to extreme weather conditions (Podgornik et al., 2018). Water retention on the flat areas of a terrace decreases water loss by reducing surface runoff and increasing deep percolation.

Conversely, studies of rainfall erosivity for west and east Slovenia (Ceglar et al., 2008) show that agricultural areas in west Slovenia are the most vulnerable in autumn, when the number of days with rainfall amounts exceeding 40 mm is the highest. An evaluation of soil temperature found that the Sub-Mediterranean region was thermic instead of mesic in the nine years following the year 2000, indicating that the soil thermal regime is changing (Pogačar et al, 2018). Soil conservation practices will be extremely important for mitigating land degradation due to climate change. Slovenia ratified the Convention to Combat Desertification/Land Degradation (CCD) in 2001, as an affected country in the Northern Mediterranean and Central and Eastern Europe regions (Vidic et al., 2015). According to the convention, participating governments are obligated to promote long-term strategies for increased soil production potential, remediation of degraded areas, and the preservation and sustain-

Figure 4a, 4b: Stonewalled terraces in Baredi (Photo: M. Podgornik, 2018), northern Istria, with olive trees planted in 2001, one area renovated (4a) and one non-renovated (4b).

able management of soil and water resources. However, the action plan to fight the negative consequences of droughts and soil degradation, such as erosion, soil pollution, hydrogeological hazards, and soil sealing, is still in the preparation stages (Vidic et al., 2015).

In this plan, special attention should be given to the protection of agricultural land, as the agricultural sector is not strong enough to provide for its protection. Soil sealing of the best agricultural lands by urban sprawl has become a severe problem in recent decades, particularly in the coastal region (Berdavs, 2012). As the per capita areal extent of the best agricultural land is already insufficient (less than 900 m^2, Lisec et al., 2014), all agricultural land in Slovenia, but especially the highest-quality agricultural land, should be protected (Vidic et al., 2015; Grčman, Zupanc, 2018). Terracing slightly increases the arable areas of the slope lands. If done correctly, it is a useful measure to compensate for soil loss.

Terraced olive orchards as habitat

Agricultural spaces are increasingly included in European metropolitan areas, mainly in the Mediterranean basin. Urban agriculture has multiple functions beside the provision of food, including the preservation of biodiversity, the maintenance of soil fertility, and the assurance of carbon storage. Because of urban expansion, in the space of city-countryside contact, both traditional agricultural landscapes, as well as the newly realized ones, are threatened by agro-forest systems degradation (Biasi et al., 2017). A study that compares a simple landscape and a complex one showed that the complex landscape contains three times more protected habitats. Interestingly, neither landscape was economically viable, though the simple landscape fared better, showing values of 43 % below the threshold, as compared to the complex one's 185 % (Rescia et al., 2017).

In the past century, European agricultural landscapes and practices have undergone immense change. Technical advances and structural changes of the landscape enhanced productivity, while farmland ecosystems grew increasingly affected by the intensification of activities. Changes occurred not only at the field scale, but also at the landscape level through simplification of the land. Biological functions provided by the system's biodiversity (ecosystem services such as pollination, nutrient cycling, etc.) are also threatened, which could have great economic implications. Sometimes, farmers consider natural enemies as private goods, and do not consider the landscape as a resource for biological pest control by conservation, but rather as a source of pests (Salliou, Bernaud, 2017). The ecosystem services of agricultural landscapes require collective choice and complex negotiations between multiple actors at diverse levels and sectors, and more research on the effects of landscapes on natural enemies, including participatory research in-

volving dialogues between farmers, crop advisors, and scientists (Salliou, Bernaud, 2017), is needed. As many stakeholders—such as farmers, the local population, the tourism sector, hunters' associations, nature conservation or heritage organizations, water management specialists, and other competing land users—are affected differently by the quality and quantity of diverse outcomes of agricultural landscapes, someone's gain is often someone else's loss (Sayer et al., 2013).

Historically, human activities have shaped the surface of the world. However, in the Anthropocene, these processes are accelerated, sometimes exponentially, e.g., urbanization. One of the ways to reshape the landscape is through land use policy, predominantly from environmental and agricultural sectors. Cultural landscapes that were developed and maintained by traditional agricultural practices are important for the preservation of (European) biodiversity, but they are undergoing changes due to either abandonment or intensification of agricultural production. Nature conservation and agricultural policies on the EU and national levels have developed several instruments to mitigate the negative effects of these trends on biodiversity (Lestan et al., 2016). Farmers remain the most active maintainers of green space and counter-actors against permanent soil loss due to urbanization. The most sustainable strategy is to harmonize the goals of farmers, hunters' associations, and nature conservationists to preserve non-fragmented open green space.

In addition to crop production, these human-managed landscapes support a considerable proportion of the wildlife in this region, which is important for hunters' associations and nature conservationists (Pimentel et al., 1997). From a historical perspective, and from biodiversity perspective, a heterogeneous landscape with arable fields, meadows, slopes with grass margins, paths, temporary water pools, and stone fences represents a habitat mosaic that supports a large diversity of organisms. In return, farmers get ecosystem services provided by these organisms, such as crop pollination, pest control, and soil fertility enhancement. However, the functions of agroecosystems are out of balance (Guštin, 2016), particularly because of the intensification of agricultural production on the one hand and land abandonment and urbanization on the other.

Tree-crop based landscape in peri-urban areas is highly fragmented owing to urbanization (Rühl et al., 2011). Furthermore, additional vulnerability arises from the specific climate and soil threats in the urban context. A maintained traditional agricultural asset can help mitigate this by assuring a high level of habitat diversity and agrobiodiversity, including a large portion of natural capital in the cultivated spaces. Perennial crops help modern cities achieve resiliency and sustainability. There is a need to improve urban areas by including green infrastructure, which provides a favorable outlook for the environment (Ažman Momirski, 2015a). Regeneration of the expanding urban and peri-urban areas through the preservation of agro-forestry is a suitable strategy (Biasi et al., 2017), and indicates that monetary compensation for farmers maintaining or restoring non-agricultural green areas is needed. In Slovenian Istria, where flat areas are scarce, and where there is a supply of cheaper food from other Mediterranean areas, terraced landscapes with olive orchards can be mosaics that also provide green, open space for wildlife. Farmers in northern Istria who cultivate olives on organic farms mow grass covered slopes only once a year to help with biodiversity.

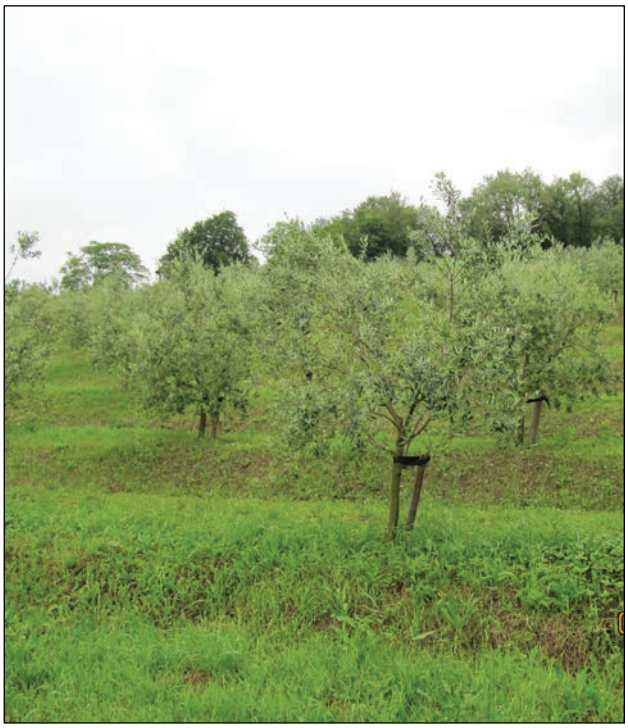

Figure 5: An olive orchard in Šempas, Vipava Valley (Photo: M. Podgornik, 2016), where olive trees were planted on the plateau of the grass slope terraces in 2011. This is an example of a modern era olive orchard, where mechanized tillage is possible.

The presence of the terraced agro-ecosystem increases the likelihood of environmental friendly agriculture, owing to the terrace's high provision of ecosystem services, which exerts a positive effect on the preservation of environmental resources in metropolitan cities (Biasi et al., 2017). Understanding the vulnerability determinants of the agro-forestry systems in the metropolitan area could allow us to build an agricultural landscape resilient to soil consumption and biodiversity depletion.

Cultural ecosystem services of the terraced landscapes

Terraced landscapes provide several cultural ecosystem services, primarily through aesthetic value and land-

Figure 6a, 6b: Cultural landscapes provide a broad spectrum of ecosystem services, from food production and soil-water conservation to habitats and recreational areas, as indicated on these photos of terraced olive orchards in Krkavče and Izola, Slovenian Istria (Photo: M. Podgornik, 2018). On the left, dry olives are damaged from the frost in winter 2017–18.

scape identity. Olive tree cultivation in the Mediterranean goes back to ancient times. During the Roman Age, olive cultivation spread to the entire Mediterranean basin. The Greeks and Romans worked hand in hand with the natural environment as they developed farming and used terraces for olive oil production. Uncultivated landscape was also important to them; hunting was a key social ritual for Greek and Hellenistic elites, and 'wild' places were not considered wastelands but areas that played an essential economic role (Shipley, 2013). This is also true today, as ecosystem services are delivered through physical and experiential interactions, which in modern times are of recreational value, e.g., walking, hiking, and leisure hunting, all of which provide opportunities to enjoy the wilderness and landscape ecosystems.

Olive trees are economic, social, and cultural symbols of the inhabitants of this basin and help determine its rural landscape (Loumou, Giourga, 2003). Therefore, it is not surprising that coastal tourist establishments seek to expand their offerings of activities in protected areas and cultural landscapes, such as saltpans (Faganel and Trnavčevič, 2012) and terraced agricultural landscapes (Ažman Momirski, 2015b). The fast paced, unsuitably planned urban expansion currently occurring in a dispersed pattern in the area is increasing the fragmentation of unbuilt areas (Berdavs, 2012). Unfortunately, as Guštin (2016) indicates, the cultural landscape identity of northern Istria is changing, and traditional landscapes require protection or they are subject to disappearance. This is happening throughout the Mediterranean, where cultural landscapes are currently undergoing intense transformations, resulting in a polarization of land uses across an intensification-abandonment continuum (Martinez-Sastre et al., 2017).

As shown by Guštin (2016), there is a substantial discrepancy between the present state of the cultural landscape and the landscape as presented in materials intended to attract tourists. Tourist brochures often present the rural Istrian landscape as an idyllic place. In their descriptions they usually mention agricultural elements of the landscape (e.g., vineyards, olive orchards, agricultural terraces, hard-working farmers). In reality, the identity of contemporary rural areas is shaped by a mix of production, protection, and agriculture, and on the coastal region, these three functions are not in balance (Guštin, 2016), with added on-going urban expansion (Berdavs, 2012). Rural areas are connected to the Mediterranean (with vineyards, olives, terraces, and food) and to other regions (with thematic trails and brochures), with an implied connection to past time periods. The promotion of the cultural landscape describes a rural landscape the general public wish existed (Guštin, 2016), rather than the current reality; however, in farther-flung areas that are disconnected from the coastal areas, tourist farms can offer a secluded green oasis of terraced landscapes among the hills.

Today, olive cultivation in the Mediterranean is an additional income source that provides winter support for rural populations that profit from summer and sea tourism activities. Although it is an agro-ecosystem, the olive grove resembles the natural Mediterranean ecosystem, and when they are abandoned, they transform into natural Mediterranean-type forests. The change of use from olive cultivation to pasture degrades the ecosystem and decreases the available natural resources because of over-grazing (Loumou, Giourga, 2003). In Slovenia, the importance of olive production shows in the increase in olive orchards and the popularity of Slovenian olive oil, where demand surpasses supply. As in the past, in addition to its provisional function as the main source of nutritional fats, olive oil is the Mediterranean's most val-

uable export product, and is identified with its culture (Loumou, Giourga, 2003). There are also several festivities in close, direct relation to olive production in the coastal region. A new wave of olive growers started their businesses after 1985, when the area under cultivation for olive orchards slowly expanded from an estimated 400 ha to the current 2,293 ha.

In the Mediterranean area, lower, flatter areas are areas of both traditional and intensive forms of olive cultivation. In more marginal, upland areas, there are traditional terraced olive groves, some of which are being abandoned (Allen et al., 2006). In Slovenia, the natural conditions do not allow intensive, irrigated olive production in flat areas, and olive production is limited to smaller, fractioned terraced landscape. However, fragmentation can also be a positive trait. The "mosaic landscape" scenario was widely recognized as the most desirable future landscape configuration, as it allows the supply of a balanced flow of ecosystem services and reduces ecosystem services trade-offs and conflicts among stakeholders (Martínez-Sastre et al., 2017).

RESULTS AND DISCUSSION

Our working hypothesis was that terraced landscapes provide ecosystem services in three categories – provisioning, regulation and maintenance, and cultural.

Distinctive agricultural landscapes, formed by past and present farming practices, growing conditions, and agricultural ecosystems, are multifunctional places of food, fiber, feed and energy production, and also areas of heritage and identity (Penker, 2017). Terraced landscapes provide habitats, help preserve wildlife and distribute genetic material, and improve biodiversity, which benefits people in multiple sectors. Ecosystem services are gaining recognition for their value to people engaged in activities other than agriculture, such as those in the tourism or environmental protection sectors. For stakeholders in tourism sectors, terraced landscapes provide open green space for recreational purposes, human leisure activities, and cultural identification, and improve the aesthetic value of the landscape. Terraced landscapes planted with olive orchards are intricately integrated in the Slovenian coastal region, and they have increasing importance in olive oil production.

Generally, stakeholders in the agricultural space – such as farmers, the local population, the tourism sector, hunters' associations, nature conservation or heritage organizations, water management specialists, and other competing land users – each benefit from different ecosystem services (Penker, 2017).

Land use is under the influence of changing conditions in national and international markets, the evolution of population pressure, the expansion of some subsidized crops to marginal lands, and the development of new terraces affected by landslides and intense soil erosion during extreme rainstorm events (García-Ruiz et al., 2011). However, ecosystem services, such as the conservation of soil and the decrease of surface water flow and erosion rates benefit not only people in the agricultural sector, but also the broader community, as they need e.g., less road maintenance and removal of channel and river bed sediments. Yet, agriculture is the most important maintainer of green space, and in order to protect the ecosystem services of agricultural landscapes and prevent abandonment, multiple actors at diverse levels and sectors must reach an agreement. Acknowledging that different legal regulations restrict farmers in their land-use choices in favor of societal landscape goals (Penker, 2017), recent EU agriculture and nature conservation policies explicitly target cultural landscape preservation (Golobič, Lestan, 2016), recognizing the importance of the ecosystem services cultural landscapes provide, and the necessity for monetary compensation for the farmers. The premise is that while more than one sector benefits from terraced landscapes with olive orchards, the cost and duty of maintenance of terraced landscape falls solely on individuals active in agricultural sector.

A study evaluating the impact of EU policy on land use changes in Slovenia showed positive impacts in areas where either intensification or afforestation processes have already diminished landscape diversity (Golobič, Lestan, 2016). The area planted with olive orchards is increasing, and in the absence of agricultural land in flat areas, new terraced orchards are constructed. Due to the method of construction, their perseverance is connected with regular maintenance of the slopes and grass cover, which is subsidized (RDP 2014–2020). Olive cultivation has left its mark on life in the Mediterranean and has contributed to the sustainability of natural resources. Nevertheless, it can succumb to the pressure of current socioeconomic situations. Today, the conservation of olives in production constitutes a necessity for fragile Mediterranean ecosystems and a challenge for everybody involved (Fleskens, de Graaff, 2008; Loumou, Giourga, 2003).

Furthermore, across the Mediterranean, the intensification of olive cultivation has been encouraged by subsidies from the European Union, leading to rapid landscape change (Allen et al., 2006).

In areas with more intensive olive production, two major factors threaten traditional olive cultivation: (i) competition from intensive olive groves in plain and irrigated areas and (ii) competition from cheaper seed oils. These factors intensify the risk that traditional olive groves will be abandoned or converted pasture, resulting in the deterioration of the ecosystem (Loumou, Giourga, 2003). In Slovenia, pure olive oil producers face uneven competition from olive oil providers who mix cheaper seed oil with olive oil to decrease prices, and have called for stricter control. Currently, there is a stable demand for Slovenian olive oil, which favorably influences the construction of terraces and the planting

of new olive orchards. As olive trees are known for their longevity, with suitable policies terraced landscapes could remain a key part of complex agroecosystems in peri-urban areas.

CONCLUSION

In the past, people built terraces primarily to create favorable conditions for growing crops, ensure food production, protect the land from erosion, and ensure a beneficial microclimate for crops. Today terraced landscapes are widely recognized for their multifunctional value and ecosystem services as providers of flat areas for crop production and measures against land degradation and landslides, as well as preservers of biodiversity, cultural identity, and soil water for climate change adaptation and mitigation.

Though terraced landscapes, particularly those in remote areas disconnected from the more populated coastal areas, face land abandonment, poor maintenance, and overgrowing, their value is recognized in other sectors. As a cultivated cultural landscape element, olive orchards on terraces play an important role in tourism and could provide much needed added value for local small businesses and tourist farms.

The phenomenon of terraces in northern Istria is therefore just as important as it was in the past. The skills and experience of the past generations that built and maintained terraced landscapes are not outdated. Such a valuable landscape must be dealt with comprehensively, systematically, and with a long term strategy.

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PRIDELAVA OLJK NA TERASIRANI POKRAJINI V SEVERNI ISTRI

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POVZETEK

Obdelovalne terase severne Istre so pomemben, značilen element kulturne krajine, ki nudi in omogoča številne ekosistemske storitve. Odprt zelen prostor je podvržen spremembam zaradi širitve urbanih naselij, gradnje infrastrukture ter opuščanja obdelave tal. nasadi oljk so edina kategorija rabe kmetijskih zemljišč, katere površina se je povečala v zadnjih dvajsetih letih. V prispevku obravnavamo različne ekosistemske storitve terasirane krajine z oljčniki na območju severne Istre. Terasirana krajina ohrani večnamensko vrednost pri boju proti degradaciji tal ter izboljšanju vodne bilance tal, kar je pomembno za prilagoditev na in blaženje učinkov klimatskih sprememb. Nadalje, terasirana krajina, še zlasti v zaledju, na območjih, ki niso v stiku z bolj poseljenimi območji neposredno ob obali, je izpostavljena zaraščanju, slabemu vzdrževanju in zapuščena. Vendarle se kaže pozitiven trend v porastu površin pod terasami z oljčniki. K temu prispeva povpraševanje po slovenskem oljčnem olju. Prav tako se vedno bolj prepoznava vrednost tega tipa krajine pri drugih deležnikih rabe prostora, kot so turizem in prosti čas ter storitve za biotsko pestrost. Kot prepoznaven, sestavni del kulturne krajine lahko oljčniki igrajo pomembno vlogo v ponudbi turističnih kmetij.

Ključne besede: kulturne terase, severna Istra, ekosistemske storitve, erozija tal, degradacija tal

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