© *Acta hydrotechnica* **22/37 (2004)**, Ljubljana
ISSN 1581-0267

UDK/*UDC*: 551.3.053+556.166(497.4)
Pregledni znanstveni prispevek – Review scientific paper

Prejeto/*Received*: 20. 1. 2005
Sprejeto/*Accepted*: 5. 5. 2006

POPLAVE IN ZEMELJSKI PLAZOVI V SLOVENIJI
FLOODS AND LANDSLIDES IN SLOVENIA

Matjaž MIKOŠ, Mitja BRILLY, Mihael RIBIČIČ

V preglednem prispevku o poplavah in zemeljskih plazovih v Sloveniji so najprej opisane in grafično prikazane za te naravne pojave najpomembnejše naravne danosti, kot so padavine, odtok, hidrogeološke razmere in relief. Nadalje so podrobneje opisana in grafično prikazana posamezna ogrožena območja zaradi delovanja zemeljskih plazov in poplav v Sloveniji. Ta območja v Sloveniji prekrivajo velik odstotek površine, saj zemeljski plazovi in erozijski procesi izrazito delujejo na 44 % površine Slovenije. Celotna poplavna površina ob ekstremnih poplavah (Q_{100}) je 695 km^2 ali 3,5 % celotne površine, od tega je 25 km^2 urbanih površin. Sledi kratek pregled zgodovinskih poplav in večjih zemeljskih plazov v Sloveniji. Prispevek se zaključi s kratkim pregledom zakonodajne ureditve obravnavane problematike v Sloveniji.
Ključne besede: *zemeljski plazovi, zemljinski plazovi, kamninski plazovi, podori, poplave, Slovenija, naravne nesreče, naravna tveganja, rizični menedžment*

In this review paper on floods and landslides in Slovenia firstly the most important natural conditions for these natural processes are described and graphically shown, such as precipitation, runoff, hydrogeological conditions, and topography. After that, hazard areas of landsliding and flooding are described and graphically represented in more detail. These areas cover a substantial part of Slovenia's territory, as landsliding and erosion processes are openly present in about 44 % of the territory. The total inundated area under extreme flood events (Q_{100}) is 695 km^2 or 3.5 % of the total surface, out of which 25 km^2 are urban areas. Further on, a short review of historical floods and recent landsliding events in Slovenia is given. The paper ends with a short review of relevant legislation in Slovenia.
Key words: *landslides, rock slides, earth slides, rock falls, floods, Slovenia, natural disasters, natural hazards, risk management*

1. NARAVNE RAZMERE

Poplave in zemeljski plazovi so kompleksni naravni pojavi, ki jih povzročajo za njihov nastanek ugodni lokalni naravni pogoji. Ti postajajo z nadaljnjim razvojem v prostoru vse bolj odvisni od človekovih dejavnosti. V Sloveniji so glavni vzroki nastanka teh pojavov neugodne geološke razmere, razgibana morfologija in obilne padavine (dež).

1.1 Padavine in odtok

Za Slovenijo so značilna tri različna podnebja: celinsko, alpsko in sredozemsko. Za obdobje 1961–1990 (slika 1) so povprečne

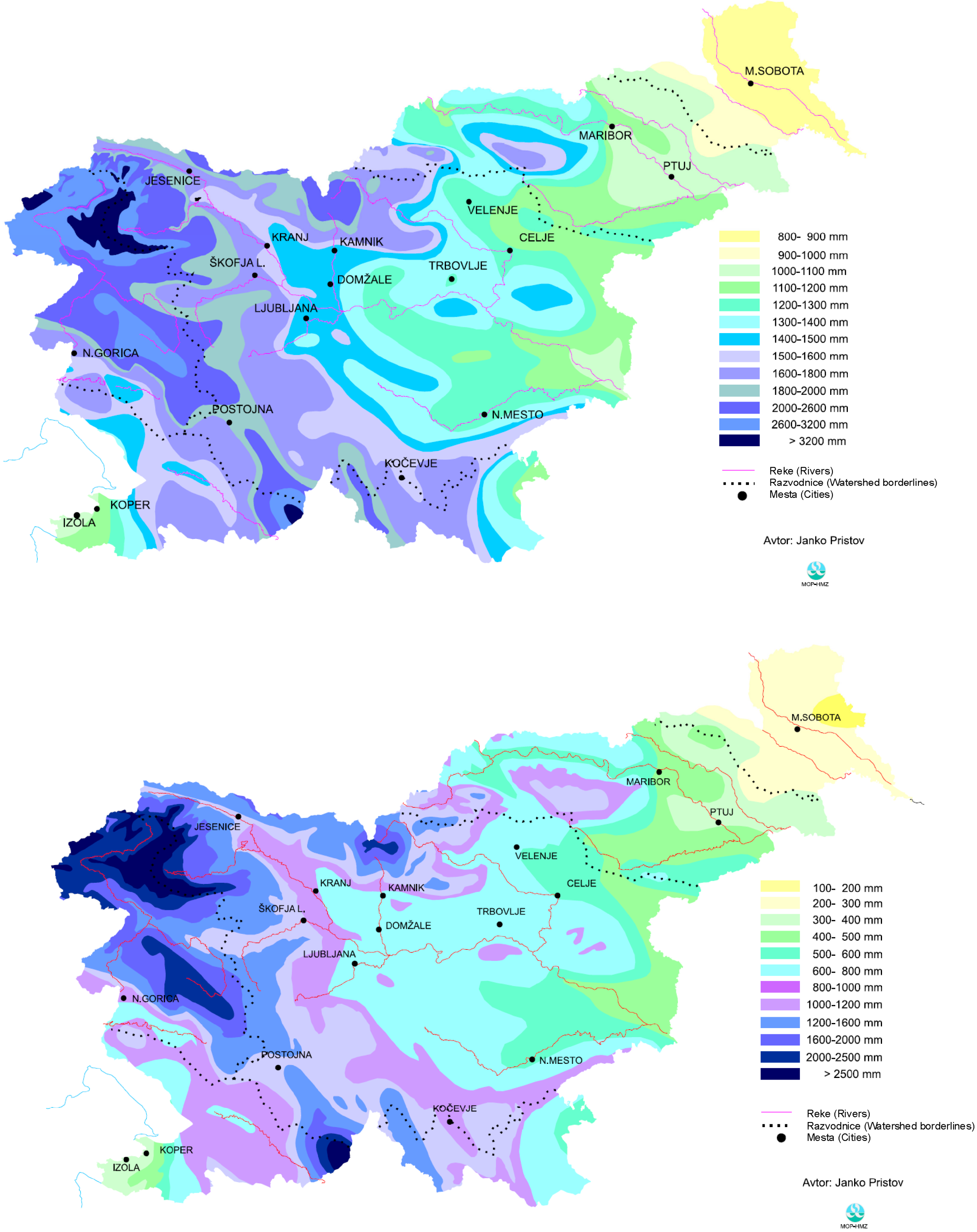
1. NATURAL CONDITIONS

Floods and landslides are complex natural phenomena caused by local natural conditions favourable for their occurrence. With advancement in spatial development they are becoming more and more influenced by human activities. In Slovenia, unfavourable geological conditions, diverse morphology and abundance of precipitation (rainfall) are the major causes of these disasters.

1.1 Precipitation & runoff

Slovenia has three different climates: continental, alpine and Mediterranean. For the period 1961–1990 (Fig. 1), the average annual letne padavine 1567 mm, povprečni letni odtok 917 mm in povprečno letno izhlapevanje 650 mm (Kolbezen & Pristov, 1998).

precipitation is 1567 mm, average annual runoff is 917 mm, and average annual evaporation is 650 mm (Kolbezen & Pristov, 1998).



Slika 1. Povprečne letne padavine v mm (zgoraj) in povprečni specifični odtok v mm (spodaj), podana za obdobje 1961–1990 (ARSO, 2005b).

Figure 1. Average annual precipitation depth in mm (up) and specific runoff in mm (down) given for the period 1961–1990 (ARSO, 2005b).

Slovenija je z vodnimi viri bogata država, ki jih sestavljajo predvsem podtalnica in izviri. Vode se s površine 16.373 km^2 stekajo v Donavo (Črno morje) in s površine 3.857 km^2 v Jadransko morje (Kolbezen & Pristov, 1998).

Srednje letne padavine so zelo različne, tudi za skoraj faktor 5:

- ~ 800 mm/leto v severovzhodnem celinskem podnebju v Prekmurju;
- okoli 1000 mm/leto v jugozahodnem sredozemskem podnebju;
- > 3200 mm/leto v severozahodnem alpskem podnebju Julijskih Alp – klimatološko najvišje dolgoletne povprečne padavine v Alpah.

Strm relief močno vpliva na vse vrste padavin. V Sloveniji nastopijo najneugodnejše padavinske razmere kot kombinacija frontalnih padavin z orografsko pogojenimi konvekcijskimi padavinami.

Porečje zgornje Soče ob meji z Italijo je območje z najvišjimi letnimi padavinami v državi. Statistična analiza dolge časovne vrste merjenih močnih padavin je pokazala, da to območje v povprečju izkazuje okoli 40 močnih neviht na leto. V preteklosti so bile tu izmerjene padavine intenzitete več kot 400 mm/dan in več kot 100 mm/h (HMZ, 1995).

Zaradi visokih letnih padavin in slabo prepustne podlage je nastala gosta hidrografska mreža tekočih površinskih voda (26.989 km strug vodotokov, povprečna gostota 1,33 km/km^2, ponekod tudi preko 2 km/km^2, slika 2, Kolbezen & Pristov, 1998). Slovenija leži v povirnih delih večjih rek, zato so pogoste hitre hudourniške poplave. Izjemi sta reki Drava in Mura, ki v Slovenijo pritekata iz Avstrije. Za Slovenijo sta značilna dežni in snežni odtočni režim. Obilne so tudi snežne padavine, toda v nižjih nadmorskih višinah snežna odeja ni stalna in se tudi pozimi večkrat stali.

Poplave lahko v Sloveniji nastopijo preko vsega leta, najpogostejše in največje so spomladi in v jeseni. Vlažno podnebje in visok letni odtok okoli 1000 mm povzročata visoke vode z neizrazitimi razlikami med pretoki poplavnih voda različnih verjetnosti nastopa: razmerje med Q_{100} in Q_5 je 1,42 za reko Sočo, 1,36 za reko Savo in 1,4 za reko Dravo (ZVSS, 1978). V Sloveniji ni večjih naravnih jezer ali umetnih zadrževalnikov voda, ki bi pomembno vplivali na naravne poplavne pretočne razmere.

Slovenia is a country rich in water resources, comprising mainly of groundwater and springs. Of its territory, 16,373 km^2 drains into the Danube River (the Black Sea), and 3,857 km^2 into the Adriatic Sea (Kolbezen & Pristov, 1998).

The average annual precipitation varies within a factor of nearly 5:

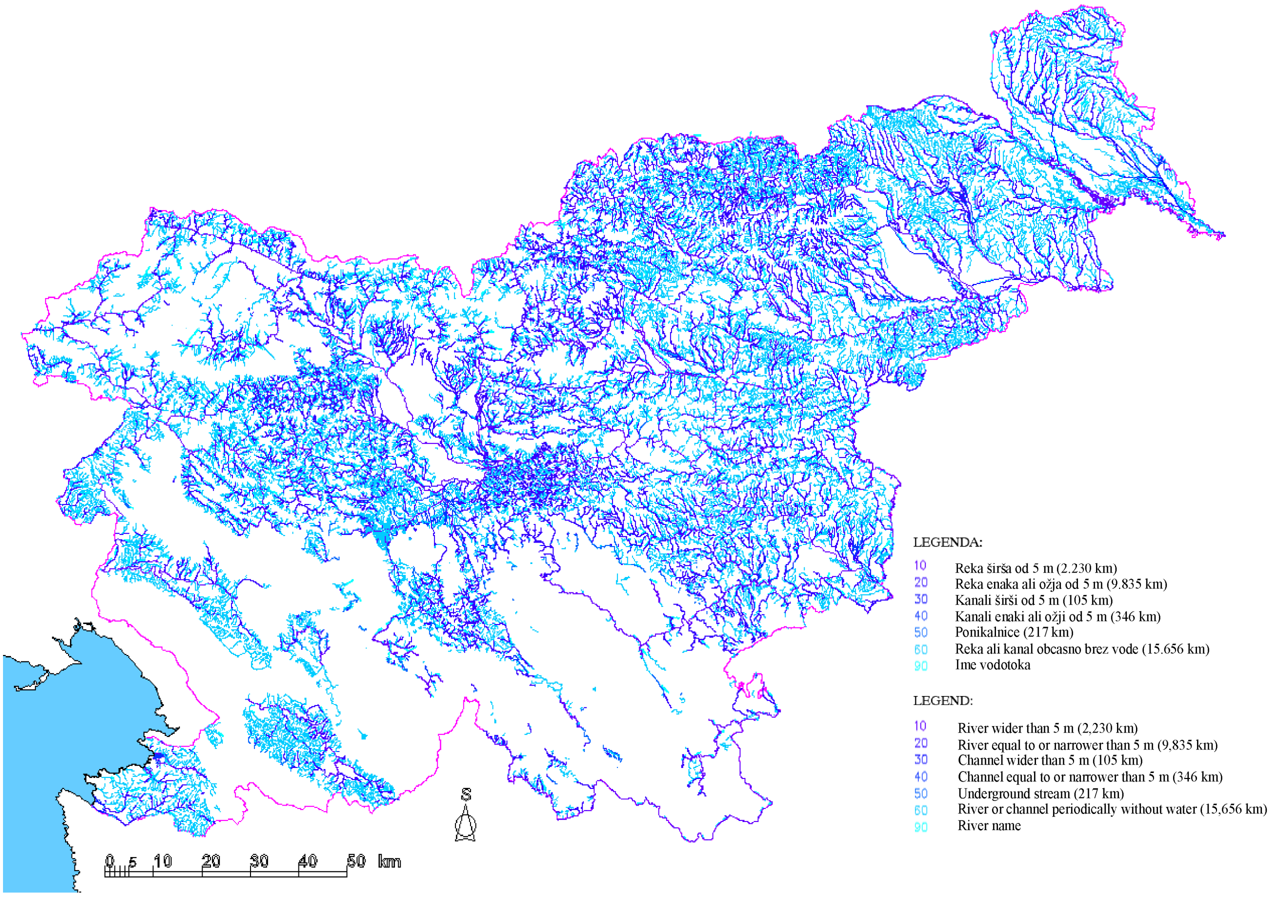
- ~ 800 mm/year in NE continental climate of the Prekmurje plains;
- around 1000 mm/year in SW sub-Mediterranean climate;
- > 3200 mm/year in NW alpine climate of the Julian Alps – climatologically the highest long-term precipitation in the Alps.

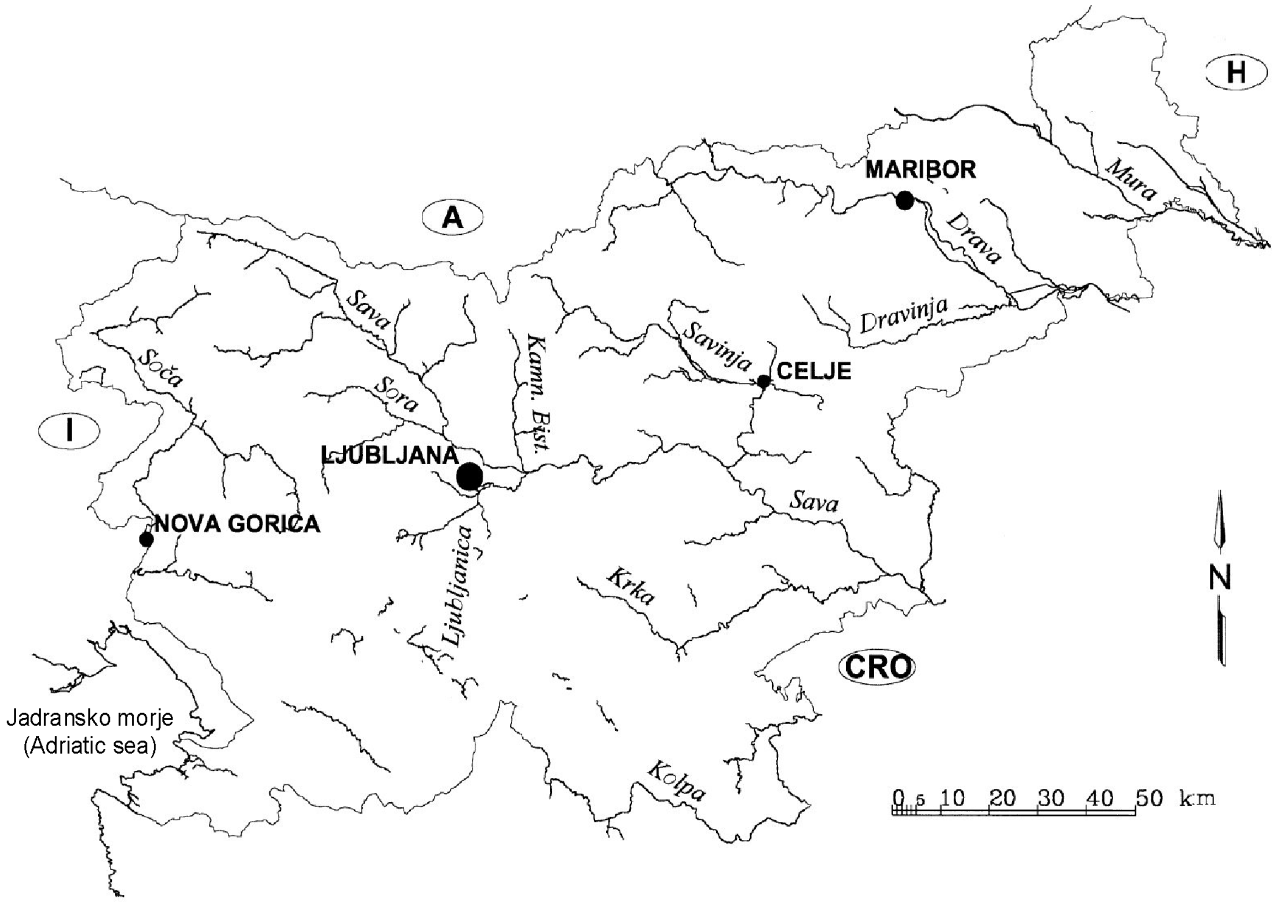
The steep terrain strongly influences all types of precipitation. In Slovenia, the worst precipitation situation is the combination of frontal precipitation with the orographically forced convection precipitation.

The Upper Soča River basin on the border with Italy is the region with highest annual precipitation in Slovenia. The long-term statistical analysis of heavy rainfall events shows on average more than 40 such events a year in this region. More than 400 mm/day and more than 100 mm/h have been registered in the past (HMZ, 1995).

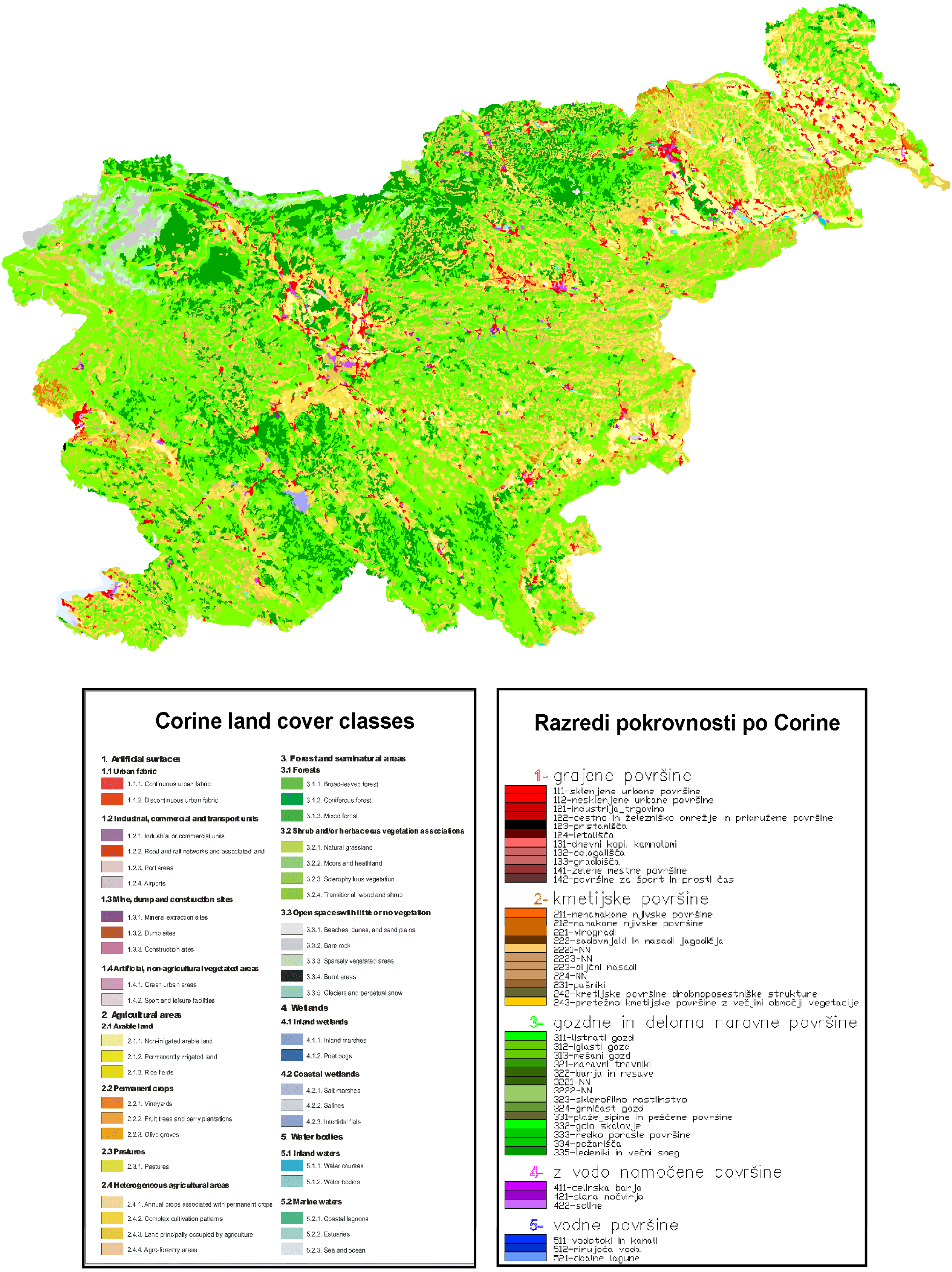
The high annual precipitation and terrain of low permeability produce a dense hydrographic network of running waters (26,989 km of stream channels, average density of 1.33 km/km^2, in some areas over 2 km/km^2, Fig. 2, Kolbezen & Pristov, 1998). Slovenia is situated in the headwater areas of its major rivers, and flush floods are quite typical. Exceptions are the Drava and Mura Rivers, flowing to Slovenia from Austria. The typical runoff regimes are pluvial and nival. There is also significant snowfall but at lower altitudes the snow pack is typically non-continuous and disappears several times during the wintertime.

Floods in Slovenia can occur at any time of the year, but most of them and the heaviest ones occur in spring and autumn. The humid climate and high annual runoff of about 1000 millimetres per year produce high flows with insignificant differences between flood discharges: the ratios between Q_{100} and Q_5 are 1.42 for the Soča River, 1.36 for the Sava River, and 1.4 for the Drava River (ZVSS, 1978). There are no large-sized lakes or artificial reservoirs that would significantly impact natural flood discharges.

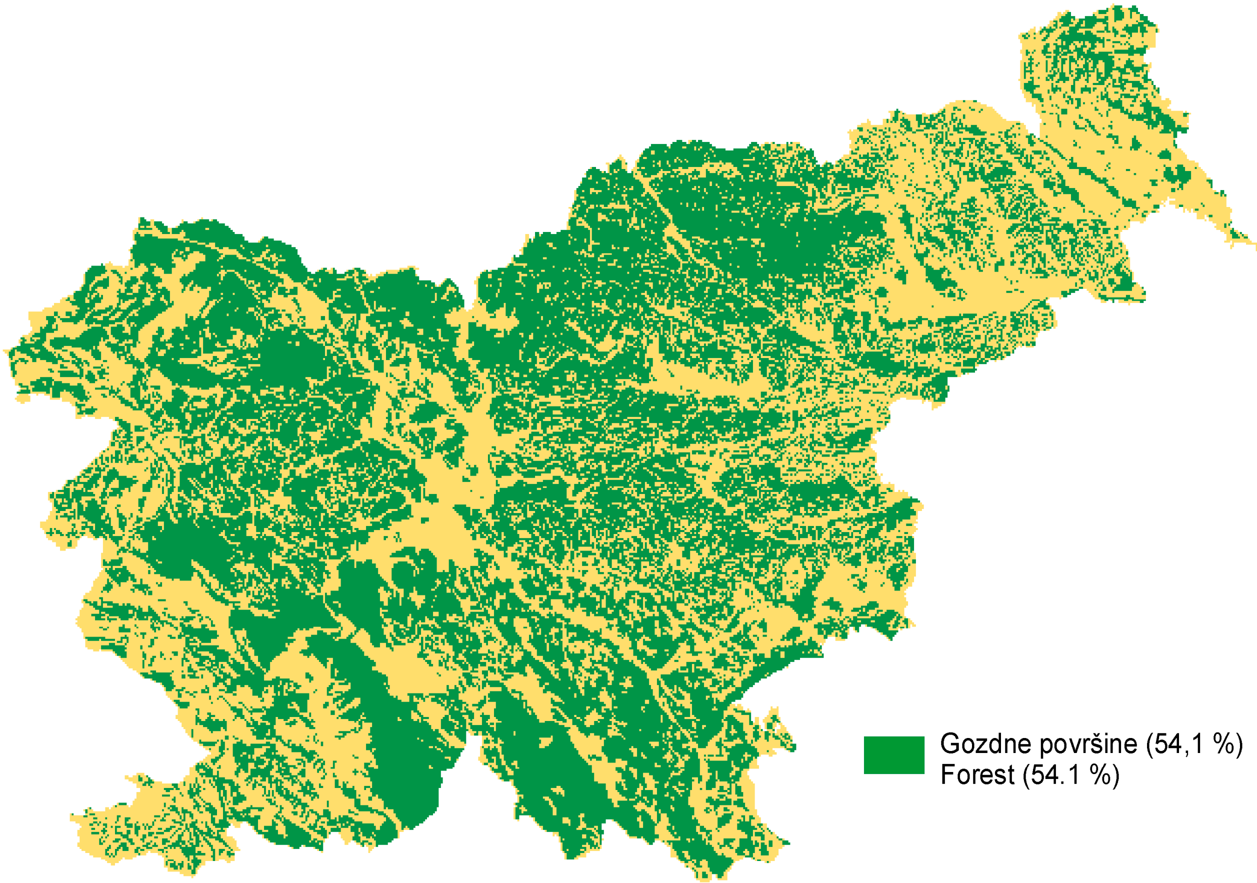




Slika 2. Hidrološka mreža rek (zgoraj) in glavne reke v Sloveniji (spodaj) (KSH, 2005).
Figure 2. The hydrological network (above) and the major rivers in Slovenia (below) (KSH, 2005).



Slika 3. Raba tal po podatkih CORINE 2000 (KSH, 2005).
Figure 3. Land use according to CORINE 2000 data base (KSH, 2005).



Slika 4. Delež gozdnih površin (KSH, 2005).
Figure 4. Forest areas in Slovenia (KSH, 2005).

V zadnjih desetletjih je bila v Sloveniji zelo intenzivna naravna sukcesija (zaraščanje) opuščenih kmetijskih površin (sliki 3 in 4). Leta 2001 je bilo gozdnatih površin 63,3 %, vseh kmetijskih površin 30,5 %, odprtih površin 1,6 %, voda 0,7 %, pozidanih površin 2,8 %, cest 1,0 % in železnic 0,1 % (SURS, 2005).

Gosto rastje na eni strani uspešno zmanjšuje erozijo prsti, na drugi strani pa zmanjšuje nizke pretoke in je tako povzročilo v zadnjih vročih poletjih zadnjega desetletja hidrološko sušo v vodotokih in kmetijsko sušo na nenamakanih kmetijskih površinah.

Meritve padavin so se v Sloveniji začele v sredini 19. stoletja, istočasno z drugimi deli Avstro-Ogrske monarhije. Danes potekajo meritve padavin na 290 ombrometrih in 49 ombrografih. Za meritve padavin je v uporabi tudi meteorološki radar v srednjem delu Slovenije (Lisca) (ARSO, 2005c).

In the last decades, natural reforestation (succession) of abandoned agricultural land has been very intense (Figs. 3 & 4). In 2001, the land use was as follows: wooded areas 63.3 %, agricultural areas 30.5 %, bare soils 1.6 %, water 0.7 %, built-up areas 2.8 %, roads 1.0 %, and railways 0.1 % (SURS, 2005).

On one hand, dense vegetation helps to effectively reduce soil erosion; on the other hand it reduces low flows and has caused hydrological droughts in streams and agricultural droughts on non-irrigated agricultural land in warm summers in the last decade.

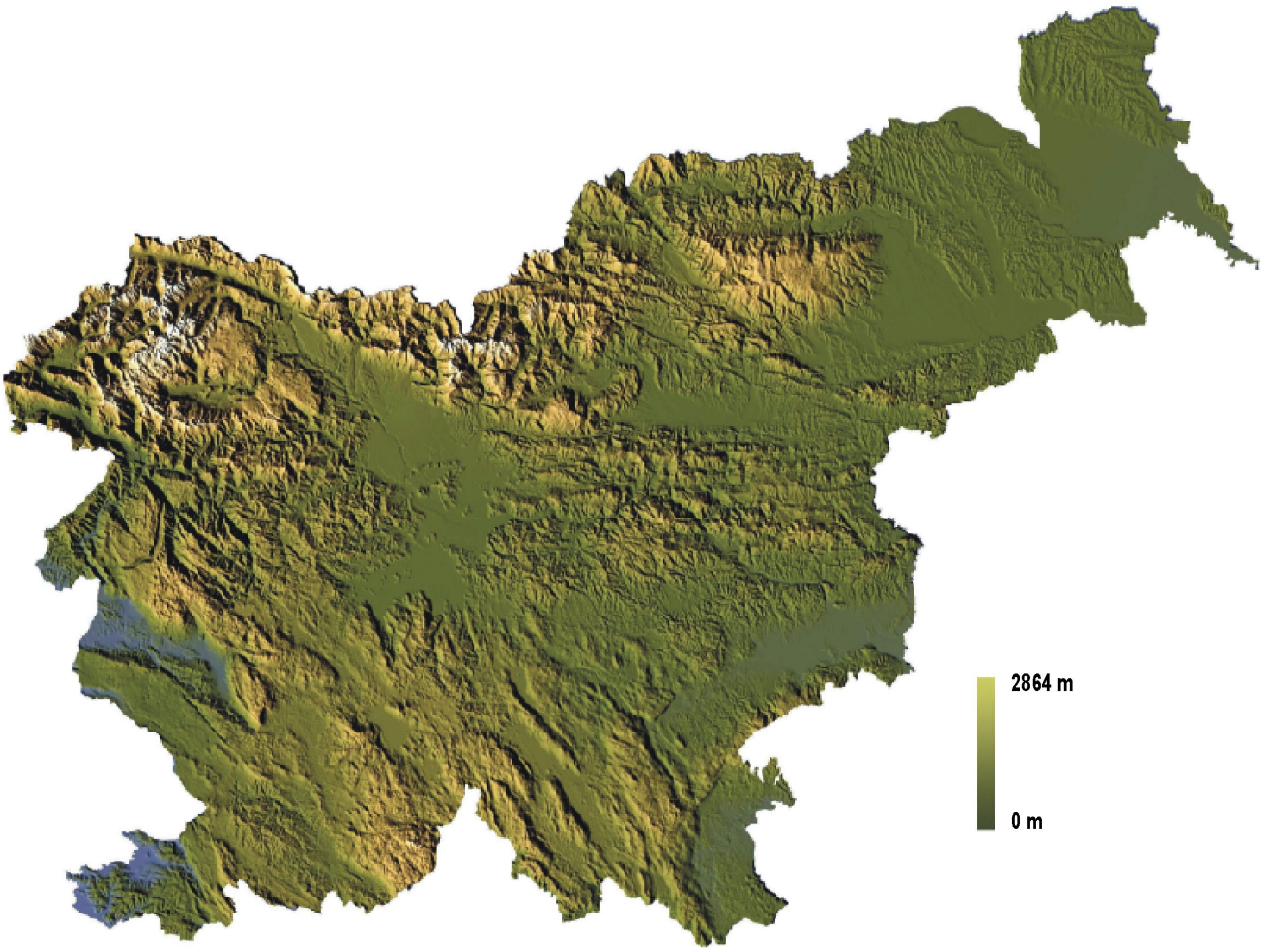
In Slovenia, the precipitation measurements started in the mid-19th century, simultaneously to other parts of the Austro-Hungarian monarchy. Today, 290 ombrometers and 49 ombrographs are in operation. For precipitation measurements a C-band meteorological radar situated in the central part of the country (Lisca) is also used (ARSO, 2005c).

2.2 Hidrogeologija in relief

Slovenija je gorata in gričevnata dežela (slika 5). Samo 8,6 % njenega površja obsegajo površine z naklonom manjšim od 4 % (digitalni model terena 20 x 20 m; SURS, 2005). Ravninske dele sestavljajo zelo prepustne prodnate in peščene naplavine in podtalnica v vodonosnikih, ki so zelo občutljivi na onesnaženje.

2.2 Hydrogeology & topography

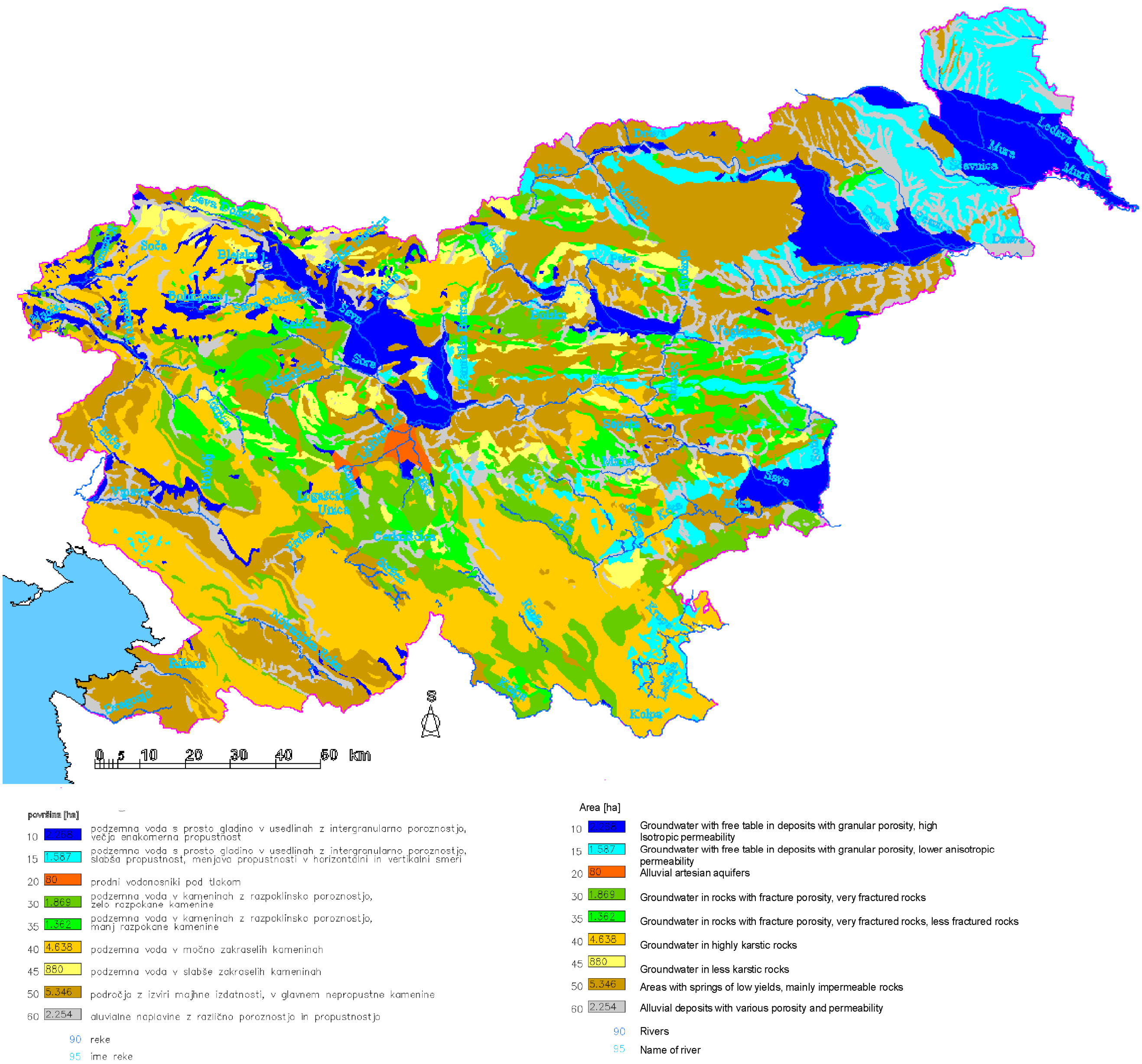
Slovenia is a mountainous and hilly country (Fig. 5). Only 8.6 % of its territory are areas with inclination less than 4 % (DTM 20; SURS, 2005). The plain lowlands consist of very permeable alluvial gravel and sand deposits with ground waters in large aquifers vulnerable to pollution.



Slika 5. Relief Slovenije (KSH, 2005).
Figure 5. Relief of Slovenia (KSH, 2005).

Pomembna hidrogeološka značilnost Slovenije je dejstvo, da je 44 % njenega površja kraškega značaja (LMTe, 1987, slika 6). Za kras so značilne posebne oblike površja in podzemni vodni tok. Padavinske vode in kraške reke izginejo pod površino in se pojavijo v močnih kraških izvirih. Kraška območja imajo nizko gostoto rečne mreže in so občasno podvržena sušam. Gostota rečne mreže Ljubljanice je tako 0,98 km/km^2 in Pivke samo 0,55 km/km^2 (Kolbezen & Pristov, 1998).

An important hydrogeological characteristic of Slovenia is that about 44 % of its territory is karstic (LMTe, 1987, Fig. 6). The Karst is characterised by special landforms and ground water drainage. Precipitation water and karstic rivers disappear underground, and reappear in strong karstic springs. The karst region has low stream density, and occasionally suffers from droughts. The drainage density for the Ljubljanica River is 0.98 km/km^2 and for the Pivka River only 0.55 km/km^2 (Kolbezen & Pristov, 1998).



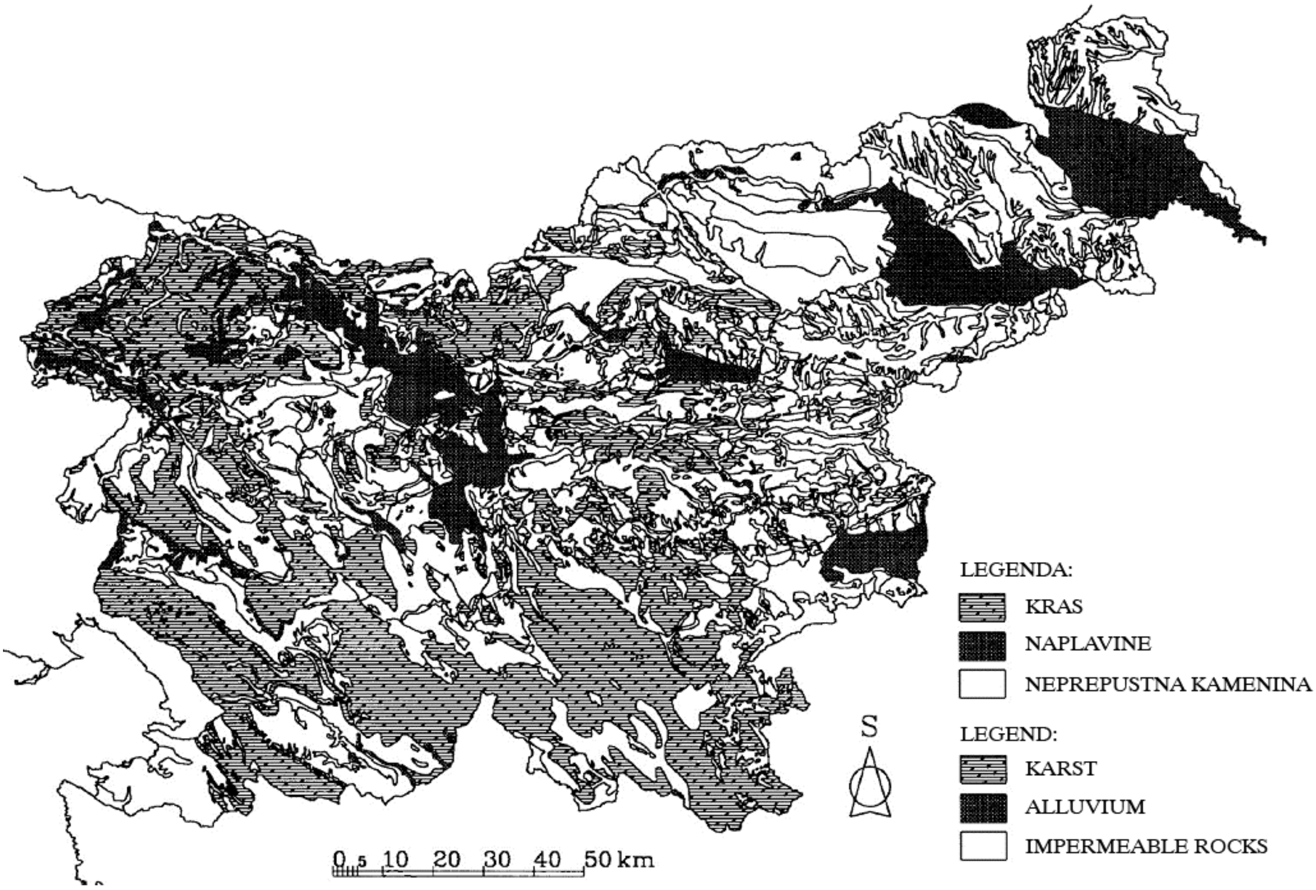
Slika 6. Hidrogeološke značilnosti tal v Sloveniji (KSH, 2005).
Figure 6. Hydrogeological characteristics of rocks in Slovenia (KSH, 2005).

Izjeme so kraška polja. So ena redkih območij, kjer so življenjske razmere primerne za človekovo poselitev, toda obenem so ta območja stalno poplavljena v mokrem obdobju leta (predvsem pomladi in jeseni). Poplave povzroči zlasti premajhna požiralna zmogljivost kraških požiralnikov.

Za strme apneniške gore alpskega sveta so značilni visoki kras, veliki površinski odtoki ob močnih padavinah in na obrobju Alp izdatni kraški izviri (npr. izvir Hubelj s srednjim pretokom 3,03 m^3/s za obdobje 1961–1990, Kolbezen & Pristov, 1998).

Karstic poljes provide an exception. These are the only areas where living conditions are favourable to human settlements, but they are also regularly flooded during the wet period of the year (especially in spring and autumn). Flooding is often caused simply by the limited capacity of the karstic sinks.

The steep calcareous mountains of the alpine region are characterized by high karst, large surface runoff during high precipitation and at the peripheries of the Alps karst springs of great yields (e.g. spring Hubelj with mean discharge of 3.03 m^3/s for the period 1961–1990, Kolbezen & Pristov, 1998).



Slika 7. Glavne hidrogeološke enote v Sloveniji (KSH, 2005).
Figure 7. Main hydro-geological units in Slovenia (KSH, 2005).

Kras nastopa tudi na jugozahodu države, npr. na Krasu, Notranjskem in Dolenjskem (slika 7). Drugi deli države so zgrajeni iz prepustnih in manj prepustnih kamnin, tako da so hidrogeološke razmere zelo spremenljive. Neogeni glinasti sedimenti vzhodne Slovenije so vzrok za slabe vodooskrbne razmere.

The karst is present also in the southwest of the country, i.e. in Kras, Kočevsko and Dolenjsko regions (Fig. 7). Other parts of the country consist of both, permeable and less permeable rocks, so that the hydrogeological conditions are highly variable. Neogene clayey sediments of the eastern Slovenia are the cause of poor water supply conditions.

2.3 Ogrožena območja

V Sloveniji so najnevarnejši naravni pojavi podori, plazenje tal, hudourniška erozija in rečna bočna erozija. Plazenje tal in erozija tal potekata na okoli 43 % slovenskega ozemlja (okoli 8.800 km^2 labilnih ali potencialno nestabilnih tal). Prepreda jih 8.000 km hudournikov, ki odvodnjavajo skoraj 400 hudourniških območij (Mikoš, 1995; Repe, 2002).

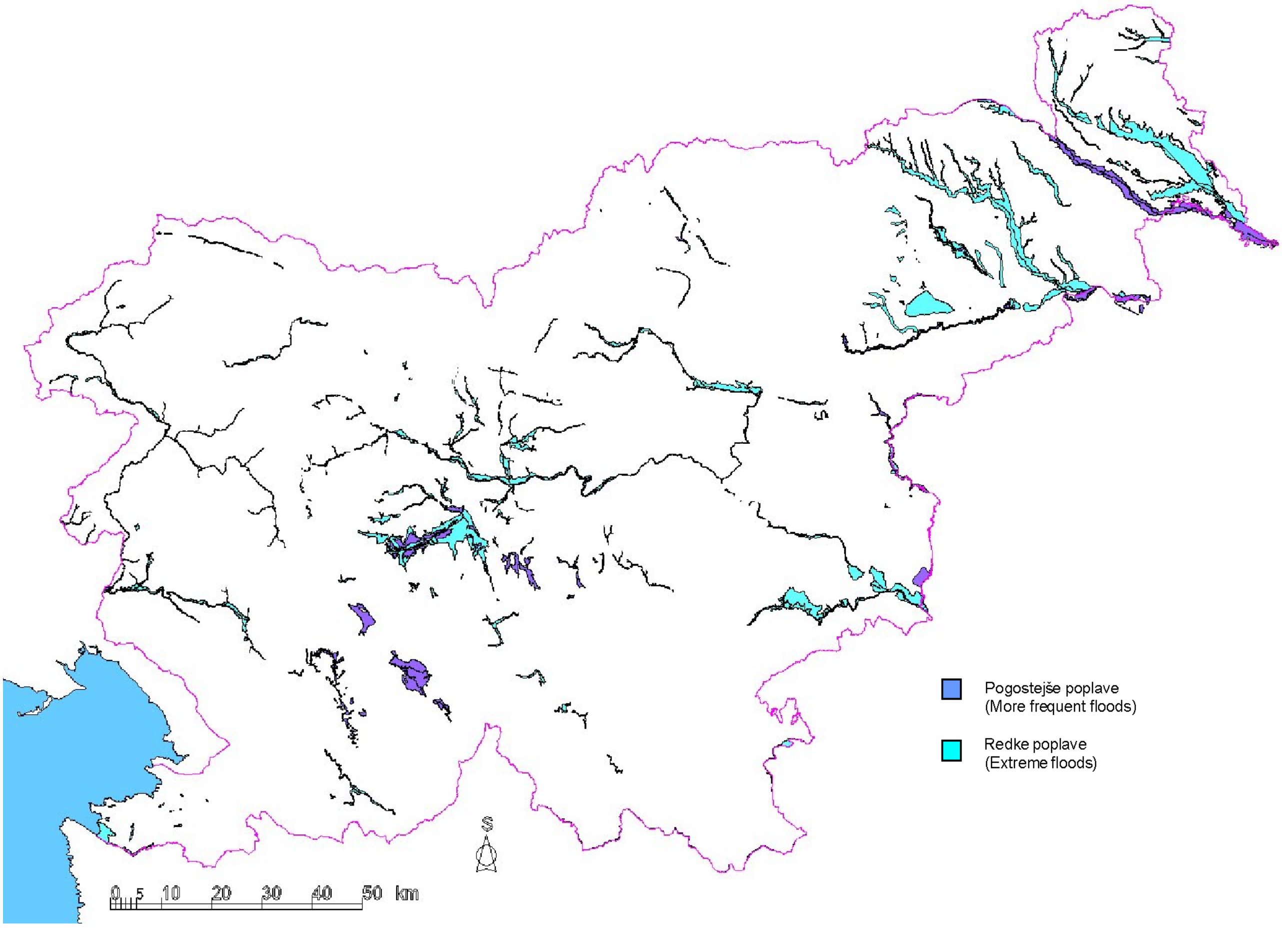
Zmerne hudourniške poplave in kraške poplave so vsakoletni dogodki, zato prebivalci te pojave poznajo. Večja poplavna območja so v nižinskem svetu ob večjih vodotokih in na

2.3 Hazard areas

In Slovenia, rock falls, landslides, torrential erosion in headwaters, and riverbank erosion are the most hazardous phenomena. Land sliding and erosion is present in about 43 % of the Slovenian territory (some 8,800 km^2 of labile or potentially unstable slopes), where some 8,000 km of torrential streams drain water from nearly 400 torrential watersheds (Mikoš, 1995; Repe, 2002).

Moderate flash floods, torrential floods and karstic floods are yearly events and therefore the population is familiar with these phenomena. The large inundated areas are in kraških poljih. Na teh območjih so ogrožene tudi kmetijske površine z intenzivno proizvodnjo in pomembnejše prometne povezave. Celotno poplavno območje v primeru ekstremnega poplavnega dogodka (Q_{100}) obsega 695 km^2 ali 3,5 % površine državnega ozemlja (slika 8), od tega je 25 km^2 urbanih območij, npr. deli Celja (tretjega največjega slovenskega mesta) in južni del Ljubljane (LMTe, 1987).

lowland areas along large rivers and on karst poljes. In this areas, agricultural land of intensive production and some vital traffic connection are under threat. The total inundated area under extreme flood event (Q_{100}) is 695 km^2 or 3.5% of the surface of the state territory (Fig. 8), out of which 25 km^2 are urban areas, i.e. parts of the City of Celje (3rd largest town) and the south part of Ljubljana (LMTe, 1987).



Slika 8. Poplavne površine v Sloveniji za pogostejše poplave (Q_{20}) obsegajo 19.990 ha in za redke poplave (Q_{100}) 69.543 ha (KSH, 2005).

Figure 8. Flooded areas in Slovenia for more frequent floods (Q_{20}) total to 19,990 ha and for extreme floods (Q_{100}) total to 69,543 ha (KSH, 2005).

Ljubljansko barje je največje poplavno območje v Sloveniji. V času katastrofalne poplave je poplavljenih 56 km^2, letne poplave pa obsegajo površino 23 km^2.

The marshes of Ljubljansko barje are the largest flooded area in Slovenia. When flooded, 56 km^2 are inundated by a catastrophic flood and yearly floods inundate an area of 23 km^2.

3. POPLAVE V SLOVENIJI

3. FLOODS IN SLOVENIA

Najstarejši zapisi o poplavah v Sloveniji segajo v srednji vek. Zapisi o poplavah na Ljubljanskem barju so nastali v letih 1190,

The oldest written records of floods in Slovenia date back to the medieval time. There are records about floods on the Ljubljansko

1537 in 1589. Prvi projekt protipoplavne zaščite Ljubljane je nastal leta 1554. Leta 1780 so izkopali Gruberjev kanal, ki poteka vzporedno naravni strugi reke. V Celju, ki je poplavno najbolj ogroženo mesto v Sloveniji, je še vidna oznaka poplave z datumom 25. september 1672. Maksimalna višina te poplave še ni bila presežena.

Novejši podatki o poplavah segajo nazaj v leto 1851, ko je pretok reke Drave dosegel 1000-letno povratno dobo. Drugi pomembnejši dogodki so bili naslednji: 1874 na reki Muri, 1876 na reki Ljubljanici, 1882 na Koroškem, 1885 na reki Dravi, 1893 na Ljubljanici in Dravi, 1898 na Vipavi, 1901 po celi Sloveniji, 1905 na območju Krasa in 1910 v prispevnem območju reke Drave. Med 1. in 2. svetovno vojno so bile katastrofalne poplave leta 1923 posledica izjemno močnega deževja (več kot 240 mm v 24 urah) in topljenja polmetrske snežne odeje. Nekoliko manj izjemne poplave so zabeležili v letih 1925, 1926 in 1933. Po 2. svetovni vojni je bila večja poplava leta 1954 v povodju reke Savinje. Med letoma 1963 in 1965 so bile po celi Sloveniji zabeležene številne poplave (geslo Poplave: ES, 1995).

Po letu 1965 ni bilo večjih poplav do leta 1983 in 1987, ko so poplave prizadele Novo Gorico. Leta 1989 so bile katastrofalne poplave v povodju reke Savinje, kar je bil le uvod v večje poplave, ki so prizadele večji del Slovenije 1990 (med poznim oktobrom in zgodnjim novembrom) in znova leta 1998 (zgodnji november). V obeh primerih je bilo poplavljeno več kot 500 km^2. Poplavi sta povzročili močno obrežno erozijo, uničenih ali poškodovanih je bilo na desetine mostov, industrijskih obratov in na stotine hiš; oba pojava so spremljali tudi plazovi. Skupna škoda je bila ocenjena na več kot 500 milijonov € (za poplave leta 1990) oziroma 170 milijonov € (za poplave leta 1998).

4. ZEMELJSKI PLAZOVI V SLOVENIJI

Hribinski in zemljinski pojavi porušitev naravnega ravnovesja so v Sloveniji predvsem vezani na geološke in morfološke razmere.

V Alpskem svetu so pogosti hribinski

barje dated 1190, 1537, and 1589. The first flood protection scheme of Ljubljana was proposed in 1554. In 1780 the Gruber canal was dug out, running parallel to the natural river channel. In Celje, which is in terms of flooding the most endangered town in Slovenia, there is a flood benchmark, dating back to September 25, 1672. Its maximum level has yet to be exceeded.

More recent flood records date back to 1851, when the Drava River discharge reached the 1000-year return period. Other significant events occurred as follows: 1874 on the Mura River, 1876 on the Ljubljanica River, 1882 in the Koroška region, 1885 on the Drava River, 1893 on the Ljubljanica and Drava Rivers, 1898 on the Vipava River, 1901 throughout Slovenia, 1905 in the area of the Kras, and 1910 in the Drava River drainage basin. Between World Wars I and II there occurred the catastrophic flood of 1923, in which the extremely heavy rainfall (more than 240 mm in 24 hours) was combined by the melting of a half-meter snow cover. Somewhat less exceptional floods were recorded in 1925, 1926, and 1933. After World War II, a large flood was recorded in 1954 in the Savinja River basin. The period between 1963 and 1965 was a period of frequent flooding throughout Slovenia (entry Floods: ES, 1995).

After 1965, large floods did not occur until 1983 and 1987, when the town of Nova Gorica was affected by flooding. However, in 1989 a catastrophic flood occurred in the Savinja River basin. This was just a prelude to larger floods that affected the greater part of Slovenia in 1990 (late October–early November) and again in 1998 (early November). Both floods inundated more than 500 km^2. Floods caused severe stream bank erosion, destroyed or damaged tens of bridges, several industrial facilities and hundreds of houses; both were accompanied by numerous landslides. Their total damage was estimated at more than 500 Mio € (for 1990 floods) and 170 Mio € (for 1998 floods), respectively.

4. LAND SLIDING IN SLOVENIA

Rock slides and landsliding phenomena of failures of the natural balance in Slovenia have been mostly associated with geological and morphological conditions.

Rock sliding phenomena frequently occur

pojavi – hribinski zdrsi in podori. Gorat svet v Sloveniji je značilen za Julijske in Kamniško-Savinjske Alpe, Karavanke in deloma Pohorje ter mejo z Italijo in Avstrijo. Hribinski podori nastopajo tudi na območjih, kjer so se karbonatne kamnine narinile na mehkejše klastične (primer: Trnovski gozd nad Vipavsko dolino) in kjer so se največje slovenske reke prebile skozi trdne karbonatne kamnine ter pri tem ustvarile debri (primer: soteska Save med Litijo in Hrastnikom). Ob zadnjih potresih leta 1976, 1998 in 2004, ki so prizadeli severnozahodno Posočje, se je v alpskem svetu sprožilo tudi veliko hribinskih podorov in zdrsov.

Zemljinski plazovi nastopajo predvsem v nižjem hribovitem in gričevnatem svetu. Hribovja, ki so značilna za predalpski svet in osrednjo Slovenijo, gradijo karbonatne in klastične kamnine. Metamorfne klastične kamnine (filiti, gnajsi in blestniki, andezitske, keratofirske in tufske kamnine) izdanjajo na pobočjih Pohorja, na Kobanskem in deloma v Karavankah. Druge klastične kamnine (peščenjaki, laporji, skrilavci) so razprostranjene po celi Sloveniji, večje enote so na Primorskem (fliš) in v okolici Ljubljane (permokarbonski skrilavi glinavci). Veliki plazovi so v teh kamninah pogosti, pri čemer plazi debel preperinski pokrov. Pod strmimi pobočji iz karbonatnih kamnin so pogosti vršaji in pobočni grušči, ki so močno podvrženi plazenju, posebej če so v podlagi klastične kamnine.

V vzhodni in severnovzhodni Sloveniji je pogost gričevnat teren z razmeroma položnimi pobočji in širokimi dolinami. Gradijo ga glinaste in meljaste zemljine, ponekod tudi laporovci, peski in glinasti prodi. Te polhribine (soft rocks) intenzivno preperevajo in plazijo. V njih so zelo pogosti zdrsi debelega preperinskega pokrova. Preperinski zemljinski plazovi so številni, prav tako porušitve ob glinastih plasteh, kadar so nagnjene.

Območja, kjer so plazenja redka ali jih ni, so kraške planote in hribovja Dolenjske, Notranjske in Krasa ter seveda široke ravninske kotline in doline, kjer tečejo največje slovenske reke. To so Ljubljansko in Kranjsko-Sorško polje, Dravska dolina, Celjska kotlina, in Krško-Brežiška kotlina.

in the Alps – rock slides and rockfalls. In Slovenia, mountainous areas are typically found in the Julian Alps, Kamniško-Savinjske Alps, Karavanke Mountains and partly in Pohorje and the area bordering Italy and Austria. Rockfalls also occur in areas, where the carbonate rock thrust over the softer clastic rock (e.g. Trnovski gozd above the Vipava valley), and where the largest Slovenian rivers found their way through the hard carbonate rock and hence created deep and narrow valleys (the Sava River gorge between Litija and Hrastnik). During the last earthquakes in 1976, 1998, and 2004, which affected the area around the Soča Valley (Posočje), several rock slides and rock falls were triggered in the Alps.

Landslides occur mainly in lower hilly areas. The hilly areas, being typical of the pre-Alpine areas and central Slovenia, consist of carbonate and clastic rock. Metamorphic clastic rocks (phyllites, gneiss and mica, andesites, keratophyre and tuffaceous rocks) are found in the Pohorje slopes, in Kobansko and partly in the Karavanke Mountains. Other clastic rocks (sandstone, marl and slate) are found all over Slovenia, with higher occurrence in the Primorska region (Flysch) and around Ljubljana (Permian-Carboniferous slate clays). Large landslides in these rocks are frequent, involving the sliding of the thick weathered cover. Below the steep slopes consisting of carbonate rock there are numerous alluvial fans and slope screes that are highly susceptible to sliding, especially if the bedrock consists of clastic rocks.

In E and NE Slovenia the hilly terrain is characterized by gently undulating slopes and fairly wide valleys. Clayey and silty rocks occur, and also marl, sands and clayey gravel. These soft rocks are highly weathered and susceptible to sliding. Failures of the thick weathered cover are frequent, as well as failures of clayey layers when sloping.

The areas with little or no sliding include Karst plateaux, and the hills of the Dolenjsko, Notranjsko and Karst regions, as well as broad lowland basins and valleys of major Slovenian rivers. These are the Ljubljansko and Kranjsko-Sorško plains, the Drava River valley, and the basins of Celje and Krško-Brežice.

Slovenia is categorized as a seismically active area with an expected earthquake

Slovenija leži v seizmično aktivnem območju s pričakovanimi jakostmi potresov do 9° EMS lestvice. Glavni razlog za nastanek potresov so premiki na stiku afriške in evrazijske celinske tektonske plošče. Pritisk afriške plošče proti evrazijski je v geološki zgodovini povzročil dvig alpskega gorovja. Med obema velikima ploščama je manjša jadranska mikroplošča, na severnozahodnem obrobju katere leži slovenski prostor. Ta plošča se premika proti severo-severovzhodu s hitrostjo 2–3 cm na leto. Poleg aktivne jadranske mikroplošče kopni del Slovenije geotektonsko pripada še Dinaridom, Alpam in Panonskemu bazenu. Jadranska mikroplošča pritiska na Dinaride, zato na stiku nastajajo narivi in prelomi dinarske smeri (severozahod-jugovzhod). Najpomembnejša sta idrijski in savski prelom.

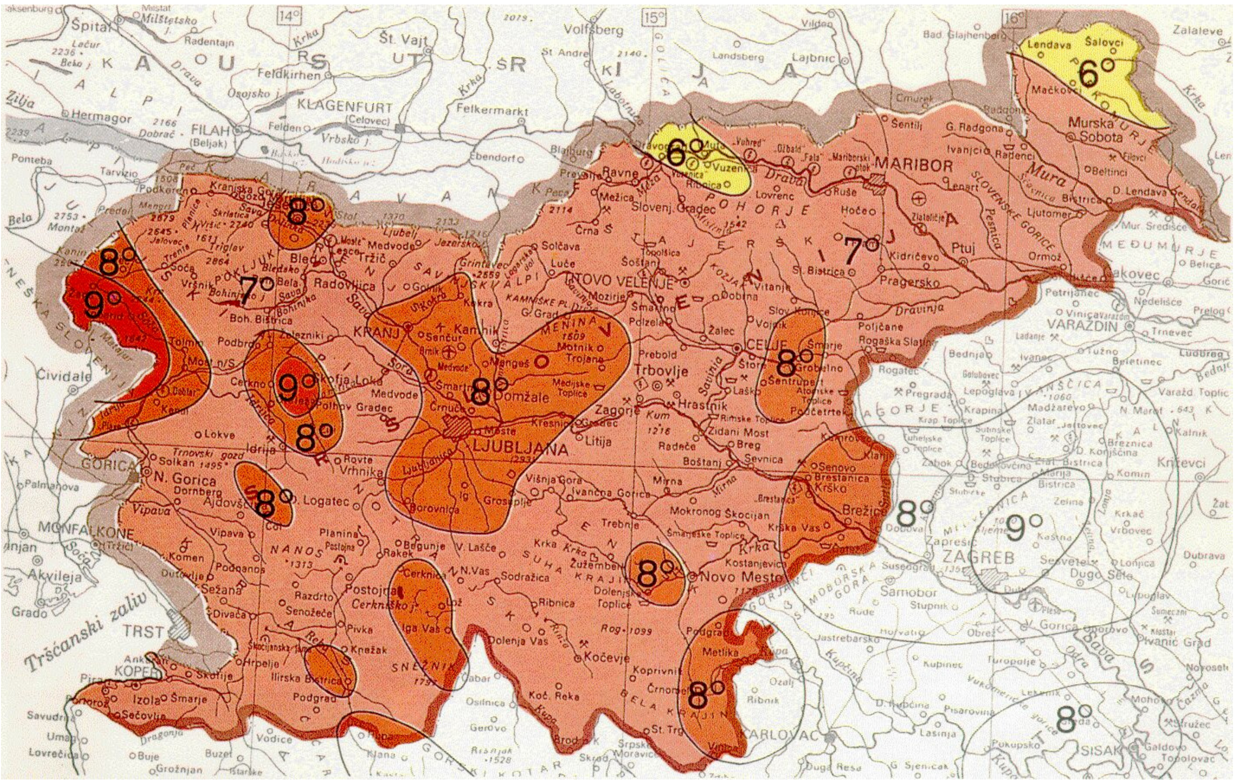
Tudi v alpskem prostoru je narivanje glavni tektonski proces, ki pa ga spremljajo premiki ob subvertikalnih prelomih. Panonski bazen pa je masa, ki se upira premikom. Za današnjo tektonsko dogajanje je značilno aktiviranje prelomnih struktur v smeri sever-jug pa tudi premiki ob starejši dinarski smeri. Ti tektonski procesi so nosilci potresov v Sloveniji. Potresi so večinoma plitvi in globoki okoli 10 km. V preglednici 1 podajamo nekaj najmočnejših potresov, ki so bili po letu 500 po našem štetju zabeleženi v Sloveniji in njeni bližini.

magnitude of 9° on the EMS scale. The main reason for the occurrence of earthquakes are displacements at the contact line of the African and Euroasian continental tectonic plates. The African plate is pushing into the Euroasian landmass, which in geological history resulted in the rising of the Alps. Between the two large plates, there is a smaller Adriatic microplate – Slovenia is situated in its northwestern fringe. The microplate moves in the N–NE direction at a rate of 2–3 cm/year. Next to the active Adriatic microplate, the territory of Slovenia geotectonically belongs to the Dinarides, the Alps, and the Pannonian Basin. The Adriatic microplate pushes against the Dinarides thus resulting in overthrusts and faults of Dinaric direction (NW–SE). The Idrija and Sava faults are the most prominent.

Overthrusting is the main tectonic process in the Alps, accompanied by displacements along the subvertical faults. However, the Pannonian Basin is the mass that offers resistance to these displacements. For today's tectonics the activation of fault structures in direction N–S is characteristic, as well as displacements along the older Dinaric direction. These tectonic processes are the main cause of earthquakes in Slovenia. The earthquakes are mostly shallow, having a depth of around 10 km. Table 1 gives some of the strongest earthquakes that were recorded in Slovenia and its neighbouring territories after 500 A.D.

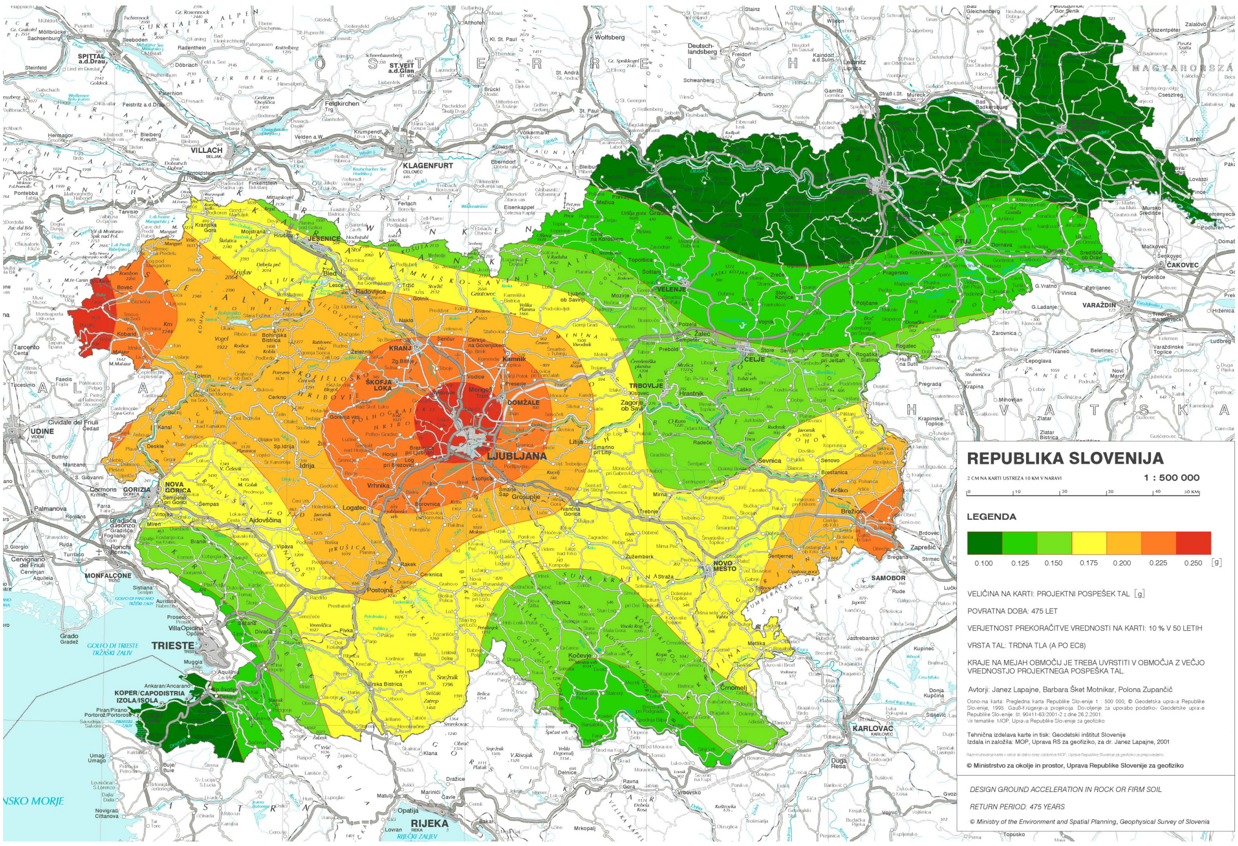
Preglednica 1. Pregled potresov največje jakosti v Sloveniji (po Ribičič & Vidrih, 1998; Zorn, 2002).
Table 1. Overview of the strongest earthquakes in Slovenia (after Ribičič & Vidrih, 1998; Zorn, 2002).

datum / *date*	jakost (MCS) / *magnitude*	lokacija epicentra / *epicenter location*
III. 792	VIII ?	osrednja Slovenija / *central Slovenia*
1000	VIII	Ljubljana
26.3.1081	VIII	Ljubljana
4.5.1081	VIII	Vitanje
25.1.1348	X (EMS)	domnevno Furlanija / presumably *Friuli*
24.3.1511	VIII-IX	Okolica Ljubljane / *near Ljubljana*
26.3.1511	IX-X	Okolica Ljubljane / *near Ljubljana*
17.6.1628	VIII	Krško
1.5.1634	VIII ?	Novo mesto
14.4.1895	VIII-IX	Ljubljana
29.1.1917	VIII	Brežice
6.5.1976	VIII	Breginj (Furlanija / *Friuli*)
15.9.1976	VIII	Breginj (Furlanija / *Friuli*)
12.4.1998	VII-VIII	Posočje / *Soča River valley*
12.7.2004	VI-VII	Posočje / *Soča River valley*



Slika 9. Potresna karta Slovenije za povratno dobo 500 let (ARSO, 2005a).

Figure 9. Seismic map of Slovenia for the return period of 500 years (ARSO, 2005a).



Slika 10. Projektni pospeški tal za trdna tla v Sloveniji v enotah zemeljskega pospeška $g = 9{,}81\ m/s^2$ in s povratno dobo 475 let (ARSO, 2005a).

Figure 10. Design ground accelerations in rocks and firm soils in Slovenia given in units of gravity $g = 9.81\ m/s^2$ and for the return period of 475 years (ARSO, 2005a).

Na osnovi preučevanja epicentrov zabeleženih potresov, neotektonike slovenskega ozemlja in deloma sestave tal je izdelana seizmična rajonizacija Slovenije, ki deli ozemlje v seizmične stopnje od 7° do 9° po EMS lestvici (slika 9). S sprejemom EUROCODE 8 je bila izdelana tudi karta projektnih pospeškov tal (slika 10). Obe karti uporabljamo v gradbeništvu za dimenzioniranje objektov.

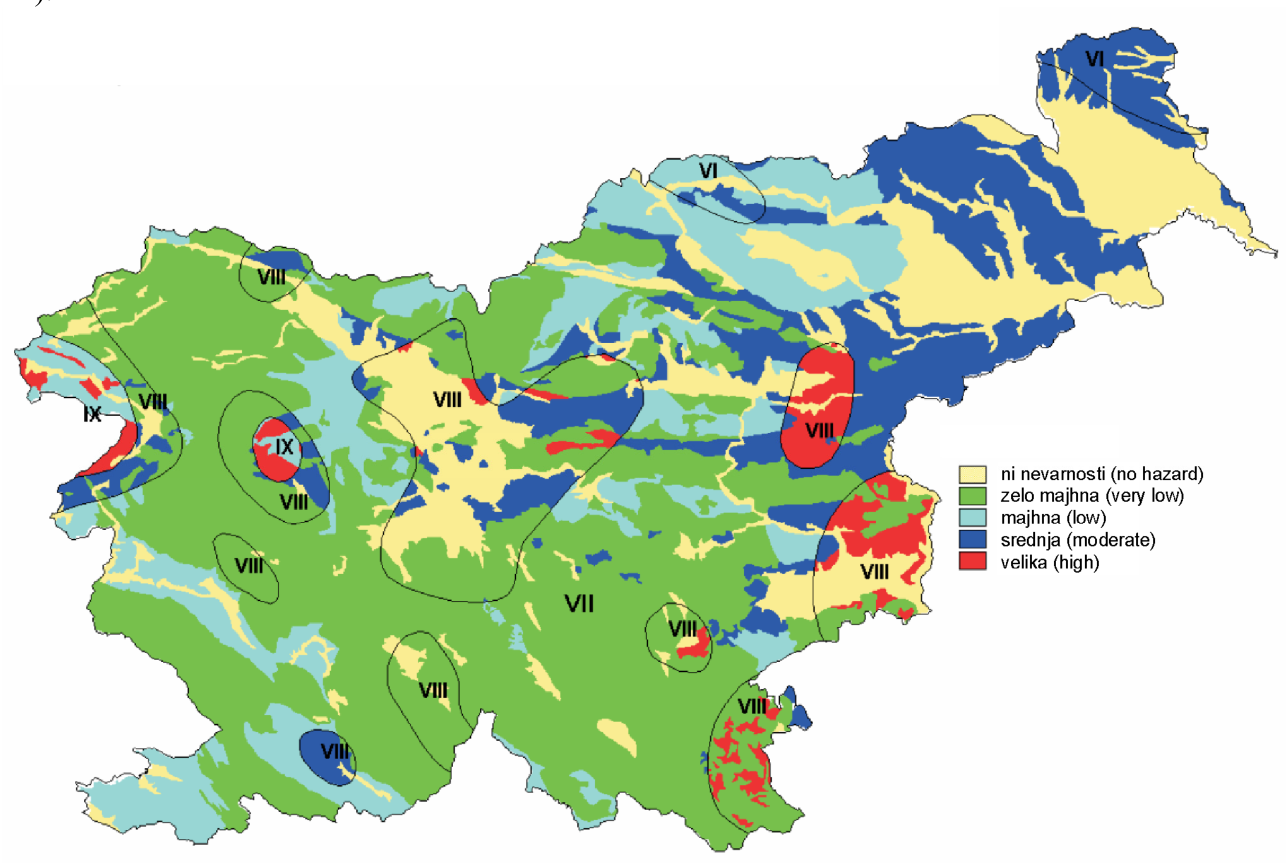
Based on studying the epicenters of the recorded earthquakes, neotectonics of Slovenian territory and partly soil composition, a seismic categorization of Slovenia was prepared, dividing the territory into seismic levels 7° to 9° on the EMS scale (Fig. 9). With the adoption of the EUROCODE 8 a map of designed ground accelerations was made (Fig. 10). Both maps are used for dimensioning in civil engineering.

5. EROZIJA TAL V SLOVENIJI

5. SOIL EROSION IN SLOVENIA

Dve tretjini slovenskega ozemlja sta podvrženi različnim erozijskim procesom in procesom nestabilnosti pobočij (za nevarne pojave, sprožene ob potresih, glej sliki 11 in 12).

Practically two thirds of the Slovenian territory are subjected to different erosion processes and slope instability phenomena (for hazardous earthquake-induced processes see Figs. 11 and 12).



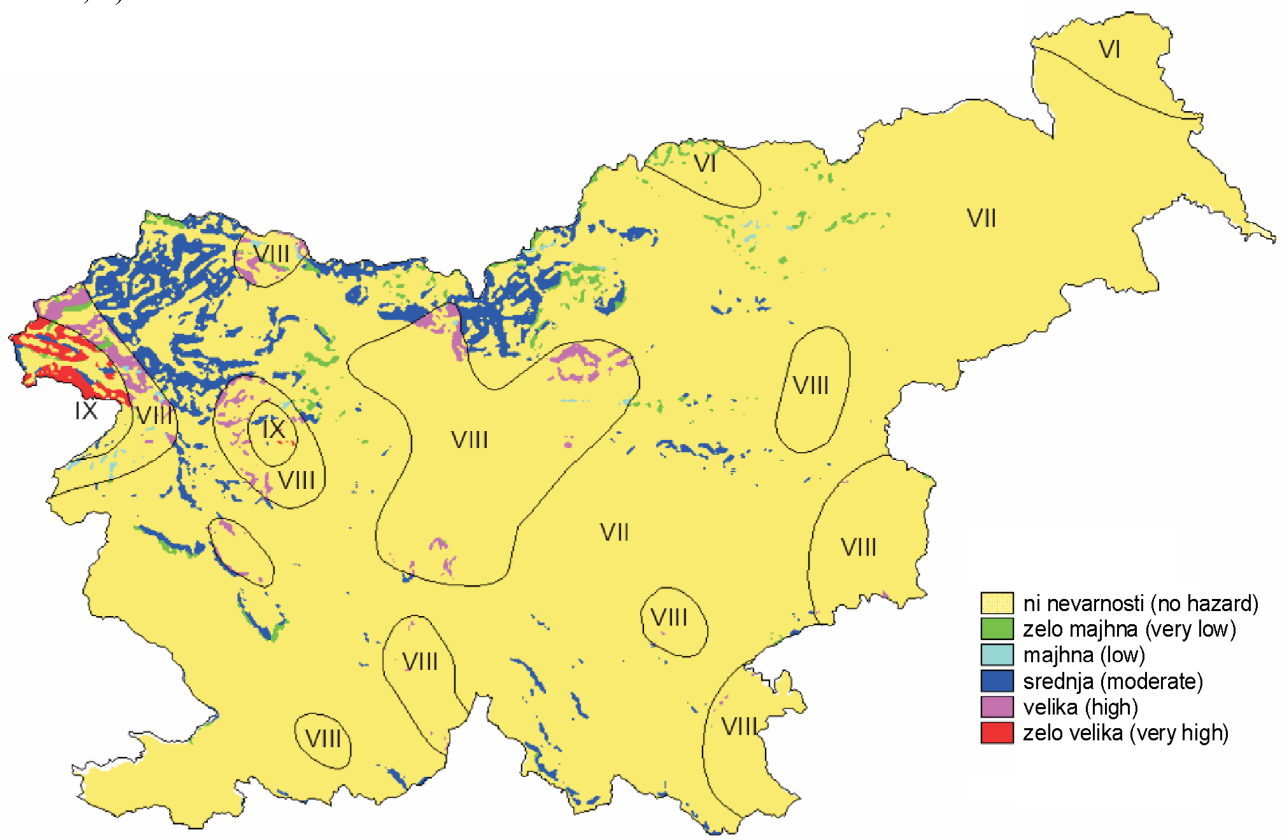
Slika 11. Karta nevarnosti nastanka plazov zaradi potresov (ARSO, 2005a).
Figure 11. Earthquake-induced landslide hazard map of Slovenia (ARSO, 2005a).

Povprečna letna količina sproščenih sedimentov v povirnih delih je ocenjena na pribl. 5 milijonov m^3 v povprečnem hidrološkem letu (Mikoš, 1995). Specifična letna količina sedimentov je ocenjena na 250 m^3 km^{-2} leto^{-1} oziroma podana kot denudacijska stopnja 0,25 mm/leto (Mikoš &

The annual average sediment production in headwater areas in Slovenia is estimated at around 5 million m^3 per average hydrological year (Mikoš, 1995). The specific annual average sediment production is estimated at 250 m^3 km^{-2} year^{-1} or it is given as the denudation rate of 0.25 mm/year (Mikoš &

Zupanc, 2000), ki je še veliko večja v aktivnih erozijskih žariščih (Pintar & Mikoš, 1983). V povprečju hidrološko mrežo doseže skoraj polovica tega materiala (okoli 2,3 milijonov m^3/leto; Mikoš, 1995), ki se zlagoma premešča v sedimentacijske bazene (Sredozemlje in Črno morje). Skoraj 0,5 milijona m^3/leto se začasno odlaga v rečnem sistemu, predvsem v umetnih zadrževalnikih, ki so bili zgrajeni za hidroelektrarne ob večjih slovenskih rekah (Soči, Savi in Dravi) v Sloveniji (Mikoš, 2000a; b).

Zupanc, 2000), being even higher in active sediment sources (Pintar & Mikoš, 1983). On average, nearly half of this material (around 2.3 Mio m^3/year; Mikoš, 1995) reaches the hydrological network and is slowly transported towards sedimentation basins (Mediterranean & Black Sea). Nearly 0.5 Mio m^3 a year is on average temporarily deposited within the fluvial system, mainly in artificial reservoirs, built for hydropower plants along the major Slovenian rivers (Soča, Sava, and Drava) in Slovenia (Mikoš, 2000a; b).



Slika 12. Karta nevarnosti nastanka podorov zaradi potresov (ARSO, 2005a).
Figure 12. Earthquake-induced rockfall hazard map of Slovenia (ARSO, 2005a).

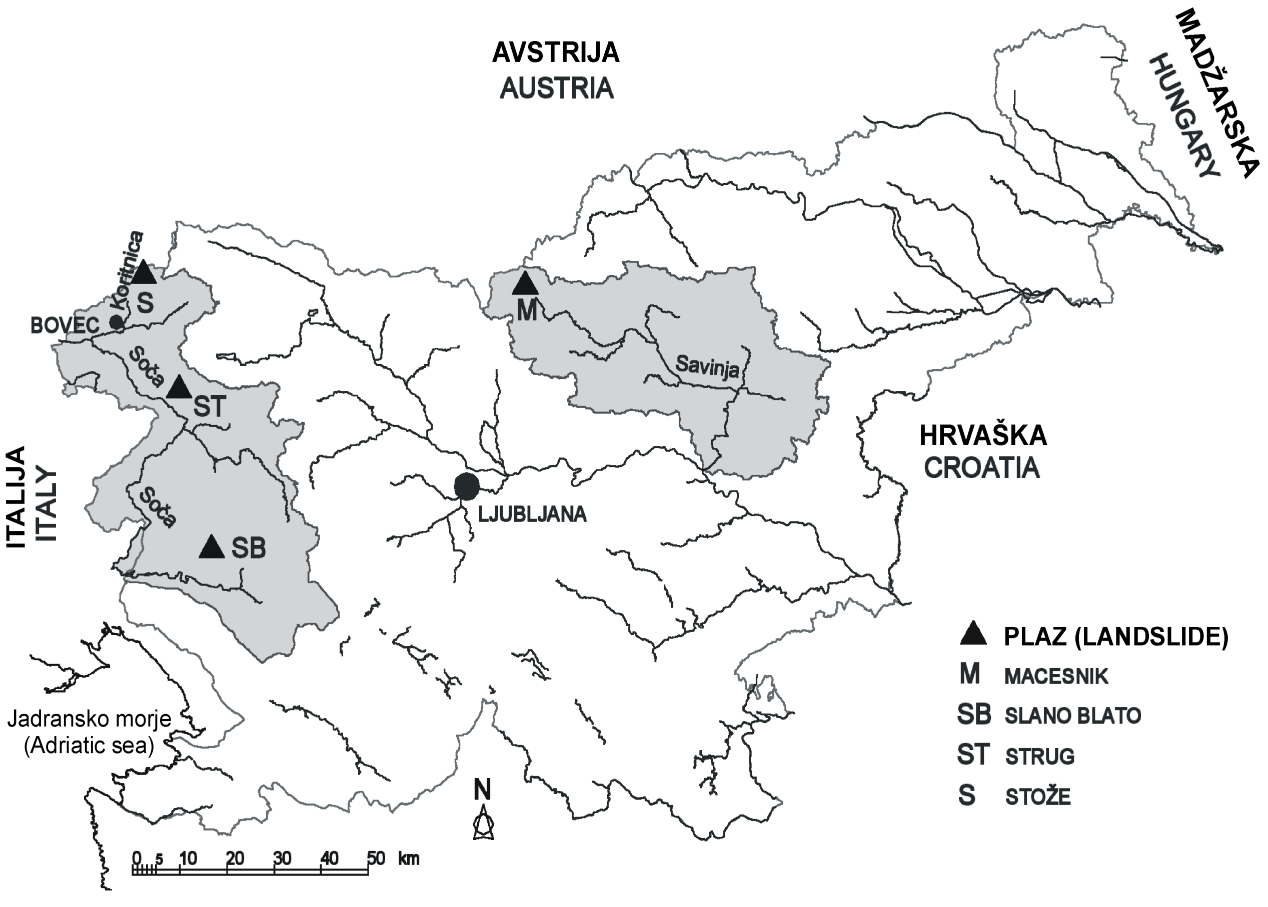
Plazenje ne ogroža le zgradb in infrastrukture, temveč je tudi vzrok za morfološke spremembe terena. Plazovi pogosto premaknejo večje količine sedimentov, ki ne le, da ne ostanejo na pobočjih, temveč dosežejo fluvialno mrežo. V katastrofalnih pogojih so lahko posledice plazenja hudourniški izbruhi, drobirski tokovi ali porušutveni valovi ob porušitvah naravnih pregrad. V Sloveniji smo da danes zabeležili okoli 2500 predvsem manjših plazov. Z izdelavo pojavnih kart plazenja tal se je uradni register plazov (elektronska baza podatkov, ki

Land sliding not only threats buildings and infrastructure, but also causes morphological changes of the terrain. Landslides often move large amounts of sediments, which not only stay on slopes, but also reach the fluvial network. Under catastrophic conditions, land sliding may lead to torrential outbursts, debris flows or dam-break waves after a dam-breach of natural dams. In Slovenia, more than 2500 mostly minor landslides have been reported (registered) so far. The official landslide inventory cadastre (electronic database developed and maintained by the Ministry of jo razvija in obnavlja Ministrstvo za obrambo) vključilo v okolje GIS. Imenuje se GIS_UJME in vključuje več kot 1500 plazov, ki ne vključujejo padanja kamenja in hribinskih zdrsov. Bazo enote civilne zaščite uporabljajo za koordiniranje reševanja po naravnih nesrečah in se ne uporablja v preventivne namene. Žal so v bazi podani zgolj centroidi plazov v Gauss-Kruegerjevem koordinatnem sistemu. Baza se ves čas obnavlja.

Manjši plazovi so različnih oblik (večinoma so to plitki plazovi in usadi). Večinoma se sprožijo med kratkotrajnimi, a intenzivnimi padavinami ali po dolgotrajnem deževnem obdobju z zmernimi padavinami. Njihova povprečna masa je reda 1000 m^3, redko pa 10.000 m^3. Nekatere plazove so stabilizirali tehnični posegi, drugi so še vedno aktivni. Neugodne geološke razmere so poglavitni vzrok za tako visoko gostoto plazenja (> 1 plaz/10 km^2), kljub dobrim vegetativnim razmeram. Drugi dejavnik je velika količina padavin oziroma število dni z dnevno količino padavin nad 20 mm.

Defence) was incorporated into the GIS environment. It is called GIS_UJME and it includes more than 1500 landslides without rock falls and rock slides. This database is now used only for immediate relief actions by Civil Defence units and not for prevention purposes. In this database, unfortunately, only the centroids of landslides in Gauss-Krueger co-ordinates are given. Today, this database is being updated.

Minor landslides are of different forms (mainly shallow slides and slumps). They are mainly triggered during short and intense rainfall events or after prolonged rainfall periods of moderate intensities. The order of their average volume is 1000 m^3, rarely 10,000 m^3. Some of them have been stabilised using technical measures, others are still active. Unfavourable geological conditions are the main causes for such a high slide density (> 1 slide/10km^2), despite good vegetation conditions. The next contributing factor is the abundance of precipitation and a high number of days with daily totals above 20 mm.



Slika 13. Aktivni plazovi večjega obsega v Sloveniji v letu 2004.
Figure 13. Active large landslides in Slovenia in 2004.

V zadnjih desetletjih 20. stoletja so prevladovali manjši plazovi. Primer so številni usadi in zemeljski tokovi v povodjih Kozarice in Lahomnice med poplavo leta 1989. Z večjimi poplavami v porečju Savinje leta 1990 je bil povezan tudi večji plaz v bližini vasi Luče. Potrebnih je bilo več let, preden se je območje uspešno saniralo.

V bližini vasi Solčava se je leta 1990 sprožil Macesnikov plaz v starem fosilnem plazu. Plaz, katerega masa znaša prek 2 milijona m^3, je še vedno aktiven.

V zadnjih letih so se v Sloveniji sprožili še trije večji plazovi (Stože, Strug, Slano blato, slika 13). Vsak od njih ima prostornino reda velikosti 1 milijon m^3.

V zelo mokrem letu 2000 sta postala aktivna plazova Stože in Slano blato. Decembra 2001 se je sprožil plaz Strug kot kombinacija primarnega padajočega kamenja, drugega (sekundarnega) plazenja in občasnih drobirskih tokov iz izvirnega območja padajočega kamenja.

Vse lahko uvrstimo v kategorijo plazov, ki so posledica padavin, postali pa so postali aktivni zaradi neugodnih geoloških razmer. Podobne izkušnje imajo tudi drugod v alpskem prostoru in v Karpatih.

Ti štirje plazovi oziroma njihova sanacija so bili predmet posebnega zakona, ki je bil sprejet marca 2002. Njihova dokončna sanacija bo končana po letu 2006. Skupna vsota, ki bi pokrivala stroške vseh načrtovanih sanacijskih ukrepov, je bila ocenjena na skoraj 33 milijonov €. To vsoto je treba prišteti 69,1 milijonom €, namenjenih sanaciji manjših plazov v Sloveniji.

Količina sedimentov teh treh večjih plazov je primerljiva z letno količino sproščenih sedimentov v Sloveniji (povprečno okoli 5 milijonov m^3 na površini 20.257 km^2). Toda vnos sedimentov v fluvialni sistem s teh plazov je bistveno drugačen. Plazovi občasno lahko sprožijo večje količine sedimentnega drobirja, ki vstopa v fluvialno mrežo in povečuje sedimentno premeščanje s povirij. Pomemben podatek je tudi, ali material doseže vodotoke. Če se plazenje spremeni v hitrejše pojave premeščanja gradiva, kot sta blatni tok in drobirski tok, potem nestabilne mase lahko v rečni sistem prispevajo velike količine sedimenta.

In the last decades of the 20th century smaller rainfall-induced landslides were prevailing, such as numerous slumps and earth flows in the Kozarica and Lahomnica catchments during the 1989 flood. A large landslide near the village of Luče was associated with the large floodings in the Savinja River basin in 1990. It took several years before the affected area could be successfully rehabilitated.

Near the village of Solčava, in the same event in 1990, the Macesnik landslide was initiated in an old fossil landslide. This landslide grew up to a volume over 2 Mio m^3 and it is still active.

In the last years, three more large landslides (Stože, Slano blato, Strug, Fig. 13) were triggered in Slovenia. Each of them had a volume of the order of 1 Mio m^3.

In the very wet year of 2000, the Stože and Slano blato landslides became active. In December 2001, the Strug landslide was initiated as a combination of a primary rock fall, a secondary landslide and occasional debris flows from the rock fall source area during intense rainfalls.

All of them can be placed in the category of rainfall-induced landslides that became active in unfavourable geological conditions. Similar experience can be found elsewhere in the Alps and Carpathians.

These four large landslides and their mitigation have been subjected to a special law adopted in March 2002. Their final mitigation is to be finished after 2006. A total sum to cover the costs for all the planned activities in terms of mitigation of these large landslides in Slovenia was estimated at nearly 33 Mio €. This sum should be added to the estimated sum of 69.1 Mio € as the sum of remediation costs for smaller landslides in Slovenia.

Sediment production of these large landslides is comparable to the annual average sediment production in Slovenia (around 5 Mio m^3 on average a year on 20,257 km^2). The sediment delivery to the fluvial system from these landslides is very different. They may occasionally release large amounts of sediment debris, which enter the fluvial network and increase the sediment supply from headwaters. An important point is whether or not the sliding mass reaches the watercourse. If land sliding changes into faster moving mass wasting phenomena, such as mudflows or debris flows, the unstable landslide masses may contribute large amounts of sediment to the fluvial system.

6. PRIZADEVANJA NA PODROČJU ZAKONODAJE

Urad za upravljanje z vodami deluje v okviru Ministrstva za okolje in prostor. Leta 2004 smo praznovali 120. obletnico organiziranega varstva pred hudourniki. Nekateri kamniti objekti, zgrajeni pred sto leti, so še danes v dobrem stanju in služijo svojemu namenu.

Leta 2002 je bil sprejet novi Zakon o vodah. Zakon podaja posebno ureditev, ki je bila pripravljena za izdelavo kart nevarnosti za potrebe prostorskega planiranja. Ta preventivni pristop pri kartah nevarnosti predvideva kartiranje snežnih plazov, poplav, zemeljskih plazov, hribinskih plazov in procesov rečne in hudourniške erozije. Pripravljene so bile ustrezne metodologije za karte nevarnosti za poplave in zemeljske plazove.

Na področju varstva pred poplavami se uspešno uporablja kombinacija vremenskih napovedi, meteoroloških modelov za omejena območja (ALADIN-SI; ARSO, 2005c) ter 24-urnih informacijskih centrov. Služba Civilne zaščite in gasilci, ki so odgovorni za opozarjanje, alarmiranje in reševanje v primeru naravnih nesreč, so pod nadzorom Ministrstva za obrambo.

Podrobnejšo analizo preventivnega obvladovanja tveganj zaradi naravnih nevarnosti s pregledom postopkov v alpskih deželah in v Sloveniji podajamo drugje (Đurović & Mikoš, 2004).

7. ZAKLJUČKI

Na osnovi prikazanega pregleda lahko zaključimo, da je precejšen del Slovenije podvržen nevarnim naravnih procesom in zaradi razpršene poselitve in goste mreže prometnic tudi relativno ogrožen s pojavi plazenja tal, odlomi kamenja in skalnimi podori ter poplavami. Na to kažejo tudi pogoste ujme, ki vsako leto obremenjujejo državni proračun in predvsem lokalne skupnosti. Te so v večini primerov premajhne, da bi se lahko same lotile odprave posledic večjih naravnih nesreč (zemeljskih plazov in

6. LEGISLATION EFFORTS

The sector of water management in Slovenia is under responsibility of the Ministry of the Environment and Spatial Planning. In 2004, torrent control in Slovenia celebrated the 120-year anniversary of organised torrent control service. Some control structures built of stone even a hundred years ago are still in good condition and in operation today.

In 2002, a new Water Act was adopted. It provided for special regulations prepared for the making of hazard maps, used in spatial planning procedures. This prevention approach includes hazard maps of snow avalanches, floods, landslides and rock falls, river and torrential erosion processes. Adequate methodologies for hazard maps of floods and landslides have been prepared.

In the field of flood defence, a combination of weather forecasts using the limited area meteorological model (ALADIN-SI; ARSO, 2005c) and emergency information centres with 24-hour service is quite effective. The civil protection service and fire brigades that are responsible for warning, alarming and rescuing during natural disasters are under the control of the Ministry of Defence.

A detailed analysis of preventive management of risks due to natural hazards with an overview of procedures in the Alpine countries and in Slovenia is given elsewhere (Đurović & Mikoš, 2004).

7. CONCLUSIONS

On the basis of the overview given in this paper one may conclude that a considerable part of Slovenia is subjected to natural hazards. Due to the dispersed settlement pattern and dense traffic network it is under relatively high risk imposed by landsliding, stonefalls, rock falls, and floods. This situation is confirmed by regular disasters that handicap the state budget and especially the local communities each year. Rural communities are in the majority of cases too small to proceed with mitigation of increasingly frequent natural disasters (landslides and floods). In poplav). V takih razmerah lokalna skupnost čaka in računa na pomoč države.

Nujno je nadaljnje delo na področju "rizičnega menedžmenta", zlasti krepitev strokovnega dela na področju preventive, uvajanje podrobnejših zakonskih določil s tega področja, predvsem pa določanje ogroženih območij in sprejem zakonskih predpisov.

such circumstances, local communities wait for and rely on the help of the state.

Further work in the field of "risk management" is necessary, especially the strengthening of the professional work in the field of prevention, introduction of detailed legislation rules related to natural disasters, and above all the delineation of hazard areas and the adoption of legal acts.

VIRI – REFERENCES

ARSO (2005a). http://www.arso.gov.si/podro~cja/potresi/podatki/

ARSO (2005b). http://www.arso.gov.si/podro~cja/vode/poro~cila_in_publikacije/

ARSO (2005c). http://www.arso.gov.si/podro~cja/vreme_in_podnebje/napovedi_in_podatki/

Đurović, B., Mikoš, M. (2004). Preventivno obvladovanje tveganj zaradi naravnih nevarnosti – postopki v alpskih državah in v Sloveniji = Preventive management of risks due to natural hazards – procedures in Alpine countries and in Slovenia. *Acta hydrotehnica* **22/36**, 17–35.

ES (1995). Enciklopedija Slovenije = Encyclopaedia of Slovenia, Vol. 9, Plo–Ps, Mladinska knjiga, Ljubljana, 416 p. (in Slovenian).

HMZ (1995). Klimatografija Slovenije 1961–1990 – padavine = Climatography of Slovenia 1961–1990 – Precipitation. Hidrometerološki zavod Republike Slovenije, Ljubljana, 366 p.

Kolbezen, M., Pristov, J. (1998). Površinski vodotoki in vodna bilanca Slovenije = Surface Streams and Water Balance of Slovenia. Ministry of the Environment and Physical Planning, Hydrometeorological Survey, Ljubljana, 45 p.

KSH (2005). http://ksh.fgg.uni-lj.si/ewnsi/

LMTe (1987). Vodnogospodarska urejenost posameznih OVS – Informacijski sistemi = Water Management Status of Single Regional Water Authorities – Information Systems. Report No. d-268, Laboratory of Fluid Mechanics, University Edvard Kardelj, Ljubljana, 84 p.

Mikoš, M. (1995). Soodvisnost erozijskih pojavov v prostoru. *Gozdarski vestnik* **53**, 342–351 (in Slovenian with English abstract).

Mikoš, M. (2000a). Prodna bilanca reke Save od Jesenic do Mokric = Sediment budget of the Sava River from Jesenice to Mokrice. *Gradbeni vestnik* **49**, 208–219 (in Slovenian with English abstract).

Mikoš, M. (2000b). Zasipavanje akumulacijskih jezer na reki Savi = Sedimentation of retention basins on the Sava River. *Gradbeni vestnik* **49**, 224–230 (in Slovenian with English abstract).

Mikoš, M. & Zupanc, V. (2000). Erozija tal na kmetijskih površinah = Soil erosion on agricultural land. *Sodobno kmetijstvo* **33**, 419-423. (in Slovenian).

Mikoš, M., Četina, M., Brilly, M. (2004). Hydrologic conditions responsible for triggering the Stože landslide, Slovenia, *Engineering Geology* **73**, 193–213.

Pintar, J. & Mikoš, M. (1983). Izdelava smernic in normativov z globalno usmeritvijo urejanja po ekosistemih, pojavnostih in ekološki primernosti ter načinov gospodarjenja s povirji voda = Making of guidelines and normatives with global control orientation according to ecosystems, phenomena, and ecological suitability, and to methods of watershed management. Unpublished Report C-493, Water Management Institute, Ljubljana, 90 p.

Repe, B. (2002). Soil degradation threat to Slovenia's landscapes = Ogroženosti slovenskih pokrajin zaradi degradacije prsti. *Acta geographica* **42**, 99–121.

Ribičič, M. & Vidrih, R. (1998). Plazovi in podori kot posledica potresov = Earthquake-induced landslides and rockfalls. *Ujma* **12**, 95–105.

SURS (2005). http://www.stat.si/

URSZR (2005a). http://www.sos112.si/slo/tdocs/met_zemeljski_2.pdf
URSZR (2005b). http://www.sos112.si/slo/tdocs/zem_plaz_gis_ujme.pdf
Zorn, M. (2002). Podori na Dobraču = Rockfalls on Mt. Dobratsch. *Geografski vestnik* **74**(2), 9–20. (In Slovenian with English summary).
ZVSS (1978). Vodnogospodarske osnove Slovenije = Water Management Fundamentals of Slovenia. Zveza vodnih skupnosti Slovenije, Ljubljana (in Slovenian).

Naslov avtorjev – Authors' Addresses

izr. prof. dr. Matjaž Mikoš
Univerza v Ljubljani – University of Ljubljana
Fakulteta za gradbeništvo in geodezijo – Faculty of Civil and Geodetic Engineering
Oddelek za gradbeništvo – Department of Civil Engineering
Jamova 2, SI-1000 Ljubljana
E-mail: mmikos@fgg.uni-lj.si

prof. dr. Mitja Brilly
Univerza v Ljubljani – University of Ljubljana
Fakulteta za gradbeništvo in geodezijo – Faculty of Civil and Geodetic Engineering
Oddelek za gradbeništvo – Department of Civil Engineering
Jamova 2, SI-1000 Ljubljana
E-email: mbrilly@fgg.uni-lj.si

doc. dr. Mihael Ribičič
Univerza v Ljubljani – University of Ljubljana
Naravoslovnotehniška fakulteta – Faculty of Natural Sciences and Engineering
Oddelek za geologijo – Department of Geology
Aškerčeva 12, SI-1000 Ljubljana
E-email: mribicic@ntfgeo.uni-lj.si