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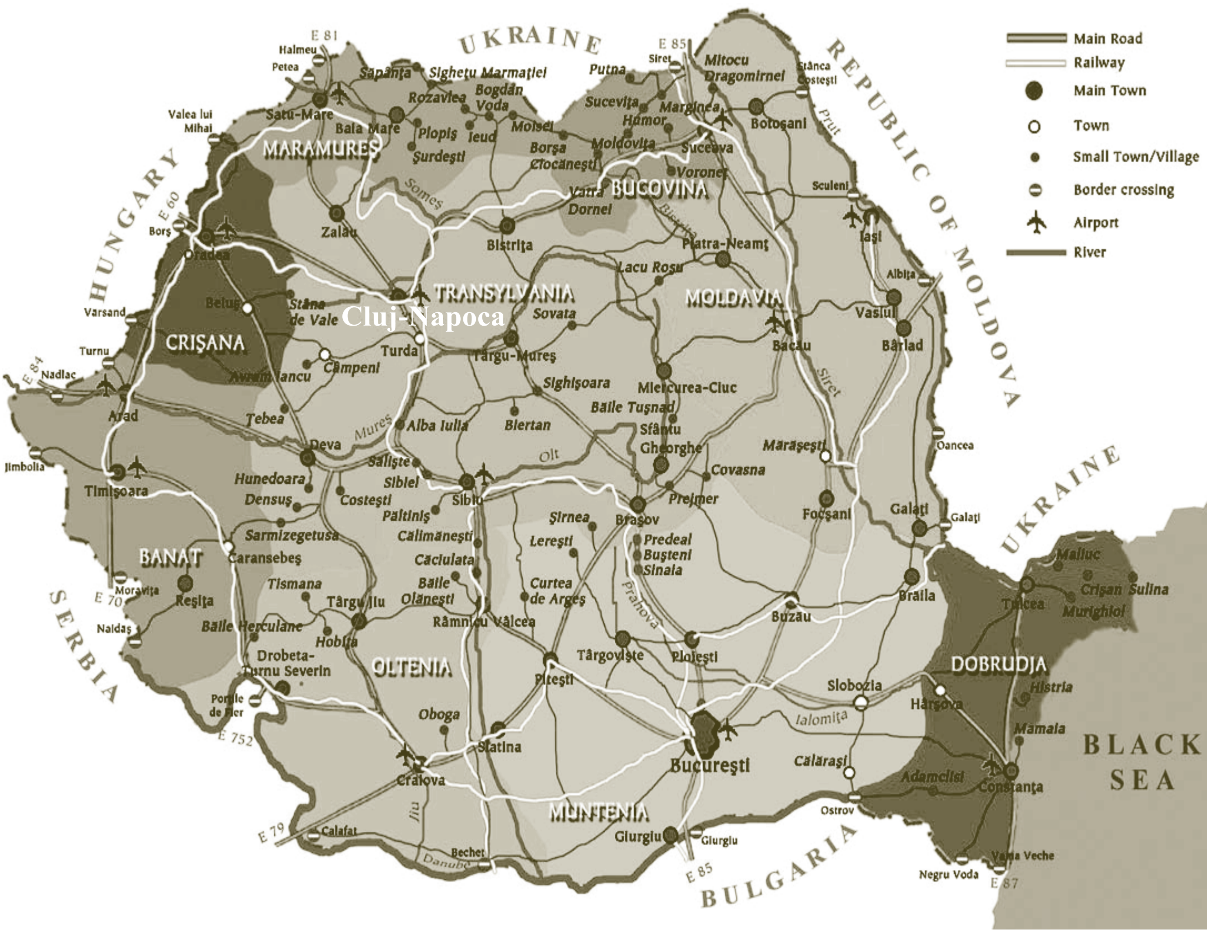

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R E V I E W

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SUBMONTANE PARAMESEȘ DEPRESSIONS IN THE STRUCTURAL CONTEXT OF THE TRANSYLVANIAN BASIN

I. A. IRIMUŞ[1], CORINA BOGDAN[1]

ABSTRACT. – Submontane Parameseș Depressions in the Structural Context of the Transylvanian Basin. The structure of the Alpine orogeny of the Silvania Mountains reveals fascinating and controversial Variscan remnants of the Hercynian orogeny. The Meseș hemi-anticline, incorporated into the alpine nappes structures of the Apusenides (Săndulescu, 1988) reflects the convulsions of the last thermo-tectonic Alpine cycle in a convergent geodynamic setting. The Meseș Mountains belong to an Alpine collisional chain of the Silvania Mountains, located in Northwestern Romania, as a wide V-shaped chain, detaching from the North Apuseni Mountains in the form of Variscan remnants.

Keywords: *hemi-anticline, mesozonal metamorphism, sedimentary basins, Neogene depressions, the Meseș Mountain.*

1. INTRODUCTION

The Meseș Mountains share a border with Ortelec Valley to the north, which separates them from Dumbrava Brebi Hill (557 m) and Someș Depression (Jibou-Ulmeni); Zalău Depression, Crasna Depression and Oșteana Piedmont to the west; Crişul Repede Valley separates them from Vlădeasa Massif and Gilău Massif to the south while the eastern border is represented by Almaș-Agrij Depression. The Meseș Mountains, as part of the Eastern Silvania Mountains, represent a hemi-anticline with the eastern flank oriented SW-NE, having a length of around 35 km and a width of 2-5 km.

The Meseș hemi-anticline separates the Șimleu Basin (as part of the Pannonian Basin) from the Transylvanian Basin (represented by its northwest sector, respectively the Almaș-Agrij Depression). The geodynamic evolution of the Meseș Mountains is linked to the Triassic back-arc basins in the South of the Meliata-Maliac domain, formed as a result of crustal shortening due to the

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opening of the Central Atlantic and to the rotation of Africa towards Europe. The roll-back processes in the Maliac-Meliata Ocean led to the opening of Vardar Ocean (Late Jurassic) and controlled the successive collision phenomena of the *arc-trench Vardar system* with the Meliata passive margin (Cavazza,W., 2004). The orogenic events *around Vardar* began in Late Jurassic and were completed in the Albian-Cenomanian through mollase-type sediments which constitute the tertiary fill of Șimleu and Transylvanian basins. The tectonic setting near the Meseș Mountains is relatively complex. East of the Meseș Mountains, the pre-collisional tectonic framework of the Transylvanides was that of *island arc* accompanied by a marginal basin subducted under the *Pre-Apulian Plate* (Nicolae et al.,1992). The Alpine orogen of the Sylvania Mountains to which the Meseș Mountains belong was formed in the Upper Cretaceous through the convergence of Tisia and Dacia microplates.

From a tectonic point of view, the Meseș Mountains belong to the Apusenides formed during the pre-Gosau tectogenesis. These are part of the Pre-Apulian or Tisia Block and represent nappes with north-northeast vergence from "Precambrian and Paleozoic" metamorphic rocks (granite rocks at local level) and their sedimentary cover. The oldest cooling ages indicate that during middle Cretaceous the location of the nappes was accompanied by a strong exhumation, which removed the configuration of the last Cretaceous sedimentary cycles (Dallmeyer et al., 1999; Sanders, 1999). The collision culminated during Middle Cretaceous (Săndulescu, 1988; Balintoni, 1994), but the local shortening would have continued at local level by the Cenomanian–Coniacian. Schuller (2004) interpreted these phenomena as a *hard collision* (lifting) during the early Cretaceous, followed by a *soft* Cretaceous collision during the late Cretaceous between the Tisia and Dacia microplates, as the subduction ceased and the local subsidence installed. The final suture probably took place during the Paleogene (Mațenco et al., 2005) and has been associated with an inversion at a smaller scale of the basin (De Broucker et al, 1998; Ciulavu et al., 2000). The last Cretaceous extension is linked to the post-orogenic collapse of the Cretaceous orogen (Sanders 1999;Ciulavu et al, 2000). The final location of *Pienidic nappes* induced flexures in the formation of the Transylvanian Basin.

The regional oligocenous compression in the eastern part of the Meseș Mountains may be linked to the beginning of the final closure of the Pienidic domain (Györfi et al, 1999). The northern Transylvanian Basin was affected by these flexures, indicated by a general thickening to the North of the oligocenous deposits (Săndulescu and Micu, 1989; Aroldi 2001), context in which the Transylvanian Basin was considered a reverse-rotation suction basin (Balintoni, 2003) and the basins on the eastern border of Meseș Mountains (the Almaș, Agrij Parameş basins) are *transformation and transcurrency sedimentary basins* located on continental crust.

Fig. 1. Ciumărna, Treznea and Stâna Depressions within the eastern part of the Meseș Mountains (source: the author)

The Meseș continental transform fault presents inflexions that can be relaxing curves (transtensive) and contracting (transpresive). The middle area of the Almaș-Agrij basin corresponds to a transversal inflexion on Meseș, which favoured the triggering of intense erosion processes especially in the upper basin of Agrij and Almaş. The western part of the Meseș Mountains belongs to the Pannonian Basin, respectively to one of its bays, the "Şimleu Basin", which was formed as a result of Badenian extensions of the Tisia Block. The system of "extensional-transtensional" Neogene depressions is associated with this bay. The North Transylvanian, Bogdan Vodă and Meseș faults control the tectonic evolution of the Transylvanian Depression (Almaș-Agrij Basin). In this respect, the elevation areas, in our case the Meseș hemi-anticline and descent areas (Agrij-Almaș Basin) are controlled by these faults. The first two faults belong to the category of left-lateral *strike slip* faults. Along the North Transylvanian fault, *strike-slip* tectonic movements took place on the basis of a transpresive tectonic regime that caused the strain of crystalline blocks and of sedimentary deposits within the Cenozoic cover of Meseș Mountains. They were generated on the peneplenized area of the Hercynian structures and took birth through their partial regeneration (Mutihac, V.,1990), reality confirmed by the presence of these Variscan remnants in Alpine nappe structures. The Meseş fault is a reverse fault, characterizing the eastern versant of the Meseș Mountains, from South of the Vlădeasa area, Crişul Repede Valley to the Moigrad fault area. It has a SW-NE direction and represents a longitudinal fracture towards the Meseş crystalline with a throw of 500 m as suggested by Clichici (1973). The eruptive rocks in the Vlădeasa area have a tectonic position, covering the Paleogene deposits from the Transylvanian Depression. It is a curved fault, an overthrust fault at surface and a gravity fault in depth, giving an asymmetrical aspect to the Meseş crystalline.

The evolution of the Meseș sedimentation area has been linked to the Permian-Mesozoic rifting and extensions which led to the individualization of the Pre-Apulian craton or Tisia. During the Mesozoic Era, it functioned as a *carbonate platform basin*. Between Upper Eocene and Lower Oligocene, major changes took place, induced by the pre-Pyrenean tectogenesis that led to the formation of thrust and fold systems as well as to a redistribution of emersed areas from the Meseș Mountains. The geological framework of the Meseș Mountains is given by the border formations and its basement. The basement is represented by the Bihor Autochthonous, characterized by the two crystalline series, *Someș and Arada*, and a sedimentary suite (*Permian, Triassic, Cretaceous*), divided into uplifts and grabens, as a result of diastrophisms, which took place from the Cretaceous until the Pliocene and which affected both the crystalline basement and sedimentary cover according to Clichici (1973). The Codru thrust line, the "main element subject to deformation processes" of meso-Cretaceous movements, was preceded by "a complicated system of faults", as noticed within The Meseș Mountains, that, in some sectors, gives a "clear ruptural character" and implicitly, the shear nappe character, to the tectonic relations between nappe and Autochthonous. As regards the post-tectonic cover, after the meso-Cretaceous folding, respectively the thrust of Codru nappe, the North Apuseni Mountains functioned as a more rigid unit, because the upper Cretaceous deposits have a distinctive facies and appear both on the Codru unit and on the Bihor Autochthonous, covering the main thrust and leading to the post-tectonic cover character of the respective deposits, predominantly detrital, being developed in Gosau-type facies. The Cretaceous evolution of the Apuseni Mountains and especially of the Meseș Mountains took place within Gosau-type basins. In the Meseș Mountains, as previously mentioned, shallow marine sediments laid down, the sedimentation processes started during the Turonian and ended during the Cretaceous. The "Gosau-type" sea entered in the form of large bays, one of them in the Șimleu Depression, separating the Preluca crystalline from that of the Prisaca, the latter, together with the Codru, Hăghișa, Măgura Șimleului and Plopiș crystalline, being during those days a large island with some bays, the Gilău-Preluca island, where both the detrital deposits of the shore area and the organogenic deposits were sedimented (Clichici, 1973). At the level of the Gilău sedimentation area, the pre-Pyrenean tectogenesis led to the emersion of large areas in north-western Transylvania which correspond to the Valea Nadăşului and Turbuţa formations specific to the Meseș Mountains. At local level, the invasive tendencies of the marine domain during the Priabonian are important, with the initial installation of evaporitic facies (the Foidaş Formation), followed by an extended carbonate platform (the Cluj Limestone Formation) which gradually passed to a basinal domain (the Brebi Formation, where is also the Eocene-Oligocene boundary). What we have to highlight is the advanced continentalization we can notice at the level of Moigrad Formation, dominated by red bed deposits. This continentalization, consisting of the installation of some fluvial system deposits in the sedimentation area of Gilău and Moigrad, continued during the Rupelian. The Moigrad Formation is characterized by the predominance of *red beds deposits* in fluviatile facies (Fărcaș, 2011). In other words, this marine-salmastrian alternation expresses nothing but the instability of the basins which developed having as basement the Apuseni orogen.

2. METHODOLOGY

The cartographic method (geological-morphological) and GIS analysis (Irimuș, I.A., 2005) allowed us to realize the geomorphologic and geologic profiles through which we underlined three subdivisions: The Meseș hemi-anticline alignment, separating the Pannonian Basin and the Transylvanian Basin within the Austroalpine system, intra-Meseș sedimentation area, the contact depressions from the external frame of the Meseș Mountains, a reflex of the integration of the internal and external geodynamics.

3. THE CONTACT DEPRESSIONS FROM THE EXTERNAL FRAME OF THE MESEŞ MOUNTAINS

The genesis of the Parameseş depressions, as contact depressions, from the external frame of the Meseş Mountains, is related to the Meseş fault, also known as Meseş overthrust line (the Paleogene strata are overthrown and overlapped by crystalline) the fault being active especially during the Miocene.

This overthrust occurred along with the Neo-Styrian paroxysm through the underthrusting of the Transylvanian Depression, which led to the folding of the Paleogene deposits from the proximity of the overthrust line. The Meseş Fault is a main overthurst fault, accompanied by numerous perpendicular or parallel secondary faults that affect the sedimentary deposits and the crystalline structures, under the form of a *transverse fractures system* oriented WSW - ENE to E - W, due to some displacements from west to east, with maximal intensity during the Badenian.

The morphodynamics in the Parameseş sedimentary area is characterized by piedmont glacis, by the piedmonts generated on the fault coasts and last but not least by the contact depressions (Irimuș, I.A., 2010) detached by fluvial erosion by the tributaries of Agrij and Almaș, a series of small depression basins, built-up of some old human settlements, with silvo-pastoral traits: Hodiș, Huta, Sângeorgiu de Meseș, Bogdana, Buciumi, Bodia, Bozna, Treznea, Ciumărna, Stâna. Towards east, these erosive contact depressions are confined by the Almaș-Agrij Basin, made of upper Oligocene - Aquitanian deposits. The Almaş Basin is considered a paralic basin, the coals being formed in a lagoonal environment with excess humidity.

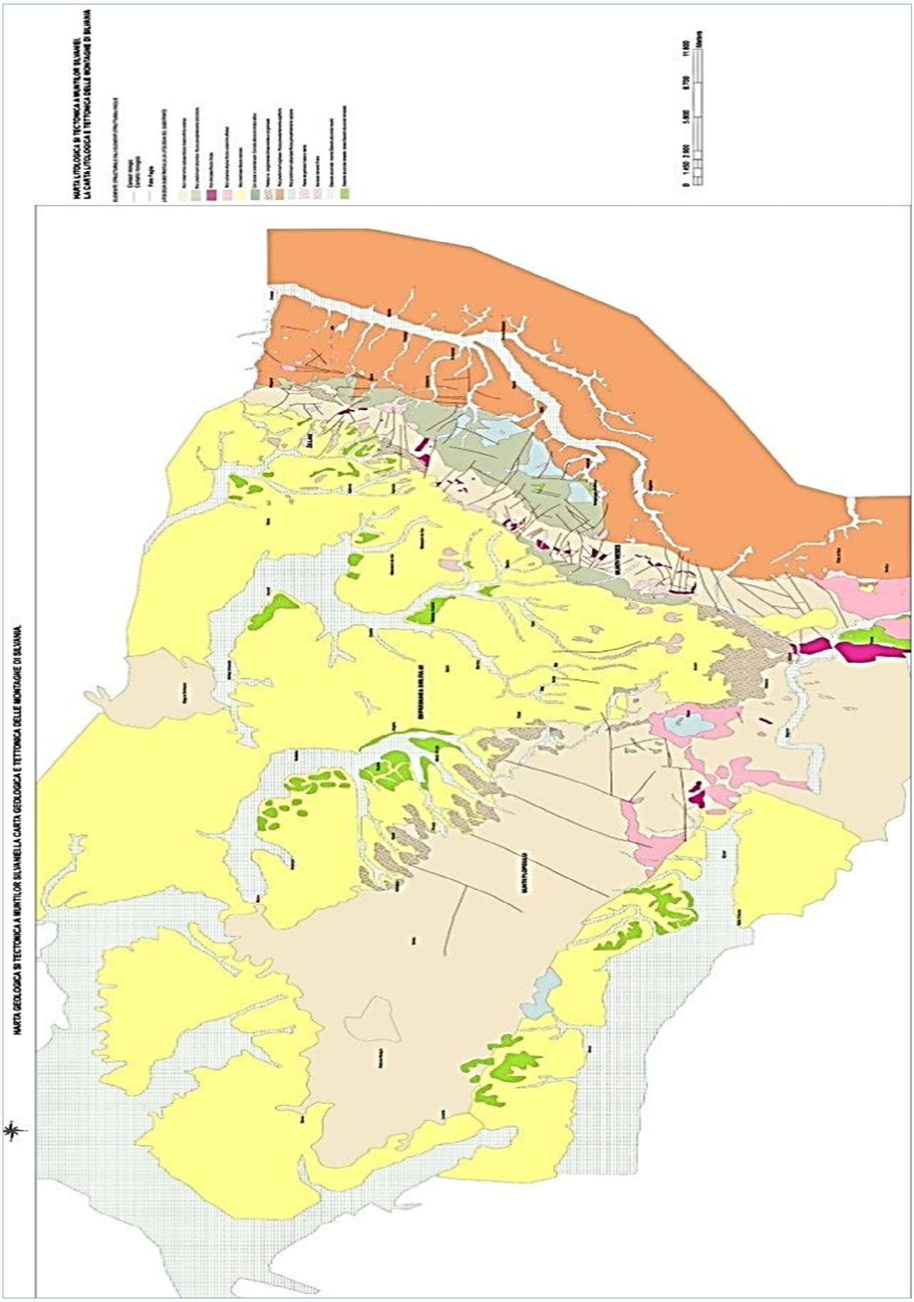

Fig. 2. The geological map of the Silvania Mountains, its legend and that of the geomorphological maps (source: the author)


HARTA GEOMORFOLOGICA A MUNTILOR SILVANIEI.
LA CARTA GEOMORFOLOGICA DELLE MONTAGNE DI SILVANIA.
AUTOR : CORINA BOGDAN.
I.ELEMENTE GEOLOGICE SI STRUCTURALE.
ELEMENTI GEOLOGICI E STRUTTURALI.
(I). 1.LITOLOGIA SUBSTRATULUI.
LITOLOGIA DEL SUBSTRATO.
Roci metamorfice sistoase.Rocce metamorfiche scistose.
Seria de Meses (Paleozoic Inferior- Precambrian).
Seria de Somes (Precambrian Superior).
Roci vulcanice efuzive.Rocce vulcaniche effusive.
Magmatite neogene-dacite si andezite.
Magmatite Senonian-Paleocene (dacite).
Roci silicioase.Rocce Silicee.
Camplian Inferior-Werfenian (gresii silicioase).
Roci predominant calcaroase.Rocce prevalentemente calcaree.
Priabonian.
Roci predominant dolomitice. Rocce prevalentemente dolomitiche.
Priabonian.
Roci predominant argiloase .Rocce prevalentemente argillitiche.
Oligocen-Miocen Inferior, Stratele de Moigrad (Chattian-Rupelian).
Roci marnoase.Rocce marnose.
Pannonian (Malvensian),Lutetian.Badenian.Sarmatian.Miocen.
Pietrisuri si conglomerate.Ghiaie sciolte e conglomerati.
Pleistocen Inferior.
Contact litologic.Contatto litlogico.
(I). 2.ELEMENTE TECTONICE.ELEMENTI TETTONICI.
Falie. Faglia
II.FORME STRUCTURALE SI VULCANICE.
FORME STRUTTURALI E VULCANICHE.
(II). 1. FORME STRUCTURALE. FORME STRUTTURALI.
Fronturi de cuesta. Orlo di cuesta.
Front de suprafata structurala. Orlo di scarpata strutturale.
Inseuare.Sella.
(II). 2.FORME VULCANICE. FORME VULCANICHE.
Neck vulcanic.Neck vulcanico.
Con polifazic. Cono poligenico.
Dyke. Dicco.
III. FORME, PROCESE SI DEPOZITE DE VERSANT
DATORATE GRAVITATIEI.
FORME, PROCESSI E DEPOSITI DI VERSANTE
DOVUTI ALLA GRAVITA.
(III). 1.FORME DE EROZIUNE.
FORME DI EROSIONE.
Alunecari de teren.Frane.
Fenomene de creep. Fenomeni di creep.
Suprafete cu forme de curgere concentrata
(ravene si torenti).Superficie con forme di dilavamento
concentrato (ravene e torenti).
(III).2.FORME DE ACUMULARE.
FORME DI DEPOSITO.
Con detritic activ. Cono detrittico attivo.
Con detritic inactiv. Cono detrittico inattivo.
Depozite eluviale.Depositi eluviali.
IV.FORME SI DEPOZITE FLUVIALE DE VERSANT
DATORATE SCURGERII.
FORME E DEPOSITI FLUVIALI DI VERSANTE
DOVUTI AL DILAVAMENTO.
(IV).1. FORME DE EROZIUNE.
FORME DI EROSIONE.
Curs de apa permanent.
Traccia di corso di acqua estinto.
Vai fluviale de tip V. Vallecola a V.
Vai cu fund concav.
Vallecola a fondo concavo.
Front de terasa aluvionala.
Orlo di terazzo alluvionale.
Suprafete cu forme de curgere difuze.
Superficie con forme di dilavamento diffuso.
(IV).2. FORME DE ACUMULARE.
FORME DI DEPOSITO.
Depozite aluvionale recente.Depositi alluvionali recenti.
Holocen.
Depozite aluvionale terasate, terase.Depositi alluvionali terrazzati.
Pleistocen.
Depozite coluviale. Depositi colluviali.
Cuaternar.
Curgeri noroioase. Depositi di debris flow.
Con aluvial si torential activ. Conoide alluvio torrentizio attivo.
Con aluvial si torential inactiv. Conoide alluvio-torrentizioinattivo.
V.FORME SI DEPOZITE DE ORIGINE CARSTICA
(V).1. FORME DE EROZIUNE.
FORME DI EROSIONE.
Dolina cartografiabila. Dolina.
VI.FORME SI DEPOZITE DE ORIGINE PERIGLACIARA.
FORME E DEPOSITI DI ORIGINE PERIGLACIALE.
Panza de grohotis.Falda di detrito.
VII. FORME RELICTE, SUPRAFETE DE NIVELARE
SI FORME ASOCIATE CU O GENEZA COMPLEXA.
FORME RELITTE, SUPERFICI DI SPIANAMENTO
E FORME ASSOCIATE TALORA
DI GENESI COMPLESSA.
Suprafata de nivelare I Pria - Merisor(800-1000m).
La superficie di spianamento Pria- Merisor (800- 1000m).
Suprafata de nivelare II Talhareasa -Secatura (650-750m).
La superficie di spianamento II,Secatura- Talhareasa(650- 750m).
Martori de eroziune.Testimoni di erosione
VIII.FORME, DEPOZITE SI ACTIVITATI ANTROPICE.
FORME , DEPOSITI E ATTIVITA ANTROPICHE.
Mina, galerii de excavare antropica.
Cava, imbocco di galleria di scavo antropico.
Suprafete de excavare antropica.
Superficie di sbancamento.

3.1. The Hodiş Depression is situated east of the southern Meseş, in the sector of Grebeni - Coastei – Carelor peaks, being the result of the erosion of the rivers Hodișu (tributary of Crişul Repede) and Valea Peșterii (right tributary of Almaş) in the Oligocene structures of the Zimbor strata, mainly shaly, and the lower and upper Ticu strata. Towards west, the contact with the upper Senonian and Paleogene magmatites (Dacites) of the Meseş Mountains is made through the Meseş Fault and some secondary reverse faults. The Hodiş Basin is entirely overlapped to the mainly shaly Zimbor strata. In the Zimbor (Chattian) formation, there are coal strata. As the clay is less resistant to erosion, it determined a convergent drainage network which submitted the landscape to a strong hydrographic fragmentation, leading to hilly ridges (Rengheț Hill, Fârțe Peak, Prislopului Hill), where we can find erosion witnesses. The erosion processes were favoured by the presence of fault fronts, which, at the contact with the volcanic structures from Meseş, formed detached detritus. The clay landscape in the Hodiş Depression is characterized by pseudo-solifluxional processes and landslides, north of Valea Peşterii. These processes determined a progressive decrease of slopes and the presence of rounded forms. At the base of the main valleys' slopes or in the areas of inter-flow with the main reservoirs (Agrij, Almaș), there are numerous debris cones. The morphology of Poicu Valley and Ragu Valley draws the attention through the presence of the thalweg on a fault line and through the asymmetric transverse profile, as a result of the selective erosion. The formation of these valleys was favored by the tectonic displacements, which determined a process of mechanical fragmentation of the rock, according to the fault planes.

3.2. The Huta-Bogdana Depression is located in the area of Huta and Bogdana origin basins tributaries of Agrij Valley, under Măgura Priei (996 m). They are entirely on the Oligocene structures of the *lower Zimbor strata,* being confined by fault compartments. At the contact between the red clay characteristic of the Zimbor strata and the crystalline schists of *Meseș Series*, stands a strip of Priabonian limestones confined by reverse and strike-slip faults. Within these depressions, we can notice Brătinesei Hill (552 m), Albului Hill, Jurchii Hill (529 m), Gropii Hill (511 m) south of Agrijului Valley and Porcărețului Hill, Cucului Hill, Gorunel Peak (513 m) north of it. The general morphology is sustained by the mass displacement processes: landslides, mudflows (Porcărețului Hill) and rolling processes in the detritus nappes. The fluvial shaping of the landscape falls on Agrij Valley, which springs from the south-eastern slope of Măgura Priei (996 m). The mountain sector of the valley is narrow, with a high profile in "V", widening only downstream of the Bogdana village, from where the flow is parallel with Almaş Valley (Rus, M.I., Irimuș, I.A., 1992). Its left tributaries converge towards the spot of Românași (Sângeorgiu, Izvorul, Pârâul Pe Vale, Treznea, Ciumărna, Chichișa, Prunetului Valley, Lunca

Brazilor Valley, Ortelec), being situated in *the rain shadow* of Meseş, which mirrors in the flow regime and fluctuations. The landslides in the proximity of Gorunel Peak, the pseudo-solifluxional processes, the creep and the torrential regime of the versant and riverbed drainage lead to risk phenomena in these origin basins. The accumulation forms are the active alluvial-fans from the Agrij Valley, the colluvium at the base of the morphodinamically unstable slopes and the numerous Quaternary eluvial deposits on the interfluves.

3.3. The Sângeorgiu de Meseș Depression spreads east of the central compartment of Meseş (Meseșul Central - Poiana Tâlhăresa and Gorunul Păstăești), being confined by the Sângeorgiu valley at south and Valea Izvodul at north. The basin is formed of post-tectonic covers of the Occidental Dacides (Apusenides), respectively of the Paleogene epicontinental formations. The basin is filled with highly faulted Priabonian strata (Brebi Marls, Cluj Limestone, Turbuța Strata and Hoia Strata) and Lutetian strata (Mortănușa Marls, Căpuș Strata and Jibou Strata). In the immediate proximity of the Meseş Mountains, under the local subsidence of Jibou, the rivers Agrij and Almaş submitted to strong erosion the post-tectonic cover of the Apusenides. Thus, a strip of Priabonian limestones (mainly limestone, dolomite and marlstone), sloped south-east, under the form of a 200-400 m uneven step above the crystalline, but tightly linked to it, through a strong tectonic and morphologic contact, was detached through daily erosion. Through regressive erosion, the stream flow of the Sângeorgiu and Izvodul valleys detach important stretches of the fault front which remain islanded in the geomorphologic landscape as outliers, extremely numerous in the general morphology. North of Gorunel Peak (513 m), the Moigrad strata are inconsistent above the lower Zimbor strata, the contact between them being marked through a structural surface. The landscape is mainly structural, namely structural surfaces maintained by limestone and dolomite (suggestive is the one of Gorunul Păstăești, Panului Hill, Păltiniș, 687 m), which spreads west - east. We can see remnants of the old piedmont surfaces under the form of the outliers, inconsistent over the sedimentary formations: Leardora (550 m), Pietri Hill, Pietriș Hill (456 m), Dumbrava (473 m). The tectonic complexity becomes more prominent towards north, where we can find Ragului Valley, developed as a result of the selective erosion on strike-slip faults which cross-cut a consistent stratum of plaster and Priabonian dolomicrite, deposing active clastic cones and colluvial deposits. Towards the mountain frame, at the contact between the crystalline schists of the Someş series and the Brebi marl, there are landslides, and east of Prislop Hill there are detritus nappes which materialize the lithological contact between the crystalline (metamorphic rock) and clay (sedimentary rocks), the latter being poorly cohesive rocks prone to physical and chemical disintegration. The accumulation forms in the Păltiniș Hill (687 m) are large colluvial deposits, while the erosion processes are the flows and creep processes.

3.4. Buciumi Depression spreads north of Izvodul Valley. Lupuleţului Valley detaches north-west structural outliers, a proof of the past large piedmont covers: Flămând Hill (424 m) towards south, Măgura Buciumi (590 m) and Ursului Hill (540 m), the last one north of Valea Ragului, towards west. In this sector the strata present a normal polarity, as a result of the formation of the area of plaster, (Priabonian) dolomite and marl, marlstone, respectively the *Strata with Numulites Perforatus*. The main characteristic of this sector's structural landscape (on dolomite deposits) is the presence of structural areas and a horizontal fragmentation which affects the entire eastern slope of the Meseş, generating the erosion basins. These structural attributes are completed by a diversified lithology, given by the presence of marl, loamy horizons subject to linear and areal erosion.

The anticlinal structure (the anticline Ursu-Căţelu, with the axis oriented SW - NE, from Ursului Hill to N-W of Căţelului Hill), sustained by Priabonian - Lutetian marl, marlstone, plaster and dolomite, was submitted to dismantling through erosion. This resulted in erosion basins, confined by fault lines (the cross-cut profile SW - NE in the sector Ciucea – Buciumi, fig 3). As for the sector Sîngeorgiu de Meseș - Stâna - Moigrad, the transition from marine to continental is made gradually, in a continuous succession which does not imply sedimentation lacunae (Fărcaș, 2011). The sedimentation lacunae are present on a limited area. The continental formations - Valea Nadăşului, Turbuţa, Moigrad alternate with marine or marine-salmastrian formations. The upper Eocene (Priabonian) continental sequence has a base structure according to the sedimentation area, respectively the carbonate platform of the Viștea limestone Formation (in the areas of Gilău and partially Meseş) or the siliciclastic rocks of the Rakoczy Sandstone Formation (the areas of Meseș and especially Preluca).

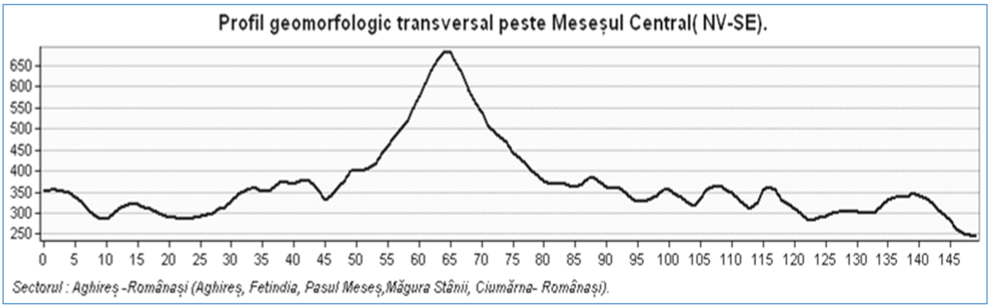

Fig. 3. Transversal geomorphological profile across the Meseș Mountains

At the base, on a reduced area in Gilău and Preluca, but extended in Meseş, we can find the anhydrites of the Jebuc Formation, which include paralic coaly deposits. Consequently, these determine the Priabonian age for the upper Eocene continental sequence from Transylvania. Turbuţa Formation (Lower Priabonian) is the lateral correspondent of Valea Nadăşului Formation, being similar to it, as a result of the depositional environments in which they formed. Both are deposits of flood plains, except that Turbuţa has a more flooded aspect (Fărcaş, 2011).

3.5. Bodia Depression spreads asymmetrically, on the right side of the creek Pe Vale, under the Obârșia peak (868 m). The basin is filled with Oligocene deposits (the Zimbor strata - the horizon of red clay and the Moigrad strata) and Priabonian deposits (Brebi Marl, Cluj limestone, plaster, dolomite, marl, marlstone and sandstone - the *Strata with Numulites Perforatus*). The general morphology detaches Măgura Bodiei (625 m) and Cățelului Hill (621 m) as imposing limy promontories, sustained by the Cluj limestone and detached through transverse faults. The processes of linear erosion (the formation of gullies) and areal erosion (landslides, pseudo-solifluxion) generated colluvial and proluvio-colluvial deposits, which dims the contact with the depressionnary area through a series of anthropically exploited glacises (Vâtca, A.M., Irimuș, I.A., Roșca, S., 2014).

3.6. Bozna Depression, north of Bodia Depression, between the Pe Vale creek at south and Treznea at north, on sedimentary deposits, is similar to Bodia (Oligocene and Priabonian deposits), except that Brebi Marl is better represented here and is strongly faulted, thus, we can find transversal, longitudinal and strike-slip faults. In the general geomorphology, Măgura Bozna (635 m), Corbului Hill (479 m) and Făgetului Hill stand out.

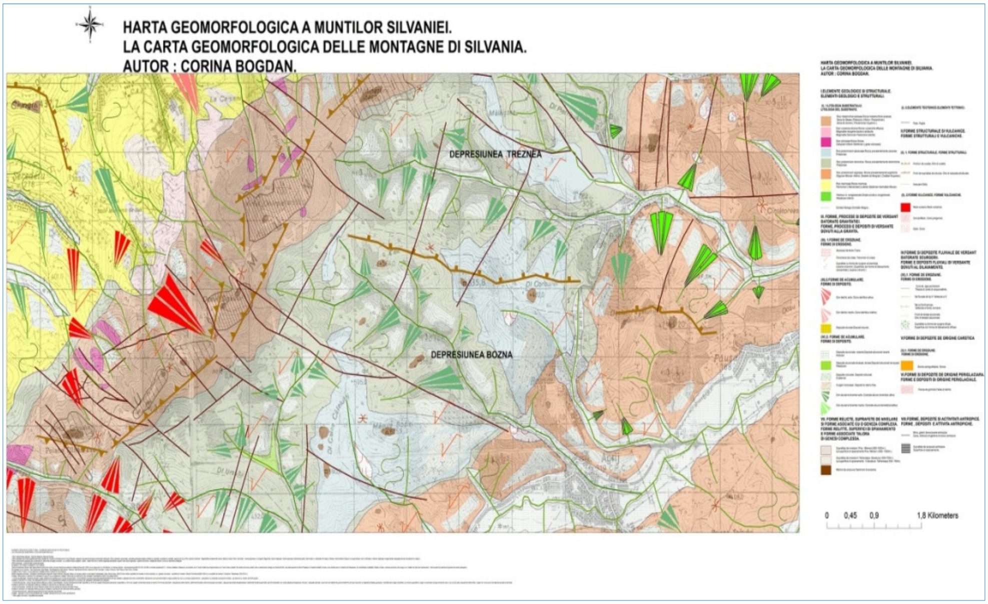

Fig. 4. Bozna and Treznea Depressions, geomorphological map (source: the author)

The first two are maintained by structural surfaces with structural outliers on the marlstone with Numulites Perforatus. Along Pârâul Pe Vale and Treznea we can see active alluvial fans, landslides in Corbului Hill and colluvial deposits affected by scattered flow phenomena.

3.7. Treznea Depression spreads north of Bozna Depression to Valea Ciumărna, being situated east of Mânăstirii Hill (658 m). The geological conditions of formation are the faults' systems and the lithological constitution, respectively the large development of *Cluj Limestone* and *Brebi Marl* (significantly extended, and proves the unstable character of the sedimentation conditions of the Paratethys, at the level of the sedimentation area of Gilău), the Oligocene Creaca (limy sandstones) and Curtuiuş (marl, clay) Beds. The general geomorphological landscape is dominated by fluviodenudational processes, marked by the interfluves Mălăiștea Hill (459 m), Pietrișului Hill (424 m), Dosu Crucii Hill (436 m) and La Măgură Hill (420 m). They are confined by vertical and sub-vertical faults which enabled a strong fracturing of the *Cluj limestone*, over which is disposed the *Brebi marl*. On the slopes, we can find colluvial deposits. Treznea Valley led to active alluvial fans. North of Treznea we can observe the presence of nest-like landslides, favored by the mostly loamy lithology of *Moigrad strata. Treznea fossiliferous point* coincides with the short episode of the formation of a freshwater marsh (Fărcaș, 2011).

3.8. Ciumărna Depression spreads between the valleys of Ciumărna, at south, respectively Chichișa, at north. The basin's fill is relatively similar to that of Treznea basin, except that, here, the *Curtuiuș and Moigrad Oligocene strata* are better represented, with a marly-loamy lithology. The lithology and strong faulting of deposits enabled a depressionary basin. The Meseş Mountains' slopes present large detritus nappes. La Arini Hill (416 m) and Țifla Peak (478 m) stand out in the general morphology, Țifla Peak being a structural outlier incorporated into a structural area maintained by the limy sandstones of the *Creaca strata.* The sandstones horizon is more conspicuous for the landscape, with headland caps and structural outliers. West of Țifla Peak (478 m), on Ciumărna Valley, an obvious anticline stands out, with adjacent slopes affected by linear erosion processes (rills, gullies) and areal erosion (landslides). Along its tributaries, we can also find numerous inactive alluvial fans.

3.9. Stâna Depression spreads north of Ciumărna Depression and east of Măgura Stânii (716 m) on Chichișa Valley.

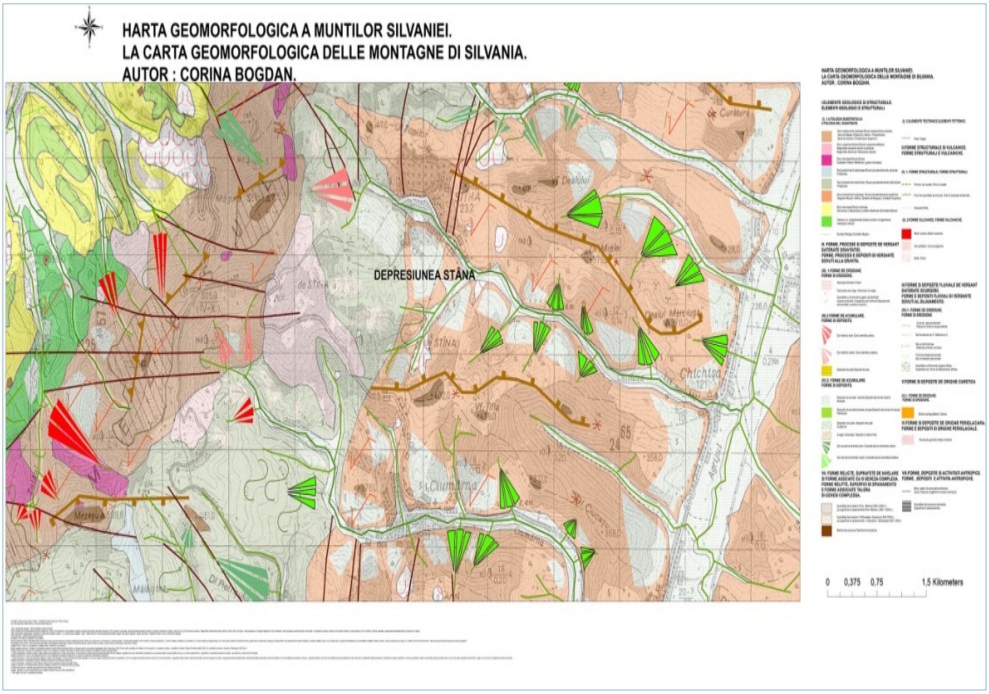

Fig. 5. Stâna Depression, geomorphological map (source: the author)

The fill of the basin is different from the others' fill. *The Cluj Limestone* is intensely folded and Brebi marls cover it as discontinuous and discordant strips. *The Turbuța Strata* and the plaster horizon are well represented in comparison with the other basins. From West to East, the Piatra Albă Hill, Topilor Hill (441 m), Pleșița (380 m), Vârful Dealului (414 m) detach from a morphological point of view as structural witnesses. The Chechișa Valley versants receive colluvial deposits and its tributaries laid down alluvial fans, at present inactive, to which is added the insular presence of the landslides on the structural fronts from the Topilor Hill (470 m) and Vârfului Dealului (414 m). At the base of the crystalline coast, detritus fields (the land of the Stâna locality) were accumulated, transformed by the torrential erosion. The sequence of Eocene deposits, where the platers (Stâna) are interbedded, indicate the gradual retreat of marine waters, and the result was the uplift of a littoral piedmontan platform, covered by the formations of the Romanian accumulation piedmont.

4. CONCLUSIONS

The submontane depressions on the external border of Meseș Mountains, due to the complexity of the geological and tectonic context in which they evolved, offer a wide range of natural resources belonging to the tertiary deposits: limestone, sandstone, dacitic tuffs, clays, clays, marble, sands and coal. Some of these resources, as the caolinic sand (Jac, Var), siliceous sand (Jac, Creaca), quartz sand (Var), kaolin (Ruginoasa), river aggregates (Almaşu, Românaşi), Eocene plasters (Stâna și Jibou), crystalline and eruptive rocks (andesites exploited at Moigrad) with important reserves, can be a solid base for the argumentation of regional recovery programs and the reduction of unemployment rate in Sălaj. The geomorphological subdivision of these depressions was made in the context of the Morpho-climatic Miocene-Pleocene and Quaternary matrix, which is reflected by the pedogenetic profile of these depressions. The soil resources (cambosoils, luvosoils and preluvosoils), affected by numerous processes of degradation (geomorphological, water, anthropic), which determines whether the loss of the (rich) soil horizon from the surface, the deformation of the terrain, the sedimentation and clogging, the compaction, the salinization; the acidification or pollution. The soil erosion remains the most important degradation factor, having serious consequences for agriculture, by withdrawing from the agricultural circuit some areas of land. In terms of landscape, all these depressions from the external frame of the Meseș Mountains are suitable for recreational activities.

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FACTORS AFFECTING LAND USE CHANGE AND ITS IMPACTS IN THE EASTERN HILLS OF NEPAL

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ABSTRACT. – Factors Affecting Land Use Change and Its Impacts in the Eastern Hills of Nepal. The objective of this paper is to explore factors causing change in land use and land cover categories in the Eastern Hills of Nepal's during the past 24 years between 1986 and 2010. The paper draws data and information from three different map sources —land resource mapping project 1986, toposheet 1996 and Landsat imagery 2010. In addition, the mapping data being generated were verified in the field through using observation, reality check approach and consultation workshops held at different places in the Eastern Hills of Nepal. The study area comprises four contagious hill districts such as Bhojpur, Dhankuta, Sankhuwasabha, and Terhathum.

A significant change has occurred particularly in two major categories of land use and land cover in the Eastern Hills of Nepal over the past two and half decades. While forest land increased consistently over the past 24 years, cultivated land area increased during the years 1986-1996 but decreased between 1996 and 2010. In agriculture, patches of abandoned agricultural land have also been observed in areas away from road facility in the recent years due to out-migration of youths. Intensification of agriculture practice was found along and around roads, wherein traditional subsistence cereals crops have been replaced with commercial vegetables and high value crops such as large cardamom, ginger, seeds and fruits.

Three major factors comprising community forestry program, construction of roads, and introduction of improved agriculture development programs have contributed to internal trading between major land use and land cover categories. Further, these changes have offered benefits like nature conservation, internal and international trade of local products, and better living conditions of local communities. These development efforts should be kept in mind for policy measures in regard to conservation and development management of land use and land cover categories in other areas of Nepal.

Keywords: *land use change, Eastern Hills, Nepal, arable land, forest land, GIS.*

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INTRODUCTION

Land is a crucial natural resource in Nepal, where agriculture is the main economic base. However, Nepal is facing a major challenge with improper use of land resource. There is lacking of land use plan and acts in Nepal and as a result, no land use is being practiced to provide a vision for land based sustainable development, as well as to regulate land uses in an efficient way, thus to prevent land use conflicts and safeguard other natural resources in the country (FAO, 1993).

Investment in development projects has been increasing over time across Nepal, causing change in land use and land cover. In this regard, there is urgency of an integrated land use planning as a tool that combines interactive relations between the development activities and use of land resource. In 2002, National Land Use Project was set up and since then, efforts have been continued through research projects to generate databases necessary to the land use planning in Nepal. Only in 2013, the Government of Nepal promulgated National Land Use Policy.

Land use often changes due to human interventions and natural causes. Current land use patterns in any area are the result of human activities over the years, but they are strongly influenced by natural conditions. The heterogeneous landscapes with mosaic of arable land, patches of natural vegetation, grassland, agro-biodiversity, built-ups and others reflect the diverse land uses in the area. Lourenco et al. (1997) have found that external factors such as agricultural and forest conservation policies, transport development, hydro dam works, etc. are driving forces behind frequently changing in the use of land in rural areas. Axinn and Ghimire (2011) have found in their studies that social, economic, and demographic changes affect land use patterns over time.

Land use studies generally concern with the spatial and temporal patterns of land conversion at different geographic scales by human activities and understanding the causes and consequences of these changes. They also deal with explaining the economic process, viz. human behavioral component that underlies land use change, i.e. causal relationships between individual choices and land use change outcomes (Axinn and Ghimire, 2011). As human systems of production change, be they shifting cultivation, subsistence agriculture, or commercial production, patterns of consuming land change and these changes alter the use of the land and the nature of the resulting land cover. According to Gautam et al. (2002), Virgo and Subba (1994), Thapa (1996), Jackson et al. (1998), land use in an area represents an insightful reflection of human interaction with its environment and development interventions such as infrastructure, introduction of new technologies, changes to policies, etc. are likely to change in land use and socioeconomic development in response to these drivers of change. Provisions of schools, health services, markets, and transportation services may all change social life in consumption patterns of land. These changes in patterns of consuming land are likely to have important consequences for local land use and land cover.

Land use is a fundamental measure of how the environment is organized in a setting. Changes in land use are reflected in the relative magnitude of the land area being devoted to agricultural and non-agricultural activities. Over time, as the population changes, as the economy grows, and as the government infrastructure spreads, land use is likely to be transformed in many ways, for instance, the conversion of agricultural land to land for housing and other non-agricultural enterprises, the reduction of public forest and grazing lands, and the intensification of farm land.

This paper intends to explore factors responsible behind changing in land use and land cover and their impacts in the Eastern Hills of Nepal.

1. Data Sources and Methods of Analysis

1.1 Land use definitions and classifications

In this paper, land use is defined to refer to the proportion of total land area shared by different land use categories. Based on the 1996 topo sheet of Nepal (SD 1996), five broad categories of land use such as arable land, forest, shrubland, grassland and other lands can be ascertained. Arable land refers to the land being used for cultivation of cereal crops like rice, wheat, maize, and millet and other crops like vegetables, tea, fruits trees etc.; forest lands include all lands having permanent forests and trees with more than 10 percent crown cover (DFRS 1999). Shrub refers to bush, or degraded forest or secondary growth forest, where there are scattered trees standing or with less than 10 percent crown cover; grassland comprises meadows and pastures; and other lands include settlement built-ups, roads, barren or bare land, water bodies, snow land, rock and ice. This definition is broadly to include the social and economic purposes and contexts for and within which lands are managed or left unmanaged. Change in land use type refers to those occurred in three different map year points1986 (KESL, 1986), 1996 (SD, 1996) and 2010 Landsat imagery. The factors of land use change may include human activities, including local culture, economics, and land policy and development and environmental change.

These works are to calculate and compare change in the land use categories by location in those three years. The rationale behind considering those broad land use types is that each of them has significant role to development and nature conservation in Nepal. For instance, forest contributes to rural development by providing forest products such as firewood, fodder, timber and herbs to rural communities, and by regulating atmospheric conditions. In addition, the forests are also essential to sustain agriculture and livestock (buffaloes, cows and goats) rearing in the Eastern Hills. Arable land is a fundamental resource to support living of majority of the rural people. There is a close link between agriculture and forest resources. The former derives products from the latter such as fodder, leaf-litter, etc. to maintain the nutrient levels and soil structure. Grassland has an immense role to contribute not only to raising livestock such as cows, sheep, and yaks in the high mountains, but also to maintain the watershed.

Thus, the data for this paper has been acquired from both analogue and digital map sources of those three map years so far available in Nepal. The 1986 map data has been considered as the benchmark year for spatial database of land use and land use change. The topo sheet digital data sets have two scales such as 1: 50,000 and 1: 25,000. The mapping resolution of Landsat imagery is 30 m. The 1:25,000 has been set as the base map scale, with minimum mapping unit of 2.5 hectare. In so doing, a careful choice of appropriate GIS functions together with field verification of land use and land cover categories at the training sites particularly along the road access and towns, where change in land uses often assumed to have occurred, were used so that loss or uncertainty of land use and land cover information particularly from 1:50,000 to 1:25,000 was minimised at maximum possible level. Further, the Eastern Hills also lacked reliable baseline household data, which was needed to comprehensively capture the complex relationships between land use change and its impacts on the social and economic conditions.

1.2 GIS mapping procedure

The spatial data transformation process in GIS format being adopted in the study is as follows:

1. The analogue datasets of 1986 map sheets were scanned and processed into the compatible data form by adopting all steps such as geo-referencing, digitizing (missing features), topology building, editing, edge matching, appending, and map layouts in the ArcGIS format. Likewise the digital data features of topo sheet of 1996 including river levels, road types, and contours were defined and edited as to the need of this study. In case of Landsat imagery 2010, the digital data processing included all steps such as re-projecting to the modified Universal Transverse Mercator coordinate system (adopted by the Survey Department of Nepal) through re-sampling of <0.5 pixel (equivalent to approximately 10-15 m),

selection of training sites (based on in-situ assessment provided by ground trothing work), creation of multiple signatures, identification and classification of land use and land cover by maximum likelihood classifier, post reclassification assessment (based on existing land use, digital elevation model and field data), and refinement of classification by filtering. The classification accuracy as explained by the Kappa statistics was at 85.3 per cent.

2. The likelihood changes of land use and land use categories in the Eastern Hills of Nepal were verified in the field, particularly at training sites accessed by roads. The attribute data available over time from the record or base data at the district level were limited and inconsistent. So data verification in the field was carried out in two steps. First, consultation with representatives of various district line agencies at the headquarters of four Eastern Hill districts of Nepal was carried out to determine whether there was any change in land use types on 2010 based enlarged land use color maps generated by GIS. In the meantime, all gray reports and data available at the districts were also acquired. Secondly, key features such as newly built roads, commercial vegetables patches, cardamom and *Amreso* (broom grass), abandoned arable land patches, hāt bazaars, health service, and place names were verified by visiting the locations. GPS equipment (3m-resolution) and color topo sheets (1996) as reference maps were used for verification in the field. Updating of the land use features incorporating field verification information and final layouts in GIS environment were prepared.

3. The attribute data including population, production of major agriculture crops such as off-season vegetables, cardamom, ginger, non-timber forest products (e.g. herbs) and woods were gathered from different sources (publications, documents, reports, statistical and digital data and maps) by visiting all related organizations. Integration of the attribute data related to land use at the district level has been made based on standard coding system of the Central Bureau of Statistics (CBS). These were made to see change in the land use pattern and identify gaps to help explain the key factors responsible behind land use change, as well as change in the social and economic conditions of the people of the study region.

4. Change in the land use categories has been computed by the overlay function between a pair of two consecutive years, such as: (i) 1986 and 1996 and (ii) 1996 and 2010. Magnitude of change (in percent) in land use categories has been determined at four levels, such as: <25, 26–50, 51–75, and >75, based on the mappable polygon size. The map layouts of land use categories have been prepared following the standard colors, and other GIS functions such as buffer and overlay were employed wherever feasible.

2. Results and Analysis

2.1 The study area – an introduction

For this paper, the Eastern Hill region of Nepal comprises four districts such as Bhojpur, Dhankuta, Sankhuwasabha and Terhathum (Figure 1). The study area extends over 6,557 km^2, sharing 4.4 per cent of the country's total land area (147,181 km^2). The neighboring districts of the study area are Khotang (Hill) to the west, Ilam (Hill) to the east and Morang and Sunsari in the south Tarai (plain), which borders with India. In the north lies Tibet of China. These surrounding areas have linkages to land use change in the study area.

The physical settings of the Eastern Hills are characterised by rugged topography that presents a maze of spurs and valleys; the elevation of which ranges from 300 to over 8,000 masl (Figure 2). The hills traverse from east through west and there are a number of narrow longitudinal river valleys, which are extensively brought under cultivation through terrace farming. The Himalayas confine in the northern part, extending up to the Tibetan border. This belt also consists of rolling pastureland, where sheep and yaks graze. There are historically important trading routes leading to Tibet through the passes. The Koshi River together with its principal tributaries such as the Arun, the Sunkoshi, and the Tamor drain the study region (figure 3). The Koshi is also the largest river of Nepal. The Monsoon is the main system to affect climate of the study region. Over 80 per cent of the annual precipitation of 1,500 mm occurs during June-September months, which generally decreases from east to west whereas the mean temperature increases from north to south. While the moist sub-tropical climate prevails in the southern half, the temperate climate and tundra types of climate are found in the northern part of the Eastern Hill region.

The total population of the study region was 609,407 in 2011 census, mainly occupying the lower hill slopes and river valleys in the Eastern Hill region (figure 4) and giving an average density is 93 persons per square kilometer. The study region saw overall a negative growth rate of -0.52 percent during 2001-2011 decade, unlike the national population growth rate of 1.4 percent during the same decade. The region consists of diverse ethnic groups. The Rais and the Limbus are the indigenous inhabitants. There has been a tendency of flow of people from the hills to the Tarai in the Eastern region from the very beginning. In 1991, for example, the population migrating out in the Eastern Hill region has grown drastically by 3.1 percent as compared to 8.4 percent in 2001.

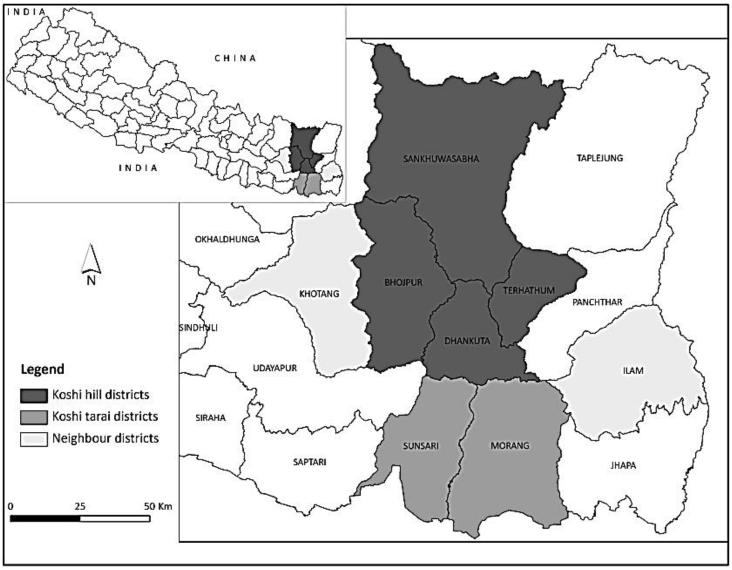

Figure 1. Location of Eastern Hill Region, Nepal

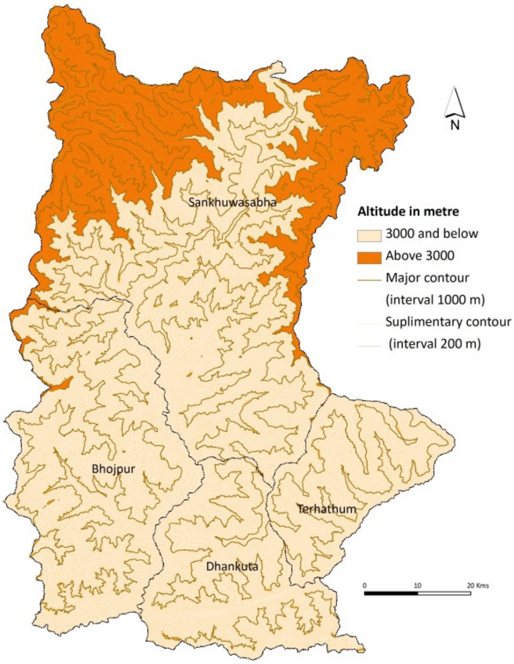

Figure 2. Relief features by elevation, the Eastern Hills of Nepal

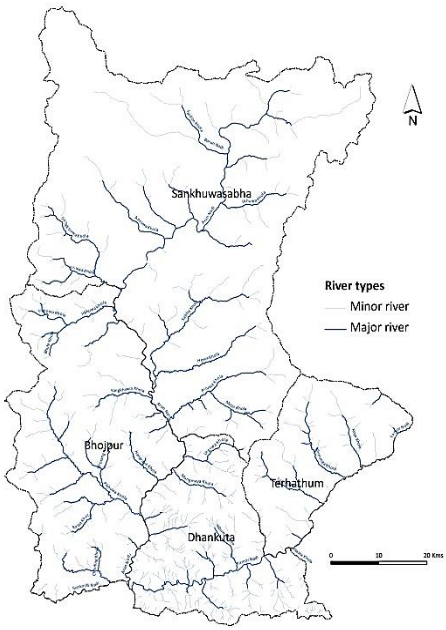

Figure 3. Drainage systems, the Eastern Hills of Nepal

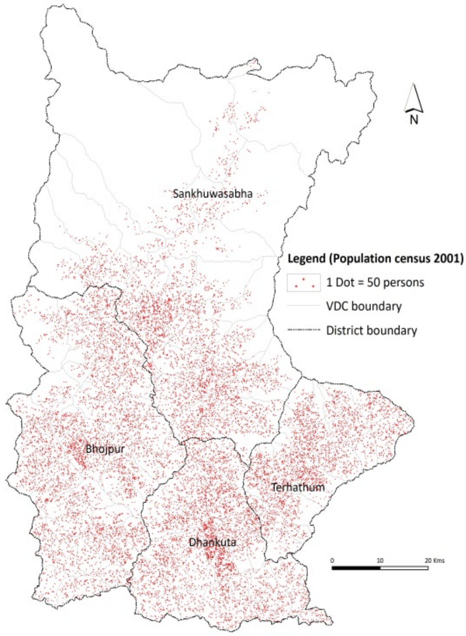

Figure 4. Distribution of population in Eastern Hills of Nepal, 2001

In the Eastern Hills, agriculture is the principal economic activity, with 67 percent working population in engaged in this sector. But the agriculture is predominantly of subsistence nature, except in few areas accessed by roads where intensive cultivation of vegetables is being practiced. One of the main sources of income is remittance, with about 56 percent households receiving remittances from foreign labour. The manufacturing sector is primarily based upon local raw materials and products. Each of the four districts of the study area is characterised by their unique products such as tea estates in Dhankuta, Dhaka (cotton cloth) in Terhathum, Allo (a kind of NTFP) in Sankhuwasabha and paper in Bhojpur. In 2011, a total of 1,774 were registered mostly based on the indigenous products such as textiles (Dhaka, Allo cloths) and handicrafts (bamboo products, embroidery products). The Dhankuta and Terhathum districts were included under 'Tea Zones' by the government in 1982. In addition, various users' groups and associations related to milk, vegetables, live animals, retail outlets, wholesale, etc. have been emerged in recent decades for promoting internal marketing systems. However, market integration has been the main hurdle due to limited market places and very limited access roads (figure 5).

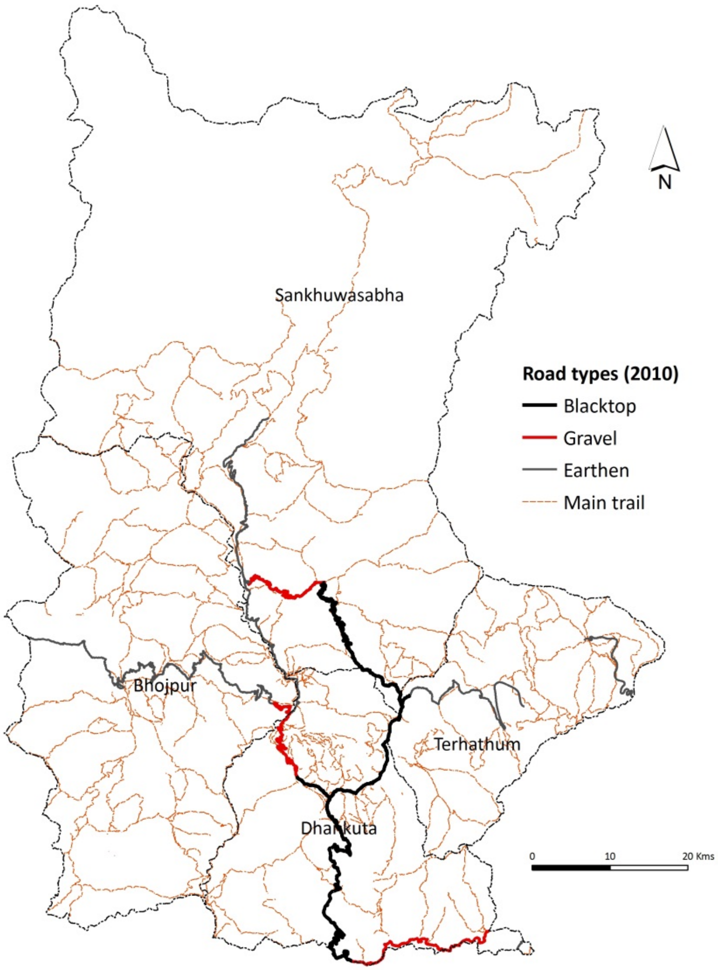

Figure 5. Distribution of roads and major trails in the Eastern Hills of Nepal, 2010

Road for the first time came in the Eastern Hills in 1982. Now the highways have opened up extending forward linkages and other links of the local produce with large cities of Dharan and Biratnagar in the Tarai and then other places across the country, as well as with India. There is also air service between the study region and Kathmandu, the national capital city and Biratnagar, the regional city of Eastern Nepal. Here, fuel wood is the major source for cooking and kerosene is next important fuel basically for lighting purpose. The literacy is over 52 percent.

2.2 Change in Land Use

(a) Distribution of land use by mapping years

Of five major land use categories in the Eastern Hills, forest is by far the largest coverage, making up of 47 percent. Next is the arable land, sharing nearly 30 percent. So in 2010, they combining together occupied dominant position in all land use categories, accounting for over three-fourths of total area of the Eastern Hills. They also had predominated in the previous two mapping point years – 1996 and 1986 (table 1).

Table 1. Distribution of land use categories by year, the Eastern Hills

Land use Categories	1986		1996		2010	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Arable	199,404	30.4	219,688	33.5	196,400	29.9
Forest	259,366	39.5	245,918	37.5	307,154	46.8
Shrub	60,541	9.2	61,946	9.4	11,544	1.8
Grassland	59,254	9.0	20,718	3.2	36,216	5.5
Others	77,551	11.8	107,846	16.4	104,802	16.0

Sources: LRMP 1986, Toposheet 1996, and Landsat imagery 2010

However, the spatial distribution of two major land use categories – forest and arable land– varies remarkably that seems to be related to relief features in the study region. In all three mapping years: 1986, 1996 and 2010 (figures 6, 7, and 8), the arable land generally appears to be confined to the river basins and the lower and middle slopes of the hills, whilst the forest has occupied the areas around the riverbanks characterized by hot summer climate, as well as the high and steep slopes of the mountains and hills. At the individual district level too, the forest is the largest natural resource in terms of area coverage of Bhojpur and Sankhuwasabha, whereas the arable land is the most important resource in terms of area coverage of Dhankuta and Terhathum. In 2010, the districts of Bhojpur and Sankhuwasabha had forest coverage with 46 and 51 percent respectively, while in the same year Dhankuta and Terhathum districts had over 46 percent arable land coverage (see table 3). These juxtaposing distribution patterns of forest and arable land among the districts are mainly due to variation in terrain across the study region.

(b) Change in land use and land cover (1986-2010)

Over the past 24 years, there has been a remarkable change in land use and land cover in the Eastern Hills of Nepal. Of all land use categories in the study region, arable land and forestland show remarkable changes. There was an increase by 10.2 percent in arable land between 1986 and 1996, while a decrease by 5.2 percent in forest between the same two years (Table 2). Contrary to these changes, arable land decreased by 10.6 percent, while forest saw an increase of 25 percent in 2010 as compared to 1996. By 1996, forest coverage decreased to 37.5 percent while arable land increased to 33.5 percent, but however forest coverage sharply increased to 46.8 percent in 2010 while arable land coverage reduced to 29.9 percent in the same year. The coverage of shrubland remained at around 9 percent in 1986 and not so changed in its area in 1996 but declined sharply to 1.8 percent in 2010. Grassland experienced a decrease from 9 percent in 1986 to 5.5 percent in 2010. Other land uses comprising water bodies, snow land, bare land, rock and ice, built-ups, and roads shared 11.8 percent in 1986 and rose to around 16 percent in the following two mapping point years.

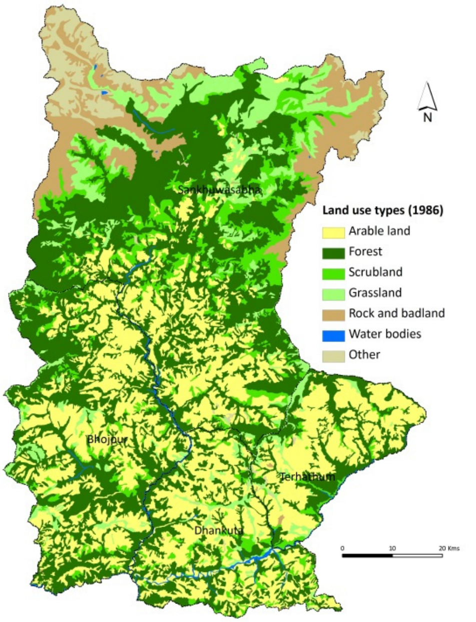

Figure 6. Distribution of land use and land cover in Eastern Hills of Nepal 1986

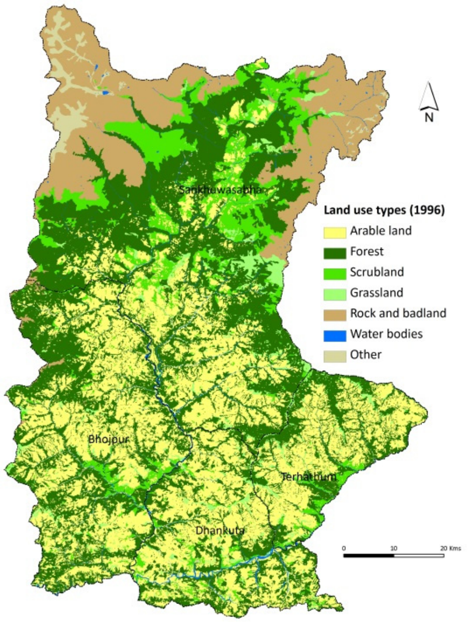

Figure 7. Distribution of land use and land cover in Eastern Hills of Nepal, 1996

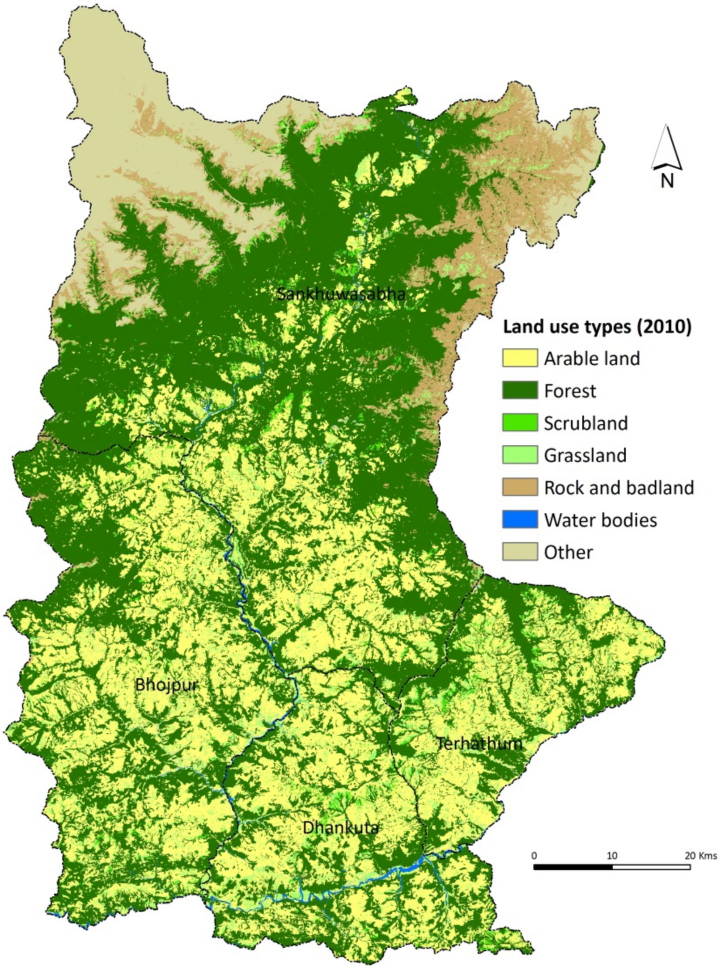

Figure 8. Distribution of land use and land cover in Eastern Hills of Nepal, 2010

Table 2. Magnitude in change (%) in land use categories by year, Eastern Hills of Nepal

Land use Categories	1986-96		1996-2010		1986-2010	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Arable	20,284	10.2	23,288	-10.6	3,004	-1.5
Forest	13,449	-5.2	61,236	24.9	47,788	18.4
Shrub	1,405	2.3	50,402	-81.4	48,997	-80.9
Grassland	38,536	-65.0	15,498	74.8	23,038	-38.9
Others	30,295	39.1	3,044	2.8	27,251	35.1

Sources: LRMP 1986, Topo sheet 1996, and Landsat imagery 2010

Firstly, the arable land area has decreased by 1.5 percent while that of forest has increased by 18.4 percent in the Eastern Hills over the past 24 years. But a remarkable change has occurred in shrubland and grassland during the same duration of years. Table 3 depicts that the grassland declined by 65 percent during the decade of 1986-96, but increased to75 percent between 1996 and 2010, while during the 1996-2010 decades, the shrubland declined by 81.4 percent. Thus during 1986-2010, the shrubland and the grassland declined by 81 and 39 percent respectively.

Table 3. Magnitude in change (%) by land use category in the Eastern Hills, 1986-2010

Land use Type	Year	Bhojpur	Dhankuta	Sankhuwasabha	Terhathum	Relative share %
Arable	1986	42.7	52.0	14.5	55.7	30.4
	1996	49.0	52.6	17.0	53.0	33.5
	2010	44.5	48.4	15.6	46.3	29.9
Forest	1986	46.0	33.9	39.6	31.8	39.5
	1996	42.5	30.6	36.8	36.2	37.5
	2010	45.8	38.6	50.8	39.5	46.8
Shrub	1986	5.3	7.0	12.4	4.9	9.2
	1996	3.9	4.9	13.9	4.9	9.4
	2010	1.6	2.2	1.5	3.0	1.8
Grassland	1986	4.8	4.4	12.7	5.7	9.0
	1996	2.3	3.0	3.2	4.7	3.2
	2010	6.7	8.7	3.3	10.1	5.5
Others	1986	1.1	2.6	20.8	1.9	11.8
	1996	2.3	2.6	29.1	1.2	16.4
	2010	1.4	2.2	28.8	1.1	16.0
Total area (ha)		152,325	89,854	346,896	67,040	656,115

Note:
- *The values were derived from land use GIS map*
- *The summation of the values of the five land use categories along the column of each district of a single year gives 100 per cent, e.g. (42.7+46.0+5.3+4.8+1.1 = 100)*

Secondly, land use change at district level presents different features from those in the whole study region. In 1986, arable land shared 52 percent in Dhankuta but that decreased to 48.4 percent in 2010.But the arable land in

Terhathum decreased continuously over the past 24 years. Changes have occurred in arable land coverage in Bhojpur and Sankhuwasabha with similar pattern: first it increased and then decreased. For instance, the arable land in both districts: Bhojpur and Sankhuwasabha occupied the largest area with 49 and 17 percent respectively in 1996, while it declined in 1986, as well as in 2010. The pattern of change in the forest land in Bhojpur and Sankhuwasabha appears to be the same; first decreased and then increased (see Table 3). In 1996, forest occupied the lowest coverage at 42.5 and 36.8 percent respectively in both districts. By 2010, it rose substantially to around 51 percent in Sankhuwasabha and 46 percent in Bhojpur. Terhathum has shown continually increased in the forest coverage in all three-mapping point years. On the whole, there was an increase in the forest coverage in all three districts except in Bhojpur during the past 24 years.

Thirdly, the overall patterns of change in the land use categories appear to be in differential manner in the Eastern Hills. Three distinct patterns of change are discernible (table 3).The year 1996 seemed to be crucial in the coverage of arable, forest, grassland, and ‘other land’. First, the relative share of arable land and ‘other land’ in that year was highest in the Eastern Hills and then declined before (1986) and after (2010).Secondly, forestland and grassland had relatively lowest share in 1996 and then increased in both years: after (2010) and before (1986). Thirdly, the relative share of shrubland has constantly decreased over the past 24 years in the Eastern Hills.

Fourthly, there also exists distinctive differential manner of change in the land use categories at individual district level during the past 24 years. In Terhathum, for instance, arable land has continually declined, while the forest land has continually increased. Conversely, there is different pattern of change in land use categories in other three districts: Bhojpur, Dhankuta and Sankhuwasabha. In these three districts, the year 1996 seemed to be crucial. The arable land and ‘other land’ occupied the highest relative share in 1986 and then declined before and after that year, while the coverage of forest and grassland was the lowest in 1996, but increased in both years – 1986 and 2010. In regard to shrubland, there was a declining trend during the past 24 years in Bhojpur, Dhankuta and Terhathum, but its coverage was highest in Sankhuwasabha in 1996 and then declined in both years.

Fifthly, land use change appears to be associated with elevation zones in the Eastern Hills. The distribution of arable land is confined to below 3,000 m, whereas all other categories of land use and land cover are distributed across all elevation zones at varying magnitudes (table 4). A preponderant proportion of arable land with over three-fifths appear to be concentrated in the elevation zone of 1,000-2,000 m and this together with the proportion of the arable land lying in below 1,000 m zone represents over 92 percent of the total arable land area. Only a small proportion of arable land is available between 2,000-3000 m zone and above this zone no arable land exists due to unsuitable climate. Forest is found at relatively greater proportion in the 2000-3000 m zone; shrubland in the 1000-2000m; grassland within range of 1000-3000m, and ‘other land uses’ in the zone above 4000 m where land features like snow land, bare land, and rock and ice dominant. On the other hand, changes in the land use categories by elevation zones show minimal over time. This is true in case of arable land and forest coverage. For instance arable land has decreased at a differential percent of 4 points in the zone of 1000-2000 between 1986 and 2010, while forest has decreased at 5 points per cent in the below 1000 zone between the same two years. There has been a substantial increase in the shrubland in the 1000-2000 m zone, with 70 percent in 2010 up from 36 percent in 1986, but a large decrease in two zones: 2000-3000 and 3000-4000 during the same years. A pronounced change has occurred in the grassland in all elevation zones; its substantial sharing increased in 2010 compared to that in 1986 in two zones: <1000 and 1000-2000, while its substantial sharing decreased in 2010 compared to that in 1986 in all remaining three zones above 3000 m. There has been decreased in sharing of ‘other land uses’ in 2010 than in 1986 in the zone of >4000 m, as opposed to the sharing in the zone of 3000-4000, where it increased between the two years. It appears that there exists internal trading between land-use categories over time. As no adequate evidence exists, it should be therefore of future investigation.

Table 4. Share of land use categories according to elevation zones, Eastern Hills of Nepal

Elevation Class (m)	Per centile share of total land by land use category by year														
	Arable			Forest			Shrubland			Grassland			Others		
	‘86	‘96	‘10	‘86	‘96	‘10	‘86	‘96	‘10	‘86	‘96	‘10	‘86	‘96	‘10
< 1000	30	30	31	28	25	23	15	19	13	4	10	34	7	6	4
1000-2000	65	63	61	28	31	30	36	27	70	20	29	41	1	1	1
2000-3000	5	7	7	32	35	33	20	19	8	31	44	11	1	1	2
3000-4000	0	0	0	11	9	13	25	27	8	18	15	6	4	15	15
> 4000	0	0	0	1	0	1	4	7	1	27	3	8	87	76	77

Lastly, there exists internal trade-off between land use categories, which is analyzed through the matrix table. Table 5a shows that an increase of the arable land at 10.2 per cent between 1986 and 1996 appears to be largely by encroaching upon the forestland (7.8%) and with small proportions on other three land use categories. Likewise increase in the shrubland during the decade of 1986-96 was assumed mostly due to consuming relatively greater proportion of forestland. Table 5a also shows that the arable and shrubland are the two major land use categories to consume most of the forestland during 1986-1996.The decreased in these two land uses – shrubland and grassland – could be linked to the increase in the forest coverage in Sankhuwasabha. This increase in "other lands" might be due to decrease in arable land, shrubland, and grassland. Table 5b exhibits that the decrease in the arable land between 1996 and 2010 was due to conversion of this land to grassland (7.2%) and to forest and shrubland. During that decade, increase in the forest land appears to be contributed largely by shrubland, followed by grassland and arable land, because all the latter three land use categories were found as largely declining. Thus, during the past two and half decades (1986-2010), the forest land appears to have increased at the cost of encroaching upon shrubland, grassland, and arable land. Increase in "others" land use mainly encroaching upon the forest, arable and grassland might be due to the construction of roads, expansion of settlement clusters and institution buildings, and others (table 5c). Further, the arable land increase at the cost of decreased forest land during 1986-1996 might be due to the expansion of cultivated land over the forest area by the practice of slash and burn farming of the local tribal communities, expansion of commercial farming on the land pockets lying along the road sides (figure 9) and establishment of tea estates. Patches of arable land have been turned into shrubland and grassland, which might be due to abandonment of cultivated land. The locations of abandoned cultivated land patches were found to be scattered across the Eastern Hills (figure 10), most likely due to an increase in outmigration of the labour force. This can be verified by the fact that there was absent population at 8.4 percent on average of the total population in the Eastern Hills in 2011 (CBS 2012). Thus, during the past two and half decades, only forest land has increased relatively at larger rates while the other three land use categories –arable land, shrubland and grassland– have decreased at different rates. It is evident from table 5c that the forest land increased consuming mostly the shrubland, grassland and arable land.

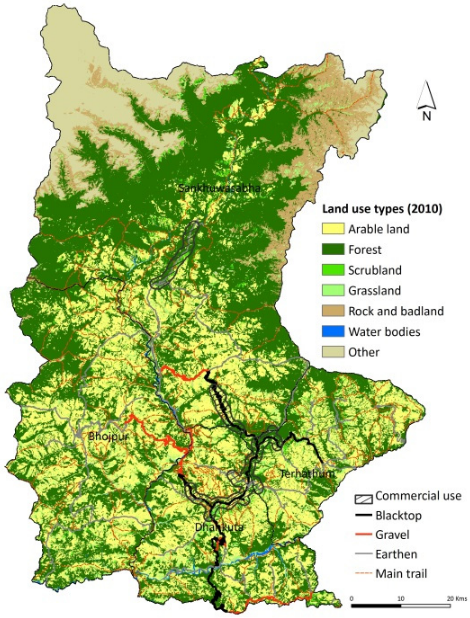

Figure 9. Location of commercialized agriculture patches in Eastern Hills of Nepal 2013

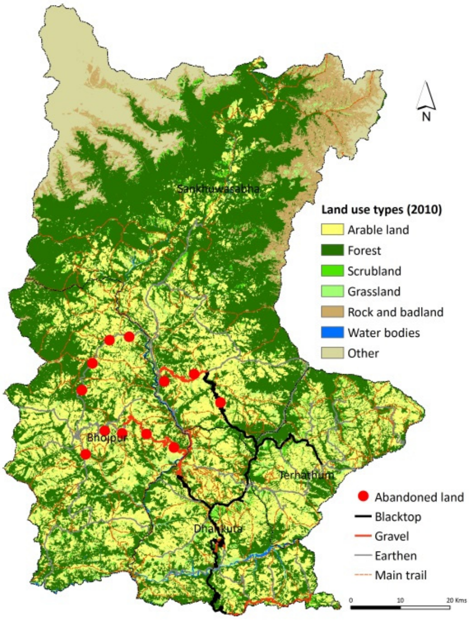

Figure 10. Location of abandoned lands in Eastern Hills of Nepal, 2013

Table 5. Matrix of relative changes (in per cent) of land use categories, Eastern Hills

(a) 1986 - 1996

Land use Categories	Change (%) in LU categories					Total	
	Arable	Forest	Shrub	Grassland	Others	Area (ha)	%
Arable	0.0	-2.7	0.5	-11.2	7.1	20,276	10.2
Forest	7.8	0.0	1.0	-11.9	8.2	-13,439	-5.2
Scrub	1.4	-1.6	0.0	-16.4	21.0	1,403	2.3
Grassland	0.7	-0.3	0.3	0.0	2.8	-38,536	-65.0
Others	0.3	-0.6	0.4	-25.4	0.0	30,295	39.1

(b) 1996 - 2010

Land use Categories	Change (%) in LU categories					Total	
	Arable	Forest	Shrub	Grassland	Others	Area (ha)	%
Arable	0.0	20.5	-7.6	13.4	-0.2	-23,288	-10.6
Forest	-1.6	0.0	-53.1	41.0	-1.9	61,236	24.9
Scrub	-1.8	1.6	0.0	4.8	-0.1	-50,402	-81.4
Grassland	-7.2	1.8	-4.5	0.0	-0.7	15,498	74.8
Others	0.0	1.0	16.2	15.6	0.0	-3,044	-2.8

(c) 1986 - 2010

Land use Categories	Change (%) in LU categories					Total	
	Arable	Forest	Shrub	Grassland	Others	Area (ha)	%
Arable	0.0	13.2	14.7	6.8	6.4	-3,004	-1.5
Forest	0.9	0.0	51.2	16.7	18.3	47,788	18.4
Scrub	0.1	1.0	0.0	1.0	1.0	-48,997	-80.9
Grassland	0.5	2.0	3.9	0.0	9.3	-23,038	-38.9
Others	0.0	2.3	11.1	14.5	0.0	27,251	35.1

2.3 Factors of Land Use Change

Change in land use is a function of multiple factors. So it is difficult to explain the 'change' due to a single factor. In the study region, the factors behind land use and land cover change are as follows.

(a) Planned development activities

Planned development efforts in Nepal concerning with the better livings of the people by providing different facilities and services were initiated through national periodic plans since 1956. The development approaches in the plans focused on fulfilling 'basic needs', 'sustainability' and 'poverty alleviation'. Until now, all national plans have identified broad development sectors such as social services (education and health), agriculture, irrigation, land reform and forestry, transport, communication and industry, commerce, and power for budget allocation. In saying so, the development activities being executed under the government programs and policies in the Eastern Hills region like other regions include the Pakhribas Agricultural Research Centre, Integrated Rural Development Programmes, Dharan-Dhankuta highway, Landscape Conservation and Planning Environmental Resources, etc. These programs involving activities like national park and ecological conservation, agriculture, tourism, climate, rural trade, etc. deal directly and indirectly with the change in land use and its impacts in the Eastern Hills.

(b) Agriculture development activities

Agricultural activities in the Eastern Hills involves complex interactions among the various agents of change in land use including availability and quality of arable land, micro-climatic condition, human resource and social structure, and formal and informal institutions. Particularly the Pakhribas Agriculture Centre since its establishment in the 1970 has worked on introducing improved varieties of wheat and maize crops, and cows and goat species suited to the specific agro-climatic conditions of the Eastern Hills. Since the early 1980s, introduction of improved agriculture development programs through Centre for Environmental and Agricultural Policy Research, Extension and Development (CEPREAD) and Eastern Seeds and Vegetables (KOSEVEG) that initiated growing of off-season vegetables, seeds, large cardamom, ginger, fruits and livestock rearing has brought significant change in agriculture systems from subsistence to commercial farming in areas around the road access (CEAPRED, 2001). The vegetable farming in particular has grown dramatically after the provision of transport linkages and market access in the late 1990s. By assessing potential risks and benefits by the farmers through adapting various higher yielding varieties of cereal crops and turning towards cash crop cultivation has also been significant in the agricultural land use.

(c) Roads and transport

Roads seem to be a crucial infrastructure for overall development in the Eastern Hills. Increase in arable land during the 1986-1996 decade could be attributed to the building of 66 km Dharan-Dhankuta road in 1985 and thereafter began modern transport service in the Eastern Hills. The construction of roads continued that reached to a total of 934 km roads by 2010. Use of land for agricultural purposes increased by 10 percent during the 1986-1996 decade, but decreased from 1996 onwards. However, the traditional subsistence cereals crops have been replaced not only with the commercial vegetable crops, but their cultivated areas have also increased substantially, particularly along the sides of roads. For instance, the farmers in the areas linked by roads have also practiced the inter-culture of '*Amreso*' (broom from grass plant) and large cardamom in the shrubland and private forests. According to the studies of Sugden (2004) and CEAPRED (2001), the coming of the roads together with the intervention of agriculture innovations has encouraged local farmers to intensify vegetables cultivation particularly along the roadsides. Patches of commercial vegetable farming mostly located along the roadsides are considered to be an impact of roads on land use patterns. Further, the road impacts are found to have declined according to increase in distance from the road-head and disappear beyond a certain threshold distance. Other studies show that differential impacts on the intensity of agricultural production and income of the farmers due to different types of road facilities such as fair weather or seasonal road and all weather road, for instance the households living along the all-weather roads got more benefits from improved agriculture than the those belonged to the fair weather roads. Furthermore, while the commercial importance and role of the roadsides market towns such as Hile, Sidhuwa, Basantapur, Leguwa, etc. has been enlarged, the role and importance of some of the traditional towns have declined sharply due to bypassing them by new roads or emergence of intervening centres, or link with larger towns, such as Taksar in the case of Bhojpur, Chainpur in Sankhuwasabha. More importantly, the local handicraft and traditional artesian products have been disappeared due to penetration of cheaper manufactured goods in the local markets. There were extremely smaller volume of goods going out from the Eastern Hills than those entering into the region and the vehicles run over the RAP roads only during the fair weather season. There has been changed or shifted in the existing transport system. *Dhākar* or *Bhariya* (porter) that had served portering of goods between market towns and villages for long has been either disappeared or replaced by motors and coolies. The mules and donkeys as local and traditional transport means have been replaced and moved to areas where there is no motor road. On social front, different kinds of people from the surrounding areas have moved to the roadside for building new settlements, or establishing business enterprises.

(d) Community Forestry Program

In the Eastern Hill region of Nepal, the conservation of forests and the expansion of forests by the initiation of community forestry, leasehold forestry and private forestry programmes, as well as the conversion of some of the shrublands into the mature forest trees assumed to be the reasons to increase in the forest land during 1996-2010. Studies indicate that community forestry, leasehold forestry and private forestry programs have been expanded over the bare lands, conversion of shrubland to mature tree canopies, plantation of tree species such as *Utis, Chiraito, Lokta, Salla,* bamboo, and growing of *Amreso* and large cardamom within the forest lands (DFID, 2013). By 2011 over 115,000 ha of forests have been handed over to a total of 1,449 Community Forests User Group (CFUGs) in the Eastern Hills. They comprised memberships of almost 142,000 households. A 1998 follow-up study on the physical resources in 288 sample sites of the Eastern Hills indicated that forest degradation had been reversed and the forests were widely regenerating. Compared to the national forest plots, there was less grazing in the CF plots, and there was an increase in numbers of species. An impact study in 2008 found that the CFs were supplying more than twice the amount of timber, poles and grasses needed by the households compared to the 2003 baseline. The study further identified that CF and the Livelihoods Forestry Project (LFP) income generating activities accounted for 25 percent of changes in household income from the 2003 baseline. Further, a 2006 mid-term review of LFP found that 71 percent of the beneficiaries of the income generation activities in the districts of Eastern Hills were women and 53 percent of the total beneficiaries were from disadvantaged ethnic groups.

(e) Makalu-Barun National Park

The Makalu-Barun National Park (MBNP) covering an area of 2,330 km^2 was set up in 1992 and the local communities have been managing it in a participatory manner. There were 88 forest user groups and 12 communities with 6,000 households getting benefits from its buffer zone. Since 1996, the development and conservation of MBNP has focused on the park development, community support, tourism facilities, and buffer zone. Tourism is another development impact in MBNP. According to NTB records, 1,000-1,500 tourists visited the park and generated an estimated of US$ 275,000 annually (Branney and Yadav, 1998). At the same time, however the increased number of visitors over the decades has also resulted in increased environmental degradation (tree harvesting, burning, grazing) along the main trails in MBNP. More importantly, the Arun III hydroelectric project, which was designed in 1994 and its site and other associated infrastructure such as road to be constructed within the MBNP, did not take place due to criticism on economic viability and environmental sustainability. The project however began in 2008 under the BOOT system (Built, Own, Operate, Transfer system) has caused both change in land use and then in the livelihood of the communities around the project area.

(f) Climate change

The Himalayan region of Nepal is one of the most sensitive hotspots to global climate change impacts. Evidence is that there is an increasing trend in temperature in the Eastern Basin with more than 0.3^{0}C per decade at elevations over 4000 m. Over 30 years (1970 – 2000), the glacier area was lost by 0.2 per cent per year in the upper Tamor River basin. Such widespread glacial retreat can have two direct consequences: changes in the hydrological regime and glacial lake outburst floods. The upper Eastern drainage basin alone has 13 out of 14 GLOFs recorded in the Nepal Himalaya (Bajracharya et al., 2007). Several GLOF events recorded in the Eastern basin – the first event occurred in the Dudhkoshi basin in 1977, then in the Bhotekoshi and the Sunkoshi basins in 1981 and with the most significant one in 1985 that caused a damage of equivalent to US$ 3 million. These events caused damages in hydropower plant, roads and bridges, main trails, cultivatable land and forest, and houses in both the headwater and down water areas. The Eastern Hill districts according to climate change vulnerability index lie in moderate to low ranges.

2.4 Impacts of Land Use Change

Land use change is a proxy indicator of development activities, which in turn has impacts on different phenomena directly and indirectly. Like factors of land use change, the impacts due to land use change also are difficult to explain, as impacts are the result of a combination of varieties of factors.

(a) Improved agriculture production systems and flows

One of the impacts of land use change seen vividly in the study region is on intensification of the agriculture systems particularly the vegetable farming that has taken place along the motor able roads. Intensification has also been observed due to inter-culture practice of two or more crops, for instance, maize with beans and/or potato, and double cropping of staple crops such as rice and wheat, or maize in areas where such farming systems are feasible and applicable due to irrigation waters, road and market access, and other associated facilities. The facts are that imports of dung (chicken and goats) loaded in trucks from the Tarai have been observed in the study region and in turn export of high value crops to the adjoining Tarai towns. Vegetables, large cardamom, ginger, tea and fruits constitute the main cash and high value crops within the study area. Studies show that the traditional subsistence cereals crops have been replaced not only with commercial vegetables, but their cultivated areas have also increased substantially (Pant, 2002; Sugden, 2004; Shrestha, 2006). Further, reliance on subsistence farming has declined as opportunities were increasing in off-farm income (Virgo and Subba, 1994). The vegetables, which were produced only for own consumption in the 1970s, increased to over 70,000 MT in 2004due to commercial cultivation. For instance, the large cardamom area in the study region grew from 1,564 ha in 1991 to 3,224 ha in 2008 and ginger area rose by 3 folds and fruits area by 28 percent in holdings during 1971-2007. It was observed that the rise in production of vegetables and spices has been due to development of markets (near district headquarters), linking with demand centers in the Tarai lowlands (and further access to markets border towns of India) and the increased access to technical inputs and credit. Another impact is on renting of cultivated land for sharecropping, which was increased from 9 percent in 1981 to 23 percent in 2001. Investment in the acquisition of land in the Eastern Hills has also risen due to increasing remittance from ex-Gurkhas, as well as from the local workers in abroad (middle east countries, Malaysia, Korea, etc.). There is growing pressure on arable land in the headquarters towns, as well as in and around areas accessed by roads due to internal shifts of population.

Impact also found on adopting improved breeds or varieties of pigs, cows and buffalos due to the Pakhribas Agriculture Centre. The number of livestock holdings increased by 22 percent between 1981 and 2001. Though livestock rearing has traditionally been an essential component of farming systems in the Eastern Hills in terms of providing manure, drought power, as well as acting as a coping mechanism in times of food insecurity, the adaption of new breeds livestock since the past few years to improve productivity of milk and meat has been high amongst the local farmers and has been a source of income from selling milk and milk products and live animals. The number of modern livestock raising including milk processing through chilling facility, vehicles with refrigerators for transporting milk, milk collection and chilling centers for small dairy farmers is on the rise.

Further, the outflows of local products being traded through the towns and the district headquarters of the Eastern Hills include vegetables such as cabbage, cauliflower, tomato, radish, etc. and other high value products like species (*Akabare*, cardamom, ginger), fruits (orange, lemons), potato, and tea (table 6). Vegetables share the largest with about 56 percent of the total volume of outflows, followed by potato and orange. However, the exported products particularly vegetables differ in volume and types among the Eastern Hills districts. Overall, Dhankuta sharing about 41 percent of the total traded volume of the Eastern Hills became the largest district, while Sankhuwasabha with 10 percent being the smallest. Other two districts each shared about one-fourth.

Table 6. Outflows volume (m tons) of local products from the Eastern Hills districts

Export goods	Bhojpur	Dhankuta	Solukhumbu	Terhathum	Total	%
Akabare chilly	70	122	-	-	192	0.1
Cardamom	222	177	959	3,000	4,358	2.9
Ginger	4,010	2,261	572	2,000	8,843	5.8
Lemons	665	-	-	-	665	0.4
Orange	4,701	2,688	1,672	2,000	11,061	7.3
Potato	21,335	2,860	6,051	12,050	42,296	27.8
Tea	-	-	6	-	6	0.0
Vegetables	6,460	53,485	5,505	5,505	5,505	5,505
Total	37,463	61,593	14,765	38,340	152,161	100

***Source**: District Consultation Workshops and Record files of the Eastern Hill districts, June 2012.*

Major local products, mainly high value crops entered into trade since the last few years included cardamom, ginger, vegetables, potato, fruits, tea, dairy products, herbs etc. In terms of volume of trade and value of money, ginger is by far the largest local commodity. Next exported items include cabbage, orange and so on. *Chiraito* comprised around 75 percent of the total cash value and 60 percent of the total volume of trade from the study region. An estimated of 140 tons of *Chiraito* passed through the Hile-Basantapur road during the 1992-93 trading season, while that of cardamom and herbs through the same route was 424 tons/year in 1991-1992. Terhathum alone exported cardamom of 290 metric tons in 2011 to India, Pakistan and the Gulf. Potato was also an important export agricultural product, accounting for 18.4 per cent followed by vegetables (14%), ginger and cardamom (11.3%) and fruits (3.3%). Fluid milk is the next important export product of Terhathum.

There are two types of flows of the local products in the study region. First, flows of local products have taken place through already existing network of market centres, including the hāt bazaars across each district, and then with major trading centres of other districts where there are road links. These outflows of the products have taken place through hierarchical levels of market places, for instance, trade flows of the local goods from small centers to the higher collection centers and then to other places-cities outside of the Eastern Hills within the country as well as of India.

2.5 Change in spatial location and structure of human settlements

Change in land use occurs by elevation zones over time and human intervention is crucial to this change in the study region. These processes affect to determine the location of settlements that directly concern with changing surrounding land use. Change in land use together with the change in population (increased during 1991-2001 and decreased during 2001-2011) in the Eastern Hills is assumed to cause change in spatial distribution of settlements according to elevation over time.

While the GIS overlay function being performed between the layers of location of population clusters in the form of dots and the elevation zones in the Eastern Hills, the result exhibits the elevation zone 1000-2000m being the most favorable. This zone inhabited over 70 percent of the total population (table 7). Next to it is the elevation zone below 1000m, where shared about 23 percent of the total population. Only in Sankhuwasabha, some settlements are found in the zones above 3000m, while in other three districts all settlements are within the elevation zones below 3000m.

As compared the distribution of population clusters between 1991 and 2001 with elevation zones, there was no significant variation (Table 7). Two reasons to explain it are: first only little population increase at 8.8 percent (51,868 people) between 1991 and 2001 across the 6,557 km^2 of the Eastern region and the other, internal shift of settlements/population within the same zone.

Table 7. Distribution of settlements (values in per cent) by elevation zone and by year

Elevation Classes	Bhojpur		Dhankuta		Sankhuwasabha		Terhathum		Total	
	1991	**2001**	**1991**	**2001**	**1991**	**2001**	**1991**	**2001**	**1991**	**2001**
< 1000	20.6	21.2	32.6	32.3	31.1	31.0	8.4	8.2	24.0	24.2
1000 – 2000	73.7	73.1	65.3	65.2	59.6	59.7	83.6	83.7	69.9	69.6
2000 – 3000	5.7	5.6	2.2	2.5	9.1	9.0	7.9	8.1	6.0	6.1
3000 – 4000	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
> 4000	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0

The distribution of population appears to be closely associated with the distribution of arable land in the Eastern Hills. Over 90 percent of the population clusters are concentrated in two elevation zones: 1000-2000 and <1000 where over 90 per cent of the total arable land is found. On average about 6 per cent population clusters found to be in the elevation zone of 2000-3000, due to dominant of grassland where major occupations of the people are animal husbandry and tourism. Administrative headquarters, major market towns, road alignments, basic facilities such as schools and health, religious monuments and other amenities are generally having major population clusters. It appears that people tend to have moved to places for permanent settlement where there are roads and other facilities, but those still living in the remote areas are devoid of basic facilities. This process of development and migration of people nexus has created disparity in the level of development, as well as differentials in the impacts of development interventions.

3. Discussions

The two main natural resources of the Eastern Hills in terms of coverage are forest and arable land. The forest is the largest, as it covers around 40 percent of the total study area, followed by arable land with 33 percent. They are significant for the products for use by rural communities, valuable bio-diversity, and regulation of hydrological and atmospheric conditions. They are also an important part of the cultural heritage and a valuable asset for the tourist industry.

The forest occupying dominant position in the land use categories appears obvious in the Eastern Hills, where high hills and mountains are preponderant. Since the late 1980s a growing recognition of the role of 'sustainable environmental management' led to focusing on the forest conservation and management by involving local communities as 'user groups', as integral element of improving livelihoods in terms of social and economic well-beings. Since then the community forestry program is being carried out under the policies and acts under the government system across the country. There is evidence that community forestry has been able to provide improved access of the poor to its resources. The revenue contributed by the forest products in the Eastern Hills has been largely from the private forests, followed by the community forests and non-timber forest products (NTFPs) including herbs. This means that the private forests are a likely source of good income for the households owning them. Apart from the forest products such as timber, fuel wood and animal fodder, the NTFPs are also an important source of revenue for communities in the rural areas. Government policy in Nepal has recognised the importance of NTFP based enterprises as a potential means to contribute to poverty reduction and an important source for government revenue. There are forest products based enterprises in the involving in making essential oils, handmade paper, fruit squash, briquettes, ginger, spices and vegetables, and *Chiraito*.

The prime agricultural lands are confined to the major river valleys such as the Arun, the Sunkoshi and the Tamor that lie below 3000 m. The arable land is mostly used for subsistence production by the terrace-fields method. However, the LRMP (1986) has found that about 30 percent of the total cultivated land together with the dispersed rural settlements located in areas above 15^0 slope in the hills and mountains across the country, including the study region was technically vulnerable to disasters such as landslides and soil erosion. Such sloppy lands are rather better feasible for home gardening, fruits farming and pasture growing for animal rearing, according to the APROSC (1996).

Over the past 24 years, significant changes have occurred in overall land use, indicating the dynamics of land use. During the years 1986-2000, forest land grew with a little ratio, arable land at over 2 percent increase, and the increase in shrub was by over 6 percent. An increase in the forest coverage during 1996-2000 can be attributed to the initiation of forest conservation programs such as community forestry and leasehold forestry in the late 1970s and 1980s, while a decrease in the forest coverage during 1986-1996 coincided with an increase in arable land; the latter can be attributed to the building of Dharan-Dhankuta road in the early 1980s and the introduction of intensive agriculture system (off season vegetables) that demanded much arable land. Further, use of land for agricultural purpose appears to have decreased slightly during the years 1996-2010, but during the 1986-1996 decade, there was an increase in cultivated land, which coincided with a decrease in the forest coverage. On the other hand, there was a decline in population at an average of 38.3 percent in the Eastern Hills during the years 1991-2011 due mainly to out-migration (absent population). Further, a considerable internal trading appears to have occurred between land use categories, such as "forest" and "shrub" or "grassland," demonstrating a fluidity of land use. Shrubland and grassland are converted to more productive categories of forest land, reflecting the care of communities in managing and conserving their own forest resources. The private forest areas and shrubland are also being used for growing *Utis* cum *Amreso* (broom grass) and large cardamom. Change in the two land use categories – arable and forest of the Eastern Hills can be compared with that of neighboring districts including two Tarai districts - Morang and Sunsari and two hill districts - Ilam and Khotang. In the Eastern Hills, the forest coverage declined from 39.5 in 1986 to 37.5 per cent in 1996, but the arable land increased from 30.4 to 33.5 per cent during the same two years. Available sources indicate that arable land coverage of the Tarai two districts was 65 per cent in 1986 (LRMP 1986) that continued to increase to 74 per cent in 2000 (JFTA, 2001). But the forest coverage of these Tarai districts was only 24 per cent in 1986 and it further declined to 17 per cent in 2000. Over the past 14 years (1986-2000), there was virtually no change in arable land coverage in the neighboring two hill districts, but the forest coverage declined from 53 per cent in 1986 to 40 per cent in 2000.

Climate change impacts seem to have occurred on land use in the Eastern Hills. Studies on agriculture in the six case villages of the Dudhkoshi basin depict that the effects of a much weaker monsoon were evident, particularly in relation to crop production in 2009. As a result, many rice terraces were left unplanted due to lack of sufficient water, and many rice crops that were planted dried out and left unusable due to the delay in consistent rainfall. Further, the study in Terhathum district carried out in 2011 found that the Monsoon rainfall with its erratic behavior got to be delayed the onset of the monsoon over the last 10 years and increasing cases of dry spells during the monsoon period. There has been changes in behavior in rainfall pattern, for instance, winter rain has been highly variable with almost none falling in the past 2 years. Cash crops such as cardamom, ginger and broom grass, which were proliferated in Terhathum, reduced in harvests and thus income due to decrease in water availability. In addition, the study also predicts that there is likely to be an increasingly positive correlation between urban migration and impacts of climate change, with more and more "climate refugees" moving to urban areas. Furthermore, farming land abandonments across different parts of the Eastern Hills have been observed due to decreases in manure supplies from livestock, as well as in agricultural labor forces, the latter is a recent phenomenon whereby youth migrants have a tendency to leave their areas in abroad for employment.

Change also has occurred in the trading pattern through the traditional trade centers such as Chainpur, Dhankuta and Olangchung of the Eastern Hills. These towns have evolved through historic time from the traditional role of long distance trading posts or centres of entrepôt trade for facilitating complementary goods between Tibet and India now to the market integration of local products. Some of the major development events occurred in the Eastern Hills in the early 1970s and 1980s that brought about changes in the existing marketing pattern and extended market integration with the Tarai and other parts of the Hills included: Dhankuta as a regional headquarters centre of the Eastern region, shift of district headquarters from Chainpur to Khandbari in Sankhuwasabha, development of Hile town by the families from Olangchung who established trade outlets there, construction of the Dharan-Dhankuta highway, and agriculture improvement programme. Those families at Hile town continued to live entirely on trade in cloth and other consumer goods, but since the last few years, the trading pattern has been changed and included *Chiraito* and cardamom of local produce as the most important trading commodities. A number of enterprises based on the non-timber forest products appear to have existed to produce essential oils, handmade paper, fruit squash, briquettes, herbs and Chiraito, and *Allo* based handicraft production (Kunwar et al., 2009).

Improvement in some of the social indicators such as education and health can be attributed to land use change and development impacts. In 2001, literacy rates for males and females in the Eastern Hill were 65 per cent and 42 per cent respectively which increased from 1971, showing also relatively better as compared to those of other regions in the country. The increase in adult literacy and in the levels of education among both males and females has had likely impact on economic profile of the population, which has been changing with an increase in non-farm (services, clerical jobs and sales) and off-farm employment opportunities. The Eastern Hills saw a decrease in the fertility rate and increased knowledge about health care, which can be correlated with the rising educational status. The proportion of malnourished children below 3 years of age declined from around 30 per cent in 1994 to below seven per cent for three districts except Dhankuta. The Safe Motherhood Innovation Project (SMIP) found that there was an increase in awareness and utilization of maternal health services from 22 percent in 2004 to 66 percent in 2007. The GIS analysis shows that preponderant proportions of population found to have lived within 3 km buffer zone of the health facility location in the years of 1996 and 2010, which were either due to moving of people closer to facility location or improved in the number of health facilities, or both. This is very significant, since roads are available connecting only few places across the region. In case of road accessibility, there are still largest proportions of population living within 'above 5 km' buffer zone, indicating enormous travelling time required to reach the road-head point, though there was a significant decline of the population living in this buffer zone in 2010 compared to 1986.

CONCLUSIONS

A significant change has occurred in all land use categories in the Eastern Hills of Nepal over the past 24 years. Forest land and arable land have increased, while shrubland and grassland decreased. There exists a considerable internal trading between land use categories, especially forest and shrub or grassland, demonstrating a fluidity of land use across the Eastern Hills. These changes have several implications in land use policy measure and planning.

The distribution of population appears to be closely associated with the arable land in the Eastern Hills. Over 90 percent of the population clusters are concentrated in two elevation zones: 1000-2000m and over 1000m, where over 90 percent of the total arable land is found. Two reasons to explain it are: (i) increase of population between 1991 and 2001 across the entire Eastern Hills and (ii) internal shift of population within the same zone, as well as in areas having facilities of roads and other facilities such as schools, health and markets. Yet, no improvement has taken place significantly in the long existing traditional pattern of scattered settlements over the hills that are extremely lagging behind in the basic facilities and development indicators.

Government's development initiatives appear to be crucial towards impacting on land use change. For instance, the Community Forestry Programme and the Makalu-Barun National Park have contributed to increase and conserve the forest coverage in the Eastern Hills. Further, the Community forestry activities have possibly contributed to a significant improvement in availability of fodder, fuel wood, and fruit tree resources, providing a beneficial effect on the balance of land use. Shrubland and grassland are being converted to more productive categories of forest land, reflecting the care of communities in managing and conserving their own forest resources. Similarly, intensification in agriculture production systems including growing of off-season vegetables, seeds, large cardamom, ginger, fruits and livestock rearing has occurred due to improved agriculture development programmes and building of roads linking producing areas and demand centers for export of local products.

The GIS digital database being created provides benchmark of land use and change in the Eastern Hills for the three map point-years: 1986, 1996 and 2010. However, the GIS mapping tool should also be used to look into further spatial analysis such as factors of remarkable changes in land use, social and economic impacts on land use, facility accessibility, flows of goods and people between places over time, etc. Such spatial database on land use requires updating in the future to see the impacts of human intervention on changing land uses vis-à-vis cultural landscape change.

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CHANGES IN LANDSCAPE METRICS INDUCED BY DEFORESTATION IN ROSCI0358 PRICOP-HUTA-CERTEZE NATURE 2000 SITE

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ABSTRACT. – Changes in Landscape Metrics Induced by Deforestation in RoOSCI0358 Pricop-Huta-Certeze Nature 2000 Site. The paper analyzes the changes in the landscape structure within the territory of the Site of Community Interest ROSCI0358 Pricop-Huta-Certeze as a consequence of deforestation. Deforestations between 1972 and 2010 were analyzed and mapped. GIS instruments have been used in order to identify the changes in the spatial structure of landscape units induced by deforestation (changes in land parcels shape, number, edge etc.) by the help of some relevant landscape metrics indices. Results are discussed in relation to the protection status of the area (included in the Nature 2000 ecological network) and its conservation objectives.

Keywords: *landscape assessment, landscape metrics, deforestation, Nature 2000*

1. INTRODUCTION

Landscape structure and the resulting spatial patterns can be described and quantified by means of landscape metrics (Waltz, 2011). Such instruments have been used for more than 20 years in Europe and North America in cavrious scientific and experimental areas (Waltz, 2011). During the last period, diverse applications have been developed in various fields, such as spatial planning (Botequilha Leitão and Ahern, 2002, Szabo et al., 2012), road network development (Patarasuk, R., 2013, Fu et al., 2010, Corpade et al., 2014), landscape connectivity (Saura et al., 2011), ecosystems and landscape monitoring (Tasser et al., 2008), nature protection (Blaschke, 2000, Uuemaa et al., 2009, Vorovencii, 2015).

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ROSCI0358 Pricop-Huta-Certeze, with a surface of 3168 ha, was declared in 2011 as Site of Community Interest (Nature 2000 Ecological Network), in order to preserve or enhance the conservation state of 3 deciduous forest habitats, 5 mammals and 3 amphibians. It is located in north-western of Romania, in the volcanic mountainous and pre-mountainous area of Oaş Mountains and overlaps the administrative territory of four communes in Maramureş and Satu-Mare Counties (Remeţi, Săpânţa, Bixad and Certeze). The site is mainly covered by forests (2118 ha), being managed by two forest ranges: Negreşti-Oaş (Satu-Mare County) and Sighetu-Marmaţiei (Maramureş County).

By approaching landscape assessment in nature protected area, the paper will provide with scientific knowledge for using landscape assessments in the management of nature protected areas. Landscape metrics is used to analzye the composition and spatial arrangement of landscapes (size, shape, edge etc.). Using landscape metrics in protected areas management is extremely important, as protected areas features changes throughout time, driven by natural or cultural forces and landscape indicators could point out the evolution of these changes and provide with important information for management and monitoring (Corpade et al., 2016). At the same time, biological diversity in all its dimensions and facets is always tied to habitats, which need a concrete territory for their existence (Waltz, 2011). Biological diversity is therefore always defined for a certain reference area, and landscape structure is a key element for the understanding of species diversity (Waltz, 2011). Spatial diversity or heterogeneity, as an indicator of landscape structure, is an essential element for the explanation of the occurrence and distribution of species from the local to the global level (Ernoult et al., 2003). At the same time, deforestation is also an important issue to be analzyed, taking into account the major ecological services that forests provide with. Despite their ecological importance and sometimes despite the protection status, in Romania, forested areas continue to decrease in surface at alarming rates due to deforestation, storm damages, improper logging practices or fires. Ecosystem services they provide (such as genetic resources, protection from natural hazards and riparian functionality) are thereby diminished (Keeton et al., 2007; Wirth et al., 2009, apud Knorn et al., 2012) and biodiversity they harbour is threatened (Knorn et al., 2012).

2. MATERIALS AND METHODS

Deforestations were analyzed and mapped between 1972 and 2010 by digitizatizing them from topographical maps (1972 edition), ortophotoplans (2006 and 2010 editions) and satellite images (2014 edition).

Two datasets of land cover types distribution in the envisaged Nature 2000 site were generated, one taking into account the deforested areas and another one in which the deforested areas were assimilated to the primary land cover type or habitat, point thus out how these practices influenced landscape structure.

In order to express landscape cover changes induced by deforestation, a spatial analysis method applied to landscape units was applied. The input database consisted of Corine Land Cover Database 2006 and 2012. For the statistical analysis of landscape structure for the two databases (with deforestation and without deforestations), we employed Patch Analyst (PA), an ArcGIS extension that facilitates the spatial analysis of landscape patches and the modeling of attributes associated with patches (Corpade et al., 2014). The program includes capabilities to characterize patch pattern and the ability to assign patch values based on combinations of patch attributes (Corpade et al., 2014). Patch Analyst can calculate not less than 15 landscape indicators, but for the paper purpose we have considered that four were more relevant as they can outline the evolution of land cover changes induced by deforestation in the analyzed protected area: Number of Patches, Mean Patch Size, Total Edge and Edge Density.

NumP (Number of Patches) measures the total number of patches of a specified land use or land cover class. When NumP is too high, it indicates that the patch class is highly fragmented. The total number of patches in a landscape results from first defining connected areas of each cover type *i* (Gergel and Turner, 2005, Corpade et al., 2014).

Patch density and size metrics (Mean Patch Size). Mean Patch Size (MPS) is an indicator representing the average size of patches of a particular class level or of the whole landscape. According to McGarigal and Marks (1995), patch area is one of the most important and useful information that can be obtained in a landscape analysis.

Mean patch size is often used when assessing landscape undergoing transformation induced by urban or transportation sprawl. MPS at the class level equals sum of the area of the patches across all patches of the corresponding type divided by the total number of patches of the same type, being calculated through the following formula (Leitao et al., 2006, Corpade et al., 2014):

$$\text{MPS} = \frac{\sum_{j=1}^{n} a_{ij}}{n_i} \quad (1)$$

a_{ij} = area of the patch (m^2) and n_i = number of patches in the landscape of patch type.

Edge Metrics (Total edge, Edge Density). Edge calculations provide a useful measure of how dissected a spatial pattern is and can be calculated in a variety of ways. An edge is shared by two grid cells of different cover types when a side of one cell is adjacent to a side of the other cell. The total number of edges in a landscape can be calculated by counting the edges between different cover types for the entire landscape, every edge being counted only once (Gergel et al., 2002, Corpade et al., 2014).

Edge density (in m/ha) equals the length (in m) of all borders between different patch types (classes) in a reference area divided by the total area of the reference unit. The index is calculated as:

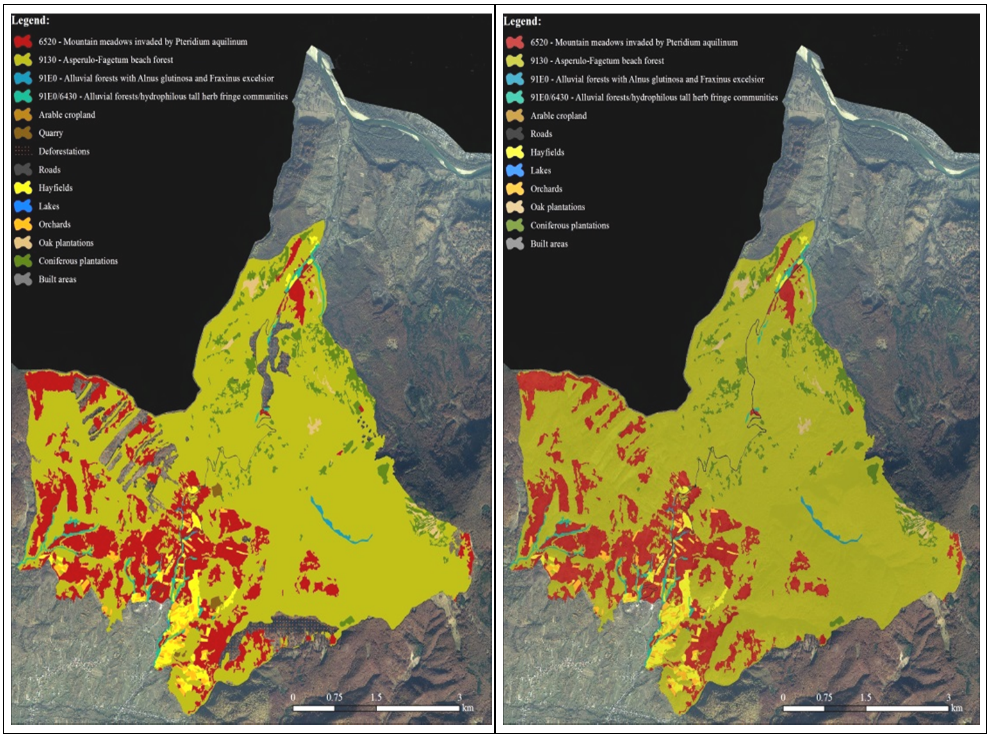
$$ED = \frac{E}{A} \quad (3)$$

E = total edge (m)
A = total landscape area (ha)

After calculating the landscape metrics indicators for both envisaged years, the transition of land cover types between 2006 and 2012 was calculated, in order to identify ecosystems evolution trends and provide with useful instruments in the management of the area and act as basis for the setting of appropriate conservation measures.

3. RESULTS AND DISCUSSIONS

The analysis of the land cover types distribution (Fig. 1) outlines some important changes in the landscape composition, as well as in the natural habitats distribution. Between 1972 and 2010, around 110 ha of forests were cleared. Deforestation mainly took place in Sighetu-Marmaţiei Forest Range, along Sugătagu Mare Valley, near the national road no 19, but also in Negreşti-Oaş Forest Range, within Şesu Forest. Deforestation occurred for industrial purposes, some volcanic rock quarries being open here, but also for domestic purposes, wood exploitation being a traditional occupation in the area and one of the most profitable and in spite of the protection status of the Nature 2000 site, it is still present, degrading the natural habitats, the biotopes of the protected species and the landscape as a whole. Two land cover types appeared in the landscape as a result of deforestation: quarries (4 patches) and deforested areas (48 patches).



a. With deforestations b. Without deforestations

Fig. 1. Land-cover types

As related to landscape metrics indicator, the following conclusions could be mentioned (Table 1, Figure 2):

- All the changes in landscape structure occurred within the territory occupied by the habitat 9130 *Asperulo-Fagetum* beech forests, whose total edge, mean patch size and edge density decreased slightly, while the number of patches increased;
- Deforestation did not affect any other land cover type in the focused Nature 2000 site, it did not even trigger the extension of forest roads, meaning that deforestation took place near existing roads;
- Fragmentation of landscape increased slightly, as the total number of patches increased with 52 new patches.

Table 1. Numeric results of the landscape metrics analysis for ROSCI0358 Pricop-Huta-Certeze without deforestation

No	Land cover type	Total edge (m)	Edge density (m/ha)	Mean Patch Size (ha)	Number of patches
1	Habitat 6520	188595.79	59.50	3.40	153
2	Habitat 9130	307779.52	97.10	15.63	151
3	Habitat 91E0	4952.42	1.56	1.90	4
4	Mixed habitats 91E0_6430	32479.39	10.25	1.27	29
5	Arable cropland	580.44	0.18	0.07	5
6	Roads	21821.41	6.88	3.15	3
7	Hay fields	36437.86	11.50	1.13	57
8	Built area	4103.20	1.29	0.02	66
9	Coniferous forests	81713.77	25.78	0.65	176
10	Oak plantations	15946.57	5.03	0.72	30
11	Orchards	24847.74	7.84	0.35	91
12	Lakes	169.56	0.05	0.02	3

Table 2. Numeric results of the landscape metrics analysis for ROSCI0358 Pricop-Huta-Certeze with deforestation

No	Land cover type	Total edge (m)	Edge density (m/ha)	Mean Patch Size (ha)	Number of patches
1	Habitat 6520	188595.8	59.50	3.40	153
2	Habitat 9130	333250.2	105.14	13.7	158
3	Habitat 91E0	4952.42	1.56	1.90	4
4	Mixed habitats 91E0_6430	32479.39	10.25	1.27	29
5	Arable cropland	580.44	0.18	0.07	5
6	Querry	2168.84	0.68	1.80	4
7	Deforestations	52624.22	16.60	3.95	48
8	Roads	21821.41	6.88	3.15	3
9	Hay fields	36437.86	11.50	1.13	57
10	Built area	4103.20	1.29	0.02	66
11	Coniferous forests	81713.77	25.78	0.65	176
12	Oak plantations	15946.57	5.03	0.72	30
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14	Lakes	169.56	0.05	0.02	3

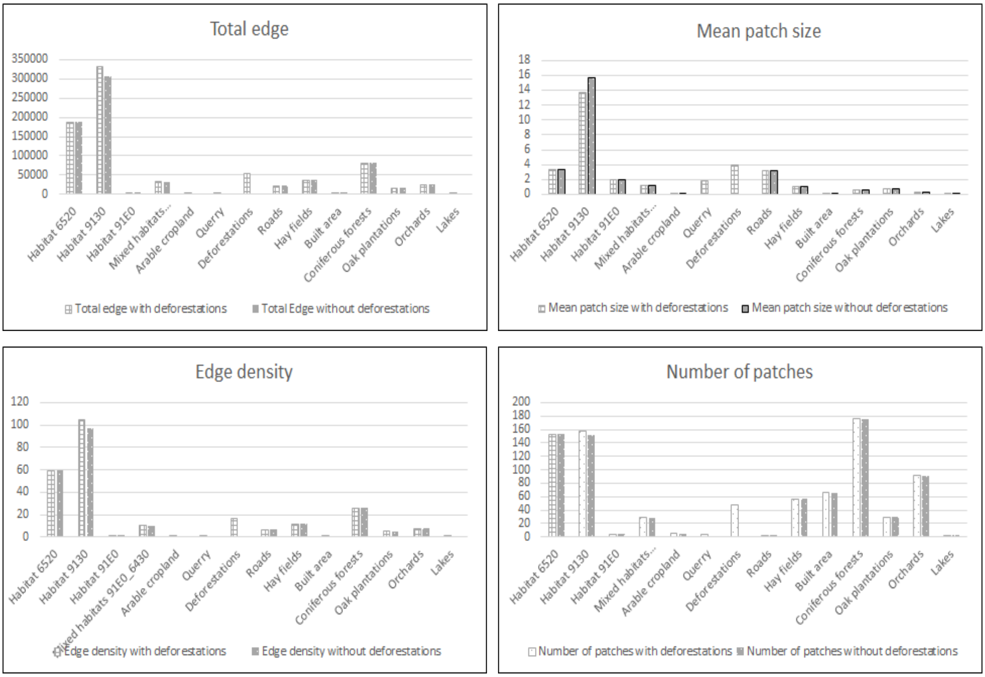

Figure 2. Graphic results of the landscape metrics analysis for ROSCI0358 Pricop-Huta-Certeze

4. CONCLUSIONS

As a conclusion, it can be stated that because biological diversity is rather complex, most researchers choose to analyze it at the habitats and species level. Through this paper, we intended to prove that landscape analysis can be a good tool in biodiversity monitoring as significant changes in landscape metrics values can serve as early warnings, pointing out the demand for further detailed investigations and thus protected areas management and monitoring become more efficient and less costly, as investigations in the field requires far more time and money. In the case of the analyzed area, deforestations and the induced change of the landscape pattern may endanger the favourable conservation status of the protected forest habitats, thus forestry management in the area should be reconsidered and, besides the economic value of the forest, the ecological one should receive more attention.

ACKNOWLEDGEMENTS

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VARIABILITY AND TRENDS IN THE VIȘEU RIVER RUNOFF REGIME

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ABSTRACT. – Variability and Trends in the Vișeu River Runoff Regime. The classic hydrological water management dealt with the changing resources by assuming the existence of stationarity. Once stationarity is neglected in the design of hydraulic engineering, numerous errors and risk may exist in the operations and management strategies and will lead to unforeseen losses. Thus, one of the most important questions in today's hydrology are: *Did stationarity die*? and if it is true *How did stationarity die*? As we know the climatic change is widely accepted so it is sad that by 2050 the effects of climate change may have a generally larger effect on flow regimes than it is estimated that dams and water withdrawals. If this is so, we must consideration that in this moment one of the most important aspect/moment is the change point identification in a period, from where significant change has occurred in a time series, for this we choose to use the Ms Excel Addinsoft XLStat to assess the homogeneity of the data by the Pettitt's test, the von Neumann ratio test, the Buishand range test and also the standard normal homogeneity tests (SNHT). For the trend analysis we used the Mann-Kendall test and the classic linear regression test. Based on the results, we conclude that in case of the Vișeu watershed stationarity is questionable if not totally missing. As we see even if the precipitation values do not show significant changes regarding their homogeneity, the runoff series are changing, and in most cases this change is identified in the 20thcentury last decade. These results urge us to rethink and to reevaluate our sustainable water resource management for the future.

Keywords: *Vișeu Catchment, runoff trend, change point detection, statistical tests, Mann-Kendall test*

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INTRODUCTION

Over the last century, a global environmental change which seems to be the result of human activity mainly has become increasingly noticeable (Vitousek et al., 1997; Vorosmarty et al., 2000, IPCC 2014, Zhang et. al., 2016). The change is mainly due to climate change and is primarily characterized by the change in precipitation and temperature and in the magnitude and occurrence of extreme climatic phenomena like droughts and floods. Taking into considerations the significant global hydrological changes, they are characterized by reductions in water resources and significant increasing of extreme hydrological events.

In various areas due to the climate change and also due to human activities, which changed the land use/cover and implemented large-scale water management projects, the extremes are intensifying. In general, the man-made changes resulted in numerous complications, such as water shortages, floods, and droughts (Vorosmarty et al., 2010).

The classic hydrological water management dealt with the changing resources by assuming the existence of stationarity. As we know stationarity represents the notion that all natural systems fluctuate within an unchanging limit, is a fundamental assumption of designs and operations in water resource engineering. Once stationarity is neglected in the design of hydraulic engineering, numerous errors and risk may exist in the operations and management strategies and will lead to unforeseen losses.

Milly et al. (2008) rises the problem that stationarity in case of hydrological data series is continuing to decrease due to human disturbances in river basins. Thus, it is necessary to identify and study these variations in order to understand the changing hydrological processes and select the most appropriate methods for hydraulic engineering design and water resources management in the future (Galloway, 2011).

Thus, one of the most important questions in today's hydrology are: *Did stationarity die?* and if it is true *How did stationarity die?* As we know the climatic change is widely accepted so it is sad that by 2050 the effects of climate change may have a generally larger effect on flow regimes than it is estimated that dams and water withdrawals have had until now (Döll and Zhang, 2010). Taking this to consideration we can say that stationarity is dead because men's considerable impact on Earth's climate is altering the characteristics of precipitation, evapotranspiration and automatically the rivers runoff.

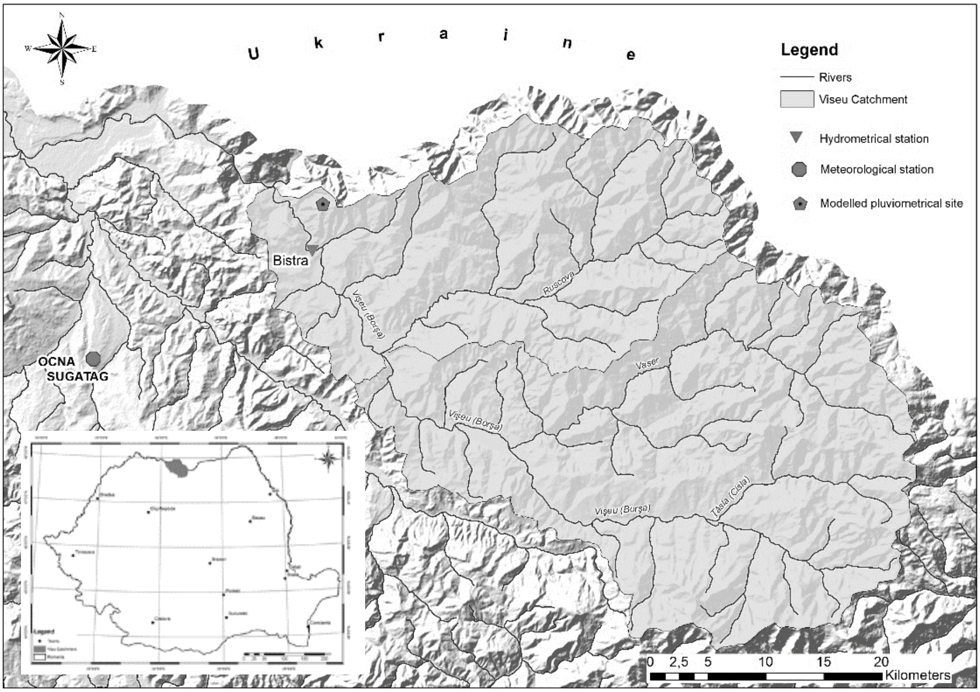

Fig. 1. Vișeu watershed – study area

STUDY AREA, DATA AND METHODS

As the main tributary of the Tisa River from Romania's Maramureș Basin, Vișeu River gathers its waters from a 1606 km^2 catchment and it is 80 km long. In significant parts (over 60%) the catchment is characterized by a mountainous relief, collecting the waters from the slopes of the Maramureș and Rodna Mountains with heights over 2300 meters. The high mean altitude (997 m) and the northern position give its runoff regime a moderately nival characteristic (Ujvari, 1972).

For the analysis we used mean monthly discharge data from Bistra hydrometric station, for the 1950-2008 period, the discharge data was taken from the GRDC (Global Runoff Data Centre) database. Even if in the Vișeu catchment there are several other hydrometric stations, we have chosen Bistra because all major tributaries flow into Vișeu River before this station; for this reason, the stream flow measured here can be considered the best indicator of stream flow in the study area

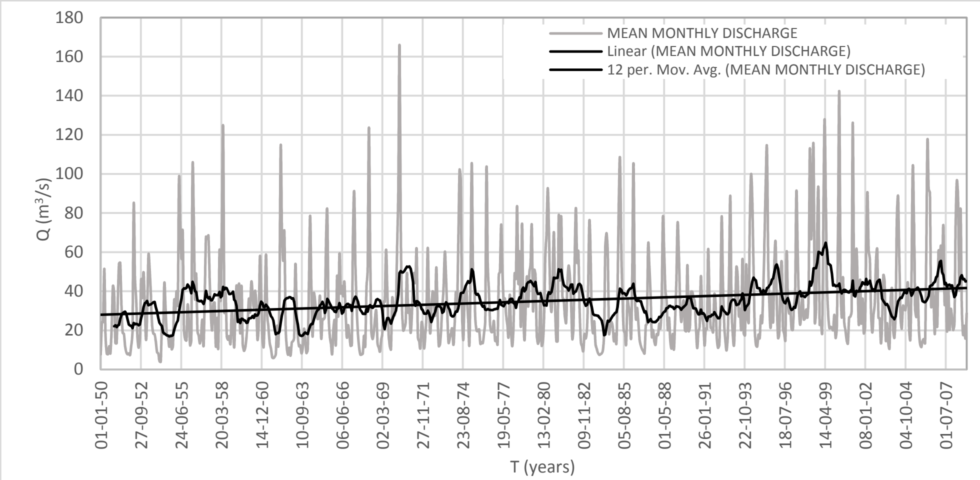

Fig. 2. Vişeu hydrometric station 1950-2008 mean monthly discharge data

Also we used mean monthly precipitation values from two sources, a measured one at Ocna Şugatag and a modeled one from the CARPATCLIM project. For this we choose the closest point generated by the models to the hydrometrical station, the correlation analysis between the two pluviometric data points shows a good coefficients of determination (R2): 0.85 (fig. 3), so we considered that the modeled data (which is closer) will be sufficient for the analysis.

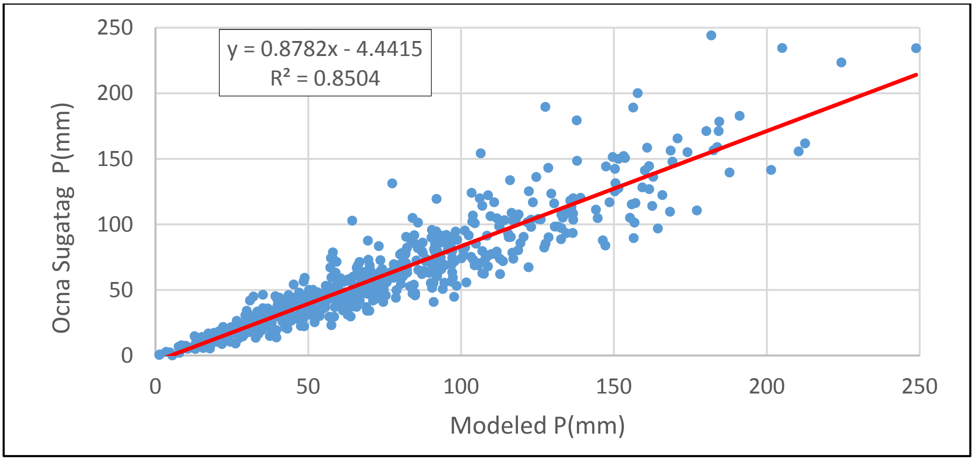

Fig. 3. Correlation between the measured and modeled (CarpatClim) precipitation data CARPATCLIM Database © European Commission - JRC, 2013

Taking into consideration that in this moment one of the most important aspect/moment is the change point identification in a period, from where significant change has occurred in a time series (Jaiswal et al., 2015), we choose to use the Ms Excel Addinsoft XLStat to assess the homogeneity of the data by the Pettitt's test, the von Neumann ratio test, the Buishand range test and also the standard normal homogeneity tests (SNHT). We summaries in a few lines the details of various change point tests applied in the study.

The Pettitt's test for change detection, developed by Pettitt (1979), is a well-documented non-parametric test, which is useful for evaluating the occurrence of abrupt changes in data series, it is the most commonly used test for change point detection because of its high sensitivity to breaks. The Pettitt's test is a method that detects a significant change in the mean of a time series when the exact time of the change is unknown (Winingaard, 2003, Jaiswal et al., 2015).

The von Neumann ratio test is closely related to first-order serial correlation coefficient (WMO 1966). According to the von Neumann ratio test, if the sample or series is homogeneous, then the expected Neumann value equals 2 under the null hypothesis with constant mean. When the sample has a break, then the value of the test must be lower than 2 otherwise we can imply that the sample has rapid variation in the mean (Jaiswal et al., 2015). The standard normal homogeneity (SNH) tests statistic is used to compare the mean of first n observations with the mean of the remaining (n-k) observations with n data points.

We analyzed also if we can identify a trend in the data series, for this we chose the widely used Mann-Kendall test which is recommended because it is a non-parametric test which does not require the data to be normally distributed; this test has also a low sensitivity to abrupt breaks due to inhomogeneous time series (Jeneiová et al., 2014, Jaiswal et al., 2015), which is important in case of hydrological data, also we analised the data with the classic linear regression test, which supposes that a straight line is fitted to the data and the slope of the line may be significantly different from zero or not.

ANALYSIS AND RESULTS

In the present study, first we ran various change point tests including Pettitt's test, von Neumann's ratio test, Buishand's range test and SNH test to detect change point in monthly, annual and seasonal discharge series at Bistra station (Jaiswal et al., 2015) and also at the nearby pluviometric modelled point.

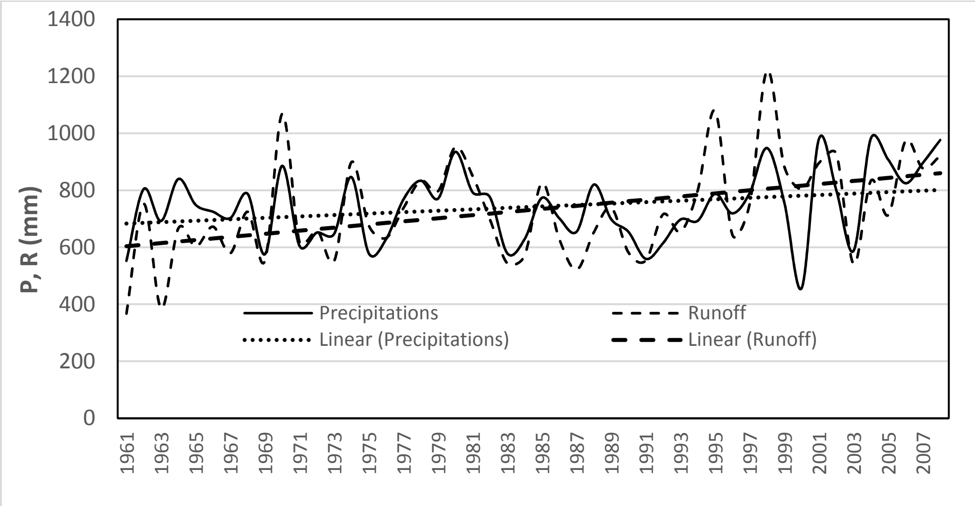

Fig. 4. Visual comparison of the mean yearly precipitation and runoff values

First, we analyzed the precipitation data series assuming a good correlation between the precipitation values and the runoff, because of the spatial nearness, as the Fig. 4 shows in part there is a one, until the 90s than the runoff values increase significantly returning to previous values only at the end of the 20th century. Change can be identified also in the precipitation data in this interval, besides the Pettitt's test which is also close (table 1), all tests present a change in the precipitation data series, thus they are not homogeneous. The von Neumann's test N value is 1.688 in case of the monthly data and 1.708 in case of the mean yearly data, this test doesn't identify the change point but it shows that there is one. All the other test identified change in the 90s (Table 1).

Table 1. Change point detection test results monthly precipitation data (1961-2008)

Buishand's test		**Standard normal homogeneity test**		**Pettitt's test**	
Q	32.636	T0	10.193	K	9304.000
t	01.04.1997	t	01.03.1998	t	01.05.1993
p-value	0.043	p-value	0.070	p-value	0.118
alpha	0.1	alpha	0.1	alpha	0.1

We must emphasize the fact that in case of the mean monthly or mean yearly data there are only a few cases when the test identified change, largely the results show homogeneous data series.

The results regarding the homogeneity of the runoff data are different, the tests show in numerous cases in the 90s a change in the data series (table 2).

Table 2. Change point detection test results runoff data (1950-2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Pettitt's test:	1992	1993	1993	1997	1977	1968	1968	1971	1974	1988
SNHT	2006	2006	1998	1997	1969	1964	2007	1954	1976	1990
Buishand's test:	1993	1993	1993	1993	1969	1964	1968	1954	1976	1990
Neumann's test										
	Nov	**Dec**	**Spring**	**Sum.**	**Aut.**	**Wint.**	**Year**	**Max**	**Min**	
Pettitt's test:	1968	1988	1993	1968	1988	1988	1993	1993	1992	
SNHT:	1989	1988	1993	1954	1989	1992	1993	1993	1994	
Buishand's test:	1989	1988	1993	1968	1988	1992	1993	1993	1994	
Neumann's test										

SNHT - Standard normal homogeneity test
- white squares - Data are homogeneous, no change detected
- grey squares - There is a date at which there is a change in the data

1993 is the year in which the test identified the most change points in runoff (March, Spring, year) (fig. 3).

The XLStat MS Excel Addin can automatically generate the chart form of the analysis, thus we can follow also visually the change in the data series evolution (fig. 5).

After the homogeneity analysis, we used the Mann-Kendall test to assess if there is a trend in the data series. In case of the monthly precipitation data there is no trend identified in the series but in case of runoff we identified an increasing trend in both form of the test, the classical and the seasonal. Regarding the other analyzed data intervals the results show and increasing trend in both cases, but in case of the precipitations only in one month (September) and in case of the runoff in six (table 3).

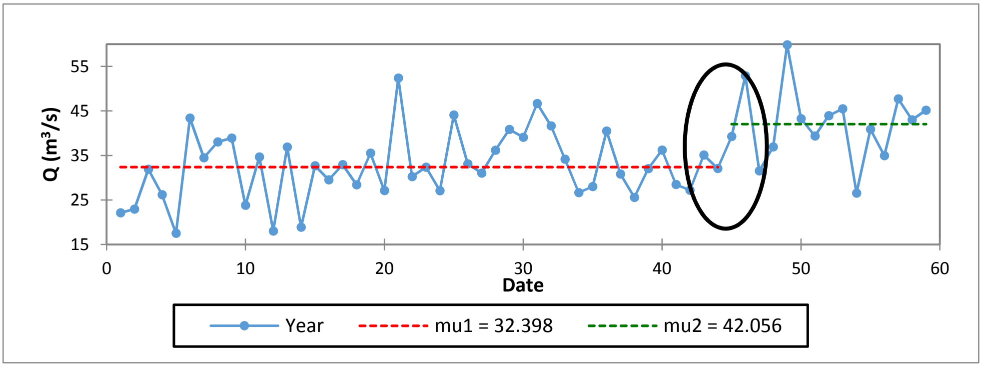

Fig. 5. Example of change point detection with the Standard normal homogeneity test (SNHT) yearly mean runoff 1950-2008

In case of the four seasons the precipitations shows an increase only in the autumn and the runoff increases in the winter and summer. The extremes show also an increase trend in case of the maxima for both series and also in case of the runoff for the minima. The Sen's slope it is positive in all cases for the runoff and in case of the precipitation shows negative values only in 3 months when the test doesn't identify a trend anyhow.

Table 3. Mann-Kendall test results interpretations

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitations	-	-	-	-	-	-	-	-	↑	-
Runoff	↑	-	↑	-	↑	-	-	-	↑	↑
	Nov	**Dec**	**Winter**	**Spring**	**Summer**	**Autumn**	**Max**	**Min**	**Year**	
Precipitations	-	-	-	-	-	↑	↑	-	↑	
Runoff	↑	-	↑	-	↑	-	↑	↑	↑	

- There is no trend in the series
↑There is an increasing trend in the series

For the long-term variation of the data series we analyzed the data also with the classic linear regression test, which supposes that a straight line is fitted to the data and the slope of the line may be significantly different from zero or not, in case of the runoff all the data shows a positive increasing trend, only in case of the precipitations there are three month (June, November, December) in which the trend is negative, in case of the monthly values as shown in the Fig. 4 both trends show an increasing slope.

CONCLUSIONS

Assessing the temporal variation of various climatic variables due to a possible climate change or direct human intervention it is unquestionably important for water resources planning and management at both the regional and local scale. In the present study we used several change point detection tests which were followed by two type of trend analysis with different non-parametric statistical tests to identify these variations. The change point has been detected using Pettitt's test, von Neumann ratio test, Buishand's range test and standard normal homogeneity test on monthly, seasonal and annual long-term series, in case of the trend analysis for the same time intervals we used the Mann-Kendall test and the classic linear regression test to identify the variation's trend.

We must conclude taking into consideration the results of this study that in case of the Vișeu watershed stationarity is questionable. As we see even if the precipitation values don't show significant changes regarding their homogeneity, the runoff series are changing, and in most cases this change is identified in the 90s, the 20th century last decade. These results urge us to rethink and to reevaluate our sustainable water resource management for the future.

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MONITORING THE EFFECTS OF EXCESSIVE USE OF CHEMICAL FERTILIZERS ON UNDERGROUND WATERS BY USING THE GIS TECHNIQUE

GABRIELA BIALI[1]

ABSTRACT. – Monitoring the Effects of Excessive Use of Chemical Fertilizers on Underground Waters by Using the GIS Technique. This paper highlights the increase of nitrates and nitrites content in the underground waters, in correlation with the levitation to the underground of the nitrogen quantity on the agricultural lands, by using a modelling method through the GIS technique.

The research is conducted for the underground waters of an area of Prut River catchment, and for the assessment of NO_2, NO_3 concentration, water samples are taken from a limited number of boreholes (44 boreholes). These boreholes are randomly distributed in the area and only some pieces of information are acquired from the laboratory tests. Based on this source data, by means of an interpolation method under software Surfer 8.1, the maps of NO_2, NO_3 concentration distribution were created. The spatialisation is made on 1880 cells and the results set out herein are at the level of a 2015 survey year.

The Romanian Law on fresh water sets out that although the nitrites and nitrates are within the admitted maximum limits 0.5 mg/l and 50 mg/l, respectively, another indicator should also be taken into consideration:

$$\frac{Nitrates}{50} + \frac{Nitrites}{3} \leq 1$$

Thus, in the application, the mathematical modelling generated a map of the above mentioned indicator distribution. One can notice that, under certain circumstances, although the NO_2 and NO_3 indicators are within the admitted maximum limits, this indicator is still exceeded. This leads to the conclusion that in certain areas of the analyzed region there is significant chemical pollution, fact that leads to safety actions concerning the use of well water.

Keywords: *modelling, underground waters, spatial distribution*.

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1. INTRODUCTION

The incorrect irrigation and drainage, associated with other inappropriate practices (monoculture or short term cropping systems, excessive loosening of the soil, especially through numerous superficial works etc.) to which are sometimes added the inexistence of anti-erosion systems of culture on the agricultural versants, determine the appearance and intensification of physical and chemical degradation of lands.

Both the physical pollution through processes such as: water or wind erosion, the destructuring, compacting etc. and chemical pollution through the alluvial transport with significant pesticide quantities, contribute in this manner even more to sensitizing, favouring and emphasizing the degradation of the quality of underground waters, considered as being "*the last hope of drinkable water*".

The activity of knowing the quality of underground waters is carried out at the level of large hydrographic basins, on morphological units, and within them, on aquiferous structures (underground), through the hydrogeological stations, comprising one or more observation forages.

The probable causes for which in the majority of causes the groundwater do not correspond to the requirements to use them in potable purposes:

- The pollution of surface waters;
- The conditions and natural hydro geochemical processes that favour the passage to solution of different anions and cations;
- The intensive development of agriculture in the last decades with the excessive use of chemical fertilizers based on azoth and phosphor and of pesticides, led to their accumulation in the soil (or the accumulation of degradation products);
- The effects of the passivity of former zootechnical complexes of high capacities regarding the measures for the conservation of environment factors;
- The climatic, hydro geological particularities and the exploitation of irrigation systems that contributed to the mineralization of organic matter from the soil and the migration of substances resulted from these processes.

A special problem regarding the quality of underground waters is represented by their content in nitrates -NO_3 and nitrites -NO_2.

In order for the underground waters to be considered appropriate from the qualitative point of view, it is necessary that the quality indicators belong to the maximum admitters-MAC concentrations, imposed through the Law of Potable Water no. 410 /2002 modified and completed with Law 311/2004. In addition, the assessment of underground water quality supposes a complex action of interpreting all the quality indicators, of correlating the values obtained in the laboratory for different indicators, even in the situation that, by comparison with MAC, we ascertained that the concentrations were situated within these limits.

The main sources of accumulated nutrients are represented by the direct evacuations from agriculture, drains and erosion, and by the effluents of the localities' sewage stations.

We estimate that the largest part of the quantity nutrients is due to the sources from agriculture (diffusion sources). For the underground waters to be considered potable, the value of indicators NO_3 and NO_2 must be situated within MAC, imposed by the Law of potable Water (NO_3-50 mg/l, NO_2-0,5 mg/l). On the other hand, although the values of NO_3 concentrations, respectively NO_2 do not exceed MAC, a certain condition for which the following formula is applied, must be complied with:

$$\frac{nitrates}{50} + \frac{nitrites}{3} \leq 1 .$$

In which the nitrates and nitrites concentrations are expressed in mg/l.

2. STUDY AREA

The underground waters from the Prut River catchment area are quartered in porous-permeable deposits of Quaternary and Tertiary age disposed over older Cretaceous, Silurian and Presilurian formations, situated at different depths but which, because of climatic and layer conditions generally have reduced debits and high content of salts.

The underground waters within the Moldavian platform, in relation with the natural possibilities of drainage, respectively of their connection with the surface waters are: under pressure (depth) and phreatic (free).

In the category of free underground waters, we include the aquiferous waters without pressure, where we notice a supply area and an unloading area; therefore, they are naturally drained.

The phreatic waters are accumulated in the first horizon of permeable rocks and are supplied from precipitations, from the hydrogeological neighbour units and locally from the overflow of rivers.

The waters under pressure are accumulated in permeable deposits intercalated between the loamy-clay layers distributed on several levels are encountered in the areas sectioned by the valleys of rivers. The supply of this type of aquiferous is ensured from the hydrogeological superior units through the higher end of the layer and the drainage occurs through the lower end.

Most of the times, the deposit conditions are favourable to the water mineralization; to these, the salts from the soils washed from the infiltrated precipitations are frequently added, and as a result the phreatic waters have a higher mineralization degree.

In the Prut catchment area (Fig. 1) the groundwater are quartered in sandy deposits of quaternary age, with clay intercalations of small hydrogeological importance and gypsum horizons. In these conditions, the exploitable conditions are encountered in the rivers' meadows, in weakly permeable and sulphated deposits. Generally, we notice the sulphated waters with mineralization and high hardness with a reduced debit degree.

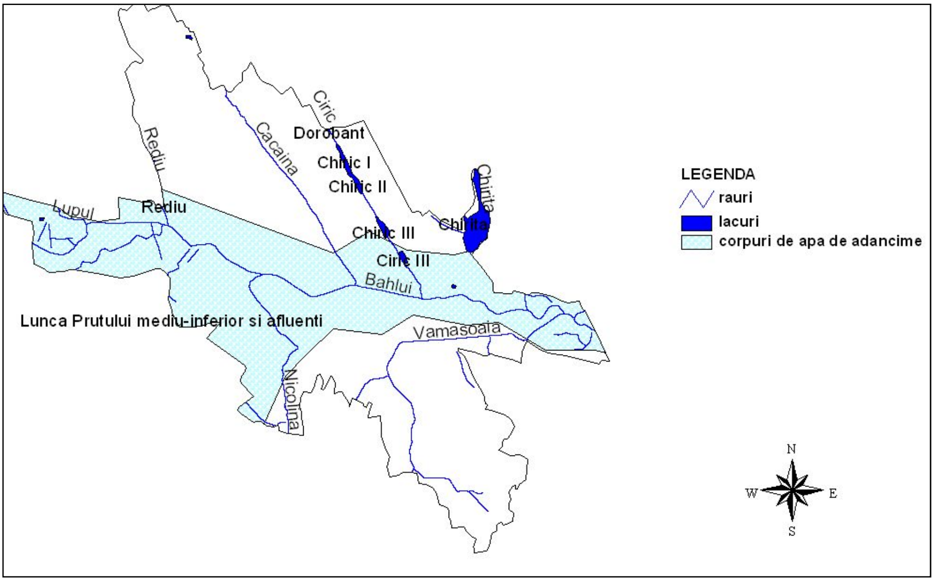

Fig. 1. Study area: Iași City

3. METHODS OF THE RESEARCH

3.1 Entry data

As entry data, we used the values NO_2, NO_3 (mg/l) determined in the Laboratory Water Quality belonging to the Prut Water Direction at the level of 2015. The analyses were made on water samples assayed from 44 observation forages from the Prut hydrographic basin (located through the STEREO 70 coordinates) belonging to the National System of underground waters quality Surveillance, e.g. (Table 1).

Then we calculated the value of the indicators assessing the water potability:

$$\frac{nitrates}{50} + \frac{nitrites}{3} \leq 1$$

Table 1. Drilling parameters of the study area

Forage no.	Plan coordinates in the STERO 70 projection		NO_2 (mg/l)	NO_3 (mg/l)	INDICATOR: $\frac{nitrates}{50} + \frac{nitrites}{3}$
	X (m)	Y (m)			
1	634150.562	751325.439	0.026	5.065	0.1100
2	633863.404	750817.791	0.42	44.67	1.0334
3	658289.763	722926.687	0.803	19.621	0.6601
4	667731.251	701856.350	0.0385	97.695	1.9667
5	667133.890	701741.096	0.016	0.8	0.0213
6	665339.264	701495.313	1.022	261.53	5.5712
7	696082.457	653053.352	0.570	5.80	0.3060
8	693880.402	653097.634	0.240	8.30	0.2460
9	690868.400	653521.559	0.05	3.70	0.0900
10	691156.982	650027.408	1.40	46.90	1.4030
11	691159.514	649927.431	0.37	5.75	0.2367
12	710883.965	637421.058	0.10	3.80	0.1095
13	706655.705	634513.032	0.38	5.55	0.2360
14	720455.610	622856.785	0.12	1.80	0.0743
15	717542.139	619381.882	0.15	1.00	0.0700
16	740100.524	589639.041	0.006	30.55	0.6130
17	747776.891	570825.278	0.0495	27.075	0.5580
18	743885.527	538616.078	0.008	27.385	0.5504
19	739858.249	611963.055	0	17.225	0.3445
20	615773.355	714936.515	0.0785	3.865	0.1035
21	646264.066	708012.499	0.023	3.35	0.0747
22	646069.205	707807.432	0.041	0.59	0.0255
23	645874.343	707602.365	0.052	16.275	0.3428
24	659898.363	683348.529	0.098	9.36	0.2199
25	658908.750	682923.178	0.169	9.715	0.2506
26	637665.861	688184.548	0.055	3.05	0.0793
27	646075.989	683997.085	0.0735	0.2975	0.0305
28	646222.338	658591.021	0.05	1.50	0.0475
29	711030.507	631622.380	0.09	8.80	0.2062
30	711249.593	634829.224	0.195	4.40	0.1530
31	649494.205	651871.758	0.03	2.25	0.0552

Forage no.	Plan coordinates in the STERO 70 projection		NO_2 (mg/l)	NO_3 (mg/l)	INDICATOR: $\frac{nitrates}{50}+\frac{nitrites}{3}$
	X (m)	Y (m)			
32	655811.718	647330.530	0.07	1.25	0.0488
33	655421.985	646920.496	0.02	1.20	0.0292
34	657439.168	646271.449	2.02	1.54	0.7045
35	657113.880	647263.549	0.45	43.50	1.0200
36	637851.363	720103.554	0.066	2.65	0.0750
37	670722.327	674719.812	0.38	3.85	0.2020
38	748618.872	557241.570	0.467	48.65	1.1287
39	746724.431	556993.839	0.0085	11.615	0.2351
40	745319.914	580868.538	0.015	1.06	0.0262
41	745945.104	546232.553	0.043	2.675	0.0678
42	745845.131	557225.907	0.021	0.275	0.0125
43	749219.143	602851.455	0.06	0.775	0.0355
44	746924.780	592018.866	0.03	0.97	0.0294

3.2 The creation of thematic layers regarding the distribution of NO_2, NO_3 concentrations

Because their evaluation is made by assaying water samples from a limited number of forages distributed randomly in the territory, according to the laboratory analyses, only punctual information is obtained (Biali et al., 2013).

Starting from a limited number of forages and respectively samples, it is only possible to approximately assess the quality of underground waters from the entire territory, being difficult to elaborate in due time the most adequate intervention measures.

Starting from this source data, the concentrations of different pollutants (in the case of our application) represented in MNT are generally derived with the help of an interpolation. For this application GIS we used the Surfer 8.1 software (method of interpolation – Kriging) (Fig. 2).

Among the 12 interpolation methods put at the disposal by Surfer we chose in order to space the punctual information the Kriging interpolation method and obtain of thematic layers regarding the distribution of NO_2 (Fig. 3) and NO_3 concentrations (Fig. 4).

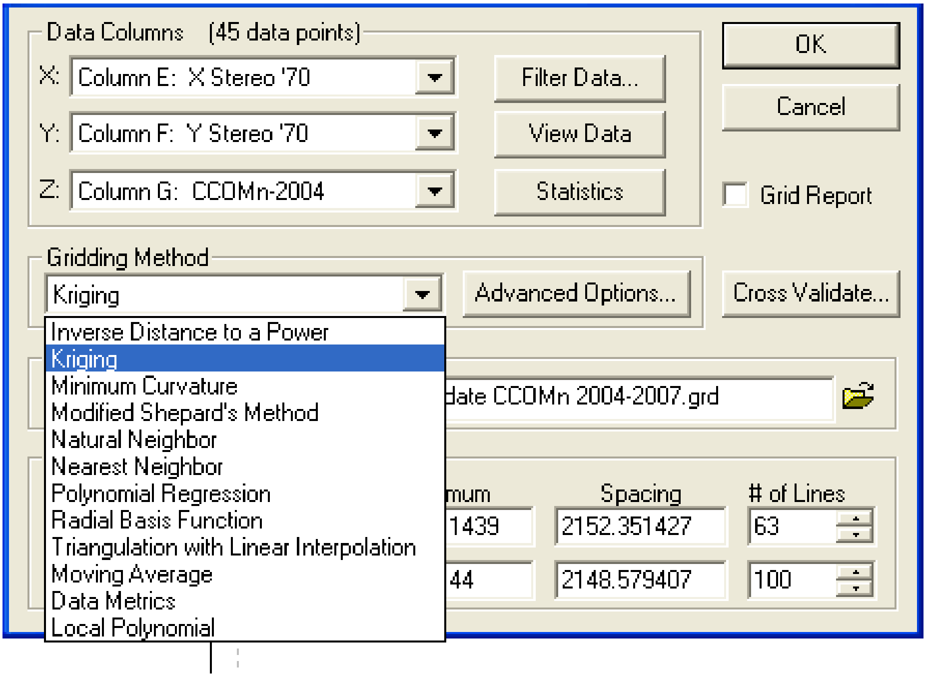

Fig. 2. Detail Surfer software; choosing the method of interpolation and setting the pixel size

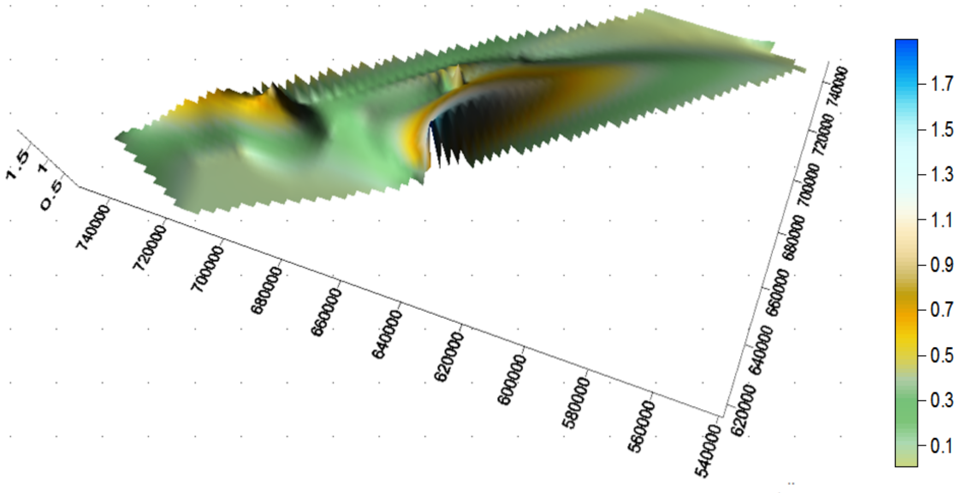

Fig. 3. The thematic layer regarding the distribution of NO_2 (mg/l) in the territory studied in 2015; 3D representation

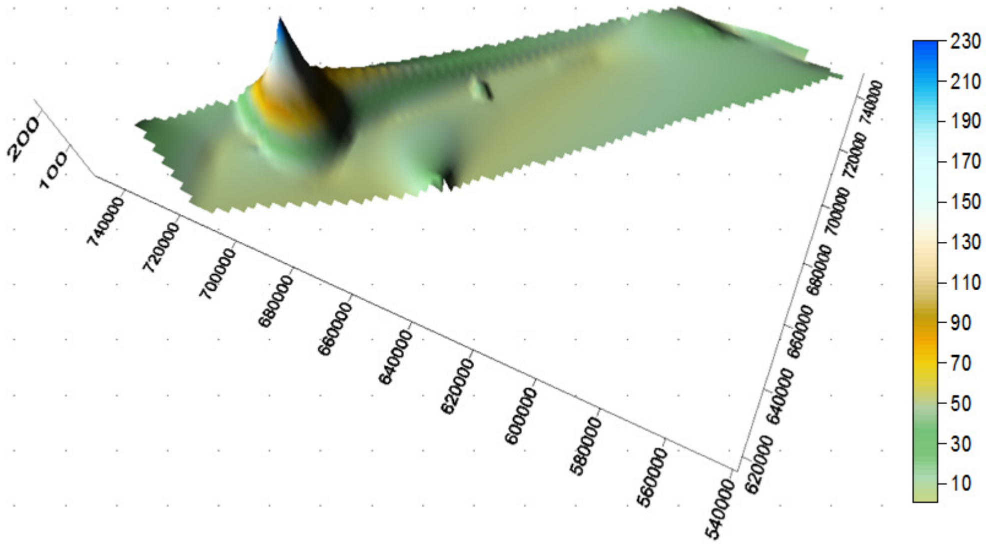

Fig. 4. The thematic layer regarding the NO_3 (mg/l) distribution in the territory studied in 2015 3D representation

4. RESULTS AND DISCUSSIONS

Starting from the values of concentrations determined in the laboratory on water samples assayed from the 44 forages, after the interpolation, we obtained concentrations in 1880 points.

Also we will achieve a spatiality of the indicator $\frac{nitrates}{50} + \frac{nitrites}{3}$.

The values obtained afterwards in all the raster points (located through the X and Y coordinates) after interpolation, in each point situated in the centre of a cell (Table 2).

With Surfer software one obtains the thematic layer regarding the distribution of the values of the indicator $\frac{nitrates}{50} + \frac{nitrites}{3}$ (Table 2) and (Fig. 5).

Table 2. The values obtained after interpolation with SURFER, in each of a cell

Cell No.	X (m) Stereo '70	Y (m) Stereo '70	NO_2 (mg/l)	NO_3 (mg/l)	$\frac{nitrates}{50}+\frac{nitrites}{3}$
1	742762.1	542913.2	0.031926	23.3845	0.478331865
2	740609.7	545061.8	0.035238	24.0515	0.492776112
3	740609.7	547210.4	0.051815	22.16654	0.460602676
4	742762.1	547210.4	0.041741	18.80309	0.389975532
5	742762.1	542913.2	0.031926	23.3845	0.478331865
…………………………………………………………………					
1465	652363.3	691165.2	0.245243	49.75168	1.076781388
1466	654515.7	691165.2	0.296957	63.04128	1.359811051
1467	656668	691165.2	0.352662	77.70399	1.671633735
…………………………………………………………………					
1500	676039.2	693313.8	0.388856	44.77624	1.025143427
1501	678191.5	693313.8	0.505746	29.65145	0.761611042
1502	628687.5	695462.4	0.066127	3.256486	0.087171995
…………………………………………………………………					
1568	671734.5	699759.5	0.396986	49.84778	1.129284183
1569	673886.8	699759.5	0.55154	29.90772	0.782001106
1570	624382.8	701908.1	0.070366	3.463758	0.09273046
…………………………………………………………………					
1614	669582.1	704056.7	0.466425	45.10777	1.057630446
1615	622230.4	706205.3	0.07223	3.654572	0.097168085
1616	624382.8	706205.3	0.069843	3.942739	0.102135922
…………………………………………………………………					
1879	637296.9	744879.7	0.257995	19.82124	0.482423055
1880	635144.5	747028.3	0.290876	28.09792	0.658916941

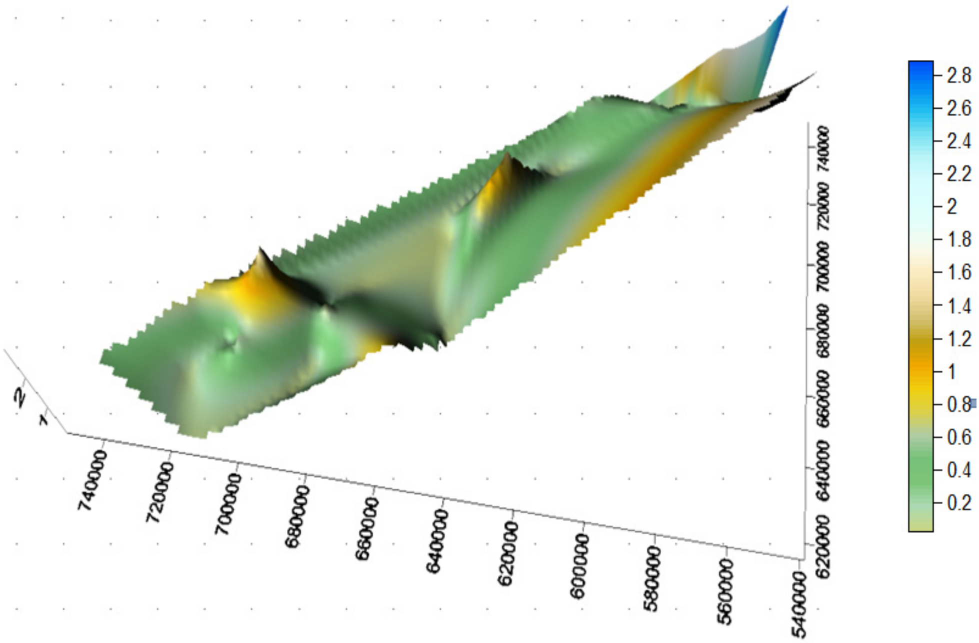

Fig. 5. The thematic layer regarding the distribution of the values of the indicator $\frac{nitrates}{50}+\frac{nitrites}{3}$ in the territory studied in 2015 (3D representation)

4.1. The interpretation of results obtained

For the results interpretation, we compared the values of NO_2 and NO_3 measured in the laboratory on water samples taken in 2015 from the 44 surveyed boreholes of Prut catchment area, with the maximum admissible values of Law no. 458/2002, as amended and supplemented through Law no. 311/2004.

The maximum admitted concentration for NO_2 is of 0.5 mg/l, and for NO_3 is of 50 mg/l. The value of indicator $\frac{nitrates}{50}+\frac{nitrites}{3}$ should be lower or equal to 1 (Table 3).

Table 3. Summary of the results

Range of values	Indicator
Range of values	NO_2 (mg/l)
0 mg/l - 0,5 mg/l	93,5 %
>0,5 mg/l	6,5 %
Range of values	NO_3 (mg/l)
0 mg/l - 50 mg/l	93,2 %
>50mg/l	6,8 %
Range of values	$\frac{nitrates}{50} + \frac{nitrites}{3}$
0-1	89,65 %
> 1	10,35%

5. CONCLUSIONS

1. Monitoring the underground water quality implies a complex action of assessing all quality indicators and of performing the existing correlations between indicators. It is not enough to compare the determined value of each quality indicator with the CMA required by the Law on fresh water, being required to interpret, from a chemical point of view, the existing correlations between various quality indicators.

2. The activity of knowing the quality of the underground water at the level of large catchment areas can only take place within a GIS, where the punctual pieces of information acquired following the laboratory tests in a limited number of profiles are subject to spatialization within a MNT, in order to conduct a complex analysis at each point of the analyzed area.

3. The NO_2, concentration exceeds CMA in up to 6.5 % of the analyzed area and the NO_3 concentration exceeds CMA by 6.8% (according to Table 3).

4. The indicator: $\frac{nitrates}{50}+\frac{nitrites}{3}$ exceeds the maximum admitted value by 10.35 % (according to table 3).

5. The use of GIS enables the spatialization of these indicators in the area, and thus the knowledge of areas with exceeded concentrations is important. Through permanent monitoring, the potability sanitary bodies can classify the water sources based on the concentration of nitrates and nitrites in the water, compared to CMA, so that these would not be used, in order to prevent the occurrence of diseases.

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LANDSLIDE SUSCEPTIBILITY EVALUATION USING GIS. CASE STUDY: SILVANIA HILLS (ROMANIA)

KEREKES ANNA-HAJNALKA[1], HORVÁTH CS.[1]

ABSTRACT. – Landslide Susceptibility Evaluation Using GIS. Case Study: Silvania Hills (Romania). Landslides are destructive natural or human-induced hazards, therefore an assessment of landslide susceptibility becomes essential in an area that is prone to landslide through its geographical features. Landslide susceptibility maps provide valuable information for disaster mitigation works and land planning strategies. Silvania Hills are highly prone to landslide due their lithological and geomorphological structure. The purpose of this paper is to prepare a reliable landslide susceptibility map, which was obtained using the maximum entropy model. The model was run considering twelve environmental factors: lithology, slope, aspect, land use, land cover type, precipitation, temperature, terrain roughness, depth of fragmentation, drainage density, profile and plan curvature. The resulting map was grouped into five landslide susceptibility classes: very low, low, moderate, high and very high class. The results indicated that the land use and -cover type, slope and depth of fragmentation are the three most influential landslide predisposing factors. The accuracy of the resulted map was verified by generating a receiver operating characteristic (ROC) curve. The area under the curve (AUC) showed a good performance (0.847) of the analysis.

Keywords: *natural hazard, landslide, susceptibility analysis, mapping susceptibility, database, MaxEnt model, Silvania Hills, GIS, ROC curve.*

1 INTRODUCTION

Landslides are destructive natural or man-induced hazards caused by a sudden rapid movement of a cohesive mass of bedrock that is saturated with moisture. This damaging disaster can affect properties and land use, thus threatening the economic system and infrastructure. In Romania, landslides represent the natural hazards with the highest occurrence frequency and they have the widest manifestation area (Surdeanu, 1998).

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Landslide susceptibility maps describe the tendency of a territory for landslides, using appropriate, accurate methods and data (known causing factors of the local terrain conditions). Therefore, the purpose of landslide susceptibility mapping is to highlight the regional distribution of potentially unstable slopes (Grozavu et al., 2013). Spatial analysis is particularly significant and often used in mapping susceptibility. Thus, these maps provide valuable information for infrastructure and land planning strategies, land use, hazard mitigation design, protection of environment and responsible resource exploitation.

In the recent years, many methods were applied and evaluated for preparing landslide susceptibility assessments. These methods include bivariate (Bilașco et al., 2011, Conforti et al., 2011), fuzzy logic (Schernthanner, 2005), multivariate logistic regression, artificial neural network (Pradhan and Lee, 2010; Grozavu et al., 2013) and maximum entropy analysis (Davis and Sims, 2013).

Due to its particular structural, geomorphological and geological setting, the Silvania Hills is widely affected by landslides. The main objective of the present study is to prepare an accurate landslide susceptibility map which will help reducing the risks caused by landslides in the Silvania Hills. The map was prepared by using GIS analysis and maximum entropy model, taking into consideration twelve landslide causing factors.

2 STUDY AREA

2.1 Literature review

Previously, few studies were carried out on landslide susceptibility, hazard and risk analysis on the Silvania Hills. Geomorphological studies, landslides processes and their impacts have been investigated by Posea (2005), Bilașco (2006), Filip (2008), Blîdiță (2009), Arghiuș (2010), Zaharia, Driga & Chendeș (2011), Pop (2014) in this area, at a local scale. These studies were investigating environmental components and their relations between each other in order to predict important areas that could be affected by geomorphological hazards. Another aim of these studies was to recognize the cause of such failures and to bring to attention the fact that measures must be taken in order to prevent further hazards. For this purpose, the researchers used GIS spatial analysis models and classical identification, inventory and mapping methodology.

2.2 Description of the study area

The area under investigation is part of the Western Hills, located in the north-western hilly region of Romania (fig. 1). The area of the region is 3960 km^2, altitudes range from 126m to 670m with an average of around 400m.

From a regional point of view, the studied area is divided into the following main subdivisions: Basin of Baia Mare, Basin of Sălaj, Basin of Crasna, Basin of Barcău, Basin of Zalău, Codru Hills, Crasna Hills, Sălaj Hills, Șimleu Hills (Ielenicz and Pătru, 2005).

Geologically, the Silvania Hills are mostly composed by sedimentary rocks (clay, gravel, marl, sands) from the Mio-Pliocene (Posea et al., 1974). The sedimentary rocks were formed by the accumulation of the gravel and sands carried by rivers, which had their sources in the Carpathian Mountains (Ielenicz and Pătru, 2005).

Morphologically, the region is characterized by steep slopes (the slope varies from 0^0 to 41^0), thus the region is affected by intense denudation processes. The slope angle is the most important factor which influences the dynamics of the down-slope movement.

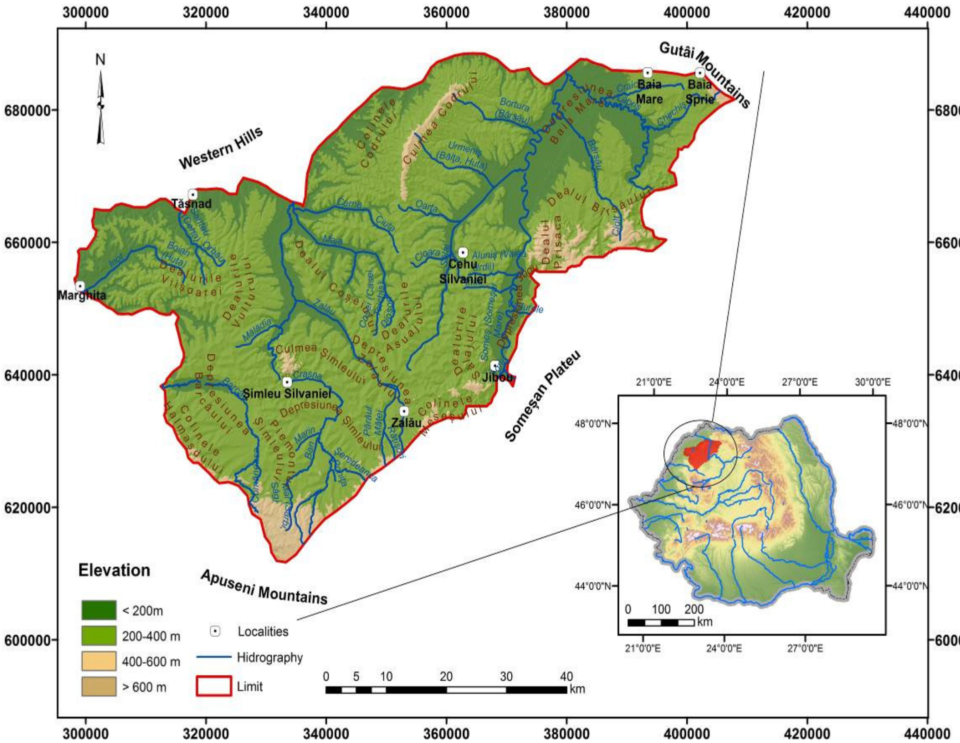

Fig. 1. Geographical position of the study area

Mass movements are also triggered by climate characteristics and human activities. Sudden, intense rains can cause landslides, but the present human activities in the study area, like mining, edifice and road construction, deforestation, over-grazing and over-cultivation are main factors that have significant role in landslide occurrence.

3 METHODOLOGY AND DATA COLLECTION

3.1 Spatial database

The first steps in landslide susceptibility zonation are identifying the causative factors of landslide hazards and preparing the corresponding data sets. In order to generate relevant factor maps, GIS software was used, which allowed for the setting up of spatial analyses. By using this technology, it was possible to investigate qualitative and quantitative information specific for the identified natural hazard.

For this research we used a wide range of data, represented by spatialized geographic elements. Based on these, a spatial database (table 1) that considers the causative factors of the landslides was created for the area under investigation. This database includes twelve landslide predisposing agents: lithology, land use (qualitative information), NDVI (Normalized Difference Vegetation Index), precipitation, temperature distribution and DEM (Digital Elevation Model) derived factors - slope aspect, slope angle, depth of fragmentation, drainage density, profile and plan curvature, terrain roughness (quantitative information).

Table 1. Spatial database

No.	Name	Type	Structure	Source
1	Landslide inventory	Vector	Polygon	Aerial orthophotograms and satellite imagery
2	Lithology	Vector	Polygon	Geology Map 1:100000
3	Land use	Vector	Polygon	Corine Land Cover 2006
4	NDVI	Raster	Grid	Landsat TM imagery
5	Precipitation	Raster	Grid	National Administration of Meteorology, Romania
6	Temperature	Raster	Grid	National Administration of Meteorology, Romania
7	Slope	Raster	Grid	DEM (30x30) derived
8	Aspect	Raster	Grid	DEM (30x30) derived

No.	Name	Type	Structure	Source
9	Depth of fragmentation	Raster	Grid	DEM (30x30) derived
10	Drainage density	Raster	Grid	DEM (30x30) derived
11	Profile and plan curvature	Raster	Grid	DEM (30x30) derived
12	Terrain roughness	Raster	Grid	DEM (30x30) derived

3.1.1 Landslide inventory

Landslide related data must be collected accurately, thus a valid landslide susceptibility analysis can be carried out. Landslide inventories offer essential information for evaluating landslide vulnerability, hazards or risks. These maps show the spatial distribution of existing landslides and the potential for future ones.

The research began with the preparation of a landslide inventory map (fig. 2) based on high resolution satellite imagery, aerial photographs (source: ANCPI, 1:5 000; Google Earth) and large-scale topographical maps (1:25 000). A number of 622 landslides were identified and mapped in the study area. They occupy 18.12 km^2 and correspond to 0.45% of the total area.

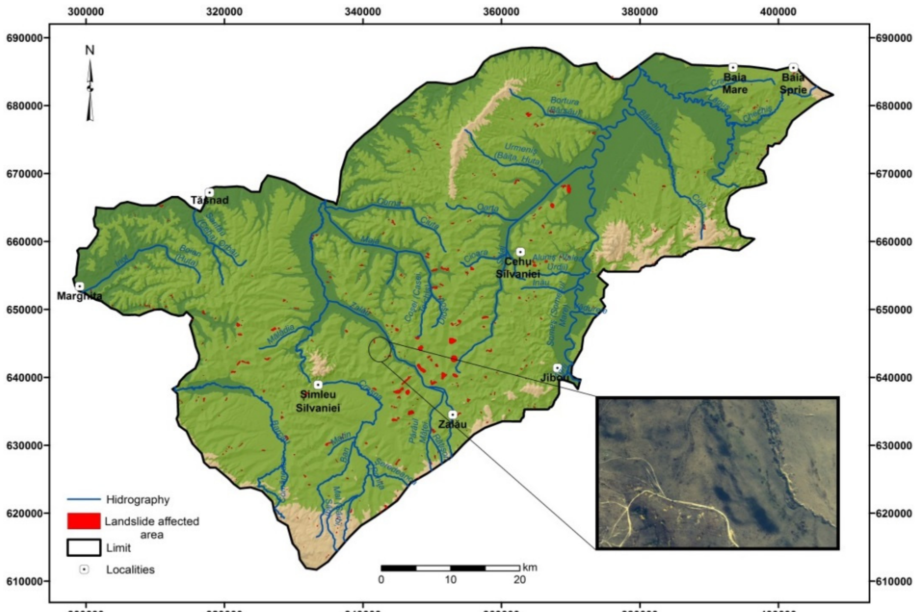

Fig. 2. Landslide inventory

3.1.2 Landslide influencing factors

In the study, twelve possible landslide predisposing factors (fig. 3) were analyzed. From these landslide-related factors, thematic layers were generated using the Spatial Analysis Tool in ArcGIS 10.2 software.

One of the most important and frequently used factors which affects the occurrence of landslides is the *slope of the terrain*. All mass movements occur on slopes under the influence of the gravitational force. A requirement in landslide occurrence is the existence of a minimum slope angle to enable sliding. Without it, the unstable deposits might be affected only by subsidence and resetting (Bilașco et al., 2011). The slope angle map was created from the digital elevation model, which had 30x30 m resolution. The raster map was grouped into 7 classes: 0^0-2^0, 2^0-5^0, 5^0-10^0, 10^0-15^0, 15^0- 25^0, 25^0-35^0, 35^0-41^0. Most of the landslides occurred between 5^0 and 10^0, but over 35^0 any of them were identified.

Another essential predisposing agent is *geology*. This factor induces the process of land sliding through its lithological and structural features and characteristics. These types of geomorphological processes mostly occur on sedimentary rocks (clay, marls, poorly consolidated sands). When their surface becomes wet, they deform, in the lack of solid base, in the direction of movement. Thus, a large amount of material is failing simultaneously. Analyzing the geology map of the studied area, the most widespread lithology is Mio-Pliocene sedimentary rock (67.66%), which explains the high occurrence of landslides.

Land use and -cover type are significant causative factors because sparsely vegetated areas are more exposed to faster denudation processes and instability than forests. Vegetation through their root system has a soil-binding power, thus the soil becomes more resistant to erosion. Using these two factors, environmental and human-induced impacts can be identified, such as deforestation, exploitation of natural resources, road cuts, construction activities and over-grazing. These activities can contribute to a major loss of vegetation thus the exposure to landslides becomes higher.

The database used in the spatial analyses was derived from the vector layer Corine Land Cover 2006 and from the raster layer Normalized Difference Vegetation Index (NDVI).

Landsat TM (30-m resolution) imagery was used to create the NDVI. The NDVI is a numerical indicator that represents the relative density of vegetation, thus the indicator assesses whether the observed area contains live green vegetation or not. NDVI values range from -1.0 to +1.0 and were obtained by the combination of visible red band and near-infrared band. The equation of the indicator is as follows:

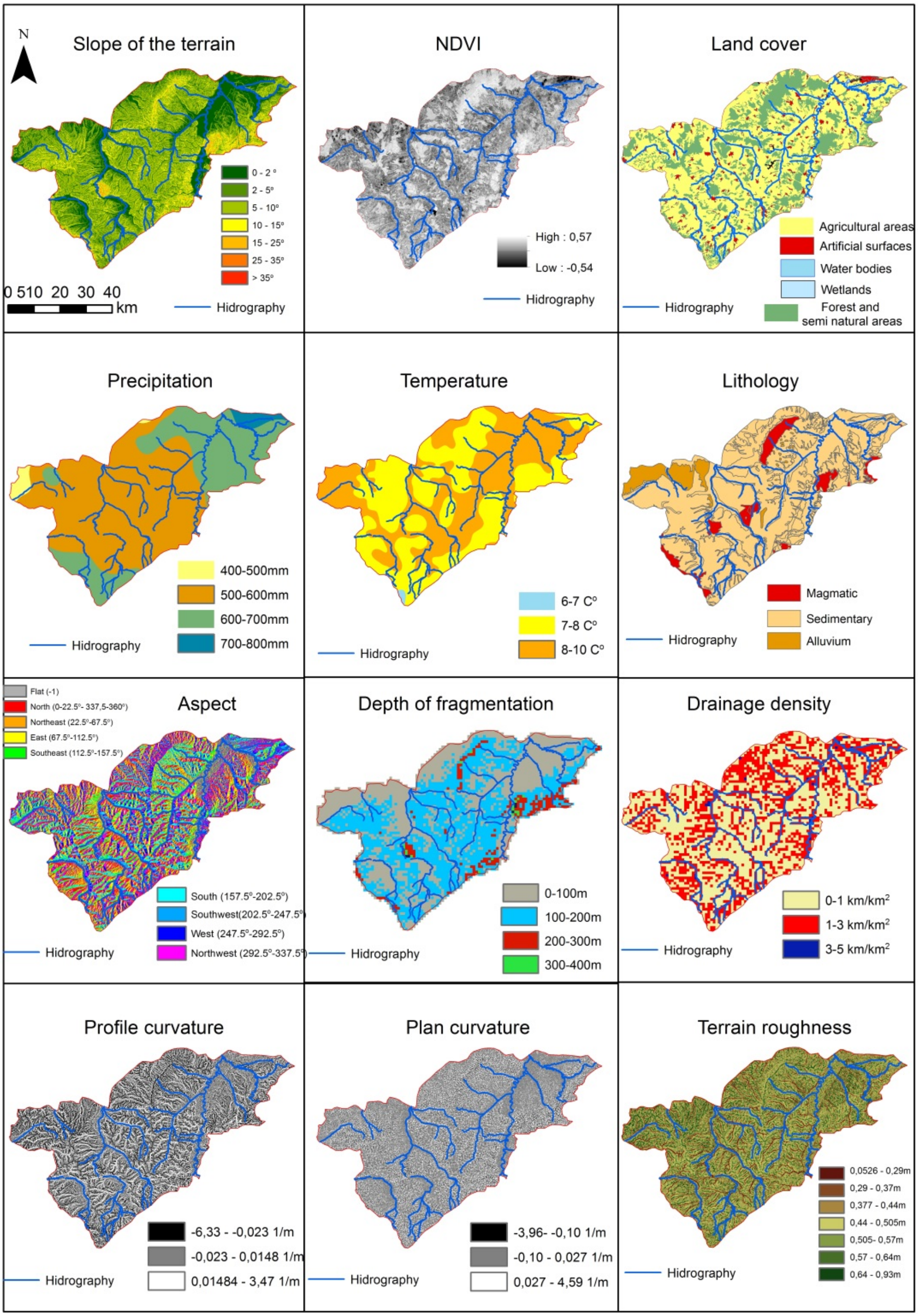

Fig. 3. Landslide predisposing factors

NDVI=(NIR-RED)/NIR+RED)

where NIR= near infrared band and RED= visible red band. High NDVI value indicates higher density of vegetation, low NDVI value indicates artificial and water surfaces, snow, sand or rock (Bayes et al., 2015).

The land use, based on the Corine Land Cover 2006 database, was grouped into 5 classes: agricultural areas, artificial surfaces, forests and natural areas, water bodies and wetlands. Analyzing this factor map, it is observed the fact that 96.08% of landslides occur near artificial surfaces and 3.54% of landslides appear on agricultural and natural areas. This is explained by the human-induced impacts presented in the description of the study area.

Precipitation influences the down-slope movement process by sudden, intense rains and snow melting. Landslide occurrence is favoured by significant rainfalls that follow a drought period when the existing fissures enable water penetration (Bilașco et al., 2011). The precipitation map was reclassified into four groups: 400-500mm, 500-600mm, 600-700mm, 700-800m. The highest average precipitation values were identified in the hilly areas, between 400-600m elevation.

Temperature has an effect on the freeze-thaw and wetting-drying processes, thus contributing to slope instability and down-slope movement. The raster map was reclassified into three classes: 6^0-7^0, 7^0-8^0, 8^0-10^0.

Aspect derives from the DEM. As a landslide-conditioning factor, it describes the direction of slope (Chen et al., 2016). The orientation of slope produces major differences in climatic parameters that are unevenly distributed on the surface: insolation, solar radiation, precipitation. Thus, slopes with south and south-west orientation receive more solar energy. The slope aspect map was reclassified into eight directional classes: flat (-1), north (337.5^0- 360^0, 0^0-22.5^0), north-east (22.5^0–67.5^0), east (67.5^0–112.5^0), south-east (112.5^0–157.5^0), south (157.5^0–202.5^0), south-west (202.5^0–247.5^0), west (247.5^0–292.5^0), and north-west (292.5^0–337.5^0). Differences were observed between the south, south-west facing slopes and the north facing slopes: 28.9% of landslides occur on the south, south-west exposed slopes and 24.9% of landslides occur on the north faced slopes.

Depth of fragmentation is a geomorphological indicator and expresses the relative altitudinal difference for a certain area. This factor has an important influence in the instability of slopes: the higher is the depth of fragmentation, the greater becomes the slopes angle, therefore down-hill mass movement becomes predisposed. The map was grouped into 4 major classes: 0-100m, 100-200, 200-300m, 300-400m. A significant part of the landslide affected areas (97.9%) were identified between 0-200m.

Drainage density is another geomorphological indicator and expresses the total length of all the streams and rivers in a drainage basin divided by the total area of the basin. Thus, this indicator measures the horizontal fragmentation of a drainage basin. Highly fragmented territories have high slope terrain values, therefore the steeper is the slope, the higher the probability for mass movement. The map was divided into three classes: 0-1 km/km^2, 1-3 km/km^2, 3-5 km/km^2. Most of the existing landslides (61.22%) were identified in the second class.

Profile and plan curvature were calculated via the curvature tool. Profile curvature is parallel to the direction of the maximum slope and it measures the rate of change of the slope. Plan curvature is perpendicular to the direction of maximum slope, thus influencing the convergence or divergence of downhill flowing water. The maps were classified in three groups using the natural jenks method. Positive profile and plan curvature values indicate high concavity, therefore the landslide occurrence probability is high (Petrea et al., 2014). The plan curvature was classified into the following groups: -3.966 - -0.106 1/m; -0.106 – 0.027 1/m; 0.027 – 4.59 1/m. Most of the landslide affected areas (71.17%) were identified in the second group. The profile curvature was classified into the following classes: -6.33- -0.1 1/m; -0.1 – 0.053 1/m; 0.053 – 3.47 1/m. 79.78% of the existing landslides were identified in the second class.

The concept of *terrain roughness* was introduced by Riley et al. (1999), and it indicates terrain ruggedness and a local elevation index. Terrain ruggedness is useful for identifying landscape patterns. The raster was classified into seven groups using the natural breaks method: 0.05-0.29m; 0.29-0.37m; 0.37-0.44m; 0.44-0.50m; 0.50- 0.57m; 0.57-0.64m; 0.64-0.93m. A significant part of the landslide affected areas (38.98%) were identified in the fourth class.

3.2 Spatial analyses

In order to prepare a landslide susceptibility map, there was used the maximum entropy model. The landslide susceptibility map was generated by the MaxEnt software using all the generated thematic maps.

Maximum entropy was used in the analysis of a variety of earth system processes, like species distribution. The presence-only nature of landslides—or the limited knowledge of absence locations—makes maximum entropy methods designed for species habitat analysis appealing (Davis et al., 2013). MaxEnt compares the conditional density function of covariates (predictor variables) at presence sites $f_1(z)$ to the marginal (background) density of covariates in the study area f(z), to derive the conditional occurrence probability $Pr(y = 1|z)$ (Elith et al. 2011). Also, in the recent years, MaxEnt was used for creating landslide susceptibility maps.

The maximum entropy model has many advantages and a few drawbacks. The advantages are the following: it requires only presence data, together with environmental information for the whole study area; it can utilize both continuous and categorical data; the MaxEnt probability distribution has a concise mathematical definition, and is therefore amenable to analysis; MaxEnt is a generative approach, which can be an inherent advantage when the amount of training data is limited (Philips et al., 2005).

The MaxEnt model was run using the thematic layers. The resulted values were grouped into five classes, using the natural jenks distribution: very low, low, moderate, high and very high susceptibility class of landslides (fig. 4).

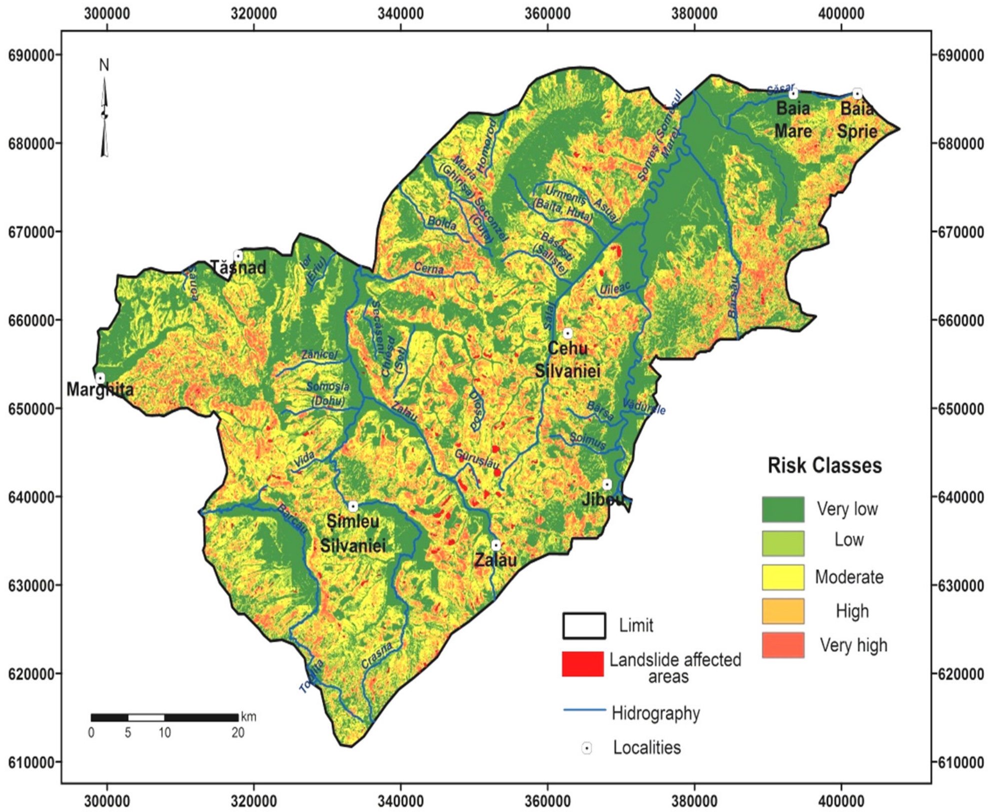

Fig. 4. Landslide susceptibility map

4 RESULTS AND VALIDATION

Analyzing the results, 74.29% of the mapped landslides are included in the high and very high susceptibility category, 16.8% in the moderate category, and less than 9% of the areas affected by this natural hazard are situated outside the area characterized by a high susceptibility for landslides.

According to the susceptibility map classification, areas with very high and high susceptibility (22.9%) are located mainly in the north, north-eastern and north-western part of the hills (Sălaj, Prisaca, Bîrsău, Vulturul Hills), followed by areas with moderate susceptibility (17.9%) located in the south and south-western part of the studied territory. Areas classified into low and very low susceptibility categories represent 59.2% of the total area (fig. 5). They are located mostly in the Someșul Mare, Zalău and Sălaj Corridor (caused by the large extension of the flat floodplains) and at the contact between slopes and floodplains.

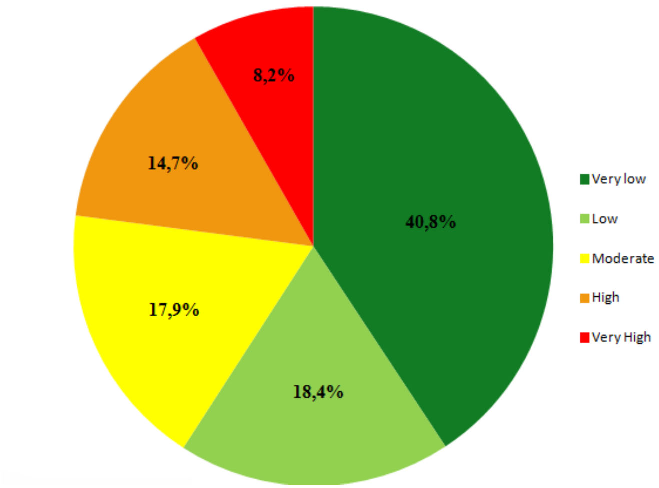

Fig. 5. Percentage distribution of the susceptibility classes

The MaxEnt software calculated the contribution (in percentage) of each landslide predisposing factor. The results showed that the land use and -cover type, slope and depth of fragmentation are the three most influential landslide causative agents of the study area (table 2). Analyzing these three factors, it can be concluded that the most predisposed areas are located near artificial surfaces. Agricultural lands are also threatened (caused by human impact). Slopes between 5^0-15^0 and 0-100m depth of fragmentation are the most favorable values for the occurrence of further landslides.

Table 2. Factor contribution

Landslide predisposing factor	Percent contribution (%)
Land cover	37.5
Slope	26.8
Depth of fragmentation	14.3
Plan curvature	8.5
Topograpghic roughness	4.2
Precipitation	2.4
Profile curvature	1.7
Lithology	1.6
Aspect	1.4
Temperature	1.2
Drainage density	0.3

Validation of landslide susceptibility models is an essential requirement to check the predictive capabilities of the landslide susceptibility map produced (Chung and Fabbri, 2003). In order to test the reliability of the resulted susceptibility map, a receiver operating characteristic curve (ROC curve) was generated with the MaxEnt software. The ROC method tests the predictability rate of the method applied for the study area by comparing the map of susceptibility with the landslide inventory.

For the validation of the susceptibility analysis, area under the ROC curve (AUC) was also applied. The values on the X axis represent the false positive rate (areas with high susceptibility rate, but with no landslides). The values on the Y axis represent the true positive rate (areas with high susceptibility rate where landslides occur). While AUC values between 0.7 and 0.9 indicate reasonable discrimination ability, values higher than 0.9 are typical of highly accurate classification models (Swets, 1988). Values under 0.5 indicate poor performance of the applied method.

The AUC value for the maximum entropy was estimated at 0.847 (fig.6), which indicates reasonable discrimination ability. Therefore, it can be concluded that the selected landslide predisposing factors are relevant for the model applied.

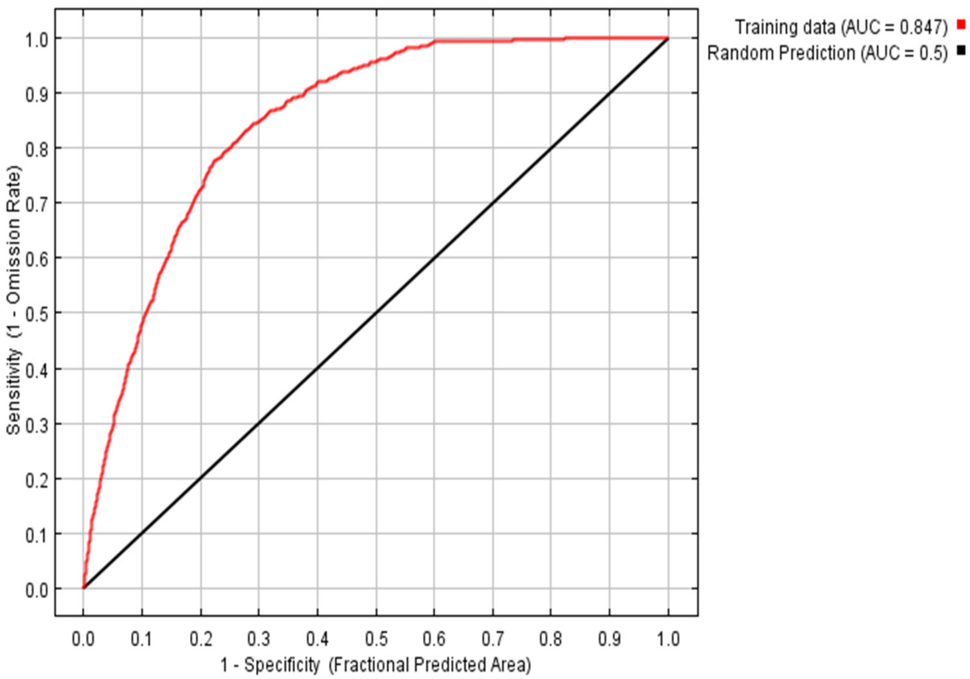

Fig. 6. ROC curve

5 CONCLUSIONS

Landslides are devastating natural or human-induced hazards, affecting a significant number of people, threatening economy and damaging properties. Therefore, a statistically valid susceptibility map should be used for territories where landslide occurrence is very high, thus analyzing this map, it can be possible the prevention of further land sliding. The prevention of further landslides requires a complex analysis of the causative factors. The most sever predisposing factors are human induced impacts, such as exploitation of natural resources, road cuts, construction activities, over-grazing, deforestation. As we know, the soil is the most important natural resource for the entire humanity. It is very important to understand the severity of the possible consequences. Thus, the prevention of landslides becomes possible just by protecting our natural resources and by responsible human activity.

The aim of this article was to prepare a valid susceptibility map, using an optimal combination of landslide causing factors, for the Silvania Hills. Analyzing the Silvania Hills, 622 landslides were identified, and considering that the geology, in a high percentage, is made up of sedimentary rocks, this territory becomes predisposed for further land sliding.

A maximum entropy model was run using twelve landslide causing factors. The results indicated that the most influential landslide predisposing factors are the land use and -cover type, slope and depth of fragmentation. This fact can be explained by the high rate of human impact in this area.

The model was validated using a ROC curve, its high AUC (0.847) value shows a good performance of the analysis. Thus, the applied model has a very good correlation with the chosen predisposing factors.

The validation shows that the model has a good predictability, thus becoming useful for further analyses and research. Based on the resulted map, it can be concluded that the implementation of land planning strategies are necessary to reduce the risk caused by landslide hazards in the Silvania Hills.

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THE LOSS OF VILLAGES IN ROMANIA AFTER 1990

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ABSTRACT. – The Loss of Villages in Romania after 1990. Settlement development is a continuous process significantly influenced by population dynamics. Population decrease through migration and low birth rate has become an issue at European level, and in the case of Romanian rural areas the situation proves even more severe. The aim of our study is to analyse the evolution of rural settlements from emergence to decline based on a seven-stage development cycle and emphasize on the phenomenon of rural settlement disappearance in Romania after 1990. Results show that even without first-sight visible or significant effects at national level, the number of rural settlements that have disappeared is continuously increasing, therefore becoming an issue for the development of rural areas. Particularities of the current condition of the built-up area of each of the analysed villages revealed various levels of destruction from incipient decline (whole built-up area) to total collapse (very few remains of the built-up area, and even incorporated in the natural environment). We thus create a typology of disintegrated villages, which are currently found at national level and we reveal their administrative and geographical distribution. We conclude that settlement evolution and the risk of their disappearance should be on the shortlist of priorities of the national policies, strategies and projects designed for the development and planning of rural areas.

Keywords: *settlement dissapearance, depopulation, evolution stages, typology of dissapeared villages, built-up area, functional transformation, functionality and decline of human settlement*

1. INTRODUCTION

The disappearance of geosystemic structures, namely settlements, is a both a current and extremely relevant subject due to the numerous effects they generate socially, economically, environmentally and spatially. Similar to any other geosystemic structure, human settlements have limited existence, while depending on circumstances and favourable factors that contribute to their

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emergence and development. Consequently, appearance and disappearance of settlements is a natural process, triggered by positive or negative dynamics of population, level of economic development, administrative and political changes, yet their unintended disappearance at an accelerated pace becoming problematic. This means that, even though a dynamic system, settlement needs to find certain equilibrium to ensure its existence over time. For instance, the fortuitous disappearance of settlements in cases of political conflicts or natural disasters is understandable, but their collapse during peacetime is synonymous with the death of a man who still had days but the social and medical system killed him because he was not able to care for his health. The disintegration and eventual disappearance of any settlement is a tragic event for the socio-geosystem and related remaining communities, them being required to take the territory of the disappeared village under their administration. At the same time, the energy, social and economic flows in the territory are once again restructured. Therefore, the resilience of settlements in the context of severe population decline, acceleration of population ageing, and rural-urban migration at European and national level is a matter of great importance. The latest global and European studies reveal that Romania registers one of the greatest decrease rates of population shrinking in Europe and it is projected to have a sharp population decline of 22.1% by 2050 (European Commission, 2014; United Nations, 2015).

Rural settlements are the focus of our study. The aim is to identify rural settlements that have already disappeared in Romania, in the last three decades, considering the size of phenomenon and major causes, and depict particularities of their collapse in order to elaborate a typology. After we reveal the current situation of rural settlement disappearance, we also emphasize on the severity of this phenomenon. Given that more than 1% of villages in Romania have disappeared in the last three decades, it is projected to double the rate of extinction in the next decade. In this context, the obvious question to ask is whether this phenomenon of settlement disappearance should just be observed by local and regional authorities and decision-makers or if they need to start making concise interventions to stop it and develop programs to regenerate the vulnerable settlements. Since the settlement system proves adaptable to a certain degree, then the suitable reply is that rural settlement resilience building should be part of the agenda of rural spatial planning and design (Heijman et al., 2007). Karcagi Kováts & Katona Kovács (2012), have elaborated one of the most comprehensive studies on rural population decline as approached and analyzed at the European level (in the EU sustainable development policies and strategies and rural development programmes and measures of action), showing that most of them, including Romania, acknowledge population decline as a negative issue, but it seems a secondary aspect to be approached in the process of rural development.

Authors then conclude that, since there is no commonly accepted objective or principle to react against the negative demographic changes in rural areas, strategic documents should pay more attention to ecologic, economic and social effects of this phenomenon. In this regard, National Rural Development Plan 2014-2020 acknowledges that Romanian rural population is facing demographic decline and considers the constant depopulation of villages and ageing population a threat for the future socioeconomic development of the rural areas. The main identified driving factors are: low level of fertility, high mortality, urban and abroad migration, urbanization and ageing. However, due to the numerous deficiencies rural areas are affected by, the objectives for the current development plan are mainly related to the sustainable management of resources and economic revival, consistent with priorities of knowledge transfer, innovation, biodiversity protection, social inclusion and natural risk management due to climate change (NRDP, 2014).

2. THEORY AND METHODOLOGY

The debate on this particular subject in the national literature is reduced, only limiting to general aspects or concrete analyses mostly on factors driving changes and transformation of rural areas. In this respect, this paper is the first carried out at national level and covers a period of three decades, and it should be perceived as an incipient initiative to explore and assess the overall and visible effects of population decline and aging within the rural areas, particularly the transformation or shrinkage of villages. Nationally, there are numerous newspaper articles covering this phenomenon, but no scientific work has yet thoroughly analysed its magnitude and implications, especially in the context of sustainable development and spatial planning. At European level there are several successful attempts of research projects that approached the phenomenon of population decline and settlement shrinkage in which they debated, analysed and designed strategies and scenarios for the better management and planning of land and population in certain affected rural areas, focusing on economy, land-use, social aspects, cultural heritage, ecology and others (Westhoek, van den Berg, Bakkes, 2006; van der Schoot et al., 2014).

Our paper is structured in several sections, as follows: i. in the first section we debated on settlement evolution and we elaborated on the distinct stages of settlement life cycles and the major alterations occurring in the structure of settlement system; ii. in the next section we focused on the reality of lost villages in Romania in the period between 1986 and 2016, concentrating on the dynamics of the phenomenon and representing it at county and national level;

iii. in the third section of the paper we depicted a typology of currently disappeared settlements by considering two of the main factors namely, population number and the state of the built-up area. Each of the categories were analysed in terms of resilience (what is left, what has already been adapted and what cannot be regenerated anymore). We then mapped the categorized villages in order to reveal their spatial distribution administratively at national level and morphologically, thus, underpinning the geographical units most affected by this phenomenon; iv. in the last section we emphasize on the definite effects of settlement disappearance socially, economically and territorially.

We examined population changes in the Romanian rural villages using the national censuses conducted by the National Institute of Statistics in 1992, 2002 and 2011. Supplementary data on the endangered or already collapsed rural localities were collected from the list of disappeared or unpopulated localities in 2015 published open-access, this incipient set of data, including the names of 126 rural localities, being the starting point for our research. This data was collected during the Open Data Hackathon in 2015 and was consistent with data provided by the study for the update of National Spatial Plan – Section: Settlement Network in 2014 (Ministry of Regional Development and Public Administration) which revealed a number of 114 villages that registered 0 inhabitants at the 2002 census. Each of the villages was verified regarding the administrative status in the past and present, the exact toponym and the historical administrative changes, if the case (Law 2/1968; Law 351/2001; Suciu, 1966, 1968; Ghinea & Ghinea 2000). For each of the categories we chose an illustrative example by using recent satellite images (Google Maps, 2016, INIS Viewer Inspire Geoportal, 2016). The aggregated data on all the identified villages that registered less than 3 or zero inhabitants are presented in Appendix 1. The synthetic table provides readers with related information on name of the villages, name of the communes and counties they were administratively part of, number of population in 1992, 2002 and 2012, the condition of the built-up area and the geographical location. We elaborated a typology of the disappeared villages according to the condition of the built-up area.

2. 1. Settlement development – evolution phases

Base on the truth that no system grows ad infinitum and nothing remains stable ad infinitum (Mella, 2012), the process of settlement development consists in the completion of several distinct evolutionary phases, at the end of which settlement can enter a new development phase or ends their life cycle, their decline being irreversible. Each of these stages of evolution is characterized by distinct features. To better understand how rural settlements change over time, Collins-Kreiner (2013) came up with a theoretical model of village transformation by using the “Product life cycle” based on 4 main development stages (birth, development, stagnation, decline, death) a products goes through on the economic market. Also, the model mentions the possibility of regeneration after the completion of these four stages. In our analysis however, we decided to conceptually define seven stages of settlement development: emergence, growth, development, consolidation, maturation, stagnation and post-critical evolution (Fig. 1).

Settlement emergence is the first evolution stage and may be equated with beginning and formation as a composite result of several intrinsic and extrinsic factors. The reason for forming new settlements is to provide population (families, social groups, communities) with housing. The decision to create new settlements is based on multiple reasons, namely political, economic, social, administratively and strategic. Subsequently, a first form of settlement is shaped. This is made up of households with related families, who begin to use and manage the available land and set the basis for the future complex shape.

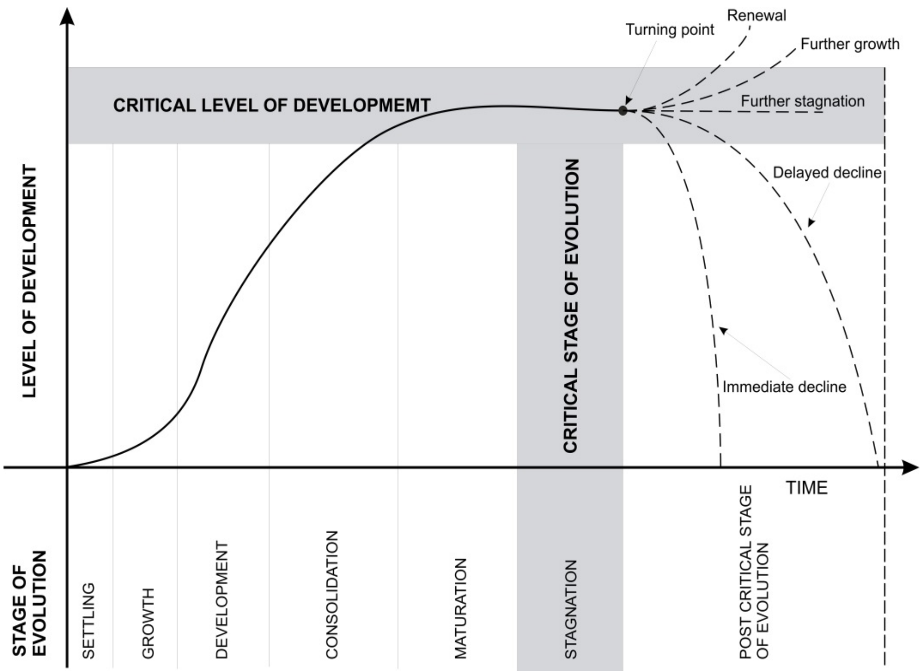

Fig. 1. Phases of settlement development

Settlement growth is the second evolution phase, mainly characterized by increase in the number of households and related population, including new-comers into the community either by migration or by natural reproduction. This stage essentially confirms the appearance of the settlements and lays the foundation for the next development stage.

Settlement development consists in setting up facilities providing permanent housing and most needed public amenities to support the sustainability of settlement. Simultaneously with demographic increase, major economic activities are developed and accessibility is improved. Thus, functional zoning becomes essential and cooperative relations with other settlements in the territory are established.

Consolidation is the fourth stage of evolution, when settlement reaches the maximum development level in the given historical, political and economic context. It is mainly characterized by diversification of facilities and services, economic activities and communication network. This stage is also of the longest duration, settlements completing the development process and stabilizing their position in the territorial hierarchy, even outranking other settlements.

Maturation is the fifth stage of evolution, characterized by latent development, consisting in processes of realignment, reorganization and re-adaptation to changes, driven by internal and external factors. Development has reached the critical level of sustainability, settlements becoming fully structured and representative for the territory they polarize. Since they are at their development peak in the given context (historically, politically and economically) settlements turn now to the critical stage of development – stagnation.

Stagnation is the sixth stage of settlement evolution, when settlements are searching for new development opportunities, while affected by a slight decline and numerous uncertainties. By the end of this stage, settlements find themselves at a crossroads. Consistent with several active control development factors, when they reach this turning point they choose a new defining evolution trajectory. It can then be towards renewal, future development, further stagnation, delayed decline or immediate decline. In case new opportunities for development appear, settlements will then rebound, either following a regeneration path or a new development direction, thus overcoming the critical level, and ensuring their continuity and existence. In the case opportunities for development are only foreseeable, but not yet available, stagnation phase may further extend, but only for an indefinite and finite time. Duration is conditioned by the internal capacity of settlements and their associated structures to perpetuate on their own forces and also by the population choice to still live there. Where opportunities for development are no longer visible, settlements evolve towards decline and can be placed on two possible evolution trajectories: late decline or immediate decline. Late decline is characteristic to settlements that have reached advanced development level and whose internal inertia extends this phase of involution over a long period, for decades or even for centuries. On the contrary, the less developed medium and small size settlements, with reduced internal inertia, are placed on the trajectory of immediate decline, thus reaching collapse in several decades. First, the demographic component disappears, then the built-up area dismantles, and finally the entire settlement system is absorbed by the natural environment and reintroduced into the natural circuit (Fig. 2).

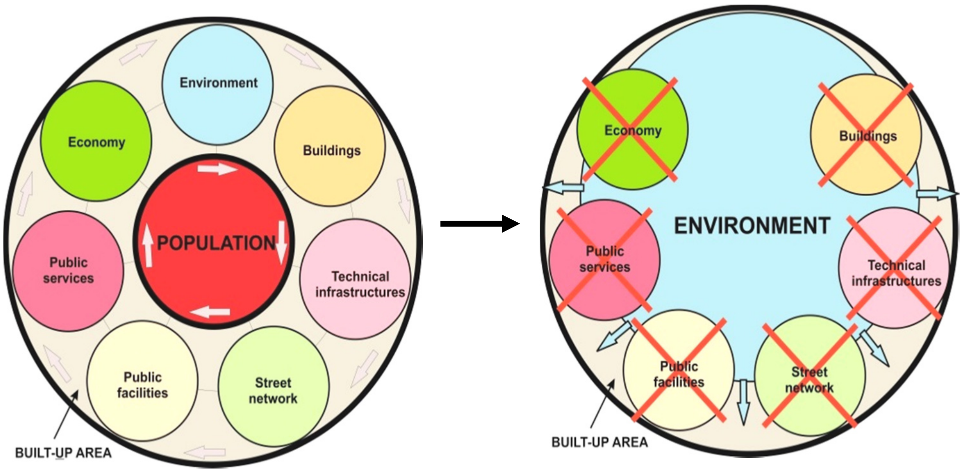

Fig. 2. Functionality and decline of human settlement

In reality, settlements have their own destiny, evolutionary path, duration of functionality and level of complexity in terms of development and particular way of collapse. As compared to large urban settlements, whose level of complexity of development makes their lifespan be of centuries and even millennia, the small and especially the smallest rural settlements are the most susceptible to go through evolutionary stages extremely fast, usually ending their physical existence through a spectacular event or most of the times by depopulation.

3. RESULTS AND DISCUSSION

3.1. The disappearance of rural settlements in Romania after 1990

In the last almost three decades (1992-2016) Romania has registered significant settlement losses, mainly due to depopulation. Rural population decline has started in the ‘60s of the 20th century, when the maximum value was registered (67.9%). Since then, rural population has followed a constant negative trend until today. Altogether, 9,695,506 people live in rural areas in 2016, which is 43.59% of the total Romanian population (NIS, 2015; NIS, 2016). Administratively, they are resident in 2,861 communes (consisting of 12,368 villages). The 928 villages currently found within the administrative borders of cities or towns, were not classified as rural settlements (villages). Urban population, representing 56.41% of the total national population is resident in 320 urban localities (towns and cities). In the last three decades, Romania has lost 182 villages, representing 1.35% of total number of settlements. This is quite an alarming value if we consider that several other localities seem to be on the same path of disappearance in the next period, mainly due to depopulation. The situation at national level is revealed in table 1.

Table 1. Dynamics of settlement collapse rate in Romania after 1990

No. crt.	**County**	**Period 1992-2002**	**Share of the total national (%)**	**Period 2002-2011**	**Share of the total national (%)**	**Period 2011-2016**	**Share of the total national (%)**	**Period 1992-2016**	**Share of the total national (%)**
1	Alba	6	3.30	10	5.49	1	0.55	17	9.34
2	Argeș	1	0.55	4	2.20	1	0.55	6	3.30
3	Bacău	6	3.30	5	2.75	0	0.00	11	6.04
4	Bihor	0	0.00	1	0.55	0	0.00	1	0.55
5	Brăila	8	4.40	0	0.00	0	0.00	8	4.40
6	Botoșani	13	7.14	1	0.55	0	0.00	14	7.69
7	Buzău	3	1.65	1	0.55	0	0.00	4	2.20
8	Cluj	5	2.75	0	0.00	2	1.10	7	3.85
9	Calarasi	7	3.85	0	0.00	0	0.00	7	3.85
10	Caras-Severin	1	0.55	3	1.65	0	0.00	4	2.20
11	Constanța	3	1.65	0	0.00	0	0.00	3	1.65
12	Covasna	2	1.10	0	0.00	0	0.00	2	1.10
13	Dolj	6	3.30	1	0.55	2	1.10	9	4.95
14	Gorj	0	0.00	1	0.55	0	0.00	1	0.55
15	Galați	2	1.10	0	0.00	0	0.00	2	1.10

No. crt.	County	Period 1992-2002	Share of the total national (%)	Period 2002-2011	Share of the total national (%)	Period 2011-2016	Share of the total national (%)	Period 1992-2016	Share of the total national (%)
16	Hunedoara	4	2.20	8	4.40	0	0.00	12	6.59
17	Harghita	4	2.20	2	1.10	1	0.55	7	3.85
18	Ialomița	2	1.10	0	0.00	0	0.00	2	1.10
19	Iași	1	0.55	0	0.00	0	0.00	1	0.55
20	Mehedinți	2	1.10	0	0.00	0	0.00	2	1.10
21	**Mureș**	**6**	**3.30**	**13**	**7.14**	**1**	**0.55**	**20**	**10.99**
22	Neamț	0	0.00	2	1.10	0	0.00	2	1.10
23	Olt	1	0.55	0	0.00	0	0.00	1	0.55
24	Prahova	4	2.20	2	1.10	0	0.00	6	3.30
25	Sibiu	1	0.55	1	0.55	0	0.00	2	1.10
26	Sălaj	1	0.55	1	0.55	1	0.55	3	1.65
27	Satu Mare	3	1.65	1	0.55	0	0.00	4	2.20
28	Suceava	2	1.10	1	0.55	0	0.00	3	1.65
29	Tulcea	3	1.65	1	0.55	0	0.00	4	2.20
30	Timiș	3	1.65	1	0.55	0	0.00	4	2.20
31	Teleorman	1	0.55	1	0.55	0	0.00	2	1.10
32	Vâlcea	1	0.55	0	0.00	0	0.00	1	0.55
33	Vrancea	2	1.10	0	0.00	0	0.00	2	1.10
34	Vaslui	7	3.85	1	0.55	0	0.00	8	4.40
34	***Total national***	111	60.99	62	34.07	9	4.95	182	100.00

Looking closely, the phenomenon of settlement disappearance is found in 33 of the 41 Romanian counties, yet with significant values in the counties of Mureș (15), Botoșani (14), Alba (12) and Bacău (11) (Fig. 3). The period with the highest number of settlement losses is between 1992 and 2002 when 32 counties in Romania recorded such phenomena, except for Gorj and Bihor counties.

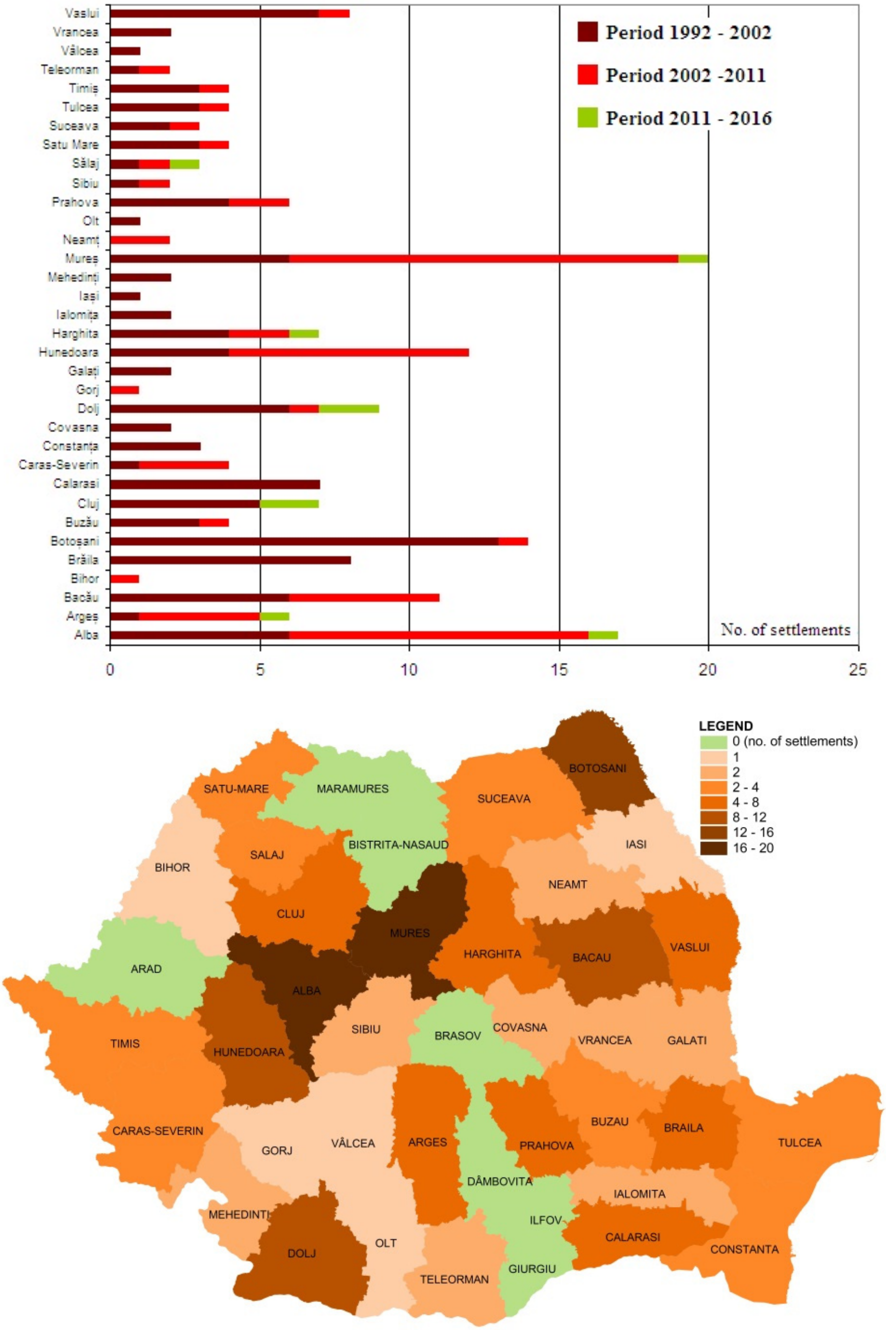

Fig. 3. Spatial distribution of disappeared villages at county level

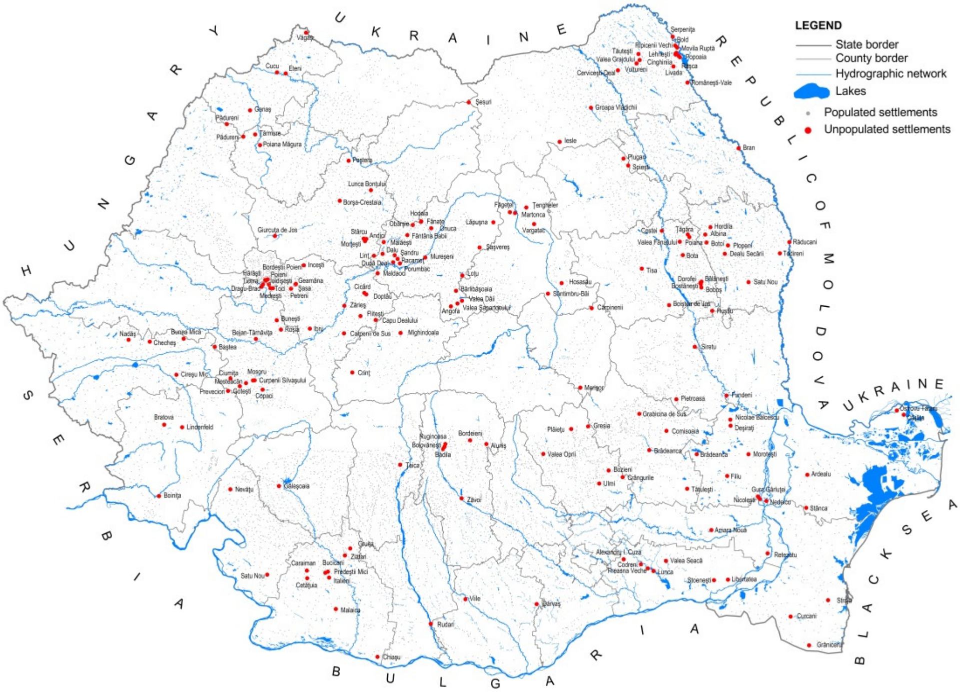

Fig. 4. Territorial distribution of disappeared villages in Romania

Between 2002 and 2011 the phenomenon of settlement disappearance decreased at national level, though remaining high in the counties of Mureș, Bacău and Alba. However, halfway through the 2010-2020 decade, depopulation still persists and it has already been recorded in counties such as Cluj, Mureș, Alba and Harghita. It also seems possible that several other localities will be included in this list by the end of this decade.

The geographical distribution of missing settlements highlights the fact that most of them are grouped into four areas: Apuseni Mountains, Transylvania Plain, Moldavian Plain and Central Moldavian Plateau. Dissapeared settlements in these morphological units seems to have reached the critical conditions that caused the manifestation of this phenomenon: demographic ageing, depopulation, low potential for communication, economic decline, lack of services and public facilities, lack of state interest for the revival of settlements that are in critical condition etc. On the other hand, there are geographical areas where this phenomenon has not occurred at all and settlements are vigorous and register positive development trend, such as: Maramureș, Bistrița, Neamț, Brașov, Bihor, Arad etc.

3.2. Typology of disappeared settlements in Romania

Morphologically, villages have two components, the social component and the built component, and the functionality of the settlement fractures if either one is compromised. The built-up area represents the core of the village and the land here is the most intensively used (Mandal, 2001). The complementary morphological elements of the village consist of street network, residential area and agricultural area. In case of population decline, due to economic reasons or natural dynamics, anyone of the components is subject to transformation or disintegration. On closer examination we find that lost rural settlements fall within a certain typology in terms of population dynamics and the condition of built-up area (Fig. 5). In order to illustrate the main features of each category, we selected one most expressive village for each of them. By using satellite images provided by Google Maps we were able to reveal the current state of the selected villages, indeed, with limitations (given the uncertainty of the time of capturing the satellite images and in the absence of field work).

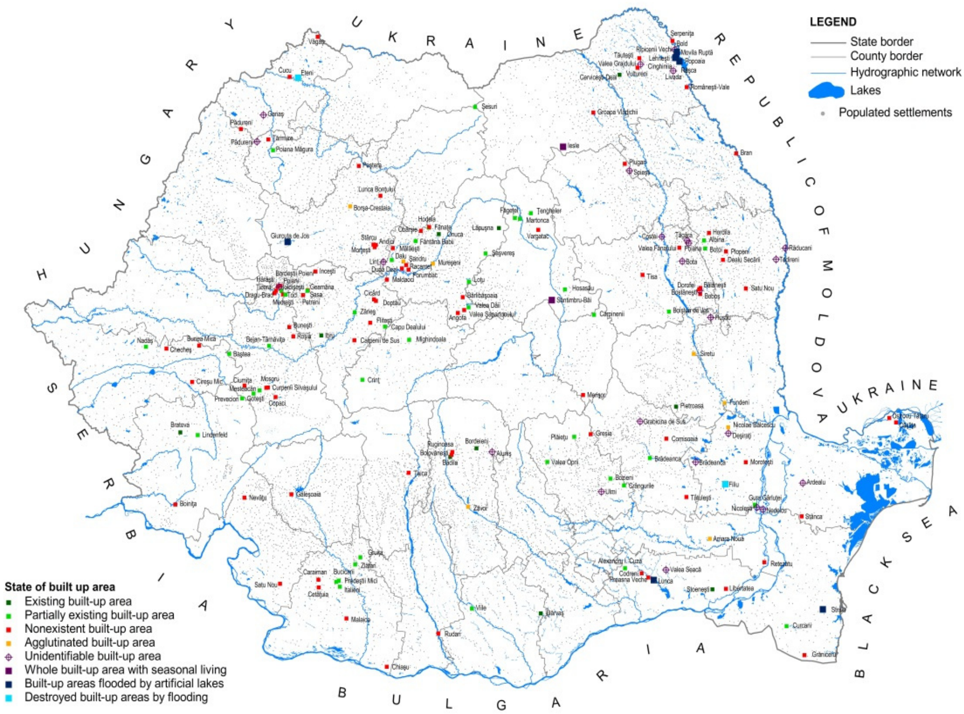

Fig. 5. Spatial distribution of disappeared localities classified by the state of built-up area

Demographically, all of the analyzed villages have lost their population, today being registered without inhabitants or with a population of less than 3 people at the 2011 census (Table 2). The loss of population was achieved either naturally by high mortality rate amid advanced aging population, or through intense migration, and in some cases through the relocation of all residents into another village. This situation has created the main circumstance under which settlements disappear – the demographic loss.

The level of destruction of the built-up area depends on the length of time that passed after population loss. In case settlements have been depopulated for over a decade we can already see the first effects of destruction, whereas in case population loss was more than two or more decades ago, we note the total destruction or even the disappearance of the built-up area and their assimilation into the natural environment.

The analysis on the state of the built-up area revealed that disappeared settlements can be grouped into eight distinct subtypes: *i. existing built-up area, ii. partially existing built-up area, iii. nonexistent built-up area, iv. agglutinated built-up area, v. unidentifiable built-up area, vi. whole built-up area with seasonal living, vii. built-up areas flooded by artificial lakes, viii. built-up areas destroyed by flooding*. They are described below with an illustrative example for each of them.

i. Settlements with intact built-up area. We included here villages that have recently lost their population, while their other components have not yet entered the process of decline. Results show that 10 of the disappeared villages at national level could be included in this category. Households, as well as basic public utilities, are maintained intact (especially the electricity network, where existent) (Fig. 6). Usually, these settlements are seasonally inhabited by owners' descendants, for a period of time (usually several years), subsequently starting the process of household selling. In case settlements are attractive due to their geographical location or benefit from good potential of communication, they may recover from this process of property trading, and resume their function of habitation.

A suitable example to be considered here is Casele Micești village, Feleacu commune, Cluj County, which, after the 1992 census when it recorded 0 inhabitants, at the censuses of 2002 and 2011 it registered demographic growth, today having a population of 30 inhabitants. This is mainly determined by the proximity to an important urban center, Cluj-Napoca municipality, and to the favorable position of the city within Făget forest. Subsequently, it was quickly revived by those eager to live out of town, in homes perfectly integrated into the natural environment. Moreover, the value of land and households in such a settlement, on the verge of disappearance, has grown exponentially, becoming accessible only to wealthy people with substantial revenues. Therefore, we do not exclude that this revival phenomenon of newly abandoned settlements to be repeated in other cases under similar circumstances (Fig. 7).

Fig. 6. Depopulated settlement with intact built-up area. The case of Șandru village, Papiu Ilarian commune, Mureș County, Romania *(Source: Google maps)*

Fig. 7. Depopulated settlement with intact built-up area. The case of Brădeanca village, Buzău County, Romania *(Source: Google maps)*

Another example could be Brădeanca village of Vernești commune, Buzău County, which is located at a distance of only several kilometres from Buzău municipality. After losing its entire population, it has entered a long process of regeneration, households being purchased and reconstructed by new owners, aiming to use them as main or secondary residences (Fig. 8).

Fig. 8. Depopulated settlement in the first stage and then regenerated under favourable conditions. The case of Brădeanca village, Buzău County, Romania *(Source: Google maps)*

ii. Settlements with partially intact built-up area are those that lost their inhabitants a while ago (approximately a decade) and they have already entered the destruction phase because they did not benefit from location or other advantages. Some households have been preserved during this period and used as second homes or have been prepared for selling. The remaining households either degraded to self-demolition or were demolished by the descendants of owners, who reused the construction materials. Results show that 43 of the disappeared villages at national level are depopulated for about 10 years and their built-up areas are partially destroyed. The fact is that these settlements have lost the competition for survival and find themselves on the trend towards destructuring or functional transformation. It could either become an agricultural holding or a tourist village, which would include the renewal of the built-up area by the construction of accommodation infrastructure and other tourism-related facilities (Fig. 9).

Fig. 9. Depopulated settlement with partially intact built-up area. The case of Bârlibășoaia village, Albești commune, Mureș County, Romania *(Source: Google maps)*

In the example above, the built-up area was populated with boarding facilities, mainly guesthouses, thus the village changing its function from residential into tourism and leisure one. This should be seen as a beneficial conversion, investments in infrastructure and utilities being recovered through the change in the use of the built-up area (Fig. 10).

Fig. 10. Depopulated settlement in the first stage and in process of regeneration due to the presence of favourable conditions for tourism development. The case of Bârlibășoaia village, Albești commune, Mureș County, Romania *(Source: Google maps)*

In geographic areas where there are no favourable factors for settlement development, villages in this phase continue to dismantle up to total destruction of built-up area, subsequently being assimilated by the natural environment.

iii. Settlements with nonexistent built-up area. Results show that 85 of the disappeared villages at national level are depopulated for about 10-20 years and their built-up area is entirely destroyed. Since they did not benefit from positional or other advantages, they have already completed the process of material destruction. The sites are empty of any buildings or structures, currently being given agricultural use or even becoming part of the natural environment. The only elements that recall of the former settlement are the cemeteries, remnants of building foundations and various other traces (abandoned orchards, agro-terraces which used to be economically exploited etc.) (Fig. 11, 12).

Fig. 11. Depopulated settlement with nonexistent built-up area. The case of Checheș village, Secaș commune, Timiș County, Romania *(Source: Google maps)*

Each of these settlements has a particular story until they reach this stage of final and irreversible destructuring. They can thus become testimonies to be considered to avoid the reoccurrence of such events in the future and to improve the quality of management in the case of still existing settlements. Each collapsed settlement represents an immense loss for Romania and an attack on our identity as a nation.

Fig. 12. Settlement with nonexistent built-up area. The case of Checheș village, Secaș commune, Timiș County, Romania (*Source: http://debanat.ro/2015/02/trei-sate-din-timis-nu-exista-in-romania-sunt-126-de-localitati-fantoma_97863.html)*

iv. Settlements with agglutinated built-up area. Results show that 4 of the disappeared villages at national level can be included in this category. Along with their inhabitants they have undergone agglutination by a nearby urban or rural locality, thus losing the status of self-contained villages. This can be a natural process when two localities of different size and economic power meet, and the smaller and inferior one represents an obstacle for the development of the largest one. Agglutination is carried out gradually but quite rapidly, especially in the case of urban assimilation. It is eventually acknowledged administratively by transforming the incorporated village into part of the urban locality as residential neighbourhood. Thus the functions of the former village change, along with landscape alterations, according to the needs of the city (Fig. 13). In this case, most often the residential needs prevail, and the rural settlement is converted into residential neighbourhood with individual housing facilities (Fig. 14).

Fig. 13. Settlement with agglutinated built-up area by a city. The case of Mureșeni village, Târgu Mureș Municipality, Mureș County, Romania *(Source: Google maps)*

Fig. 14. Settlement with agglutinated built-up area by a city and transformed into residential neighbourhood. The case of Mureșeni village, Târgu Mureș Municipality, Mureș County, Romania *(Source: Google maps)*

Following the completion of agglutination process of the former settlement, the aim is to maximise the advantages provided by the newly integrated territory. In order to ensure the development of the monopolizing urban settlement, public authorities shall initiate a comprehensive development process: upgrade urban infrastructure (construction of new housing), rehabilitate technical infrastructure and street network, and set up public services and new economic activities.

v. Settlements with unidentifiable built-up area. Results show that 25 of the disappeared villages have been depopulated for more than 20 years at national level and built-up area proves difficult to be identified. The settlement suffered total material destruction. The site is either absorbed into the natural environment or was assigned another economic use (agricultural, industrial, etc.). Villages, whose site can no longer be identified today, disappeared before the '90s of the 20th century, when Romania went through rural systematization process, under the communist rule. The former policy provisioned the forced displacement of population from unviable rural settlements, demolition of settlement and changing the land use either into industrial or agricultural. Subsequently, dozens of villages and their inhabitants disappeared without a trace, being displaced from their former site and relocated in urban residential neighbourhoods and assimilated by the industrialization process, transforming peasants into industrial labour force.

vi. Seasonally inhabited localities (whole built-up area). Results show that 2 of the disappeared villages at national level are depopulated but the built-up area is partially or entirely maintained due to seasonal living. Even though affected by depopulation, these settlements have retained the built-up area entirely or partly. They are seasonally inhabited by the descendants of former owners. In cases where geographical position, potential of communication, or local resources are available and attractive, they can become tourist villages. Although changing the initial function of the village, by setting up tourist-related facilities and accommodation infrastructure, the regeneration of the settlement can become visible. (Fig. 15).

These cases are not especially numerous, although it should become a rule and also a solution to save some of the endangered localities (Fig. 16).

In the case of Iesle village of Mălini commune, Suceava County, taken as an example for this category, we can note that it met only favourable conditions to further maintain built-up area and enhance seasonal living due to its geographical position in the mountainous area, the highly attractive landscape, presence of modernized roads, water and wood resources, electricity, etc. These circumstances favoured not only the seasonal living but even the regeneration of settlement through investments in tourism accommodation infrastructure (lodges, guesthouses and secondary residences). This determined the beginning of the regeneration of the village by filling the built-up area with new constructions. It is therefore the ideal solution for any village in state of decline, thus being able to ensure the continuity of existence.

Fig. 15. Settlement with whole built-up area with seasonal living. The case of Iesle village, Mălini commune, Suceava County, Romania *(Source: Google maps)*

Fig. 16. Settlement with whole built-up area with seasonal living. The case of Iesle village, Mălini commune, Suceava County, Romania *(Source: Google maps)*

vii. Settlements with built-up areas flooded by artificial lakes (destroyed by the construction of dams for water accumulation). Results show that 8 of the disappeared villages at national level could be included in this category. They represent the extreme cases of localities that disappeared fortuitously by the construction of artificial lakes. Such situations were registered in Romania before 1989, during the socialist regime, when electricity consumption grew due to accelerated industrialization, and the energy potential of the internal rivers was valorised at maximum. Thus, several accumulation lakes were built over three decades, some of them extending over territories occupied by settlements (Beliș-Fântânele, Tarnița, Gilău I and II on Someșul Cald River, Stânca Costești on Prut River, Bicaz on Bistrița River, Vidraru on Argeș River, etc.). In such cases, some of the most important settlements were relocated to a new site, being entirely rebuilt, for instance Beliș locality, in Cluj county. The old village is now covered by the waters of Beliș-Fântânele Lake. Others were abandoned, and their inhabitants being forcibly relocated. These abandoned settlements were flooded by artificial lakes, or reservoirs in mining areas, being invisible in the current landscape, only traces of them and life stories maintaining over time.

Fig. 17. Settlement with built-up area flooded by artificial lake. The case of Giurcuța de Jos village, Cluj County, Romania *(Source: Google maps)*

Another notorious example is the village of Geamăna, Lupșa commune, Alba County, which disappeared due to the construction of a tailings pond (Valea Șesii pond) for the gold and silver mining activities in the area. Only some of the households remained, the rest of them being on the bottom of the lake next to the village church. Today the area is strongly affected by chemical pollution and cyanide, while the remaining residents are affected by many diseases associated with pollution, particularly cancer.

Fig. 18. The flooded remainings of Giurcuța de Jos village, Cluj County, Romania. The ruins of the Orthodox Church observed when emptying the accumulation lake *(Source: http://subversiv.info/locuri-de-o-frumusete-rara-bisericile-scufundate-din-romania/)*

Fig. 19. The flooded remainings of Geamăna village, Lupșa commune, Alba County, Romania. The ruins of the Orthodox Church *(Source: Google maps)*

Such cases of settlements cannot be recovered and regenerated for housing, thus remaining just sad examples of the Romanian "golden age".

viii. Settlements with built-up area destroyed by flooding. Results show that 2 of the disappeared villages at national level could be included in this category. They were villages located in floodplains and which suffered total destruction during catastrophic flood events with high flows (e.g. the floods in 1970). These settlements were not rebuilt on the former sites, due to the high risk of flooding reoccurrence and consequently they disappeared, the population being relocated in the nearby villages. The best example in this case is Filiu village, belonging to Bordei Verde commune in Brăila County, which was completely destroyed during floods in 1970, due to its location in low plains, where water stagnated for a long period of time.

Fig. 20. The ruins of the Orthodox Church in Filiu village, Brăila County, destroyed by floods in 1970 *(Source: https://commons.wikimedia.org/wiki/File:2013_-_Biserica_din_satul_Filiu_comuna_Bordei_Verde_in_ruina_-_Exterior. png)*

Most of the buildings here were made of bricks dried in the sun. This construction material swollen from excessive moisture and thus all houses were destroyed. The testimony for the existence of this village is represented by the ruins of the Orthodox Church and cemetery, the site of the former village being given agricultural use during the ample process of rural systematization.

Nationally, the disappearance of localities by destruction caused by floods is particularly specific to river basins, such as Someș-Tisa, Mureș, Siret, Prut and others.

3.3. Effects of settlement disappearance

Undoubtedly, the disappearance of settlements entails multiple effects socially (particularly culturally), economically, ecologically and territorially, some of them having only local repercussions, while others reverberating to regional and even national scale. The social effects are represented by the dissolution of human communities that lived within the village and the loss of cultural heritage generated throughout their existence. It directly entails depopulation of the territory and decrease in economic polarization. The decrease of economic polarization brings out other economic negative effects such as: disappearance of some local production centres, destruction of facilities and equipment with subsequent effects on the exploitation of local resources (land, subsoil etc.), abandonment of agricultural land and degradation through fallow, destruction of public service facilities that were developed with material and financial resources of the local communities, destruction of transport and communication infrastructure, etc. Altogether, social and economic effects lead to negative manifestation of territorial effects, most notably being the decreasing degree of spatial accessibility affected by the disappearance of settlements. This inevitably leads to isolation and finally it re-enters the natural cycle. Another territorial effect is felt in the settlements system, balanced through actions of administrative-territorial reorganization. This way, such administrative units are dismantled and new ones are created by merging the unviable ones or by transferring villages from one commune to another. Another side effect of the disappearance of settlements appears at the political level, this phenomenon being somewhat speculated especially for electoral purposes, being frequently indicated by the opposition as an example of territorial mismanagement on behalf of the local authorities and interested decision makers.

4. CONCLUSIONS

Rural and urban settlement evolution is a continuous process. Among the majors factors affecting the evolution and development of rural settlements are demographic ageing and migration. Nevertheless, the dynamics of urban settlements is the most visible and significantly approached by the specialists in the field. Still, the dynamics of rural settlements are of the same importance and have implications in the development and functionality of the rural areas. Most of the international and national researchers and policy-makers are focused on the factors affecting the evolution or development, on the partial effects of these factors or on the revitalization of rural areas economically, socially or environmentally.

In this study we aimed to highlight the perceptible changes in the number of rural settlements, revealing the disappearance of a significant number of villages mostly due to depopulation in an almost three-decade period in Romania (1992-

2016). At this point, the phenomenon of settlement disappearance has become a certainty in Romania's development. Along with the weak policies for local development and the non-involvement of the state in this issue over the past 25 years, more and more settlements have been declining demographically and economically and subsequently they disappeared. The spatial changes are noticeable and highlighted in the case of 182 villages at national level, each of them being classified into a certain category according to their structural remains. Other settlements in Romania are already being placed on trajectories of sharp involution seeming doom to disappear in the next decade. All these will have wider negative effects socially, economically and territorially, which is a proof that Romania is also subject to internal vulnerability. We therefore estimate that, in the next decade, the extinction rate of settlements in Romania will increase up to almost double the current value based on ageing and depopulation of existing settlements.

Even though it is such an important aspect in the functionality and development of rural areas, the transition of villages from birth to disappearance, and especially the phase of immediate or late decline, proves to be insufficiently insisted on in the European or national strategies for rural development and planning. They should promote and implement action plans focused on the regulation of the trend and not only to solve problems that may be irreversible in some cases. The ultimate purpose in the end should be to increase village resilience and enhance the power of their communities to adapt socially, environmentally and economically.

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APPENDIX 1.

List of depopulated and disintegrated settlements in Romania after 1990. Administrative location, number of population officially recorded at the 1992, 2002 and 2001 censuses, state of built-up area and geographical location.

No. crt.	Village	Commune Town	County	No. of population			* State of the built-up area	Geographical unit
				1992	2002	2011		
1	Bordeştii Poieni	Vidra	Alba	12	1	0	3	Munţii Apuseni (Depresiunea Câmpeni)
2	Capu Dealului	Cenade	Alba	11	3	**	2	Podişul Secaşelor
3	Cărpenii de Sus	Şpring	Alba	4	0	0	3	Podişul Secaşelor
4	Cicârd	Lopadea Nouă	Alba	7	0	0	3	Dealurile Lopadei (Pod. Târnavei Mici)
5	Doptău	Şona	Alba	0	0	0	3	Dealurile Lopadei (Pod. Târnavei Mici)
6	Fliteşti	Municipiul Blaj	Alba	4	4	0	3	Podişul Secaşelor
7	Geamăna	Lupşa	Alba	7	1	0	3	Munţii Apuseni (Munţii Metaliferi)
8	Hărăşti	Vidra	Alba	9	0	0	3	Munţii Apuseni (Depresiunea Câmpeni)
9	Ibru	Blandiana	Alba	9	3	0	1	Munţii Apuseni (Munţii Metaliferi)
10	Inceşti	Poşaga	Alba	3	0	0	3	Munţii Apuseni (Masivul Muntele Mare)
11	Joldişeşti	Sohodol	Alba	18	14	0	2	Munţii Apuseni (Masivul Găina)
12	Medreşti	Sohodol	Alba	6	4	0	3	Munţii Apuseni (Masivul Găina)
13	Toci	Sohodol	Alba	14	8	0	2	Munţii Apuseni
14	Poieni	Vidra	Alba	15	0	0	5	Munţii Apuseni (Depresiunea Câmpeni)
15	Şasa	Lupşa	Alba	25	17	**	2	Munţii Apuseni (Munţii Metaliferi)
16	Petreni	Bucium	Alba	10	6	**	3	Munţii Apuseni (Munţii Metaliferi)
17	Zărieş	Mihalţ	Alba	0	8	4	2	Culoarul Mijlociu al Mureşului

No. crt.	Village	Commune Town	County	No. of population			* State of the built-up area	Geographical unit
				1992	2002	2011		
18	Aluniș	Mioarele	Argeș	6	7	**	5	Subcarpații Getici
19	Bădila	Valea Iașului	Argeș	4	3	**	1	Subcarpații Getici
20	Ruginoasa	Valea Iașului	Argeș	8	2	0	3	Subcarpații Getici
21	Bolovănești	Mușătești	Argeș	5	3	**	3	Subcarpații Getici
22	Bordeieni	Godeni	Argeș	7	0	0	1	Subcarpații Getici
23	Zăvoi	Oras Ștefănești	Argeș	0	0	1053	4	Piemontul Cândești Câmpia Română
24	Bălăneşti	Dealu Morii	Bacău	5	2	**	3	Podișul Central Moldovenesc
25	Boboş	Dealu Morii	Bacău	4	0	0	3	Podișul Central Moldovenesc
26	Bostăneşti	Dealu Morii	Bacău	2	5	**	5	Podișul Central Moldovenesc
27	Dorofei	Dealu Morii	Bacău	7	1	0	3	Podișul Central Moldovenesc
28	Boiștea de Jos	Coțofănești	Bacău	16	29	0	2	Subcarpații de Curbură
29	Bota	Ungureni	Bacău	0	0	0	5	Podișul Central Moldovenesc
30	Coștei	Săucești	Bacău	0	0	0	5	Culoarul Siretului
31	Poiana	Coloneşti	Bacău	0	0	**	5	Podișul Central Moldovenesc
32	Tisa	Sănduleni	Bacău	6	4	0	3	Subcarpații de Curbură
33	Ţâgâra	Plopana	Bacău	0	0	0	5	Podișul Central Moldovenesc
34	Valea Fânaţului	Secuieni	Bacău	0	0	0	3	Podișul Central Moldovenesc
35	Pădureni	Viișoara	Bihor	2	2	**	3	Dealurile Viișoarei
36	Brădeanca	Jirlău	Brăila	0	0	0	5	Câmpia Băraganului
37	Deşiraţi	Scorţaru Nou	Brăila	0	0	0	5	Câmpia Băraganului
38	Nicolae Bălcescu	Scorţaru Nou	Brăila	0	0	0	4	Câmpia Băraganului
39	Filiu	Bordei Verde	Brăila	0	0	0	8	Câmpia Băraganului
40	Gura Gârluţei	Berteștii de Jos	Brăila	6	0	0	2	Lunca Dunării
41	Morotești	Unirea	Brăila	0	0	0	3	Câmpia Bărăganului
42	Nedeicu	Mărașu	Brăila	0	0	0	5	Lunca Dunării

No. crt.	Village	Commune Town	County	No. of population			* State of the built-up area	Geographical unit
				1992	2002	2011		
43	Nicoleşti	Berteştii de Jos	Brăila	0	0	0	5	Lunca Dunării
44	Bold	Manoleasa	Botoşani	0	0	0	5	Câmpia Moldovei
45	Şerpeniţa	Manoleasa	Botoşani	0	0	0	3	Culoarul Prutului
46	Cinghiniia	Ripiceni	Botoşani	0	0	0	3	Culoarul Prutului
47	Lehneşti	Ripiceni	Botoşani	0	0	0	7	Culoarul Prutului
48	Movila Ruptă	Ripiceni	Botoşani	0	0	0	7	Culoarul Prutului
49	Popoaia	Ripiceni	Botoşani	0	0	0	3	Culoarul Prutului
50	Râşca	Ripiceni	Botoşani	0	0	0	7	Culoarul Prutului
51	Ripicenii Vechi	Ripiceni	Botoşani	0	0	0	7	Culoarul Prutului
52	Livada	Dobârceni	Botoşani	0	0	0	5	Câmpia Moldovei
53	Româneşti-Vale	Româneşti	Botoşani	0	0	0	3	Câmpia Moldovei
54	Cerviceşti-Deal	Mihai Eminescu	Botoşani	4	11	0	1	Câmpia Moldovei
55	Tăuteşti	Ungureni	Botoşani	0	0	0	3	Câmpia Moldovei
56	Valea Grajdului	Unţeni	Botoşani	0	0	0	5	Câmpia Moldovei
57	Vultureni	Unţeni	Botoşani	0	0	0	3	Câmpia Moldovei
58	Brădeanca	Verneşti	Buzău	0	0	0	2	Câmpia Bărăganului
59	Comisoaia	Zărneşti	Buzău	0	0	0	3	Câmpia Bărăganului
60	Grabicina de Sus	Scorţoasa	Buzău	111	3	0	5	Câmpia Bărăganului
61	Tătuleşti	Padina	Buzău	0	0	0	3	Câmpia Bărăganului
62	Andici	Ceanu Mare	Cluj	0	0	0	3	Colinele Luduşului
63	Morţeşti	Ceanu Mare	Cluj	11	3	5	3	Colinele Luduşului
64	Stârcu	Ceanu Mare	Cluj	17	9	6	3	Colinele Luduşului
65	Borşa-Crestaia	Borşa	Cluj	2	0	0	4	Dealurile Clujului (Podişul Someşan)
66	Giurcuţa de Jos	Beliş	Cluj	0	0	0	7	Platoul Padeşului
67	Lunca Bonţului	Fizeşu Gherlii	Cluj	0	0	0	3	Dealurile Sicului (Câmpia Transilvaniei)
68	Peştera	Municipiul Dej	Cluj	0	0	0	3	Dealurile Dejului (Podişul Someşan)

No. crt.	Village	Commune Town	County	No. of population			* State of the built-up area	Geographical unit
				1992	2002	2011		
69	Alexandru I. Cuza	Oraş Fundulea	Călăraşi	0	0	0	2	Câmpia Română (Câmpia Nana)
70	Codreni	Gurbăneşti	Călăraşi	0	0	0	3	Câmpia Română (Câmpia Nana)
71	Libertatea	Dichiseni	Călăraşi	0	0	0	3	Câmpia Română (Câmpia Călăraşului)
72	Lunca	Valea Argovei	Călăraşi	0	0	0	7	Câmpia Română (Câmpia Nana)
73	Preasna Veche	Gurbăneşti	Călăraşi	0	0	0	3	Câmpia Română (Câmpia Nana)
74	Stoeneşti	Modelu	Călăraşi	0	0	0	1	Câmpia Română (Câmpia Călăraşului)
75	Valea Seacă	Oraş Lehliu Gară	Călăraşi	0	0	0	5	Câmpia Română (Câmpia Lehliului)
76	Bratova	Târnova	Caraş-Severin	11	47	0	1	Dealurile Ezerişului (Dealurile de Vest)
77	Boiniţa	Dalboset	Caraş-Severin	18	17	**	3	Depresiunea Bozovici
78	Lindenfeld	Buchin	Caraş-Severin	1	0	0	2	Munţii Semenic
79	Preveciori	Băuţar	Caraş-Severin	19	10	**	2	Munţii Poiana Ruscă
80	Curcani	Cobadin	Constanţa	0	19	4	2	Câmpia Română (Câmpia Călăraşului)
81	Grăniceru	Oraş Negru Vodă	Constanţa	0	0	0	3	Câmpia Română (Câmpia Călăraşului)
82	Straja	Cumpăna	Constanţa	0	0	0	7	Podişul Medgidiei (Podişul Dobrogei)
83	Cărpinenii	Estelnic	Covasna	4	0	**	2	Munţii Nemira (Carpaţii Orientali)
84	Merişor	Sita Buzăului	Covasna	0	0	0	3	Munţii Întorsurii (Carpaţii Orientali)
85	Bucicani	Predești	Dolj	16	7	**	2	Piemontul Bălăciţei
86	Predeștii Mici	Predești	Dolj	17	24	3		Piemontul Bălăciţei
87	Caraiman	Brabova	Dolj	0	0	0	3	Piemontul Bălăciţei
88	Cetăţuia	Vela	Dolj	2	0	0	3	Piemontul Bălăciţei
89	Chiaşu	Oraş Dăbuleni	Dolj	0	0	0	3	Lunca Dunării
90	Gruiţa	Goieşti	Dolj	28	3	0	2	Podişul Tesluiului
91	Italieni	Bucovăţ	Dolj	0	0	0	2	Piemontul Bălăciţei
92	Malaica	Cerăt	Dolj	48	0	0	3	Câmpia Băileştilor
93	Zlatari	Goiești	Dolj	8	0	0	2	Podişul Tesluiului

No. crt.	Village	Commune Town	County	No. of population			* State of the built-up area	Geographical unit
				1992	2002	2011		
94	Găleşoaia	Câlnic	Gorj	260	140	0	3	Depresiunea Târgu-Jiu
95	Fundeni	Fundeni	Galați	0	0	0	4	Culoarul Inferior al Siretului
96	Huştiu	Priponeşti	Galați	0	0	0	5	Podişul Central Moldovenesc
97	Baştea	Lăpugiu de Jos	Hunedoara	5	0	0	2	Dealurile Lăpugiului
98	Bejan-Târnăvița	Şoimuş	Hunedoara	5	2	**	2	Munții Zărandului
99	Buneşti	Balşa	Hunedoara	10	0	0	3	Munţii Metaliferi (Munţii Apuseni)
100	Ciumiţa	Lunca Cernii de Jos	Hunedoara	4	0	0	3	Munţii Poiana Ruscă
101	Copaci	Toteşti	Hunedoara	5	3	0	3	Depresiunea Haţegului
102	Curpenii Silvaşului	Toplița	Hunedoara	0	0	0	3	Munţii Poiana Ruscă
103	Dragu-Brad	Blăjeni	Hunedoara	13	6	**	3	Munţii Apuseni (Masivul Găina)
104	Goteşti	Răchitova	Hunedoara	10	3	**	2	Munţii Poiana Ruscă
105	Mesteacăn	Răchitova	Hunedoara	25	11	0	2	Munţii Poiana Ruscă
106	Mosoru	Toplița	Hunedoara	3	1	0	3	Munţii Poiana Ruscă
107	Roşia	Balşa	Hunedoara	17	7	**	3	Munţii Apuseni (Munţii Metaliferi)
108	Ticera	Bulzeştii de Sus	Hunedoara	13	1	0	3	Munţii Apuseni (Masivul Găina)
109	Făgeţel	Remetea	Harghita	19	4	**	2	Depresiunea Gheorgheni
110	Martonca	Remetea	Harghita	0	0	0	2	Depresiunea Gheorgheni (Carpaţii Orientali)
111	Hosasău	Leliceni	Harghita	1	1	0	2	Depresiunea Ciucului (Carpaţii Orientali)
112	Sântimbru-Băi	Sântimbru	Harghita	0	0	0	6	Munţii Harghitei (Carpaţii Orientali)
113	Şaşvereş	Praid	Harghita	0	0	0	2	Depresiunea Sovata
114	Ţengheler	Ditrău	Harghita	0	0	0	2	Depresiunea Gheorgheni
115	Vargatac	Municipiul Gheorgheni	Harghita	16	8	7	3	Depresiunea Gheorgheni (Carpaţii Orientali)
116	Amara Nouă	Amara	Ialomiţa	0	0	7	4	Câmpia Română (Câmpia Bărăganului)
117	Retezatu	Stelnica	Ialomiţa	33	0	0	3	Lunca Dunării

No. crt.	Village	Commune Town	County	No. of population			* State of the built-up area	Geographical unit
				1992	2002	2011		
118	Bran	Golăiești	Iași	1	0	0	3	Culoarul Prutului
119	Nevățu	Balta	Mehedinți	0	0	0	3	Podișul Mehedinți
120	Satu Nou	Punghina	Mehedinți	0	0	0	3	Câmpia Băileștilor
121	Angofa	Municipiul Sighișoara	Mureș	4	4	**	3	Podișul Vânători
122	Bârlibășoaia	Albești	Mureș	0	0	0	3	Dealurile Dumbrăveni (Podișul Târnavei Mare)
123	Valea Dăii	Albești	Mureș	7	4	0	2	Colinele Comlodului
124	Valea Șapartocului	Albești	Mureș	6	223	0	3	Podișul Vânători
125	Dalu	Sânger	Mureș	8	6	0	2	Colinele Ludușului (Câmpia Transilvaniei)
126	După Deal	Cuci	Mureș	0	0	0	3	Colinele Comlodului
127	Fânațe	Fărăgău	Mureș	22	13	**	2	Colinele Comlodului
128	Hodaia	Fărăgău	Mureș	0	0	0	3	Colinele Mădărașului
129	Onuca	Fărăgău	Mureș	102	71	0	1	Colinele Mădărașului (Câmpia Transilvaniei)
130	Lăpușna	Ibănești	Mureș	71	1	**	1	Munții Burghiului
131	Linț	Chețani	Mureș	4	2	0	5	Colinele Ludușului
132	Loțu	Oraș Sângeorgiul de Pădure	Mureș	15	6	**	2	Podișul Târnavei Mari
133	Mălăești	Valea Larga	Mureș	13	5	**	3	Dealurile Comlodului
134	Maldaoci	Ațintiș	Mureș	0	0	0	3	Podișul Târnăveni
135	Mureșeni	Municipiul Târgu Mureș	Mureș	970	947	0 ***	4	Culoarul Mureșului
136	Obârșie	Râciu	Mureș	5	3	**	3	Colinele Comlodului
137	Fântâna Babii	Pogăceaua	Mureș	2	0	0	2	Colinele Comlodului (Câmpia Transilvaniei)
138	Porumbac	Oraș Iernut	Mureș	53	32	3	3	Colinele Mădărașului
139	Racameț	Oraș Iernut	Mureș	33	26	0	3	Colinele Comlodului
140	Șandru	Papiu Ilarian	Mureș	2	0	0	4	Colinele Comlodului
141	Plugari	Urecheni	Neamț	18	9	**	3	Culoarul Moldovei
142	Spiești	Pastrăveni	Neamț	7	4	**	5	Culoarul Moldovei

No. crt.	Village	Commune Town	County	No. of population			* State of the built-up area	Geographical unit
				1992	2002	2011		
143	Rudari	Scărişoara	Olt	0	0	0	3	Lunca Oltului
144	Bozieni	Fântânele	Prahova	76	1	**	2	Subcarpaţii Curburii
145	Crângurile	Baba Ana	Prahova	0	0	0	2	Subcarpaţii Curburii
146	Gresia	Starchiojd	Prahova	17	8	**	3	Subcarpaţii Curburii
147	Plăieţu	Măneciu	Prahova	0	0	0	2	Munţii Ciucaşului (Carpaţii Orientali)
148	Ulmi	Oraş Urlaţi	Prahova	0	0	0	5	Subcarpaţii Curburii
149	Valea Oprii	Cornu	Prahova	0	0	0	2	Subcarpaţii Curburii
150	Crinț	Oraş Săliște	Sibiu	1	0	0	2	Munţii Cindrelului
151	Mighindoala	Seica Mare	Sibiu	11	2	**	2	Podişul Secașelor
152	Pădureni	Camăr	Sălaj	0	0	0	5	Dealurile Vulturilor
153	Poiana Măgura	Şărmăşag	Sălaj	33	11	3	2	Culmea Șimleului (Dealurile de Vest)
154	Ţărmure	Şărmăşag	Sălaj	5	1	**	3	Dealurile Vulturilor (Dealurile de Vest)
155	Cucu	Odoreu	Satu Mare	0	0	0	3	Câmpia Someșană (Câmpia de Vest)
156	Eteni	Odoreu	Satu Mare	0	0	0	8	Câmpia Someșană (Câmpia de Vest)
157	Ganaș	Acâș	Satu Mare	0	6	0	5	Câmpia Tășnadului (Câmpia Transilvaniei)
158	Văgaș	Tarna Mare	Satu Mare	0	6	0	3	Munţii Oaș (Carpaţii Orientali)
159	Groapa Vlădichii	Moara	Suceava	0	0	0	3	Podişul Sucevei
160	Iesle	Mălini	Suceava	0	0	0	6	Munţii Suhardului (Carpaţii Orientali)
161	Șesuri	Cârlibaba	Suceava	35	12	**	2	Valea Bistriței
162	Ardealu	Dorobanţu	Tulcea	0	0	0	5	Munţii Măcinului
163	Câşliţa	Chilia Veche	Tulcea	1	13	0	3	Delta Dunării
164	Ostrovu Tătaru	Chilia Veche	Tulcea	0	0	0	3	Delta Dunării
165	Stânca	Casimcea	Tulcea	0	0	0	3	Podişul Casimcei (Podişul Dobrogei)
166	Bunea Mică	Oraş Făget	Timiş	0	0	0	3	Dealurile Lipovei
167	Checheş	Secaş	Timiş	0	7	0	3	Dealurile Lipovei
168	Cireşu Mic	Criciova	Timiş	0	0	0	3	Dealurile Lugojului

No. crt.	Village	Commune Town	County	No. of population			* State of the built-up area	Geographical unit
				1992	2002	2011		
169	Nadăș	Oraș Recaș	Timiș	0	0	0	2	Dealurile Lipovei
170	Dărvaș	Bujoreni	Teleorman	0	0	0	1	Câmpia Română (Câmpia Călniștei)
171	Viile	Scrioastea	Teleorman	8	5	0	2	Câmpia Română (Câmpia Iminogului)
172	Țeica	Oraș Ocnele Mari	Vâlcea	77	0	0	3	Subcarpații Getici
173	Pietroasa	Tâmboești	Vrancea	172	0	0	1	Subcarpații Curburii
174	Siretu	Oraș Mărășești	Vrancea	0	0	0	4	Culoarul Inferior al Siretului
175	Albina	Ivănești	Vaslui	0	0	3	2	Podișul Central Moldovenesc
176	Botoi	Dragomirești	Vaslui	0	0	0	2	Podișul Central Moldovenesc
177	Dealu Secării	Poienești	Vaslui	6	0	**	3	Podișul Central Moldovenesc
178	Hordila	Pungești	Vaslui	0	0	0	3	Podișul Central Moldovenesc
179	Plopeni	Bogdana	Vaslui	0	0	0	3	Podișul Central Moldovenesc
180	Răducani	Lunca Banului	Vaslui	9	2	**	5	Culoarul Prutului
181	Satu Nou	Banca	Vaslui	0	0	0	3	Podișul Central Moldovenesc
182	Todireni	Pădureni	Vaslui	0	0	0	5	Podișul Central Moldovenesc

Notes:

* Condition of the built-up area
1 - existing built-up area
2 - partially existing built-up area
3 - nonexistent built-up area
4 - agglutinated built-up area
5 - unidentifiable built-up area
6 - whole built-up area with seasonal living
7 - built-up areas flooded by artificial lakes
8 - built-up areas destroyed by flooding

** less than three inhabitants were registered

*** locality integrated within the administrative borders of Târgu Mureș municipality

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COAL OF PETROŞANI BASIN, A DESIDERATUM BETWEEN SUSTAINABLE EXPLOITATION AND ENERGY SECURITY

C. NIMARĂ[1], GR. BUIA[2]

ABSTRACT. – Coal of Petroşani Basin, a Desideratum between Sustainable Exploitation and Energy Security. Along with the market economy, sustainable development, ecological balance, property, economic freedom, financial system, social protection and scientific research, the natural resources of a country are the basis for building a modern, stable and strong economy. So, natural resources, including energy security are among the values of economic interest for national security. Being deeply interdependent, any malfunction in one of these areas significantly influences the other components of economic security. This paper aims to present the strategic role of the coals quartered in Petroșani Basin based on analyzes and highlighting the economic problems raised by the close of mining in the context of sustainable development of the region. The statistics show that in Petroșani Basin, the hard coal can also be extracted for approximately 60 years.

Keywords: *coal, mining activity, coal, Petroșani Basin, energy, sustainability.*

1. INTRODUCTION

Petroșani Basin, generically named "Jiu Valley" is the main bituminous coal resource of the country, which until 1990 provided raw materials for steel, metallurgy and energy (Pop, 1993). The national program has been operational since 1970 and 1980 providing a considerable increase in the quantity of coal to power plants and the use of oil and natural gas for electricity should have decreased from 50% in 1981 to 5% in 1990, while that, at those years, coal production was about 11 mil. tons/year. The transition from planned economy to market economy has led to a decrease in mining, ie the number of employees and hence the production of coal. Currently, the staff numbers from the production is 4700 people.

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Jiu Valley mining has a history of over 200 years and the Romania's industrialization could not be achieved without the deposit from here. During the economic boom, there were 48 active mines, four coal pits and five processing plants. In 2015 functioned seven mines and a processing plant at Vulcan. Currently only four mines are considered viable: Lonea, Livezeni, Vulcan and Lupeni (figure 1). Although the state is no longer interested in the Romanian domestic coal, the coal deposit is far from finished.

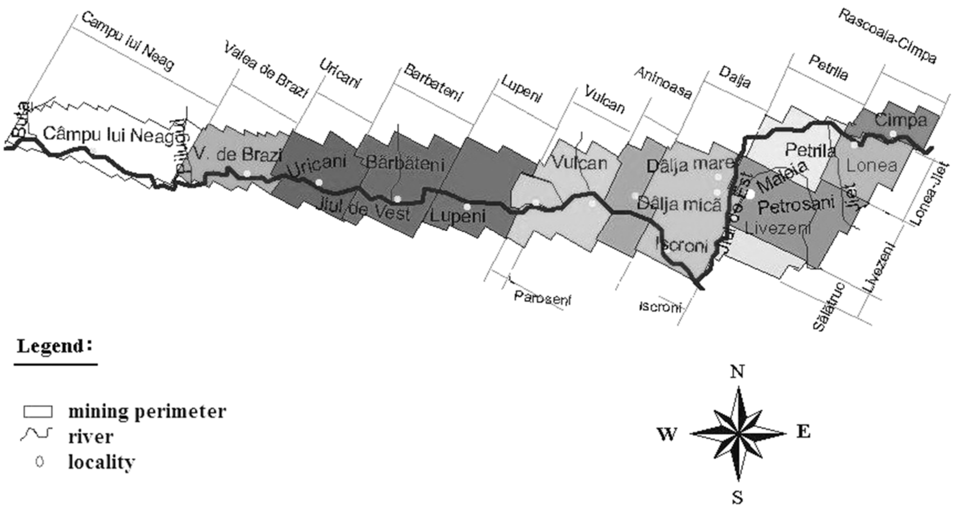

Fig. 1. Mining perimeters from Petroșani Basin
(Source: Nimara, 2010)

Given the characteristics of coal extracted from Petroșani Basin (energy coal with calorific value of 3650 kcal / kg) its use in power plants can only be equipped for this fuel and located as close to suppliers (Fodor, Pleșea, 2006). Currently, in Romania there are four power plants that use coal, two of which are in Hunedoara County (Paroşeni and Mintia). For these reasons, coal is a captive primary energy carrier and can not be subject to coal market in the true sense of the word.

Romania's coal deposits are located in complex geo-mining conditions and mineralogical characteristics that influence the quality are at the lower end. In terms of economic and energy for electricity production, indigenous coal, without subsidies becomes a marginal source.

2. SUSTAINABLE EXPLOITATION IN THE CONTEXT OF ENERGY SECURITY

Energy has become a strategic factor in global politics, a vital component for economic development and progress of society as a whole, generating a number of concerns worldwide since the immediately period following World War I.

Energy security occupies a key position on the international agenda and in the Romanian Energy Policy, its strategic goal is to ensure energy security, based on an efficient supply of primary resources (fossil energy resources and renewable resources), the production, distribution and supply, ensuring a continuous supply of all consumers in terms of accessibility, availability and affordability of prices, taking into account the evolution of environmental quality.

Romania has a wide range, but reduced quantity of primary fossil energy resources and minerals: oil, natural gas, coal and uranium, as well as an important potential of renewable resource. A fair assessment of the possibilities coverage requirement of primary energy resources must start from the current situation of proven reserves, coupled with realistic estimate of potential resources and in close correlation with consumption forecasts of resources determined by final energy demand. From this point of view at the moment it can be made the following estimation:

- lignite reserves can still ensure efficient exploitation for about 40 years at a production level of about 30 mil. tons/year (www.wmc.org.pl). The extraction of lignite in the level of state intervention is reduced, being limited to subsidies only for the exploitation of underground subsidy will be eliminated over time;

- in terms of coal reserves, restriction and closure of non-performing mining perimeters led to a situation where only 30% of the total geological reserves of coal are found in the concession perimeters of CEH. According to the guidelines, U.E. allows the coal subsidy to continue the operation for 2018 and this condition of strict implementation of a program of closing loss-making mines. It can be estimated that changes in production costs, the extra cost of CO_2 emissions and the removal of subsidies on production (required by the E.U.) will reduce the competitiveness of domestic production of hard coal and therefore the significant restriction of production (Proiect SPOS, 2008).

Even if they were closed based on economic or political issues, the mining perimeters still have important geological reserves that could be operated (table 1, table 2) (Buia et al., 2014):

Table 1. Situation of geological reserves from the closed mining perimeters (thousand tons)

Category	Câmpu lui Neag	Valea de Brazi	Aninoasa	Dâlja	Petrila Sud	Lonea Pilier
Probable geological reserves	978	18,355	99,678	24,254	27,209	41,693
Total geological reserves from mining perimeter	1,748	88,352	99,849	84,367	87,063	94,353
Energy value (kcal/kg)	4,776	5,343	5,539	5,434	5,566	5,788

Table 2. Situation of geological reserves from the closed mining perimeters, considered to be profitless (thousand tons)

Category	Uricani	Paroșeni	Petrila
Probable geological reserves	62,924	19,039	69,720
Total geological reserves from mining perimeter	110,769	41,473	88,457

The Romanian Government concluded that it can not endlessly keep alive the companies that go to loss. Currently, CEH is an insolvent company with a debt to the state budget of 165 981 506 lei and 2 180 403 lei from local budgets and short-term domestic bank loans of 486 320 182 lei and long-term bank loans of 117 240 591 lei.

In the last 20 years ago one could discuss the social impact of mine closure (dismissal of miners). Miners who currently were working in 1990 almost all of them got retired, considering that the retirement age is 45 years. So miners who will lose their jobs are those employed after the moment when the decision factors knew that mining should be restructured. As early of 2004 it was known that for 1000 lei of useful product from CEH is spent 4000 lei and CEO is the only coal mining company which still has competitive sides.

The electricity production from fossil fuels represents an important share in Romania. Much of this production is represented by the coal, which is a cheap fuel. In recent years there have been successes in terms of combustion gases remediation, for example at Paroșeni and Mintia power plants, which have gone through stages of refurbishment, which imposed long periods of stagnation of electricity production based on coal. Given that these steps were perfect, yet only four mines remain in operation, as shown below (figure 2):

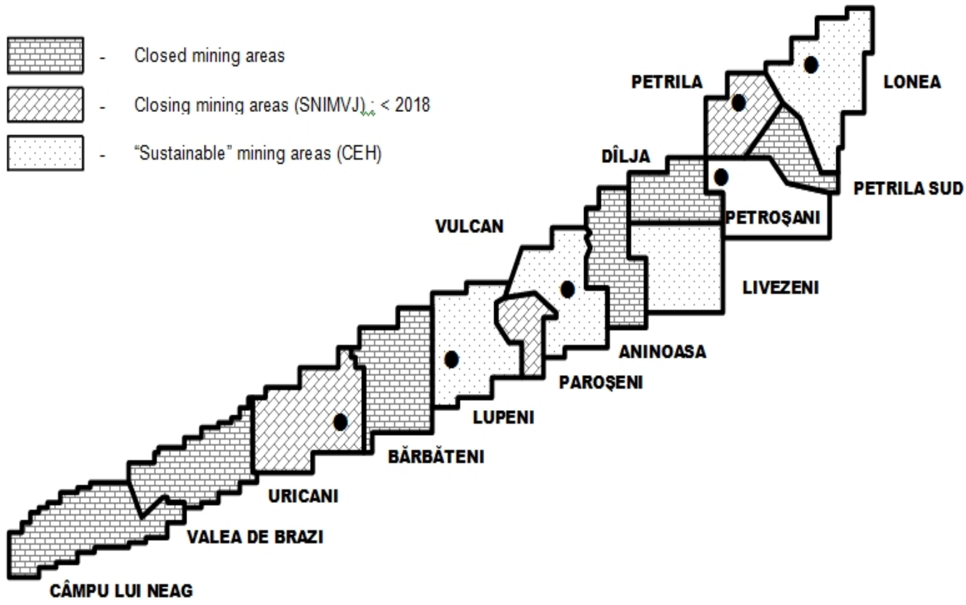

Fig. 2. Present situation of mining perimeters in Petroşani Basin
(Source: Buia Gr. et al., 2014)

The Mining Division of Hunedoara Energy Complex has over 87927 m of underground workings (shafts, galleries, inclined planes etc.) and the construction area (administrative buildings, fans stations, mechanical and electrical workshops etc.) to all of the four mines. Currently, Branch Mining Division has two coal faces with mechanical complex (E.M. Livezeni and E.M. Lupeni), equipped with SVJ pillars and GSA beams.

According to statistics, the total exploitable geological reserves from the reliable mining perimeters are considered to be 154 377 million tons (see table 3) and from the perimeters considered unsustainable are 89.016 million tons (www.cnhd.ro).

According to the Romania's energy development strategy, was established as a strategic objective, the improving energy efficiency in the whole system: natural resources, production, transport, distribution and final use, through optimal use of mechanisms of market economy, with an estimated reduction of 3% per annum in energy intensity of the national economy by 2020.

Table 3. Situation of geological reserves from the reliable mining perimeters (thousand tons)

Category	Lupeni	Vulcan	Livezeni	Lonea
Certain geological reserves	31,676	23,569	76,484	22,648
Probable geological reserves	35,547	33,570	93,200	44,425
Total geological reserves	67,223	57,139	169,684	67,073

The coal offer of the Romania's producers is 33 mil. tons, with about 5 mil. tons less than estimated demand for the period 2010-2020 and the level of insurance production is 38.6 years for coal to 14 years for lignite. Industrial reserves of Petroșani Basin coal is 56 mil. tons and the average production capacity is about 1.5 mil. tons / year.

In terms of social and economic development of the Petroșani Basin, the strategy of mines closure policy has taken into account the possibility of retraining of unemployed persons. Given the location of the mining basin in a mountain Basin with a real potential tourism, it was often put the issue of economic and professional integration of former miners in the tourism sector.

Professional conversion of the employees from mining sector and integration within the tourism sector in our view is a difficult and very slow process. This resides in the fact that we are dealing with two different economic sectors (mining-secondary sector and the tertiary sector, tourism), the preparation of human relations is different; most often acquired through education, culture, experience and not accessed in a short time, as is the case of training courses in tourism. For this reason, allocated funds for vocational retraining should be rethought somewhat.

3. CONCLUSIONS

Delayed restructuring and privatization of energy sector, were made at the insistence of international organizations (EU, World Bank, IMF, USAID), with modest results. Major issues of the energy sector (great energy losses in industry and residential sector, settlements heating the deficiencies of the energy market, the higher impact of energy on the environment, sources of low investment and others) make it to be unsustainable today and this is largely due to the absence of an adequate institutional framework (Tofan, 2016).

The coal from Petroșani Basin is an average quality coal with high extraction costs, requiring subsidies of about 40-50%. Low domestic production of coal (deliberately), requires an appreciably higher coal import. Instead, lignite is lower quality coal, with a low calorific value, high humidity and ballast is obtained from surface exploitation without the necessary subsidies. Lignite remains profitable in economic terms if it is extracted at the surface, the transport cost being prohibitive.

Sustainable economic and social development of Petroșani Basin on medium and long term is conditioned by mining activity, being related to a performing energy sector, which in turn is determined by a modern institutional and legislative framework, aligned to energy policy and environmental policy of E.U.

The key question to be answered by a country's energy strategy is the cost limit on and can it afford to increase its energy security, in terms of economic efficiency. To a similar question will be answered in the case of environmental protection, aspect which usually conflicts with a policy of minimizing costs.

In conclusion, energy security is a complex concept: political, technical, economic, commercial and social. As an axiom, there is no absolute energy security. It can be achieved at a level of acceptable risk, with an acceptable cost.

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ASPECTS OF ECONOMIC GEOGRAPHICAL DISPARITIES WITH INDUSTRIAL SPECIFICITY IN CRASNA BASIN, SĂLAJ COUNTY

ROZALIA BENEDEK[1]

ABSTRACT. – Aspects of Economic Geographical Disparities with Industrial Specificity in Crasna Basin, Sălaj County. Before the 1990s, the drivers of economic development in the county of Sălaj were mainly based on industrial activity, which also generated a rupture compared to the lifestyle and traditional mentality of the inhabitants. The only outlined direction of progress was the industrialization with a powerful multiplying effect which was shaken by the legislative and managerial decisions, national and particular decisions, following the changes of the last 26 years (privatizations, lack of outlet, migration of workforce, technological and entrepreneurial innovations etc.). Through the thematic of this research paper, the analysis of economic geographical industrial disparities, in the basin sector of Crasna River highlights the territorial administrative structure and historical specificity in the economic context of the area; pursuing the identification of industrial entrepreneurships from the research perimeter, which was dominantly rural. The presence of industrial activities is defining for the town of Şimleu Silvaniei, found on the second place as importance in the county, after the city of Zalău. Another perspective will be offered through the analysis of disparity aspects as a result of the accounting of the data of companies with industrial profile.

***Keywords**: industry, development, economic geographical disparities, Șimleu Silvaniei, Crasna, Pericei*.

1. THEORETICAL INTRODUCTION OF RESEARCH

Regional development represents an assembly of factors by which the geographical space suffers permanent anthropogenic changes, focusing or dissipating the potential of value available, introducing qualitative and quantitative discrepancies at the level of each economic sector. Thereby, the uniformity of the rate of development by applying coherent levers becomes a clearly defined purpose in well-determined competition conditions.

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Having in view the possibility of attracting non-refundable European funds for development of national, regional and local economic structure, we can emphasize the need for realization of concrete studies regarding the economic, geographical and sector disparities, reaching the fields of interest expressed hierarchically. Therefore, the use of structural funds can offer solutions for the unblocking of some economic activities, producing a sustainable effect in regional development.

"The policy of the EU which has the purpose of reducing the lags that exist between the regions of Europe is known as cohesion policy, being first of all, a solidarity policy. It is mainly based on financial solidarity, i.e. the redistribution of a part of the community budget achieved through the contribution of the member states, to the less prosperous regions of the EU, for the purpose of promoting a high level of competitiveness and workforce occupation" (Elena Ionescu, 2009, p. 2).

Therefore, the pace of regional development at the EU level is determined by the stimulation of local efforts of initiation and implementation.

The highlighting of regional and national disparities in the EU is achieved through data converted into macroeconomic language, which represents the value of goods and services created at national and regional level, estimated for a period of time, related to the total number of inhabitants. But, on the other hand, this formula used by Eurostat does not offer concrete radiographies regarding the potential of the development of regional or local economic structure, generating the illusion of equal benefits of all the inhabitants, directly and unconditionally for gross domestic product without being able to distinguish the regional economic structure from the economy structure applied at household level.

Having in view the historiography of the issue we can see that the researchers preoccupied with the study of disparities have the tendency to operate with statistical data applied at the EU level, by comparing the average of gross domestic product per capita from various geographical perimeters, and they notice that the development regions overcome statistically the areas with low potential. Therefore, we can see the need of application of a research method by which we analyze the economic geographical structure of the region, in the context of processing the statistical data of economic sectors.

This present work consists in the application of methodology of investigating of disparity issues, elaborated as a result of the PhD studies regarding the "Economic geographical disparities in the North-Western Region of Romania" (Rozalia Benedek, 2013).

Procedurally the research requires the accountability of statistical data of economic structure and the hierarchical highlighting of development level of administrative areas from the geographical area studied, which became useful in the strategic management of development of the region in question.

The premise of research is the application of the calculation method of disparity (Rozalia Benedek, 2013- Ph.D thesis, p. 26-38; Rozalia Benedek, 2013; Rozalia Benedek, (I), 2014, p. 633-634) and differences at the micro region level of the upper valley of Crasna River with potential of easy application in the development projects.

The objectives proposed in the analysis are: general illustration of the regional identity elements, identification of the industrial development level of administrative areas and their typological integration in disparity.

2. DEFINING ELEMENTS OF REGIONAL ECONOMY

The regional microsystem of Crasna Basin (fig. 1), in Sălaj County, Romania, represents the central part of Șimleu Basin, being bordered in the South by the Oșteana Piedmont (F. Bențe, 1974) and Măgura Priei (997 m), the components of Northern digitations of Apuseni Mountains, composed of Meseș Mountains, to the east and Plopiș, to the west; and in the north it "closes" by epigenetic strait sawn in the crystalline structure of Măgurii Șimleului (597 m), between the town of Șimleu Silvaniei and the village Uileacu Șimleului. The boundaries on the east side and the west side are marked by hilly watersheds with average altitudes of 300 to 400 m, between the rivers Crasna and Zalău (hills: Viilor-387 m, Rotund-358 m, Carpenilor-335.2 m), respectively between the rivers Crasna and Barcău (hills: Crasnei-388.6m, Bănișorului-389.8 m etc.).

The toponymy of the analysed region, although has a Slavic resonance, with the meaning "beautiful, pleasant" (Gh. Chende-Roman, 2006, apud. I. Iordan, p. 126), is generated probably by the presence of the Stronghold of Crasna (*idem*), a centre of habitation and economic development, completed by the median localization of the homonymous river, in the direction south-north, east-west. The whole regional assembly covers 39% of the area of the "neogenic golf" (E. Nicorici, 1972, p.13), of Șimleu.

The economic support of the natural framework (fig. 1.) is assured by the favourability of conditions for the establishment of human settlements by morphological and morphometric elements of basin area and a shelter climate with oceanic influences against the temperate continental climate. Thus, the basin sector of Crasna along with the small basins of its tributaries, is structured on 9 administrative units, coordinators of development plans. The economic, social and cultural polarization of the region is assured by the town of Șimleu Silvaniei and the small town of Crasna, being followed by the administrative centres: Pericei, Vârșolț, Horoatu Crasnei, Meseșenii de Jos, Bănișor, Cizer and Sîg. Thanks to localization and spatial extension, Sîg commune overlaps partially on both catchment areas of Crasna and Barcău, but from economic, medical and educational perspective it gravitates towards Crasna and Șimleu Silvaniei, and extra-regionally to Zalău.

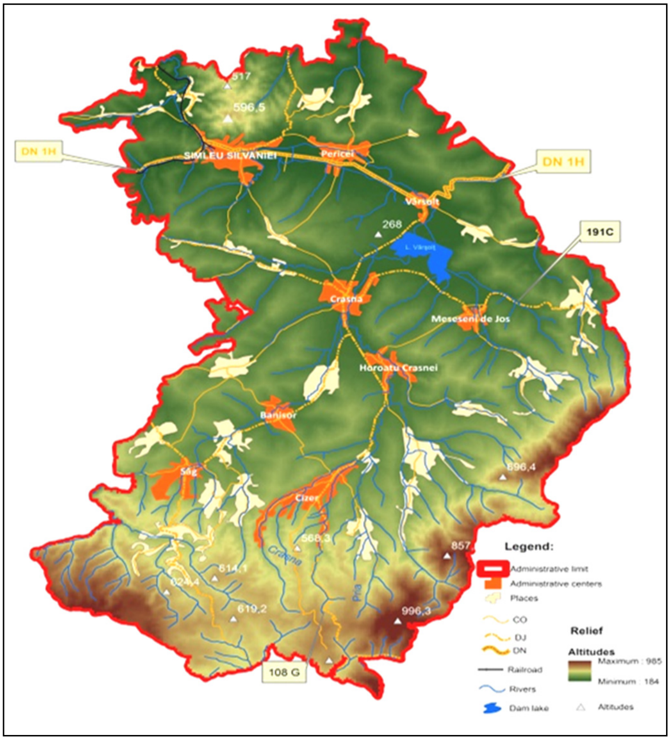

Fig. 1. *Crasna Basin. Territorial delimitation of industrial development framework*

The main collector of the valley is Crasna River with its source in the plateau sector of Cizer commune, at 475 m altitude. The asymmetric form of the valley, with the development of series of extended terraces on the left side of the river in the plateau area and eastern slopes and the relief of marbles is developed on the subsequent sectors of the valley, downstream from Horoatu Crasnei (F. Bențe, 1974, p. 14), in Șimleu Silvaniei, Pericei and Recea, being facilitated by the presence of underlayer composed of Pliocene deposits. The watershed hills and the plateau units are dominated by plantations of fruit-bearing trees and vineyards, especially in the area of Șimleu Silvaniei-Pericei and Crasna-Bănișor. Silvania vineyards on the western and southern slopes of Măgura Șimleului, but also from the neighbouring areas represented the foundation of their industrialization under the form of carbonated wine, the "Silvania" brand, with tradition in the region since the 1970s.

The local economy capitalizes the water reserves both for irrigations, water supply for households, entertainment and for industrial activities or tourism (Șimleu Silvaniei, Crasna, Meseșenii de Sus, Vârșolț). Water resources are collected either directly from the source (spring, fountain, drill), or by the centralized system of water supply, from the accumulation lake of Vârșolț, built to assure the consumption needs of the inhabitants and industries from the county seat, the city of Zalău, and the town of Șimleu Silvaniei, the only urban centre of the analysed perimeter.

The infrastructure is mainly represented by roads. The links of the town of Șimleu Silvaniei with the neighbouring polarization centres Zalău and Nușfalău are made through DN 1H national road, having a northern location in the region of Crasna, on the east-western direction, on the axis Zalău – Hereclean - Vârșolț - Pericei - Șimleu Silvaniei - Nușfalău - Aleșd, which makes the connection to the European traffic on E81 at Hereclean and E60 at Aleșd.

Crasna, the second regional centre in the homonymous basin, located 20 km away from Zalău and at 17km away from Șimleu Silvaniei, is connected with them by the county roads 108G in Vârșolț, connecting to DN 1H and E60, in north-south direction, and the county road 191C, connecting to E81 in Zalău.

The connection to railways is made via the town of Șimleu Silvaniei, allowing for the access to the area regarding the economic development before 1989. Now, in the region, the transport of merchandise and passengers on railway is difficult. The few passengers of railway transportation in the area are students, coming from the towns connected by this transport system and who commute to the high schools in Șimleu, which offers the possibility of primary qualification of workforce both in agricultural and industrial fields.

Therefore, by taking into account the territorial concentration of factors mentioned, one can outline the existence of two polarization centres of the region, both being not only economic centres and “markets” but also educational centres of regional importance marked by the town of Șimleu Silvaniei, and local importance marked by the small town of Crasna.

3. DIFFERENCES OF DEVELOPMENT AND DISPARITY ASPECTS IN THE SECONDARY SECTOR

The basis for development of industry regarding the researched area is found in the period before 1989, being the beneficiary of a centralized planned development. This period includes the years 1950-1989, when the national development orders were expressed by five-year plans which targeted a series of investments in territory following the concentration of industrial activities, respectively the “welfare” offered and by the infrastructures built for the purpose of economic growth and urbanization level.

The economic specificity of the rural is described by maintaining the agricultural tradition, which knows different forms of application, in Communism, including expropriations and amalgamations. But, with the passage to market economy, the economic aspect changes, some activities are maintained, others disappear according to the criteria of their profitability.

In the year 2013, the economy of the basin area of Crasna was maintained and developed by the foreign and local investors, entrepreneurships which managed to attract certain amounts from structural funds, by developing 80 companies, some of them lhon type, which assured a total number of 1508 jobs, engaging in the industrial production 6.36% of the active population (data calculated, from the statistics of Tempo online), which represents 3.43% of the region's residents, region which has 43,404 inhabitants. The companies recorded operate in the following fields of industry: food industry (Șimleu Silvaniei, Crasna, Meseșeni, Horatu Crasnei and Bănișor), manufacturing of beverages (Șimleu Silvaniei and Crasna), manufacturing of textile products (Șimleu Silvaniei), manufacturing of clothes (Șimleu Silvaniei, Crasna, Pericei), leather dressing and finishing (Șimleu Silvaniei), wood processing (Șimleu Silvaniei, Pericei, Cizer), manufacturing of rubber and plastic products (Crasna, Bănișor and Meseșenii de Jos), industry of constructions and metal products (Șimleu Silvaniei, Pericei and Meseșenii de Jos), manufacturing of electric equipment (Șimleu Silvaniei), manufacturing of furniture (Șimleu Silvaniei, Pericei), and other industrial activities (Șimleu Silvaniei, Crasna).

The industrial environment of rural administrative units represents a series of enterprises with food profile, wood processing and production of furniture, which represent 22.5% of the number of companies and 11.27%, of the number of employees involved in the activity of companies in the region.

Worth mentioning for the region are the company brands which activate in this area among which the luxury furniture producer "Simex" and the unit of shoes producer "Ara" with production in lhon regime in Șimleu Silvaniei, and the industrial unit of swimming pools and bathtubs "Fibrex" in Crasna.

According to the research methodology the determination of the level of differences from the economic sector approached is shown by the calculation of difference in value of the economic structure, processing in brief the statistical data of indicators expressed by: number of companies, number of employees, turnover – representing the capital of the company, to which we add the profit earned in a calendar year. Thus, one obtains an expression of economic superstructure called by us (Utf) – Units total final.

The need of identification for the superstructure expressed by the value of Utf, is confirmed by the success of concrete radiography of economic geographical space investigated, making visible the development stage of administrative area, potential interregional competitors and polarization centres. Another beneficial hypostasis of the methodology applied makes possible a hierarchization as a whole of capital attracted in administrative area, which expresses the profitability of the activities carried out.

The representation of economic superstructure expressed by the selected indicators and the amount (Utf), can materialize by using a table for illustration in hierarchical order or certain graphic illustrations from accounting field and the geographical field is shown by cartographic illustration with GIS programmes.

The hierarchization of administrative areas (Z), from the economic space investigated is made by an accounting system in the table below (Tab.1.).

Table 1. Table instrument for hierarchical accountability of economic industrial superstructure-Utf, in 2013

Rank	Hierarchization of administrative areas (Z)	Number of companies	Number of employers	Capital of the company	Profit	∑ Ut industrial
1	Șimleul Silvaniei	41	1121	84799888	5195132	89996182
2	Crasna	13	210	25671147	1333386	27004756
3	Pericei	8	100	9207652	121202	9328962
4	Meseșenii de Jos	9	66	7526400	131107	7657582
5	Bănișor	3	4	3250456	30560	3281023
6	Cizer	5	6	268956	1006	269973
7	Sâg	1	1	9480	0	9482
8	Horatu Crasnei	0	0	0	0	0
9	Vârșolț	0	0	0	0	0
Sum of Units (U)		**80**	**1508**	**130733979**	**6812393**	**Ut_f=137547960**

Source: data processed from the database of Lista firmelor.ro (February 2015)

On top of the classification is the town of Şimleu Silvaniei, being followed by Crasna commune – with a proportion of 70% difference (Utf), which represents the two intraregional polarization centres. The communes Pericei, Meseşenii de Jos, Bănişor, Cizer and Sâg, occupy the remaining positions of hierarchy. Yet, on the radius of administrative units Horoatu Crasnei and Vârşolţ, we do not record economic activities in the field of industry.

The cartographic representation of development lags is made by using a code of colours, indicating by dark hues the high values of economic superstructure expressed by the value (Utf), the light hues represent the descending hierarchical rows of the values of superstructure Utf, and the areas represented by a white field express the lack of activities in the investigated field as it results from the figure (fig. 2).

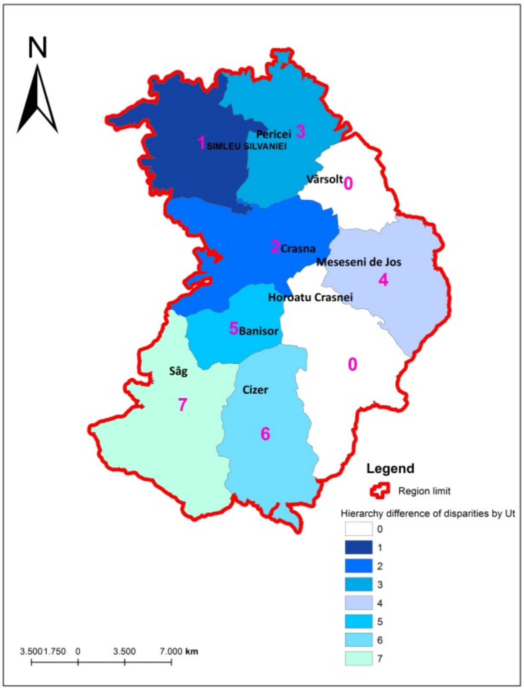

Fig. 2. Economic geographical hierarchical disparities in the industrial superstructure in 2013

Following the hierarchization of administrative areas, according to methodology, we established the average of disparity aspects (M_{Ad}), calculated as average of development ratio between the value Utf of administrative area which reached the maximum value of industrial superstructure and the area with minimum development value.

The average value of disparity aspects proposes to be the reporting norm for the administrative areas of hierarchical row which represents the average of development potential, as you can see in table (table 2).

The administrative areas which exceed the M_{Ad} value remove the surplus of optimal potential of development of analysis perimeter, which represents the average descending disparity aspect. The administrative areas which range in value below M_{Ad} level have to grow to reach the balance level established by M_{Ad}, being called average ascending disparity aspects.

The value Utf of the town Şimleu Silvaniei, exceeds the average of disparity aspects (M_{Ad}), with a value of 0.03%, being an average descending disparity aspect and in the case of the other administrative areas we can see average ascending disparity values.

Table 2. Differences and disparity aspects shown at superstructure level (2013)

Rank	Hierarchization of administrative areas (Z)	Ut_f	A_{dif}	Disparities aspects
1	Şimleul Silvaniei	89996182	44993350	99.97%
M_{Ad}		45002832		100.00%
2	Crasna	27004756	17988594	39.97%
3	Pericei	9328962	35673870	79.27%
4	Meseşeni de Jos	7657582	37345250	82.98%
5	Bănişor	3281023	41721809	92.70%

Source: author, data processed based on Lista firmelor.ro (February, 2016)

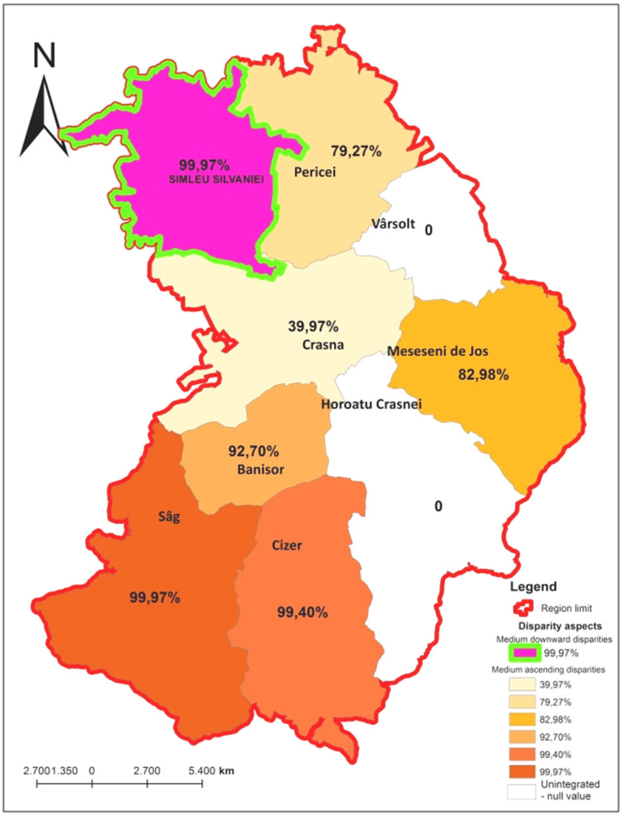

Fig. 3. Cartographic illustration of average ascending and descending disparity aspect of industry in 2013

4. CONCLUSIONS

Whereas the difficulty given by processing of accounting statistical data to succeed in highlighting the difference aspects and disparity aspects, the research of economic geographical disparities requires a multidisciplinary approach, generating avoidance among researchers. But from the point of view of management of regional development, the application of this methodology confers the logistic basis in the geography of economic progress, being recommended to specialists concerned with the clear illustration of economic structures at the level of spatial scales.

Crasna Basin is a central component of Sălaj County and it is located in one of the geo-strategic important areas of North-Western Development Region of Romania, because of its natural, cultural, multi-ethnic values, but also the economic branches developed in the town of Şimleu Silvaniei. However, the specialized literature gives few perspectives for the development of this area.

By applying the methodology of doctoral research, we obtained several results regarding the development of the industrial sector in Crasna Basin and we identified the development level of administrative areas.

The realization of objectives proposed in the theme of work was assured by the presentation of a new method of approaching disparities, trying to introduce the analysis of disparity aspects, separating methodologically the macroeconomic approaches from the illusion that the industrial production data could influence directly the household economy of population.

It is worth mentioning that the study of economic geographical disparities receives a new outline because the entrepreneurship is interested in all the information of regional economic structure that can be approached in view of increasing the efficiency of the business.

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BOOK REVIEW

Iulia Floriana Ciangă, 2016, *Peisajul urban în vedutismul transilvan (The Urban Landscape in the Transylvanian Vedutism)*, Risoprint, Cluj-Napoca, 442 p.

In the already very long series of PhD theses defended at the Faculty of Geography in Cluj-Napoca, only a few has been remarked for the unusual subject approached and the connections between Geography and other fields of sciences and arts. Others became known due to the use of new and brave approaching techniques of analysis and representation. One of such works – Iulia Floriana Ciangă's "*The Urban Landscape in the Transylvanian Vedutism*" – makes a lasting impression because of the unprecedented subject approached but also, in my opinion, because it connects Geography to Arts and especially visual arts, like painting and graphics. This fact provides a touch of beauty and warmth, as it was „compelled" to break the geographical long-standing and repetitive standards (although it is a sum of several sciences!).

The author is passionate about the artistic representations of human settlements, of what we call *veduta* – cityscapes or panoramas, and the phenomenon – *vedutism*. She is a graduate of Graphical Arts (2003) at Cluj-Napoca University of Arts and Design and she has a Master Degree in the History of Arts (2005) at "Babeș-Bolyai" University of Cluj-Napoca. She received mobility grants for research and specialization at the University of Vienna, at the *Institut für Osteuropäische Geschichte* (Institute of Eastern European History), and in Rome at the Faculty of Architecture. Her complex interdisciplinary study concerning the Transylvanian urban landscape as reflected in the vedutas of the 17^{th} to 19^{th} centuries, is the fruit of thorough research and of exceptional archive, documentary and bibliographical investigations which materialized in this book, her PhD thesis in Geography defended in 2013. The large volume of 442 pages, richly illustrated, is structured in two parts. The first part, "*The city and the urban landscape in Transylvania*", presents the emergence and the specific characteristics of the Transylvanian urban network. The second part, "*Urban landscapes in Transylvania reflected in vedutas, 17^{th} to 19^{th} centuries*", highlights the representations of the Transylvanian urban landscapes by means of vedutas and their complex analysis.

The work starts with an "*Introduction*", in which the author demonstrates that diverse urban strata are superimposed in the complex process of the urban evolution. Each of them has its own specificities and personality, and together they finally provide an urban landscape. As an integrating element, the urban landscape is changing permanently, is in a continuous transformation, in the case of sustainable development. The paintings and graphics that have an urban subject appeared in the eve of the Renaissance (13th and 14th centuries) in Italy. Called *"vedutas"*, meaning "views", they were subsequently disseminated throughout Europe and in the world. They immortalized the image of the city as perceived by the illustrating artists. Transylvania, a Romanian geographical-historical province, entered the framework of Central and Western European values earlier than the other Romanian provinces – the Danube principalities. Transylvania was therefore visited more frequently by many travelers and artists who wanted to illustrate what they have seen. As Transylvania has an ancient urban network, its cities and some of the noblemen manors constituted the main subjects for the foreign and domestic artists and engravers. A whole set of "*vedutas*" – views resulted. They were created in different times and places and provide a proof of the geographical evolution of Transylvanian cities, highlighting their structural and functional transformations. They are important documents from this geographical perspective.

The first chapter – "*Theoretical and methodological aspects"* – includes the description of the methods to approach the subject, the principles of analysis that are specific for the geographical manner of approaching. From the very beginning, the author clarifies the conceptual frameworks: the city and the urban environment, in the light of some well-known authors, who studied the Romanian and foreign urban phenomenon. Naturally, more attention has been given to terms like "*cultural landscape*", "*urban landscape*", "*urban image*", with pertinent references to authors and geographical schools in this field of research. These subjects belong to the second chapter, "*The concept of urban landscape*".

The third chapter, "*The Transylvanian city and urban landscape* ", is very consistent and concerns "*the genesis and evolution of the Transylvanian cities*". Cities represent the subject of many vedutas which the author analyzed in the second part of the book, a fact which explains the investigation of this subject, materialized and illustrated with the help of many maps, diagrams, tables and suggestive images.

The genesis and evolution of the Transylvanian cities, focusing on generations of cities, and happily supplemented by maps and synthetic tables, reflects the author's exceptional research in the archives. The same geographical manner is used in the presentation and analysis of the numerical evolution and national structure of the Transylvanian urban population, including its classification and ranking (represented also graphically and in tables at different characteristic moments) and its functional and typological structure (on altitude levels and landforms). In the subchapter 3.3.5., "*Types of evolution and development significant for the Transylvanian urban landscape*", the author diversifies the analysis and enlarges the study by including architectural and urban elements like fortresses (either royal, noblemen or peasant ones) and their elements (dungeons, curtains, towers). Many of them have been built by powerful guilds whose number increased significantly over time.

Another architecture and heritage-related element that has a high visual impact is represented by the churches and other religious buildings "*with landscape impact and visibility*" which left a print of identity for Transylvanian cities. The chapter ends with a synthesis of the territorial evolution of 23 Transylvanian cities since the Middle Ages until the modern age (the 19th century). They are true case studies, illustrated with plans, sketches, old and new images (the new ones belonging to the author), recasts, which together render suggestively the evolution of the cities.

After finishing the geographical analysis, the author exclusively consecrates the second part of the book to the Transylvanian urban landscapes as reflected in the vedutas, between the 17^{th} and the 19^{th} centuries. Initially, she reviews the terminology and the meaning of the terms belonging to the family of words related to the neologism "vedutism". The author briefly describes the artistic techniques used to perform the vedutas, as well as the iconographic premises of their emergence. Iconographic examples of the most frequent and popular engraving techniques would have been useful. The author makes an interesting foray in the evolution of the urban image, graphically exemplified, from the first representations of cities as centers located on certain routes, as scenographic sites for the development of certain religious events or facts, to urban portraits, finally, whose practice developed on the European continent as a result of the intensification of the "*Grand Tour*" practice, initiated by the English aristocracy. In Great Britain, such travels represented an integrated part of the education. This phenomenon scattered across the continent later on, gradually reaching its eastern parts, including the Romanian lands. The author limits herself to present the "*Romanian routes*" of the Grand Tours, especially because they were located on the terrestrial trade ways to Constantinople, as illustrated on a suggestive map. Also, the author highlights the contribution of the Italian and Flemish painting schools and their most notable contributions. She does not ignore the similar artistic achievements in the United Kingdom, France or Germany but stress is laid on the Venice school of vedutism, among the most prestigious ones, proving the development and importance of the Venice Republic between the 13^{th} and the 19^{th} centuries.

For an "*education to look*" at the vedutas and for the research of the urban landscape by their means, the author appeals to methods operated by the Italian urban planning school, briefly presented, sometimes by using her own sketches and representations!

Chapter VI, "*Transylvanian urban landscapes reflected in vedutas, 17^{th} to 19^{th} centuries*", represents the core of the book, naturally flowing from the preceding preparing chapters which familiarize the less specialized readers with the Transylvanian urban landscape, on one hand, and the veduta-type representations which emerged and spread across Europe. The author presents the vedutas of Transylvanian cities, identified as a result of hard work research in the archives, from edited and unedited, primary and secondary sources. The chapter is richly illustrated with images, sketches, figures, maps, integrating synthetic tables, which prove the professional processing and analysis of Transylvanian vedutas. The author includes the phenomenon of Transylvanian vedutism in the European context and makes reference to the age of vedutism. She also publishes the titles of the albums and map collections which comprise representations of Transylvanian cities, focusing on those belonging to the period between the 17^{th} and 19^{th} centuries. She points out their features: the historical, often "*Hunnic*", attitude; the emergence of city portraits; the realistic and documentary-type urban landscape subjects; the "inventory" of space during the "picturesque" travels, mentioning the foreign and domestic authors who are most famous in the field. She makes a typological classification of European vedutas. The round vedutas are the most early ones, performed "*as the crow flies*" ("*a volo d'uccello*") in the 16th century. The profile vedutas are also from the 16th century; the topographical vedutas and the partial vedutas emerged later, in the 18th century.

For the Transylvanian geographical space, the author classified the vedutas according to the composition criterion, in: portrait vedutas; general (or global) vedutas; partial vedutas; and mixed vedutas. They all have different weights in the total number of 338 vedutas that have bee identified and studied. The data statistic processing allowed the identification of the cities represented in the vedutas, their frequency and weight, the author selecting the following classification: cities with 1 to 5 vedutas; with 6 to 10 vedutas; with 11 to 50 vedutas; with 51 to 70 vedutas; and above 70 vedutas – as the maximum number is 75, in the case of Sibiu! Analyzing the Transylvanian vedutas, the author uses the following criteria: chronology; exactity-veridicality – according to which some vedutas are really the result of fantasy; functionality, regarding the building they focus on; style, according to which vedutas may be gothic, renaissance, baroque, classical-romantic or realistic-romantic.

The vedutas are documents that provide clues to the evolution of cities, using the perspective of observation points. The vedutas of the most representative Transylvanian cities: Sibiu, Braşov, Alba Iulia, Cluj, Sighişoara and Târgu Mureş were the object of an analysis, comparing the historical situation and the present one. One may therefore follow the evolution of the city, the density and physiognomy of the buildings in the built-up area, the dimension of the transformation processes from a spatial and temporal perspective.

The conclusions reached by the author mark the possibility for a better knowledge of the stages of urban evolution, noticing the preservation or degradation of the architectural heritage throughout the times, the possibilities for capitalizing the architecture heritage by means of tourism and leisure, as a result of a continuous and heterogeneous multinational life which provides the charm, variety and identity of the Transylvanian urban network. One should also remark the English summary, including the titles of illustrations (maps and images), which gives the opportunity for foreign specialists to study the book. The bibliography includes 169 book references, as well as 20 websites. A special mention should be made of the "*Appendices*". Thoroughly worked, they are true syntheses containing many pieces of important information, provided either in tables (appendices I, II, III and IV) or in images (the replicas of vedutas, in an order given by their frequency, suggested in the appendix IV).

This is a large and valuable book which brings to front a novel subject geographically speaking, that is largely searched for today, the veduta-type urban images. They are heritage documents and by their means, the local, regional and national communities assert, cultivate and promote their cultural and material identity. The Transylvanian cities, as a component part of a larger Romanian cultural space, are happilly included in the evolution of the Central-European cultural space, as a consequence of a specific historical background. By these linking bridges, the Romanian identitarian space asserts itself in the European context, also by using this peculiar type of representation, the veduta.

In the future, escaping the straps of a PhD-type approach, the young researcher, Iulia Floriana Ciangă may propose in a more relaxed way, creatively and in a personalized manner, an image excursion in the Romanian settlements. This is a vast subject, that lend itself to various analyses and approaches. The research field is also very vast but the author has the qualities for approaching it in a brave manner, to perform a "*beautiful geography*" or a "*poetical geography*", as Georges Duhamel stated, pleading for a "*cordial geography, caligeography or beautiful geography*", asserting that "*there is a cordial geography, meaning a poetical, sentimental, fanciful and imaginative geography*"! in this way, having more freedom, the author might sink into a series of "*house stories*", so much enjoyed nowadays, after a half ofr century of egalitarian darkness, with lots of words and few choices. They would link us deeper to the European stories…

The book addresses to a wide range of readers: from specialists in fields like cultural heritage, architecture, urban planning, landscape, history, geography, to the large and heterogeneous public who is animated by the curiosity of searching and finding the identity elements of places and their proper assertion.

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