Extended Abstract DOI: https://doi.org/10.64862/ajeg.2025.2sp.53.168 Open Access

The "River Functional Flooding Space" Concept for Bridge Construction in Nepal: How to Cope with Floods

Narayan Gurung[1], Monique Fort[2*], and Gilles Arnaud-Fassetta[2]

[1]Kadoorie Agricultural Aid Association, Pokhara, Nepal
[2]Université Paris Cité, UMR 8586 PRODIG, 75205 Paris Cedex 13, France

([*]Corresponding E-mail: fort.monique@gmail.com)

Received: September 26, 2025, Accepted: October 27, 2025

Abstract: The encroachment of floodplains by anthropogenic activities is an increasing trend in developing Nepal. However, unplanned infrastructures like bridges constructed in hazard prone areas in the valley floor will never be sustainable. From a few study cases, we illustrate the concept of "river functional space" (lateral space, erosion, deposition) as an approach respective of nature and river-flows dynamics, and economically positive. We discuss the possible options between bridges and fords.

Keywords: ***River functional space, Bridge construction, Fjord, Nepal.***

Introduction

Analysis of the river functional flooding space (the area that can be naturally inundated during peak floods) shows that anthropogenic activities such as constructing infrastructures and settlements within areas prone to maximum flooding have heightened the risk of flood hazards escalating into disasters (Gurung et al., 2021). Managing floods is most effective when utilizing the river's functional flooding space, as global events have shown that structural flood protection measures within this space are often short-lived. Structural control measures constructed within a river's freedom space may be subject to repeated impacts during flood events. Providing more space for rivers to migrate and flood naturally reduces fluvial risk by allowing excess water to disperse safely, which minimizes damage to nearby communities and infrastructure. This not only protects human lives and properties but also reduces the costs associated with flood damage repairs.

Concept and methods

Before deciding on the best option, (1) preliminary studies are necessary on the selected catchment(s). Key factors are size, topography, longitudinal profile, cross-section variations, geology, Quaternary mate-rials, climate, and discharge records. All these help clarify hydro-geomorphological and hydro-sedimentary processes using HEC-RAS modeling. (2) The site(s) planned for bridge construction must be analyzed in detail, including field observations, aerial photos and/or satellite images analysis) to map the river functional space. It will be delineated from five mapping steps: (i) the maximum flooding area, (ii) the amplitude of active channel, (iii) the historical wandering pattern and (iv) the residual wandering areas that may affect hydrological conditions (i.e. pile-bridge protection, embankments), and (v) the potential erodible zones.

Study cases

1st case: Khaarpaani Tatopani bridge (Pokhara valley), that was destroyed by the 2012 Seti River flash flood (Gurung et al., 2021). The new bridge has been built without considering the high level of this flood and the river functional space.

2nd case: Dana bridge (Myagdi district) along the small Ghatte Khola (GK) catchment (Figure 1) prone to landslides outburst debris floods. The bridge was destroyed in 2019 by such a flood, but it was reconstructed without any change in the original design nor any consideration of the river-flow dynamics of the GK catchment (Gurung et al., 2020).

Figure 1, Bridge built in a downstream, narrower section of the Ghatte Khola, with piles in loose material.

3rd case: Thaplyang bridge (Myagdi district), across a new torrential catchment (right bank of the Kali Gandaki) that has dramatically evolved since 2014, due to road opening and cutting through thick paleo-landslide material (Fort et al. 2022). The induced repeated slope collapses in the lower part of the catchment feed an active debris fan during each rainy season, with unsuccessful new bridge construction (Figure 2).

Figure 2, Under-construction Thaplyang bridge buried by a debris flow (piles sited in the active debris fan)

The two last examples are the bridges destroyed by the Aug. 2023 flood of the Jhong Khola (Mustang District):

4th case: A still truss bridge (between Jharkot and Jhong, upper valley), was washed away by the flood, then rebuilt by KAAA, with 2 m higher and a doubling of the previous length (inclusion of river functional space).

5th case: The BRI Kagbeni Road bridge to Upper Mustang was built upstream from Kagbeni village, without considering the high level of such potential flood, and with a width reduction corresponding to half the width of the natural active bed (Figure 3). A temporary Bailey bridge has been built by GoN in August 2025.

Figure 3, Destroyed Kagbeni bridge (collapse of the bridge deck, with only piles remnants).

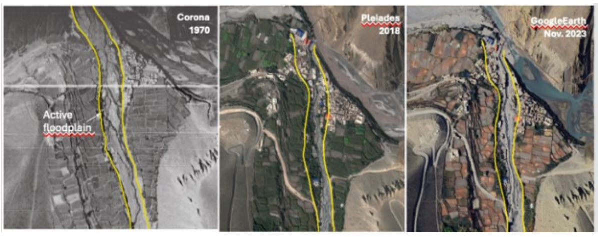

Figure 4, Evolution (1970–2023) of the Jhong Khola active floodplain at Kagbeni. Left (1970): an active floodplain with intermittent flows and gravel bars bounded by cultivated lower terraces. Middle (2018): settlement expansion into the former floodplain. Right (2023): the Jhong Khola reoccupied its natural flooding zone during the flood.

With touristic development from 1977 onward, the village expanded closer to attractive riverbanks, which were canalized with reduced section widths compared to the natural river freedom space, causing the destruction of many buildings and bridges (Figure 4). Yet, some buildings are being rebuilt in the same locations without adequate planning, increasing the risk of past problems recurring – especially given climate change (Fort et al., 2025).

Discussion and conclusion

The opening and maintenance of the International Kali Gandaki Corridor (BRI) Highway necessitates bridge designs with adequate consideration of geo-hazards and river-flow dynamics to avoid deck collapse or bridge burying. The bridge design (arch, suspension, beam, truss) and material (concrete, bailey, steel) are certainly important, but the bridge location (consideration of river functional flooding space concept) remains a priority.

Another choice concerns tributaries whose flow discharge can vary greatly throughout the year: should a bridge be built to cross them, or would a ford suffice? A concrete ford would probably be a better, sustainable and less expensive solution, requiring regular maintenance (cleaning off after a flood event).

“River functioning flooding space” should be included in bridge construction to support economic development and enable permanent movement of people and goods across valleys and in Nepal.

References

Fort, M., Gurung, N., Bell, R., Andermann, C., Cook, K. L., Marc, O., and Burrows, K. (2022). Natural hazards evolution in a context of climate evolution and infrastructure development: The Kali Gandaki valley case, West-Central Nepal. Geophysical Research Abstracts, 24, EGU22-6457. https://doi.org/10.5194/egusphere-egu22-6457

Fort, M., Gurung, N., Yvrard, Y., Bell, R., Burrows, K., Rimal, B., and Arnaud-Fassetta, G. (2025). The Kagbeni flood event (August 13, 2023), Mustang District (Nepal): Triggers, sediment cascades, aggravating infrastructures and disaster risk management. Géomorphologie: Relief, Processus, Environnement, 31(4). https://doi.org/10.4000/154up

Gurung, N., Fort, M., Arnaud-Fassetta, G., Bell, R., and Sherchan, B. (2020). Bridge construction vs. natural dynamics of a debris flows prone catchment in Central Nepal, Myagdi District. Géomorphologie: Relief, Processus, Environnement, 26(3), 195–215.

Gurung, N., Fort, M., Bell, R., Arnaud-Fassetta, G., and Maharjan, N. (2021). Hydro-torrential hazard vs. anthropogenic activities along the Seti Valley, Kaski, Nepal: Assessment and recommendations from a risk perspective. Journal of Nepal Geological Society, 62, 58–87. https://doi.org/10.3126/jngs.v62i0.38695