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Research Paper

Land Use Dynamics Across Rural-urban Transition of Bengaluru

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ABSTRACT

Growth and transition of various land use categories (LUC's) in urban, peri-urban and rural areas of Bengaluru North was analysed using compound annual growth rate (CAGR) and Markov chain analysis. Area under non-agricultural uses has increased significantly across all areas. But, its growth is relatively high in urban and peri-urban more specifically in Devanahalli *taluk* (3.62 %) where LUC's like cultivable waste (-0.72 %), permanent pasture (-2.11 %), tree and groves (-2.26 %) and net sown area (-1.20 %) have seen significant decline in their growth due to relatively more developmental pressures from augmented urbanization effects of Bengaluru. In urban, the net sown area has decreased significantly with CAGR of 4.62 per cent (district) and 3.9 per cent (*taluk*). In rural, permanent pastures and cultivable waste categories seen significant decline in their growth due to their nature of property right i.e. commons. Transitional probability matrix (TPM) of urban revealed that, area under non-agricultural uses, forest and net sown area were most stable whereas, permanent pasture, barren and uncultivable area were least stable on the basis of their probabilities. Similarly in peri-urban, area put to non-agricultural uses, net sown area were most stable whereas, barren and uncultivable area, cultivable waste and other fallow land were least stable. In rural current fallow category is least stable which is influenced by rainfall.

HIGHLIGHTS

- Net sown area is relative more stable in rural gradient compared to urban and peri-urban gradients.
- In the last two decades the area put to non-agricultural uses has increased significantly across all the gradients.
- In the urban gradient, the net area sown has decreased significantly at the rate of 4.62 per cent and 3.9 per cent respectively, at district and *taluk* level during last two decades.

Keywords: Urbanization, land use categories, CAGR, Markov chain analysis and Transitional probability matrix

India is in transition from rural and agrarian based country to urban and industry based country since, urban areas and population density are pegging up in the wake of industrial revolution. For the first time since independence, the absolute increase in population was more in urban areas than that of rural areas, wherein the level of urbanization in India increased from 27.81 per cent in 2001 census to 31.16 per cent as per 2011 census. Meanwhile, the proportion of rural population declined from 72.19 per cent to 68.84 per cent (ORGI, 2011).

As the urbanization increases more and more of agricultural land is converted to non-agricultural uses and which will have a bearing on agricultural production (Malik and Ali, 2015). Besides land use changes from agriculture to non-agricultural uses, the process of urbanization brings changes within

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agriculture also by way of reduction in area under field and traditional crops or increase in area under commercial crops as induced by urban demands (Mwangi and Yu, 2015).

Bengaluru is one of the fastest growing cities in the world and is globally known for its development in terms of information technology, biotechnology, real estate and its diversity and it has topped the list of 134 world's most dynamic cities in 2017. Though urban sprawl is mounting in all directions of the city but is more pronounced in the North of Bengaluru because of developments like establishment of international airport, up gradation of national highway to six lanes, signal-free corridor on a stretch of elevated express way, hardware park, financial city project etc. These developmental pressures have led to transition in land use, land values, labour markets, water resources, lifestyles and livelihood options towards that gradient.

The major impact of the urbanization that could be expected is the structural change in the land use systems as triggered by augmented farm land sales due to surge in land prices. The structural change that can be expected varies from gradient to gradient based on the urban influences. Hence the Markov chain framework was deployed to know the changes that could have happened in the structure of land use across the three gradients viz., Urban, Peri-Urban and Rural.

MATERIALS AND METHODS

A multistage purposive sampling procedure was employed for the selection of study area. At first level, Bengaluru Urban (Urban), Bengaluru Rural (Peri-Urban) and Chikkaballapur (Rural) districts were selected and in the next level Bengaluru North (Urban), Devanahalli (Peri-Urban) and Gudibande (Rural) taluks were selected. The main criterion for delineating the three gradients as urban, peri-urban and rural is geographical location of the districts from centre of Bengaluru towards North direction.

Secondary data on land utilization of the districts (Bengaluru urban: 2001-2002 to 2019-20, Bengaluru rural and Chikkaballapura (2007-08 to 2019-20)) and taluks (period 2001-2002 to 2016-17) representing three gradients were collected from Directorate of Economics and Statistics (DES), Bengaluru. In the year 2007, some taluks were removed from Bengaluru rural district and Chikkaballapura is a newly formed district, so the data for these districts is analysed for the period of post restructuring or formation.

DES has classified the Land Use Categories (LUC's) into nine categories viz., I. Land put to non-agricultural uses, II. Barren and uncultivable area, III. Cultivable waste, IV. Permanent pasture, V. Tree and Groves, VI. Current fallow land, VII. Other fallow land, VIII. Net sown area and IX. Area under forest

Compound annual growth rate*:* In order to assess the growth in area under different LUC's between 2001-02 to 2019-20 across different areas both at district and *taluk* levels, CAGR analysis was employed. CAGR were computed using the exponential function of the form:

$$Y_t = ab^t u_t$$

Where, Y_t = Area under land use type at time '*t*', a = Intercept, *b* = Regression coefficients

t = Years which take values, 1, 2, …,16 (2001-02 to 2016-17) and u_t= Error term

Markov chain analysis*:* The Markov chain analysis was carried out to examine shifts in land use pattern as influenced by urbanization for the period 2001-02 to 2019-20. The area under different LUC's in the respective districts and *taluks* was subjected to Markov chain analysis. Reddy, D.R. & Achoth, L. (2000), Rao & Parwez (2005), Kammar & Basvaraja (2012), Ardeshna & Shiynai (2013) and Manwar & Nagpure (2017) used the Markov chain analysis in the context of estimation of structural changes of cropping pattern. Whereas Kammar (2010) has used the methodology in the context of estimation of structural changes in the LUC's. Here in this study category of each individual LUC is considered to be a random variable and which depended only on its previous LUC area.

The Markov chain analysis was used to estimate the value of transitional probability matrix "*P*". The element P_{ij} of this matrix denotes the probability of shift of area from "i^{th}" LUC to "j^{th}" LUC over time *t*. The diagonal values of P_{ij}, where $i = j$ quantify the probability of area retained by the same LUC i.e. high stability. Hence the diagonal element denotes the strength of the particular LUC to retain in the same category in the given time period.

It can be denoted algebraically as,

$$E_{jt} = \sum_{i=1}^{n} E_{it-1} * P_{ij} + e_{jt}$$

Where, E_{jt}= Area under LUC "j" in the year t, E_{it-1}= Area under LUC "i" in the year t–1

P_{ij} = Probability that area will shift from "i" LUC to "j" LUC

e_{jt} = Error-term which is statistically independent of E_{it-1}, n = Number of LUC's

The transitional probabilities P_{ij} of ($c \times n$) matrix order will have the following properties,

$$\sum_{i=1}^{n} P_{ij} = 1$$

Where, $0 \leq P_{ij} \leq 1$

The transitional probability matrix is estimated in the linear programming (LP) frame work by a method referred to as minimization of mean absolute deviation.

The LP formulation is stated as,

$$Min\ OP^* + I\ e$$

Subject to,

$$X\ P^* + v = y$$

$$GP^* = 1$$

$$Q^* \geq 0$$

Where, "P^*" is a vector of the probabilities P_{ij}, "O" is a vector of zeros, "I" is an appropriately dimensioned vector of a LUC, "e" is the vector of absolute errors ($|U|$), "y" is the vector of proportion of area under each LUC, "x" is a block diagonal matrix of lagged values of y, "v" is the vector of errors and "G" is a grouping matrix to add the row elements of P arranged in P^* to unity.

The set of equations for LP framework is obtained from customized excel sheet called "New markov" and the equations are solved using IDE called "LPSolve".

RESULTS AND DISCUSSION

The land put to non-agricultural uses includes the build up area, parking area and area put to other uses. In the last two decades the area put to non-agricultural uses has increased significantly across all the gradients (Table 1). But, the rate of growth is relatively high in urban and peri-urban gradients more specifically Devanahalli *taluk* (3.62%) where the cultivable waste (-0.72 %), permanent pasture (-2.11 %), tree and groves (-2.26 %) and net sown area (-1.20 %) have seen significant decline in the growth of area due to the relatively more developmental pressures (viz., establishment of international airport and hardware park etc.). In urban gradient, the net area sown has decreased significantly at the rate of 4.62 per cent and 3.9 per cent respectively, at district and *taluk* level. Lintelo *et al.* (2001) in the context of Delhi reported decrease in net area sown by 16.09 per cent and increase in non-agricultural land use by 11.42 percent during 1990-91 and 1996-97.

The findings of Rimal (2013) in the context of Pokhara sub-metropolitan city of Nepal, Rani (2014) in the context of Jalandhar and Kavitha *et al.* (2015) in the context of Bengaluru city also portrayed the similar growth in the said LUC's. In the rural gradient the area under permanent pastures and cultivable waste land has seen significant decline in their growth due to their nature of property right i.e. commons.

The estimates from Markov chain analysis i.e. transitional probabilities are established in the matrix (Table 2). In the urban gradient at district level the area put to area under forest, non-agricultural uses and net sown area were found to be most stable with probabilities of 0.899, 0.885 and 0.880, respectively. Whereas, permanent pastures, cultivable waste land and barren and uncultivable area were found to be least stable with probabilities of 0, 0.011 and 0.256, respectively and the probabilities that these LUC's may lost to land put to non-agricultural uses is 0.91, 0.914 and 0.233, respectively. These probabilities indicates that the LUC's like permanent pastures, cultivable waste land and barren and uncultivable area have high tendency for putting them to non-agricultural uses. Similarly at *taluk* level barren and uncultivable

Table 1: Compound annual growth rates of different LUC across the gradients (%)

Gradient	Land use category	I	II	III	IV	V	VI	VII	VIII	IX
Urban	District: Bengaluru Urban@	2.03**	0.30*	-0.40^{NS}	0.25^{NS}	-1.63**	0.64^{NS}	5.47**	-4.62**	2.42**
	Taluk: Bengaluru North#	2.07**	-0.13**	-1.27^{NS}	-0.10**	-0.06^{NS}	-0.98^{NS}	3.77^{NS}	-3.90**	0.00^{NS}
Peri-Urban	District: Bengaluru Rural$	1.81**	0.00^{NS}	0.00^{NS}	0.00^{NS}	-16.97*	1.10^{NS}	1.07^{NS}	-0.32^{NS}	0.00^{NS}
	Taluk: Devanahalli#	3.62**	0.00^{NS}	-0.72**	-2.11**	-2.26**	5.12^{NS}	7.57^{NS}	-1.20*	0.00^{NS}
Rural	District: Chikkaballapura$	0.28**	0.00^{NS}	-0.63^{NS}	-0.68**	0.00^{NS}	-7.32^{NS}	8.74*	0.48^{NS}	0.00^{NS}
	Taluk: Gudibande#	0.16*	0.00^{NS}	-5.7**	-5.93**	0.00^{NS}	-11.35^{NS}	23.98**	1.06^{NS}	0.00^{NS}

Note: *@ period: 2001-02 to 2019-20, # period: 2001-02 to 2016-17, $ period: 2007-08 to 2019-20; **Significant at 1 per cent level, * Significant at 5 per cent level and NS- Non-significant.*

Table 2: TPM of land use pattern urban gradient (Bengaluru Urban district, 2001-20)

	I	II	III	IV	V	VI	VII	VIII	IX
I	0.885	0.015	0.000	0.014	0.000	0.082	0.003	0.000	0.000
II	0.000	0.256	0.080	0.519	0.051	0.000	0.000	0.000	0.093
III	0.961	0.014	0.011	0.015	0.000	0.000	0.000	0.000	0.000
IV	0.901	0.099	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V	0.000	0.019	0.238	0.067	0.552	0.000	0.060	0.060	0.004
VI	0.129	0.015	0.052	0.013	0.090	0.364	0.051	0.284	0.000
VII	0.274	0.012	0.000	0.000	0.000	0.000	0.714	0.000	0.000
VIII	0.019	0.015	0.014	0.013	0.030	0.030	0.000	0.880	0.000
IX	0.101	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.899

Table 3: TPM of land use pattern urban gradient (Bengaluru North *taluk*, 2001-17)

	I	II	III	IV	V	VI	VII	VIII	IX
I	0.834	0.024	0.007	0.015	0.008	0.105	0.000	0.000	0.007
II	0.000	0.000	0.000	0.000	0.990	0.000	0.000	0.000	0.010
III	0.000	0.032	0.677	0.000	0.000	0.000	0.000	0.284	0.007
IV	0.844	0.078	0.000	0.072	0.000	0.000	0.000	0.000	0.006
V	0.819	0.025	0.000	0.014	0.107	0.000	0.028	0.000	0.007
VI	0.111	0.028	0.000	0.015	0.010	0.439	0.073	0.317	0.007
VII	0.498	0.030	0.000	0.016	0.002	0.000	0.448	0.000	0.007
VIII	0.005	0.028	0.004	0.015	0.013	0.105	0.041	0.781	0.007
IX	0.000	0.000	0.000	0.000	0.476	0.000	0.000	0.000	0.524

area (0), permanent pasture (0.072) and tree and groves (0.107) LUC's have found to be least stable and the latter two LUC's were found to have high tendency for putting them to non-agricultural uses with probabilities of 0.844 and 0.819, respectively (Table 3).

In peri-urban gradient, at district level LUC like area put to non-agricultural uses, net sown area were found to be most stable with probabilities of 0.850 and 0.892, respectively (Table 4). Whereas all other LUC have shown least or no stability as their probabilities is zero or near to zero. The LUC like area under forest (1.000) and area under permanent pasture (1.000) have high tendency of loss towards barren and uncultivated area and cultivable waste land, respectively as revealed by their probabilities. At *taluk* level, land put to non-agricultural uses (0.901) and area under permanent pasture (0.849) were found to show high probability of retention. Whereas barren and uncultivated, cultivable waste and area under trees and groves LUC were found to be show least retention with zero probabilities and their probabilities have indicated that they may shift to LUC's like area under forest and net sown area, respectively (Table 5).

Table 4: TPM of land use pattern peri-urban gradient (Bengaluru Rural district, 2007-08 to 2019-20)

	I	II	III	IV	V	VI	VII	VIII	IX
I	0.850	0.000	0.000	0.000	0.000	0.000	0.150	0.000	0.000
II	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
III	0.000	0.947	0.006	0.000	0.000	0.000	0.000	0.000	0.047
IV	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
V	0.000	0.000	0.000	0.000	0.312	0.419	0.269	0.000	0.000
VI	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.999	0.000
VII	0.290	0.000	0.000	0.000	0.130	0.579	0.000	0.000	0.000
VIII	0.021	0.000	0.000	0.000	0.063	0.000	0.024	0.892	0.000
IX	0.000	0.657	0.000	0.343	0.000	0.000	0.000	0.000	0.000

Table 5: TPM of land use pattern peri-Urban gradient (Devanahalli *taluk*, 2001-02 to 2016-17)

	I	II	III	IV	V	VI	VII	VIII	IX
I	0.901	0.000	0.000	0.000	0.000	0.099	0.000	0.000	0.000
II	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
III	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000
IV	0.000	0.000	0.000	0.849	0.000	0.000	0.000	0.151	0.000
V	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000
VI	0.000	0.000	0.054	0.004	0.131	0.301	0.000	0.511	0.000
VII	0.000	0.000	0.039	0.002	0.000	0.149	0.138	0.672	0.000
VIII	0.043	0.000	0.056	0.004	0.148	0.038	0.076	0.635	0.000
IX	0.000	0.649	0.000	0.000	0.000	0.000	0.000	0.000	0.351

Table 6: TPM of land use pattern rural gradient (Chikkaballapura district, 2007-08 to 2019-20)

	I	II	III	IV	V	VI	VII	VIII	IX
I	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
II	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
III	0.000	0.000	0.073	0.000	0.000	0.431	0.047	0.449	0.000
IV	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000
V	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
VI	0.000	0.000	0.041	0.000	0.000	0.057	0.000	0.902	0.000
VII	0.000	0.000	0.000	0.000	0.000	0.000	0.645	0.355	0.000
VIII	0.000	0.000	0.020	0.000	0.000	0.061	0.019	0.901	0.000
IX	0.000	0.690	0.000	0.000	0.130	0.000	0.000	0.000	0.180

Table 7: TPM of land use pattern rural gradient (Gudibande *taluk*, 2001-02 to 2016-17)

	I	II	III	IV	V	VI	VII	VIII	IX
I	0.151	0.000	0.000	0.000	0.002	0.000	0.000	0.848	0.000
II	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
III	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
IV	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000
V	0.000	0.000	0.000	0.000	0.880	0.000	0.120	0.000	0.000
VI	0.133	0.000	0.000	0.000	0.002	0.240	0.017	0.608	0.000
VII	0.083	0.000	0.000	0.000	0.001	0.000	0.253	0.663	0.000
VIII	0.133	0.000	0.000	0.000	0.002	0.016	0.000	0.848	0.000
IX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000

In rural gradient, except barren and uncultivated land, trees and groves, current fallow land, cultivable waste and forest land other LUC's have exhibited better retention or stability as indicated by their probabilities at district level (Table 6) and the probabilities of these least stable LUC's have shown their tendency of transition towards area under forest and net sown area. Similarly at *taluk*

level, area put to non-agricultural uses fallow lands (both current and other) have exhibited least retention through probabilities and all other LUC's have relatively better stability (Table 7). Since being the rural gradient the dependence on agriculture for the livelihood is more compared to other two gradients and rainfall is a deciding factor of current fallow land in a year. The least stable LUC's have shown their tendency of transition towards net sown area with probabilities of 0.848, 0.608 and 0.669 respectively. The *taluk* level findings i.e. transition probabilities are in line with the finding of Kammar, (2010).

CONCLUSION

The transition probabilities from Markov chain analysis have reiterated that the stability of net sown area is relative high in rural gradient when compared to urban and peri-urban gradients. Whereas the stability of area put to non-agricultural uses is relatively higher in urban and peri-urban gradients when compared to the rural gradient. So the findings have highlighted the future threat on the agricultural land as influenced by the urbanization. Hence policy measures on land use need to be effectively enforced to curtail the unlawful conversion of farm lands for non-agricultural uses.

REFERENCES

Ardeshna, N.J. and Shiyani, R L. 2013. Dynamics of Cropping pattern in Gujarat State: A Markov Chain Approach. *Asian Academic Res. J. Soc. Sci. and Humanities*, **1**(9): 56-66.

Kammar, A. 2010. Economics of land use and cropping pattern in northern transitional zone of Karnataka. Thesis M Sc (Ag). University of Agricultural Sciences, Dharwad, Karnataka, India.

Kammar, A. and Basvaraja, H. 2012. Structural changes in cropping pattern in Northern transitional zone of Karnataka. *Int. Res. J. Agric. Econ. and Stat.*, **3**(2): 197-201.

Kavitha, A., Somashekar, R. K. and Nagaraja, B. C. 2015. Urban expansion and loss of agriculture land - A case of Bengaluru city. *Int. J. Geomatics and Geosci.*, **5** (3): 492-498.

Lintelo, T.D., Marshall, F. and Bhupal, D.S. 2001. Peri-urban agriculture in Delhi, India. *Food Nutri. Agric.*, **29**: 4-13.

Malik, R. and Ali, M. 2015. The impact of urbanization on agriculture sector: A case study of Peshawar, Pakistan. *J. Resources Dev. and Management*, **8**: 79-85.

Mwangi, E.M. and Yu, B. 2015. Agricultural diversification and land use patterns in Southeast Asia. In Proceedings of 29th International conference of Agricultural Economists 8-14th August 2015. The Italian Association of Agricultural and Applied Economics, Milan, Italy.

ORGI. 2011. Census of India, Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, New Delhi, India.

Rani, S. 2014. Monitoring land use/land cover response to urban growth of the city of Jalandhar using remote sensing data. *Int. J. Adv. Res.*, **2**(6): 1122-1129.

Rao, D. and Parwez, S. 2005. Dynamics of cropping pattern in sorghum growing states in India. *Ind. J. Agric. Econ.*, **60**(4): 644-659.

Reddy, D. R. and Achoth, L. 2000. Dynamics of Changes in Karnataka: A Markov Chain Approach. *Mys. J. Agric. Econ.*, **34**(4): 376-381.

Rimal, B. 2013. Urbanization and the decline of agricultural land in Pokhara sub-metropolitan city. *Nep. J. Agric. Sci.*, **5**(1): 54-65.