



# Land use changes and dynamics over the last century around churches of Moldavia, Bukovina, Northern Romania – Challenges and future perspectives



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## ABSTRACT

In this study, the land use around the Churches of Moldavia, UNESCO WH (World Heritage) sites, has been analysed using photo interpretation and GIS. The cartographic analysis used historical maps and modern orthophotos to highlight the main changes that took place over the last century in the area surrounding the sites, which has been extended to 1 km buffer. Historical maps and orthophotos of the years 1917, 2005, and 2016 have been processed to identify the present and historical changes in one of the most well-known historical areas of Eastern Europe. Monuments have a significant universal, national, and local value, contributing to the touristic development of the area. The most important processes that can affect the integrity of the monuments are the deforestations and the anthropogenic environmental changes. Significant changes took place around Probota, Humor, Patrauti and Arbore churches, while Sucevita, Voronet and Moldovita churches still preserve the natural landscape specific to the Bukovina historical area; Suceava church is part of a strongly urbanised landscape.

## 1. Introduction

The monuments included in the UNESCO WHL (World Heritage List) are considered to be of high significance for the past, but especially for the future; they have a vital historical importance. Monuments listed in the UNESCO WH have a buffer area around them, which comes as a protected area to combat new constructions or modifications, which will have an impact on the World Heritage Site property and could menace its outstanding universal value. UNESCO WHL comprises 1052 properties, divided into three categories: cultural sites, natural sites, and mixed sites ([whc.unesco.org/list](http://whc.unesco.org/list)). Romania has in the UNESCO WHL a number of seven properties; out of which one natural site (Danube Delta) and six cultural sites: Villages with Fortified Churches in Transylvania (Biertan, Calnic, Darjiu, Prejmer, Saschiz, Valea Viilor, Viscri), Historic Center of Sighisoara, Monastery of Horezu, Dacian Fortresses of the Orastie Mountains, Wooden Churches of Maramures (Barsana, Budesti, Desesti, Ieud, Plopiș/Sisesti, Poienile Izei, Rogoz/Targu Lapus, Surdesti/Sisesti), and Churches of Moldavia. They were inscribed in UNESCO WHL in 1993, except the Church of the Resurrection of Sucevita Monastery, which was inscribed in 2010. The most remarkable site in Moldavia is undoubtedly the Church of Voronet

Monastery, due to its blue colour pigments (Buzgar, Buzatu, Apopei, & Cotiuga, 2014).

In order to monitor the natural (Furlanetto and Bondesan, 2015) and anthropogenic (San-Antonio-Gómez et al., 2014) landscape changes, historical maps (Nicu, 2016) and orthophotos were used and integrated into a GIS with the help of remote sensing techniques (Banerjee & Srivastava, 2013). Historical maps are a reliable source of information, which can be used to follow the landscape dynamics (Nicu, 2017a), landscape reconstruction (Schaffer and Levin, 2016), etc. Tracked changes are the natural changes (lateral erosion and floods) (Nicu, 2017b, 2018a; Nicu and Romanescu, 2016) and the human-induced activities (land use and the extension of settlements). The most common natural hazard to affect cultural heritage is flooding (Romanescu and Stoleriu, 2017), because they are located on the valley bottom or near a watercourse. The river beds from the Eastern Carpathians are characterised by degradation (over 52%), aggradation (29%), and the rest have a stable elevation (Radoane et al., 2010). Moreover, the rivers discharge has an upward trend, due to the increased quantities of precipitation on the background of the global climatic changes (Croitoru & Minea, 2014).

UNESCO WHS and cultural heritage sites in general are well known

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for having a significant touristic and economic potential (Amit-Cohen & Sofer, 2016; Petr, 2015), which is controlled by different specific local factors like security (Wang, 2015), management (McKercher et al., 2005), natural hazards (Nicu, 2017c; Vicol, 2013). The landscape in Romania has a great ecological (Cirnu & Nichiforel, 2014) and cultural value (Sutcliffe et al., 2013). The immovable cultural heritage of Romania has an enormous economic potential, especially the archaeological sites (Romanescu, 2016) and the sites listed in the UNESCO WHL from the northern part of the country (Pohoata et al., 2013). Cultural heritage is a fundamental component of a European set of values (Sesana et al., 2018) and appreciation of the legacy that our ancestors left to us.

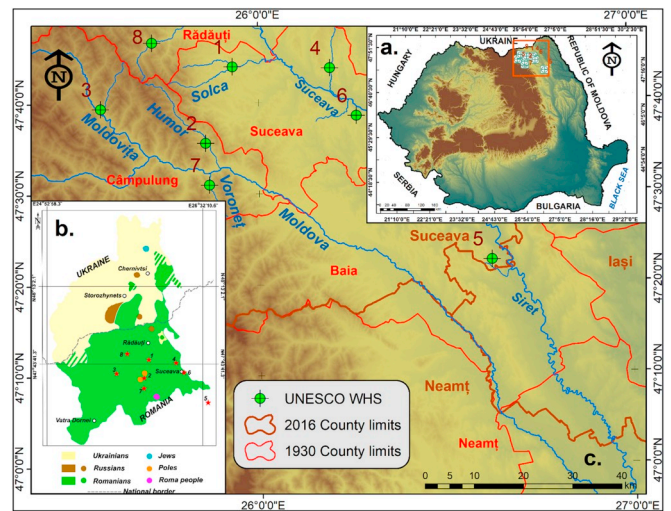
The landscape is a territorial unit with specific characteristics, which are imposed by the structure, content, and the dynamics of the physical, biotic and anthropogenic elements within it. Protecting landscapes goes beyond the limited protection of natural and cultural elements considered valuable, at the same time making reference to the protection of the complex system that ensured their appearance. The fact that the monuments are located in an area with such a huge historical significance gives a tremendous value to the landscape; we could state that they are placed in a cultural landscape (Lewis, 1979; Schulp et al., 2019). Heritage and landscape have a tight connection, being closely connected in time and space.

Despite the fact that due to a bad management of the touristic process, the number of tourists is quite small, yet there is a risk assessment for these sites. This is important because they are unique in Europe and the world. Moreover, they are a crucial legacy for future generations (Gavriletea and Dumbrava, 2008). A significant role in the land use dynamics were the Land Laws from 1864, 1877, 1881, 1918–1921, 1945, and Law no. 18/1991. The last law led to a high degree of fragmentation with disastrous outputs; following this, the development of Romanian agriculture was almost impossible. This led to important changes in land use (Vorovenci, 2003), followed by the increased intensity of soil erosion (Nicu, 2018b, 2019). As shown in European Environmental Agency report from 2011 (EEA, 2011) and then verified by Patru-Stupariu et al., 2015, the true level of fragmentation in Romania was underestimated; this is comparable to other Eastern European countries, namely Estonia, Latvia, Lithuania, Poland, Slovakia, Slovenia, Hungary and Bulgaria (Patru-Stupariu et al., 2015). Presently, agriculture represents one of the primary industries (Andrei, Mieila, & Panait, 2017).

Romania is well known for its sloppy laws and regulations regarding the environment and cultural heritage protection, that is why the sites listed in UNESCO WHL are no exception; personal and financial interest of the landlords and local stakeholders dominate the latter. Amongst the anthropic elements, the evolution and expansion of human settlements are the leading factors which have a direct impact on cultural heritage sites integrity and value (Agapiou et al., 2015; Nicu, 2016, 2017a). Having a good knowledge about the land use dynamics, rural development and morphology (Ciutacu, Chivu, & Andrei, 2015; Li et al., 2018) will lead to a better assessment and mitigation on humans and nature (di Giulio et al., 2009), to a proper risk management and risk reduction (Saunders and Kilvington, 2016) for cultural heritage (Nicu, 2018b, 2019; Romanescu and Nicu, 2014), and a powerful tool to provide policy guidance to governments and planners.

At an international level, there are a few studies regarding the use of landscape metrics applied for UNESCO biosphere reserves (Béliveau, Germain, & Ianas, 2017; Masný and Zaušková, 2015), and even few regarding the sustainability of rural world heritage sites (Gullino et al., 2015). However, there are no studies regarding the use of landscape metrics for immovable cultural heritage sites (UNESCO listed) for almost a century timeframe.

The main aims of this study is to fill the gap and to depict the spatial fragmentation degree and land use dynamics for almost a century for the UNESCO Churches of Moldavia; in order to do this, we will apply a set of landscape metrics: Shannon's diversity index, mean shape index,



**Fig. 1.** a. Geographical location of the UNESCO Churches of Moldavia; b. Ethnic map of Bukovina (based on Ukrainian 2001 and Romanian 2002 census data) and the location of the Churches of Moldavia within the historical province; c. Churches of Moldavia: no. 1 – Church of the Beheading of St. John the Baptist of Arbore, no. 2 – Church of the Assumption of the Virgin of the former Monastery of Humor, no. 3 – Church of the Annunciation of the Monastery of Moldovita, no. 4 – Church of the Holy Rood of Patrauti, no. 5 – Church of St. Nicholas and the Catholicon of the Monastery of Probota, no. 6 – Church of the St. George of Suceava, no. 7 – Church of the St. George of the former Voronet Monastery, no. 8 – Church of the Resurrection of Sucevita Monastery.

total edge, mean patch size, number of patches, mean patch edge, patch richness. Anthropogenic changes near the Voronet Monastery are a very typical example of local authorities not applying the UNESCO regulations regarding the building of new structures in the proximity of the sites.

## 2. Study area and sites description

The study area is located in the northern part of Romania in the east of Suceava County (Fig. 1a); this area is historically known as Bukovina (Fig. 1b). The subject is the eight Churches of Moldavia, part of UNESCO WHL (Fig. 1c). Out of eight monuments (Table 1), only one is located outside the historical Bukovina – Church of Probota.

The external walls covered in fresco paintings are masterpieces inspired by Byzantine art: external mural painting, covering all the facades, with complete cycles of religious themes, having outstanding artistic value – composition, chromaticism and elegance of figures. They represent an outstanding and unique artistic phenomenon manifested in Moldavia (late 15th century – late 16th century): architecture, artistic expression – external and internal mural painting, rich decoration blend with the specific surrounding countryside. The historical Bukovina is an area with a peerless natural beauty, simplicity, and a troubled history (as shown in section 3.2), which stretches over a period of roughly seven centuries. The area represents the typical rural landscape left unchanged from the 19th century. Bukovina represents one of the most representative touristic areas when it comes to the beauty of the landscape with the local people spirituality and hospitality. Besides the rich cultural heritage of Bukovina, there are a number of 22 natural reserves (six botanical, eight forest reserves, five geological reserves, and two mixed natural reserves) (Stoican et al., 2013).

### 2.1. Church of the Beheading of St. John the Baptist of Arbore

(Fig. 2a) – is located in Arbore village, Iaslovat Depression, close to the junction of Clit in Solca River; it was built in 1502 by the landowner

**Table 1**  
List of UNESCO churches of Moldavia.

UNESCO ID	Date inscribed	Name & Location	Coordinates	Area		Geographical unit (sub-division)
				Core zone	Buffer zone (established by UNESCO)	
598-001	1993	Church of the Beheading of St. John the Baptist of Arbore	N47d43m59s E25d55m58s	2.54 ha	28.59 ha	Iaslovat Depression
598-002	1993	Church of the Assumption of the Virgin of the former Monastery of Humor	N47d35m38s E25d51m15s	4.27 ha	27.9 ha	Humor Depression
598-003	1993	Church of the Annunciation of the Monastery of Moldovita	N47d40m39s E25d32m50s	4 ha	44 ha	Moldovita Depression
598-004	1993	Church of the Holy Rood of Patrauti	N47d43m58s E26d11m41s	0.67 ha	26.64 ha	Mitoc Plateau
598-005	1993	Church of St. Nicholas and the Catholicon of the Monastery of Probota	N47d22m30s E26d37m24s	1 ha	28.54 ha	Tatarusi Plateau
598-006	1993	Church of the St. George of Suceava	N47d38m30s E26d15m46s	1.34 ha	4.84 ha	Vulturesti Plateau
598-007	1993	Church of St. George of the former Voronet Monastery	N47d31m02s E25d51m50s	3.27 ha	37.71 ha	Voronet Depression
598bis-008	2010	Church of the Resurrection of Sucevita Monastery	N47d46m42s E25d42m42s	1.4 ha	36.4 ha	Scorusset Hills
<b>Total</b>				<b>18.49 ha</b>	<b>234.62 ha</b>	

Legend: d = degrees, m = minutes, s = seconds.

Luca Arbore. It is listed in the List of Historical Monuments under the code SV-II-a-A-05487. The first historical mention of Arbore village is in a document from 15th of January 1418 at the Alexandru cel Bun Royal Court. In 1541 the painting of the church was partially restored; the church and its interior paintings had degraded in the 17th and 18th centuries when the building remained without a roof until northern Moldavia was occupied by the Austrians. Along time, the church underwent partial repairs, restoration and consolidation, which have not altered the original architecture (Caprosu, 1974).

### 2.2. Church of the assumption of the virgin of the former Monastery of Humor

(Fig. 2b) – is placed within the Gura Humorului commune, Humor Depression, close to the Humor River; it was founded in the 14th century and destroyed in the 16th century. It was rebuilt in 1530 with the help of the landowner Toader Bubuiog, his wife Anastasia, and Prince Petru Rares. The painting was made in 1535 by Toma of Suceava; the scenes are displayed according to the different sections of the church, the most famous being considered “The Siege of Constantinople” (Fig. 3c), located on the right side of the doorway. It is listed in the List of Historical Monuments under the code SV-II-a-A-05570. It has a series of particularities that differentiate it from other churches; there is no nave above the steeple and the presence for the first time in the Moldavian architecture, of an open porch (instead of an enclosed one). Another specific characteristic is the use of the red colour for the paintings (Porcescu, 1974).

### 2.3. Church of the annunciation of the Monastery of Moldovita

(Fig. 2d) – located in the Vatra Moldovitei village, Moldovita Depression, close to the Ciumarna and Moldovita Rivers junction. It is listed in the List of Historical Monuments under the code SV-II-a-A-05673. The village Vatra Moldovitei has the oldest mention, dating from 1401, among all the villages in the region (Iosep, 2004). There is no precise date when the monastery was built, but there is a documentary mention from 1410 when Alexandru cel Bun refers to the newly constructed Moldovita Monastery; the old construction collapsed somewhere in the 15th century due to a landslide, the ruins being visible even today at about 500 m away from the new monastery. Interestingly, the geomorphological processes are discussed in the documentary record (Bals & Nicolescu, 1958). Along through time, the

monastery had different roles religious, economic and military; the monastery was initially designed as a citadel, being surrounded by stone walls and having a strategic position close to the main commercial road – *drumul Dornelor (Dornelor road)* – connecting Moldavia and Transylvania (Nicolescu, 1967). If for Voronet Monastery is specific the blue colour, for Arbore the green, at Moldovita Monastery dominates the brown-red; it was painted in 1537, both inside and outside, with a good general status of the colours, except for the northern facade, much more degraded due to meteorological conditions (Fig. 2e).

### 2.4. Church of the Holy Rood of Patrauti

(Fig. 2f) – began to be built on 13 June 1487 by the ruler Stefan cel Mare (Stephen the Great) to serve as location for the convent of nuns which functioned until the end of the 18th century when it was closed by the Austrian administration; the church is located on the Mitoc Plateau, north-eastern part of Patrauti village, at 200 m west of Patrauteanca River. It is listed in the List of Historical Monuments under the code SV-II-a-A-05581. The monument is characterised by a few superlatives, which makes it unique and extremely valuable in the international context: the oldest preserved church that was ruled by Stefan cel Mare, the oldest Orthodox Church of UNESCO from Romania, the single nun monasteries founded by Stefan cel Mare, the church with the oldest interior and exterior painting in Moldavia, the oldest preserved church built in Moldavian style (on triconical plan with the tower supported by four rotated arches above the nave and a specific orthodox subdivision of the space in narthex, nave and altar). The inside frescoes represent the work of a fine Greek artist. Assessment has shown that the church is found within the first class of seismic risk; rehabilitation work has paid off and the monument is in no danger of collapse (Soveja and Gosav, 2014).

### 2.5. Church of St. Nicholas and the Catholicon of the Monastery of Probota

(Fig. 2g) – this property is located in Probota village, Dolhasca city, in the relief sub-unit Tatarusi Plateau; it was built in 1530 by the ruler Petru Rares. Between 1522 and 1677 it has fulfilled the role of a royal necropolis (Zahariuc, 2015), containing the tombs of rulers Petru Rares (1526–1538, 1541–1546), Stefan Rares (1551–1552), and other members of the ruling family. It is listed in the List of Historical Monuments under the SV-II-a-A-05592 code. The church St. Nicholas is a masterpiece of Romanian medieval architecture and is distinguished by an



**Fig. 2.** a. Church of the Beheading of St. John the Baptist of Arbore; b. Church of the Assumption of the Virgin of the former Monastery of Humor; c. The painting “The Siege of Constantinople” from Monastery of Humor; d. Church of the Annunciation of the Monastery of Moldovita; e. Degradation of the northern façade due to harsh meteorological conditions; f. Church of the Holy Rood of Patrauti; g. Church of St. Nicholas and the Catholicon of the Monastery of Probota; h. Church of the St. George of Suceava; i. Church of the St. George of the former Voronet Monastery; j. Church of the Resurrection of Sucevita Monastery.

elegant shape, rich forms and architectural elements, aesthetic refinement, craftsmanship, complexity and ornamentation; as well as through the implementation of seascape paintings combined with naturalness and realism of the characters (Iacobescu, 1979). It is entirely built out of stone, with three rows of bricks, laid out horizontally. The church was painted in the fresco Byzantine style both indoors and outdoors (Buzatu, 1974). Due to its historical importance and the interest of specialists from Japan, the complex and the church were subjected to ample research, restoration and valorisation under the aegis of UNESCO and took place between 1996 and 2001.

## 2.6. Church of the St. George of Suceava

(Fig. 2h) – also known as Mirauti Church, located within Suceava city, in the south-eastern extremity, Vulturesti Plateau, about 1.5 km south-west of the Suceava River. 650 m towards north-east is located Suceava citadel (built at the end of the 14th century). The church is listed in the List of Historical Monuments under the code SV-II-a-A-05475. It was built in the 14th century then rebuilt in the 17th century and considered to be one of the oldest churches in Moldavia. The church has had a troubled and tumultuous history, becoming the Metropolitan Church of Moldavia starting in 1402, being almost ravaged in 1513; during the Austrian Empire it was on the point of being demolished on the order of the Austrian authorities, in 1815 was claimed by the Lutheran community in Suceava, then in 1825 became a storage place for cereals for a military unit stationed in the area. It was renovated in 1898–1901 by the Austrian architect Karl A. Romstorfer, which introduced new elements in the church architecture (Hostiuc, 2010).

## 2.7. Church of the St. George of the former Voronet Monastery

(Fig. 2i) – located in the Voronet village, part of Gura Humorului city, Voronet depression, at about 150 m south from Maghernita and Voronet rivers junction. It is listed in the List of Historical Monuments under the code SV-II-a-A-05675. It was built and founded in 1488 by Stefan cel Mare in just three months and three weeks, which was a record for those days; being one of the most famous monasteries among the eight painted Churches of Moldavia due to its exterior frescoes, hundreds of well-preserved figures painted on a blue background (the main colour of the artwork from Voronet), and for the imposing *Last Judgement* scene on the west wall. The present church was built over the former remains of a wooden church, in a perfect symbiosis combining Gothic and Renaissance styles. It is often named the Sistine Chapel of the East (Simionovici, 2001).

## 2.8. Church of the Resurrection of Sucevita Monastery

(Fig. 2j) – located in Sucevita village, close to the junction of Bercheza and Neagu streams in Sucevita River, relief subdivision Scoruset Hills. It is listed in the List of Historical Monuments under the code SV-II-a-A-05651. It is known for the Epitaphios (164 cm long and 126 cm wide) dating from 15th century, which represents the Lamentation (part of the Liturgical embroideries and veils collection in the Sucevita Monastery Museum). The main characteristic is that is worked with gilded silver thread and coloured silk on a red atlas background, on a red damask support, doubled with linen canvas (Muzicescu and Dobjanschi, 1985). Following the mass spectrometry analysis of the dyes it was identified as the use of kermes, the most expensive source of red in the second half of the 15th century; this puts the embroidery from Sucevita at the same level as the famous Grave cover of Princess Maria of Mangop and the Cover lectern/61 (Petrovicu et al., 2011). These are the only three embroideries which used the unique and rare kermes red pigments.

## 3. The evolution of administrative-territorial organisation of Romania and Bukovina

### 3.1. The evolution of administrative-territorial organisation of Romania

The state of the cultural heritage is closely related to the administrative-territorial organisation of the territory, especially with the land laws (which induce very fast changes of the land-use for which a certain zone is not yet prepared or does not have the certain means to induce those changes). Land grabbing represents one of the most fundamental problems of the Romanian economy (Ciutacu, Chivu, & Andrei, 2017). For almost a century (since 1918) there were no less than 13 models of

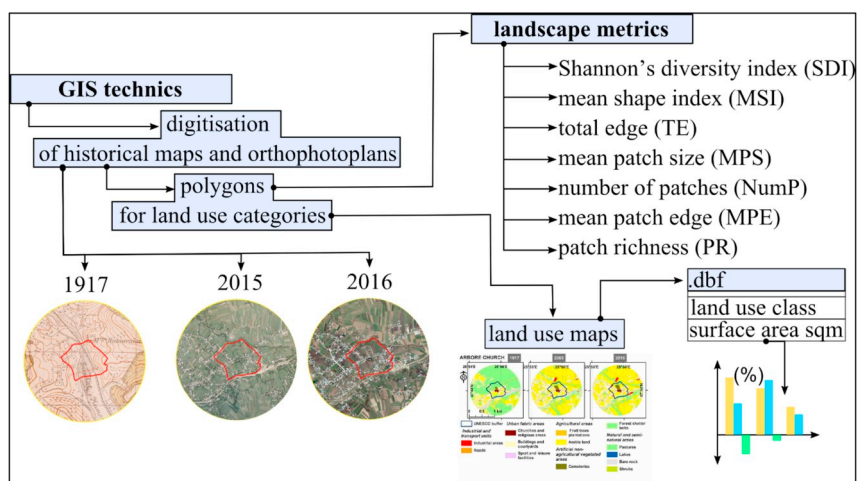


Fig. 3. Flow diagram of the methodology used in the study.

territorial division, which had a strong impact on the transformation of landscape; they are as follows 1918–1925 (76 counties), 1925–1940 (71 counties), 1929–1931 (seven ministerial directorates, 71 counties), 1938–1940 (ten provinces, 71 counties), 1940–1950 (58 counties), 1950–1952 (28 regions), 1952–1956 (18 regions), 1956–1960 (16 regions), 1960–1968 (16 regions), 1968–present: 39 counties (1968–1981), 40 counties (1981–1997), 41 counties and Bucharest municipality (1997–present), eight development regions (officially from 1998). To this, the four major changes that took place in only one century: the great agrarian reform in 1921, the agrarian reform of 1945, agriculture collectivization from 1949 to 1962, and the enforcement of the Land Law from 1991 (Otiman, 2012).

### 3.2. The evolution of administrative-territorial organisation and rural space in Bukovina

Bukovina is a historical region divided between Ukraine and Romania. The name Bukovina has been officially used since 1775 when it became part of the Habsburg Empire. In Romania, the name is still used, unlike Ukraine where the name is unofficial and it is part of the Chernivtsi Oblast (Cook, 2014). The annexation of Bukovina by the Habsburg Empire in 1775 had a positive impact on economic and social development; industry grew fast: milling, breweries, logging (Maha et al., 2010); the existence of high quantities of mineral resources represented one of the main advantages of the new territory annexed to the Austrian Empire (Popescu and Popescu, 2016). However, there was an adverse attitude of the Austrian Empire regarding the financing of the churches, with fewer funds being available for maintenance and preservation. The population of Bukovina has a high confidence in the Orthodox Church and believe in the supernatural (evil eye) (Söukand and Pieroni, 2016).

Another thing that had a significant importance in the development and transformation of the rural Bukovina were the three topographical survey campaigns (18th century, 1806–1869, 1869) made by the Austrian Empire, as the annexed territories were considered of high interest and a detailed cadastre was needed. The region was administratively reorganised, in 1873 Bukovina became an archdiocese and Metropolitanate (Bukovina-Dalmatia), then by the Austrian Constitution of the 4th March 1849 Bukovina was appointed a Duchy (crown land of the monarchy) until 1860; being part of the Austrian Empire, the region had a significant economic growth (Scharr, 2007) and was integrated into the European economic circuit. The main economic partners were Russia, Romania, Italy, France, Germany and Turkey. The spectacular economic growth leads to an increase of population, Bukovina becoming in 1869 the 9th region of the Austrian Empire in what concerns the number of inhabitants (with a density of

76.8 inhabitants/km<sup>2</sup>). During this period Bukovina was a dynamic and rich region in regards to economic, social, educational and political sectors, even attracting migrants for seasonal work. The war had disastrous effects on the province by reducing the number of inhabitants and many factories being destroyed (Maha et al., 2011). In 1919 Bukovina became part of Romania, through the Peace Treaty with Austria. In June 1940 the northern part of the region is occupied by the USSR, but in 1941 the Romanian Army takes this part back as related regions that had a governor. In 1944 the northern Bukovina is re-occupied by the Red Army, remaining until today as part of Ukraine (Carare, 2010) and south Bukovina as part of Romania.

With the development and modernisation of the Western World, the eastern part of Europe tends to follow, more or less, the same tendency. This is also reflected in the case of Romania, especially in Bukovina, by the changes within the cultural landscape. The cultural landscape could be defined as a compromise between the visible and the hidden, between reason and emotion, between morphology and functions (Czeczynski, 2006). The new modern houses rarely cope within the typical cultural landscape of Bukovina, due to a multitude of reasons which are more or less specific to the Romanian people and society: avoidance of conflicts with the voters, lack of specialists in landscape planning, lack of urban plans and urban documentation, fear of being associated with the former socialist centralised planning strategies, sloppy legislation; there has to be a balance between combining the pressure of modernisation and the need for sustainable regional development (Chasovschi, 2016).

## 4. Methodology and data

As shown by Bandarin (2009), buffer zones are an important tool for conservation of properties inscribed in the WHL; the protection of these areas was considered an essential component of the conservation strategy, for both cultural and natural sites. The buffer zone has the aim of protecting WHS from negative influences; the significance of the environment for the property has to be properly recognised to be able to define a convenient perimeter as well as protection measures for the buffer zone. Besides the buffer areas that were established by UNESCO, in the present study buffer area was extended to 1 km around the site. Following the buffer analysis, out of eight sites, six are located within the 1 km radius from a river. In this way, they are likely to be affected by floods (Romanescu and Stoleriu, 2017), which are a real problem in this part of the country.

The historical maps used in the study are as follows Historical Army Maps or Shooting Plans, scale 1:20.000 (edition 1917), orthophotos, scale 1:5000 (edition 2005), Google Earth images (2016). The data was digitised with the help of ArcGIS software in Romania's official

projection Stereo 70. The land use classes were kept according to the European methodology (EEA, 2006).

Following the digitisation of the historical maps, orthophotos, and Google Earth images, there have been extracted 23 land use categories; these categories were grouped into five classes: **urban fabric areas** (churches and religious areas, buildings and courtyards, fortress, sport and leisure facilities, statues and monuments), **industrial and transport units** (roads, industrial areas, heliport, parking areas, pedestrian zone), **artificial non-agricultural vegetated areas** (cemeteries, green spaces, forest plantation areas, forest shelter belts), **agricultural areas** (arable land, fruit trees plantation – orchards, vineyards), **natural and semi-natural areas** (rivers, lakes, pastures, shrubs, forests, bare rock). For these categories, the surfaces were calculated and their distribution diagrams were made (Fig. 3).

In order to highlight the spatial fragmentation degree and land use dynamics, we calculated indexes of landscape metrics (Wang et al., 2014) using Patch Analyst tool (Corry, 2005; Hietala-Koivu, 1999). Landscape metrics are simple quantitative indices that examine the information on landscape patterns and highlights its spatial configuration and structural composition (Aysegul, 2016; Wu, 2001). Among indexes of landscape metrics we selected Shannon's diversity index (SHDI), mean shape index (MSI), total edge (TE), mean patch size (MPS), a number of patches (NP), mean patch edge (MPE), patch richness (PR).

Patch Analyst is an extension to the ArcGIS software that helps in the spatial analysis of landscape patches and the modelling of attributes associated with patches. It is often used for spatial pattern analysis, forest management and biodiversity conservation (Rempel et al., 2012). In this study, we used the Patch Analyst 5.0 extension to analyse the landscape metrics over almost a century around the most important UNESCO sites from the northern part of Romania.

#### 4.1. Landscape metrics

Shannon's diversity index (SHDI) is the most popular diversity index and is based on information theory; it is used as a relative index for comparing different landscapes or the same landscape at different times, as it is in our case. SHDI is calculated using the Eq. (1), and equals minus the sum, across all patch types, of the proportional abundance of each patch type multiplied by that proportion; the value of this index could be  $\geq 0$  (zero); when it is equal to 0 it means that the landscape contains only one patch (no diversity). The index value increases as the number of different patch types increases and/or the proportional distribution of area among patch types becomes more equitable. It is used as a relative index for comparing different landscapes or the same landscape at different times (McGarigal et al., 2012).

$$SHDI = - \sum_{i=1}^m (P_i * \ln P_i) \quad (1)$$

where  $P_i$  represents the proportion of the landscape occupied by patch type (class)  $i$ .

Mean shape index (MSI) represents a shape complexity; MSI is equal to 1 when all patches are circular (for polygons) and it increases (no limit) with an increasing patch shape irregularity. It is calculated taking into consideration all patches of a particular type simultaneously, instead of considering a single patch and by using Eq. 2

$$MSI = \frac{\sum_{i=1}^m SI_i}{NP} \quad (2)$$

where NP represents the number of patches.

Total edge (TE) represents an absolute measure of the total edge length of a particular patch type (class level) or of all patch types (landscape level); in our case of all patch types. When the value is equal to 0, it means that there is no edge in the landscape; the value of this index can be  $\geq 0$  (McGarigal et al., 2012).

$$TE = \sum_{k=1}^m e_{ik} \quad (3)$$

where  $e_{ik}$  represents the total length (m) of an edge in landscape involving patch type (class)  $i$ .

Mean patch size (MPS) offers a measure of central tendency in the corresponding patch characteristic across the entire landscape; metrics based on the mean patch characteristics display a fundamentally patch-centric perspective of the landscape structure. MPS can be successfully used as a habitat fragmentation index (McGarigal et al., 2012).

$$MPS = \frac{A}{N} \left( \frac{1}{10000} \right) \quad (4)$$

Number of patches (NP) – when is applied at the class level, it measures the degree of fragmentation of the focal patch type; applied at the landscape level it measures the graininess of the landscape. In this study, we applied it at a landscape level (McGarigal et al., 2012).

$$NP = n_i \quad (5)$$

Mean patch edge (MPE) represents the average amount of edge per patch and is calculated using equation (6)

$$MPE = TE / NumP \quad (6)$$

Patch richness (PR) measures the number of patch types existent; it is not influenced by the relative abundance of each patch type or the spatial arrangement of patches. This index is an important element of landscape structure because the variety of landscape elements present in a landscape can have a significant influence on different land use categories (McGarigal et al., 2012).

$$PR = m \quad (7)$$

## 5. Results

Generally speaking, for the eight study sites, it is observed that the spatial dynamics of land use categories are dominated by natural and anthropogenic phenomena. Thus, natural phenomena are manifested by floods, lateral erosion, and succession; the anthropogenic intervention is manifested by changing of land use category through retro-migration (urban towards rural) (Gmelch, 1980), abroad migration, industrialisation, deforestation, house construction, tourism and associated structures (guest houses, parking places, pedestrian areas, green areas).

Between 1917 and 2016 there was a general increase in areas occupied by buildings and courtyards (from 10.3% in 1917 to 14.1% in 2016), arable lands (from 8.1% in 1917 to 25.7% in 2016); this indicates that the population number has grown. However, there is a decrease in areas occupied by pastures (from 45.11% in 1917 to 20.72% in 2016), rivers and bare rock (from 2.85% in 1917 to 1.37% in 2016). Forests and forest shelterbelts are not subject to significant spatial dynamics.

During the approximately 100 year timespan, new categories of sport-related and leisure facilities, statues and monuments, parking areas, industrial areas and orchards have emerged (Table 2). During almost a century, there has been an increase in the anthropogenic intervention, in regards to natural categories (rivers, lakes, forests, pastures, shrubs, bare rock), by replacing the semi-natural categories with buildings and courtyards, industrial areas, parking areas, pedestrian zone, etc. From the natural-anthropogenic category ratio viewpoint, it is noticed that Sucevita (Fig. 4a), Voronet (Fig. 4b) and Moldovita (Fig. 5c) still preserve the natural landscape specific to the low mountain areas, while Arbore (Fig. 5a), Humor (Fig. 5b), Patrauti (Fig. 6a) and Probota (Fig. 6b) are characterised by an anthropic rural-agrarian landscape. Only Suceava (Fig. 6c) is part of a strongly urbanised landscape (Table 3).

Landscape metrics fragmentation indices show an increase in the division of analysed areas into a 1 km buffer around UNESCO sites over

**Table 2**  
Aggregated areas by land use category for the eight UNESCO sites analysed (1 km buffer).

Year	1917		2005		2016	
Land use categories	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
<b>Urban fabric areas</b>						
Churches and religious areas	10.2	0.4	9.2	0.4	9.5	0.4
<b>Buildings and courtyards</b>	<b>259.6</b>	<b>10.3</b>	<b>334.3</b>	<b>13.3</b>	<b>355.3</b>	<b>14.1</b>
Fortress	0.8	0.03	0.8	0.03	0.8	0.03
Sport and leisure facilities	-	-	0.4	0.02	0.9	0.04
Statues and monuments	-	-	0.1	0.004	0.1	0.004
<b>Subtotals</b>	<b>270.6</b>	<b>10.8</b>	<b>344.7</b>	<b>13.7</b>	<b>366.6</b>	<b>14.6</b>
<b>Industrial and transport units</b>						
Roads	76.4	3.0	91.3	3.6	92.7	3.7
<b>Industrial areas</b>	<b>0.0</b>	<b>0.0</b>	<b>6.3</b>	<b>0.3</b>	<b>13.0</b>	<b>0.5</b>
Parking areas	-	-	9.6	0.4	10.7	0.4
Heliport	-	-	0.1	0.003	0.1	0.003
Pedestrian zone	-	-	-	-	1.3	0.1
<b>Subtotals</b>	<b>76.4</b>	<b>3.0</b>	<b>107.3</b>	<b>4.3</b>	<b>117.8</b>	<b>4.7</b>
<b>Artificial non-agricultural vegetated areas</b>						
<b>Cemeteries</b>	<b>6.3</b>	<b>0.3</b>	<b>14.4</b>	<b>0.6</b>	<b>21.5</b>	<b>0.9</b>
Green areas	8.9	0.4	31.9	1.3	32.2	1.3
Forest plantation areas	-	-	-	-	2.4	0.1
Forest shelter belts	136.6	5.4	131	5.2	135.4	5.4
<b>Subtotals</b>	<b>151.9</b>	<b>6.0</b>	<b>177.4</b>	<b>7.1</b>	<b>191.5</b>	<b>7.6</b>
<b>Agricultural areas</b>						
<b>Arable lands</b>	<b>203.8</b>	<b>8.1</b>	<b>664.7</b>	<b>26.4</b>	<b>646.9</b>	<b>25.7</b>
Orchards	0.3	0.0	20.4	0.8	16.8	0.7
Vineyards	-	-	-	-	0.4	0.01
<b>Subtotals</b>	<b>204.2</b>	<b>8.1</b>	<b>685.0</b>	<b>27.3</b>	<b>664.2</b>	<b>26.43</b>
<b>Natural and semi-natural areas</b>						
Rivers	14.9	0.6	9.9	0.4	7.2	0.3
Ponds	-	-	1.2	0.05	1.3	0.1
<b>Forests</b>	<b>568.1</b>	<b>22.6</b>	<b>476.5</b>	<b>19</b>	<b>573.4</b>	<b>22.8</b>
<b>Pastures</b>	<b>1133.6</b>	<b>45.1</b>	<b>576.4</b>	<b>22.9</b>	<b>520.7</b>	<b>20.7</b>
Shrubs	36.5	1.5	101.3	4.0	43.2	1.7
Bare rock	56.8	2.3	33.2	1.3	27.1	1.1
<b>Subtotals</b>	<b>1809.9</b>	<b>72.0</b>	<b>1198.5</b>	<b>47.7</b>	<b>1172.9</b>	<b>46.7</b>
<b>Total</b>	<b>2512.9</b>	<b>100.0</b>	<b>2512.9</b>	<b>100.0</b>	<b>2512.9</b>	<b>100.0</b>

the analysed period (Table 4). Moldovita, Sucevita and Voronet stand out by approximately doubling the NP along with the increase of PR (number of land use categories). For the other categories, an increase of between 500 and 700 patches is observed. The patches diminish in the period 1917–2016, therefore as the MPS decreases by an average of 0.34 ha, generating an increase in the total length of the patch perimeter (TE) and a decrease in the MPE. The shape of the patches varies in small limits and they have a mixed, rarely tentacular appearance (MSI ranging from 1.47 to 1.69). The diversity of land use increases from one period to the next, so SDI is more obvious as a dynamic for Moldovita, Patrauti, Probota, Suceava and Sucevita.

The Suceava church, in its surrounding area (1 km buffer) is highly affected by the diversification of land use (an SDI value of 1.56 in 1917 to 2.39 in 2016) (see Supplementary Material). For the analysed period, the following phenomena, processes and activities are observed: floods, lateral erosion, reforestation, land use change, construction of buildings (industrial, churches, dwellings, guest houses). The increasing number of new buildings in the rural area (except Suceava church) is caused by replacing the old houses with new ones, building new annexes inside the same yard, modernizing and extending the old dwellings, annexing two nearby dwellings.

The changes were sustained over time in two stages: first stage 1917–1990 when the birth rate of Romania grew from about 13 million in 1917 (INS, 2013) to 23.2 million people in 1990 (ADR-centru, 2010), and the second stage after 1990 when Romania faces a demographic decline (22.2 million people in 2016, according to INSSE).

The positive and negative fluctuations in demography led to an increase in the rural and urban population by 1990, generating changes within the 1 km buffer area; the most important changes was the reduction of grassland areas and an increase in the farmland surface and

new dwellings. An example of a modification of the existing built area is the Suceava church surrounding area (Fig. 6c); in 1917 the landscape was dominated by buildings with households, then by the modernisation and development of Romania after the Second World War, the landscape changed into a specific urban environment, by building blocks for housing.

Another example of significant anthropogenic change is the case of the Arbore church (Fig. 5a), where a decrease of pastures (from 50.5% in 1917 to 5.66% in 2016) is registered in favour of arable land (from 12.47% in 1917 to 51.47% in 2016). These dynamics are also specific to the sites located in the plateau area (Patrauti, Probota). The 1 km buffer area of the sites located near or within the mountainous area (Sucevita, Voronet, Moldovita, and Humor) which do not have large areas occupied by pastures. This is because of the limited space along the narrow mountain valleys.

After Romania joined the European Union (1 January 2007), the migration caused a demographic decline, especially in the rural area specific to the UNESCO sites (Arbore, Humor, Patrauti, Probota, Moldovita, Sucevita, Voronet). Through this migration, an infusion of financial capital took place (and continues) through the investments of migrants in the construction of new housing, guest houses, and agriculture development. However, around Voronet, Sucevita and Moldovita sites, the architectural landscape has changed, from the traditional to the modern one. The proximity of Suceava city and its accessibility by European and national roads (not more than 1 h and 50 min to each of the sites) has stimulated investment through the purchase of land for the construction of temporary residences such as the adjacent area to UNESCO sites of Arbore, Patrauti and Probota (located within a radius of up to 50 km).

Between 2006 and 2010, the Siret basin, the one in which UNESCO

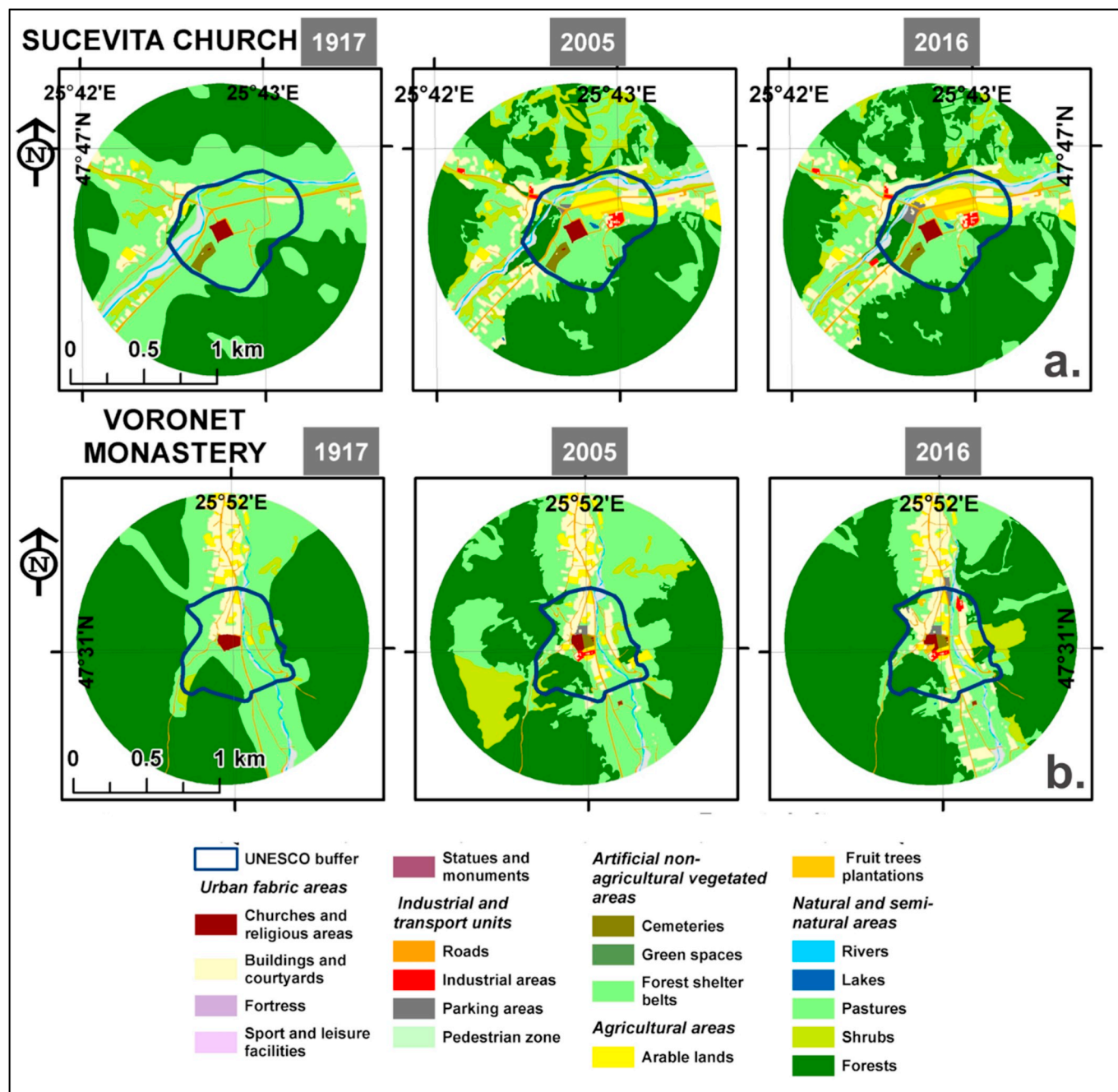


Fig. 4. a. Land use dynamics for Sucevita Church from 1917 to 2016; b. Land use dynamics for Voronet Monastery from 1917 to 2016.

sites analysed are located, experienced extreme hydrological events (Romanescu and Stoleriu, 2017). In the proximity of Arbore church, there were three floods within Solca watershed. The 2006 flood caused the deaths of 11 people and the destruction of approximately 30 households. Therefore, extreme natural phenomena are a major cause of change in the land use category (Fig. 7).

The case of the Voronet monastery is a very particular one; due to its easy access location and the promoting process, Voronet monastery is the most famous out of the eight sites. Over the last years, the area encountered an upward trend in regards to the number of tourists (due to the attraction of European funds and local investments in the infrastructure, parking places, local shops, etc.). No doubt this has a significant role in boosting the economic contribution for the inhabitants and local authorities. However, some irregularities have been observed during field trips. A new accommodation unit is being built at an

approximate distance of 110 m from the monastery's surrounding wall. This fact is breaking the general and specific rules of UNESCO, which forbids any modifications in the buffer area; most likely, this is made with the approval of local authorities, which do not comply with the rules of UNESCO. A 3D Google Earth view (Fig. 8a) is showing us the overall situation, and then the photos made in the spring of 2018 highlight the anthropogenic interventions that occur in the close proximity of the Voronet Monastery; a new access path was under construction implementing stone thresholds (Fig. 8b) by using heavy trucks (Fig. 8c), which were making a lot of noise and producing vibrations. A view from the newly built path (Fig. 8d) shows how close is the monastery of the new accommodation unit.

Not even the new accommodation unit is built too close to the monastery, the style of the building is not in accordance with the local style (Fig. 8e and f). This fact is decreasing the value of the landscape



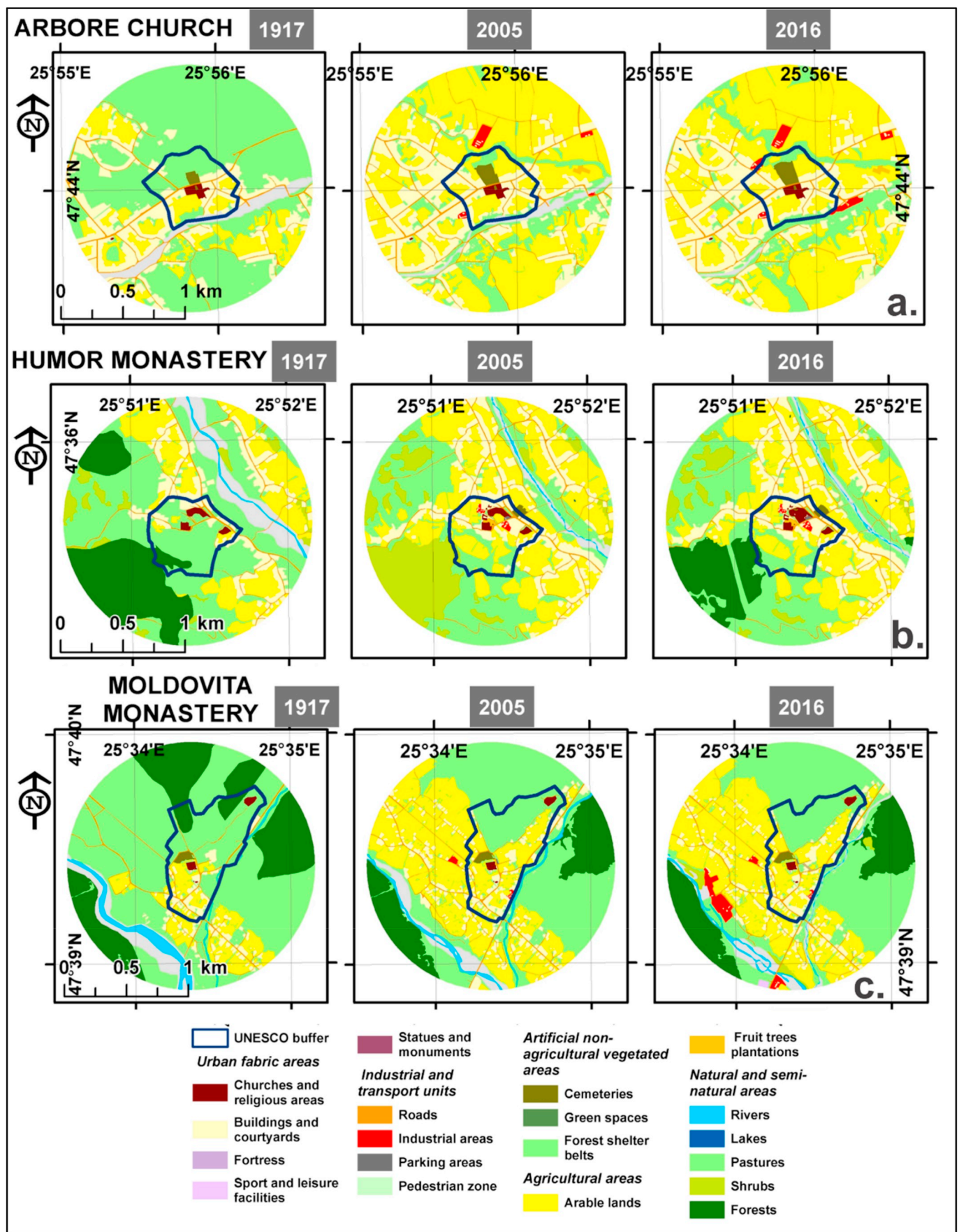
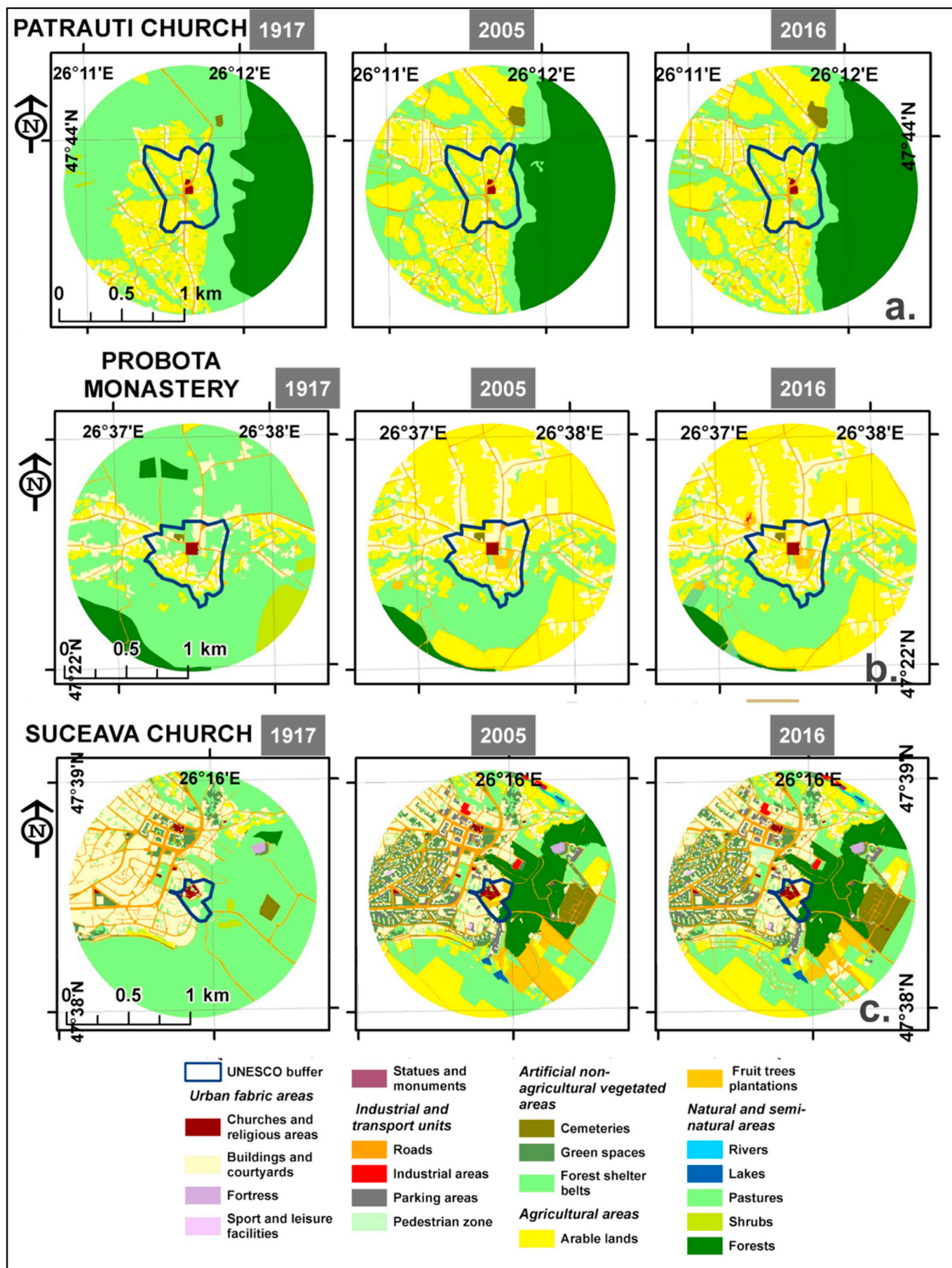


Fig. 5. a. Land use dynamics for Arbore Church from 1917 to 2016; b. Land use dynamics for Humor Monastery from 1917 to 2016; c. Land use dynamics for Moldovita Monastery from 1917 to 2016.



(caption on next page)

**Fig. 6.** a. Land use dynamics for Patrauti Church from 1917 to 2016; b. Land use dynamics for Probota Monastery from 1917 to 2016; c. Land use dynamics for Suceava Church from 1917 to 2016.

**Table 3**  
Semi-natural-anthropogenic land-use category ratio within 1 km buffer.

Natural-anthropogenic category ratio	1917	2005	2016
Sucevita	15.9	7.3	6.3
Voronet	6.9	6.8	6
Moldovita	4.3	1.1	1.1
Probota	2.5	0.3	0.2
Humor	2.1	1	1
Patrauti	2.	1	1
Arbore	1.2	0.1	0.1
Suceava	1.1	0.5	0.4

and shows the fact that the law is not applied as it should be, and this is not the only case.

**6. Discussion**

After analysing the indices it can be observed the fact that there are three major categories of landscape within our 1 km buffer area: a natural landscape (which keeps the traditional way, where dominant is the natural categories, e.g. Voronet, Sucevita, Patrauti; they are located at a higher distance from the main roads), a transition landscape between rural and urban (e.g. Probota, Arbore, Humor, Moldovita), and an urban landscape that is surrounding Suceava Church, which is included in the built-up area. No doubt, agricultural areas play a significant role in the way that land use and humans are dependent; in Romania, agriculture was practiced since early Neolithic, and this influenced in how Romanians are connected with their land. The connection is very strong because the land is passed from generation to generation, this being their legacy for the next generations. Very often, the landowners refuse to sell it due to the wrong way in which the agrarian reforms were implemented along time (Petrescu-Mag et al., 2017). In this way, the fragmentation is higher. Subsistence agriculture and agricultural households of under 1 ha dominate the area; this being the general trend for the whole country. Within the study area, arable land is frequently replaced by residential buildings. Thus, the localities

**Table 4**  
Indexes of landscape metrics.

UNESCO site	Year	SHDI	MSI	TE (m)	MPE (m)	MPS (ha)	NP	PR (1 km buffer) (number)
Arbore church	1917	1.52	1.49	238044	184.96	0.24	1287	8
	2005	1.51	1.48	305242	181.37	0.19	1683	11
	2016	1.52	1.47	310868	177.03	0.18	1756	13
Humor monastery	1917	1.82	1.57	203835	222.77	0.34	915	10
	2005	1.77	1.55	274658	205.89	0.24	1334	14
	2015	1.86	1.55	296758	199.43	0.21	1488	15
Moldovita monastery	1917	1.51	1.62	191263	210.41	0.35	909	10
	2005	1.73	1.60	281274	165.16	0.18	1703	12
	2015	1.83	1.60	292762	164.38	0.18	1781	15
Patrauti church	1917	1.50	1.56	213948	164.20	0.24	1303	9
	2005	1.64	1.54	287565	154.77	0.17	1858	11
	2016	1.68	1.52	298489	146.97	0.15	2031	11
Probota Monastery	1917	1.39	1.48	193729	216.46	0.35	895	10
	2005	1.50	1.45	252241	198.30	0.25	1272	9
	2016	1.56	1.45	264357	193.24	0.23	1368	12
Suceava church	1917	1.54	1.55	364930	175.62	0.15	2078	12
	2005	2.35	1.56	447777	180.77	0.13	2477	17
	2016	2.39	1.55	470123	180.89	0.12	2599	18
Sucevita church	1917	1.32	1.72	108468	433.87	1.26	250	10
	2005	1.66	1.66	182996	368.20	0.63	497	15
	2016	1.62	1.65	189636	355.79	0.59	533	15
Voronet monastery	1917	1.19	1.69	117266	288.83	0.77	406	10
	2005	1.46	1.64	164734	286.49	0.55	575	14
	2015	1.28	1.61	167460	227.53	0.43	736	17

near Suceava (Arbore – 35 km, Patrauti – 14 km, and Probota – 59 km) face a spray of agricultural surfaces (highlighted by low values of MP and increasing of NP). This dynamic in changing the land use category, which is characteristic of the areas surrounding the residential cities in Romania, has been manifested in the last 12 years due to investments in house construction by the Romanian diaspora. Unless significant changes are made, Romania's agricultural production will not be able to reach the average EU-27 until 2038 (Feher et al., 2017).

The rural population does not have many ways of income, therefore the agriculture represents the main source to sustain everyday life. It has also been noticed that agriculture was one of the causes of forest clearance, especially before 1990; after this year, a huge amount of forest loss has been reported due to heavy illegal logging (Munteanu et al., 2014). In the more isolated localities (Voronet, Moldovita, Sucevita), the most affected land use categories are the ones used for grazing and meadows. Meadows and hayfields face change as residential areas, arable land and the natural restoration of forest. The residential areas of these localities have functionality for the touristic process. The spatial fragmentation of the 1 km buffer zone around UNESCO sites is generated by the increasing number of tourist boarding houses and implicitly the accommodation capacity. Territorial fragmentation due to increasing number of constructions and the replacement of agricultural land and grassland with residential areas, part of which have a touristic purpose, is “supported” by a low degree of involvement of the local administration in issuing sustainable spatial planning policies. The spatial fragmentation indexes for the studied UNESCO sites are quite dynamic, and for the analysed period they highlight decreasing values of MPS (of about 0.7 ha), growth of NP (of about 500 polygons), and decreasing values of MPE (of about 300 m). Our analysis has shown the fact that throughout almost a century a diversification of land use categories (PR) in relation to an increase of NP; a high degree of diversification of land use categories is identified for Sucevita (in 2015, NP – 533 and PR – 15) and Voronet sites (in 2015, NP – 736 and PR – 17). This diversification is determined by the expanding of the touristic process (tourist boarding) by accessing European funds both for building new touristic houses and for various

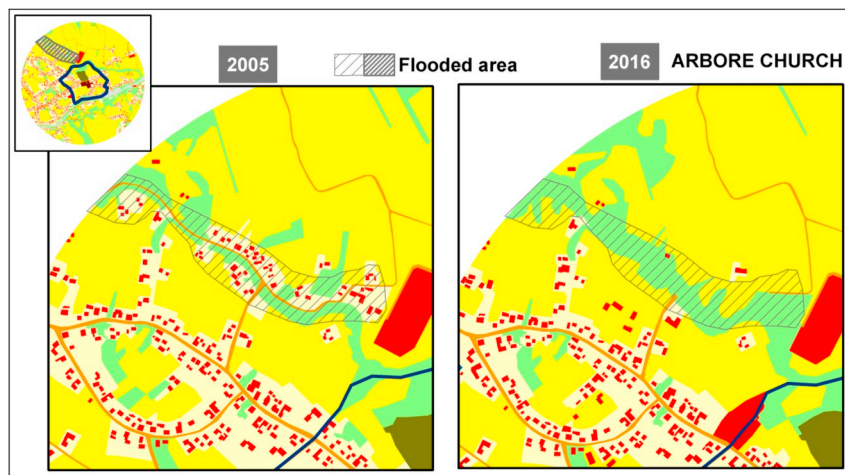


Fig. 7. Land use modifications between 2005 and 2016 in Arbore village due to floods.

hydro-technical works for river bank consolidation and stabilisation.

An analysis at the European Union level regarding the modelling of different land use scenarios (Schulp et al., 2019), has shown that the highest threat is the agricultural policies; they are followed by natural

policies and other spatial restrictions. Same threat was identified in this study. The value of the Bukovina's cultural landscape is very high, both in the account of the troubled history and the presence of the churches listed in the UNESCO WHL. It is important to know what kind of



Fig. 8. a. Voronet Monastery 3D Google Earth view, with the details highlighting the proximity of a new accommodation unit of considerable size; b. Stone thresholds built to reinforce the road; c. Heavy truck on the road to the new unit; d. Concrete thresholds in order to reinforce the slope; e, f. Specific local houses that keep the old style of this historical area.

development takes place around the UNESCO Churches of Moldavia, not only because of their global significance but also in order to check if the local authorities comply with the UNESCO regulations. Unfortunately, this is not the case of Voronet Monastery, as shown above. By studying the land-use dynamics around the Churches of Moldavia, an important fact was highlighted; the UNESCO directives are not respected, and this may have short and long-term consequences in what concerns the specificity of the place and the universal value. Both at a local and global level, more studies that use landscape metrics and land use scenarios (Shao et al., 2018) are needed, in order to track the historical changes of the landscape and to compare cultural heritage policies under different political regimes; this is one of our future directions to be investigated.

## 7. Conclusions

A diachronic analysis was performed over a timespan of approximately 100 years (1917–2016) regarding the Churches of Moldavia, UNESCO WH (World Heritage) sites, from the north-eastern part of Romania. Land use dynamics were followed using modern remote sensing techniques and the integration of spatial data in a GIS. In the buffer zone of 1 km for the eight areas of interest, it is observed that the spatial dynamics of the land use categories is governed on the one hand by natural phenomena and on the other by the anthropogenic ones. Natural phenomena are manifested by floods (Arbore, Voronet), lateral erosion (Arbore, Sucevita, and Moldovita), the variability of the water flow within the catchments, reforestation (Voronet). Anthropogenic phenomena are manifested by the land use category changes (Arbore, Probota, Patrauti) through retro-migration (urban towards rural), migration, industrialisation, household construction, tourism and the construction of the associated building (mainly in Voronet, Sucevita, Moldovita and Suceava). Landscape metrics fragmentation indicates an increase in the division of analysed sites within the 1 km buffer area. Being familiar to the land-use dynamics around UNESCO sites can improve and boost their future touristic process; moreover, it represents an important tool for local authorities and policymakers in their future management plans, attracting European funds, disaster risk management and mitigation measures, sustainable land use policies and conserving the cultural landscape's biocultural diversity. Europe's and Romania's cultural heritage represent a fragile resource and subjected to increasing urbanisation and failure of local authorities to implement UNESCO's base rules of preservation and preventive measures. Living in a world that is continuously changing, our ways of thinking and perceiving cultural heritage is in a permanent dynamic.

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## Declarations of interest

None.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.habitatint.2019.04.006>.

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## Further reading

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