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Editorial overview: Keeping fit in the dynamics of coupled natural and human systems

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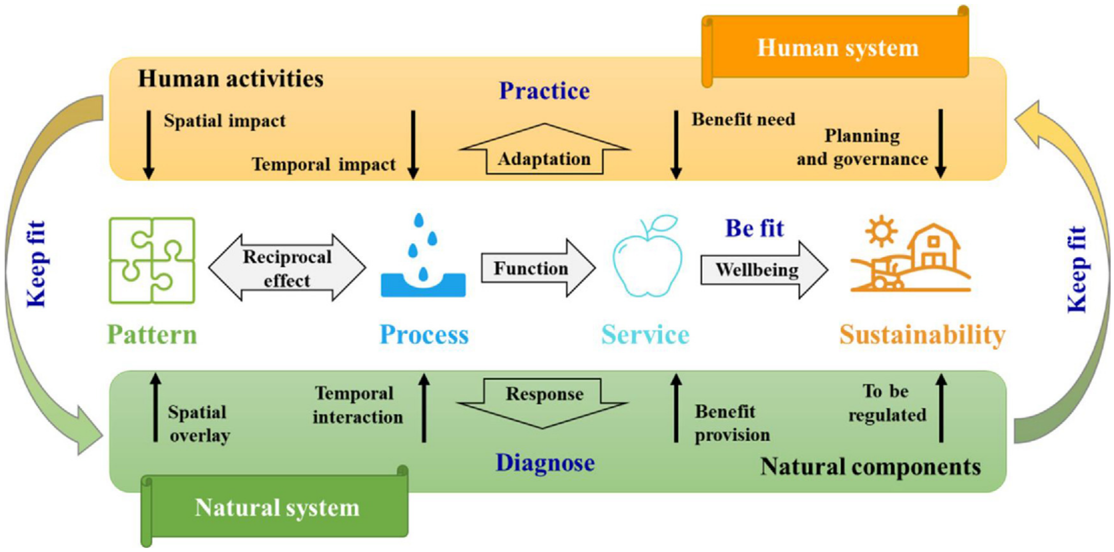
Growing populations, urbanization, land use change, and climate change have largely modified the Earth's surface where humans live, as well as altered the relationships between humans and nature [1]. Thus, there is great need to observe, analyze, assess and predict the changes in human–nature relationships and to determine if humans are 'fit' rfor these changes [2]. Fit means '*adapted, suited, proper, competent, prepared, ready or in good physical condition*' (http://www.thesaurus.com). It is the goal of each human as an individual to exist in his/her environment. 'Keep fit' is defined as '*exercises designed to promote physical fitness if performed regularly*' in the dictionary (http://www.thesaurus.com). Such exercises are a daily practice required for most people to be fit. However, humans as a group have learned numerous unpleasant lessons for keeping fit for changes in coupled natural and human systems (CNH). That is why the Sustainable Development Goals (SDGs) are globally advocated. Furthermore, as suggested by the Future Earth 'Research for Global Sustainability' platform, we have a limited understanding of the dynamic mechanisms of CNH; therefore, we have been unable to provide a manual for humans' ability to keep fit for a more sustainable global environment. This issue, entitled '*System Dynamics and Sustainability*', aims to contribute to filling this knowledge gap.

The problem regarding keep fit is about linkages between different systems [3]. We consider keep fit as the process of matching a socioeconomic system with its biophysical environment across temporal and spatial scales, while bidirectional coupling exists between environmental changes and socioeconomic changes. This issue uses the conceptual cascade of 'pattern — process — service (function) — sustainability' (Figure 1) to develop an understanding of diagnoses and practices for keeping fit in CNH. The former refers to understanding the dynamics of CNH, and the latter refers to management policies and practices for improving sustainability.

The dynamics of CNH forms the bidirectional links between natural system and human system [4]. In order to keep fit in CNH, researchers should diagnose the response of human impact on natural system, and detect the practice way to adapt the environmental change. In particular, to be fit for a systematic sustainability, researchers should quantify the reciprocal effect between pattern and process, identify the ecosystem services among various ecosystem functions, and reveal the contribution of ecosystem services on human wellbeing. Human activities such as planning and governance are

Figure 1



The concept of keep fit in coupled natural and human systems (CNH).

typical adaptations to regulate the natural components towards sustainability. This issue contains progress reviews, theoretical research and empirical studies on the interaction between the biophysical and social processes of CNH dynamics from different regions of the world.

This issue includes four articles about understanding the processes of CNH. Zeng *et al.* found that Earth's greening is a prominent driver of terrestrial evapotranspiration (ET) intensification over recent decades, as evidenced by observation-based statistical analysis and observation-driven model simulations [5]. Li *et al.* found that above-ground net primary production, belowground net primary production, and species richness showed strong negative responses to 4°C warming, 50% precipitation decreases and high grazing intensity [6]. Setting Southern Africa as a case study area, Musakwa and Wang found that agriculture and urban growth are key drivers of landscape change in Southern Africa [7]. Zhang *et al.* developed a mechanistic framework of catchment hydrological processes for understanding the effects of climate and land-use change on water yield [8]. These findings, from the perspective of the influencing factors on a single process, help improve our diagnosis capacity for keeping fit in CNH.

This issue includes four articles about understanding CNH from the ecosystem/ecosystem services perspective. Lu *et al.* argued that ecosystem services concepts and methodologies such as ecosystem services hotspots, trade-offs, supply-demand analysis and ecosystem services valuation are highly useful in resolving environmental issues and in achieving sustainable goals for dryland ecosystems [9]. Zhao *et al.* proposed a network connectivity-based assessment framework for quantifying the connections among ecosystems, ecosystem services, ecosystem services beneficiaries, ecosystem services management organizations and external drives [10]. Tian *et al.* proposed an integrated modelling system for the food-energy-water nexus by coupling an ecosystem model, an economic model, and a regional climate model, aiming to mimic the interactions and feedbacks within ecosystem-human-climate systems [11]. Wang *et al.* noted that CNH systems have their own structures, functions, and dynamic mechanisms [12]. Wang *et al.* de-structured the fit, including the boundary fit, structural fit, and dynamic fit. These frameworks and models help improve our capacity to diagnose if humans keep fit in CNH from a system perspective.

As a core component, this issue contains four articles on the influences of socio-institutional factors on the dynamics of CNH. They contribute to both the diagnoses and practices of keeping fit. It starts with Feng *et al.*'s work [13]. This article argued that the potential conflict between supply and demand of water for nature and human beings, the impact of climate change and human activities on water distribution in CNH, and the trade-offs of water-related ecosystem services are three key issues for keeping fit in CNH. Wei *et al.* highlighted the crucial roles of economy (market regulation), government (macro-control), and human value (cultural role) in shaping the complex interplay of socio-ecological systems [14]. Lu *et al.* proposed a socio-hydrological water balance framework for water allocation between human and natural systems, which represented social processes with three interactive variables: societal value change, technological progress and governance reform [15]. Sanderson

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