Chapter

Introductory Chapter: Current Practice in Fluvial Geomorphology: Research Frontiers, Issues and Challenges

Krishna Gopal Ghosh and Sutapa Mukhopadhyay

1. Current research direction/inclination in Fluvial Geomorphology

Over the last one and half century, the prime interest area of fluvial geomorphology has meandered from global system and local process [1]. Returning to the discipline's critical role in regional-to-local scale problem solving [2], fluvial geomorphology has experienced awesome progress in understanding of the trends and patterns of riverine landscape dynamics [3, 4]. However, it is necessary to understand the current research interests of the fluvial geomorphologists amid the global challenges. In this direction, all regular research articles allied to fluvial geomorphology in one of the leading geomorphological journals, *Geomorphology* (ISSN: 0169-555X), are scrutinized for 2018. Among all the 329 regular articles published in 24 volumes (300–323) during 2018, 112 (34%) are within the discipline of fluvial geomorphology. Afterward, the subject matters of the selected articles are grouped into 10 broad themes (**Table 1** and **Figure 1**). As this review work considers one single globally recognized journal and takes a single year as sample therefore, the result may not necessarily highlight all the current research progresses but obviously could detect the directions in which the subject is developing/inclining.

While going through the title and abstracts of the 112 sampled research papers, we have grouped them quite readily into 10 broad themes (**Figure 1**) which are addressed further in turn by the focal words (**Table 1**). The theme 'Fluvial sediment environment' had the greatest number of papers counting 25 (22%); 20 (18%) fall within 'Holocene Fluvial Chronology (Historical Channel change, Stratigraphy, Paleo Hydrology)', 18 (16%) in 'Modelling fluvial environment and application of advanced techniques', and 11 (10%) in 'Anthropogenic Controls'. 'Fluvial morphology (Processes and forms)' and 'fluvial hydraulics' include 7 (6%) articles each, while 6 (5%) fall under '(Neo)tectonics', and 'Gully and hill slope erosion'. Apart from these, 5 articles (4%) addressed Riverine ecology and 7 (6%) fall within 'cross-cutting fields' (i.e. fluvial geomorphology in association with other branches of geomorphology). It is interesting to note that there is no article pertaining to 'river management and restoration' which is one of the focal themes in present research frontiers of fluvial geomorphology [5].

In consideration of the popular remark 'Geomorphology is largely an intellectual child of the Twentieth Century' [6], the review results show that fluvial geomorphology is continuously refocusing on process and forms and thereby making interface with other disciplines like sedimentology. Moreover, much of the research articles we have revisited for the present assessment are basically geomorphological

Broad theme	**(Neo) tectonics (6)**	**Fluvial morphology (processes and forms) (7)**	**(Holocene) fluvial chronology (20)**	**Fluvial erosion (6)**	**Fluvial sediment environment (25)**	**Fluvial hydraulics (7)**	**Modeling fluvial environment, advanced techniques (18)**	**River ecology (5)**	**Anthropogenic controls (11)**
Focusing words	**Th1**	**Th2**	**Th3**	**Th4**	**Th5**	**Th6**	**Th7**	**Th8**	**Th9**
	Morphotectonic (4), geological controls (1), active tectonics (1)	Channel form and processes (1), channel bed resiliency (1), bedrock morphology (1), river morphology (1), bedform migration (1), meander hydromorphology (1), morphology and spacing (1)	Channel evolution (1), drainage development (1), evolution of a natural river (1), drainage geomorphic evolution (1), geomorphologic changes (1), temporal patterns (1), drainage system evolution (1), escarpment evolution (1), terrace formation and evolution (1), landscape change (1), evolution of a colluvial hollow (1), late Pliocene exorheic drainage (1), Holocene and historical floods (1), paleo-dam (1), stratigraphy and	Gully erosion (1), gully trajectories (1), badass gullies (1), eroding gully complex (1), gully-affected areas (1), soil erosion and sediment transport (1)	Sediment yield (3), sediment load (2), river load (1), suspended sediment (3), sediment transport (2), fluvial fluxes (1), bedload flux (1), bedload transport (1), mixed-size sediment transport (1), sediment accumulation (1), sediment routing (1), sediment recovery(1), water and sediment balance (1), sediment continuity (1), sediment connectivity (1), sediment magnetic properties (1),	Flow behaviour and mobility (1), hydrodynamic behaviour (1), three-dimensional flow structure (1), flow resistance (1), magnitude and frequency (1), water storage and discharge (1), scaling of urban surface water (1)	Simulation model (1), multivariate geostatistical modeling (1), models for sediment yield (1), modelling sediment movement (1), discriminant method (1), climate-scale modeling (1), coupled three-layer model (1), evolution model (1), model solutions (1), integrated cascading model (1), computerized approach (1), flume experiments (1), experimental study (1), factorial kriging (1), DEM (3),	Deltaic ecosystems (1), habitat along the embanked floodplain (1), niche construction within riparian corridors (1), channel bed disturbance-benthic chlorophyll (1), influence of spawning fish on river profile (1)	River engineering (1), regulated river (1), human influence (1), gravel mining (1), human impact (1), impacts of dam (1), impacts of dams and levees (1), historical metal mines (1), hydropeaking and instream mining (1), intensified human activities (1), reaction and relaxation (1)

Broad theme	**(Neo) tectonics (6)**	**Fluvial morphology (processes and forms) (7)**	**(Holocene) fluvial chronology (20)**	**Fluvial erosion (6)**	**Fluvial sediment environment (25)**	**Fluvial hydraulics (7)**	**Modeling fluvial environment, advanced techniques (18)**	**River ecology (5)**	**Anthropogenic controls (11)**
			fluvial style change (1), fluvial terrace deposits (1), temporal patterns of sedimentation (1), chronology of alluvial terrace sediment accumulation (1), luminescence dating (1), flood history (1)		river-floodplain sediment exchange (1), sedimentary response (1), catchment scale weathering fluxes (1)		spaceborne and ground-based SAR data (1)		
Cross-cutting (7)	**Th10**	Fluvio-karst landscape evolution (1), fluvial and wave-driven erosion (1), ice sheet meltwater routing (1), debris-charged flood hazard (1), submarine channel evolution (1), debris flows over low gradient channels (1), river-damming and late-Quaternary rockslides (1)							

Table 1.
The distribution of broad themes and focusing words of research articles related to fluvial geomorphology published from the journal Geomorphology [ISSN: 0169-555X] in 24 volumes (300–323) during 2018.

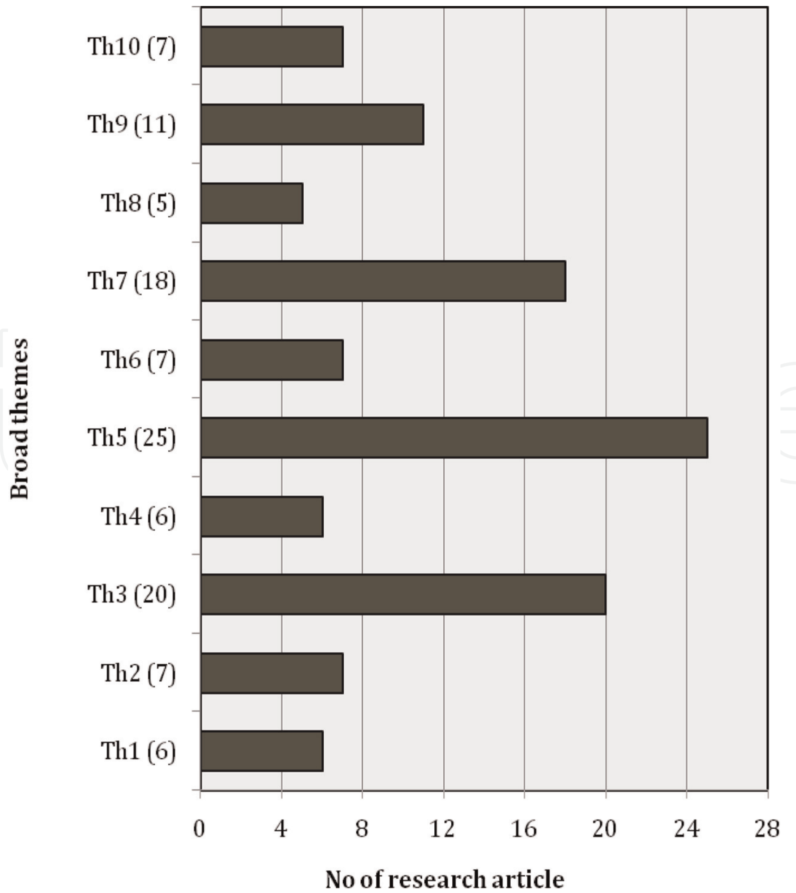

Figure 1.
Number of research articles pertaining to 10 broad themes derived from examining 24 volumes of the journal Geomorphology *in 2018. Note: Th 1, Th2 … indicates the broad themes as mentioned in* **Table 1**.

but did not inevitably come within fluvial geomorphology largely due to the opening out of techniques and wider interest of the contemporary practitioners of other fields toward riverine landscape. Therefore, although fluvial research, including the cross-cutting fields, comprised 34% of the current geomorphological research, in the upcoming days via technical advances (modeling and GIS) and data acquisition (e.g. remote sensing), the discipline will serve to initiate new arena of research which will be more interdisciplinary. Optimistically, the discipline fluvial geomorphology is going through renaissance in quest of elucidating the genesis, dynamicity and diversity of fluvial landscape [7].

2. Current research frontiers, issues and challenges ahead

2.1 Contemporary research questions in Fluvial Geomorphology

At the very beginning of the twenty-first century, fluvial geomorphology has emerged as a new arena of research in multiple dimensions. In this direction, the National Research Council (NRC) [8] has addressed nine obvious confronts in Earth surface process discourse:

- What does our planet's past tell us about its future?
- How do geopatterns on Earth's surface arise and what do they tell us about processes?

- How do landscapes influence and record climate and tectonics?
- How does the biogeochemical reactor of the Earth's surface respond to and shape landscapes from local to global scales?
- What are the transport laws that govern the evolution of the Earth's surface?
- How do ecosystems and landscapes coevolve?
- What controls landscape resilience to change?
- How will Earth's surface evolve in the 'anthropocene'?
- How can Earth surface science contribute toward a sustainable Earth surface?

These key research questions may be taken effectively by the Earth scientists for further research.

2.2 Current research frontiers in Fluvial Geomorphology

In view of the aforementioned challenges in contemporary Earth surface process discourse, NRC [8] has focused on four major research frontiers, relevant for fluvial geomorphology:

- Interacting landscapes and climate
- Quantitative reconstruction of landscape dynamics across time scales
- The convolution of ecosystems and landscapes
- The future of landscapes in the 'anthropocene'

2.3 Reading a fluvial landscape: issues and concerns

Reading of a fluvial landscape could proceed through four consequent steps [9, 10]:

- *Step 1:* Identification and interpretations of fluvial landscapes and their process-form relations that resolve the respective process regime
- *Step 2:* Assessment of the assemblage of riverine landscape elements at the reach scale
- *Step 3:* Explanations of the controls at the reach scale and understanding of their adjustment with time
- *Step 4:* Integrated understanding of the catchment scale control on channel processes (at the reach scale)

Indeed, comprehensive appraisal of a fluvial landscape requires understanding of the landscape form, function and evolution [11]. However, instead of viewing the regional landscape (area/polygonal approach) as a whole, reference site (i.e. place/location) based studies (location/point approach) are in practice these days [12]. This often results misleading outcomes [13]. Another threat in contemporary research direction is that high-resolution, real-time large remote sensing datasets pertaining to riverine landscape emphasize mastery over techniques and draftsmanship rather than enriching critical interpretation skills. This leads to the question—'What is it we are training geomorphologists to do?' [14] 'Should we value quantitative applications over and above anything else in landscape analysis?' [15, 16]. Therefore, in view of the multidisciplinary roots of fluvial geomorphology [17], there is a need to understand the conjectural principles of the geomorphological dynamics of river systems apart from skill development to process and contextualize remotely sensed observation.

3. Epilogue

The current advances in the arena of fluvial geomorphology in association with other Earth system science disciplines are broadly as a result of the contemporary advances in data acquisition and modeling techniques particularly due to the progress in geophysical data acquisition tools, computer programming, geoinformatics, numerical modeling, computational fluid dynamics, numerical dating, laboratory experimentation, etc. With these aids obviously the future prospect of fluvial geomorphology is very promising. However, there is a need to refocus on the fundamental scientific issues concerning landscape dynamicity and diversity over time and space. Amid the global challenges like climate change and anthropogenic intervention to the natural systems, the emphasis could be laid upon understanding the consequent changes in fluvial systems. Moreover, there is a need to address management and restoration issues with the aim to manage the decaying fluvial environment.

Acknowledgements

For the book as a whole, we express our sincere thanks to each of the contributors for their patience during the review process. We are also indebted to Ms. Ivana Barac—the author service manager—for her assistance during the entire process. The work embodies an overwhelming support from our colleagues and dozens of well-wishers. Special thanks to all of them. Lastly, we would like to express our sincere thanks to IntechOpen for providing us the academic editor role and publish the book under open-access platform.

Author details

Krishna Gopal Ghosh[1*] and Sutapa Mukhopadhyay[2]

1 Faculty of Natural and Mathematical Sciences, Department of Geography, Presidency University, West Bengal, India

2 Department of Geography, Vidya-Bhavana, Visva-Bharati University, Santiniketan, West Bengal, India

*Address all correspondence to: k.g.ghosh@mail.com

References

[1] Church M. The trajectory of geomorphology. Progress in Physical Geography. 2010;**34**:265-286

[2] Tooth S. Invisible geomorphology? Earth Surface Processes and Landforms. 2009;**34**:752-754

[3] Richards K. Fluvial geomorphology. Progress in Physical Geography. 1986; **10**:401-420

[4] Small MJ, Doyle MW. Historical perspectives on river restoration design in the USA. Progress in Physical Geography. 2012;**36**:138-153

[5] Plater AJ, Daniels MD, Oguchi T. Present research frontiers in geomorphology. In: Shroder J, Orme AR, Sack D, editors. Treatise on Geomorphology. Vol. 1, The Foundations of Geomorphology. San Diego, CA: Academic Press; 2013. pp. 349-376

[6] Graf WL. Fluvial Processes in Drylands. Berlin/Heidelberg: Springer Verlag; 1988

[7] Tucker GE, Hancock GR. Modeling landscape evolution. Earth Surface Processes and Landforms. 2010;**35**:28-50

[8] NRC: National Research Council. Landscapes on the Edge: New Horizons for Research on Earth's Surface. Washington, DC: The National Academies Press; 2010. DOI: 10.17226/12700

[9] Brierley G, Fryirs K, Cullum C, Tadaki M, Huang HQ, Blue B. Reading the landscape: Integrating the theory and practice of geomorphology to develop place-based understandings of river systems. Progress in Physical Geography. 2013;**37**(5):601-621. DOI: 10.1177/0309133313490007

[10] Fryirs K, Brierley GJ. Geomorphic Analysis of River Systems: An Approach to Reading the Landscape. Chichester: Wiley; 2013

[11] Slaymaker O. The future of geomorphology. Geography Compass. 2009;**3**:329-349

[12] Montgomery DR. Faith in floods: Field and theory in landscape evolution before geomorphology. Geomorphology. 2012;**200**:9-19. DOI: 10.1016/j.geomorph.2012.10.006

[13] Milner VS, Gilvear DJ, Willby NJ. An assessment of variants in the professional judgement of geomorphologically based channel types. River Research and Applications. 2013;**29**(2):236-249

[14] Tadaki M, Salmond J, Le Heron R, et al. Nature, culture, and the work of physical geography. Transactions of the Institute of British Geographers. 2012; **37**:547-562

[15] Parsons AJ. Whither geomorphology (re-)revisited. Earth Surface Processes and Landforms. 2006;**31**:1595-1596

[16] Wainwright SP. Science studies in physical geography: An idea whose time has come. Progress in Physical Geography. 2012;**36**:786-812

[17] Osterkamp WR, Hupp CR. The evolution of geomorphology, ecology and other composite sciences. In: Rhoads BL, Thorn CS, editors. The Scientific Nature of Geoorphology. Chichester, U.K.: John Wiley and Sons; 1996. pp. 415-441