INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr II/2/2015, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 483–497
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2015.2.2.039

ANALYSIS OF RELIEF IMPACT ON LAND USE STRUCTURE ON AN EXAMPLE OF NOWY TARG DISTRICT

Barbara Prus, Łukasz Budz
University of Agriculture in Krakow

Summary

The article is the analysis and attempt at an assessment of relief impact on the land use. The investigations focus particularly on the analysis of percentage share of agricultural land in Nowy Targ district computed for selected land slope intervals. Land use, conditioned by human activity is strictly dependent on historical conditions, physiographic location and climate, as well as on the land form. The relief has a significant impact on the quality of agricultural production area. Indirectly it also influences the other components of the environment, i.e. soils, water and climatic conditions. Directly it impacts the organisation of agricultural production influencing the difficulty of soil tillage and intensity of soil erosion. Agricultural land adjustment to the type of relief diminishes the erosion hazard and improves agrotechnological assessment of the soil tillage difficulty.

The investigations were conducted on an example of Nowy Targ rural district. The district has diversified land relief resulting among others from its localisation close to the foothills. The analysis bases on the image of land use obtained from Corine Land Cover 2006. Average land slope was established on the basis of digital land model determining the selected slope intervals.

Key words: slopes, land use/cover

INTRODUCTION

While analysing area relief for the needs of protection and space shaping of agricultural production it may be stated that the form of land directly and indirectly affects the quality of agricultural production space. It directly influences the organisation of agricultural production, setting e.g. boundary slopes for farm machinery use (Szymański 1969, Hopfer al. 1982), determining soil erosion intensity (Józefaciuk, Józefaciuk 1995; Józefaciuk, Józefaciuk 1996; Gliński, Przesmycki 2011) or difficulties in soil tillage (Prus, Salata 2014). Land slope limits cultivation treatments or transport, diversifying agroecological conditions, but also influences the occurrence of individual agricultural suitability of soil complexes. The relief in the first place indirectly impacts the environment components, i.e. soils, water and climatic conditions. The knowledge of the area relief is also crucial for the realisation of spatial policy or developing planning documents (Baran-Zgłobicka et al. 2011; Salata, Prus 2012).

Relief is one of the basic elements effecting the land use method. It is a determinant of potential area use (Baran-Zgłobicka et al. 2011). Land form is also a crucially important factor affecting human activities and rational utilisation of space in the process of planning and space management. The principle of sustainable development imposes an obligation of such space management that all elements of human environment are balanced and at the same time the natural conditions enabling optimal utilisation of space are considered (Kryk 2010; Staniak 2009; Adamowicz, Dresler 2006). The minimum substantive scope of the arrangements stated in planning documents require taking into consideration also detailed conditions of land management and limitations in its use (Ustawa 2003).

Digital recording of the information about the land elevation (Digital Elevation Model) as a regular two dimensional matrix sampled against altitude reference system (Moore at al. 1991) enables including the area relief parameters in the research. The land slope – a morphometric indicator – shows the digitised landforms (Pasławski 2010). The slope inclination, or maximum gradient, set on the basis of digital land model is determined along the line corresponding to the greatest angle of terrain, i.e. perpendicular to the level surface.

Typical of southern Poland farmland mosaics combined with grasslands, forests and settlement units forms a traditional agricultural landscape (Staniak 2009, Baran-Zgłobicka, Zgłobicki 2012). The landscape is the result of specific landform but also overlapping effects of social interests of: landowners, inhabitants, tourists, local authorities but also planners and architects (Eiter et al. 2014). The landscape is a cultural mosaic of proofs of human presence and his way of life. Rural landscape of southern Poland, shaped by agriculture is characterised by a rich biodiversity (Andrzejewski, Weigle 2003). Unfortunately, socio-economic changes and intensification of agriculture brought new cultivars and therefore changes in land use (Bürgi et al. 2005) and in traditional land mosaics (Baran-Zgłobicka, Zgłobicki 2012). On the other hand, transformations in land use influence the changes in the natural environment (Bucała, Starkel 2012; Bański 2003; Pohl 1978). Land use results from a combination of land cover with its use (Zwoliński 2006). Analysis of land cover and use is possible owing to realization of European Environment Agency programme CORINE Land Cover in the years 1990, 2000 and 2006 (Ciołkosz, Bielecka 2005).

The paper aims at an analysis of land use presented in CORINE land Cover 2006, databases, in the area of a sub-mountain district of Nowy Targ in Małopolska region. The analysis of land use was conducted in confrontation with average land slopes determined on the basis of digital land model. The Authors were seeking the answer to a question how land use changes depending on land slope classes and which forms of land use prevail within the individual slope ranges.

Table 1. Land cover classes in CORINE Land cover databases

Level 1	**Level 2**	**Level 3**		ID
1. Anthropogenic surfaces	1.1 Urban fabric	1.1.1	Continuous urban fabric	1
		1.1.2	Discontinuous urban fabric	2
	1.2. Industrial, commercial areas and transport units	1.2.1	Industrial or commercial unit	3
		1.2.2	Road and rail networks and associated land	4
		1.2.3	Port areas	5
		1.2.4	Airports	6
	1.3. Mine, excavation and construction sites	1.3.1	Mineral extraction sites	7
		1.3.2	Dump sites	8
		1.3.3	Construction sites	9
	1.4. Urban green and leisure areas	1.4.1	Green urban areas	10
		1.4.2	Sport and leisure facilities	11
2. Agricultural areas	2.1. Arable lands	2.1.1	Non-irrigated arable land	12
		2.1.2	Permanently irrigated arable land	13
		2.1.3	Rice fields	14
	2.2. Permanent crops	2.2.1	Vineyards	15
		2.2.2	Fruit trees and berry plantations	16
		2.2.3	Olive groves	17
	2.3. Meadows and pastures	2.3.1	Meadows and pastures	18
	2.4. Heterogeneous agricultural areas	2.4.1	Annual crops associated with permanent crops	19
		2.4.2	Complex cultivation patterns	20
		2.4.3	Land principally occupied by agriculture with high share of natural vegetation	21
		2.4.4	Agro-forestry areas	22

Level 1	Level 2	Level 3		ID
3. Forest semi – natural areas	3.1. Forests	3.1.1	Deciduous forests	23
		3.1.2	Coniferous forests	24
		3.1.3	Mixed forests	25
	3.2. Tree and shrub plant communities	3.2.1	Natural grasslands	26
		3.2.2	Moors and heathlands	27
		3.2.3	Sclerophyllous vegetation	28
		3.2.4	Transitional woodland-shrubs	29
	3.3. Open area without vegetation or sparsely covered with vegetation	3.3.1	Beaches, dunes, sands	30
		3.3.2	Bare rocks	31
		3.3.3	Sparsely vegetated areas	32
		3.3.4	Burnt areas	33
		3.3.5	Glaciers and permanent snowfields	34
4. Wetlands	4.1. Inland wetlands	4.1.1	Inland marshes	35
		4.1.2	Peatbogs	36
	4.2. Riparian wetlands	4.2.1	Salt-marshes	37
		4.2.2	Salines	38
		4.2.3	Intertidal flats	39
5. Water-bodies	5.1. Inland waters	5.1.1	Water courses	40
		5.1.2	Water bodies	41
	5.2. Marine waters	5.2.1	Coastal lagoons	42
		5.2.2	Estuaries	43
		5.2.3	Sea and oceans	44

Source: Own studies on the basis of (Ciołkosz, Bielecka 2005)

MATERIAL AND METHODS

The analysis of the analysed land cover was conducted on the basis of CORINE Land Cover 2006 model as 100 meter pixel raster images. The models were obtained free of charge from the European Environment Agency (EEA) web page http://www.eea.europa.eu/data-and-maps/explore-interactive-maps/corine-landcover.

CORINE data were calibrated to WGS 84 reference frame. Area relief analyses were conducted using digital land model (DLM) ASTER Global Digital Elevation Map (GDEL) with 30m resolution. The study of slopes was conducted basing on DLM and assumed interval classes. The transformation enabled the analysis of the lie of the land in confrontation with the land cover. Results of the analysis were elaborated as spatial intersection between: land slopes and land use structure layers. The results of modelling were obtained by means of Idrisi Andes and Golden Software Surfer 8 programmes used for GIS analyses. In order to analyse the land use within the administrative boundaries of Nowy Targ district, a reclassification of the raster was made.

Spatial multicriteria analyses (Gotlib et al. 2007) allowed to present the investigated issues as resultative layers and their additional compilation by means of simple statistical analyses. Table 1 shows classes of land cover recorded in CORINE Land Cover databases. The 44 land cover classes were defined in these bases. The 31 classes were noted in Poland, whereas in Małopolska region 28 land cover classes are visible (Ciołkosz, Bielecka 2005). It should be noticed that CORINE database stores raster data with the smallest mapped surface corresponding to 25 hectares and minimum width of 100m. Changes may be introduced to the database only at five-hectare change of separation range or twenty five-hectare change in case of new land cover form.

The investigated area of Nowy Targ district is located in the Małopolska region in the area of Nowy Targ county. It covers the area of ca. 207,6 km^2 and has diversified land forms. It is situated within three physiographic units. The Gorce Mountain range, a part of the Beskidy Zachodnie range, occupies the northern part of the district. The southern part is located within the Orawa-Nowy Targ Basin characterised by a plain relief.

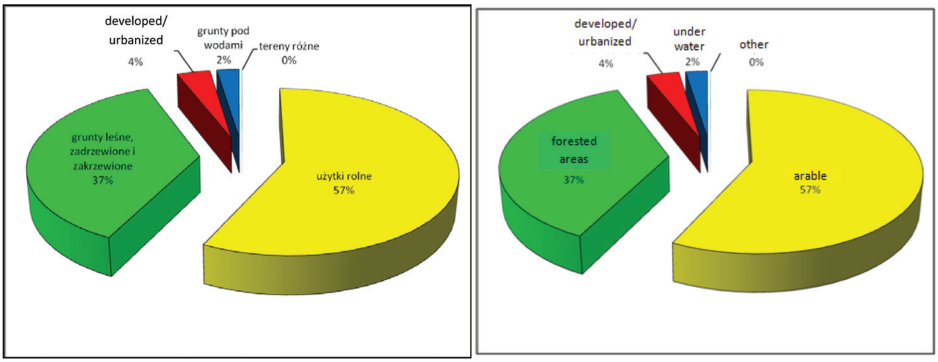

Figure 1. Land use structure in Nowy Targ district. Source: Authors' own studies based on data supplied Nowy Targ District office, as of December 2013

The southern and south-eastern ends of the district comprise the Pieniny Klippen Belt. Over 56% of land in Nowy Targ district is agricultural land (Figure 1.), of which 37% are arable lands, whereas about 20% permanent grasslands (Figure 2.). Approximately 27% of the district area is covered by forests, whereas about 2,5% is land under water. The percentage share of agricultural lands and forest areas evidences that the rural district of Nowy Targ has a agro-forestry function.

The district location in the sub-mountain area is characterised by considerable height differences and land slopes. Analysis of the digital land model revealed that almost 30% of Nowy Targ district area (6 061 ha) is situated on the terrain with land slopes of 0-3°, whereas about 18% is the land with inclination within the 3°-6° interval.

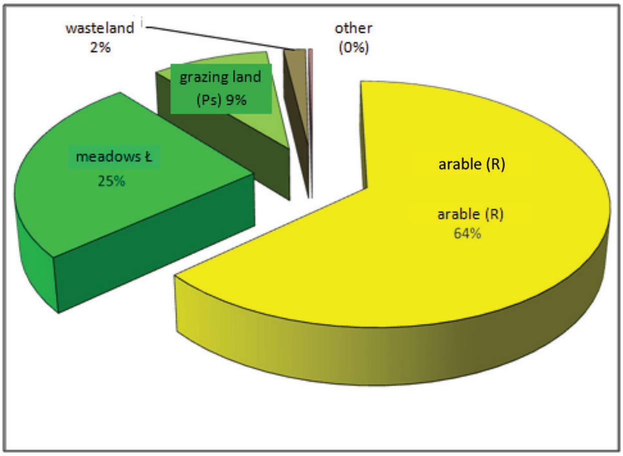

Figure 2. Agricultural land structure in Nowy Targ district. Source: Authors' own elaboration on the basis of data supplied by Nowy Targ District Office, as of December 2013.

About 21% of the total district area, i.e. 4224 ha is the land situated on slopes from the 6° to 10° interval. A comparable percentage of the district area (20%) are terrains with 10°-15° slope, while about 19% are terrains with inclination within the 10°-15° interval.

About 2.6% of Nowy Targ district lands is localised on slopes exceeding 20°. These conditions have a significant impact on land use and kind of land cover.

RESULTS AND DISCUSSION

Analysis of CLC 2005 raster images for Nowy Targ district in confrontation with land slopes made possible investigating the land cover forms in respective slope intervals. Eleven forms of land cover were registered in the area of the analysed district, including: densely built up areas, green areas, orchards, other permanent crops, so called annual crops associated with permanent crops, so called complex cultivation patterns, agro-forestry areas, deciduous forests, coniferous forests, mixed forests and few areas marked as sclerophyllous vegetation and inland marshes.

CORINE Land Cover raster illustrated in Figures 4 to 10 show land cover in Nowy Targ district in the slope intervals determined, according to the legend in Table 1. Results of the analyses were also presented in Table 2. The research demonstrated that out of 773 ha of built up area about 33% (257 ha) is located on the terrain with up to 3° slopes and about 25% on the terrain with 3°-6°. A comparable area under high density housing is within the 6°-10° slope interval. Much less, i.e. about 15% of the built-up area in on the terrains with 15°-20° slopes. It may be assumed that on slopes of above 20° high density housing is almost absent. The highest percentage of the meadow and pastures area – c.a. 36% occupies the terrains with up to 3° land slopes, i.e. almost flat. Comparable grassland areas occur on the slopes between 3° and 6° and 6°-10°, respectively c.a. 24% and 23%. Slightly less grasslands, i.e. about 19% is situated on the terrains with 10°-15° slopes.

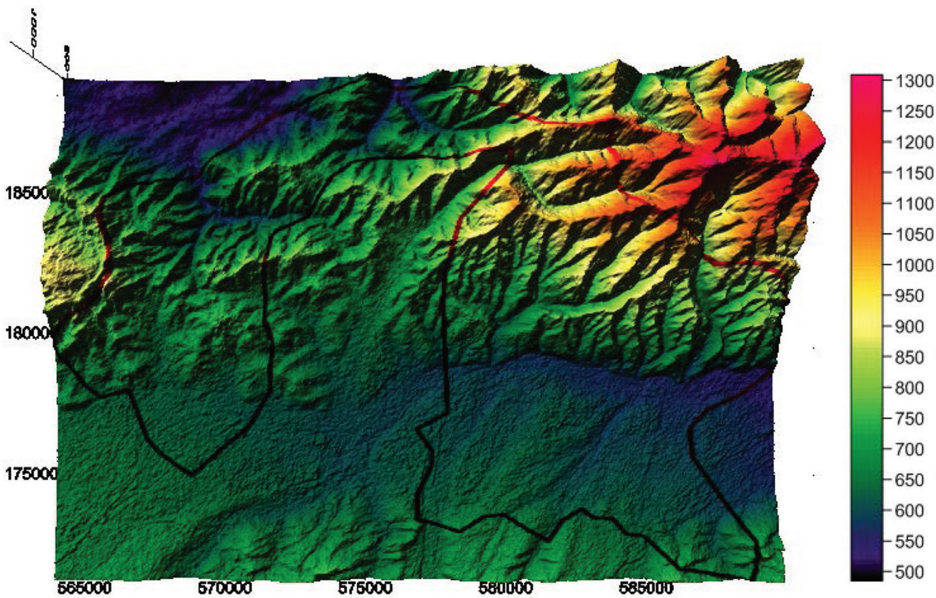

Figure 3. Digital land model Aster GDM in Nowy Targ district boundaries. Colour scale shows the elevation above sea level (m). Source: http://www.nowytarg.e-mpzp.pl

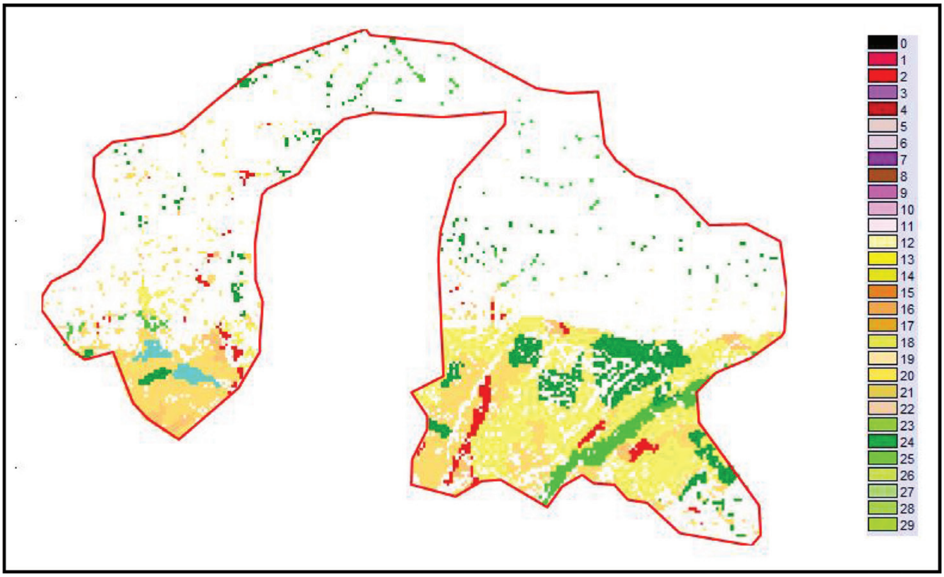

Figure 4. Land use in Nowy Targ district in the 0°-3° slope interval.
Legend: see Table 1

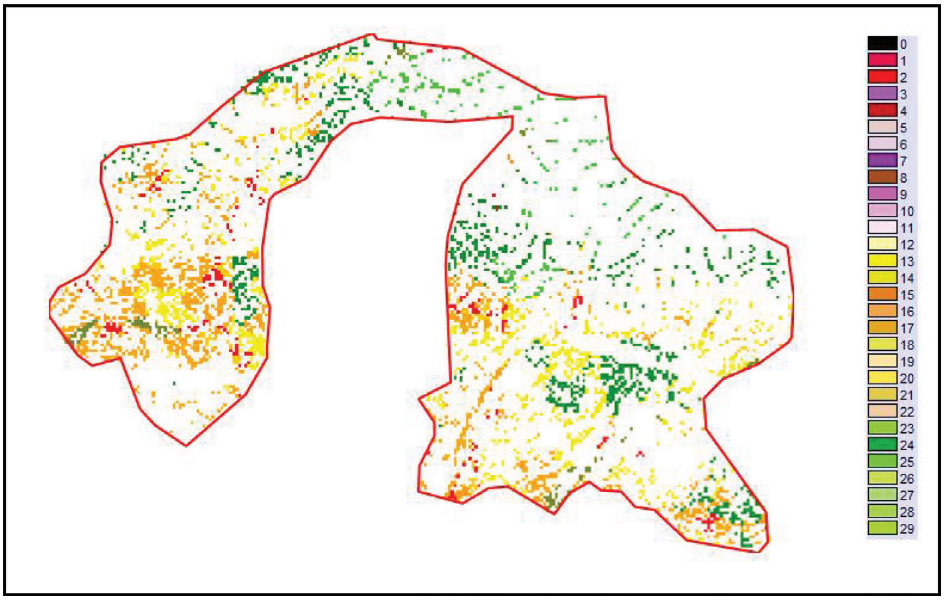

Figure 5. Land use in Nowy Targ district in the 3°-6° slope interval.
Legend: see Table 1

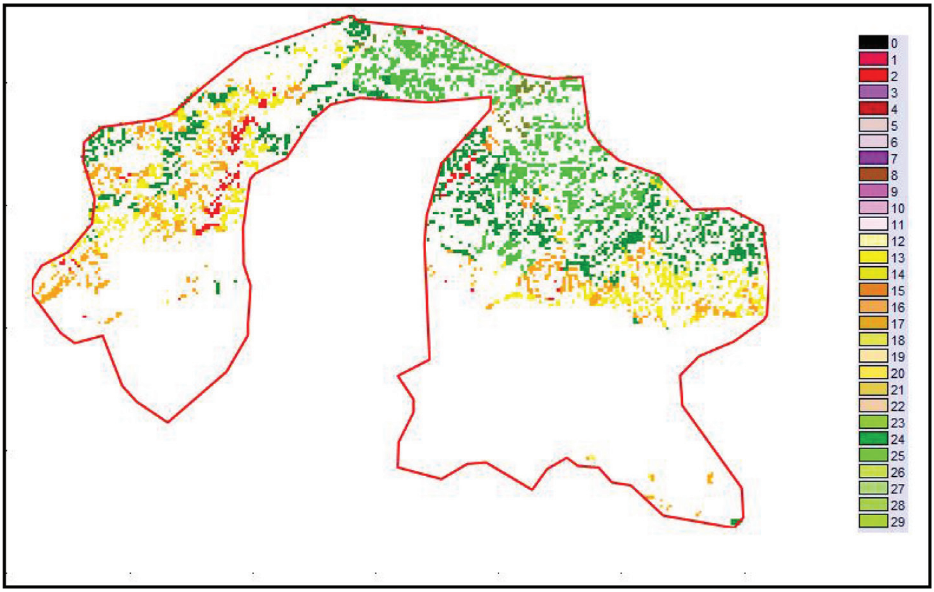

Figure 6. Land use in Nowy Targ district in the 6°-10° slope interval.
Legend: see Table 1

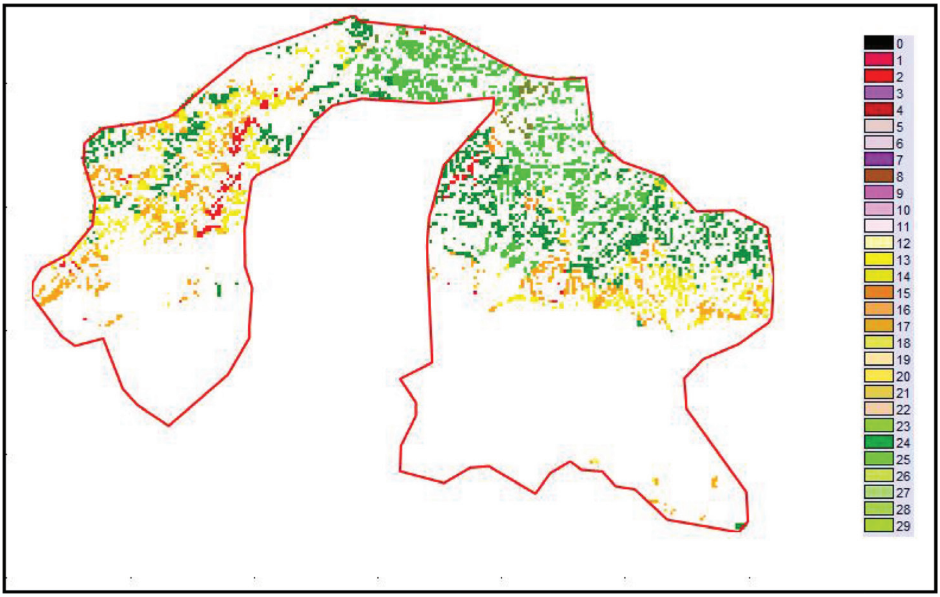

Figure 7. Land use in Nowy Targ district in the 10°-15° slope interval.
Legend: see Table 1

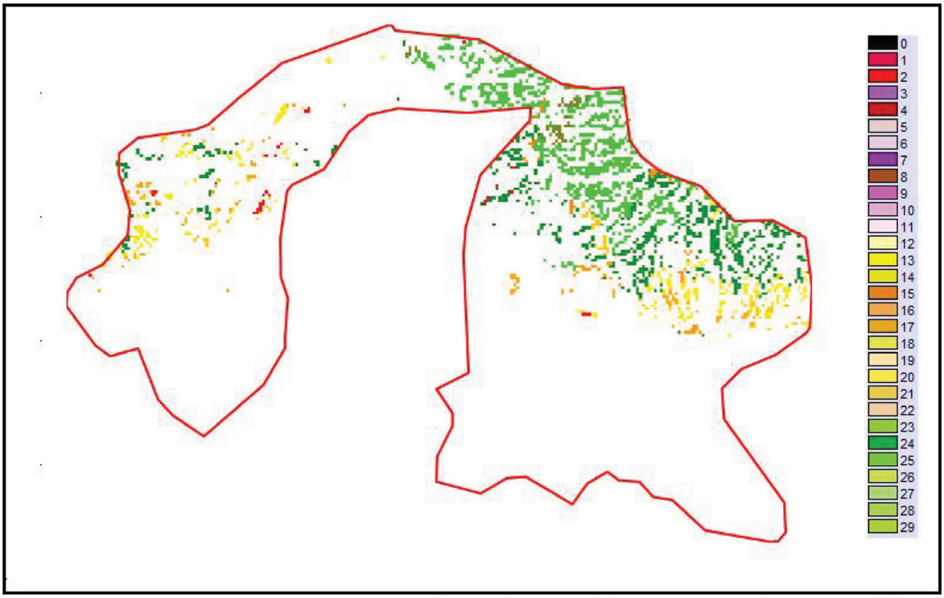

Figure 8. Land use in Nowy Targ district in the 15°-20° slope interval.
Legend: see Table 1

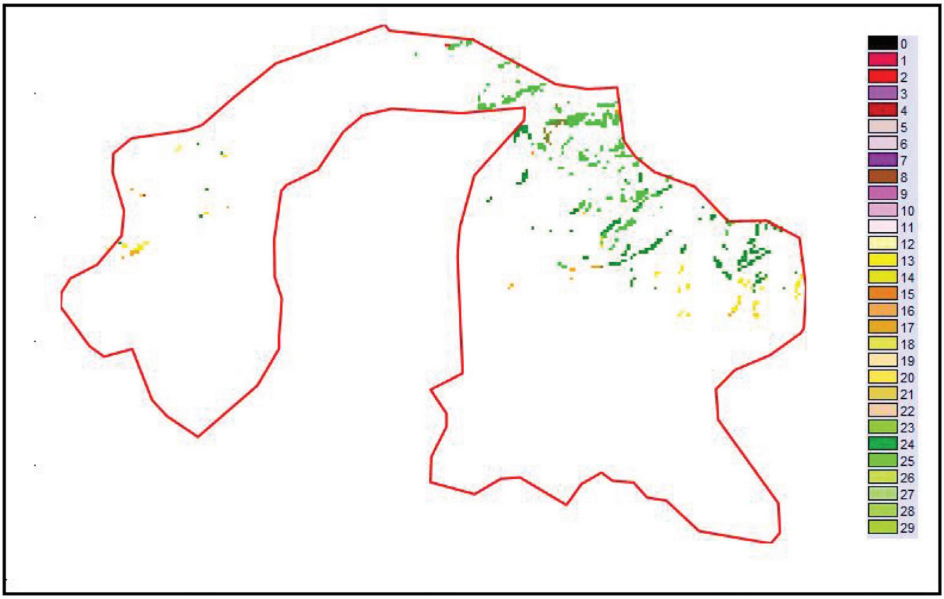

Figure 9. Land use in Nowy Targ district over 20° slope interval.
Legend: see Table 1

Meadows and pastures occur also on terrains with the greatest slopes. About 14% of grassland is situated in the 15°-20° slope interval, whereas ca. 10% on over 20° slopes. The investigations revealed that arable lands occur in the areas within all identified slope intervals. The highest share – 2476 ha, i.e. almost 38% of the arable land is localised on terrains with 3°-6° gradient, while ca. 20% on 6°-10° slopes. A considerable percentage of ploughlands, ca. 13% is localised in the 10°-15° slope interval, whereas just over 5% of arable lands is situated above the limit gradient of 15°. A significant percentage of Nowy Targ district area – 7917 ha (ca. 39%) is covered with forests, of which ca. 66% is deciduous forest, 33% coniferous forest and only 1% mixed forest. A majority of forest grounds in the analysed district (over 50%) occur on terrains with gradient between 6° and 15°. Respectively, about 18% of forest occurs in the 15°-20° slope interval, whereas on the terrains with up to 6° gradient, there are about 25,6% of forest areas. Slightly over 5% of forest areas are situated on the terrains with gradient over 20°.

Table 2. Area and percentage share of land form uses in determined slope intervals in Nowy Targ district

(ha) / %	**0-3°**		**3-6°**		**6-10°**		**10-15°**		**15-20°**		**>20°**		**total**	
	(ha)	%	(ha)	%	(ha)	%	(ha)	%	(ha)	%	(ha)	%	(ha)	%
built up and urbanised area	**257**	33.2	**196**	25.4	**180**	23.3	**114**	14.8	**25**	3.2	**1**	0.1	**773**	100
	4.2	X	5.3	X	4.3	X	3.0	X	1.2	X	0.2	X	3.8	X
meadows and pastures	**2205**	43.2	**900**	17.7	**953**	18.7	**708**	13.9	**274**	5.4	**55**	1.1	**5095**	100
	36.4	X	24.3	X	22.6	X	18.5	X	13.6	X	10.4	X	25.0	X
arable lands	**2476**	38.6	**1513**	23.7	**1257**	19.7	**813**	12.7	**287**	4.5	**48**	0.8	**6394**	100
	40.9	X	40.8	X	29.7	X	21.3	X	14.3	X	9.1	X	31.4	X
forests	**1015**	12.8	**1082**	13.7	**1824**	23.0	**2159**	27.3	**1414**	17.9	**423**	5.3	**7917**	100
	16.7	X	29.2	X	43.2	X	56.4	X	70.4	X	79.9	X	38.9	X
wastelands	**108**	62.2	**15**	8.6	**10**	5.7	**29**	16.7	**10**	5.7	**2**	1.1	**174**	100
	1.8	X	0.4	X	0.2	X	0.8	X	0.5	X	0.4	X	0.9	X
total	**6061**	29.7	**3706**	18.2	**4224**	20.8	**3823**	18.8	**2010**	9.9	**529**	2.6	**20353**	100
	100	X	100	X	100	X	100	X	100	X	100	X	100	X

Source: Authors'own studies

Considering a dominant land use in the determined slope intervals it may be noticed that agricultural lands prevail on flat and slightly sloped terrains (to 3°) covering total over 77% of the area, in which arable lands constitute ca. 41% and ca. 36% is grassland. A significant percentage, ca. 17% of the slightly sloped areas is also covered by forests.

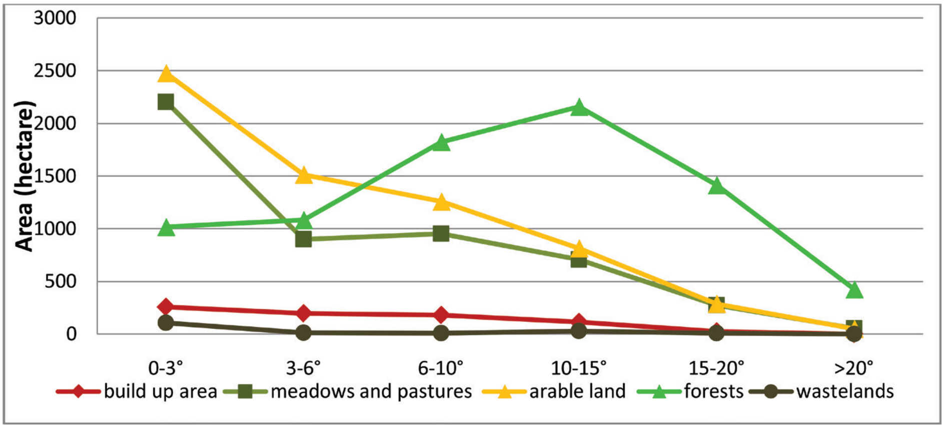

Figure 10. Farmland area in determined slope intervals. Source: Authors' own studies

Built up and urbanised areas cover ca. 4% of the terrain with up to 3° slope. On the terrains with 3°-6° slopes arable lands have the highest share, exceeding 40% of the area. About 30% of the area within this slope interval is covered by forest and slightly less by grasslands (24%). Built up and urbanised areas cover over 5%, while terrains with 6°-10° are covered mainly by forests which constitute here over 43%. Almost 30% of the area is occupied by arable lands and ca. 22,5% by grasslands. Built up and urbanised areas occupy slightly over 4% of the area. Similarly forests prevail on the terrains with slopes within the 10-15° interval covering ca. 56,5% of the area. Arable land covers about 21% of the area and grasslands slightly less – 18,5%. Built up and urbanised areas cover about 3% of the area. In the 15°-20° slope interval forest areas are dominant, occupying more than 70% of the terrain, whereas arable lands respectively 14% and 13,6%. Urbanised areas cover only 1,2% of the area. On the terrains with land slope higher than 20°, the highest percentage of the area, almost 80% are forests, grasslands about 10% and arable lands 9%.

CONCLUSIONS

Analysis of land use confronted with average slope intervals determined on the basis of digital land model allowed to formulate several conclusions. In Nowy Targ district, the agricultural land area diminishes with increasing land slope, while the percentage share of afforested and shrubbed areas increases, considerably exceeding the percentage of areas under the other land use forms. However, on slightly inclined areas individual agricultural lands are distributed evenly. The share of agricultural lands including ploughlands and grasslands, afforested and shrubbed areas is similar. The analysis revealed also that built up and urbanised areas cover on average several percent of the area within each slope interval. Despite physiographic constraints in the area destination for housing, in Nowy Targ district ca. 18% of built up and urbanised areas is localised on the terrains with over 10° slopes. These are partly holiday and recreational areas. Particular attention should be paid also to arable lands situated on the terrains with over 10° slope. Like in case of built up and urbanised areas they make up a high percentage, i.e. 18% of the area. These terrains in case of wrong cropping system may undergo water erosion. It may be also inferred that these areas will be classified to the category of disadvantaged areas due to constraints in farm machinery use and difficult transport between the field and farm. There is also a strong possibility that some land with high inclinations will have a disadvantageous northern exposure on which among others snow cover lies longer.

Physiographic conditions affect, including these resulting from the land form, limitation in land use for agricultural and investment purposes. Analysis of the area relief should provide a basic premise for rational space utilisation both in spatial planning and making decisions concerning future land use.

ACKNOWLEDGEMENTS

The results of research carried out under the project No DS 3371/ KGPIAK/2014 financed by the Ministry of Science and Higher Education.

REFERENCES

Adamowicz M., Dresler E. 2006. Zrównoważony rozwój obszarów wiejskich na przykładzie wybranych gmin województwa lubelskiego. Zeszyty Naukowe Akademii Rolniczej we Wrocławiu. Nr 540 Rolnictwo. Wrocław. s.17-24.

Andrzejewski R., Weigle A. (red.) 2003. Różnorodność biologiczna Polski. Wyd. Narodowego Funduszu Ochrony Środowiska. Warszawa. ss.284.

Bański J. 2003. Współczesne i przyszłe zmiany w strukturze przestrzennej obszarów wiejskich – wybrane zagadniania (w:) Górz B., Guzik C. (red.), Współczesne przeobrażenia i przyszłość polskiej wsi. Studia Obszarów Wiejskich, 4, s. 11-25.

Baran-Zgłobicka B., Zgłobicki W. 2012. Mosaic landscape of SE Poland:should we preserve them? Agroforest Syst (2012) 85:351-365.

Baran-Zgłobicka B., Gawrysiak L., Warowna J., Zgłobicki W. 2011. Znaczenie rzeźby terenu w planowaniu przestrzennym na obszarach wyżynnych. Architektura. Czasopismo techniczne Politechniki Krakowskiej. Z. 17. 6-A/2011. s.101.

Bucała A., Starkel L. 2012. Wpływ gwałtownych i powolnych zmian użytkowania ziemi na przekształcenia środowiska polskich Karpat. Wyd. Instytut Geografii i Przestrzennego Zagospodarowania PAN. Warszawa

Bürgi M., Hersperger A. M., Schneeberger N. 2005. Driving forces of landscape change – Current and new directions. Landscape Ecology, 19(8), 857-868.

Ciołkosz A., Bielecka E. 2005. Pokrycie terenu w Polsce. Bazy danych CORINE Land Cover. Wyd. Główego Inspektoratu Ochrony Środowiska, Warszawa.

Eiter S., Fjellstad W., Stokstad G. 2014. Agricultural landscapes of Norway: Farmland continuity and change, and their driving forces. (w:) Bicik I., Himijama Y., Feranec J., Kupkova L. (Editors) Land Use/ Cover Changes in Selected Regions in the World. Volume IX. Prague.

Gliński P., Przesmycki J. 2011. Wpływ erozji wodnej na krajobraz. Teka Kom. Arch. Urb. Stud. Krajobr. – OL PAN. S. 99-107.

Gotlib D., Iwaniak A., Olszewski R. 2007. GIS. Obszary zastosowań. Wyd. PWN, Warszawa.

Hopfer A., Cymerman R., Nowak A. 1982. Ocena I waloryzacja gruntów wiejskich. PWRiL. Warszawa.

Józefaciuk A., Józefaciuk Cz. 1995. Erozja agroekosystemów. Państwowy Inspektorat Ochrony Środowiska. Biblioteka Monitoringu Środowiska. Warszawa.

Józefaciuk Cz., Józefaciuk A. 1996. The Erosion Mechanisms and Methodological Indicators for the Research on Erosion. Biblioteka Monitoringu Środowiska.

Kryk B. (red.) 2010. Zrównoważony rozwój obszarów wiejskich aspekty ekologiczne. Wyd. Economicus, Szczecin. ss. 297.

Moore I. D., Grayson R. B., Ladson A. R. 1991. Digital terrain modeling – a review of hydrological geomorphological and biological applications. Hydrological Processes, 5, s. 3-30.

Pasławski J. (red.) 2010. Wprowadzenie do kartografii i topografii. Wyd. Nowa era. Wrocław.

Pohl J. 1978. Związki rolniczego użytkowania ziemi ze środowiskiem przyrodniczym we wschodniej części Karpat. Prace Geograficzne, z. 125, s. 123-143.

Prus B., Salata T. 2014. Influence of physiographic conditions on the quality of agricultural production area. Geomatics 4/2014. Kraków.

Salata T. Prus B. 2012 Delimitacja obszarów na potrzeby planowania przestrzennego. Acta Scientiarum Polonorum. Administratio Locorum 11(3) 2012 s. 215-225.

Staniak M. 2009. Zrównoważony rozwój obszarów wiejskich w aspekcie środowiskowym. Woda – Środowisko – Obszary Wiejskie. T.9. Z.3 (27), s.187-194.

Szymański M. 1969. Geodezja rolna w planowaniu przestrzennym wsi. PPWK, Warszawa.

Ustawa z dnia 27 marca 2003r. o planowaniu i zagospodarowaniu przestrzennym (Dz.U. 2003 nr 80 poz. 717)

Zwoliński Z. 2006. Program pomiarowy: Pokrycie terenu i użytkowanie ziemi, *www.staff.amu.edu.pl/~zmsp/wyt2006/19_program_P1.pdf,* access: 01.12.2013.

dr inż. Barbara Prus
University of Agriculture in Krakow
Department of Spatial Planning and Landscape Architecture
ul. Balicka 253c, 30-149 Kraków
e-mail: b.prus@ur.krakow.pl

mgr inż. Łukasz Budz
Graduate of the University of Agriculture in Krakow
Faculty of Environmental Engineering and Land Surveying
e-mail: budz.lukasz@gmail.com

Received: 05.01.2015
Accepted: 14.05.2015