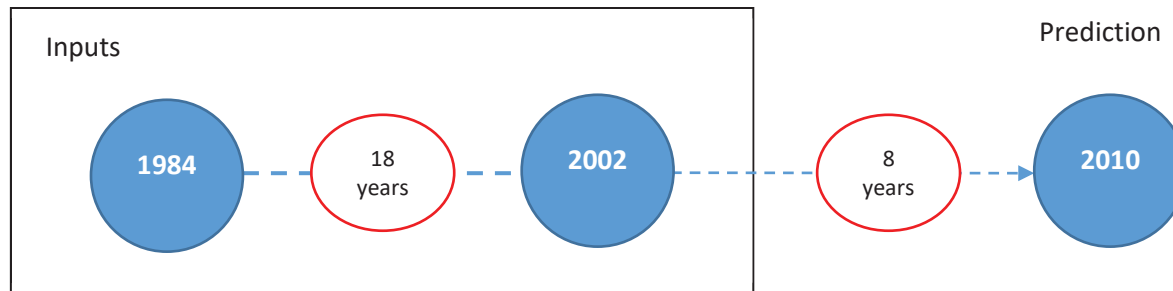


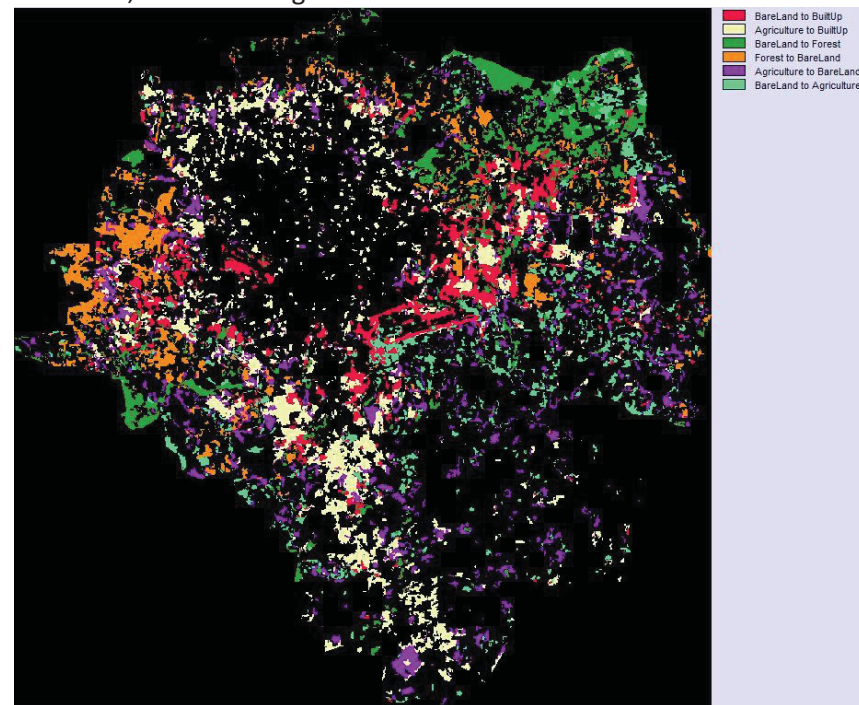
### 3. ANN-Markov chain prediction results and accuracy assessment

- Task #1



Major land use changes from 1984-2002 → Changes greater than or equal to 1000 Hectares

Four sub models have been developed for training the ANN i.e. Built up, Bare land, Forest and Agriculture

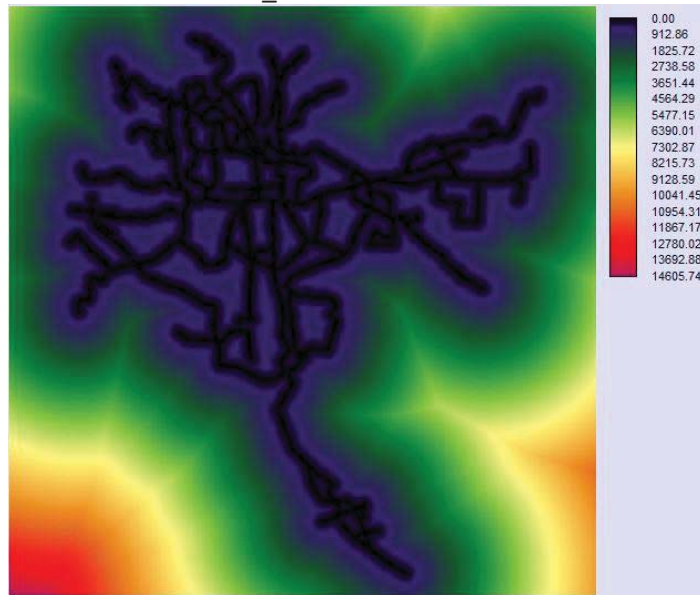


Planned street segments (2010)

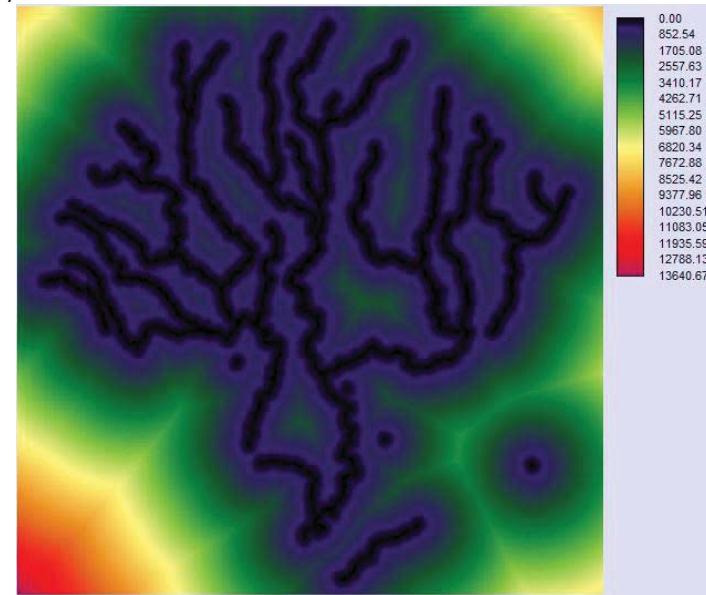


- Input variables for the ANN

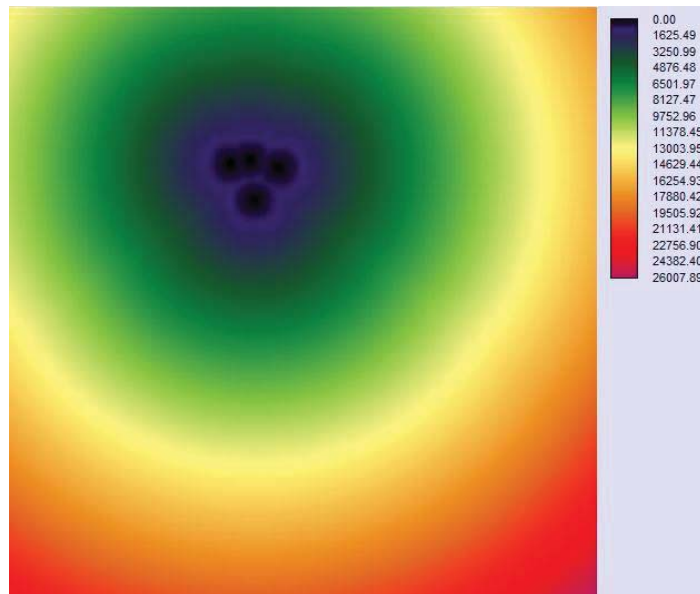
1) Distance from roads\_2002



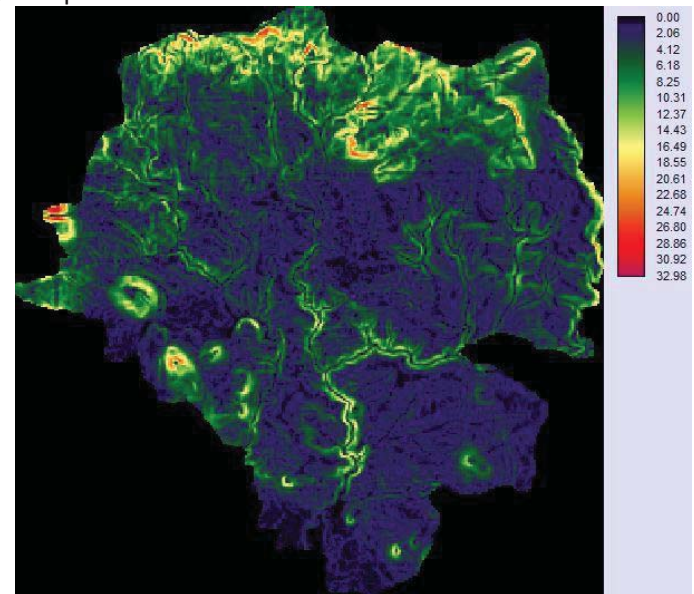
2) Distance from streams



3) Distance from Centers

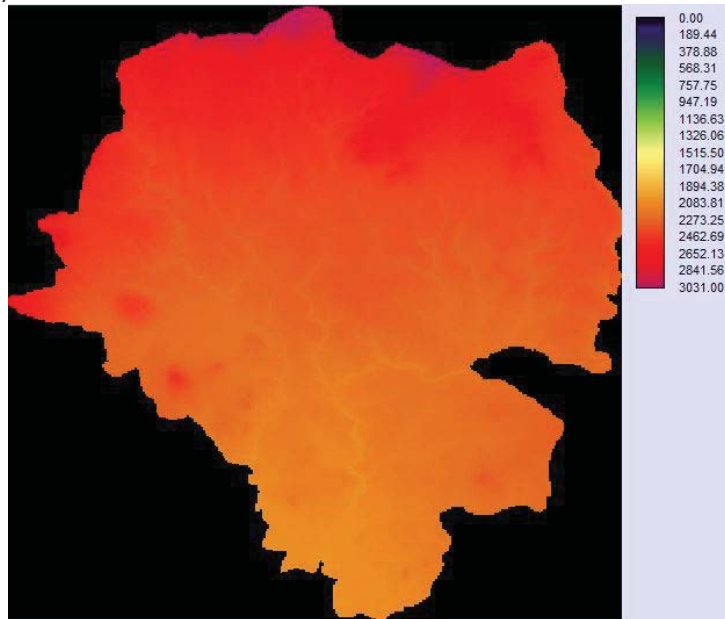


4) Slope

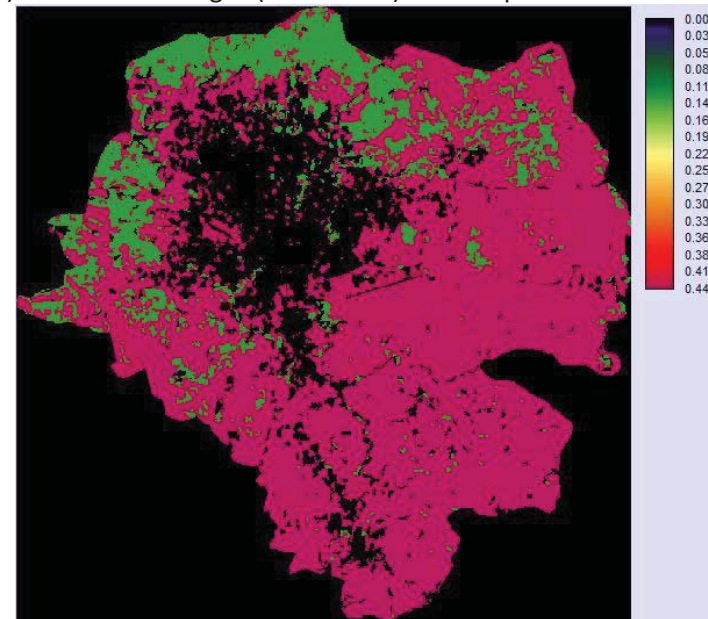




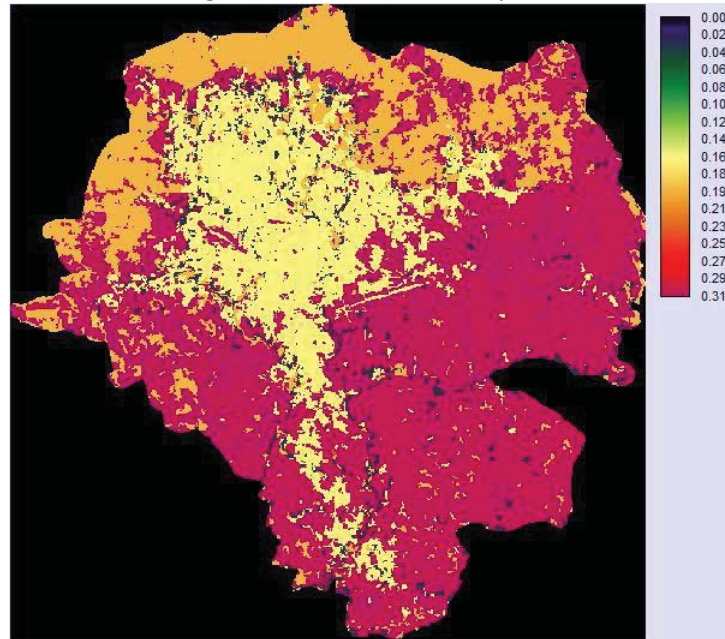
5) Elevation



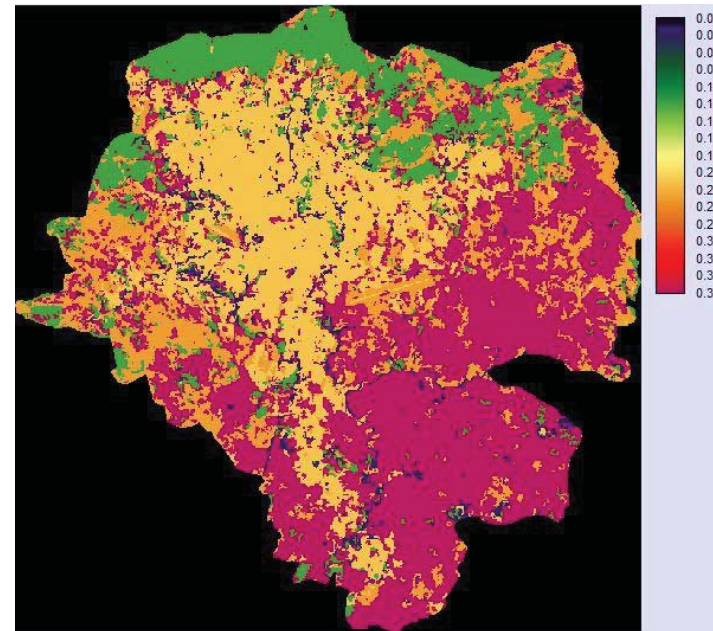
6) Land use changes (1984-2002) with respect to Land use (1984)



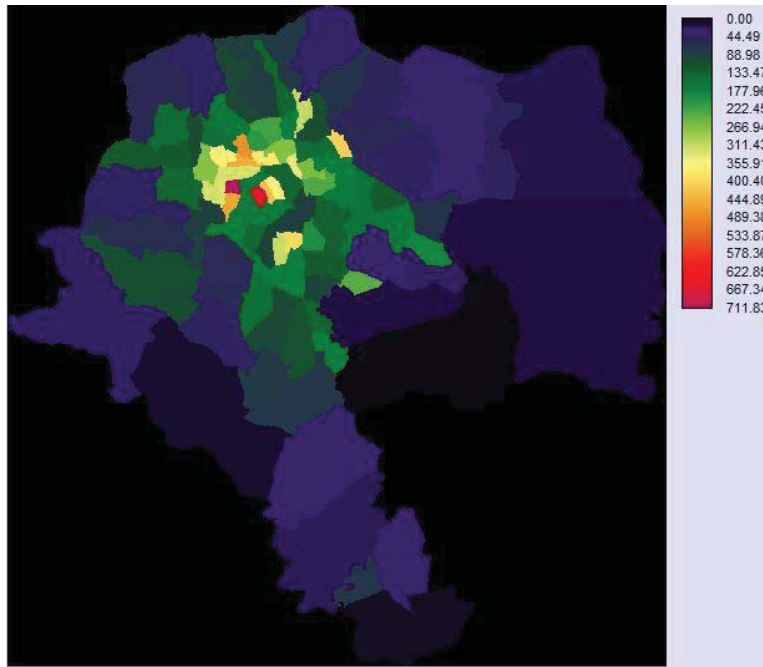
7) Land use changes (1984-2002) with respect to Land use (1990)



8) Land use changes (1984-2002) with respect to Land use (1996)



## 9) Population density



- Model training**

### Sub-Model 1: Bare Land

Constant forcing results (Holding variables that has least effect constant)

Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	78.48	0.7130
Step 1: var.[2] constant	[1,3,4,5,6,7,8,9]	78.46	0.7128
Step 2: var.[2,3] constant	[1,4,5,6,7,8,9]	78.24	0.7099
Step 3: var.[2,3,1] constant	[4,5,6,7,8,9]	77.93	0.7057
Step 4: var.[2,3,1,7] constant	[4,5,6,8,9]	77.20	0.6960
Step 5: var.[2,3,1,7,5] constant	[4,6,8,9]	73.87	0.6516
Step 6: var.[2,3,1,7,5,9] constant	[4,6,8]	66.22	0.5496
Step 7: var.[2,3,1,7,5,9,4] constant	[6,8]	65.74	0.5432
Step 8: var.[2,3,1,7,5,9,4,8] constant	[6]	49.80	0.3306



Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	78.30	0.7107
Step 1: var.[1] constant	[2,3,4,5,6,7]	77.92	0.7056
Step 2: var.[1,5] constant	[2,3,4,6,7]	77.60	0.7013
Step 3: var.[1,5,7] constant	[2,3,4,6]	75.26	0.6702
Step 4: var.[1,5,7,3] constant	[2,4,6]	66.59	0.5545
Step 5: var.[1,5,7,3,2] constant	[4,6]	66.07	0.5477
Step 6: var.[1,5,7,3,2,6] constant	[4]	50.35	0.3379



### Sub-Model 2: Forest

Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	76.27	0.5254
Step 1: var.[4] constant	[1,2,3,5,6,7,8,9]	76.70	0.5340
Step 2: var.[4,6] constant	[1,2,3,5,7,8,9]	76.70	0.5340
Step 3: var.[4,6,9] constant	[1,2,3,5,7,8]	76.39	0.5278
Step 4: var.[4,6,9,7] constant	[1,2,3,5,8]	75.60	0.5119
Step 5: var.[4,6,9,7,3] constant	[1,2,5,8]	76.08	0.5216
Step 6: var.[4,6,9,7,3,1] constant	[2,5,8]	74.43	0.4887
Step 7: var.[4,6,9,7,3,1,5] constant	[2,8]	71.87	0.4373
Step 8: var.[4,6,9,7,3,1,5,2] constant	[8]	71.54	0.4309



Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	75.00	0.5000
Step 1: var.[7] constant	[1,2,3,4,5,6]	75.03	0.5006
Step 2: var.[7,3] constant	[1,2,4,5,6]	74.96	0.4992
Step 3: var.[7,3,5] constant	[1,2,4,6]	74.94	0.4988
Step 4: var.[7,3,5,2] constant	[1,4,6]	73.31	0.4663
Step 5: var.[7,3,5,2,4] constant	[1,6]	72.02	0.4404
Step 6: var.[7,3,5,2,4,1] constant	[6]	72.13	0.4426

### Sub-Model 3: Agriculture

Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	68.40	0.3681
Step 1: var.[6] constant	[1,2,3,4,5,7,8,9]	68.40	0.3681
Step 2: var.[6,7] constant	[1,2,3,4,5,8,9]	68.32	0.3665
Step 3: var.[6,7,1] constant	[2,3,4,5,8,9]	68.23	0.3647
Step 4: var.[6,7,1,3] constant	[2,4,5,8,9]	68.45	0.3691
Step 5: var.[6,7,1,3,9] constant	[2,4,5,8]	68.10	0.3621
Step 6: var.[6,7,1,3,9,4] constant	[2,5,8]	67.31	0.3463
Step 7: var.[6,7,1,3,9,4,2] constant	[5,8]	66.61	0.3323
Step 8: var.[6,7,1,3,9,4,2,5] constant	[8]	66.62	0.3325



Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	68.02	0.3604
Step 1: var.[6] constant	[1,2,3,4,5,7]	67.67	0.3534
Step 2: var.[6,2] constant	[1,3,4,5,7]	67.38	0.3476
Step 3: var.[6,2,7] constant	[1,3,4,5]	68.00	0.3600
Step 4: var.[6,2,7,1] constant	[3,4,5]	67.11	0.3422
Step 5: var.[6,2,7,1,4] constant	[3,5]	66.57	0.3314
Step 6: var.[6,2,7,1,4,3] constant	[5]	66.44	0.3288

### Sub-Model 4: Built up

Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	65.90	0.5453
Step 1: var.[2] constant	[1,3,4,5,6,7,8,9]	65.66	0.5421
Step 2: var.[2,9] constant	[1,3,4,5,6,7,8]	65.27	0.5369
Step 3: var.[2,9,7] constant	[1,3,4,5,6,8]	64.00	0.5200
Step 4: var.[2,9,7,6] constant	[1,3,4,5,8]	62.85	0.5047
Step 5: var.[2,9,7,6,8] constant	[1,3,4,5]	61.01	0.4801
Step 6: var.[2,9,7,6,8,4] constant	[1,3,5]	56.57	0.4210
Step 7: var.[2,9,7,6,8,4,5] constant	[1,3]	49.36	0.3248
Step 8: var.[2,9,7,6,8,4,5,3] constant	[1]	37.71	0.1695

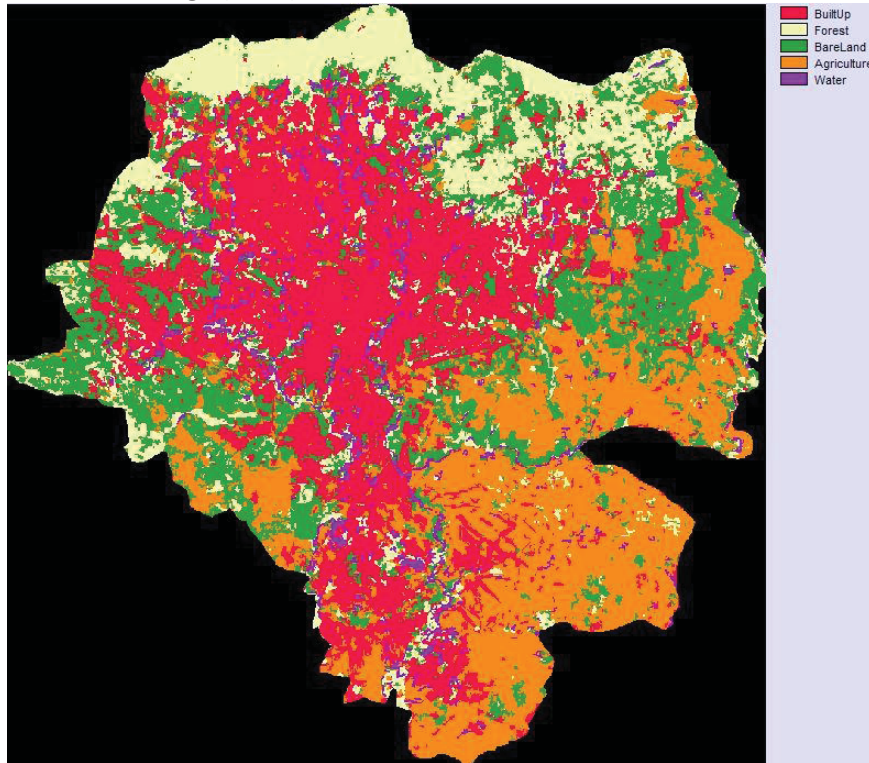


Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	66.15	0.5487
Step 1: var.[8] constant	[1,2,3,4,5,6,7]	66.12	0.5482
Step 2: var.[8,6] constant	[1,2,3,4,5,7]	65.50	0.5400
Step 3: var.[8,6,5] constant	[1,2,3,4,7]	63.89	0.5186
Step 4: var.[8,6,5,4] constant	[1,2,3,7]	61.27	0.4836
Step 5: var.[8,6,5,4,7] constant	[1,2,3]	56.29	0.4173
Step 6: var.[8,6,5,4,7,3] constant	[1,2]	46.98	0.2930
Step 7: var.[8,6,5,4,7,3,2] constant	[1]	36.85	0.1580

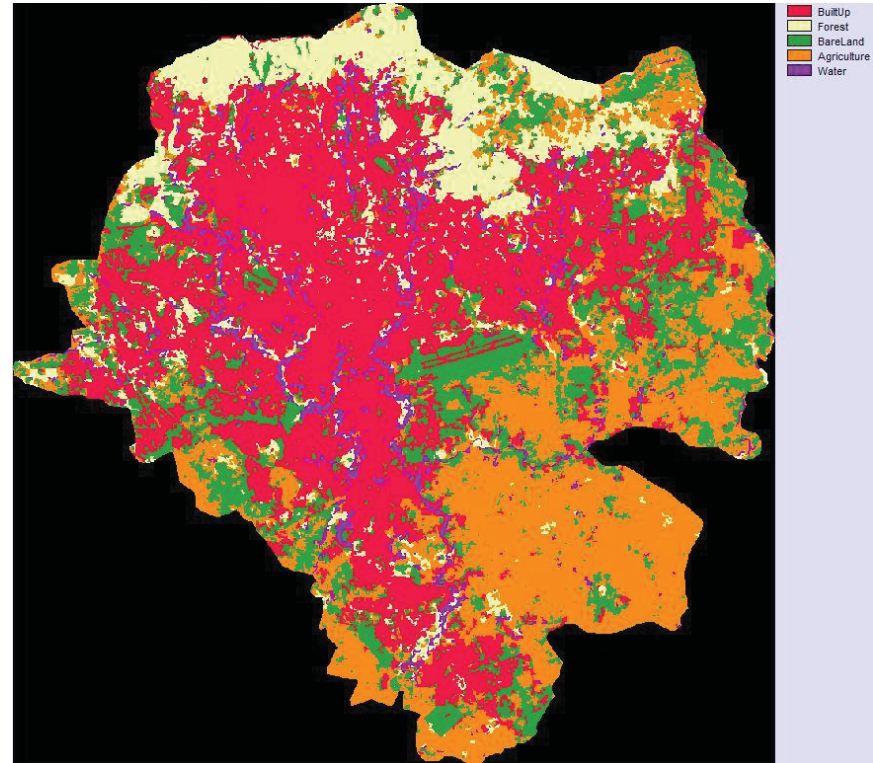
- The land use change from the year 1984 to 2002 is found to be hard to predict due to unpredicted changes that occurred due to external factors such as the regime change in 1991 and the consequent changes in land policy where the new land policy motivates urban development and construction which was not given much attention during the communist regime before 1991.

- **Prediction Result**

Predicted change (2010)



Actual land use (2010)

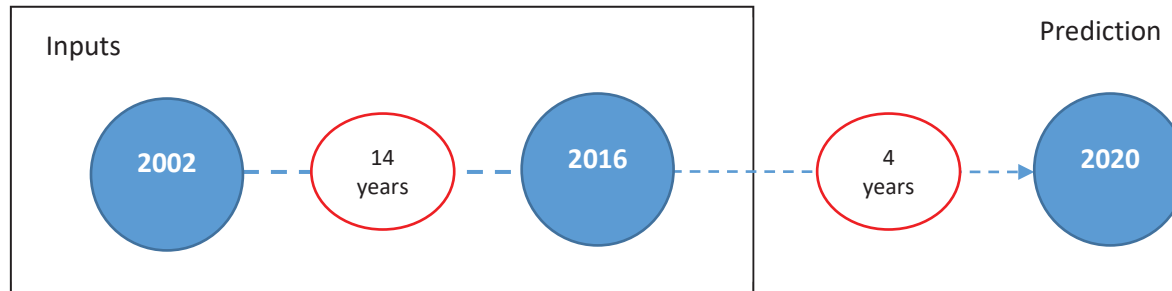


Possible reasons for the gap between predicted land use and actual land use

- Land policy change in 2002 and
- The new public housing program called the integrated housing development program (IHDP) approved and implemented after 2005

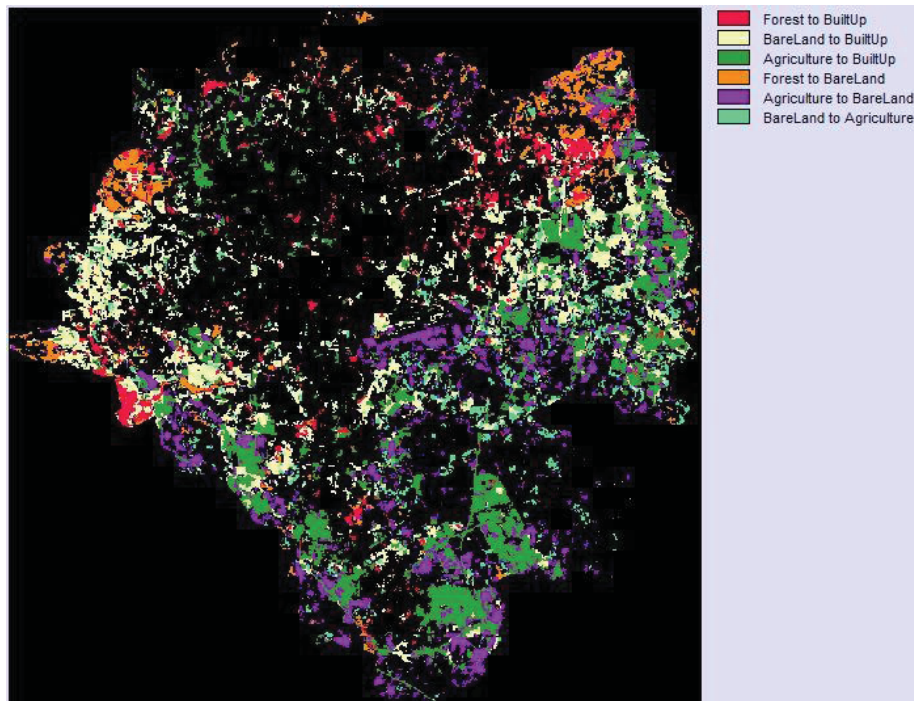


- **Task #2**



Major land use changes from 2002-2016 → Changes greater than or equal to 1000 Hectares

Three sub models have been developed for training the ANN i.e. Built up, Bare land and Agriculture



### Sub-Model 1: Built up

Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	99.69	0.9963
Step 1: var.[4] constant	[1,2,3,5,6,7,8]	100.00	1.0000
Step 2: var.[4,1] constant	[2,3,5,6,7,8]	100.00	1.0000
Step 3: var.[4,1,2] constant	[3,5,6,7,8]	100.00	1.0000
Step 4: var.[4,1,2,3] constant	[5,6,7,8]	100.00	1.0000
Step 5: var.[4,1,2,3,6] constant	[5,7,8]	100.00	1.0000
Step 6: var.[4,1,2,3,6,8] constant	[5,7]	100.00	1.0000
Step 7: var.[4,1,2,3,6,8,5] constant	[7]	49.74	0.3968

### Sub-Model 1: Bare land

Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	99.82	0.9976
Step 1: var.[2] constant	[1,3,4,5,6,7,8]	100.00	1.0000
Step 2: var.[2,1] constant	[3,4,5,6,7,8]	100.00	1.0000
Step 3: var.[2,1,4] constant	[3,5,6,7,8]	100.00	1.0000
Step 4: var.[2,1,4,6] constant	[3,5,7,8]	100.00	1.0000
Step 5: var.[2,1,4,6,7] constant	[3,5,8]	100.00	1.0000
Step 6: var.[2,1,4,6,7,8] constant	[3,5]	100.00	1.0000
Step 7: var.[2,1,4,6,7,8,5] constant	[3]	49.95	0.3327

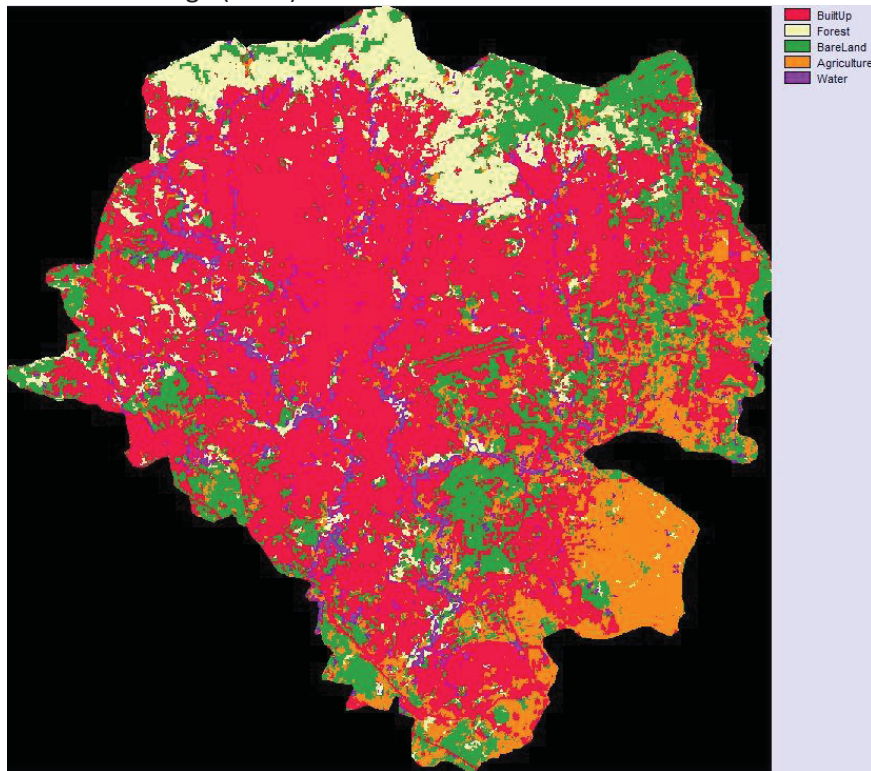
### Sub-Model 1: Agriculture

Model	Variables included	Accuracy (%)	Skill measure
With all variables	All variables	91.22	0.8245
Step 1: var.[3] constant	[1,2,4,5,6,7,8]	99.65	0.9930
Step 2: var.[3,4] constant	[1,2,5,6,7,8]	100.00	1.0000
Step 3: var.[3,4,1] constant	[2,5,6,7,8]	100.00	1.0000
Step 4: var.[3,4,1,2] constant	[5,6,7,8]	100.00	1.0000
Step 5: var.[3,4,1,2,5] constant	[6,7,8]	100.00	1.0000
Step 6: var.[3,4,1,2,5,6] constant	[7,8]	100.00	1.0000
Step 7: var.[3,4,1,2,5,6,8] constant	[7]	100.00	1.0000



- Prediction Result

Predicted change (2020)



Actual land use (2020)

