Linking urban growth patterns and the Food-Water-Energy Nexus in Pune, India

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Capturing urban growth dimensions

Pune is one of India's most rapidly growing cities. Between 1941 and 2011 (Census of India 2011), the municipal corporation's population has grown from ca. 375,000 inhabitants to 3.1 million. The urban agglomeration (Pune Metropolitan Region, PMR) has recently surpassed the 5-million threshold (Census of India 2011). Until 2075, Hoornweg and Pope (2017) estimate the PMR to host around 15 million residents (Fig. 1).

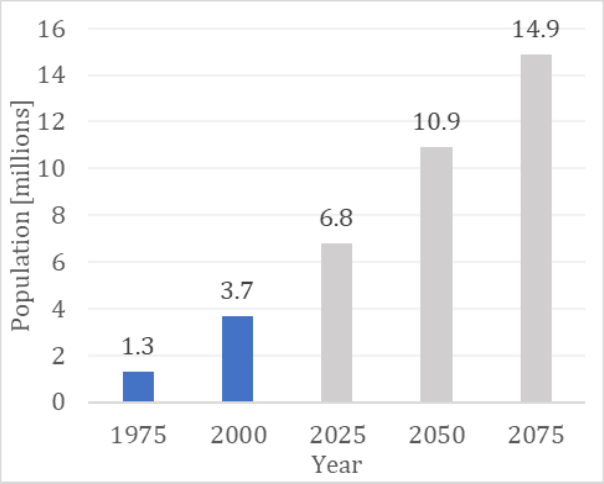

Fig. 1: Population of Pune Metropolitan Region (in millions). Past growth and predictions (own draft; sources: Census of India 2011, Hoornweg & Pope 2017)

Various factors contribute to the city's rapid population growth. On the one hand, due to the young population profile, the rate of natural increase is still positive despite a low TFR (total fertility rate) of ca. 2.0 (Pune district; Guilmoto & Rajan 2013). On the other hand, Pune is increasingly acting as a magnet for domestic migration, which today contributes approx. half of the city's population growth. 660,000 residents (20%) of Pune are considered migrants with two thirds of them being from Maharashtra and most of the rest from neighboring states (Butsch et al. 2017).

Different migration patterns can be observed: migrants come to Pune both from rural areas and from other urban centers. The latter is often the case when it comes to the city's attractive job and education opportunities. As Krishnamurthy et al. (2016) note, almost 60% of the IT workers in Pune have migrated from other cities, and as many as 200,000 students from outside Pune are enrolled in one of the city's many universities and colleges. Spill-over effects from Mumbai also constitute a major urban-urban growth effect (ibid).

Among the reasons for the migration of formerly rural residents to Pune, a number of push and pull factors can be identified. On the push factor side, Khairkar (2008) finds the inability of farmers to support themselves and their families due to under-employment, lacking access to education and (agricultural) technology as well as increasingly difficult agricultural conditions in some regions due to change in climatic conditions. Employment opportunities, higher wages, education and health infrastructure, and the promise of better living standards in the city act as pulling factors (ibid.). Of all push and pull factors, Khairkar (2008) found employment to be the dominating reason (71%) to come to the city, followed by natural hazards (14%) and poverty (10%) (Non-representative sample).

Largely based on anecdotal evidence, Saunders (2011) further elaborates on the increasingly difficult conditions in rural Maharashtra: decreasing yields through soil degradation and droughts, shrinking plot sizes (increasingly practiced distribution of estates among heirs instead of leaving all to firstborn), and often high levels of debt have created vicious cycles in many places. Temporary or permanent migration to urban slums has been found as an often-sought coping strategy where resources and social networks allow for it. Consequently, in 2006 more than half of the new arrivals settled in slums (Krishnamurthy et al. 2016).

The strong population increase of Pune comes with significant changes in resource consumption patterns. In the FUSE project, we focus on the food-water-energy (FWE) nexus and the pressure urbanization exerts on it. Rural-urban migration may play a special role in it, since it exacerbates the shift of resource use from rural to urban and with it an increasing concentration of the same. A better understanding of the drivers and their individual relevance is required when attempting to model future migration-induced changes in resource consumption. In

the FUSE project, push and pull factors related to the FWE nexus will be investigated. This will be based on existing data and previous studies in India (e.g. Murali & Afifi 2012), as well as quantitative and qualitative data collection.

Land, a resource with strong links to the FWE nexus, is particularly affected by the ongoing population increase. While sprawl into the periphery takes place predominantly on former farmland and thus affects local food systems, infill development, especially vertical growth of informal settlements, poses additional stress on water and energy infrastructure. Therefore, an understanding of total demand for land and spatial distribution of new developments is critical.

Spatial growth

Between 1973 and 2013, PMC's built-up area increased by the factor 7.5 to then ca. 140 km². More than 200km² are expected to be built-up by 2030 (Butsch et al. 2017), entailing major environmental effects due to the loss of open surface, and the associated altering of the hydrological cycle, e.g. through reduced soil infiltration and evaporation.

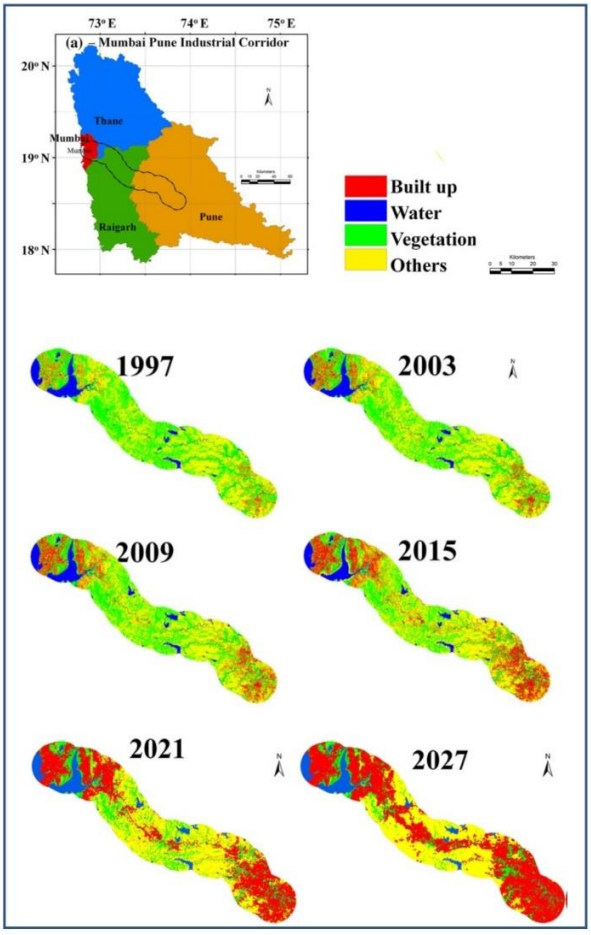

Fig. 2: Observed and simulated LUC in Pune-Mumbai Corridor (adapted after Ramachandra et al. 2019)

Typical for growing (mega)cities in the South, Pune experiences three types of growth: core infilling (densification of the urban center), ribbon development (primarily along transportation axes) and scattered development in the periphery (ibid).

Even more dynamic growth than within the PMC can be observed in the city's periphery, where development has been rapid and largely unplanned. As Kantakumar et al. (2016) show, built-up area almost tripled in the study region (encompassing PMC, PCMC and adjacent villages) between 1992 and 2013. It is further shown that the effect of a regional development plan on the actual urban growth was limited in the past (Kantakumar et al. 2019).

The state government of Maharashtra reacted by establishing the *Pune Metropolitan Region Development Authority (PMRDA)* in 2015 to design and implement a development plan for the PMR. Progress however, has been slow and PMRDA as a small and young authority does not have an enforcement power comparable to PMC. Thus, it is can be expected that the development outside PMC will continue to be at most partially planned.

Pune is part of an urban-industrial corridor connecting it to the neighboring metropolitan areas of Mumbai and Thane. It is also planned to be integrated into the Delhi-Mumbai Industrial Corridor (DMIC), bringing further infrastructural upgrades and industrial zones with it. It is expected that the area between the megacities will continue to urbanize, forming one major urbanized corridor. This trend is modelled by Ramachandra et al. (2019), who found a decline of vegetation cover in the corridor from 41.27% in 1997 to 24.64% in 2015 and predict a further decline to 17% by 2021 and 11.10% by 2027 (Fig. 2).

Conclusion and Outlook

As one of India's largest and most rapidly urbanizing cities, an accurate understanding of its growth patterns is essential to capture Pune's development trajectories. Census and remote sensing data show the growth of the last decades and several studies have attempted to project future developments of both demographic and spatial growth. As a major driver of population growth, rural-urban migration has been identified, though data on migration flows and drivers of the same is scarce. Here, further work is needed to quantify future migration-based population growth. This would provide important inputs to physical growth models (e.g. cellular automata) aiming at allocating future developments of built-up area in and around Pune.

Urban growth and the change in resource availability and consumption patterns are closely intertwined. This is especially pronounced for the FWE nexus, which is heavily affected by urbanization and in turn acts as a driver of the same in certain cases (e.g. when farmers are forced by insufficient water/energy availability for irrigation to give up agri-

culture and move to the city). This calls for an interdisciplinary approach bridging the different research areas. The coupled multi-agent-hydrological simulation model around which the FUSE project is centered, seeks such an integrative understanding to providing a better understanding of long-term FWE trajectories. This will yield applied knowledge in the form of scenario-based policy evaluations, fostering an integrated perspective that acknowledges the linkages between all three nexus dimensions.

References

Butsch, C., Kumar, S., Wagner, P., Kroll, M., Kantakumar, Lakshmi, Bharucha, E. & Kraas, F. (2017): Growing 'Smart'? Urbanization Processes in the Pune Urban Agglomeration. Sustainability, 9 (12): 2335.

Census. (2011): Pune City Census 2011 data. http://www.census2011.co.in/census/city/375-pune.html (01.05.2019).

Foresight (2011): Migration and Global Environmental Change. Future Challenges and Opportunities. Final Project Report. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/287717/11-1116-migration-and-global-environmental-change.pdf (01.05.2019).

Guilmoto, C. Z., & Rajan, I. (2013): Fertility at District Level in India: Lessons from the 2011 Census (Working Papers du CEPED No. 30). Paris, France. https://www.ceped.org/IMG/pdf/ceped_wp30.pdf (01.05.2019).

Hoornweg, D., & Pope, K. (2017): Population predictions for the world's largest cities in the 21st century. Environment and Urbanization, 29 (1): 195–216.

Kantakumar, Lakshmi N., Kumar, S., & Schneider, K. (2016): Spatiotemporal urban expansion in Pune metropolis, India using remote sensing. Habitat International, 51: 11–22.

Kantakumar, Lakshmi N., Kumar, S., & Schneider, K. (2019): SUSM: a scenario-based urban growth simulation model using remote sensing data. European Journal of Remote Sensing, 12: 1–16.

Khairkar, V. P. (2008): Segregation of Migrants Groups in Pune City, India. Anthropologist, 10 (2): 155–161.

Krishnamurthy, R., Mishra, R., & Desouza, K. C. (2016): City profile: Pune, India. Cities, 53: 98–109.

Murali, J., & Afifi, T. (2012): "Where the Rain falls" project. Case Study India: Results from Janjgir-Champa District, Chhattisgarh State (No. 4). Bonn.

Ramachandra, T. V., Sellers, J. M., Bharath, H. A., & Vinay, S. (2019): Modeling urban dynamics along two major industrial corridors in India. Spatial Information Research, 27 (1): 37–48.

Saunders, D. (2011): Arrival city. Über alle Grenzen hinweg ziehen Millionen Menschen vom Land in die Städte, von ihnen hängt unsere Zukunft ab (1. Aufl.). München.

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