17

GEOMORPHIC HAZARDS

Hazards have attracted increasing interest over recent decades and the concept of geomorphic hazards embraces all those natural and technological hazards that impact on the Earth's surface, often inducing changes of morphology. Investigations have focused on individual hazards but it is also possible to envisage the way in which a combination of hazards can contribute to the hazardousness of a place. Geomorphic contributions have mapped and modelled hazards, analysed vulnerability, hazard and risk, and suggested management options including those for the prevention of natural disasters. Particular studies have been made in drylands including desertification, as well as in urban areas. Future potential includes improvement in understanding of geomorphic hazards by research into the characteristics of hazard events and predicting their occurrence especially as affected by global climate change.

BOX 17.1

World headlines often demonstrate the sensitivity of the Earth's surface to hazards: an example was the Russian city of Samara being 'eaten alive' by sinkholes which appeared in *The Telegraph* 13th April 2013. In Samara, on the banks of Volga, meltwater was believed to have carried away pockets of alluvium creating dozens of holes across the city. Illustrations of the effects are shown in:

http://www.dailymail.co.uk/news/article-2306085/Samara-The-Russian-city-eaten-alive-giant-sinkholes.html#ixzz2QKwfpsfc

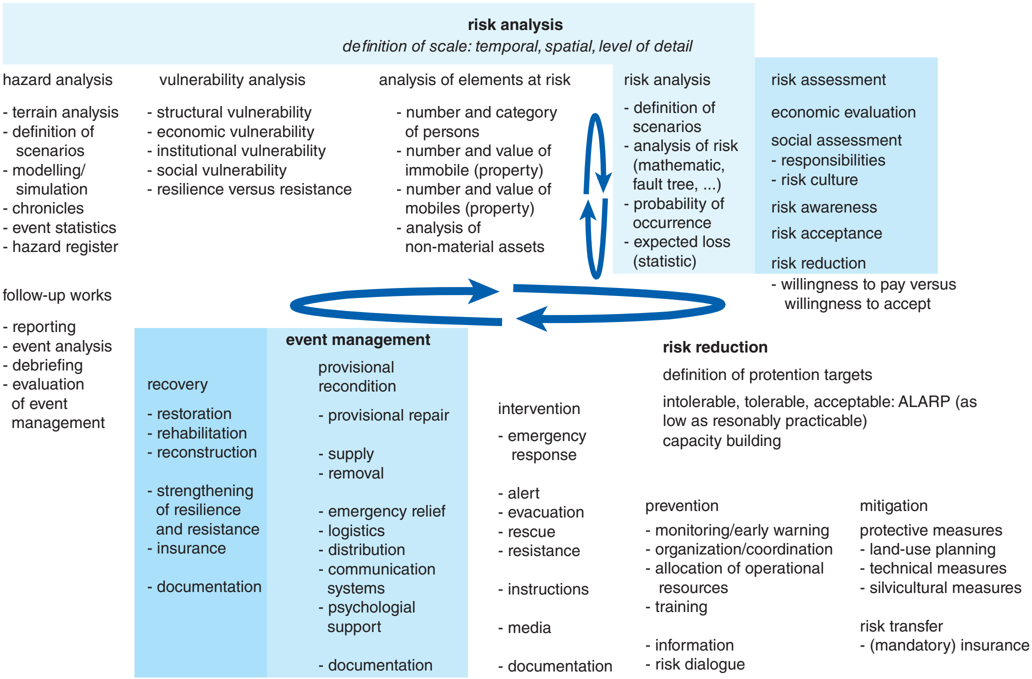

Figure 17.1 A 'risk-cycle' model of integrated risk management (adapted from Carter, 1991; Alexander, 2000; Kienholz et al., 2004) From Jasper Knight et al. Figure 10.9 in Bill McGuire and Mark A Maslin (eds) *Climate Forcing of Geological Hazards*, Wiley 2013 (with permission from Wiley)

Table 17.1 Definitions of hazards and related concepts

Term	Definition	Source
Hazard	A natural hazard is a threat of a *naturally* occurring event that will have a negative effect on people or the environment.	Wikipedia
Natural hazard	An interaction of people and nature governed by the coexistent state of adjustment in the human-use system and the state of nature in the natural event system.	White, 1974
Natural hazard	A naturally occurring condition that threatens life or property.	American Geological Institute, 1984
Natural hazards	Naturally occurring physical phenomena caused either by rapid or slow onset events which can be geophysical (earthquakes, landslides, tsunamis and volcanic activity), hydrological (avalanches and floods), climatological (extreme temperatures, drought and wildfires), meteorological (cyclones and storms/wave surges), or biological (disease epidemics and insect/animal plagues).	
Technological or man-made hazards	Such hazards (complex emergencies/conflicts, famine, displaced populations, industrial accidents and transport accidents) are events that are caused by humans and occur in or close to human settlements. This can include environmental degradation, pollution and accidents.	
Geohazards	Geological conditions capable of causing damage, or loss of property and life, are geological hazards, commonly referred to as geohazards.	PanGeo www.pangeoproject.eu/eng/what_are_geohazards_the_basics
Extreme event	An event in a geophysical system displaying relatively high variance from the mean. Inherent in hazard because they exceed the normal capacity of the human system to reflect, absorb, or buffer them.	White, 1974: 4
Geological hazard	A geological condition, process or potential event that poses a threat to the health, safety, or welfare of a group of citizens or the functions or economy of a community or larger governmental entity.	USGS, 1977: 19, 292
	Sudden event geologic hazards (events on time scales of seconds to hours); gradual change geologic hazards (time scales of tens of years or longer); geologic condition hazards.	Lundgren, 1999 (in Encyc)

(Continued)

Table 17.1 (Continued)

Term	Definition	Source
Geomorphic hazard	Results from any landform change that adversely affects the geomorphic stability of a site and that intersects the human use system with adverse socioeconomic impacts.	Slaymaker, 1994
Disaster	A natural or man-made (or technological) hazard resulting in an event of substantial extent causing significant physical damage or destruction, loss of life, or a drastic change to the environment.	Wikipedia
	An event that results from interaction between humans and natural processes resulting in injuries or loss of life accompanied by significant damage to property.	
	An environmental disaster is a disaster to the natural environment due to human activity, which distinguishes it from the concept of a natural disaster.	Wikipedia
	The interaction between extreme physical or natural phenomena.	Westgate and O'Keefe, 1976, cited by Scheidegger, 1994
	A serious disruption of the functioning of a society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using only its own resources.	IDNDR, 1992
	Some rapid, instantaneous or profound impact of the natural environment upon the socio-economic system.	Alexander, 1993
	A sudden disequilibrium of the balance between the forces released by the natural system and the counteracting forces of the social system.	Scheidegger, 1994
Vulnerability	A characteristic of individuals and groups of people who inhabit a given natural, social and economic space, within which they are differentiated according to their varying position in society into more or less vulnerable individuals and groups. It is a complex characteristic produced by a combination of factors derived especially (but not entirely) from class, gender, or ethnicity. Involves three parts: (1) livelihood resilience – the degree of resilience of the particular livelihood system of an individual or group, and their capacity for resisting the impact of hazard; (2) health – including both the robustness of individuals, and the operation of various social measures; (3) preparedness – determined by the protection available for a given hazard, something that depends on people acting on their own behalf, and social factors.	Blaikie et al., 1994, Irasema Alcántara-Ayala, 2002

Term	Definition	Source
Catastrophe	Disaster that is massive in extent and requires significant expenditure in time and money for recovery to take place. May be termed cataclysm.	*
Risk	Is present in a situation if the outcome of a choice, a decision or an action cannot be anticipated with certainty.	*Encyclopedia Britannica;* Zappellini, 1999
	Risk is a measure of the probability of a loss, life, property, productive capacity.	Peterson and Tilling, 1999

Table 17.2 The context of geomorphic hazards

Sphere		Hazard Group	Hazards
Atmosphere			Near Earth Objects (NEOs): Comets and asteroids, nudged by the gravitational attraction of nearby planets into orbits allowing them to enter the Earth's spheres. Composed mostly of water ice with embedded dust particles; see http://neo.jpl.nasa.gov/neo/
		Climatic and meteorological	Drought, hurricanes, tornadoes, lightning and severe thunderstorms, hailstorms, snow storms, frost hazards.
	Noosphere Anthroposphere	Technological or man-made hazards	Including environmental degradation, pollution and accidents, associated with complex emergencies/conflicts, famine, displaced populations, industrial accidents and transport accidents.
Hydrosphere		Hydrological	Extreme events associated with water occurrence, movement, and distribution, tsunamis, storm surges, floods and flash floods, droughts.
	Geosphere	Geomorphic	Earth surface dynamics including landform change and process extremes that can adversely affect the site stability and produce adverse socio-economic impacts.
			Endogenetic – volcanism, neotectonics.
			Exogenetic – mass movement (snow avalanche), fluvial (floods, channel erosion, sedimentation), karst (collapse), coastal (erosion, tsunamis).
			Other spheres with consequences for the Earth's surface systems.
Biosphere		Biological	Exposure of living organisms to germs and toxic substances, epidemics, insect infestation, locusts,animal stampede, fungal diseases, poisonous plants, viral diseases.
Lithosphere		Geohazards, geological, geophysical	1. Deep ground motions (earthquakes, tectonic movements, salt tectonics, volcanic inflation/ deflation); 2. Natural ground instability (landslide, soil creep, ground dissolution, collapsible ground, running sand/ liquefaction); 3. Natural ground movement (shrink-swell clays, compressible ground); 4. Man-made ground instability (ground water management – shallow compaction, ground water management – peat oxidation, groundwater abstraction, mining, underground construction, made ground, oil and gas production.

Table 17.3 Urban channel hazards in relation to effects of urbanization (developed from Gregory and Chin, 2002; Chin et al., 2013)

Urbanization: Channel effects and responses	Urban Channel Hazards
URBANIZATION EFFECTS	
Discharge increase, peak flows higher, overbank flows more frequent Sediment yield – increase during building construction, decrease with greater impervious area	***Channel system*** – compartmented by road and rail network ***Flood frequency*** – increase ***Drainage*** – temporary floods
CHANNEL RESPONSE	
Channel enlargement, widening, deepening, bank erosion, gullying Headcut/knickpoint recession upstream Channel pattern adjustment, single thread to multithread Siltation from high sediment loads Decrease in channel capacity, narrowing, shallowing Riparian vegetation, increase or decrease	***Bank erosion*** ***Scour*** – along channels, downstream from crossings, below culverts, behind revetment, at bridge piers ***Aggradation*** – along channel, above crossings, buried structures, contracted bridge openings, urban debris accumulation
MANAGEMENT RESPONSE	
Channel clearing, snagging, total vegetation clearance or removal of exotic species Resectioned channels to accommodate larger discharges Bank protection to control erosion Channelization Detention basins and ponds Culverting of streams Infilling and grading sections and crossings	***Blockage*** – due to culvert size or slope or bridge opening ***Change of aquatic communities*** – reduced species diversity, reduced productivity ***Vegetation*** – fire hazard increase, invasion of exotic species ***Quarrying of channel sediments*** – removal of gravel, sand ***Dredging***

RELEVANT ARTICLES IN *PROGRESS IN PHYSICAL GEOGRAPHY:*

Alexander, D. (1991) Information technology in real-time for monitoring and managing natural disasters, *Progress in Physical Geography*, 15: 238–60.

Gillespie, T.W., Chu, J., Frankenberg, E. and Thomas, D. (2007) Assessment and prediction of natural hazards from satellite imagery, *Progress in Physical Geography*, 31: 459–70.

Joyce, K.E., Belliss, S.E., Samsonov, S.V., McNeill, S. and Glassey, P.J. (2009) A review of the status of satellite remote sensing and image processing techniques for mapping natural hazards and disasters, *Progress in Physical Geography*, 33: 183–207.

Macdonald, N., Chester, D., Sangster, H., Todd, B. and Hooke, J. (2012) The significance of Gilbert F. White's 1945 paper 'Human adjustment to floods' in the development of risk and hazard management, *Progress in Physical Geography*, 36: 125–33.

Quincey, D.J., Lucas, R.M., Richardson, S.D., Glasser, N.F., Hambrey, M.J. and Reynolds, J.M. (2005) Optical remote sensing techniques in high-mountain environments: application to glacial hazards, *Progress in Physical Geography*, 29: 475–505.

Stoddart, D.R. and Reed, D.J. (1990) Sea-level rise as a global geomorphic issue, *Progress in Physical Geography*, 14: 441–45.

UPDATES

A book in a series on Hazards and Disasters, addresses landslides, mass movement, quick sand, ground collapses, and problem soils that are influenced by a combination of in-ground factors:

Davies, T. (ed.) (2014) *Landslide Hazards, Risks and Disasters.* Amsterdam: Elsevier.

Climate change, consequent global change including global warming and a high CO_2 world (Section 17.3, p.190) has prompted specific papers including several in a Special Issue on the impact of climate change on water in the UK. *Progress in Physical Geography* (2015) 39 (1): 3–120.

A method of reporting climate change is provided in:

Fung, F., Orr, H.G. and Charlton, M.B. (2015) Climate change impacts report cards, *Progress in Physical Geography,* 39(1): 130–34.

More generally geomorphological contributions are a part of a broad spectrum: Castree, N. (2015) Can science fix climate change? *Progress in Physical Geography,* 39 (2) and this is also relevant to Chapters 18 and 19.

Interdisciplinary research on the theme of 'feedbacks' in human-landscape systems are examined for the 2012 Waldo Canyon Fire of

Colorado when feedbacks that promoted further landscape change ultimately increased those hazards, rather than dampening the hydrogeomorphological effects of fire: Chin, A., An, L., Florsheim, J.L., Stinson and E., Wohl, E. (2016) Investigating feedbacks in human-landscape systems: Lessons following a wildfire in Colorado, USA, *Geomorphology*, 252: 40–50.

Recent articles on the UK cover several aspects of hazards:

On occurrence of devastating floods in the British uplands during the first two decades of the twenty-first century and analyse all lichen-dated upland flood records in the United Kingdom (UK) to establish the longer-term context and causes of recent severe flooding. Although analysis of torrential sedimentary deposits shows that twenty-first century floods are not unprecedented in terms of both their frequency in some areas recent floods have either equalled or exceeded the largest historical events so that that geomorphological based flood series extensions must be placed at the centre of flood risk assessment in the UK uplands and in similar areas worldwide: Foulds, S.A. and Macklin, M.G. (2016) A hydrogeomorphic assessment of twenty-first century floods in the UK, *Earth Surface Processes and Landforms*, 41: 256–70.

Understanding of how flood frequency is affected by geomorphic changes in river channel capacity remains limited, so that hydrometric records from 41 stream gauging stations were used to measure trends in the flood stage with findings suggesting that overlooking the potential influence of changing channel capacity on flooding may be hazardous: Slater, L.J. (2016) To what extent have changes in channel capacity contributed to flood hazard trends in England and Wales?, *Earth Surface Processes and Landforms*, in press.

Providing the current context an article in *Progress in Physical Geography* on anthropogenic climate change on water in the UK and looks at projections of future change: Glenn Watts, Richard W. Battarbee, John P. Bloomfield, Jill Crossman, Andre Daccache, Isabelle Durance, J. Alex Elliott, Grace Garner, Jamie Hannaford, David M. Hannah, Tim Hess, Christopher R. Jackson, Alison L. Kay, Martin Kernan, Jerry Knox, Jonathan Mackay, Don T. Monteith, Steve J. Ormerod, Jemima Rance, Marianne E. Stuart, Andrew J. Wade,Steven D. Wade, Keith Weatherhead, Paul G. Whitehead and Robert L. Wilby (2015) Climate change and water in the UK – past changes and future prospects, *Progress in Physical Geography*, 39: 6–28.

An issue of the jounal *Geomorphology* has focused on 'Geohazard Databases: Concepts, Development, Applications' (Klose et al. (eds) (2015) *Geomorphology*, 249: 1–136). Eathquake and landslide databases were particularly highlighted in a range of national contexts. Cataloging methods outlined included the use of remote sensing imagery and a search of newspaper archives.

A review of risk reduction measures for the tropics is provided by:

Maes, J., Kervyn, M., de Hontheim, A., Jacobs, L., Mertens, K., Vanmaercke, M., Vranken, L. and Poesen, J. (2017) Landslide risk reduction measures: A review of practices and challenges for the tropics, *Progress in Physical Geography*, 41: 191–221.

An elaboration of the concept of urban surfaces shows that their hydrological character is not stable through time with implications for hydrological modelling and urban surface water management planning as provided by:

Redfern, T.W., Macdonald, N., Kjeldsen, T.R., Miller, J.D. and Reynard, N. (2016) Current understanding of hydrological processes on common urban surfaces, *Progress in Physical Geography*, 40: 699–713.

Growing interest in physical geography in urban settings has implications for the discipline and for geomorphology:

Ashmore, P. and Dodson, B. (2017) Urbanizing physical geography, *The Canadian Geographer/Le Géographe canadien*, 61: 102–6.