Watersheds in planetary health research and action

Watersheds (also known as water catchments and river basins) are recognised in contemporary science as important natural systems in which to investigate the complex socioecological foundations of health.[1] A watershed is the spatially bound geophysical unit within which surface and shallow groundwater drain to a single collecting stream or river (see appendix). Watersheds are physical and abstract systems: they are open and hydrologically permeable, yet can be represented as functionally distinct. Collectively, watersheds comprise a complex hierarchical network, and thus exemplify the upstream and downstream nature of ecosystems.[2] Watersheds include the social actors, relationships, and institutions located within their boundaries.[3] This means that distant individuals residing within the same watershed might share a more common history of social and environmental exposure than nearer individuals located closer to each other, but in separate watersheds.[1]

Watersheds are the geographical space in which water flows, as well as a subsystem in which driving forces of change manifest: agriculture, industrial development, population growth, climate change, and governance.[3,4] They therefore offer an ideal context for transdisciplinary research and development solutions that extend beyond resource governance to providing settings for health, including that of humans, other species, and ecosystems.[2-4] As an example, we can relearn several principles of sustainability by drawing from indigenous, pre-colonised Hawaiians, who managed socioecological processes within watersheds, from upland forest to downstream fringing reefs, as distinct governance units (*ahupua'a*) to enhance food production and social wellbeing.[3] There have been recent calls for the development of a discipline of "watershed epidemiology", recognising this geophysically bounded landscape as a socioecologically relevant unit of investigation to improve our understanding of the water-land-human health nexus.[5]

Few studies have explicitly connected watershed condition with public health. A review of scientific literature published between 2000 and 2010,[6] revealed that human health is addressed in only 3·5% of academic journal articles on watershed management, and watershed management is virtually absent from public health literature. The publications on environmental management, while acknowledging the importance of watersheds for human health, are not specific about the nature of health outcomes and mainly discuss biophysical, rather than social determinants. Despite the potential for synergistic benefits for food and water security, as well as reductions in biodiversity loss and disease, there is a lack of integration across the fields of water governance, ecosystem management, and public health.[4,6]

See Online for appendix

However, recognition of these potential synergies is growing, with recent studies linking some specific health consequences to watershed condition. In a study involving 35 developing countries, Herrera and colleagues[7] found that higher upstream tree cover was associated with a lower probability of childhood diarrhoeal disease downstream. This association was seen in rural areas, where a 30% increase in upstream tree cover had a similar effect to that of improved sanitation. Jenkins and colleagues[8] showed how anthropogenic alterations of land cover and hydrology within watersheds in Fiji facilitate the transmission of typhoid fever, through processes of increased erosion and flooding. Previous research into the same degraded watersheds, under conditions of reduced natural hazard protection during severe storms, revealed the absence of the migratory fish species that traditionally formed the staple diets of inland communities.[9] This aquatic biodiversity not only represents a major part of the diet of many Indigenous communities, but also has important cultural totemic value. Many Indigenous groups celebrate migratory aquatic fauna, reflecting a deep appreciation of interconnections among land, freshwater, sea, culture, and human wellbeing.[3,10] The loss of aquatic biodiversity, therefore, has important implications for both nutrition and culture, while simultaneously increasing susceptibility to waterborne diseases. These studies reinforce the proposal that addressing the upstream determinants that negatively affect watersheds can also strengthen cross-sectoral engagement, improve biodiversity, ecosystem services, and public health, and might represent the most cost-effective intervention when multiple long-term benefits are considered.

The recent *Call to Action on Making the World Safe from the Threats of Emerging Infectious Diseases* at the

2018 Prince Mahidol Award Conference in Bangkok, Thailand, recognises that changing environmental and climatic conditions are linked to the emergence of novel infections and the redistribution of existing diseases. Needed in this call is an effective place-based functional unit. Watersheds offer a coherent and ecologically representative entity that can be used to address multiple environmental, socioeconomic, and health objectives together, linked to achieving the Sustainable Development Goals (SDGs). Watershed stewardship exemplifies this by providing safe drinking water, flood mitigation, biodiversity conservation, food production, and other key ecosystem services, which make vital contributions to disease prevention and improved wellbeing. In response to the integrative demands of both the SDGs and planetary health, watersheds warrant ongoing attention as domains for research and action.

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