Project Details	
Project Code	MRCPHS25Ex Panici
Title	An integrated hydro-epidemiological approach to prevent and mitigate water-related zoonotic diseases leveraging nature-based solutions
Research Theme	Population Health Sciences
Summary	Waterborne zoonotic diseases, such as Cryptosporidium, E.coli, and Leptospira are a serious threat to drinking water safety, especially in rural, farm-dominated lands. Nature-based solutions (NbS) in hydrology and landscape management are highly effective in improving catchment water quality (by reducing agrochemical loads) and enhancing biodiversity. However, benefits of NbS in preventing waterborne zoonotic disease have been largely unexplored. This PhD, will utilise hydro-epidemiological modelling and spatial data analysis to investigate how NbS can effectively prevent and mitigate waterborne zoonoses outbreaks at multiple spatial scales, and will inform management and prevention of public health agencies and water companies.
Description	Waterborne zoonotic diseases pose a significant threat to public health, particularly in rural and agricultural regions. Pathogens are often released through runoff from manure and slurry heaps, contaminating water streams and affecting wildlife, recreational activities, and water supplies. Incidents in water distribution networks can also result in contaminated runoff causing severe consequences. Identifying and eradicating some waterborne zoonoses is challenging. For instance, Cryptosporidium, which recently caused an outbreak in Devon appearing in the news, is highly resistant to chlorine disinfection and persists in water environments. E.coli can cause severe gastrointestinal distress, and Leptospira bacteria, shed in the urine of infected animals, can lead to severe kidney damage, liver failure, and respiratory distress, especially in areas with heavy rainfall or flooding. These pathogens can spread through water, affecting distant populations. Addressing this issue involves identifying potential sources of pathogens and preventing or mitigating outbreaks at the source. Nature-based solutions (NbS) in hydrology and landscape management have emerged over the last decade as effective strategies to improve water quality in areas affected by high concentrations of agrochemicals. NbS store water in the landscape, slow the flow in streams and hillslopes, reduce sediment erosion, and encourage natural processes such as groundwater infiltration and natural filtering. An example is the Upstream Thinking programme in South-West England (developed since 2010 by the University of Exeter/CREWW and South West Water), where NbS reduce both point and diffuse pollution from agriculture. Hydrological NbS include wetland restoration, which acts as natural filters trapping sediments and pollutants, riparian buffer zones that reduce runoffs and sediment transport, and sustainable agricultural practices like cover cropping, reduced tillage, and controlled grazing. While NbS are documented for improving water quality and enhancing biodiversity, their effectiveness in preventing and mitigating waterborne zoonotic disease outbreaks remains largely unexplored. This PhD project aims to investigate how NbS can be leveraged to manage waterborne zoonoses, and will be achieved through advanced hydro-epidemiological modelling and spatial data analysis.

	Key Research Question: How can nature-based solutions effectively prevent and mitigate waterborne zoonotic disease outbreaks at multiple spatial scales? Objectives: O1 – Systematic review of the scientific literature. Identify key zoonotic pathogens (or groups of pathogens) that originate in rural and farm-dominated lands. Review bio-hydrological mechanisms on how these waterborne zoonotic diseases originate, travel, and spread in water systems. Evaluate the physical processes of NbS improving water quality and their applicability to controlling waterborne pathogens. O2 – Develop a conceptual framework for NbS application linking hydrological NbS with the prevention and mitigation of waterborne zoonotic diseases. Utilise geospatial analysis of land cover/land use, hydrological patterns, potential (or history) of disease outbreaks, and location and type of NbS. O3 – Develop a hydro-epidemiological model. Create an integrated modelling framework combining hydrological/hydraulic models with epidemiological models to evaluates development and spread of pathogens in terms of risk of infection. To this end approaches such as quantitative microbial risk assessment or compartmental modelling of pathogen or parasite development and spread to hosts will be incorporated. Include NbS by utilising modelling analogues and perform comprehensive scenario analysis, including varying levels of NbS implementation (e.g., extent of wetland restoration, geospatial distribution of NbS) and different environmental conditions (e.g., drought vs. normal rainfall years). The model will consider sensitivity and uncertainty estimation using methods, such as Monte Carlo. The PhD aims to develop a novel, open-source integrated model based on existing codes (e.g., TOPMODEL, SWAT+, or LISFLOOD). O4 – Risk assessment and evaluation analysis. Perform risk assessment to map potential hotspots for waterborne zoonotic diseases and prioritise areas for NbS implementation. Use GIS-based risk mapping and modelling results for implementation planning and back-tracking outbreaks. Evaluate cost-benefit and feasibility for various NbS scenarios to inform decision-making by water companies, environmental authorities, and landowners. The PhD will be able to use the examples and existing data from South West England (although transferrable to other rural and farm-dominated regions) with proof-of-concepts applications to this area of study, leveraging the supervisors' decadal partnership with project partners (Environment Agency, UKHSA , South West Water) and extensive data availability. The research will also explore whether NbS can reduce the burden on water companies by improving water quality and mitigating the spread of pathogens, potentially reducing the need for intensive water treatment processes. The PhD researcher will take ownership and steer the project in the following areas: Framework Development (O1 and O2): Explore innovative approaches to integrate NbS with hydro-epidemiological concepts, contributing to new theoretical insights.

	Model Customisation (O3): Choose and refine the most appropriate modelling approach, customising it to suit specific study areas or types of NbS. Scenario Analysis (O3 and O4): Design and test various NbS implementation scenarios, tailoring them to different environmental contexts and stakeholder needs. Stakeholder Collaboration (O3 and O4): Engage with stakeholders (Environment Agency, South West Water), shaping practical recommendations based on real-world feedback and requirements.
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