Project Title	Investigation of biogeophysical controls on human-landscape-ecology interaction for resilient transportation networks under hydro-hazard risks
University (where student will register)	University of Warwick
Theme (Max. 2 selections)	Climate & Environmental Sustainability ☐ Organisms & Ecosystems ☐ Dynamic Earth ☐
Key words	
Supervisory team (including institution & email address	**PI: Dr Xueyu Geng (University of Warwick, xueyu.geng@warwick.ac.uk)** **Co-I: Nikhil Nedumpallile Vasu (BGS, nikned@bgs.ac.uk)**

Overview (including 1 high quality image or figure): *Maximum 350 words*

Hydro-hazards, including floods, droughts, onshore and offshore landslides and storm surges, can pose direct threats to lives and impact livelihoods worldwide by damaging and destroying critical lifeline infrastructure (e.g. transport links, power supplies) as well as our natural ecosystem; especially under the changing climate. To mitigate risks and protect our towns, cities and our planet, we need to improve our understanding of the human-landscape-ecology interaction and characterise the complex hierarchies of revenant proves-response systems in a context of a changing and uncertain climate and environment. Inevitably, our human decision making and processes can also shape and change the natural environment, including ecosystems, river systems, vegetation and climate. We, humans, have caused such significant environmental change, which also has caused great concern about whether social and ecological systems can coexist in a sustainable manner. There is an urgent need to seek to understand how human activities can exist without disrupting the ability of natural ecosystems to function in order to help advance the concept of sustainability, and the interaction between natural hazards and human activities in order to minimize the disturbance to the onshore soil and submarine ecosystems, especially when we consider the next generation design of critical infrastructure (e.g. transport infrastructure). In particular, for example, plant root and shoot biomass - two important ecosystem attributes - are likely to influence the stability of hill slopes in complex ways. Although there is growing awareness of the benefits of ecosystem services for sustainable livelihoods in urban contexts, e.g. on the modification of climate, hydrology or soil dynamics, the potential for ecosystem-based and hybrid solutions that combine grey and green approaches has not been tapped fully yet. Therefore, several fundamental challenges exist in current research. All these recent challenges in the maintenance of the current lifeline infrastructure and design of the future lifeline infrastructure – so to be more resilient towards the changing climates and sustainable for future changes – have emphasized the need for an inter-disciplinary approach drawing upon knowledge at the interface between traditional civil engineering with geophysics, remote sensing and earth observations, engineering geology, hydrology, meteorology, data science, uncertainty quantification and ecology.

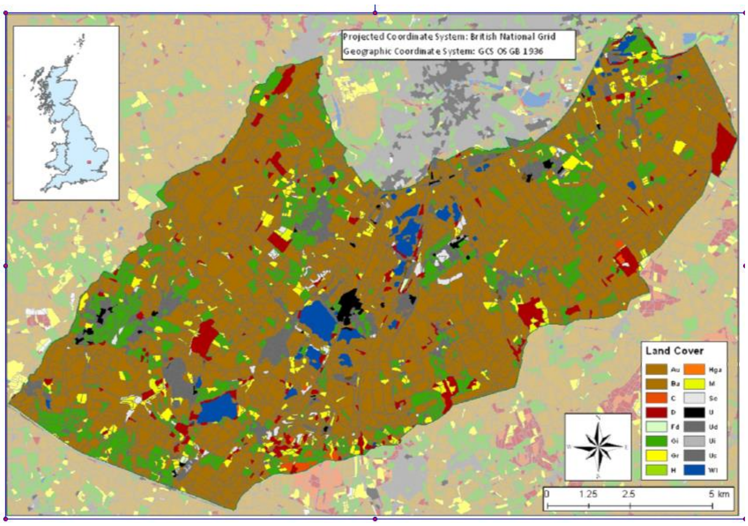

Figure 1: Fig. 1 e Broad Habitats in Marston Vale from the satellite derived Land Cover Map 2007 (Howard et al. 2013).

Methodology:

Two modelling paradigms that attempt to encompass the complexity of response in the transport system and sub-systems when subject to hydro-hazard stressors will be embedded into the proposed programme: (1) functional resilience, and (2) networked resilience. Functional resilience will describe the underpinning of normal and post-disaster dynamic behaviour, including the loss in functionality and recovery profiles. Networked resilience will characterize propagation effects that arise from cascade failures, the interdependence between infrastructures as well as the links with the surrounding ecosystems. The project will couple functional and network resilience to create a holistic understanding of transport infrastructure resilience against hydro-hazards as well as how the ecosystem has been shaped by those man-made infrastructures especially after the natural disaster, harmonizing inter-disciplinary approaches in qualitative methods (e.g. social-economic impact), and quantitative analysis (e.g. model building and data science).

Training and skills:

Students will be awarded CENTA2 Training Credits (CTCs) for participation in CENTA2-provided and ‘free choice’ external training. One CTC equates to 1⁄2 day session and students must accrue 100 CTCs across the three years of their PhD.

Training for the research will be delivered in a combination of network-wide and local activities. Local activities include combined summer training school within the related research areas by the funded projects, e.g. training courses on Remote sensing for earth observation; Advanced spatial database methods; Statistical learning theory and applications. Field trips and engagement with local industry partners will also be also provided as part of the training programme.

Partners and collaboration (including CASE):

Name of L1/L2 Partner (where applicable)	

Name of CASE partner (where applicable – project proposal **must** be accompanied by a letter of support from the CASE partner)	

Further information on partners and collaboration (including CASE):

The partners include existing links with the natural hazard partnership (consortium of 19 government departments and agencies, trading funds and public sector research establishments) which enables coordinated and coherent advice for the government and the resilience community. The NHP informs the national risk register and publishes a national-level multi-hazard daily assessment. There is also a strong connection with the UK Met Office through the daily hazard landslide assessment that BGS undertakes within the NHP framework.

<u>Respiratory and Contact Infection Resilience of the Project:</u>

The proposed is computationally modelling based, which will be less likely to be impacted by changes in the normal work patterns caused by the respiratory and contact infection pandemic. If under any circumstance, the project needs to be carried out by working from home, as long as the essential modelling software can be remotely accessed through a secured network, there should not have any major impact on the proposed project's progress.

Possible timeline:

Year 1: Conducting literature reviews, data mining and data fusion for the related datasets; develop the initial statistical data analysis method to understand the relationship between different multiscale data sources and influential factors, e.g. land-use/land-cover, topography, geology, weather data, traffic data;

Year 2: Develop machine learning algorithms for deep learning analysis to forecast the transport system resilient under the changing climate through UKCP18 dataset integration;

Year 3: Develop a risk classification map to analyse the ecosystem resilience along the transport networks.

Further reading:

Alves, A., Sanchez, A., Gersonius, B. and Vojinovic, Z., (2021) 'Selecting multi-functional green infrastructure to enhance resilience against urban floods'. In Water Security in Asia (pp. 429-441). Springer, Cham.

Chopra, S.S., Dillon, T., Bilec, M.M. and Khanna, V., (2016) 'A network-based framework for assessing infrastructure resilience: a case study of the London metro system'. Journal of The Royal Society Interface, 13(118), p.20160113.

Davis, C.A., (2021). 'Understanding functionality and operability for infrastructure system resilience'. Natural Hazards Review, 22(1), p.06020005

Filippini, R. and Silva, A., (2014). A modeling framework for the resilience analysis of networked systems-of-systems based on functional dependencies. Reliability Engineering & System Safety, 125, pp.82-91.

O'Sullivan, T.L., Kuziemsky, C.E., Toal-Sullivan, D. and Corneil, W., (2013). 'Unraveling the complexities of disaster management: A framework for critical social infrastructure to promote population health and resilience'. Social Science & Medicine, 93, pp.238-246.

Wang, S., Gu, X., Luan, S. and Zhao, M., (2021). Resilience analysis of interdependent critical infrastructure systems considering deep learning and network theory. International Journal of Critical Infrastructure Protection, 35, p.100459.