Chapter 1
Anthropogenic Geomorphology: Subject and System

József Szabó

Abstract Today the human agent is equal in importance to other geomorphic factors. Although the energy released by human society is insignificant compared to the endogenic forces of the Earth (tectonic movements, volcanic activity, earthquakes), human impact is not only commeasurable to the influence of exogenic processes but even surpasses their efficiency. Exponential population increase involved higher demands and the energy made available to meet the demands resulted in large-scale reworking of surface materials – at an even more rapidly growing rate, a process which is likely to be continued in the future. The subject of anthropogenic geomorphology is the description of the wide and ever-widening range of surface landforms, extremely diverse in origin and in purpose, created by the operation of human society. In a broader sense, artificially created landforms have manifold influences on the environment (e.g. alterations in meso- and microclimate, biota, etc.) and modify natural processes.

Keywords Anthropogenic geomorphology · Subject · System · Classification

1.1 Subject

Chapter presents – in a theoretical approach but through a wide range of examples – the complexity of direct and indirect interactions between the elements of natural systems as well as the ever-intensifying and diversifying external human interventions into such systems. The physical environment of humankind (the envelopes of the Earth, the geographical sphere) is virtually in no part exempt from some kind of human influence, usually cascading through the system and acting back on human society itself. Therefore, it is a logical research objective to

J. Szabó (✉)
Department of Physical Geography and Geoinformatics, University of Debrecen, Egyetem tér 1, 4010 Debrecen, Hungary
e-mail: wagner@puma.unideb.hu

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analyse the problems resulting from the above interactions in the most comprehensive approach possible. Now the individual disciplines of earth sciences, specialized on different spheres of the global environment, should devote more attention to research of that kind.

Tasks are also identified in the discipline of geomorphology, which studies landforms, their changes and impacts on other spheres of the global environment:

- Firstly, today the human agent is equal in importance to other factors in the shaping of the Earth's landforms. Although the intensity of its influence depends on the energy released by human society, which is insignificant compared to the endogenic forces of the Earth (tectonic movements, volcanic activity, earthquakes), it is not only commeasurable to the energy which drives most of the exogenic processes but even surpasses the effectiveness of some of them. In the estimation of R.L. Sherlock (1922), the material mobilized by human society on the territory of Great Britain amounted to ca. 30.5 km^3, which would cover the island in ca 13.3 cm depth as opposed to the ca. 7-cm deep layer removed from the surface by exogenic processes over the timespan of 2,000 years. In 1982, Holdgate estimated the annually reworked total soil and rock masses on the Earth at 3×10^{12} t (Holdgate 1982). It is two orders of magnitude higher than the annual total discharge of all rivers (2.4×10^{10} t – according to Judson 1968).
- Secondly, geomorphologists have to study this problem since the geomorphic impact of humans is growing exponentially. Exponential population increase involved higher demands and the energy made available to meet the demands resulted in large-scale reworking of surface materials – at an even more rapidly growing rate. This tendency – at least in the near future – will obviously continue. Consequently, the identification and assessment of impacts will be increasingly important.
- Thirdly, human impact on the Earth's surface does not only influence other natural systems but have a reaction on itself as well to an ever-increasing degree. The rightful judgement that humans are the inhabitants (or sometimes victims) of an environment created (or modified) by themselves is also true for the geomorphic action of humans.

The above considerations clearly pave the way to the formulation of the subject of anthropogenic geomorphology.

In the first approximation, the subject of anthropogenic geomorphology is the description of the wide and ever-widening range of surface landforms, extremely diverse in origin and in purpose, created by the operation of human society. In the above interpretation it is part of dynamic geomorphology since by now human action has established itself as one of the geomorphic agents. If the investigation of the geomorphic action of rivers and its products are labelled 'fluvial geomorphology', an analogous definition can apply to 'anthropogenic geomorphology' too. At a closer look, however, it is found that anthropogenic geomorphology can also be interpreted more narrowly and widely but certainly in a more complex way.

- In a narrower sense, although all human constructions (buildings, industrial plants) modify the appearance of the landscape, they are not regarded as subjects of geomorphological investigation. Such artificial constructions contrast with their environs in size or other properties and undoubtedly influence them. The skyscrapers in Manhattan have fundamentally transformed the landscape but they are outside the scope of geomorphology. In contrast, the Hisarlik Hills over the ruins of Troy and the tells in the Middle East are true geomorphological objects.
- At the same time, the subject of anthropogenic geomorphology is broadened by the fact that the artificially created landforms have manifold influences on the environment (e.g. alterations in meso- and microclimate, biota, etc.). In addition, they may also modify natural processes. New geomorphic processes may be initiated or active processes may be intensified or weakened or even inhibited. As a consequence, new landforms may be generated – not directly by human activities but they would have not formed or not formed in the manner they did without previous human interference. Human geomorphic action may induce cascading environmental changes, whose study obviously lies within the scope of anthropogenic geomorphology. The investigation of the impacts also covers the geomorphic processes induced by the objects which were excluded from anthropogenic geomorphological research above.
- The inevitable complexity of anthropogenic geomorphology derives from the character of natural systems and human activities. Humans interfere with these systems, including geomorphological ones, from outside and thus necessarily disturb the natural order (dynamic equilibrium) of the processes, which has evolved over timespans of various lengths. Man-made landforms are alien to the landscape and through establishing new geomorphological conditions, humans drastically upset the equilibrium. With the appearance of such landforms – if they are not used any more and not maintained by humans – tendencies towards a new equilibrium begin to show. For the society it means uncertainty or occasionally even a threat. On the one hand, it is not easy to predict either the direction of transformation or the nature of the new equilibrium. Both may be deleterious not only for society but also for other natural systems. On the other hand, in the first period of the relaxation time necessary to reach a new equilibrium, changes are rather rapid and may even lead to disastrous consequences. It is far from being a matter of chance that major accidents in the environs of human constructions (dams, waste tips, etc.) usually occur shortly after they were built.

The scope of anthropogenic geomorphology does include not only the study of man-made landforms but also the investigation of man-induced surface changes, the prediction of corollaries of upset natural equilibria as well as the formulation of proposals in order to preclude harmful impacts. The above topics and tasks make anthropogenic geomorphology a discipline of applied character. Its achievements should also serve – in addition to promoting the implementation of socio-economic tasks – environmental protection and nature conservation. When talking about the scope and tasks of anthropogenic geomorphology, another consideration cannot be

neglected either. Since most human constructions are located in an environment where natural processes are also active and occasionally even present a hazard to human constructions, human society logically attempts to defend itself against them. In this effort it tries to block or deter natural geomorphic processes and this is how it contributes to geomorphic evolution. Therefore, the protective actions against natural hazards may have implications for anthropogenic geomorphology. If the view is accepted that some structures (like settlements) are so perfectly fitted in the landscape that they function as its natural components, the protection of such structures can be approved even from the viewpoint of nature conservation. The mode of protection, however, is also of importance. When modifying the surface in order to protect us against harmful influences, the considerations of environmental protection and nature conservation have to be taken into account and anthropogenic geomorphological research should cover this field, too.

1.2 System

The thematic complexity and multiple tasks of anthropogenic geomorphology call for a clear internal systemization of the discipline. It is a widespread approach to systemize on the basis whether human action is of *direct* or *indirect* impact on the surface. The direct impact is usually intentional and conscious, leading to clearly recognizable consequences. The less readily identifiable outcomes of indirect human impact, however, are also within the scope of anthropogenic geomorphology and should also be included in its system. Spencer and Hale (1961) classified human actions according to the way their products are related to the initial surface. On this basis they distinguished constructive, excavational, hydrological and agricultural interventions. The latter two can be regarded as the planation of the surface. Similar consideration provides the background to Haigh's (1978) classification. In a simplified form his system is based on the following distinctions:

1. Direct anthropogenic processes
   1.1. constructive
   1.2. excavational
   1.3. hydrological
2. Indirect anthropogenic processes
   2.1. acceleration of erosion and sedimentation
   2.2. subsidence
   2.3. slope failure
   2.4. triggering earthquakes

The system outlined above can be made more logical and complete if, as a first step, human influences are classified from the viewpoint usual for natural geomorphological processes (Table 1.1). In the classification ideas published in the papers

Table 1.1 Geomorphic impacts of human society (with examples) (by Szabó in Szabó J & Dávid L (eds) (2006))

Type of intervention	Land-form type	Direct		Indirect	
		Primary	Secondary	Qualitative	Quantitative
Montanogenic	E	–	Open-cast pits	Subsidences	Fluvial landforms caused by mine water inflow
	P	–	Waste-filled valleys	Accumulation in pits	
	A	–	Waste tips	Bulges around tips	
Industrogenic	E	Cooling lake basins	Quarries for planation	Mass movements on industrial raw material deposition sites	Accelerated erosion by sewage inflow
	P	'Industrial estates'	Slurry reservoirs		
	A	Sockles for windmills	Slag deposition sites		
Urbanogenic	E	Cave dwellings	Loam pits	Cellar collapses	Erosion by runoff from sealed surfaces
	P	P for construction	Garbage disposal sites		
	A	Tells, burial hills	Debris hills		
Traffic	E	Road cuts	Hollow roads	Slumps on embankments	Increased piping
	P	Airfields	Mounds removed		
	A	Embankment	Roadside A		A in culverts
Water management	E	Artificial channels	Navvy pits	Abrasion due to impoundment	Rapid incision
	P	Polders	Cutoffs		
	A	Levees	A by dredging channels		A behind dams
Agrogenic	E	Waterholes	Excavation pits	Rapid gullying	Deflation forms
	P	Terraces	Pseudoterraces	Sheetflow	Silt spreading
	A	Lynchets	Stone ridges	Alluvial fans	Delta expansion
Warfare	E	Moats	Bomb craters	Avalanches caused by explosions	Erosion modified water-courses for defence purposes
	P	Airfields	Destroying settlements		
	A	Earthworks	'Trümmelberge'		
Tourism, sports	E	Recreation lake basins	Field sports (moto-cross) landscapes	Abrasion along recreation lake shores	Accelerated erosion along hiking paths
	P	Sports tracks			
	A	Ski-jumping ramps			

E = excavation processes/landforms; P = planation processes/planated landforms; A = accumulation processes/landforms

of Goudie (2007), Erdősi (1987) and Szabó (1993) are also incorporated. Erosion, i.e. processes mostly leading to material deficit, 'negative landforms' (depressions on the surface) finds its counterpart as *excavation* in anthropogenic geomorphology. Accumulation on the surface, mostly producing 'positive landforms' (elevations), can be called constructive, *aggradational* or even here accumulational landforms. The third type of landforms, frequently produced by human action, cannot be referred unambiguously into the categories of natural geomorphic processes: it is called *planation*, which can result from both erosional and accumulational processes under natural conditions. It is often the case in anthropogenic geomorphology, too. Through planation, humans can even destroy landforms created by themselves or by nature (e.g. filling a valley with debris, smoothing a sand dune or even a settlement). In a general formulation, mostly the slope of the surface is reduced. This long-term activity is a particular hazard for the natural environment. *The above listed fundamental types of human intervention into geomorphic evolution can be distinguished within both direct and indirect impacts and it is to the purpose to make this distinction in systemization.* Another aspect of the classification of direct impacts is whether the generation of the landform is the explicit objective of human action or just a more or less unavoidable by-product. When terraces are created on the slopes of hills and mountains for agricultural purposes, the changes in the character of slopes are implemented in the interest of production and, thus, terraces are *primary* landforms here. In another situation, waste tips are accumulated during mining. In this case the 'useless' material has to be deposited in order to extract useful material. Judging from the perspective of the goal of the activity, waste tips are *secondary* landforms here.

Indirect impacts can also be further subdivided. One opportunity is offered by the above section on the subject of anthropogenic geomorphology. One of the large groups of indirect impact includes processes and landforms which would not have been triggered or originated without human action. To cite an example from the field already tackled: the gorges or 'barrancos' on the slopes of waste tips, sometimes of valley size, the alluvial fans at the footslopes of tips or the landslides presenting serious hazard all fall into this category. The processes themselves (e.g. landslides) take place entirely according to physical rules and, as a consequence, the resulting landforms are not at all different from those formed as part of natural systems. Without information on their origin, however, their environmental and geomorphological significance cannot be determined. As processes and landforms of new quality are added to the landscape, they are labelled *qualitative* and are mentioned by Erdősi (1987) as *semi-anthropogenic* processes.

There is another way of operation for indirect human impacts. The activity or the resulting landforms do not induce new processes but only modify the extent and rate of already operating processes together with their consequences. Since no new process occurs here, the impact is not qualitative but quantitative on the natural evolution of an area (*quantitative* changes or natural-anthropogenic processes as called by Erdősi 1987). A good demonstration is erosion by surface runoff. It is well known that forest clearance usually increases runoff and causes floods along rivers. In addition, in the upper section of the catchment valley, incision may accelerate,

while increased sediment load of rivers arriving onto the plain enhances the intensity of accumulation there. A change on a more modest scale – although occasionally rather spectacular and rapid – can be, for instance, mine water extracted from depth during mine operation and conducted into surface water-courses. The additional discharge accelerates incision, terraces may take shape overnight, while in other places increased accumulation alters the morphology of the environs of the water-course, thereby causing a transformation also affecting human society.

An obvious aspect is to classify anthropogenic impacts *according to the character of the human activity*. Here another general principle of dynamic geomorphology is applied. Since landforms are usually produced by an interplay of different processes, it is not always easy to distinguish the contribution of the individual processes in the resulting landscape. The whole morphology, however, cannot be interpreted without precise knowledge of the characteristic mechanism and geomorphic impact of the individual processes. To this end, the geomorphic action of rivers and of wind is treated separately as fluvial or eolian geomorphology. As an analogy the impact of the individual branches of the productive activity of human society has to be also investigated separately. Given the large number of the branches, the classification may be too complicated. In a hierarchical solution the main types of social activity are first identified and then further subdivided. In the papers written over recent decades the following fields of anthropogenic geomorphology have been identified:

- *Mining*. The processes involved and the resulting landforms are usually called *montanogenic*.
- *Industrial* impact is reflected in *industrogenic* landforms.
- *Settlement* (urban) expansion exerts a major influence on the landscape over ever-increasing areas. The impacts are called *urbanogenic*.
- *Traffic* also has rather characteristic impacts on the surface.
- As the first civilizations developed, highly advanced farming relied on rivers, *water management* (river channelization, drainage) occupies a special position in anthropogenic geomorphology.
- *Agriculture* is another social activity causing changes on the surface. *Agrogenic* impacts also include transformation due to forestry.
- Although *warfare* is not a productive activity it has long-established surface impacts.
- In contrast, the impacts of *tourism and sports* activities are rather new fields of study in anthropogenic geomorphology.

References

Erdősi F (1987) A társadalom hatása a felszínre, a vizekre és az éghajlatra a Mecsek tágabb környezetében (Impact of Society on the Surface, Water and Climate in the Broader Environs of Mecsek Mountains). Akadémiai Kiadó, Budapest

Goudie A (2007) The Human Impact on the Environment. 6th edn. Blackwell, Oxford

Haigh MJ (1978) Evolution of Slopes on Artificial Landforms. University of Chicago, Blainarch, UK. Dept Geol Res Papers 183
Holdgate MW (ed.) (1982) The World Environment 1972–1982. Tycooly, Dublin
Judson S (1968) Erosion rates near Rome, Italy. Science 160: 1444–1445
Sherlock RL (1922) Man as Geological Agent. Witherby, London
Spencer JE, Hale GA (1961) The origin, nature and distribution of agricultural terracing. Pacific Viewpoint 2: 1–40
Szabó J (1993) A társadalom hatása a földfelszínre (Social impact on the Earth's surface). In: Borsy Z (ed.), Általános természetföldrajz (Physical Geography). Nemzeti Tankönyvkiadó, Budapest, 500–518
Szabó J, Dávid L (eds.) (2006) Antropogén geomorfológia (Anthropogenic Geopmorphology) University notes. Kossuth Egyetemi Kiadó, Debrecen (the Hungarian version of this book)