THE 1994 SUMMER STORM IN THE BOLSKA RIVER WATERSHED (CENTRAL PART OF EASTERN SLOVENIA)

POLETNO NEURJE V POREČJU BOLSKE LETA 1994 (OSREDNJI DEL VZHODNE SLOVENIJE)

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A typical small lanslide in the Bolska river watershed
(photography M. Natek).
Značilen usad v porečju Bolske (fotografija M. Natek).

Abstract UDC 911:502.5(497.12-11)

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On the evening of June 28, 1994, a powerful storm cloud rose over the northwestern part of the Posavje Hills and the southwesternmost edge of the Celje Basin. The storm with heavy rain, hail, and wind lasted only two hours. It was centered above Velika (Čemšeniška) planina (1200 m). In the northern part, the storm raged most in the central area of the Bolska watershed. The Bolska River and all its right-hand tributaries overflowed their banks, engulfing the flood plains and the settlements on them. Most of the local roads and river channels were destroyed and clogged with debris. Slopes which had been deforested for agricultural purposes were furrowed by fresh erosion gullies and landslides. There were seven storms followed by floods in the Bolska watershed in 1994, the worst this one which occurred at the end of June. The paper presents some of the geographical features of the Bolska watershed and the effects on the landscape of the catastrophic floods.

Izvleček UDK 911:502.5(497.12-11)

Poletno neurje v porečju Bolske leta 1994 (Osrednji del vzhodne Slovenije)

Dne 28. junija 1994 se je v večernih urah razvil močan nevihtni oblak nad severozahodnim delom Posavskega hribovja in skrajnim jugozahodnim obrobjem Celjske kotline. Neurje z močnimi padavinami, točo in vetrom je trajalo komaj dve uri. Njegovo središče je bilo nad Veliko (Čemšeniško) planino (1204 m). V severnem delu se je neurje najbolj razbesnelo v osrednjem delu porečja Bolske. Bolska in vsi njeni desni pritoki so prestopili bregove svojih strug ter preplavili obrečne ravnine in naselja na njih. Večina krajevnih cest in rečnih korit je bila uničena in zatrpana s plavjem. Pobočja, ki so izkrčena v kmetijske obdelovalne namene, so razorali sveži erozijski žlebovi ter zemeljski plazovi in usadi. V letu 1994 je bilo v porečju Bolske sedem neurij s poplavami, a najhuje je bilo konec junija. V prispevku so prikazane nekatere geografske značilnosti porečja Bolske in pokrajinski učinki katastrofalne povodnji.

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1. Introduction

The June storm which struck the central northern part of the Posavje Hills was one of the worst in the area in recent decades. Its multiple effects left a marked impression on the present landscape, and its extraordinary force transformed the physiognomy of the landscape for a long time to come. In a few hours, the powerful hailstorm, the like of which not even the oldest local inhabitants could remember, erased all traces of the numerous and most varied human activity from the landscape. Slopes became bare overnight, roads and cart tracks were turned into torrential ravines with deeply eroded gullies and trenches, and the lowland meadows and valley fields were thickly covered with various alluvia which affected and destroyed a substantial part of the crop and damaged houses, business premises, and other buildings. Homes which up to now had never suffered flood damage were covered by thin or thick flood alluvium composed mostly of mud. Most of the bridges and wooden footbridges serving local traffic were destroyed or at least damaged. Incalculable damage was done to practically all riverbed ravines and streams draining the mountainous hinterland of the Bolska and Motnišnica valleys.

The research will present and evaluate some of the geographical causes and effects of the June floods in the southwesternmost part of the Celje Basin. The analysis and presentation will be based on a description of the general geographical characteristics of the Bolska watershed, focusing primarily on the identification of the most relevant regional features and their components which give the stricken regions the sad appearance of a natural disaster. The last storm once again demonstrated that wherever man through his unwise encroachment on the environment has deliberately or unconsciously ignored the natural features and their rules (e.g., by settling in previous flood areas, by constructing new traffic routes, by introducing abrupt encroachments and changes in agricultural land use whereby changes in land cultivation technology brought about fundamental changes in the local transportation network, etc.) there has been great devastation and incalculable material damage.

As a rule, natural disasters, particularly catastrophic storms that cause the most varied and multiple effects, are more than any other landscape-forming element among those factors which with their unique occurrence most decisively influence the transformation of the landscape in the areas affected. Their impact usually has long-term consequences. Natural disasters trigger numerous natural geographical processes which introduce new relationships, functional linkages, and values between landscape-forming elements and components. Until a new and stable balance is established between them, there will frequently be undesirable changes in the environment (e.g., changes in or displacement of water sources; extensions of landslides; riverbeds clogged with gravel that present a threat and potential danger during the next larger flood; "automatic" widening and deepening of riverbeds due to side and bottom erosion; effects and consequences of every restoration attempt to create the "ideal" horizontal profile of the bed of a torrent, a ravine, the course of a stream, etc.), and this must be seriously taken into consideration. The redevelopment of an area affected by storms or any other natural disaster demands long-term and planned effort to achieve the renewal and reorganization of spatial elements and components.

It is also necessary to consider the effects of the catastrophic 1994 storm in the Bolska watershed from another angle. In the last five years, this area has been struck by numerous storms, torrents, and floods in various seasons. Their effects are manifest in the form of alluvia, undercut and generally ruined river banks, new gravel deposits in riverbeds, and above all, in great amounts of deposited rubble, gravel, and other material in various parts of the riverbeds. Damaged by landslides, new stream beds, and the partial, local, and spatially limited restoration operations carried out hastily in the most vulnerable areas, the slopes present a real threat and are a source of new disasters and the danger of further deterioration in the cultural landscape.

The paper describes the effects of the June storm in the Bolska watershed and these are drawn on the appended map. Most of the data was collected in the field during the month of July 1994 and drawn on a 1 : 25,000 scale topographic map (Motnik and Trbovlje area charts). During this period the entire Bolska watershed was surveyed and the stricken area examined in detail. Field research results were supplemented by various other published or official reports and the autumn visit to the most affected, but partly already redeveloped areas, particularly the watershed of the Zaplaninščica, Kučnica, Konjščica, and Ojstrica streams.

2. Geographical Features of the Bolska Watershed

The Bolska watershed extends over 190.3 km^2 of distinctly transitional territory in central Slovenia. It is squeezed between the central northern edge of the Posavje Hills; the southern, southeastern, and eastern slopes of the high subalpine karst plateaus (Menina planina and Dobroveljska planota); and the southwesternmost extension of the edge of the Celje Basin. These designated landscape units, which differ in origin, serve diverse functions in the landscape structure of the Bolska watershed. They contain rock of various composition and constituent landscape regions whose characteristic features form the picturesque landscape and its functional polyvalence. The geological and tectonic structure of the Bolska watershed is interesting, varied, and above all, significant since it is this structure on which the fundamental classification of the surface is based. This surface plays a vital role not only in the shaping and dissection of the watershed but also in the direction of water flow, the gradient of streams, the density of the river network, the distribution and shape of settlements, and agricultural uses. Lastly, it is also a significant factor in the construction, distribution, and dissection of the (mainly earlier) local and interregional traffic system. The newest traffic routes have also taken advantage of the relief and surface formations. The majority have followed the older routes. The tectonic composition of the Bolska watershed is evident in its rock structure which is important, among other things, for its precipitation drainage coefficient.

2.1. Geological, Tectonic, and Rock Structure

The Bolska watershed lies at the junction of three major tectonic units: the Posavje fold, the young tectonic sink of the Celje Basin, and the Savinjske Alps (Rihteršič 1960, 88; Beg 1951; Rakovec 1931; Melik 1954, 1957; Buser 1979, 43–45; Premru 1983, 46–47).

Most of the Bolska watershed is within the area of the "Posavje fault" tectonic system. It is right at this junction of tectonic units composed of various rock that the most various movements occurred, accompanied by numerous tectonic faults in different directions and magnitudes. This forms the basis for the present variety of surface rock structure. The rock which contributed not a little to the dissection of the surface and its various uses, comes from almost from all the most important geological periods. Most of the Bolska watershed extends into the northern edge of the Posavje Hills. From the tectonic and geological viewpoint, this is the northernmost part of the Posavje fold. Its tectonic composition ends in the north with the Motnik and Tuhinje syncline valley system. within it are pressed, in a very narrow belt of Tertiary, Oligocene, and Miocene sediments (Premru 1983, 27–29, 46; e.g., sand, pebbles, sandstone with marl deposits and gravel). The Motnik Syncline is surrounded on both sides by older Triassic rock which belongs to the Žovnek or Selce overlap to the north, while to the south is the Trojane Anticline or Kozjak overlap (Buser 1979, 45; Premru 1983, 46) which comprises the hills between the Tuhinje Valley and Črni graben in the south.

The Bolska catchment area extends across the northern wing of the Trojane Anticline right to its heart, where the less hardened Paleozoic rock is exposed. Along with limestone and dolomite whose surface is more hardened and permeable, the Triassic rock of the northern wing of the Trojane Anticline or Kozjak overlap is composed of a series of impermeable rock (e.g. pseudo-Zilje layers; clay slate and small broken material, quartz, and marly clay slate with breccia deposits, etc.). In the center of the Trojane Anticline, Paleozoic (carbon-Permian) flint sandstone, clay slate, sandstone, polished river stones, shale, and other rock dominate. Besides the rock mentioned above, the southeastern part of the Bolska watershed, i. e. the watershed of its right-hand tributaries (Kučnica, Konjščica, and Reka) is also composed of rock from the Cretaceous and Jurassic periods (flat Vransko limestone with quartz, marl, sandstone, breccia, limestone with quartz, slate, clay slate, etc.). Only the highest ridges with peaks which form the divide between the Sava and Savinja rivers or the demarcation between the watersheds of individual tributaries of the Bolska are composed of Triassic limestone (e.g., Smolnik 733 m, Jasovnik 765 m, Kozica 970 m, Velika Planina 1204 m, Javor 1133 m, Mrzlica 1122 m).

The southwestern margins of the Celje Basin where the Bolska receives its most important tributaries in the Šentjur Hills region is composed of impermeable or less permeable Pliocene-Quaternary layers composed of clay, acidic gravel and sand, and river sediment-alluvia and are divided into a Quaternary terrace system. The lower course of the Bolska below the town of Gomilsko where it is pushed to the very southern edge of the Celje Basin runs over alluvial sediments largely of clay sandstone. In this region, where the Bolska frequently flooded everything until it was regulated during the 1970's, a typical flood area developed (Natek 1978, 25–28). Here the Bolska receives its most important left-hand tributary, the Trnavca, which has a karst source and all the features of a karstic flood stream.

The third geotectonic unit forming part of the Bolska watershed is the Menina and Dobroveljska planota plateaus. It represents a true mountain horst which is wedged between the Gornji Grad or Zgornja Savinja basin and the northern edge of the Posavje Hills or the Posavje fold. In a geological and tectonic sense, this is the Savinja overlap (Buser 1979, 43; Melik 1954, 1957, 1959; Premru 1983, 46). The surface of Menina is covered largely with Triassic limestone and dolomites. The Bolska and its tributaries (e.g., the Motnišnica and Merinščica) do not receive large amounts of water from this area which is predominantly karst. The southern and eastern slopes of Menina are gullied by karstic stream beds, mostly of torrential origin and character. All the streams mentioned above formed their beds mostly on the surface, which is composed of Triassic clay slate, sandstone, and other less hardened and impermeable rock.

2.2. Water Network

The Bolska is a central artery that collects water from an extensive area, mainly from the mountainous and karstic world lying between the Celje and Ljubljana basins. The source of the Bolska is northwest of Trojane at an altitude of approximately 815 meters on the slopes between Reznarca Hill (913 m) and Javorje Hill (868 m). Below Prebold in the Savinja Valley, it flows into the Savinja River as a right-hand tributary. Its mouth is at the altitude of 264 meters. The total length of its course is 32.050 kilometers (SL, 1989, 26). According to my own measurement, the length of its riverbed between source and mouth is 38.750 kilometers. The average gradient of the Bolska riverbed is therefore 17.2‰ or 13.8‰. In the flat stretch between the mouth of the Motnišnica and the Bolska's outflow into the Savinja, the average gradient varies between 4‰ and 6‰. The upper course of the Bolska from its source to Ločica has torrential characteristics as the average gradient of its bed reaches 32.2‰ or more.

Almost all the right-hand tributaries which drain the extensive area between the southern divide ridge and valley or basin edge are true torrential streams, with respect to their hydrological and geographical character and destructive capability. In dry periods, the very small quantities of water in their stony and bare beds are hardly noticeable. After rains, especially sudden downpours, their beds are full of muddy torrential water which changes, destroys, and transforms the riverbeds into genuine torrential and erosive gullies. The high waters carry huge amounts of the most varied debris that has been collected or deposited during the dry and winter periods in the riverbeds, on their banks, or at the lower edges of slopes. In short, the role of the torrents in this area is to carry away slope material during high waters, "cleaning" the upper, catchment area stretches of their riverbeds of excess and unnecessary material which they normally deposit upon crossing onto the flatlands where their transporting power and destructive capability decrease abruptly.

The Motnišnica, the left-hand tributary of the Bolska at Ločica, also has many torrential characteristics. These characteristics are largely the result of its right-hand tributaries and upper branches which extend high into the northern slopes of Veliki Rakitovec (909 m), Špilk (957 m), Šipek (877 m), Reznarca (913 m), Javorje (868 m), and Vrhe (901 m), as well as into the lower eastern slopes of Kozjak (658 m) with its road pass.

Numerous smaller and shorter tributaries (e.g., Blatnica, Virtnica, Žerovnica, Selščica near Grajska vas, etc.) which join the Bolska between Vransko and Prebold and have their catchment areas based in the lower hills of Pliocene and Quaternary sediments have no major effect on the water level of the Bolska or its river regime. The karstic source tributaries (Merinščica, Podgrajščica, Trnavca, and Trebnik) which drain the southern and southeastern margin of the karstic Dobroveljska planota plateau and the eastern slopes of Menina have a more important effect, although after a short time delay, on the fluctuation of the water level in the Bolska riverbed. This occurs because between Vransko and its own mouth below Dolenja vas near Prebold, the Bolska has a relatively slow current and a small gradient (between 2.6‰ and 4.4‰). This, however, was increased a little by regulating the riverbed between Pondor and Dolenja vas.

The water network in the Bolska watershed is comparatively dense. This is mainly the result of the rock composition of the surface and its relief, which are based on the tectonic fracturing and lithological diversity of the ground. However we wish to assess the importance and role of each individual stream regarding the origins of floods, the development of the flood world, and the frequent destruction and devastation of the cultural landscape and its assets, we always return to its fundamental physical and geographical characteristics. These are drawn with the relief energy which almost always manifests itself in the gradient of a river bed, its discharge, and its current. Data on the discharge and current is generally not available for our smaller streams. An outline of hydrological characteristics is available only for the Bolska. A pluvial level river regime is characteristic of the entire Bolska watershed. The highest water levels occur during November and December, and secondary high levels in March and April. This is also characteristic of other streams in the lower hills at the edge of the Celje Basin. The spring high level of the Bolska also depends on the melting of snow (Ilešič 1947; Natek 1978, 44–46).

We calculated the gradients of all the streams in the Bolska watershed. The analysis was done on the basis of 1 : 5,000 and 1 : 10,000 scale topographical maps and partly with the help of a 1 : 25,000 scale map. The measurements and calculations indicate fundamental differences between individual sections and streams (data in Table 1 and on the appended map). The Bolska, the central water artery into which water converges from an area of 190 m^2, has an average gradient of 13.8‰. The beds of all its main streams have steeper and stronger gradients (e.g., Zaplaninščica, 26.4‰; Kučnica, 36.3‰; Konjščica, 31.6‰; Reka, 38.6‰; Mejašca, 76.7‰; Motnišnica, 15.4‰; and Merinščica 53.6‰). The Podgrajščica with 13.3‰ and the Trnavca with 5.5‰ are streams with typical karst features and have lower gradients. These are average gradients which apply to the whole length of the streams. More detailed analysis and field work revealed that the most extensive and most characteristic flood areas occur where the gradients of flood water riverbeds do not exceed 10‰. Elsewhere, the high waters with their turbulent currents cause the widest variety of damage related to river erosion and the transportation of material.

Knowledge of river gradients helps us to explain among other things the function of river material which collects in the stream beds. In this respect, we are interested mainly in the gravel deposits in the stream beds as they reduce the flow capacity of the streams. The gradient is also lower, which in turn leads to a reduction of the destructive erosive force and capability of flowing water. The gravel deposits are important landscape constituents of the river area and in them we see a potential danger which will be triggered by the first major storm to cause high water levels. The gravel deposits in the stream beds are an exceptionally mobile landscape element which in certain conditions move farther down the river. Man has found valuable building material in them which he has used to rebuild houses, repair and pave cart tracks and village streets, etc.

It is important to stress that the identical gradients of some streams do not mean identical activity in or along their riverbeds during storms. The absolute values of stream gradients are only useful in investigating and establishing geographical phenomena and processes. At the same time, it is necessary to take into account a range of unique phenomena and features which define and characterize a particular stream and its riverbed. The phenomena and all the important landscape constituent processes in the surroundings of each individual stream are in some measure autonomous and dependent on numerous local factors. Among these, we can not ignore the extent of the watershed, its geological, rock, and relief composition, the amount and distribution of precipitation, forestation or deforestation, agricultural (or other) land uses, etc. In order to make a detailed and clear characteristic analysis of any watershed or its hierarchical level, it is necessary to investigate its natural geographical characteristics and to explain and evaluate the landscape elements and components as well as their mutual relationships and structural linkages.

TABLE 1: THE GRADIENTS OF THE BOLSKA RIVERBED AND ITS TRIBUTARIES.

Major stream	Tributary I	Tributary II	Tributary III	Individual riverbed sections and branches	gradient (in ‰ or in m/1000m)
Bolska					13.8
				source – Trojane	75.0
				Trojane – Mejašca	24.6
				Mejašca – Ločica	21.5
				Ločica – Gomilsko	4.4
				Gomilsko – mouth	2.6
	Right tributaries:				
	Limovščica				72.0
	Zaplaninščica				26.4
				Podlesna voda	119.5
				Petelinškov graben	130.0
				Limovski graben	76.1
				confluence – mouth	26.4
	Smečka				100.0
	Kotnica				92.9
	Kučnica				36.3
				Vrhovčev graben	104.3
				Ravljanski graben	78.3
				confluence (Dol) – source	17.3
	Konjščica				31.6
				Medvedov graben	117.8
				Bokalov graben	141.5
				Medved – Loke	37.2
				Loke – Ojstriška vas	11.4
				Ojstriška vas – mouth	7.1
		Vetrškov graben			181.7
		Letejev graben			133.3
		Ojstrica			69.0
				to Suhi graben	91.4
				Suhi graben – Loke	16.7
			Suhi graben		108.5
			Tesen		168.9
		Gozdnica			36.6
		Reka (Grajska vas)			43.0
	Reka (Sv. Lovrenc)				38.6
				Mala Reka	71.6
				Velika Reka	44.8
				Zg. Prebold – mouth.	15.0
	Left tributaries:				
	Mejašca				76.7
	Motnišnica				15.4
				Kozjak – Belšč. mouth	21.7
				Beliščica – Globovščica	10.0
				Motnik-mouth (Ločica)	9.8
		Right tributaries:			

Major stream	Tributary I	Tributary II	Tributary III	Individual riverbed sections and branches	gradient (in ‰ or in m/1000m)
		Pustotnikov graben			115.8 and 159.5
		Jastrobeljski graben			128.8
		Podlipovski graben			130.4
		Zasmolščica			177.8
		Griževec			160.0
		Left tributaries:			
		Šedeljškov graben			171.2
		Belščica			76.1
		Globovščica			120.0
	Merinščica				53.6
				Lucijanov graben	96.8
				Močivnikov graben	205.6
				Merinca – Brode	12.1
	Podgrajščica			source-mouth (Brode)	13.3
				Globočnica	124.6
	Cerkovnica				94.1
				source – Stopnik	172.3
				Stopnik – mouth	25.8
	Polter				37.1
				source – Stopnik	60.9
				Stopnik – mouth	8.4
	Tudruščica				75.8
				source – Stopnik	101.7
				Stopnik – mouth	10.4
	Kisovski or Prekopski potok				64.3
				source – Prekopa	86.2
				Prekopa – mouth	21.3
	Trnavca				5.5
				source – Tinč	28.4
				Tinč – Glinje	3.3
				source – Glinje	7.6
				Glinje – Kaplja vas (regulated part)	3.0
		Trbolca			46.7
				Right upper branch	62.0
				source – Šmartno	107.6
				Šmartno – mouth	8.1
		Trebnik			4.5
				source – Braslovško L.	3.0
				Lake – Braslovče	6.1
				Braslovče – mouth	4.4

The presented calculations of gradients clearly reflect the important role of the rock composition and the relief of the surface in regard to differences in the gradients of the beds of individual streams. On the other hand, through the appropriate division of the stream beds into individual sections, we tried to determine the transformation processes which are created and develop during high water periods. Floods and inundations are the external and most marked physical and geographical components of the landscape. With their transformation force and capability, they influence landscape processes and their incorporation in the entire landscape physiognomy.

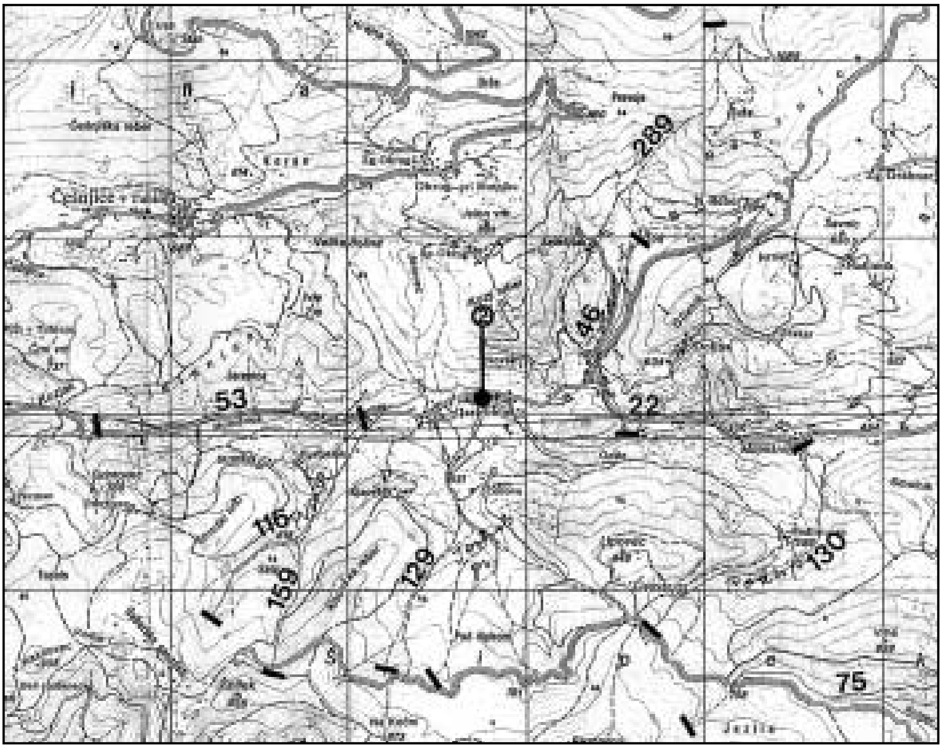


Figure 1: Some gradients of the Bolska and its tributaries (in ‰ or meters/1 km, the number in circle is the location of photography).
Slika 1: Nekateri strmci Bolske in njenih protokov (v ‰ ali v metrih/1 km, številka v krogcu označuje lokacijo fotografije).

2.3. Climate

The Bolska watershed has all the characteristics of the Savinja region climatic area of the central part of eastern Slovenia. Typical of this climate is the distinct transition between Continental, Alpine, and submediterranean climatic influences (Gams 1972).

The average annual precipitation ranges from 1250 to 1500 l/m^2. Between 1956 and 1971, the greatest precipitation occurred in 1965 at Motnik (1702 mm) and Jeronim (1800 mm), while in 1960 it reached 1524 mm in Gomilsko. The amount of precipitation and number of precipitation days increase from east to west. The wettest months are in summer (August and July) and autumn (November), while the winter months are the least wet. The most abundant rainfall, in amounts exceeding 150 l/m^2, occurs in July and June and occasionally in November.

A more detailed analysis showed the inundation and floods are caused mainly by the abundant autumn rainfall when evaporation is reduced due to the lower temperatures and reduced vegetational demand and the rains last longer. Although there is relatively greater precipitation in the summer months, as a rule its abundance is mitigated by the high temperature, high evaporation, and the biological growth demands of the blanket of vegetation. It has been established that the average annual evaporation in the Savinja Valley is 494 mm of precipitation or approximately 40% of the annual precipitation (Natek 1978, 35–43).

Hydrological data indicates and field research confirms that inundation and floods may occur in the Bolska Valley at any time of the year and almost in any month. The only months without floods are February, March, April, and May. Floods occurred most frequently in January and November, less frequently in June, September, and October, and only twice in ten years in July, August, and December. Inundations are very evenly distributed in the second half of the year, with an emphasis on the fact that that we can also expect them in November and December at least once in five years (Natek 1978, 49–51).

On the basis of the above, we recognize that aperiodic floods and inundations are also characteristic of the Bolska Valley and watershed and may occur during any month of the year. Due to their unpredictable occurrence, their destructive effect is so much the greater. Furthermore, because of their unpredictable nature, agricultural production has not been able to adapt to their destructive and devastating effects. Because the time of inundations and floods can not be determined in advance, catastrophic devastation to property and crops in the flood areas is unavoidable.

2.4. Forestry

The function of forests in the environment is polyvalent. Among other things, forests are an important indicator of natural conditions and of social and economic development. In addition, they are an important factor in the regulation of water flow. The present distribution of forests is a reflection of past historical and economic activities. The trees and vegetation give forests their basic economic features and their value which changes with the social, economic, and technological changes that accompany changes in production, transportation, and other relevant elements. In other words, forests are a valuable natural asset incorporated in the economic potential of the land and, at the same time, an important and attractive component of the landscape.

Forests occupy the cadastral districts of the Bolska watershed in various proportions ranging from 0% to 78% of their total areas. The proportion of forest in this area increases, as a rule, from east to west as well as from the center of the valley toward both sides. The more remote areas, which are also at higher altitudes, also have a greater proportion of forest.

The distribution of forests shows that compared with the southern slopes, the northern slopes are much more overgrown with forest. On numerous southern, southeastern, and southwestern slopes, the forest has disappeared because the gentle slopes and the thickness of the soil are suitable for agriculture. At higher altitudes where the population density is lower, the proportion of forest is higer. In 1993, 59.5% of the total area of the Bolska watershed was covered by forest. The area with the highest proportion of forest was the southern hilly section (69%), followed by the upper catchment area of the Bolska watershed (68%), the Merinščica watershed (66.2%), and the Motnišnica watershed (62.5%). In the valley flatland of the Bolska region, that is, between Vransko and Prebold, and in the Trnavca watershed, forest occupied 37% of the area.

There have been minor changes in the field of forestry during the last hundred years (1896–1993). Forest area has increased by 5.4% over the whole area. Regional differences are also evident in this respect. Forest areas increased in four areas and decreased in two, (by –6.6% in the Motnišnica watershed, and –3.9% in the Trnavca watershed). The most intensive forestation and decline of farmland occurred in the Merinščica watershed where forest area increased by 20% and in the southern hilly hinterland of the Bolska watershed (+ 12.2%). There was an above average increase in forest area in the Bolska catchment area (7.3%), while there were no significant changes in the plains (+ 1%).

Among other things, these facts indicate that in the hill areas there has been a re-evaluation of agriculture, and as a result, a new fundamental relationship is being established between forest and farm areas. In this process, we encounter some of the fundamental constituent landscape factors which bring about new geomorphological processes in hilly areas. The quantity of loose slope material that will be dislodged or washed away and later deposited on the lower plains in the form of fans and other fluvial accumulation alluvia depends on the relief energy, the amount of precipitation, the general weather conditions, the rock composition of the surface, its solidity or compactness, etc.

During the last 100 years, forest area in the Bolska watershed has steadily increased. In 1896, forests occupied 56.1%; in 1953, 55.6%; in 1961, 57.5%; and in 1993, 59.5%. In other words, between 1896 and 1993, 563 hectares or 5.80 hectares per year was lost to agriculture due to forestation. The process of shrinking farm land during the hundred-year period, however, was not always and in all cases linear. During the first half of the 20th century (1896–1953) deforestation was still occurring in the Bolska watershed. New farming areas were created through forest clearing and burning, especially by clearing less dense forests. During this period, forest area decreased by 181 ha. or 3.17 ha. per year. Throughout the following period, however, abandoning farmland in favour of increasing forest area became established practice. In the forty-year period following the war (1953–1993) forest area increased by 743.64 ha. (7.2%). Forestation increased by an average of 18.59 ha. per year. The most intensive forestation occurred between 1953 and 1961 when the forest area increased by 360 ha. (3.5%), an average of 44.98 ha. per year. I am certain that such rapid changes in the use of agricultural and forest land do not reflect the actual state of affairs but are primarily the result of an up-dating of cadastral land documentation which was not in compliance with the actual physical situation. During the last thirty years, forest area has increased by 384 ha. (+ 3.6%) or by an average of 12 ha. per year.

TABLE 2: FORESTS IN 1993 AND THEIR PROPORTION BETWEEN 1896–1993.

Cadastral district	Total (in ha.)	Forest (in ha.)	Proportion of Forest (in %)			
			1896	1953	1961	1993
Trojane	784	498	60.1	58.5	62.2	63.5
Hrastnik/T.	520	302	52.8	53.2	55.6	58.1
Zaplanina	1045	814	67.6	69.4	75.7	77.9
Ločica/Vr.	1087	723	60.8	62.1	63.8	66.5
Špitalič	2984	1856	69.0	61.6	61.1	62.2
Motnik	375	237	57.2	58.8	58.8	63.2
Zg. Motnik	454	290	56.5	63.4	63.9	63.9
Jeronim	1401	951	53.1	53.0	66.0	67.9
Tešova	618	386	60.2	58.6	62.0	62.5
Vransko	307	117	36.2	37.1	37.4	38.1
Prekopa	840	430	50.8	51.3	51.3	51.2
Ojstriška vas	803	270	34.2	34.0	34.2	33.6
Črni Vrh	1391	904	62.3	62.8	62.8	65.0
Vrhe	228	118	50.4	43.8	51.7	51.8
Miklavž	1280	874	60.2	59.6	60.3	68.3
Marija Reka	1962	1458	63.0	68.7	69.5	74.3
Podvrh	997	551	56.3	54.2	54.0	55.3
Šmatevž	244	55	26.7	27.1	27.1	22.5
Gomilsko	230	4	1.1	1.3	1.3	1.7
Trnava	374	–	0.1	0.12	0.1	–
Grajska vas	310	114	31.0	32.1	32.1	36.8
Prebold	333	100	31.5	29.1	29.1	32.0
Total	18,567	11,052	56.1	55.6	57.5	59.5

The analysis of changes in the proportion of forest area in specific parts of the Bolska watershed (Table 3) certainly proves and points out the importance of the landscape factors which jointly determined the latest and oldest land uses in accordance with the prevailing social and economic trends and needs. In this case too, the landscape or spatial diversity of individual areas during particular periods was evident. The newer trends of the last forty years hastened the greening and forestation, particularly of the peripheral and hilly areas. Between 1953 and 1993, deforestation took place only in the Trnavca watershed, especially in the Podvrh and Šmatevž cadastral districts, where a Žovnek farming cooperative developed fields and pastures on forest land. Elsewhere, there is abundant evidence of the gradual abandonment of farmland in favour of increased forest area. During the period after the war, forest area increased most in the Merinščica and Podgrajščica watersheds where the forest area increased by 21%. Above average forestation covered parts of the Bolska catchment area (+ 9.4%) and the southern hilly edge (+ 8.7%). Details are presented in Table 3.

The most affected areas struck by the June storm have more than 60% of forest area. The forest proportion increases from the central part of the Bolska Valley toward the south and toward the northern edge of the Posavje Hills as well as toward the divide ridge between Velika (Čemšeniška) planina and Mount Mrzlica.

TABLE 3: CHANGES IN FOREST AREA IN SPECIFIC PARTS OF THE BOLSKA WATERSHED IN PERIODS BETWEEN 1896 AND 1993.

Area	1896–1993	1896–1953	1953–1961	1961–1993	1953–1993
Bolska Catchment					
A	160	–40	26	74	200
B	107.30	98.2	105.9	103.3	109.40
C	1.65	0.70	3.25	2.31	5.00
Motnišnica Watershed					
A	–169	–207	–11	49	38
B	93.40	91.90	99.50	102.10	101.60
C	–1.74	–3.63	–1.37	1.53	0.95
Bolska Valley (Vransko–Prebold)					
A	10.18	2.18	3.23	4.77	8.00
B	101.00	100.20	100.30	100.50	100.80
C	0.10	0.04	0.40	0.15	0.20
Southern Hills					
A	365	96	41	228	269
B	112.20	103.20	101.30	107.30	108.70
C	2.76	1.68	5.12	7.12	6.73
Merinščica Watershed					
A	211	–12	203	30	233
B	119.80	98.90	118.40	102.30	121.10
C	2.28	–0.21	25.37	0.94	5.82
Trnavca Watershed					
A	–24.42	–20.06	–2.00	–2.36	–4.36
B	96.10	96.80	99.70	99.60	99.30
C	–0.25	–0.35	–0.25	–0.07	–0.11
Total					
A	563	–180.88	259.87	383.77	743.64
B	105.40	98.30	103.50	103.60	107.20
C	5.80	–3.17	44.98	11.99	18.59

Note:
A = Difference in forest area in a particular period (in ha.)
B = Index of changes in forest area in a particular period;
C = Average annual increase (or decrease) in forest area in a particular period (in ha.).

At the same time, it is worth pointing out that the technology for felling trees and transporting wood from the forest has changed radically in the last decade. This is one of the important factors which contributed to the great amounts of loose and broken slope material. The motorized transport of wood from forests to the main roads requires appropriate forestry roads. These new forestry roads cross many of the forested slopes and have become the basic focal points for the erosion processes which are transforming the slopes. Their construction has destroyed or at least damaged the surface vegetation layer and root system and has exposed slope material which is slowly but surely sliding down the slopes. In short, thoughtless encroachments in the forests have triggered numerous and unpredictable natural phenomena and processes. This has affected the economy and previous rational human encroachments on the environment have been devalued.

2.5. Settlement and the Economic Situation

There are two fundamental types of settlement in the Bolska watershed: serried settlements dominate the plains and valleys, while isolated farms and groups of hamlets dominant in the hill areas. The larger serried settlements for the most part are situated on terraces rendering them safe from normal floods. It is only individual homes of newer origin, mostly of non-agricultural nature, which have been built in the flood areas or immediately next to them that have often been struck by rising torrential waters. Among these homes or their outbuildings are mainly those which exploited water power (e.g., millers, sawyers and blacksmiths).

Settlements in the hill world reflect the mutual and complex interweaving of natural, economic, and social realities and needs. The narrow bottoms of the valleys of the Bolska tributaries are also settled with dispersed homes. Among them, there are no large farms but rather the homes of rural non-agricultural tradesmen and cottagers and, lately, the homes of workers. Those farmers who moved their homes and settled in the narrow valleys looked for locations and built their dwellings away from the streams, in most cases on terrace shelves and fans which had never been directly threatened by flood waters. Settlement in the hill world is related to numerous natural and geographical factors. These include; exposure to sun, nearness of sources of drinking water, lesser or greater degree of slope, partly the quality of the rock composition which forms the basis for the type and structure of the soil, etc.

Settlement in the hilly Bolska watershed dates back to medieval times when economic trends to enlarge farmland and increase agricultural production dominated. The Bolska and Motnišnica valleys and their plain areas were already populated in Roman times. According to known sources, the majority of hill settlements between Trojane and Mrzlica were first mentioned only in the late Middle Ages. Ojstrica Castle, which was situated on a strategic elevation in the Ojstrica catchment area, was first mentioned in 1288. The Merinca hamlet in the Merinščica catchment area below the eastern foothills of the Menina planina plateau was mentioned in 1296. Ločica was mentioned in 1130, the period to which the origins of present Vransko may be traced (1123–1146). Loke, situated at the confluence of the Konjščica and Ojstrica, was first mentioned in 1365. Ojstriška vas is first mentioned in the Gornji Grad land register of the Benedictine monastery in 1426. In short, the plain settlements in the Bolska Valley are somewhat older than the hill hamlets, most of which are first mentioned only in the second half of the 15th century (Blaznik 1986, 1988).

The age of settlements or the beginning of the colonization of the Bolska watershed provide valuable and important sources for considering and understanding man's encroachments in space. Among other things, they provide explanations for many of man's encroachments on the landscape and their consequences which are still mirrored in the physiognomy of the landscape. The older the colonization, the sooner an equilibrium was achieved between man's encroachments and the laws of natural environmental processes. In the older cultural landscape, the ratios and relationships between individual landscape forming elements were established to such an extent that it is possible to talk of a "stable landscape." Man's encroachments in the environment were "consolidated" only after being adapted to many natural laws (e.g., cultivating fields in the direction of contour lines, arable terraces, regular annual grubbing up of cleared woodland, subduing rapids and torrents with weirs and dams, regulating streams, etc.). Every new encroachment in the environment that is not in harmony with previous conditions triggers new processes which cancel the current equilibrium between the elements and constituents of the environment. From every radical encroachment in the landscape a certain time period is necessary to reharmonize the laws of the natural landscape forming proceses.

2.5.1. Density of Settlement

In 1991, there was an average of 51 people/km^2 in the Bolska watershed. Most densely settled were the lower valley plain areas where there was an average between 103 (Trnava) and 653 (Prebold) people/km^2. The central plain areas of the Bolska Valley between Gomilsko and Vransko are relatively densely populated with 145 people/km^2 at Gomilsko and 242 people/km^2 at Vransko. We determined, however, that the density of population decreases from east to west. The exception in this respect is Vransko, an old borough where some services and infrastructure activities intended as well for the surrounding population have long been located.

The social and economic orientation and relief form of the area are important criteria in determining settlement density. In industrial Prebold and neighbouring Dolenja vas, the former borough of Vransko, and Motnik, there was an average of 307 people/km^2. There were 101 people/km^2 in the central part of the Bolska Valley (Grajska vas to Brode), 19.3 people/km^2 in the Motnišnica Valley, 32 people/km^2 in the upper Bolska catchment area, and 155 people/10 km^2 in the watershed of the right-hand tributaries of the Bolska which drain the hills between Mrzlica and Velika Planina. With 35 people/km^2, the area below Dobroveljska planota is less densely populated, while there is above average population density of 118 people/km^2 along the central and lower course of the Trnavca. The density of population decreases from the center of the Bolska Valley toward its hilly margin and in the watersheds of its tributaries. The further from the main road running through the Bolska Valley an area is situated, the less it is settled.

TABLE 4: NUMBER OF RESIDENTS, SETTLEMENT DENSITY, AND % OF FARM POPULATION BY CADASTRAL DISTRICTS OF THE BOLSKA WATERSHED IN 1991.

Cadastral district	No. of residents	Density of population /km^2	% farm population
Trojane	285	36.4	10.5
Hrastnik by Trojane	368	70.8	8.1
Zaplanina	165	15.8	22.4
Ločica by Vransko	275	25.3	34.2
Špitalič	336	11.3	23.8
Motnik	200	53.5	12.0
Zg. Motnik	200	44.1	24.5
Jeronim	388	27.7	30.1
Tešova	360	58.3	22.2
Vransko	743	242.0	4.3
Prekopa	550	65.5	18.9
Ojstriška vas	1037	129.1	13.4
Črni Vrh	321	23.1	32.1
Vrhe	50	21.9	14.0
Miklavž	157	12.3	37.6
Marija Reka	225	11.5	24.9
Podvrh	317	31.8	22.4
Šmatevž	314	121.7	10.8
Gomilsko	370	145.1	18.6
Trnava	286	102.5	20.6
Grajska vas	297	87.6	12.4
Prebold	2168	653.0	2.1
Total	9412	50.8	16.3

The most sparsely populated areas are in the Motnišnica watershed. There have never been favourable conditions for the development of a larger settlement in this narrow valley. Medieval transit traffic certainly accelerated and strengthened the economic existence and development of the two most important valley settlements (Motnik and Špitalič) which have recently lost their former status in the regional structure. There were 19 people/km^2 over the entire Motnišnica watershed. This is the lowest figure that we discovered in the Bolska watershed (details in Table 4. See also Urankar 1940). Population density figures, together with the forms of settlement, offer an important criteria in determining the number or proportion of vulnerable population in the event of weather disasters. All preventive and rescue measures in extensive and sparsely settled areas are less effective and considerably more expensive than in serried settlements and urban agglomerations.

2.5.2. Population Growth

The next aspect directly linked to changes in the landscape is population growth. On its numerical increase or decrease depend landscape forming elements which influence the economic, social, demographic, and general regional development. Differences in population growth are reflected in complex economic, social, psychological, and general development circumstances and trends.

During the last hundred years (1890–1991) the population of the Bolska watershed has decreased overall by 2%. With this, settlement density also decreased from 51.8 to 50.8 people/km^2. Between 1890 and 1953, the population decreased by 5.4%. During the postwar years (1953–1991), the population grew by 3.5%, and in the last thirty years (1961–1991) by 5.2%.

The more detailed analysis of the data presented in Table 5 showed that during the last hundred years, population doubled in industrial and commercial settlements (Prebold, Dolenja vas, and Vransko), there was noticeable stagnation in the central part of the Bolska Valley, and depopulation occurred in all the other parts of the Bolska watershed. The largest population decrease (–43%) occurred in the Motnišnica watershed, while population decreased by a fifth in the catchment area or upper reaches of the Bolska river. The most intensive level of emigration occurred in the hill settlements between Velika planina and Mrzlica (–53%). There was a population decrease of 11.4% in the settlements on the southern edge of the Dobrovelje planota plateau and an increase of 2.5% in the plain areas of the Trnavca watershed. An examination of the cadastral districts reveals that the population of Miklavž near Tabor in 1991 was 62.5% less that it was in 1890. At the last population census, settlements in the Zgornji Motnik and Marija Reka cadastral districts had 58% less population than a century ago (details in Table 5).

The decrease in population, especially in the hill areas, contributed to the emptying of extensive and very sensitive space. Depopulation led to a reduction of the agricultural labour force, which had formerly ensured the continued maintenance and development of the cultural landscape. The reduced population and to some extent its unfavourable age structure are the decisive factors which prevent the planned preservation and reorganization of settlement areas in the hill world. This is where we discover one of the important links between society (man) and the geographical environment. This also leads to the most varied types of degradation phenomena and devastation which, although legitimate consequences of natural processes in space, cause immense material damage to man and his activities which can never be fully remedied.

TABLE 5: POPULATION FIGURES IN THE BOLSKA WATERSHED BY CADASTRAL DISTRICTS BETWEEN 1890–1991.

Cadastral district	1890	1953	1961	1981	1991	Growth index 1991:1890
Trojane	284	297	276	271	285	100.3
Hrastnik/Trojane	370	353	303	327	368	99.4
Zaplanina	222	206	168	161	165	74.3
Ločica by Vransko	498	409	374	289	275	55.2
Špitalič	457	374	378	318	336	73.5
Motnik	361	281	267	237	200	55.4
Zg. Motnik	472	328	260	203	200	42.4
Jeronim	467	479	431	417	388	83.1
Tešova	377	322	338	350	360	95.5
Vransko	694	633	656	761	743	107.1
Prekopa	615	575	565	559	550	89.4
Ojstriška vas	884	910	932	921	1,037	117.3
Črni Vrh	592	503	438	347	321	54.2
Vrhe	58	70	61	57	50	86.2
Miklavž	419	352	305	194	157	37.5
Marija Reka	529	395	361	236	225	42.5
Podvrh	364	399	428	325	317	97.1
Šmatevž	266	295	346	284	314	118.0
Gomilsko	398	354	340	350	370	93.0
Trnava	265	250	242	280	286	107.9
Grajska vas	308	301	304	267	297	96.4
Prebold	707	1,005	1,172	1,864	2,168	306.6
Total	9,607	9,091	8,945	9,018	9,412	97.97

2.5.3. Farm Population

We are certain that through its work, production orientation, and general everyday style of life and work, the farm population above all is the fundamental factor which directly ensures the preservation and continuous reorganization of the cultural landscape. The proportion of farm population represents the potential work force which directly accounts for the existing agricultural production, and at the same time, for all the other modern needs and requirements in the reorganization of the living environment.

The settlements in the Bolska watershed have already been considerably deagrarianized: the proportion of farm population is 14.4%, still twice as much as the national average (7.6% in 1991). The highest farm population (30%) is found in southern hilly hinterland of the right-hand tributaries of the Bolska. It reaches 26.3% in the Merinščica and Podgrajščica watershed, 17.5% in the upper Bolska catchment area, and 17.9% in the Trnavca watershed. In 1991 the farm population in the central plains of the Bolska Valley accounted for only one-eighth of the total. The Ločica pri Vranskem, Črni Vrh, and Miklavž cadastral districts had approximately one-third farm populations while there was 20% or more in the Jeronim cadastral district (30.1%), 24.9% in Marija Reka, 24.5% in Zgornji Motnik, 23.8% in Špitalič, 22.4% in Podvrh, 22.4% in Zaplanina, 22.2% in Tešova, and 20.6% in the Trnava plain.

During the last thirty years (1961–1991), the farm population has fallen overall by 69%, most strongly in the Motnišnica watershed (–74%), in the settlements in the southern hills (–72%), in the Bolska Valley (–70%), and in the Trnavca watershed (–70%). The farm population has decreased by two-thirds in the upper Bolska watershed (to Ločica) and in the settlements along the Merinščica and Podgrajščica and their hinterlands. The number of farmers in Vrhe fell from fifty in 1961 to seven in 1991 (–86%). We have not come across such drastic decreases anywhere else in the Bolska watershed (details in Table 6). This decrease in the farm population may also be illustrated by the fact there were only fifty residents in Vrhe in 1991, the same number as had farmer status thirty years earlier (in 1961). This indicates the fundamental changes the hill world has undergone during the last postwar decades.

TABLE 6: FARM POPULATION IN THE BOLSKA WATERSHED BY CADASTRAL DISTRICTS BETWEEN 1961–1991.

Cadastral district	1961	1971	1981	1991	Index of change 1991:1961
Trojane	116	78	50	30	25.9
Hrastnik/Trojane	94	73	32	30	31.9
Zaplanina	110	63	37	37	33.6
Ločica by Vransko	226	184	127	94	41.6
Špitalič	291	183	110	80	27.5
Motnik	91	56	26	24	26.4
Zg. Motnik	206	154	87	49	23.8
Jeronim	302	222	134	117	38.7
Tešova	268	146	86	80	29.8
Vransko	142	103	42	32	22.5
Prekopa	323	217	124	104	32.2
Ojstriška vas	447	292	171	139	31.1
Črni Vrh	335	230	136	103	30.7
Vrhe	50	33	12	7	14.0
Miklavž	237	151	74	59	24.9
Marija Reka	170	109	47	56	32.9
Podvrh	261	166	98	71	27.2
Šmatevž	130	90	32	34	26.1
Gomilsko	184	141	76	69	37.5
Trnava	148	109	64	59	39.9
Grajska vas	179	98	51	37	20.7
Prebold	121	95	46	45	37.2
Total	4,431	2,993	1,662	1,356	30.6

Through its methods and forms of working the land, the farm population of the countryside still remains the active factor which, along with its homes, is concerned with the regular maintenance of the wider spectrum of the cultural landscape. The new technological advancements which were first adopted in the cultivation of land in the plains contributed to a fundamental reassessment of the productive potential of farmland. During this period, this led to the rapid overgrowing of former pastures and the steepest meadows and to the exceptionally fast greening of fields which have been turned into meadows. In the hill world as well, a major mechanization of farm production occurred. Despite the fact that farm machinery has partly been adapted to the uneven form and diversity of surfaces, it was necessary to plan and arrange suitable access (cart tracks, etc.) to fully exploit it and replace human labour. Agricultural land was redivided into a network of terraces for cultivation. These are the latest encroachments and measures to introduce variations in the network system of cart tracks on uniform slope areas. All of these cart tracks with their cuts in the slopes and excess material piled along the lower edge of the tracks present a real danger of triggering landslides. The tracks cut in the forests for the mechanized transport of wood are also fresh “wounds” in the slopes and are often the cause of landslides. In addition, the various forestry roads may be transformed into torrential stream beds during storms and rain. The high water excavates and deepens these opportune channels carries along them great amounts of eroded slope material and other debris. The recent mechanization of hill farming and forestry has triggered an extraordinary number of landslides. I am certain it will take some time before the shifting of slope material stabilizes.

2.5.4. **Economy**

There is a uniform economic structure in the Bolska watershed. The rare non-agricultural and other production industries are concentrated in just four valley settlements: Prebold, Šmatevž, Vransko, and Motnik. From these towns glows the magical and attractive force that has always drawn people from the rural areas by offering them work and income. The Bolska watershed is clearly a transit area as a result of the dense transit traffic network, and therefore this transit area between the Celje and Ljubljana Basins has always been within the gravitational pull of several employment centers. This is evident in the high number of daily commuters as well as in the continuous decrease in the proportion of farm population.

2.5.4.1. Agriculture

Agriculture is a branch of the economy which depends entirely on the use of local and natural production resources and goods. It is a branch whose production orientation depends on the natural assets and labour potential of the farms and occasionally on the other, already non-agricultural work force. The natural geographical and general economic circumstances have contributed to the strong commercialization and specialization of agricultural production in during the last three or four decades. In the plain and valley areas, cultivated crops, hopgrowing, and meat and dairy farming dominate. In the last ten years, hop has been moved from the fields in the peripheral parts of the hill world which are presently used for the modest production of hoed crops, especially fodder plants on which stock breeding depends. In the remote hill areas, farm households earn their main income from stock breeding and selling wood. Natural disasters, especially inundation with all its accompanying phenomena and consequences, affect valley and plain areas most. In all areas where floods and inundation are a constant factor in determining landscape formation, agricultural production and land use have been adapted to their whims and destructive capability. Meadows dominate the flood world along the lower reaches of the Motnišnica and along the Bolska between Ločica and Dolenja vas. During the last decade and a half following the regulation of the Bolska and Konjščica rivers, the former flood world has been turned into fields with monoculture crops and plantations.

2.5.4.2. Land Ownership Structure

In the light of natural disasters, the land ownership structure in affected agricultural areas is very important. It offers the most direct delineation of man's relationship to the land and its agricultural use. The overall relationship of the population to the environment depends directly on the land ownership structure of farms and their production orientation.

The land ownership structure reflects the historical, economic, and social development of a particular area. It includes the synthesis between the natural, social, and economic components of each individual region, determines the pulse of daily life, and directly reflects man's encroachment on the environment. A highly fragmented land ownership structure is typical of the Bolska watershed. In 1991, the average size of a farm was 9.62 hectares. of which cultivated areas accounted for 31.7% or 3.05 hectares. Between 1981 and 1991, the average size of farms increased by 7.4% (from 8.96 to 9.62 ha.), primarily due to increases in forest area and infertile land.

As a rule, average farm size increases from the center of the Bolska Valley toward the west as well as in the areas of all its tributaries. Farms average 4.80 hectares in the predominantly plain areas of the Bolska Valley and 13.54 hectares in its catchment area between Trojane and Ločica. Farms averaged 19.75 hectares in the Motnišnica watershed, 13.73 ha. in the hilly southern margin, 10.33 ha. in the Merinščica and Podgrajščica watershed, and 5.38 ha. in the Trnavca watershed. The average farm household in the industrial and former commercial centers owned 4.07 hectares. The smallest farms were in the Prebold cadastral district (3.11 ha.), in Vransko (3.42 ha.), and in Šmatevž (3.94 ha.), while the largest were in predominantly hilly areas of the Zgornji Motnik cadastral district (23.97 ha.), Marija Reka (17.02 ha.), Zaplanina (16.97 ha.), Vrhe (14.90 ha.), Ločica (14.69 ha.), Trojane (14.67 ha.), and Miklavž (14.26 ha.). Parallel with the growth in size of farm properties is a decrease in the proportion of agricultural land actually farmed. This proportion varies in cadastral districts between 20% (Motnik and Zaplanina) and 61% (Trnava) and in regional units between 22% (Motnišnica watershed) and 48% (in the central areas of the Bolska watershed and in the Trnavca watershed). (Details in Table 7).

TABLE 7: CHARACTERISTICS OF FARM HOUSEHOLDS IN THE BOLSKA WATERSHED BY CADASTRAL DISTRICTS (1981 AND 1991).

Cadastral district	1981 A	1981 B	1981 C	1981 D	1991 A	1991 B	1991 C	1991 D	Index E
Trojane	40	516	176	12.90	33	484	147	14.67	113.7
Hrastnik/T.	44	368	146	8.36	39	316	115	8.10	96.9
Zaplanina	31	548	161	17.68	30	509	105	16.97	96.0
Ločica	68	861	272	12.66	62	911	223	14.69	116.0
Špitalič	59	1,344	288	22.78	62	1,397	314	22.53	98.9
Motnik	49	375	103	7.65	32	299	59	9.34	122.1
Zg. Motnik	43	938	252	21.81	38	911	200	23.97	109.9
Jeronim	64	835	209	13.05	80	856	229	10.70	82.0
Tešova	64	555	197	8.67	51	497	174	9.74	112.3
Vransko	75	213	107	2.84	48	164	80	3.42	120.4
Prekopa	116	595	281	5.13	92	555	244	6.03	117.5
Ojstriška v.	149	762	384	5.11	140	683	303	4.88	95.5
ČrniVrh	78	836	260	10.72	68	740	271	10.88	101.5
Vrhe	10	187	70	18.70	10	149	49	14.90	79.7
Miklavž	44	577	203	13.11	39	556	174	14.26	108.8
Marija Reka	54	859	199	15.91	49	834	173	17.02	107.0
Podvrh	58	481	226	8.29	46	353	135	7.67	92.5
Šmatevž	44	198	94	4.50	48	189	90	3.94	87.6
Gomilsko	56	313	168	5.59	49	283	148	5.78	103.4
Trnava	63	245	168	3.89	54	255	156	4.72	121.3
Grajska v.	54	300	149	5.56	47	229	118	4.87	87.6
Prebold	88	205	102	2.33	65	202	103	3.11	133.5
Total	1,351	12,111	4,215	8.96	1.182	11,372	3,610	9.62	107.4

Note: A = Number of farm households, B = Total farm property in hectares, C = Area of cultivated land in hectares, D = Average size of farm property in hectares, E = Index of changes in average size of farm properties (1981 = 100.0)

The size of the properties owned is important for the following reasons: (a) the majority of local residents who own large farms work their own land. This means greater and regular care and maintenance of agricultural land. Particular attention is paid to maintenance, that is, the regular repair of damage caused to paths, cart tracks, forestry roads, bridges, drainage systems, arable terraces, etc.; (b) farms whose existence depends on producing crops for market devote more care and attention to economically efficient farming and the rational use of agricultural land; and (c) the mixed structure of agricultural production which increasingly relies on the optimum use of natural resources, economic possibilities and needs, and the characteristic of the hill areas of the Bolska watershed constantly monitors its own economic success and improves its economic adjustments and success by greening the fields and foresting previously agricultural land.

It appears that more attention has been paid recently to the preservation of the present cultural landscape. In order to achieve this, the local residents who earn their living from and live with the land and the environment play the foremost role and are the most competent. That is also the reason why we do not come across major or irrational encroachments on the environment in these areas. All unconsidered and thoughtless actions, although seemingly necessary and justified economic and infrastructure measures, open the possibility that with the first major weather disaster they will become fresh focal points, causes, and sources of damage to the cultural landscape and lead to the destruction of a considerable part of the fruit of man's labour (e.g., the construction of roads without drainage, bridges and culverts with inadequate water flow capacities, water supply lines as a rule laid along the shortest rather than best routes, the clearing of trees and brush from riverbanks, the acquisition of fertile land or building lots by filling in (narrowing) river channels, etc.).

3. Frequency of Storms in the Bolska Watershed

Floods and inundation are a common type of weather disaster in the Bolska watershed. The analysis of empirical data based on a collection of hydrological data shows that on average rising water overflowed the banks of river channels at least once every year while inundations occurred approximately every third year (Natek 1978, 50–51). Some years are an exception to the stated average when streams did not cause damage across the watershed world or when their destructive force occurred several times in a single year (e.g., three times in 1969 and twice in 1965 and 1968; Natek 1978, 51). The frequency of floods depends on storms which quickly fill the riverbeds with water and carried materials. The Bolska watershed is exceptionally prone to floods which occur in various seasons, most frequently in the winter months. The only months free of floods are between February and May. In all the other months, we may expect them with higher or lower probability (Natek 1978, 50). Floods and inundation posed a greater threat to settlements and farm land in the past before the thorough regulation of the Bolska river and its tributaries (the Konjščica and the Trnavca fed by the Trebnik). From historical records and chronicles, we may summarize the following interesting information and facts about floods in the Bolska watershed. The winter inundation of January 1799 in Grajska vas and the cold that immediately followed led to the freezing of all access and village roads, totally paralyzing ordinary life in the village. In less than four months between September 29, 1842, and January 17, 1843, the Bolska and the tributaries that join it along its lower course (e.g., the Konjščica fed by the Gozdnica and the Reka and the Trnavca fed by the Trebnik) overflowed their banks five times. The settlements of Zakl, Trnava, Šentrupert, most of Grajska vas, and part of Gomilsko were seriously affected (Kuret 1989, 255).

In 1848 inundation again struck the region along the Bolska, causing great damage in the Vransko area. Part of the settlement and especially the cultivated land was flooded by the Bolska, Merinščica, and Podgrajščica rivers (Orožen 1965, 388). A catastrophic inundation that covered the whole Lower Savinja Valley and especially the area along the Bolska occurred on September 8–9, 1926 (Orožen 1974, 384). Just a few years later, on September 22–23, 1933, a downpour once again caused devastation in the lower reaches of the Bolska leaving behind catastrophic havoc (Orožen 1974, 385–386). Parts of the Bolska watershed were also flooded during the period of catastrophic inundation that flooded Celje and the eastern part of the Savinja Valley in 1954. Although the Bolska Valley was at the edge of the disastrous storm, 54 liters of rain per square meter fell in Gomilsko on the night of June 4, 1954. This amounts to between 41% (1956–1971) and 55% (1927–1940) of the multiyear

average for June precipitation. At the same time, Žalec and Celje to the east of the Bolska Valley recorded 78.5 l/m^2 and 102.8 l/m^2 respectively (Melik et al. 1954, 27–28).
In the Bolska watershed, inundation has always been one of the natural geographical constants which together with the relief of the surface has formed the origins of a typical flood world. As a rule, recent settlement has avoided such areas. The use of land for agricultural purposes has also brought about its own solutions which have made an imprint on the physiognomy of the landscape.

Figure 2: Until now, most of the homes in Loke were safe from floods, but the June inundation did not spare them. Flood debris on the site of one of the flooded homes.
Slika 2: Doslej je bila večina domov v Lokah obvarovana pred poplavami. Junijska povodenj tudi njim ni prizanesla. Ostanki naplavine na selišču enega izmed poplavljenih domov.

Larger and more extensive inundations with powerful destructive processes whose effects transformed the existing appearance of the geographical environment have occurred in the Bolska watershed in the last decades of this century. The Bolska watershed, particularly the Konjščica Valley above Loke, was severely affected by a storm in 1958 (Jordan 1987). In 1978, a violent wind tore the roof off the Goropevšek residence in Črni Vrh. A great deal of damage, which has still not been fully repaired, was caused by the inundation on November 1, 1990. The rainfall followed by inundation on October 29–30, 1992, also left visible marks in the landscape (Natek 1993). The worst year, however, was 1994 when inundation and floods ravaged the Bolska watershed seven times. The catastrophic hailstorm on the night of June 28, 1994, did the most damage. A good week later (July 6–7, 1994), the streams again overflowed their clogged beds and ruined most of the initial clean-up efforts. On August 24, 1994, an afternoon storm once again filled the riverbeds which had become too narrow for the swollen waters. There were more floods on the 4th and 28th of October and on November 10, 1994. A less severe flood occurred in the Bolska watershed on December 31, 1994, caused by a sudden thaw and the rapid melting of a more than half meter deep layer of snow together with strong rainfall (December 30, 1994). Some houses were affected (Pondor, Kapla), but the greatest damage was caused to the partly renewed stream beds.

4. Geographical Effects of the Storm of June 28, 1994

The landscape (spatial) effects of the numerous storms of the last decade in the Bolska watershed were never completely eliminated. The effects of water damage are most drastically and markedly impressed on the landscape physiognomy of the hill world, which is sparsely populated and has strong relief energy. The spatial effects of storms became more evident and more permanently marked in five landscape areas:

a) Storms almost completely transformed riverbeds and their corresponding flood plains.
b) Extensive areas were flooded on plains where the riverbeds have low gradients. Flood waters affected agricultural crops, reducing or generally depreciating their market value.
c) Inundation flooded numerous homes damaging a considerable part of the housing fund together with its movable and installed furnishings and equipment.
d) Due to numerous and frequent inundation, enormous material damage was caused to the whole infrastructure system, especially to the road network, river and stream crossings (bridges, footbridges, culverts, etc.), water supply, and so forth.
e) The most visible effects of the countless storms are in the upper reaches of streams, especially on the slopes with cultivated surfaces.

4.1. Damage Caused by Weather on June 28, 1994

Tuesday, June 28, 1994, was a hot and sultry summer day. Two independent thunderstorm areas developed over northwestern and southeastern Slovenia, bringing with them fifty liters of rainfall per square meter. In the evening between 21:30 and 22:00, a powerful thundercloud formed in a remarkably short time period (approximately 20 minutes) above the western Zasavje region and the southwestern part of the Celje basin centered between Velika (Čemšeniška) Planina (1,204 m), Mount Kisovec (1029 m), and Mount Javor (1133 m). The ensuing rain accompanied by hail and strong winds lasted almost two hours (from 22:00 until 23:45). During this time more than 100 l/m^2 of rain fell. In seventy minutes, 90 l/m^2 of rain fell on the southern slopes of Velika (Čemšeniška) Planina (M. R. Kovač).

In the northern part of the Posavje Hills, this storm most affected the watersheds of two of the Bolska's tributaries, the Zaplaninščica and the Konjščica. The Bolska Valley and its central plains were flooded once again.

The most powerful storm with catastrophic effects and consequences to the landscape was limited to a narrow part of the Bolska watershed. To the south, it extended to the divide ridges between Trojane, Velika Planina, and Mrzlica (from where it continued south toward the Kotredeščica and Trboveljščica watersheds), and to the north to a line between Vransko and Dolenja vas (Prebold). Its eastern border of the most drastic devastation extended from Štrbenkel (869 m) to Grajska vas, while its western border stretched from Trojane (Šentgotard) to Medvedov hrib (1044 m) above Zgornji Motnik. In this area, which is almost rectangular in shape (6 × 12 km) and occupies about 72 km^2 or 38% of the Bolska watershed, different areas were identified according to the level of damage caused. The most affected areas were:

a) the Konjščica watershed;
b) the watershed of the entire course of the Zaplaninščica;
c) the southern sunny slopes of the central and eastern part of Jasovnik (765 m), especially around the hamlet of Osredek;
d) the hilly watershed world between the Motnišnica and Merinščica where tremendous damage was caused to farm land, especially at Brce and Jakov Dol, and to the slopes of the Zgornji Motnik and Bela hills, which were on the edge of the storm.

A detailed examination revealed that particular parts within these areas were affected by the storm water damage only in passing. This applies mainly to sections of the northern slopes of Velika

(Čemšeniška) Planina, particularly between Prvine and Presedlje, and the Mejašca and Merinščica valleys as well as the whole watershed of the Gozdnica, a right-hand tributary of the Konjščica. In short, the most significant rainfall with the most potent surface consequences affected the southern sunny slopes devoted to the widest variety of agricultural uses. For this very reason, these slopes are subject to constant human encroachment and technological alteration and adaptation to new methods of land cultivation, and the most distinctive and most effective devastating processes occurred here. Their effects are manifest in the erosion gullies, bare and stripped soil, landslides, washed out and furrowed roads and cart tracks, fallen trees, rubble and rock alluvia on cultivated land, etc.

4.2. Inundation and Extent of Floods

It is not always possible to accurately assess flood areas. We can assess their extent and area most accurately in wider valleys and plains, it is much more difficult in the hill world (water flows down slopes and the traces of such "floods" are in the form of either erosion gullies or alluvium). All the data confirms that the June inundation in the Bolska watershed was one of the most extensive and can not be compared with the water disasters of September 1926 and November 1990. Last year's inundation also flooded the entire (former) flood plain between Vransko and Prebold. The only excep-

Figure 3: Water carried copious amounts of rough material to the Zaplaninščica Valley along an erosion gully running from below Kozica (978 m). This material clogged the plain and slowed the rapid flow of the swollen Zaplaninščica. The Kovač family, whose home is located on a fan, employed primitive measures to reduce the destructive effects of the torrent.
Slika 3: Tudi po erozijskem žlebu, ki prihaja izpod Kozice (970 m), je prinesla voda v dolino Zaplaninščice obilo grobega materiala, s katerim je zatrpala ravnino in zajezila hitrejši odtok narasli Zaplaninščici. Kovačevi, katerih dom stoji na vršaju, so s preprostimi napravami zmanjšali razdiralni učinek hudournika.

Figure 4: The June storm completely cut the road to Zaplanina. Near the Kovač home the Zaplaninščica dug itself a new riverbed in the asphalt road surface and filled the old one with alluvium. It carried away a section of a field belonging to Kovač measuring 80 to 100 m in length and 3 to 6 m in width.
Slika 4: Cesto v Zaplanino je junijsko neurje popolnoma razdejalo. Pri Kovaču si je izkopala Zaplaninščica na utrjeni asfaltirani cesti novo strugo, staro pa zasula z nanosom. Odnesla je del Kovačeve njive v dolžini 80 do 100 m in v širini 3 do 6 m.

tion was the stretch of the Bolska between Brode and Prekopa or Pondor where the riverbed is deep, carved into its own alluvium and in some places where its bottom is carved into the marly sea clay (Rihteršič 1960, 84).

All the tributaries of the Bolska overflowed their banks. Even the regulated parts of the Bolska riverbed and its tributaries were unable to accept, retain, and drain off the extremely increased amounts of water. The swollen waters of torrents and all the other tributaries exceeded their dry season minimum flow by more than 100 times. The plain between Gomilsko and Zakl all the way to Kaplja vas was a single flood lake. Below the Ljubljana–Celje highway near Grajska vas, the swollen and flooding Bolska was joined by the also extremely swollen Konjščica, and together they flooded the fields and meadows on both sides of the river. The Trnavca too, reached at Zakl by the Bolska flood waters, overflowed its banks in its lower stretch and, together with the Bolska, literally swamped the peripheral areas of Kaplja vas. The torrential stream beds of Dolgi and Globaški graben with sources on the northwestern slopes of Žvajga (626 m) flooded the yard of the Prebold textile factory. The regulated stretch of the Bolska in the Dolenja vas area was just able to allow the flow of the high water; below the village it flooded the hop fields in the "parish fields," the Žgankovo sawmill, and the meadows at Lapurje. Luckily, the Savinja did not have a high water level at the moment and was therefore able to cope with the discharge from the Bolska. The Merinščica and Podgrajščica rivers at the northern edge of the affected area both overflowed their banks. They caused most damage to fields and meadows which they filled with gravel, while mud, river sand and other eroded and carried detritus was deposited along their lower stretches. The Motnišnica and its tributaries also swelled, overflowing and eroding their banks. The most extensive flooding occurred in the lower stretch of the Motnišnica between the hamlet of Bistrica and its mouth into the Bolska near Ločica. In this area

Figure 5: There is a large confluence at Ločica where the Bolska is joined by the Zaplaninščica, Smečka, Kotnica, and Motnišnica rivers. During the last five years, inundation has regularly affected the area between the mouth of the Zaplaninščica and the Smečka. The June inundation left visible marks in the area: the stone, sand, and mud alluvium, which was as thick as 55 cm in places, destroyed the crops.
Slika 5: Na Ločici pri Vranskem je velika sovodenj: na tem območju dobiva Bolska Zaplaninščico, Smečko, Kotnico in Motnišnico. V zadnjih petih letih so povodnji redno prizadele svet med ustjem Zaplaninščice in Smečke. Junijska povodenj je zapustila na tem območju svoje vidne sledove: kamnito – peščeni in blatni nanos, ki je bil do 55 cm visok, je uničil kmetjske pridelke.

where the gradient of the Motnišnica is about 10%, the water mainly flooded meadows, fields, and the buildings of the former Španov sawmill in Ločica.
It is difficult to talk about floods in the valley of the upper reaches of the Bolska above Ločica and along all its right-hand tributaries. The specific form of valleys which have no true or wider flood plains prevent high waters from spreading onto areas along the streams. The relief characteristics of small valleys in which there is only room for the riverbed itself, a cart tracks or road, and only here and there a narrow grass belt allows the presence of high waters to observed only through a marked increased in the water level. Due to the steep gradient, the destructive force and carrying capacity of streams is exceptionally strong, especially at times of increased water flow. This was also the case during last year's summer storms. The most obvious examples of the indicated characteristics of the causes and effects of inundation were exemplified in this year's inundation in the Zaplaninščica, Kučnica, and Konjščica watersheds. All three are right-hand tributaries of the Bolska in its upper (Zaplaninščica), middle (Kučnica), and lower (Konjščica) stretches.
The Zaplaninščica watershed drains the northwestern slopes of Velika (Čemšeniška) Planina and the range of hills that rises immediately above the narrow Bolska Valley. Most of its watershed is spread over an area composed of impermeable Paleozoic rock (slate, marl, schist, breccia, etc.). This contributes to the greater flow of rainwater. In addition, it is necessary to consider the fact that there are numerous strong springs in this area which contribute considerably to the creation of numerous patches of swampland in parts of the upper Zaplanina region. The stream beds of all the catchment area branches of the Zaplaninščica which spread out in fan-shaped form and dissect the slopes

Figure 6: The Zaplaninščica just above its mouth on the Bolska near Ločica. The riverbed that had been clogged with alluvium and presented a threat to the road to Zaplanina was cleared with a dredger.
Slika 6: Zaplaninščica tik nad izlivom v Bolsko pri Ločici pri Vranskem. Strugo, ki je bila zatrpana z vodnim nanosom in je ogrožala cesto v Zaplanino, so očistili z bagrom.

have the high gradients characteristic of torrents (76‰ to 130‰). The lower course of the Zaplaninščica is much less turbulent but still stronger than average (with a 26.4‰ gradient).

The June (and subsequent) storms created numerous new erosion gullies and channels in the upper Zaplaninščica watershed. All the material collected and deposited in the riverbeds was carried away by the water, and everything that slid down the slopes and banks was immediately swept away as well. All previous accumulation that had been covering the bottom of riverbeds was removed and the water made new and deeper channels in the riverbeds. The inundation cleared all the streams of previous accumulations and enormous amounts of unsorted material were swept along and deposited in the lower stretches of the streams as well as beside them. It was evident that the gradient played a decisive role in this disastrous process.

Below the confluence of the catchment area branches of the Zaplaninščica from Dobršek downwards (a distance of 2350 m), its narrow valley was literally crammed with flood material. The deposited material did not come just along the riverbed but also from several other torrential ravines and erosion gullies which indent and divide the slopes on both sides of the valley in fan and funnel shapes. The Zaplaninščica riverbed and all the area along its banks were filled with torrential alluvium, and the Zaplaninščica therefore dug itself a temporary new channel across the asphalt road along its right bank. On removing the asphalt layer, which was deposited in large chunks on a terrace shelf some two meters higher than the level of the road, the swift flowing water carved a torrential riverbed in the road that was one meter deep or more. It tore away a considerable part of Kovač's field that was on the fan or terrace, at least 80 m × 3 to 5 m and 1 to 2 m in depth, or around 540 m^3 of soil. Along with the stony debris washed down by the torrential water, the numerous landslides, undercut and torn banks, and undercut riverside trees and brush added to the flood material carried along by the inundation, most of which was deposited in the Bolska Valley below Ločica. During the storm, the Zaplaninščica created new conditions and relationships between the main landscape forming elements

Figure 7: The remains of a »bridge« to Vrhovec (Črni Vrh) in the catchment area of the Kučnica. Erosion deepened the riverbed of the Ravljanski stream by more than a meter, widening it at the same time and washing away the cart track connecting the farm with valley.
Slika 7: Ostanek »mosta« k Vrhovcu (Črni Vrh), v povirju Kučnice. Erozija je poglobila strugo Ravljanskega potoka za več kot 1 m, obenem pa jo je tudi razširila in s tem odnesla kolovoz, ki je povezoval kmetijo z dolino.

along its lower reaches. Its riverbed was totally destroyed. Through numerous landslides, the slopes directly along its banks have changed their former role and the appearance of the landscape system. Another catastrophically affected and devastated area was in the upper half of the valley of the Kučnica River that flows into the Bolska between Pondor and Kapla. The storm with all the accompanying phenomena and processes most affected the Kučnica Valley above Tabor. From the catchment area ravines, which are of torrential nature (Vrhovčev Graben 104‰ and Ravljanski Graben 78‰), huge amounts of slope and other eroded material were carried away and deposited mostly in the Dol area (near the hamlet of Črni Vrh) where the stream riverbed has a lower gradient (17‰). The road to Dol running along the left bank of the Kučnica and the field which occupies its lower flats were thickly covered with flood material. All the crossings (bridges and footbridges) over the stream were either destroyed, swept away, or undercut. The Kučnica riverbed was clogged with sand, stone, and muddy flood material. In its lower reaches below Tabor, the Kučnica also flooded the area along the stream and destroyed all the wooden and older bridges. Just above, it flooded the Žagar home (Pondor 25) that is situated on the flood area between the Bolska and Kučnica rivers.
The Konjščica, a tributary of the Bolska in its lower reaches, caused most of the damage in its catchment area and middle section, that is, to Ojstriška vas. It is characteristic of its watershed that its eastern catchment area has an inverse current, that is, its catchment area branches are oriented far toward the east and collect water from the east to the northwest. For this reason the amount of water flowing along the Konjščica riverbed is extraordinarily large, certainly larger than the quantities in streams with normally developed river networks. The Konjščica watershed is exceptionally diverse from the

Figure 8: The inundation left behind real devastation. The cleared Konjščica riverbed between Tabor and Loke is once again performing its previous function.
Slika 8: Povodenj je zapustila pravo razdejanje. Očiščena struga Konjščice (med Taborom in Lokami) spet opravlja svojo nekdanjo funkcijo.

natural and geographical point of view as well. All its catchment area branches have distinct and unique landscape characteristics, and therefore each particular area was influenced by different landscape transformation processes during the June and subsequent storms.
From the view point of water-caused disasters, the catchment area of the Konjščica can be presented and treated at least in three characteristic parts. The greatest devastation occurred in (a) the upper and (b) the lower reaches of the Konjščica and (c) at its transition into the lower flatland regulated section of its course. The wider area around Loke at the confluence of the catchment area branches of the Konjščica was struck by a flood more severe than had ever been previously experienced. With regard to landscape transformation processes, the catchment areas of the Konjščica, Tesnica, and Ojstrica which form the upper part of the Konjščica watershed were most affected. The Konjščica Valley was clogged with very diverse flood debris. The forestry road which runs for the most part along the right bank of the stream was covered by a layer of material more than a meter thick. This part of the Konjščica riverbed was clogged by alluvia deposited by torrents or by material carried by water down erosion gullies and from numerous landslides. In the upper part of the Konjščica, the effects of this natural disaster were concentrated in a narrow valley and its torrential tributaries. These characteristically have relatively high gradients (e.g., Konjščica 141‰, Medvedov Graben 118‰, Vetrškov Graben 182‰, Letejev Graben 133‰, compared to the area between Medved and Loke where the Konjščica has a 37‰ gradient). In its upper reaches, the Konjščica riverbed was literally ruined, filled with completely destroyed banks as the torrential water dug new channels in several places.

Figure 9: With its rapid current, the inundation destroyed a bean plantation in a former hop field (Loke).
Slika 9: Povodenj je s svojim deročim tokom uničila tudi fižolov nasad v nekdanjem hmeljišču (Loke)

Figure 10: The Sušica, which is normally only filled during rain, deposited stones and gravel on Erjavec's meadow. The meadow surface was furrowed by numerous erosion ditches and gullies (Črni Vrh).
Slika 10: Sušica, ki jo napolni samo deževnica, je odložila na Erjavčev travnik kamenje in drobir. Travniško površino pa je razbrazdala s številnimi erozijskimi jarki in žlebovi (Črni Vrh).

Figure 11: At Loke only a few pilings remained of the village bridge that connected the fields on either side of the torrential Konjščica. In this area, too, the stream »uncontrollably« widened its riverbed and damaged agricultural land.
Slika 11: Loke pri Taboru: od nekdanjega vaškega mosta, ki je povezoval polja na obeh straneh hudourniške Konjščice, so ostali le nekateri nosilni stebri. Tudi na tem kraju si je potok »nekontrolirano« razširil svojo strugo, in sicer v škodo kmetijskega zemljišča.

The Tesen stream, a right-hand tributary of the Ojstrica rising behind Krvavica (909 m), covered a meadow along its lower reaches where its riverbed gradient suddenly decreases. Due to various obstacles in the riverbed, the swift water dug a channel in the middle of the meadow where it accumulated. The erosion gully was a meter deep in places.

The Ojstrica is a third catchment area branch that joins the Konjščica at Loke. Its upper section is the Kozica which rises below Presedlje (740 m) and has all the characteristics of a torrent (91‰). Its source was under the center of the worst part of the storm and therefore the effects of the ravaging waters were correspondingly severe. These effects are most clearly marked in the area where the stream flows out of the forest into cultivated farm land. The Pavšarjev Graben torrent also contributed considerably to the havoc and destruction of the agricultural area. Along with the rock alluvia which thickly filled the Kozica riverbed, landslides as well contributed to the damming of the water current. The flood covered two homesteads in Črni Vrh located on the flood plain with a thick layer of flood material.

The Konjščica and Ojstrica confluence at Loke contributed to flooding of unprecedented extent in the central part of Loke itself. The homes in Loke are situated on the edge of the Konjščica fan which turns its riverbed toward the north. Between Loke and the houses in Tabor, the flood destroyed crops, homes, and other production equipment. Along with the homes and agricultural land between the left bank of the Konjščica and the Tabor–Ojstriška vas road, the northern part of the cemetery with the mortuary was also flooded. A large part of Ojstrica vas was also flooded and covered with flood debris. The depth of inundation was more than one meter in some yards. The flood filled all the cellars, demolished part of a stable, washed away stacks of timber and firewood and everything else stored in the yards. The reasons for the catastrophic destruction from the flooding and the immeasurable quantities of flood debris may be seen primarily in the sudden reduction in the gradient of the river channel (from 37‰ to 11‰ and 7‰) as well as in the lack of respect for natural and geographical

Figure 12: The swollen Konjščica covered the Ropret orchard in Loke with a thick layer of flood material (20 to 55 cm), which was removed soon after the inundation.
Slika 12: Ropretov sadovnjak v Lokah pri Taboru je narasla Konjščica prekrila z debelo plastjo naplavine (20 do 55 cm), ki so jo odstranili kmalu po povodnji.

laws. In the most affected area, people built their settlements on flood plains, constructed bridges with very small arches, built access roads, cart tracks, and paths across the valley on dikes, and so forth. Some buildings were erected directly on the banks of the river. The regulated Konjščica riverbed between Ojstriška vas and Grajska vas was generally able to cope with all the increased amounts of water. More damage was caused in Grajska vas just above the mouth into the Bolska. Also contributing to the flooding in Grajska vas was the greatly increased water level of the Reka River which rises between Škrabarjev Vrh (850 m) and Reška Planina (925 m), the area on the eastern edge of the most intense rainfall.

In the watershed of the Reka which drains the hilly Marija Reka area between Mrzlica (1122 m) and Štrbenkel (869 m), the June storm left no major damage on the landscape. The greatest destruction and damage occurred in the catchment area branches of the (Velika) Reka. At many points, the riverbeds were clogged with alluvia, banks of streams were destroyed and washed away, and sections of the cart tracks and roads running immediately along the torrential streams were either destroyed or washed away.

The effects of inundation in the region were varied. Among the most affected were all the stream and river beds in the area struck by the storm. Apart from the destruction of the banks of all the Bolska and Motnišnica tributaries, their channels were also thickly filled with inundation alluvia. Numerous river engineering objects were either damaged or destroyed, including the stone-faced banks of regulated streams, weirs, dams, dikes, etc. The Bolska riverbed suffered considerable damage all along its course from Trojane to its mouth at the Savinja. In the stream beds, all previous gravel deposits increased in size or new ones formed leading to a reduction in the flow capability of the streams. The inundation caused a lot of damage in the flooded settlements, destroying or at least damaging homes and farms and agricultural and industrial production equipment. The spilled heating oil, washed away fertilizer, and the flooding of manure pits and cesspools contributed to environmental pollu-

Figure 13: Dried mud as the remains of flood material. The farmers removed most of the mud deposits from their fields and meadows.
Slika 13: Izsušeno blato kot ostanek poplavne naplavine. Večino blatnega nanosa so kmetje odstranili s svojih polj in travnikov.

tion not only in the immediately affected area but far beyond its boundaries. The inundation washed away wooden sheds, destroyed or washed away bridges, damaged and flooded the basements of farmhouses, and above all, soaked the foundations of houses leaving visible lines on the facades of buildings revealing the of the height of the flooding.

The closure of the Ljubljana–Celje highway to traffic between Trojane and Ločica due to landslides which blocked the road was among the external features of the natural disaster. At Kapla, the Bolska flooded 150 meters of the road.

In this area, the inundation destroyed nine kilometers of the local roads, 28 kilometers of the local roads were impassable, and 34 bridges were destroyed. The inundation covered over 1200 hectares of agricultural land and flooded 176 buildings. Of these, 109 were farm buildings and 67 were houses. The damage caused by the erosive action of the storm as the swollen waters tore and washed banks away, furrowed arable land, washed topsoil off the fields and meadows, and deposited great quantities of mud which destroyed crops in the affected fields, meadows, gardens, etc., in the lower sections of valleys is immeasurable and will never be fully assessed.

4.3. Landslides

The abundant rainfall, the inclination of slopes, and the rock and geological composition of the bedrock or surface are among the main causes of the movement and slipping of soil down the slopes. As mentioned in the introduction, most of the Bolska watershed struck by the weather disaster is composed of Paleozoic and Mesozoic slate, marl, sandstone, and Oligocene basal conglomerate containing deposits of sandstone, marl, and clay (geological map, scale 1 : 100,000, Ljubljana and Celje chart). Landslides in the Bolska watershed were concentrated in six main areas:

a) above Motnik in the north, in the catchment area of the Globovščica where the hamlets of Koprivnica and Srobotno are located;

Figure: 14: The Bolska River near Vransko. Every year storms and inundation wreak havoc to the Bolska riverbed. From year to year, larger gravel deposits form at Brode where the river turns northward in a sharp bend.
Slika 14: Bolska pri Vranskem. Strugo Bolske prizadenejo in uničujejo vsakoletna neurja in povodnji. Pri Brodeh, kjer se njen tok v ostrem kolenu preusmeri proti severu, nastaja iz leta v leto večje prodišče.

Figure 15: The meadows along the Konjščica were devastated by sand and clay flood material. A view of a layer of flood material, 30 to 50 cm thick, deposited south of Loke settlement.
Slika 15: S peščeno – glinasto naplavino so bili opustošeni travniki ob Konjščici. Pogled na plast nasutine, ki je debela od 30 do 50 cm, in je bila odložena južno od naselja Loke.

b) in the Brce area between Ločica and Jakov Del where there is abundance of various types of Triassic slate and sandstone together with pseudo-Zilje layers;
c) on the southern and southeastern slopes of Jasovnik (765 m), centered in the western part of the Osredek hamlet;
d) in the upper part of Zaplanina and below Limovce at the border between Paleozoic and Mesozoic sandstone and slate;
e) a very extensive landslide area was created in the Črni Vrh and Zahomca area, that is. in the catchment area of the Kučnica and Ojstrica rivers where Cretaceous and Jurassic clay slate, marl, sandstone, breccia, and conglomerate dominate;
f) numerous landslides occurred on the northern slopes which rise above the Konjščica Valley toward the Kisovec (1029 m) and Javor (1133 m) peaks. Elsewhere, there were isolated landslides which did not cover wider areas.

In addition to the areas mentioned above where landslides contributed notably to the transformation of the existing surface, they also occurred in individual cases in numerous other areas. Mapping and surveys have revealed that in the study area, the loosening of soil which triggers landslides is an old form of transforming the surface and slopes. This is evident on cultivated land which has unusually furrowed and wrinkled slopes. The long-term agricultural use of land for various purposes has wiped out most of the recognizable and principal traces which could warn of the phenomena and provide reasons for the transformation of slope surfaces. At the same time we realize that an unusually large number of new landslides which caused immeasurable material damage were triggered.

The landslides not only contributed to the large quantities of slope material which the swollen streams carried down their riverbeds but also transformed the surface of the hill world and depreciated the agricultural land and its use. Although the landslides covered a very wide area, it can be observed that they were more numerous in particular areas. Wherever they were concentrated on an individual farm, they threatened its very existence. The research revealed that there were ten to fifteen farms were most badly struck by landslides. In Črni Vrh, the Goropevšek and Križnik farms suffered the greatest damage. The former has approximately seventeen hectares of land, more than half of which is covered by forest. There were nineteen larger and smaller landslides on the Goropevšek farm, nine of them in the forest. The landslides and slide material resulted in one quarter of the farm property being cut off from the normal rhythm and method of farming. The Križnik farm in Črni Vrh also suffered immeasurable damage due to landslides. The June landslides left the lower and steepest part of the Križnik farm on which was overgrown with grass and planted with fruit trees completely bare.

A series of landslides were triggered on southern and southeastern slopes that prevent us from collecting detailed identification data for the individual landslides and their slide material. The landslides furrowed the dry valley systems and the eastern and southeastern slopes of Črni Vrh (715 m) where the most cultivated farmland is located. Most of the landslides were triggered above the course of the new road running across the slope in the central part of the settlement at an altitude ranging between 620 and 660 meters. For more than three weeks, the road remained covered with slide material which was trucked down to the valley where the water had washed soil from gardens and fields.

Agricultural land in the upper part of Zaplanina was affected by smaller landslides. Most occurred on surfaces composed of Paleozoic sandstone and slate, and considerably fewer in areas where flint conglomerate and Permian slate and sandstone dominate. A similar rock structure is characteristic at Limovce where smaller landslides occurred. Most of these destroyed grassy surfaces.

Numerous landslides also threatened the Ljubljana–Celje highway. Most were triggered in the Osredek area. Here, the Kolar farm was most affected, suffering at least fifteen landslides. A few smaller landslides which filled torrential riverbeds were triggered in upper Zajasovnik. Some reached and covered the highway with their material. Smaller landslide areas on agricultural land occurred in the catchment area of the Globovščica torrent below the slopes of Srebotnik (968 m). The majority of these were triggered at the dams of arable terraces and were therefore not too extensive in size. Similar and related landslides occurred in the hilly area above the left bank of the Motnišnica.

Larger landslides were triggered in the hills above the left bank of the Konjščica, especially in the areas of the watersheds of its torrential tributaries. The highest number of landslides was recorded in the area between Brložen (851 m) and Javor (1133 m) where Cretaceous clay slate, calcarenite, and limestone breccia and Triassic limestone, dolomite, marl, and slate dominate with isolated patches of

Figure 16: The lower slopes of the Križnik farm (Ojstrica below Črni Vrh) were furrowed and left bare by numerous landslides.
Slika 16: Spodnja pobočja Križnikovega hriba (Ojstrica pod Črnim Vrhom) so razorali in ogolili številni zemeljski plazovi in usadi.

Paleozoic clay slate and flint sandstone, etc., in between. Most of the landslides in this area have a narrow and elongated shape. Numerous landslides occurred on gently sloping cultivated surfaces, triggered at the upper edge of the arable terraces.

The landslides caused by the June storm fundamentally transformed the appearance and form of the slope world in many places. On the basis of mapping, around 450 movements or slips of upper surface layers formed of thinner or thicker layers of soil were identified. The most numerous affected the appearance of the cultural landscape in the areas of Črni Vrh (78 landslides), Zaplanina (76), Brce (39), Srobotno (33), Zajasovnik (41), Limovce (23), and the area between Dol and Zahomce (46). The June storm caused more than twenty slips of slope surface around the hamlets of Ravne (20) and Osredek (28). Less numerous landslides furrowed and destroyed slopes around Sv. Lenart (Vrhe with 13 slides), in the undulating areas between the upper reaches of the Konjščica and Vrhe (13), in Limovce(23), etc. The density or number of landslides and other forms of land slippage per unit of area varied greatly. Relying on the basic existing coordinate system or network drawn on the topographic map in 1 : 25,000 scale, we get the following picture. The largest number of slides of slope turf or upper slope layers per km^2 (100 hectares.) occurred in the Brce hamlet (30 cases), on the Goropovšek farm in Črni Vrh (29), around the Arhi hamlet in Zaplanina (28), in Zajasovnik at the Osredek hamlet and in the central crowded area of Črni Vrh (26), on the Pavšar farm (23), in the area of the Srobotno hamlet (22), in the catchment area of the Globovščica above Motnik, in Presedlje (17), etc. In this region which measures 9 km^2 in size, we recorded 225 landslides or half the total number. Considering that the average size of a landslide is at least 200 m^2 to 300 m^2, we reach surprising conclusions. In the areas mentioned above where the greatest number of landslides occurred, the slides covered 5.63 hectares according to our calculations. If we add an equal amount of surface where the slide material accumulated, we get at least 11.3 hectares of destroyed land. On the basis of established quantities and calculations, we discover that between 1% and 2% of agricultural land was either destroyed or at least temporarily excluded from agricultural production due to landslides in the nine most affected areas.

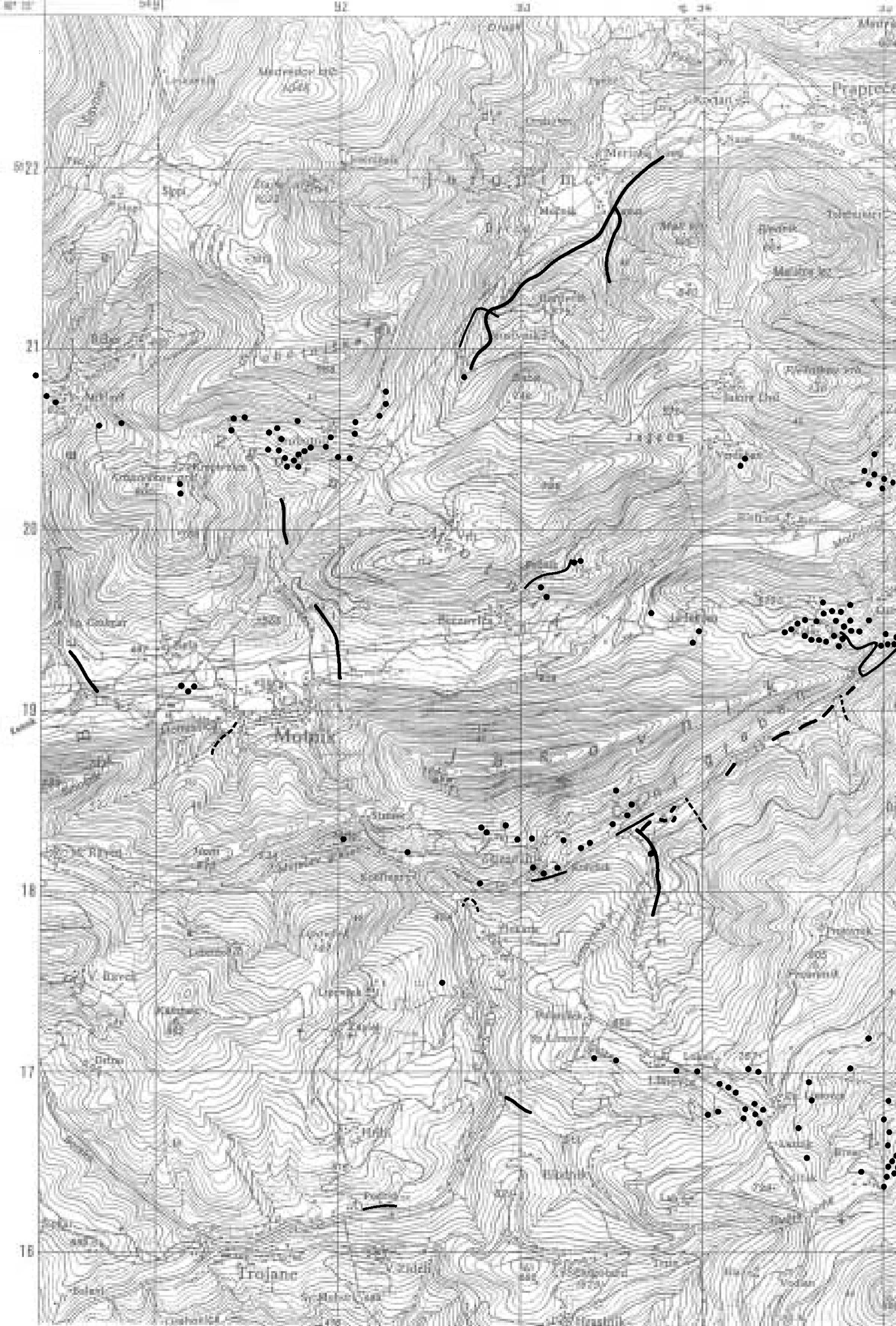
Figure 17: The grassy slopes of the Jerman farm in Dol (Črni Vrh) situated at the left bank of the Kučnica were torn up by landslides.
Slika 17: Travnata pobočja Jermanove domačije v Dolu (Črni Vrh), ki je na levem bregu Kučnice, so razrili zemeljski plazovi.

Figure 18: The southeastern slopes of Jasovnik (765 m) belonging to the farming hamlet of Osredek (Ločica), was newly divided by more than 25 landslides. Slide material also covered the Ljubljana–Celje highway.
Slika 18: Jugovzhodno pobočje Jasovnika (765 m), ki pripada kmetijam zaselka Osredek (naselje Ločica pri Vranskem), je na novo razčlenilo več kot 25 plazov, usadov in posedov. Plazovina je zasula tudi cesto Ljubljana–Celje.

According to the analysis of collected material, we may state the initial findings regarding the causes and effects of the landslides in the Bolska watershed. More than 80% of the landslides occurred on cultivated land and were mostly triggered on steeper slopes. An unusual number of slides occurred at the border between cultivated land and forest. Most of the landslides occurred in the lower half of cultivated land, especially at the boundary between natural and manmade curves in the slope where a more gentle upper section of slope turned into a steeper lower slope. Many landslides in forest areas occurred above stream beds, in the gable ends of valleys, along torrential ravines, and near springs which soak into the surrounding area. Landslides triggered in the middle of forested slopes were very rare, but where they did occur they were primarily caused or triggered by torrential water flowing down the slopes from roads or cart tracks. Erosion gullies, most of which were overgrown by forest vegetation, also contributed not a little to the creation of these landslides.

The causes behind the triggering of the greatest number of landslides may be found in the terraced slopes intended for cultivation. The arable terraces, which as a rule run parallel to the contour lines, reflect an old agricultural cultural landscape. Their elevation depends on slope material (soil), the gradient or steepness of the slope, the methods and types of cultivation, the use of farm machinery, etc. While in the past, arable or field terraces served mainly as a defense against soil erosion, to moisture preservation in the soil, and to allow the cultivation of steeper slopes with the help of yoked teams, the modern terraces serve a completely different purpose. The mechanization of farming which during the last two and a half decades spread over the hill areas of the Bolska watershed has brought about a fundamental reassessment of agricultural land use. Most of the previous arable land which dominated other farm land is now devoted to meadows and the intensive pasturing of herds. In one and a half decades, the tractor, which started to penetrate into hill farms from the mid 1960's onward,

Figure 19: Landslides damaged or destroyed electrical, telephone, and water networks. The photograph is from Črni Vrh.
Slika 19: Zemeljski plazovi in usadi so poškodovali in uničili tudi električno, telefonsko in vodovodno omrežje. Posnetek je iz Črnega Vrha.



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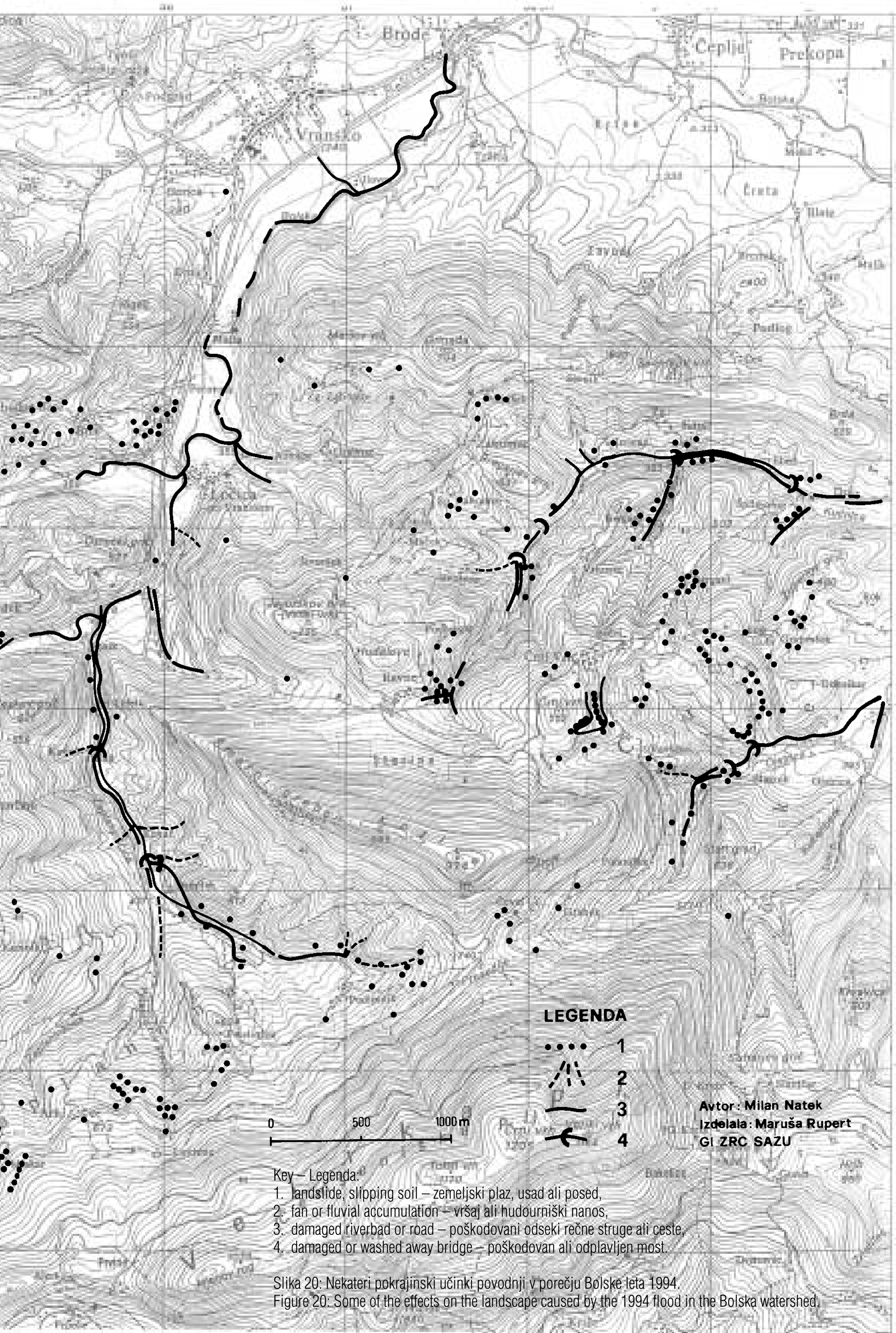

Key – Legenda:
1. landslide, slipping soil – zemeljski plaz, usad ali posed,
2. fan or fluvial accumulation – vršaj ali hudourniški nanos,
3. damaged riverbad or road – poškodovani odseki rečne struge ali ceste,
4. damaged or washed away bridge – poškodovan ali odplavljen most.

Slika 20: Nekateri pokrajinski učinki povodnji v porečju Bolske leta 1994.
Figure 20: Some of the effects on the landscape caused by the 1994 flood in the Bolska watershed.

replaced the yoked teams of oxen and horses (Meze 1981). The tractor became indispensable in the cultivation of land as well as for transporting wood from the forests. Its versatility and usefulness were initially obstructed by unsuitable paths. Forestry and other roads, along with rerouted cart tracks increased possibilities for using tractors and their attachments. The narrow and steep cart tracks which connected individual sections of farm land were also unsuitable, and numerous new roadways suitable for tractor traffic were therefore constructed on slopes with agricultural land in the 1970's and later: the more elongated the cultivated slope, the greater the number of parallel tracks. All available machinery was used in the construction of these and similar tractor roads. Constructing tractor trails made cuts in the slopes and consequently triggered the more rapid sliding of slope material (including soil) toward the valley bottoms. Above the cuts, numerous landslides are still triggered, especially during rainfall, which cover the roads with thick slope material.

The forestry roads and the network of roads connecting individual hill farms constructed over the last twenty years also caused many of the landslides.

A number of smaller landslides occurred directly above the channels or beds of streams, especially in their upper sections. The swollen waters widened and deepened the channels of their beds. Elsewhere along the rivers where there is no flood plain and the banks continue directly into the slopes of the ravine, there were numerous landslides. This material filled up the stream channels and was carried down to lower areas. Landslides in forest areas also sweep trees, piles of brush, fallen or cut logs, etc., into the river channels. All this contributes to the decreased capacity of the channels, while the trees present an obstacle which dams and raises the level of the torrents. And when the restrained water breaks through the barriers, its devastating power is indescribable. The torrential wave demolishes everything before it and with the carried material destroys, undercuts, and sweeps away banks, bridges, protective embankments, and everything else. All this occurred in the Bolska watershed during the catastrophic floods of June 1994.

The number of landslides triggered on the southern slopes of Jasovnik (765 m) was surprising: within a strip measuring 500 m × 2,750 m (1.375 km^2), almost seventy or an average of fifty landslides per km^2 were recorded. Nowhere else in the Bolska watershed was such a large number found. The lower sunny slopes of Jasovnik are composed of Triassic clay slate and marly clay slate with breccia deposits, while the top of the hill is composed of Triassic dolomite. The question therefore arises whether the above average frequency of landslides has anything to do with the traffic running directly below the foot of the slope. Is it possible that the storm with its powerful thunder and the passing of heavy trucks caused some kind of tremor that was transmitted up the slope to trigger a landslide of unstable and overloaded slope material? To provide an accurate answer to this question or hypothesis would require conducting a more thorough survey of the geological and tectonic composition of Jasovnik, the permeability and impermeability of its rock, the amount of rainfall on the sunny and sunless slopes, the previous and present use of the land, the vegetation and tree structure of the forest, etc.

5. Conclusion

In addition to causing enormous material damage, the catastrophic June storm in the Bolska watershed wreaked havoc in the region. The inundation which flooded and partially destroyed almost 1,200 hectares of farm land and the crops on it also damaged riverbeds, water engineering installations, roads, and water supply, electrical, and telephone networks. The official estimate of the total damage caused amounted to 2.2 billion SIT or 4.6% of the GDP of the District of Žalec.

At first glance, the fact that almost half the damage was caused to stream riverbeds, which truly suffered the greatest devastation, may be surprising. The damage caused to the streams and rivers may be documented with the following observations. Major storms had struck the Bolska watershed at least once every year during the previous five years, and the damage caused to streams was never fully repaired. The provisionally reorganized and repaired banks were still bare and without growth, mostly enclosed by banked material which the swollen waters either removed or seriously damaged with numerous undercuts. All the catchment area branches of streams are of torrential nature, while the upper and middle sections of the riverbeds are for the most part still naturally formed. Their shape

Figure 21: In its catchment area, the Reka (Marija Reka near Prebold) undercut its banks and damaged and washed away the road. Local residents used primitive means to protect the banks from further destruction.
Slika 21: V svojem povirju je Reka (Marija Reka) izpodjedla bregova svoje struge in poškodovala ter odnesla cesto. Domačini so s preprostimi posegi zavarovali brežino pred nadaljnjim uničevanjem.

and direction are frequently altered and changed. All the larger storms contribute to visible changes in the riverbeds that alter their dimensions and thus changed their specific characteristics.

On numerous occasions, storms have contributed to changes in river channels when the previous ones were filled with alluvium and other inundation debris. New channels formed alongside the old, carving into the riverside accumulation which formed the new flood plain. Most of the new riverbeds that formed in forest areas and did not obstruct the local traffic network and its installations were not returned to their previous locations and directions through human intervention. This was not the case in areas of newly cleared agricultural land. In these areas, people took great pains to protect cultivated land and therefore protected and controlled all the changes that occurred to stream channels, especially those capable of greater carrying power. In these areas we therefore find simple embankments along riverbeds that protect the streamside area from flooding. During inundations, the swollen waters demolish the embankments and most of its construction material is washed down to lower lying areas.

TABLE 8: STRUCTURE OF DAMAGE CAUSED AFTER THE JUNE 1994 INUNDATION IN THE DISTRICT OF ŽALEC.

Area	Estimated damage (in MILLIONS SIT)	%
Watercourses (riverbeds, banks, dams, weirs, etc.)	1,050	48.0
Roads	258	11.8
Bridges	102	4.7
Electrical power network	32	1.5
Telephone network	12	0.5
Agriculture	467	21.4
Forestry	26	1.2
Water distribution network and pumping stations	26	1.2
Residential and other buildings	212	9.7
Total	2,185	100.0

Man is also bears much of the blame for the damage caused. Our field investigation of the ruined region many times revealed that the damage could have been limited in most areas had the basic natural and geographical rules been observed and respected. Too little consideration is given to the fact that the Bolska tributaries are of torrential nature and that the area along the Bolska and along its tributaries is a flood world. The lowest flood plain is actually only the wider riverbed of the stream which is filled during inundation. Therefore we were even more surprised when we discovered that new residential, commercial, or other buildings were being erected immediately beside streams in typical flood areas.

All too little attention is paid to the fact that a stream is an active and dynamic landscape feature that can be "tamed" only through great effort with the assistance of appropriate and extensive material investment. There are not a few cases where the owners of riverside land wished to acquire a piece of land by narrowing the river channel through various encroachments (scarps, embankments, local regulation, etc.). These and similar encroachments do not rely on professional knowledge of the hydrological and geographical characteristics of the streams and consequently lead to serious devastation of the cultural landscape during severe storms and inundation.

The geographical characteristics and effects of storms are reflected in the immeasurable quantities of soil and other, mostly slope material washed away. Irreparable damage was caused everywhere various erosive and river transportation processes destroyed fertile land. The soil that was washed away can not be replaced with soil of equal quality. Through smaller encroachments the flat land that was furrowed by erosion gullies can be rehabilitated for further use and thus put back into the agricultural production system.

During the catastrophic June storm, the flood plains along the Bolska and its tributaries (where there were any) were covered with river and inundation alluvium. This gradually raises the level of the flatland. There are several reasons why the alluvium deposited by the inundation is important. The mineral composition of the alluvium is a basic indicator on which its economic and productive value depends. Alluvium enriches (or sometimes impoverishes) the structure of riverside soil. In many cases, alluvium has contributed to drier and therefore more fertile riverside land, which would not have been the case without it. In rare cases the alluvium has contributed to the greater bogginess of land along the streams (in spots along the Merinščica, the Vrtnica, the Žerovnica, the Gozdnica, the lower course of the Konjščica, the Trbolca, the middle reaches of the Trnavca and the Trebnik, etc.). For this reason, it is necessary and useful in assessing flood and inundation alluvium to have knowledge about its origin and source. The structure and quality of alluvium depends on the basic substratum of the soil, i. e. on the rock composition of the surface. It is also true, however, that inundation contributes to the heterogeneous rock composition of alluvium, especially in the lower parts of valleys. The June inundation in the Bolska watershed contributed enormous quantities of alluvium that were deposited in the middle and even more in the lower parts of the valleys. In the middle parts of the valleys, the alluvia was still of coarse structure and therefore damaged cultivated land. In the lower parts of the valleys where the gradient of the stream beds is almost negligible, most of the alluvium was of finer structure, and there was usually no need to remove it from agricultural surfaces. Most of the damage in these parts of the valleys was caused by the mud which not only destroyed meadow crops but also covered extensive areas of cultivated fields. Most of the mud was removed from the fields, orchards, and partly from the meadows in the first few days after the water had drained away.

The turbid flood water also contains great quantities of dissolved eroded material in suspended form. Some was deposited in the form of very fine alluvium on the meadows and fields while the rest was carried farther by the water. For this dissolved and washed away material, the previous observation applies: it can not be returned and for the affected areas this material has been lost for good.

Similarly, it was possible to evaluate and estimate most of the damage caused. Surveys and records show that the slopes were mostly left bare. The landslides ridged and furrowed many slopes previously used for farming purposes. The landslides and slide material are true wounds in the environment which present potential danger in the triggering of new landslides. At the same time, they are exposed sources supplying the streams with new quantities of fresh slope material. Therefore special care must be taken to safeguard the bare slopes when rehabilitating the riverbeds.

Figure 22: By erecting simple »scarps« with wooden supports, the owner of a vacation cottage in Marija Reka protected his garden from the sliding slope material which is abundant on the southern slope of Reška planina (925 m).
Slika 22: S preprostimi »škarpami«, lesenimi oporniki je lastnik počitniške hišice v Mariji Reki zavaroval svoj vrt proti drsenju pobočnega gradiva, ki ga je obilo na južnem pobočju Reške planine (925 m).

The consequences of storms may also be seen in the destroyed banks of river channels. In the upper stretch of the Bolska between Trojane and Ločica, the June inundation destroyed or undercut river banks in numerous places. Because the valley is narrow and there is only room for the riverbed and the road in some places, there is a greater likelihood that the road will be undercut during new floods. With its undercutting or side erosion, the June inundation reached the very edge of the road in three or four places (e.g., at Podzid below Trojane and Zajasovnik). Similar damage occurred along the Motnišnica between Motnik and Špitalič during the 1992 floods.
The inundation that occurred in the middle of the year opened numerous questions, as much in the field of physical planning and land use as in regard to the lack of consideration and respect given to certain fundamental geographical laws. On the basis of investigations into some of the geographical causes and consequences of the June natural disaster that struck the Bolska watershed, we concluded that all encroachments in the environment must be based on knowledge of the environment and its components. At the same time, it is important to have knowledge about developments that have previously taken place in the area that will allow us to evaluate the relationships and ratios between individual landscape features and then attempt to follow their developmental trend. Man can usefully and economically use space for various purposes provided he follows its fundamental disposition. This also demands a thorough knowledge of the space and the processes which man triggers through his work and manner of living. A friendly and attractive living environment can be created by establishing coexistence between society and nature and by recognizing and respecting natural and landscape forming processes. I am convinced that as long as we recognize and respect the laws of landscape formation and are aware of all the dangers and wrong turns brought about by ignoring them, it will be possible to successfully confront many of the trials and consequences of water disasters.

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7. Povzetek – Summary

Poletno neurju v porečju Bolske leta 1994

Milan Natek

Bolska je največji in najdaljši desni pritok Savinje na območju Savinjske doline. Njeno porečje meri 190,3 km^2. Pritoki Bolske, ki ima gosto hidrografsko omrežje, odmakajo predalpski hribovski svet in ravninsko-gričevnate predele skrajnega jugozahodnega dela Celjske kotline. Ta zaradi svojih geografskih značilnosti pripada zahodnemu subpanonskemu obrobju. Predalpski kraški planoti Menina in Dobroveljska planota razčlenjujejo in odmakajo levi Bolskini pritoki; večina izmed njih ima kraške hidrološke značilnosti. Desni Bolskini pritoki, ki razpolagajo z znatno reliefno energijo in so tudi bolj vodnati kot njeni levi pritoki, razčlenjujejo severni del predalpskega Posavskega hribovja, katerega geološko-tektonsko osredje temelji na zgradbi tuhinjske sinklinale in trojanske antiklinale. Že od nekdaj je po dolini Bolske speljana pomembna obalpska prometnica, ki povezuje severnojadranske pokrajine s panonskimi območji. Tudi v novejšem in današnjem času služi kot magistrala tranzitnemu prometu, ki povezuje južne predalpske pokrajine z zahodnimi panonskimi in srednjeevropskimi deželami. Zaradi gostega mednarodnega cestnega prometa, ki se je v začetku devetdesetih letih preusmeril in osredinil na kranjsko – štajersko magistralo, je postala dolina Bolske, zlasti njen zgornji del, ovira za hitrejši pretok prometa. Dodatne ovire nastopijo še ob vseh večjih vremenskih ujmah. Povodnji, zemeljski plazovi, usadi in posedi so tiste pokrajinske nevšečnosti, ki pogosto ovirajo, ali celo zaustavijo promet na tem delu (med Trojanami in Vranskim) naše obalpske ceste.
V začetku devetdesetih let je katastrofalno neurje večkrat zajelo in prizadelo dolino Bolske kakor tudi večino njenega porečja. Neurja s poplavami in povodnjimi so v zadnjih petih letih nemalo vplivala na spremembo pokrajinske fiziognomije in na podobo njenih sestavin. Samo v zadnjem desetletju je bil na obravnavanem območju izničen precejšen del človekovega dela, ki ga je bil skozi daljša obdobja vgrajeval v pokrajinsko infrastrukturno opremljenost ter v njeno podobo. S tem so se tudi spremenile posamezne pokrajinske sestavine in njihova namembnost v celostni pokrajinski podobi.

V razpravi so prikazani in ovrednoteni nekateri geografski vidiki vzrokov in pokrajinskih posledic neurij, ki so v poletju leta 1994 večkrat pustošila po območjih porečja Bolske. Samo v tem letu je bilo v dolini Bolske 7 poplav in povodnji. Največ škode je povzročilo neurje v noči med 28. in 29. junijem 1994, ko je v nekaj urah opustošilo doline, ki s svojimi povirji odmakajo hribovje med Trojanami oziroma Veliko (Čemšeniško) planino (1204 m) in Mrzlico (1122 m).
Po vsebinski zasnovi je razprava razdeljena na pet poglavij. Uvodoma so pregledno zarisane obče geografske značilnosti porečja Bolske kakor tudi potreba in namen preučevanja prostorsko-pokrajinskih posledic, ki jih vnašajo, oziroma zapuščajo naravne nesreče v pokrajini. Sanacija po neurju ali drugi naravni katastrofi uničenega ali prizadetega območja terja načrtna in dolgotrajna prizadevanja za odpravo posledic kakor tudi za vzpostavitev novega ravnotežja med posameznimi pokrajinotvornimi sestavinami.
Prikazana je geografska podoba porečja Bolske. Poseben poudarek je namenjen osvetlitvi geološkotektonske zgradbe obravnavanega ozemlja. V teh prostorskih sestavinah temelji osnova za reliefno izoblikovanost površja in za njegovo družbeno-gospodarsko veljavo na širšem območju. Porečje Bolske se je izoblikovalo v najsevernejšem delu sistema posavskih gub, kjer je izredno pisana kamninska sestava domala iz vseh najpomembnejših obdobij zemeljske zgodovine. Motniška sinklinala s terciarnimi sedimenti, kjer ima svoje povodje Motnišnica, je z obeh strani obdana s starejšimi, triadnimi kamninami, ki spadajo k sestavi žovneškega ali selškega nariva, ki je na severu. Na jugu je trojanska antiklinala oziroma kozjaški nariv.
Povirje Bolske se je zajedlo prek severnega krila trojanske antiklinale v njeno osrčje, kjer so razgaljene manj odporne paleozojske kamnine (npr. karbonsko-permski peščenjak, glinasti skrilavec, peščenjak, meljevec, skrilavec idr.). Jugovzhodni del Bolskinega porečja, to je povodje njenih desnih pritokov (Kučnica, Konjščica in Reka), sestavljajo poleg že navedenih kamnin še kredne in jurske plasti (npr. ploščati vranski apnenec z roženci, lapor, peščenjak in breča, apnenec z roženci, skrilavec, glinasti skrilavec, lapor itd.). Najvišja slemena z vrhovi, ki predstavljajo tudi razvodnico med Savinjo in Savo, ali pa razmejitve med porečji posameznih pritokov Bolske, so iz triadnih apnencev.
Podrobneje so podane osnovne hidrološke značilnosti Bolske in njenih pritokov. V strmcu rečne struge, ki je odvisen od kamninsko-reliefne zgradbe povodja, so osnovni vzroki za razdiralno moč in transportno sposobnost potokov. Povprečni strmec Bolske od njenega izvira pa do ustja znaša 1,72 % (to je 172 cm na 1 km struge). V zgornjem toku (nad Ločico pri Vranskem) ima struga Bolske povprečni strmec 3,22 %, med Ločico in izlivom v Savinjo pa od 0,4 do 0,6 %. Podrobno so ovrednoteni strmci strug vseh glavnih Bolskinih pritokov (primerjaj preglednico 1 in zemljevid, slika 1). Ugotovljeno je bilo, da so najobsežnejša in najbolj značilna poplavna območja nastala tam, kjer imajo struge poplavnih potokov strmce, ki ne presegajo 1 % (ali 10 ‰). Povsod drugod povzročajo poplavne vode s svojim burnim tokom škodo, ki je povezana z bočno in globinsko rečno erozijo ter s transportom v strugah odloženega materiala.
Za dolino Bolske so značilne aperiodične poplave in povodnji, ki se praviloma lahko pojavijo v vsakem letnem času. Brez poplav in neurij so praviloma le februar, marec, april in maj. Najpogostejše so poplave v januarju in novembru, redkejše pa v juniju, septembru in oktobru. Z njimi smemo računati tudi v juliju, avgustu in decembru.
V porečju Bolske zavzemajo gozdovi 60 % površja. Pred sto leti je odpadlo nanje blizu 56 % ozemlja; odtlej dalje se njihov delež stalno povečuje. Krčenje oziroma zmanjševanje kmetijskih površin na račun povečevanja gozdov je bilo najintenzivnejše po 2. svetovni vojni. V obdobju 1953–1993 so se povečale površine gozdov v porečju Bolske za 744 ha, ali v letnem povprečju po 18,59 ha. Najintenzivnejše ogozdovanje je bilo v obdobju 1953–1961, ko so se gozdne površine povečale za 360 ha, to je za 44,98 ha na leto (primerjaj preglednico 2 in preglednico 3). Raziskava je pokazala, da imajo območja, ki jih je najbolj prizadelo neurje v zadnjih dneh junija 1994. leta, v povprečju več kot 60 % gozdnih površin.
Večina hribovskega sveta je poseljena s samotnimi kmetijami ali z gručastimi zaselki. V dolinsko-ravninskih predelih je prišlo na 1 km^2 od 120 do 242 ljudi, v njihovih hribovskih zaledjih pa od 11 do 36 ljudi (podrobnosti primerjaj v preglednici 4). Tudi za porečje Bolske je značilna depopulacija. V obdobju 1890–1991 je število prebivalcev najbolj upadlo v porečju Motnišnice (–43 %) ter v hribovskih naseljih med Trojanami in Mrzlico (–53 %). Za 11 % pa se je zmanjšalo na južnem obrobju Dobroveljske planote. Ravninska naselja zaznamujejo stagnacijo v rasti števila prebivalcev, v in-

dustrijskih krajih in središčih pa se je povečalo število prebivalcev (npr. Prebold, Dolenja vas, Šmatevž, Vransko itd.). Z depopulacijo se je zmanjšala učinkovitost delovne sile v kmetijstvu, ki že od nekdaj vzdržuje kulturno pokrajino, še zlasti v hribovitih predelih. Manjše število prebivalcev, deloma tudi njegova neugodna starostna sestava, sta tista pomembna in odločilna dejavnika, ki preprečujeta kontinuirano vzdrževanje in negovanje poseljenih območij v hribovskem svetu. V tem spoznavamo enega izmed pomembnih dejavnikov, da prihaja ob vremenskih ujmah do tako številnih pokrajinskih degradacijskih pojavov in opustošenj v redko obljudenih hribovskih predelih.

V letu 1994 so neurja oziroma povodnji kar sedemkrat pustošili v porečju Bolske. V razpravi so podrobno prikazani in ovrednoteni pokrajinski učinki katastrofalnega neurja s točo, nalivom in viharjem, ki se je razbesnelo med Veliko planino (1204 m) in Mrzlico (1122 m) v poznih večernih urah 28. junija 1994. V manj kot dveh urah je padlo na osrednjem območju neurja več kot 100 litrov dežja na 1 m^2 površine. Nenadoma so narasli vsi hudourniški potoki, in še pred polnočjo so prestopili bregove svojih strug. Nenadoma so oživeli vsi erozijski žlebovi in lijaki, po katerih so se valile v doline ogromne količine rečnega in pobočnega materiala. Tudi gozdne ceste in strmejši kolovozi so se spremenili v hudourniške struge. Narasle vode niso prenašale samo proda in peska, temveč so z njima vred rušile bregove strug, izpodjedale in odnašale obrečno drevje in grmovje, rušile in odnašale brvi in mostove. V spodnjih delih dolin, kjer usahne erozijska moč potokov, so nastala obsežna območja z naplavinami. Največ škode je povzročilo neurje v porečjih Zaplaninščice, Kučnice in Konjščice. Ozka dolina Zaplaninščice je bila na debelo prekrita s povodenjsko naplavino. V tem delu je bila njena struga zatrpana z rečnim materialom. Deroča voda je uničila in odplavila asfaltno prevleko s cestišča, v katerega je izdolbla več kot 1 m globoko strugo. Struga Zaplaninščice je bila zatrpana s prodom in hudourniškim gradivom.

Tudi v porečju Kučnice in Konjščice je zapustilo neurje pravo razdejanje v pokrajini. Voda je odnesla ali vsaj poškodovala vse mostove. Cesti, ki peljeta ob Konjščici ali Kučnici, sta bili zatrpani z ogromnimi količinami rečnega in drugega erozijskega transportnega materiala. V ožjih delih doline so bili nasipi več kot 1 meter visoki. Poplavljena pa niso bila samo območja v zgornjih delih dolin, temveč tudi v srednjih in spodnjih delih, kjer prevladujejo kmetijske površine in je tudi gostejša poselitev. Med naseljema Loke in Ojstriška vas je bila pod vodo vsa danja ravnica, ki spremlja Konjščico. Voda je zalila skoraj celotno naselje Ojstriško vas, kar se doslej še ni zgodilo. Ob Konjščici so bili popravljeni vsi domovi, ki imajo selišče na danji ravnici.

Obilne padavine, strmejša pobočja in kamninsko-geološka zgradba tal oziroma površja ter načini in oblike človekovih posegov v pokrajino so med pomembnejšimi povzročitelji polzenja tal po pobočjih navzdol. Ugotovili in spoznali smo večino zemeljskih plazov, usadov in posedov, ki so spremenili mikropovršinske oblike, obenem pa so prispevali ogromne količine erozijskega in transportnega materiala, ki so ga prenašale in v spodnjih delih dolin odlagale narasle vode. Na prizadetem in preučevanem območju smo našteli blizu 450 premikov oziroma zdrsov zgornjih slojev površja. (Podrobnosti primerjaj na zemljevidu.)

Zemeljski plazovi in usadi so bili najpogostejši na območjih Brdc (30 primerov na 100 ha površin), Črnega Vrha (29), Zaplanine (28) itd. Plazovi so najbolj prizadeli območje, ki obsega okrog 900 ha; na teh predelih smo našteli 225 plazov, usadov ali posedov. Nenavadno številni zdrsi vrhnjih delov površja so bili na južnih pobočjih Jasovnika (765 m): v pasu, velikem 500 krat 2750 m (= 137,5 ha), smo našteli blizu 70 zemeljskih plazov, ali v povprečju 50 usadov na 100 ha površja. Več kot 80 % preučenih plazov se je utrgalo na kmetijskih obdelovalnih površinah.

Katastrofalno junijsko neurje v porečju Bolske je poleg velikanske materialne škode zapustilo še pravo razdejanje v pokrajini. Povodenj je preplavila blizu 1200 ha kmetijske zemlje in na njej je uničila znaten del letnega pridelka. Poškodovala je struge potokov, vodnogospodarske naprave in objekte, prometnice, vodovodno, električno in telefonsko omrežje. Strokovnjaki so ocenili, da je bila škoda 2,2 milijardi SIT ali 4,6 % bruto proizvoda občine Žalec. Največ škode je nastalo na strugah potokov in njihovih objektih, pa v kmetijstvu, na prometnicah itd. (Podrobnosti primerjaj v preglednici 8.)

Velik krivec za nastalo škodo je tudi človek, saj ne upošteva osnovnih naravno-geografskih zakonitosti. Zgornji tok Bolske in vsi njeni desni pritoki kakor tudi Motnišnica so hudourniškega značaja. Najnižje ravnice ob potokih so samo razširjene struge, ki jih ob visokih vodah tudi preplavijo. Po-

tok oziroma reka je živa in dinamična pokrajinska sestavina, ki jo je mogoče obvladovati z velikimi napori in nemajhnimi materialnimi vlaganji.
Znaten del škode, ki je nastala ob neurju, je bilo mogoče oceniti z vidika denarne oziroma gospodarske vrednosti. Nikdar pa ni mogoče zarisati oziroma ovrednotiti škode, ki je nastala s plazinami in plazovinami, z odnešeno prstjo z rodovitnih površin pa z nanosi grobega, ponekod povsem jalovega materiala na obdelovalne površine, z zaprtjem prometnic, s prekinitvijo električne, vodovodne in druge oskrbe itd.
Naravnost presenečeni smo, ko ugotavljamo, da načrtovalci urbanizacije in poselitve ne poznajo in ne upoštevajo temeljnih naravno-geografskih značilnosti in zakonitosti, ki veljajo za obrečni svet. V zadnjem času je segla poselitev tudi na tipična poplavna območja. Gradnja domov in gospodarskih objektov ni upoštevala osnovnih naravno-geografskih svojstev zazidalnih območij. Obravnavane gospodarske in pokrajinske posledice junijskega neurja so pokazale, da je potrebno pri vseh posegih v prostor oziroma pokrajino računati z lastnostmi in značilnostmi pokrajinotvornih sestavin. Vsak tvoren in preudaren poseg v okolje (pokrajino) zahteva podrobno členitev in poznavanje njenih temeljnih sestavin kakor tudi vrednotenje odnosov med osnovnimi in povezovalnimi pokrajinotvornimi prvinami.