

Editorial

# Special Issue “Rural–Urban Transformation of Asian Megacities from a Social-Ecological Systems Perspective”

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In 2021, 56% of the global population lived in cities, and by 2050 the ratio of urban-to-rural population is expected to reach 67% [1]. Though the current share of urban population in Asia (52%) is lower than in the Americas (82%) and Europe (75%), the average annual urbanization rate during the past ten years was highest in Africa (2.9%), followed by Asia (2.2%) [2]. As far as megacities with > 10 million inhabitants are concerned, seven of the global top ten were located in the Asian-Pacific region in 2022 [3]. These developments inspired the idea for this *Special Issue* on “Rural–Urban Transformation of Asian Megacities from a Social-Ecological Systems Perspective”, because megacities, as hotspots of human habitation and activity, have major effects on their immediate and remote neighbourhoods, in environmental, economic, social, and cultural terms. With progressive spatial expansion of the city, the surrounding rural settlements and landscapes at first transform progressively into peri-urban neighbourhoods, characterised by a dynamic mix between modern aspects of real estate development, city life, and material as well as immaterial rural tradition and land use [4]. Over time, the latter aspects dwindle and urban configurations of land use, building style, value generation, and living patterns take over, with the neighbourhoods developing into new urban quarters. Depending on the spatial location of the initially rural settlement, such processes can span a decade or more, or just take a few years, if, for example, the village is located along a highway connecting the city to an international airport [5].

Even though the call for this *Special Issue* was not proposing a specific megacity as the focal point, the contributing eight articles all report on the Indian city of Bengaluru; with 12.7 million inhabitants in 2021 [3], Bengaluru is currently ranked 17th on the list of major cities in the Asian-Pacific region. The eight articles compiled here report on research conducted in the framework of the Indo-German Research Unit FOR2432 “Social-Ecological Systems in the Indian Rural–Urban Interface: Functions, Scales, and Dynamics of Transition” funded by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) and the collaborative partner project “The Rural–Urban Interface of Bangalore: A space of Transitions in Agriculture, Economics, and Society” funded by the Department of Biotechnology (DBT), India. Furthermore, studies conducted in the framework of the graduate program “Rural–Urban Dynamics in Bangalore” (BangaDyn), funded by the University of Kassel, also contributed to this *Special Issue*.

Of the eight articles assembled here, three focus on ecosystem services provided by soil [6], water [7,8], and trees [9] in the Greater Bengaluru region, while three further contributions focus on human actors and actions as well as governance [8,10,11]. Finally, two



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studies [12,13] deal with the impact of megacity advancement and growth on dairy cattle farming as a relevant economic and cultural element of the megacity of Bengaluru [14].

The study by Moran-Rodas and collaborators [6], “*Agricultural Management Practices and Decision-Making in View of Soil Organic Matter in the Urbanizing Region of Bangalore*”, investigates how current agricultural management practices and socio-economic factors affect soil organic carbon contents in the vicinity of Bengaluru. For that purpose, the authors combined a literature review and a statistical evaluation of panel survey data. They showed that the farming and household conditions affect the choice of conservation practices and fertilization, which, in turn, affect soil organic carbon concentrations. Thus, they conclude that improving the conditions under which farmers grow their crops and fruits may increase the soil organic carbon (SOC) stock, while the degree of urbanity is not an explanatory variable for soil conservation. In contrast to pure agronomical studies, the authors included socio-economic factors in their analysis and thus provided a broader overview of the factors affecting SOC. This chain of causation may be used for decision-making in order to improve SOC content in the social-ecological system of Bengaluru and in similarly structured Asian megacities.

A side-product of the research by Moran-Rodas and collaborators [6] was that borewells are an important source of irrigation water around Bengaluru. Regarding its effect on the groundwater system, this topic is evaluated by Kulkarni and colleagues [7] in their contribution “*Deep Drilling for Groundwater in Bengaluru, India: A Case Study on the City’s Over-Exploited Hard-Rock Aquifer System*”. Since official groundwater level recordings are highly uncertain due to the huge heterogeneity of the fractured granite aquifer below Bengaluru, the authors took the approach of using bore-well completion reports of local drilling companies and evaluated the depth and the bore-well yields in space and time. It was shown that bore-well depth significantly increased from around 100 m below ground (b.g.) to 350 m b.g. in the last 60 years, with the strongest increase in the years 2000 to 2010. Stable water isotope analysis suggested that currently pumped water is not paleo-water but was recently recharged by rainfall. This leads to the conclusion that the water management in and around Bengaluru has the potential to be sustainable, although the current management is not. One special feature of this paper is the usage of data available from local bore-well drillers as an alternative to uncertain measured groundwater table data.

Additionally, with urbanization, the composition of vegetation is changing significantly. This is particularly demonstrable in connection with the tree population. In their paper “*Tree Diversity and Tree Community Composition in Northern Part of Megacity Bengaluru, India*”, Divakara and collaborators [9] present data on tree distribution, species composition, and tree species diversity along a gradient from the city centre to the rural surroundings of northern parts of Bengaluru city to demonstrate this in detail. Among the 93 observed tree species, they found an extraordinarily high proportion of non-native species. In connection with urbanization processes, an increase in the importance of ornamental and design functions of trees can be observed. In the regional context, urbanization contributes to a considerable transformation not only of the land cover, but also of the character of the trees present. The latter are larger in the urbanized area and occur less as individual trees. The gradual disappearance of regionally typical tree species contrasts with a strong differentiation of the species found in the more urbanized area. Those results may contribute to more appropriate landscape planning in the context of urbanization.

The key roles that land and its changing uses play in urbanization processes is also evident in the paper “*Negotiating Land in Rurban Bengaluru, South India*” by Schwind and Altrock [11]. They point out the complex processes of re-evaluation and negotiation over land among local residents and other actors that take place in the process. By no means can urbanization be seen as a linear process in which a profit-oriented exploitation of land through urbanization clearly and without contradiction prevails. Rather, it is a complex process of gradual change over a long period of time, in which the rural population is not at the mercy of the loss of agricultural land without resistance but succeeds in negotiating

their integration and disintegration into the urban cosmos while remaining embedded within the rural context. Depending on various social factors, some of them manage to actively intervene in the processes. The resources they use to do so typically draw on both traditional knowledge of rural ways of life and urban utilization mechanisms. In the process, urban assemblages emerge in transitory areas. The work specifically pays attention to the reshaping of subject–land relations and analyses how implicit or explicit references to the city and the countryside permeate the construction of values and uses of land among the old and new social groups in the metropolitan region.

The way different communities and areas in urbanizing contexts implicate themselves into co-management of natural resources between public, private, and civil society actors is also addressed by Lakshmisha and Thiel [8] in *“Bridging Actors and their Role in Co-Managing Lakes: Cases from Greater Bengaluru Metropolitan Region”*. In this paper, the authors wonder about the diverse roles of bridging actors in the management of numerous artificial lakes in contexts ranging from urban to rural in the Greater Bangalore Metropolitan Region. Roles and strategies of bridging actors greatly vary, as the paper illustrates by relying on a description of the way co-management is initiated, how this relates to bridging actors’ position in a network, and how they facilitate interaction, such as either through building trust or through providing access to information. The paper finds that context is of great importance to understanding which actors adopt a bridging role and what strategies need to be employed to connect actors. In more intensely used and developed areas of Greater Bangalore (a) and where actors are more heterogeneous (b), the state adopts a more prominent role in governance. Correspondingly, in the urban and peri-urban context, state agents also play an important role in facilitating co-management. Bridging actors in those cases are centrally positioned. In contrast, in the rural case, self-organization of more homogenous groups of users plays a more important role and this community-driven bridging actor is more peripheral to management than in the more state-dominated urban and peri-urban instances of co-management. Results from this in-depth study of the illustrative case of Greater Bengaluru Metropolitan Region require further testing across urbanizing areas and different types of resources to come to generalizations.

Urbanization may also offer opportunities for smallholder farmers such as business opportunities in the off-farm sector or better access to credit. These are issues addressed in the contribution *“Smallholders’ Challenges: Realizing Peri-Urban Opportunities in Bengaluru”* by Rajeev and Scherrer [10], who wonder to what extent smallholders in peri-urban areas make investments in agricultural upgrading and non-farm activities and what drives and hinders these investments. The authors engage in literature on financial inclusion as they indeed observe a much improving physical access of peri-urban populations to financial institutions. However, it seems that this hardly translates into better income opportunities and livelihoods. Instead, peri-urban populations hardly get access to advantageous formal credit because agricultural land, even if of increased value, does not effectively serve as collateral. Further, peri-urban populations often lack education and capacities to develop entrepreneurial activities that do not serve sheer quests for survival. While new cropping patterns on reduced land are spreading (floriculture), resulting income opportunities are hindered by uncertainty as they do not fall under agricultural insurances, which leaves farmers in precarious conditions. Altogether, it means that peri-urban populations hardly benefit from opportunities of urbanization. Instead, micro-credit and cooperative loan programs continue as the main providers of finance, which hardly promote entrepreneurialism given the loan structure and limited size of loans. Altogether, this article greatly contributes to our understanding of the effects of urbanization on business opportunities of smallholder farming populations and paints a bleak picture in that regard requiring policy interventions to adapt smallholders’ abilities to the opportunities of urban expansion.

Undoubtedly, mixed crop-livestock farmers who kept some dairy animals were already living in today’s Greater Bengaluru area before the city was officially founded in the 16th century [15]. The growing city that engulfs farms, transforms pastures, and reduces access to watering points is inflicting stress on both farmers and animals. Heat stress, a general

challenge in tropical regions, is reinforced by dwindling aeration, increasing heat reflection from buildings, and reduced shade by declining tree cover as urbanization increases [9]. Therefore, Mullakkalparambil Velayudhan and colleagues [12] investigate “*Effects of Heat Stress across the Rural–Urban Interface on Phenotypic Trait Expressions of Dairy Cattle in a Tropical Savanna Region*” using 96 cattle records across 35 farms in Bengaluru. The combined effects of climate, season, and farm location along rural to urban transect lines on milk production, body condition, and various hygiene scores of cattle were measured repeatedly. In particular, the environmental variables season, rural or urban farm location, and climatic conditions as expressed by the temperature humidity index significantly affected most of the measured cattle traits. The distinct trend of location along the interface in its impact on most traits points to the prevalent role of cattle management as it is shaped by the immediate farm neighbourhood in the Greater Bengaluru region. The results underline the importance of considering ecological, social, and climatic factors simultaneously in order to improve the welfare and performance of dairy cattle in a megacity environment.

The imminent influence of the immediate neighbourhood on farm animal husbandry along the rural–urban interface emerges even more during situations of crisis. The contribution of Alam and colleagues [13] on “*Impacts of COVID-19 on Small-Scale Dairy Enterprises in an Indian Megacity—Insights from Greater Bengaluru*” analyses the consequences of the first series of COVID-19 lockdowns in India, from 25 March to 31 May 2020. The severe movement restrictions of the lockdown decreased farmers’ ability to harvest or purchase cattle feed outside the farm, drastically reduced the importance of farm gate milk sales, and entailed a lack of supportive interventions by the dairy cooperatives, which also suffered from the decline in milk demand. Across a sample of 129 farmers, dwindling income from milk sales on the one hand and rising costs of feed procurement as well as lack of veterinary services on the other led to the sale of about one third of the productive dairy cows between April and August 2020. While it appeared that medium-sized dairy farms coped better with the lockdown consequences than small- and large-scale farms, a clear effect of location along the rural–urban interface could not be detected in this study. Whereas international literature points to the importance of locally produced food in situations of crisis [16], Alam and collaborators [13] demonstrate that, at the level of a megacity, the responsible public and private sector actors need to capacitate the producers of food, namely the farmers, to effectively cope with shocks.

To sum up, the eight articles in this *Special Issue* shed light on some of the biophysical, social, economic, and cultural consequences of urbanization for the human and non-human beings inhabiting the sphere of influence of the megacity of Bengaluru. Being a very dynamic amalgamate of a multitude of people and organisms, material and immaterial infrastructure, and economic, social, and political practices and developments, Bengaluru showcases the Asian megacity as a mosaic of loosely or strongly connected neighbourhoods between which the pace and impact of urbanization processes as well as their social-ecological outcomes greatly vary. In the face of progressing climate change, the risk of new pandemics, accelerating digitalization, and globalization of micro- and macro-economic processes, the challenges for inhabitants and authorities of megacities will multiply. Concerning the city residents, the eight case studies combined in this *Special Issue* demonstrate that they are able to adapt rapidly, flexibly, and creatively to the permanently changing conditions along the rural–urban interface but also that some are not capable of overcoming institutional and knowledge barriers in order to seize the opportunities that urbanization offers. Identifying and effectively supporting sustainable solutions evolving in these processes is the challenge for city planners, public and private managers, as well as civil society.

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