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Ray Ison and Yongping Wei

1 Professor of Systems, Applied Systems Thinking in Practice Group, School of Engineering & Innovation, The Open University, UK. 2 ARC Future Fellow (River Basin Management), Associate Professor, School of Earth and Environmental Sciences, Faculty of Science, University of Queensland, St Lucia, Queensland, Australia; *Corresponding author ray.ison@open.ac.uk

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Figure 1. Words clouds included in titles, key words and abstracts of 7 papers in China Science Vol 58 Issue 1 (2015) and Cheng & Li’s paper in Vol 58 Issue 7 (2015)
As outlined by Ison (2016) the use of the concept ‘system’ is widespread but all too often is employed without adequate theoretical insight. As Lakoff (2010) would say it has become a common framing choice: “And since frames come in systems, a single word typically activates not only its defining frame, but also much of the system its defining frame is in” (Lakoff 2010 pp. 71-72). The issue of boundary choice is critical to the deployment of the concept ‘system’ (Midgely 2003). Understood metaphorically the concept Earth System implies a boundary associated with the whole Earth. For example, IGBP say that ‘the term “Earth system” refers to Earth’s interacting physical, chemical, and biological processes. The system consists of the land, oceans, atmosphere and poles. It includes the planet’s natural cycles — the carbon, water, nitrogen, phosphorus, sulphur and other cycles — and deep Earth processes
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However, there is a systemic trap in the use of the concept system, a noun in the English language (Ison 2016). Whilst the concept draws attention to the elements and relationships that might exist and operate in a system of interest, what is concealed by the use of the term are (i) the act of making a boundary judgment by an observer or observers; (ii) an appreciation that making a boundary judgement realises another relational dynamic – the act of making a distinction between a system and its environment and (iii) awareness that using the term system is always a shorthand for a system-environment relationship mediated by a boundary judgement. Cheng & Li (2015) frame the watershed as a basic unit of the Earth system. They argue that watershed science shares the characteristics of fundamental research in Earth system science and ground their arguments in six intellectual platforms: (i) systems science; (ii) complex systems; (iii) scale problems and (iv) Newtonism vs. Darwinism (v) hydro and eco-economics and (vi) meta-synthesis. Consistent with their claim that watershed science ‘should be integrated with philosophical conceptualization, theorization, methodological exploration, infrastructure construction and field experimentation’ (p. 1167) it is necessary to explore how the concept ‘system’ is employed by authors and how their conceptions relate to, or shape, research practice in a new field of watershed science. We believe that philosophical clarification of the concept ‘system’ could facilitate the systemic integration of all six intellectual platforms of Cheng & Li (2015) and

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Cheng & Li (2015) argue that watershed systems are highly co-evolved, complex human-nature systems. They thus set the groundwork for how co-evolutionary processes function. However, this co-evolution is based on long term and complex ‘negotiations’ between culture and nature. The negotiation is a result of human decision-making, which is the primary driver of earth system change. We argue that any human decision is determined by the interactions between social values (willingness to change), technology progress (capacity to change) and institutional arrangements (change regulated formally by government or through self-organising informal institutions) at different system levels (Wei and Zhang, 2017 and Wei et al. 2017). Therefore, while we agree with Cheng & Li (2015) that hydro-economics is important for understanding interdependence between economic activities and natural systems, three sub-disciplinary fields from hydrology: socio-hydrology, techno-hydrology and institutional-hydrology are needed for the development of watershed systems science. Developments in these sub-disciplines can provide understanding of the mechanisms for governing the impact of human activities on the earth’s surface in the Anthropocene.

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The arguments made by Cheng & Li (2015) for the ‘atomic’ nature of a watershed, and thus its utility as a locus of study and of governance are conceptually sound. They also allow consideration of co-evolutionary dynamics between a social and a biophysical system but unfortunately many watersheds are no longer purely ‘natural systems’; when inter-basin water transfers are made, or human wellbeing is linked to economic activity that spans watersheds then the question of system boundary choice, aligned to human purpose must be addressed. A holistic science that begins with systemic sensibilities and does not privilege linear or systematic causality is needed in all situations, including an earth system, characterized by interdependency, uncertainty, complexity, and controversy. These are the features of an Anthropocene world in which human action is effecting whole earth dynamics and in which traditional understandings and practices such as commitments to stationarity in hydrological modelling are no longer adequate. Achievements from the ‘Heihe Plan’ constitute a unique opportunity and significant investment to further build on multi-disciplinary achievements. To transform further towards a mature watershed systems science we urge the systemic use of the concept ‘system’ and bringing in new social-oriented subdisciplines of hydrology. The HRB could be developed as an iconic watershed for watershed systems science – a new paradigm to understand and govern the impact of human activities on the earth’s surface in the Anthropocene.

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