Urbanisation and New Agroecologies

The Story of Bengaluru's Peripheries

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Rural–urban interfaces worldwide are increasingly witnessing massive transformations in the structure, functions, and services of complex ecosystems of these zones. An attempt has been made to understand the transitions triggered by urbanisation in the peri-urban agricultural systems of Bengaluru. Using a combination of land-use change analysis and group interactions, the temporal and spatial patterns in the impacts of urban expansion on agroecology in Bengaluru's peripheries have been traced. The varying nature of agroecological and sociocultural impacts corresponding to differences in the pattern of urban expansion along different directions from the city have also been unravelled. Further, agroecological repercussions of existing and proposed urban planning strategies for Bengaluru have been discussed.

Figures A1, A2 and A3 accompanying this paper are available on the *EPW* website.

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Urbanisation has emerged as a significant driver of agricultural transitions in the developing world with mixed outcomes on production landscapes and livelihoods. Urban expansion is estimated to result in a 1.8%–2.4% loss of global croplands by 2030, with 80% of such loss occurring in Asia and Africa, where croplands twice as productive as national averages are predicted to be converted (d'Amour et al 2017). Adding to the staggering cropland loss, other stressors of urban origin, including growing demand for exotic commodities, water and labour, seriously impinge on the overall sustainability of farming systems.

Land-use transformations are particularly pronounced in areas lying adjacent to shifting urban boundaries, variously referred to as urban fringes, peri-urban interfaces or rural–urban interfaces. These cusp regions exhibit considerable structural and functional diversity depending on the characteristics of the urban core and peripheries that comprise them. Nonetheless certain integral features of peri-urban interfaces include intense urban–rural interactions amidst coexistence of distinct rural and urban activities, diversity of resident populations and land uses, changing social structures, institutional ambiguity, unplanned growth and poor infrastructure (Tacoli 2006; Marshall and Randhawa 2017a; 2017b).

Given the intense competition for land, water and other natural resources in peri-urban areas, some scholars portray urbanisation as largely exerting negative impact on agrarian communities (Wilson et al 2003), while others recognise the potential for successful farming (Rao et al 2016) and dairy enterprises (Brook et al 2006) in peri-urban areas, tapping urban market niches and new technologies. Acknowledging the varied influences of urban expansion on peri-urban agriculture, this paper identifies changing patterns of multifaceted values and services of farming systems straddling ecological, sociocultural, and institutional dimensions (henceforth, referred to as "agro-cultural ecology") in differently urbanising peripheries of Bengaluru.

Urban Expansion in Bengaluru

Bengaluru, touted as India's technology hub, fastest-growing city, and third most-populous city, is home to nearly 10 million people. The city, whose urban growth dates back to the 18th century, expanded markedly in the east–west direction during the colonial period with the establishment of residences for factory workers under the patronage of the Mysore royalty. Post-independence growth in Bengaluru was clearly driven by the industrial mode of development. Since the 1990s, much of the city's spatial expansion has been in the southern direction with the emergence of a technology hub and adjoining residential construction. During 2005–11, the city grew mostly on the south–eastern side (Srinath 2013). The Revised Master Plan (RMP) 2015 of the Bangalore Development Authority (BDA) also prioritised north and south-eastern directions for urban expansion till 2015 (BMRDA 2016: 27).

Land cover change analysis by Aithal et al (2013) showed that Bengaluru city's built-up area increased by 125%, while vegetation and waterbodies declined by 62% and 85%, respectively, between 2001 and 2011. At the same rate of urban growth, their study predicted an increase in built-up area to 57% from the current 29% by 2020, prominently in the north and south directions.

Defining the Urban Periphery of Bengaluru

Based on evidences of intense urban growth along the north–south corridor in recent decades as described in the previous section, we consider an area within 40–45 km from the north and south boundaries of Bruhat Bengaluru Mahanagara Palike (BBMP) as its "periphery" for analysing agroecological transformations. The periphery extends to Kanakapura taluk in the south and Doddaballapur taluk in the north, located in Ramanagara and Bengaluru rural districts, respectively, and forming part of the Bangalore Metropolitan Region (BMR). Despite their proximity to the city's boundary, these taluks have more than 50% of geographical area under agriculture (Table 1) with a significant portion of people (47% in Kanakapura and 25% in Doddaballapura) deriving their income primarily from farming (GoI 2011).

Table 1: Agricultural Changes in Kanakapura and Doddaballapur Taluks, 1995–2011

Feature	Kanakapura			Doddaballapur		
	1995	2001	2011	1995	2001	2011
Net sown area (% in total geographical area)	41.9	42.8	53.6	59.8	58.1	59.7
Current fallow#	1.0	4.6	6.3	5.0	8.1	8.0
Net irrigated area#	13.5	15.2	28.2	12.3	9.1	15.0
Major crops	Finger millet, pulses, vegetables, coconut, mulberry			Finger millet, pulses, vegetables, grapes, eucalyptus		

% in net sown area.
Source: Agricultural Census (1995, 2001, 2011).

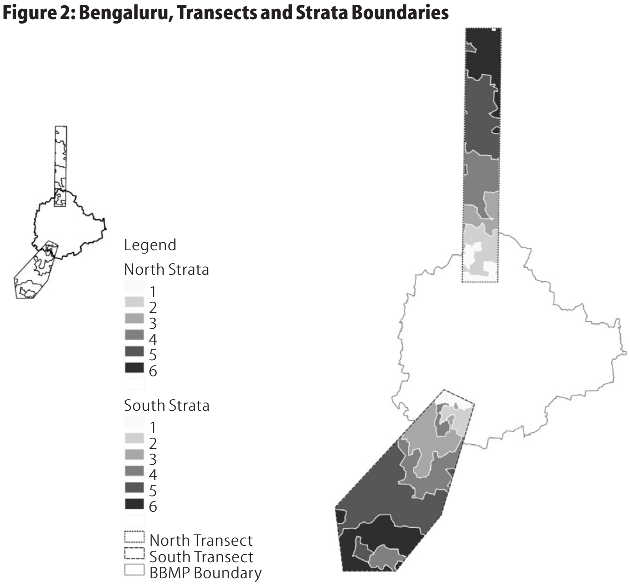
There was decline in the number of cultivators and increase in agricultural labourers in both the taluks between 2001 and 2011 despite increase in net sown area, indicating coexistence of farm and non-farm occupations. Doddaballapur has a relatively larger dependence on non-farm jobs (50,000 factory workers in 2014–15 as against 8,000 in Kanakapura) (DSO 2015, 2016), attributed to early establishment of industrial areas. The two taluks differ with respect to two crucial natural resources: forests and surface water. Nearly 28% of geographical area of Kanakapura is forest, as against 5% in Doddaballapur. Although the Arkavati river originates near Doddaballapur, it hardly has any water flowing (Srinivasan et al 2015). Kanakapura is part of Suvarnamukhi and Vrishabhavathi river basins. Vrishabhavathi that used to be a seasonal rivulet has turned into a perennial sewage flow, thanks to the city of Bengaluru that it skirts around. The seasonal Suvarnamukhi brings relatively less-polluted water originating from Bannerghatta forest.

Preliminary explorations revealed key differences in agrocultural ecology between the north and south directions of urban

Figure 1: Bengaluru and North and South Transect Boundaries

Source: BBMP boundary: http://opencity.in/data/bbmp-wards; Transect boundary: Hoffman et al (2017).

Figure 2: Bengaluru, Transects and Strata Boundaries



Source: BBMP boundary: http://opencity.in/data/bbmp-wards; Transect boundary: Hoffman et al (2017); strata boundary calculated and georeferenced by the authors.

expansion around Bengaluru. Hence, to obtain a nuanced understanding of transitions under varying patterns of urbanisation, we adopted the sample transects identified by FOR2432,[1] in both the directions for assessing spatio–temporal land use and agroecological changes (Figure 1). This exercise was expected to disclose if different modes of urbanisation have sustained the agroecological integrity of urban peripheries in these directions.

Transects in the north and south directions, covered an area of 250 square kilometre (km^2) and 300 km^2 respectively. Locations in the transects were assigned to different strata using a composite Survey Stratification Index (SSI) based on (i) aerial distance of the location from Bengaluru, and (ii) percentage of built-up area (Figure 2). The SSI values ranged from zero to one and were divided equally into six strata with the intensity of urbanisation decreasing from the first to the sixth stratum (see Hoffmann et al 2017).

The northern transect extending to Doddaballapur taluk was a rectangular area with a width of 5 km width and 50 km in length, while the southern transect spanning Kanakapura taluk was laid as an irregular polygon to include natural forest and areas irrigated by the city's waste water (Figure A1, available on the *EPW* website). In total, there were 93 villages and urban units in the north transect (henceforth, referred to as North) and 98 in the south transect (henceforth, referred to as South).

Group interactions with farmers from 34 locations in different strata (excluding stratum 1 without much agricultural area) in the two transects during March–December 2017 provided information on their agroecological and sociocultural features. Locations that were diverse in natural resources (crops, forests and lakes) and livelihood activities were selected for interactions based on Google Earth images and information from farmers. Group interactions were designed to cover aspects of the agricultural (crops, inputs for agriculture, crop marketing and dairying), social (caste, gender, social cohesion), cultural (festivals and fairs, culinary traditions), economic (livelihoods, sale of land) and ecological (water, forests, commons, biodiversity) status of the location. Land-use changes during 1992–2016 in both the transects were analysed in an open source spatial analysis platform employing Landsat TM and Landsat ETM+ data with spatial resolution of 30 metre (m) for 1992, 2000, 2011 and Sentinel data of 10m resolution for 2016–17. Data on livelihoods and land use from the 2011 Census and household survey data from I-B02[2] project of FOR2432 supplemented the analysis.

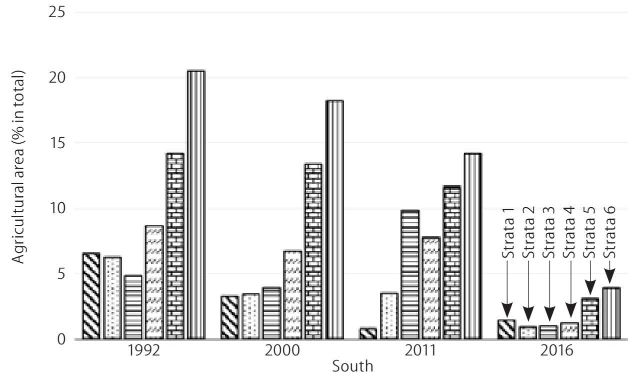
Temporal Changes in Land Use

In North, large-scale conversion of agricultural land to built-up area is a recent trend, triggered by the international airport that came up around 2007. Along the southern periphery, following the establishment of a technology hub and industrial estates since the late 1980s, built-up area grew in clusters compared to the continuous urban sprawl visible in North. Out of the eight categories (built-up, waterbodies, vegetation, agriculture, plantation, forest, fallow and others) of land use compared between 1992 and 2016 in spatial analysis, we focus on agriculture, plantation and built-up areas for explaining the agroecological trends.

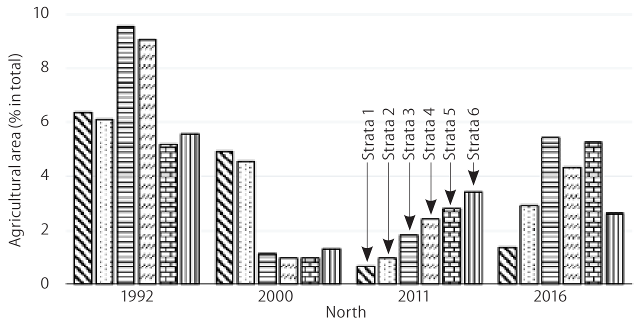
In South, built-up areas are found emerging along the state highway from Bengaluru to Kanakapura. A significant increase in the land-use category of "others" (exposed soil, rocks, quarries, etc) is noticed. Apart from the frontier expansion, four new major urban pockets prominently appeared in stratum 4 from 2000, coinciding with the development of industrial areas near Kanakapura and Bidadi. However, between 2011 and 2016, not much increase happened in the built-up area (Figure A2, available on the *EPW* website), owing to the "empty layout" phenomenon (Hoffmann et al 2017). Empty layouts are agricultural lands converted for residential purposes where construction activities did not progress. This accounts for the increase in the category of "others," and decline in agriculture between 2011 and 2016.

Since 2000, agricultural area has shrunk drastically (8.4%) while plantation (mostly mango and coconut) area increased significantly (21.6%), in response to agricultural labour shortage in areas where off-farm employment opportunities burgeoned. Between 1992 and 2016, all strata lost more than three-fourth of the agricultural area to other land uses, at an average annual rate of 3.4%. Strata 2 and 4 reported the greatest losses in agriculture land of up to 85%.

Figure 3: Changes in Agricultural Area along the Urban–Rural Gradient, 1992–2016



Source: Spatial analysis of landuse/land cover charge.



Source: Spatial analysis of landuse/land cover charge.

In North, built-up area has been gradually advancing from the city core towards rural peripheries (Figure A3, available on the *EPW* website). Built-up area substantially increased (7%) till 2011 and then declined. There was 4.8% decline in agricultural area between 1992 and 2000, but marginal increase (2%) has occurred since then. Agriculture declined at an average annual rate of 1.9%, except in stratum 5, where it remained the same over the years. Plantations (mostly eucalyptus), a dominant land use up to 2000, declined significantly (15%) from 2000–11 due to a variety of factors, including groundwater level (Srinivasan et al 2015), fall in prices and government initiatives to discourage eucalyptus plantation in private lands (KFD 2017). Land under "others" increased significantly (17%), while waterbodies marginally shrank (1.5%).

The percentage decrease in the agricultural area between 1992 and 2001 was lower for all North strata compared to South strata. The loss of agricultural area was 40%–50% in all strata, except in stratum 1 where it was 78%. Though land area under agriculture started increasing (except for strata 1 and 2) from 2001, marked increase occurred between 2011 and 2016 with all, except stratum 6 (declined by 22%) recording a 100%–200% increase in agricultural area.

In order to ascertain the alignment of the urbanisation gradient (as built-up land area) with agricultural land use, we compared the percentage land area under agriculture along both transects over time (Figure 3). In South, agricultural area as proportion of total geographic area showed an increasing trend from urban (stratum 1) to rural (stratum 6) in the four time periods compared, except for strata 1 and 3, which bucked the trend in certain years.

In the North, no clear gradient in agricultural area from urban to rural strata is visible, except in 2011. Interestingly urban strata had considerable extent of agriculture in 1992 and 2000, indicating thriving agriculture closer to the city, that later declined.

Between 1992 and 2016, South lost a higher percentage of agricultural areas in all strata compared to North. It may be inferred that the pace of urbanisation in South has recently (since 1990s) picked up, while built-up areas started appearing earlier historically in North. However, South has better correspondence of built-up area gradients to gradients of agricultural areas, while no apparent match is visible between these gradients in North. This indicates "built-up" or "others" (unused farm lands ready for building up) replacing agriculture in South, whereas in North, plantation areas get converted.

Patterns of Agroecology around Bengaluru

We characterise the agro-cultural ecology of peri-urban Bengaluru using features like agricultural production,[3] ecological parameters such as soil,[4] water[5] and biodiversity[6] and sociocultural practices[7] of the community. Group interactions with farmers and on-field assessments of soil, water and biodiversity provided information on relevant parameters.

Table 2: Pattern of Agricultural Production , 2017

	South			North		
	Commercial Crops	Food Crops	Dairy	Commercial Crops	Food Crops	Dairy
Stratum 2	1	1	1	1	3	1
Stratum 3	1	3	2	2	3	2
Stratum 4	3	3	2	3	1	3
Stratum 5	3	3	3	2	3	3
Stratum 6	3	1	3	3	1	3

1—Low; 2—Moderate and 3—High incidence of concerned parameter mentioned in the column.
Strata were ranked high, medium or low for crops—divided into commercial and food—and for dairying, based on their occurrence in terms of percentage area under crops and number of dairy farmers.
Source: Interactions with farmer groups on parameters.

Agricultural production: Although the selected transects lie contiguous with the city, food crops (finger millet and pulses) are grown in both, and remarkably close to the city in North. In farther strata of South, cultivation of commercial crops (baby corn, mulberry and fodder grass) are predominant owing to the incompatibility of food crops with sewage irrigation practised here (Table 2).

Ecological parameters: In South, waste water expelled from the city accounts for higher availability and poor quality of water in strata 5 and 6 (Table 3). In strata 2, 3 and 4, relatively unpolluted river channels provide irrigation, though not widespread. As some form of surface water is available in all strata of South, dependence on groundwater is less compared to North. In North, higher groundwater availability in strata 2 and 3 that are situated at lower elevation supports food crop cultivation.

Soil quality in stratum 4 to 6 of South was better than that of strata 2 and 3, possibly from the use of nutrient-rich waste water. Although heavy metal content in soil was not available from this area, traces (some metals in more than permissible levels) in surface water and agricultural produce have been reported by Jamwal and Lele (2017).

Forest and water resources in South make it richer in diverse species of birds, trees and crops than North. Moreover, plantations of mango and coconut in South, compared to eucalyptus or lawn grass in North, better support pollinators and biodiversity in agroecosystems.

Sociocultural practices: Farming systems are embedded in sociocultural contexts that benefit from agroecological features and shape them in turn. South, with more collective activities, appears vibrant in such features in all except stratum 5 (Table 4), while social life in the villages of North appeared

Table 3: Pattern of Ecological Parameters, 2017

	South								North							
	Water Availability for Irrigation		Irrigation Water Quality			Biodiversity			Water Availability		Irrigation Water Quality for Irrigation			Biodiversity		
	Surface Water	Groundwater	Surface Water	Groundwater	Soil Quality	Birds	Trees	Crops	Surface Water	Groundwater	Surface Water	Groundwater	Soil Quality	Birds	Trees	Crops
Stratum 2	1	1	2	2	1	3	3	1	NA	3	NA	2	3	1	1	1
Stratum 3	1	1	2	2	1	1	3	1	1	2	2	2	2	1	2	2
Stratum 4	1	1	2	2	3	3	3	3	1	1	2	2	2	2	2	2
Stratum 5	2	1	1	1	3	3	3	3	NA	1	NA	2	2	2	3	2
Stratum 6	2	3	1	1	3	3	3	3	1	1	1	2	2	3	2	2

1—Low; 2—Moderate and 3—High status of the parameter mentioned. NA—resource not available.
Soil quality parameters are top soil depth, organic matter, texture, moisture and presence of earthworms (Dang 2007); water quality was assessed using indicators of color, turbidity and odour; species richness of crops, birds and trees indicate biodiversity in agroecosystems.
Sources: Interactions with farmer groups and on-field soil, water and biodiversity assessments.

Table 4: Pattern of Social and Cultural Practices, 2016–17

	South							North						
	Social				Cultural			Social					Cultural	
	Male Participation in Collective Activities	Gifting of Crop Produce	Dependence on Others During Hardships	Female Participation in Work	Female Participation in Collective Activities	Fairs, Festivals and Recreational Activities	Consumption of Home-Grown Food	Male Participation in Collective Activities	Gifting Crop Produce	Dependence on Others During Hardships	Female Participation in Work	Female Participation in Collective Activities	Fairs, Festivals and Recreational Activities	Consumption of Home-Grown Food
Stratum 2	NA	NA	NA	NA	NA	2	NA	1	3	1	3	1	1	1
Stratum 3	2	2	2	3	3	2	1	1	1	1	3	1	1	1
Stratum 4	2	3	3	3	2	2	2	2	1	2	1	3	2	2
Stratum 5	1	1	3	1	1	2	2	3	2	1	1	3	2	3
Stratum 6	3	1	3	3	3	2	3	3	2	2	1	1	2	3

1—Low; 2—Moderate and 3—High values of social and cultural indicators, NA—data not available. Sociocultural assessment used criteria such as social capital and cohesion, gender equity and cultural practices (Woodley et al 2009; Hayati et al 2011). Values of selected indicators were computed using relevant data from a survey covering 1,200 households in the transects, collected by I-B02/B02 subproject of FOR2432. Data for the cultural indicator "fairs, festivals and recreational activities" was collected from group interactions with farmers.
Sources: Interactions with farmer groups and data from the subproject B02/I-B02.

duller in these attributes possibly due to a visible shift to non-farm occupations.

Due to easy access to non-farm occupations, female work participation was higher closer to the city in North (strata 2 and 3). Eucalyptus plantations in strata 4, 5 and 6 require minimum labour, and industrial centres for tools and machinery here employ a predominantly male workforce. The relatively low presence of womens' groups and programmes in the urban strata is the flipside of greater involvement of women in urban work. In South, all strata had a number of women working in local agriculture and agro-processing industries of various scales. Better women's participation in self-help groups (for thrift as well as enterprise activities) and government schemes in the villages of South was manifested as entrepreneurial skills in establishing and operating petty business.

Fairs, festivals and recreational events are held in all strata in South, while in North these are more in transitional and rural strata (4, 5 and 6) compared to urban strata (2 and 3) where city-based livelihood options are prevalent. Most fairs and festivals have clear linkages to traditional farming cycles. Successful cropping years, when bountiful monsoons and favourable markets assure good returns, witness grandiose celebration of fairs and festivals. Culinary habits that included home-grown food were prevalent in transitional and rural strata. Proximity to the city has a clear impact on dietary preferences by way of easy availability of packaged food and small fast-food eateries.

Linking Agroecology and Land Use

The interlinkages between agro-cultural ecology gradient and proximity to non-agricultural land use have been traced (Table 5).

Table 5: Proximity of Strata to Non-agricultural Land Uses

	South				North			
	City	Industry	Forest	Grazing Land	City	Industry	Forest	Grazing Land
Stratum 2	3	1	1	1	3	1	1	1
Stratum 3	1	1	2	2	3	1	1	1
Stratum 4	1	2	3	1	2	2	1	1
Stratum 5	1	2	3	1	3	3	1	1
Stratum 6	2	3	3	1	3	1	1	3

1 – Low; 2 – Moderate and 3– High proximity to the land use in each column.
Source: Google map and exploratory visits.

In South, proximity to urban area is high only in stratum 2. Strata 4, 5 and 6 are closer to industries as well as forests. Here, land acquisition and conversion, pollution and demand for labour from industries negatively impact farming. At the same time, forests generate environmental services such as water recharge, soil conservation and pollination that are critical to farming. A clearly increasing gradient of many agroecological parameters towards farther strata is produced from this flow of services from forest areas that mask the negative impacts of industrial clusters in these strata in South.

All strata in North are proximate to urban areas, either to Bengaluru's urban core or to the growing hubs of Devanahalli–Yelahanka and Doddaballapur in northern and north-eastern sides of the transect. Here, strata 4 and 5 have industries in close proximity, but the type of industries differ from that of South. Industrial areas in Harohalli and Ramanagara in South host baking companies and factories preparing cooking mixtures and spice powders. These present untapped potential in forging local linkages between production and processing as also in collectivising smallholders. Silk reeling units that precede the recent urbanisation boom, create demand for silkworm cocoons from neighbourhood farmers. Such regional economic linkages through small units can financially and socially support small farmers (Purushothaman and Patil 2017). In North, pharmaceutical, automobile and machine tool industries are common, while farm-based industries are absent. The absence of natural forests and surface water sources further dampens farming activities in North and the effects are observed in Tables 2 and 3.

Apart from water and soil parameters, land commons also play a vital role in cultivation and livestock keeping. Farmers in South mentioned conversion of common grazing lands for residential layouts (in strata 2, 3, and 4) or industrial estates (in stratum 5). In North, strata 5 and 6 witnessed conversion of grazing lands. Livestock rearing and availability of fuelwood, and other minor products for households are affected in the absence of commons. Vanishing commons also increases pressure on private lands to grow fodder for dairying, taking away land from food crops.

New Agro-cultural Ecologies?

Transitions in agroecological and sociocultural milieu in tune with urbanisation gradients are evident in the above description of agro-cultural ecology of peri-urban Bengaluru. From subsistence-oriented and locally or regionally integrated farming systems (for example, ragi–pulses in North and ragi–pulses–coconut in South) to increasingly commercialised and globally linked crop value chains (vegetables and flowers in North and vegetables and fodder in South), these transformations fundamentally alter the diversity, multifunctionality and resilience of agroecological systems. Dietary preferences, gender relations and social connectedness are also found to be reshaped in the emerging urbanised agroecologies. We substantiate the changing character of agro-cultural ecology using two examples that are distinct urbanisation-induced opportunities.

Lawn grass cultivations: Demand for urban landscaping has created a niche market for Mexican grass (*Lolium* sp.) for lawns. In stratum 4 of North, since the past 15 years, rain-fed crops and eucalyptus plantations in many villages have been replaced by turf grass. Turf grass now covers nearly 350 acres in just three villages. Lawn grass is capital-intensive, and requires huge initial investment for irrigation and necessary machinery. On the whole, cash cost of cultivation comes up to ₹5 per square foot of turf. Soil for lawn grass cultivation is either bought from lands converted to residential layouts (at ₹3,000 per truckload) or mined illegally from lakebeds. Women labour (at ₹250 per day) from the locality is employed for planting, watering, weeding and cutting of grass sheets. Grass is sold at the rate of ₹7–₹13 per square foot in the city, and also in the neighbouring states of Kerala, Tamil Nadu and Andhra Pradesh.

Land needs to be cleared off any vegetation and levelled to retain the right amount of moisture in the soil. The grass is harvested in sheets along with two inches of top soil to keep the roots intact.

With generous application of water and agro-chemicals, and no biomass returning to soil, the practice engenders export of virtual water and soil, imperilling the resource base for food production. Health hazards, especially for women, from chemicals and concentrated poultry manure used, is another socio-ecological cost of lawn grass.

Unlike vegetables and fruits whose prices vary seasonally, grass fetches assured income for farmers through garden contractors. But, farming turns into an individual activity, heavily exploiting ecological commons. A decline of social networks and cohesion is apparent, since as high as 70% of lawn grass growers are lessees or absentee landowners from neighbouring states enticed by potential profits.

Waste water irrigation: Farmers in rural strata 5 and 6 of South who irrigate from the Vrishabhavathi river have shifted to non-traditional crops like vegetables, fodder grass and baby corn in response to the change in water quality, and Bengaluru's demand for milk and vegetables. From seasonal rain-fed to perennial sewage-fed farming, financial returns have increased manifold. Nutrient-rich sewage reduces fertiliser expenditure, adding to the profits from perpetual urban demand. But, prevalence of skin diseases, gastric ailments and vector-borne diseases among people and livestock indicate ecological, human and social costs of polluted drinking water and soil. Vegetables and milk from these areas were found to contain harmful heavy metals (Jamwal and Lele 2017).

On the positive side, higher economic returns have helped retain people in agriculture despite the Bidadi–Harohalli industrial cluster. Many farmers are engaged in contract farming (mostly baby corn) with food retail chains that assure them stable income. Additionally, there is diversification of livelihood sources with dairying as a prominent option. Enforcement of legal and policy provisions to ensure proper treatment of sewage before discharging into the river could alleviate the hazards to a large extent. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) that advocates appropriate use of urban waste water for agriculture is such a potential opportunity (MoAFW 2015: 2). A recent scheme of the Minor Irrigation Department in Bengaluru proposes to pump secondary-treated waste water from the city to the peri-urban lakes to recharge aquifers for farming (Vishwanath 2018). Although turning waste water from the city into a resource for water-deficient agricultural peripheries implies a potential bridging of the water and nutrient rift between the production and consumption communities and landscapes, without adequate pollution control mechanisms, it proves hazardous to both producers and consumers.[8]

Balancing Peri-urban Agroecology

Recognising the inevitable transformation of sociocultural and ecological aspects of farming under urban expansion, we examine the possibility of an "agriculture-friendly" reorientation of urban growth trajectories. In the southern direction of Bengaluru, the clustered pattern where urban pockets emerge farther from the city core has driven a higher intensity of urbanisation and greater percentage loss in agricultural areas. However, this transect presented clearer gradients of agro-cultural ecology away from urban edges. Natural endowments of forests and surface water together with agro-processing units are behind this pattern in South.

North does not exhibit a clear rural–urban gradient in socio-cultural and ecological parameters, but combines early history of construction activity with non-farm jobs and traditional food crops. The thrust of urban planning on manufacturing industries and employment opportunities around the airport further weaned people away from agriculture. The expansion of apparel industries in Doddaballapur and aerospace and hardware industries in Devanahalli–Yelahanka, being a major agenda of the Revised Structure Plan (RSP)–2031, North is likely to witness more opening up for urban development and loss of agricultural land in the future. Nonetheless, there has been a resurgence of local[9] and global interest in millets that North was earlier known for, thanks to their climate-hardy nature and nutritive value. These crops, despite their lower yield levels (vis-á-vis irrigated high-value crops), present promising opportunities for preserving agroecological traditions of northern peripheries, while fostering livelihood security. The proposed RMP and RSP should promote small and medium industries for value addition of indigenous crops to boost employment in peri-urban North. In South, Kanakapura Master Plan–2031 recognises the vitality of agricultural lands and recommends designating the area as an "Agri-Export Zone" focusing on sericulture and processing industries for non-staple farm produce in Harohalli Industrial Area (BMRDA 2015: 160–62). These efforts taking advantage of the agro-ecological peculiarities, if realised in the near future, will be a major step towards ensuring livelihood diversity and security in peri-urban Bengaluru.

Our learnings from comparing agroecological changes between northern and southern directions over time indicate that the "cluster mode" proposed in RMP–2031 and RSP–2031 (BDA 2017; BMRDA 2016) encompassing multiple growth nodes and a green network could potentially sustain the agricultural strength of peripheries, compared to other scenarios of urban expansion. However, the RMP's overarching imagination of green spaces as recreational parks and lake networks portends the possibility of a "bourgeois environmentalist" (Baviskar 2011: 392) capture of peri-urban spaces as exclusive reserves-generating ecosystem services (Marshall and Randhawa 2017a) for the rich. This will most likely undermine peri-urban commons and agriculture, and deepen the inequalities that neo-liberal restructuring of the city has already perpetuated. Averting such transformations will require a deliberate pro-poor, pro-farming alignment in policy and planning for urban peripheries, embodying a distinct peri-urban "ecological democracy" (Priya et al 2017: 9). Given its vibrant agro-cultural traditions, and rich stock of ecological and human resources, the revitalisation of the peri-urban agrarian scenario does not seem elusive to Bengaluru, provided urban planning is repurposed to enhance agroecology for sustainable and inclusive food and livelihood systems around the metropolis.

NOTES

1 FOR2432 is an Indo–German collaborative project titled "The Rural–Urban Interface of Bengaluru: A Space of Transitions in Agriculture, Economics, and Society."

2 Project I-B02 titled "Attitudes and Decisions of Agricultural Households in the Rural–Urban Interface: A Survey and Comparative Analysis" under University of Agricultural Sciences, Bengaluru.

3 Strata were ranked high, medium or low for crops—divided into commercial and food crops—and for dairying, based on the percentage of area under crops, and number of dairy farmers.

4 Soil quality parameters are top soil depth, organic matter, texture, moisture and presence of earthworms (Dang 2007).

5 Water quality was assessed using indicators of color, turbidity and odour.

6 Species richness of crops, birds and trees indicate biodiversity in agroecosystems.

7 Sociocultural assessment used criteria such as social capital and cohesion, gender equity and cultural practices (Woodley et al 2009; Hayati et al 2011). Values of selected indicators were computed using relevant data from a survey covering 1,200 households in the transects, collected by I-B02/B02 subproject of FOR2432. Data for the cultural indicator "fairs, festivals and recreational activities" was collected from group interactions with farmers.

8 Recent unrest in Kolar upon receiving treated, but frothing waste water from Bengaluru is an example (Kaggere 2018).

9 Millet mela organised by the Department of Agriculture in Bengaluru (Shankar 2018) and proposal to introduce millets in mid-day meal schemes (*Hindu Business Line* 2018) and Public Distribution System (Chari 2017) are parts of Karnataka's millet propaganda.

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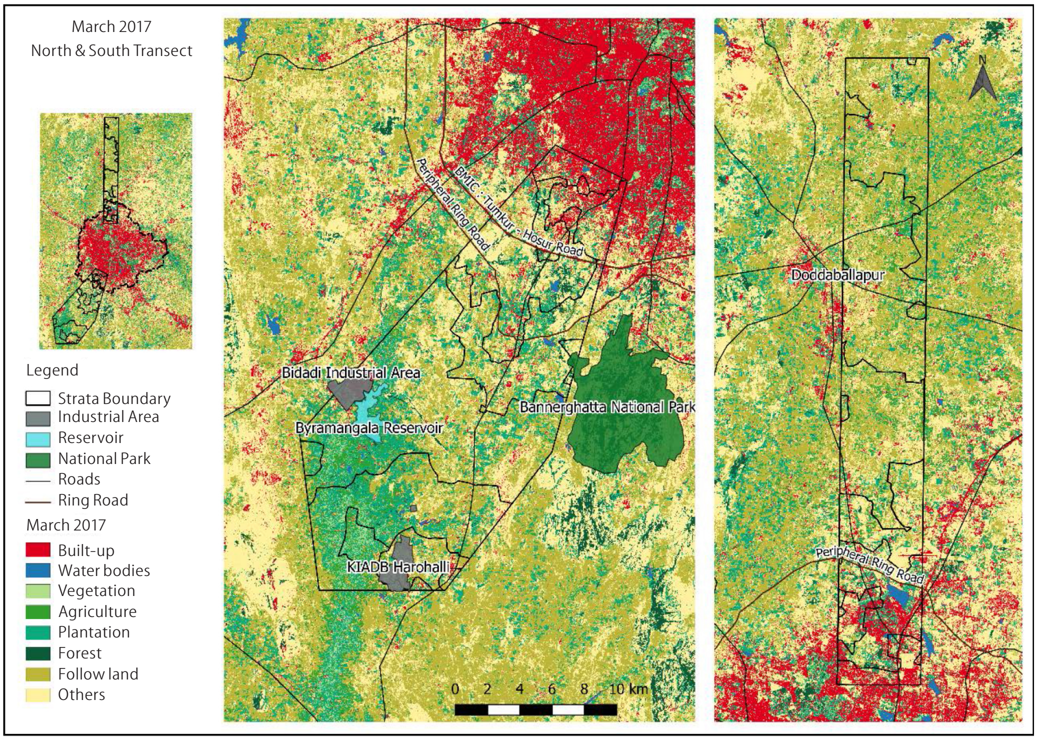
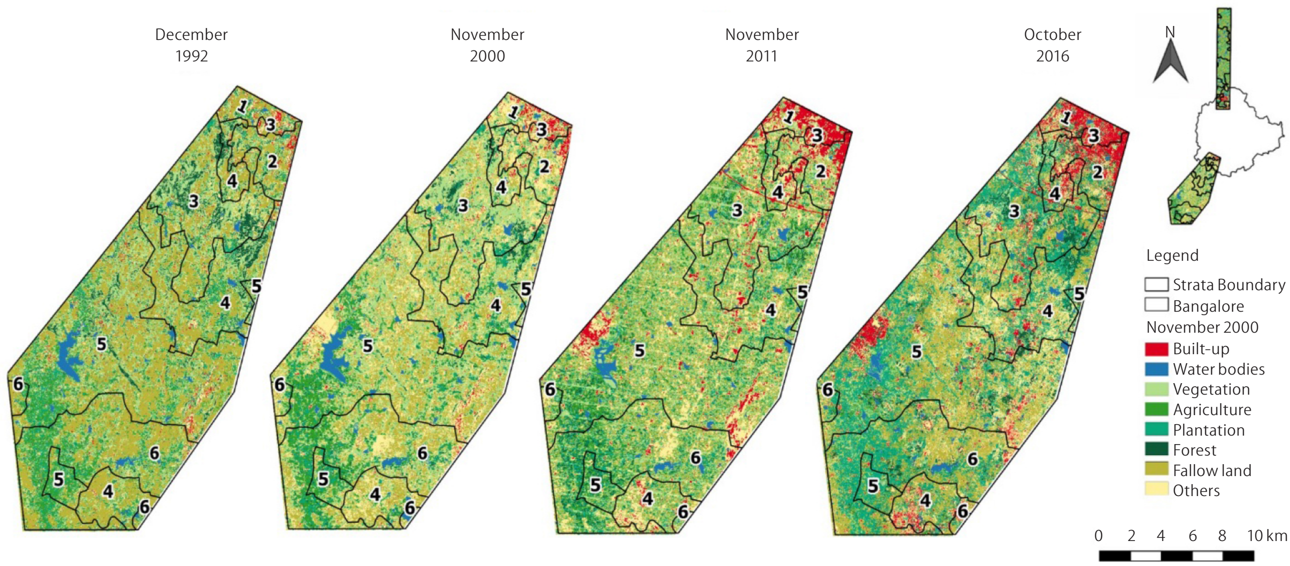
Figure A1: North and South Transects



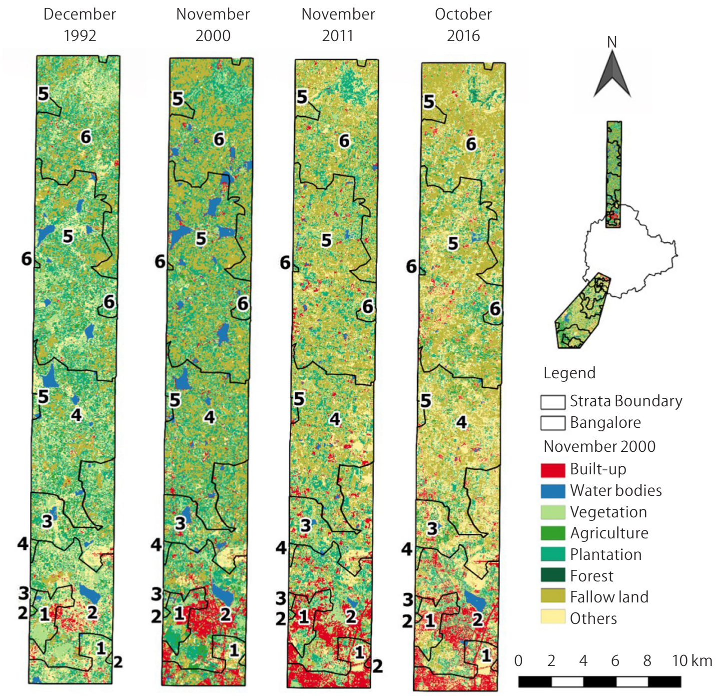
Source: Transect boundaries from Hoffman et al (2017); strata calculations and land use classification by authors.

Figure A2: Land Use Change in the South Transect between 1992 and 2016



Source: Transect boundaries from Hoffman et al (2017); strata calculations and land use classification by authors.

Figure A3: Land Use Change in North Transect between 1992 and 2016



Source: Transect boundaries from Hoffman et al (2017); strata calculations and land use classification by authors.