

Urban Expansion Occurred at the Expense of Agricultural Lands in the Tarai Region of Nepal, 1989 to 2016

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Supplementary information S1: Classification Accuracy Assessment The most important step of LULC classification process is accuracy assessment. Following equation have been applied to develop producer's accuracy (PA), user's accuracy (UA) and overall accuracy (OA) using ground truth data and classified data obtained from error matrix report.

Producer's accuracy

$$PA = a/a+i \times 100$$

where,

a =total number of correct points in a class

$a+i$ =sum of points value in the column

User's accuracy

$$UA = a/a+i \times 100$$

where,

a =total number of correct points in a class

$a+i$ =sum of points value in the row

Overall accuracy

$$OA = t/n \times 100$$

where,

t =total number of correct points for all class

n =total number of points in the error matrix

Table S1: Land-use/cover classification accuracy (%), by district and classification year (1989-2016) .
OA= overall accuracy; PA=Producer's accuracy; UA=user's accuracy.

Kanchanpur

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.

UB	90.91	85.71	87.50	80.00	85.29	82.86	91.18	88.57	88.89	91.43	89.19	94.29
CL	74.42	91.43	75.00	85.71	73.68	80.00	80.00	91.43	81.58	88.57	83.33	85.71
FC	86.11	88.57	86.49	91.43	85.71	85.71	87.50	80.00	89.19	94.29	86.49	91.43
BL	77.14	77.14	76.32	82.86	78.79	74.29	80.56	82.86	81.82	77.14	80.00	80.00
SC	80.65	71.43	84.38	77.14	73.68	80.00	78.95	85.71	81.08	85.71	82.86	82.86
WB	78.05	91.43	83.33	85.71	85.29	82.86	84.85	80.00	85.71	85.71	91.43	91.43
SA	88.46	65.71	83.33	71.43	81.82	77.14	81.25	74.29	86.21	71.43	86.67	74.29
Overall A.	81.63		82.04		80.41		83.27		84.90		85.71	

Kailali

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	87.50	80.00	87.88	82.86	88.24	85.71	91.18	88.57	83.78	88.57	88.24	85.71
CL	78.95	85.71	82.05	91.43	81.58	88.57	84.62	94.29	83.33	85.71	83.78	88.57
FC	86.84	94.29	85.71	85.71	85.71	85.71	86.11	88.57	88.89	91.43	86.84	94.29
BL	73.53	71.43	81.25	74.29	77.42	68.57	84.38	77.14	87.50	80.00	82.86	82.86
SC	73.68	80.00	76.32	82.86	70.00	80.00	78.95	85.71	81.58	88.57	82.35	80.00
WB	91.18	88.57	88.24	85.71	85.29	82.86	87.88	82.86	88.24	85.71	86.11	88.57
SA	83.87	74.29	84.38	77.14	84.85	80.00	87.88	82.86	87.50	80.00	87.10	77.14
Overall A.	82.04		82.86		81.63		85.71		85.71		85.31	

Bardiya

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	85.71	85.71	86.11	88.57	82.50	94.29	85.29	82.86	91.43	91.43	86.11	88.57
CL	80.56	82.86	83.33	85.71	84.21	91.43	82.50	94.29	88.24	85.71	88.89	91.43
FC	83.78	88.57	85.29	82.86	88.24	85.71	88.57	88.57	86.11	88.57	89.19	94.29
BL	82.35	80.00	81.08	85.71	84.38	77.14	90.32	80.00	87.88	82.86	84.85	80.00
SC	77.14	77.14	80.00	80.00	84.38	77.14	85.29	82.86	88.57	88.57	85.71	85.71
WB	84.85	80.00	85.29	82.86	82.86	82.86	83.33	85.71	82.05	91.43	87.88	82.86
SA	85.71	85.71	84.85	80.00	82.35	80.00	82.86	82.86	84.85	80.00	82.86	82.86
Overall A.	82.86		83.67		84.08		85.31		86.94		86.53	

Banke

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	84.85	80.00	78.95	85.71	83.78	88.57	85.71	85.71	82.05	91.43	85.71	85.71
CL	84.21	91.43	85.29	82.86	88.24	85.71	81.58	88.57	88.24	85.71	84.62	94.29
FC	89.19	94.29	86.11	88.57	88.89	91.43	93.75	85.71	93.94	88.57	91.43	91.43
BL	79.41	77.14	77.78	80.00	77.78	80.00	80.56	82.86	80.00	80.00	80.00	80.00
SC	76.47	74.29	79.41	77.14	79.41	77.14	82.35	80.00	80.00	80.00	82.86	82.86
WB	88.24	85.71	87.50	80.00	87.88	82.86	88.57	88.57	94.12	91.43	96.77	85.71
Overall A.	83.81		82.38		84.29		85.24		86.19		86.87	

Dang

Year	1989		1996		2001		2006		2011		2016	
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	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	80.56	82.86	84.85	80.00	85.71	85.71	85.71	85.71	86.49	91.43	88.57	88.57
CL	80.56	82.86	80.56	82.86	83.78	88.57	88.89	91.43	85.71	85.71	86.49	91.43
FC	86.11	88.57	83.33	85.71	85.71	85.71	86.84	94.29	83.78	88.57	86.11	88.57
BL	76.32	82.86	78.38	82.86	80.56	82.86	82.86	82.86	85.71	85.71	87.88	82.86
SC	81.82	77.14	80.00	80.00	80.00	80.00	80.00	80.00	80.56	82.86	81.08	85.71
WB	87.10	77.14	87.88	82.86	87.50	80.00	93.55	82.86	93.33	80.00	90.63	82.86
Overall A.	81.90		82.38		83.81		86.19		85.71		86.67	

Kapilbastu

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	85.29	82.86	83.78	88.57	85.71	85.71	85.29	82.86	88.57	88.57	88.24	85.71
CL	76.92	85.71	81.58	88.57	82.05	91.43	81.58	88.57	80.00	91.43	80.00	91.43
FC	81.58	88.57	83.33	85.71	84.62	94.29	84.21	91.43	91.18	88.57	91.18	88.57
BL	80.00	80.00	79.41	77.14	85.29	82.86	83.33	85.71	87.88	82.86	85.29	82.86
SC	77.14	77.14	80.56	82.86	80.00	80.00	80.56	82.86	83.78	88.57	83.33	85.71
WB	85.71	85.71	82.35	80.00	85.29	82.86	87.50	80.00	87.88	82.86	83.33	85.71
SA	86.21	71.43	86.67	74.29	93.10	77.14	93.55	82.86	90.91	85.71	90.32	80.00
Overall A.	81.63		82.45		84.90		84.90		6.94		85.71	

Rupandehi

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	87.50	80.00	85.29	82.86	88.24	85.71	85.71	85.71	88.57	88.57	88.24	85.71
CL	81.08	85.71	83.78	88.57	84.21	91.43	83.78	88.57	84.21	91.43	82.50	94.29
FC	85.29	82.86	86.49	91.43	86.11	88.57	82.86	82.86	83.33	85.71	86.11	88.57
BL	80.56	82.86	80.00	80.00	82.35	80.00	81.82	77.14	84.38	77.14	87.10	77.14
SC	81.08	85.71	80.56	82.86	85.71	85.71	82.86	82.86	82.35	80.00	83.33	85.71
WB	88.24	85.71	90.32	80.00	84.85	80.00	82.86	82.86	85.71	85.71	90.91	85.71
Overall A.	83.81		84.29		85.24		83.33		84.76		86.19	

Nawalparasi

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	82.35	80.00	81.08	85.71	86.11	88.57	86.11	88.57	84.21	91.43	88.57	88.57
CL	75.00	85.71	81.58	88.57	84.21	91.43	81.08	85.71	82.50	94.29	84.21	91.43
FC	81.58	88.57	80.56	82.86	84.62	94.29	81.58	88.57	85.71	85.71	86.84	94.29
BL	79.41	77.14	81.82	77.14	87.10	77.14	83.33	85.71	85.29	82.86	85.71	85.71
SC	76.47	74.29	80.56	82.86	80.56	82.86	82.35	80.00	82.35	80.00	85.29	82.86
WB	83.33	85.71	84.38	77.14	85.71	85.71	81.82	77.14	87.10	77.14	82.35	80.00
SA	86.21	71.43	84.85	80.00	86.67	74.29	87.50	80.00	84.85	80.00	87.10	77.14
OA	80.41		82.04		84.90		83.67		84.49		85.71	

Chitwan

Year	1989		1996		2001		2006		2011	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	82.35	80.00	83.33	85.71	86.11	88.57	83.33	85.71	83.78	88.57
CL	80.56	82.86	80.56	82.86	85.71	85.71	83.78	88.57	85.71	85.71
FC	81.08	85.71	80.00	80.00	86.11	88.57	84.62	94.29	86.11	88.57
BL	80.56	82.86	81.08	85.71	82.35	80.00	83.33	85.71	87.50	80.00
SC	77.78	80.00	87.10	77.14	87.88	82.86	81.82	77.14	82.86	82.86
WB	87.10	77.14	82.86	82.86	83.33	85.71	89.66	74.29	88.57	88.57
Overall A.	81.43		82.38		85.24		84.29		85.71	

Parsa

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	82.35	80.00	80.56	82.86	83.33	85.71	83.33	85.71	83.78	88.57	88.24	85.71
CL	80.56	82.86	81.08	85.71	83.78	88.57	84.21	91.43	85.71	85.71	81.58	88.57
FC	80.00	80.00	80.56	82.86	84.21	91.43	86.11	88.57	86.84	94.29	84.21	91.43
BL	88.24	85.71	80.00	80.00	82.35	80.00	83.33	85.71	87.50	80.00	87.50	80.00
SC	81.08	85.71	81.82	77.14	87.10	77.14	81.82	77.14	84.38	77.14	85.71	85.71
WB	79.41	77.14	84.85	80.00	85.29	82.86	83.87	74.29	83.33	85.71	87.88	82.86
Overall A.	81.90		81.43		84.29		83.81		85.24		85.71	

Bara

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	82.35	80.00	84.85	80.00	83.33	85.71	85.71	85.71	86.49	91.43	88.89	91.43
CL	80.56	82.86	81.58	88.57	86.49	91.43	88.57	88.57	85.71	85.71	88.89	91.43
FC	86.11	88.57	88.24	85.71	83.33	85.71	83.33	85.71	86.11	88.57	85.71	85.71
BL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC	86.11	88.57	84.85	80.00	85.29	82.86	83.33	85.71	82.35	80.00	84.85	80.00
WB	81.82	77.14	82.35	80.00	84.38	77.14	84.85	80.00	87.88	82.86	82.86	82.86
Overall A.	83.43		82.86		84.57		85.14		85.71		86.29	

Rautahat

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	82.35	80.00	82.86	82.86	83.78	88.57	88.24	85.71	84.21	91.43	86.11	88.57
CL	81.08	85.71	81.58	88.57	86.11	88.57	86.11	88.57	85.71	85.71	85.71	85.71
FC	80.56	82.86	87.50	80.00	83.33	85.71	82.86	82.86	85.71	85.71	86.49	91.43
BL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC	80.00	80.00	83.33	85.71	82.35	80.00	87.88	82.86	82.86	82.86	82.86	82.86
WB	81.82	77.14	82.35	80.00	84.38	77.14	83.78	88.57	84.38	77.14	84.38	77.14
Overall A.	82.35		83.43		84.00		85.71		84.57		85.14	

Sarlahi

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.

UB	82.35	80.00	85.29	82.86	84.85	80.00	88.24	85.71	88.24	85.71	83.78	88.57
CL	80.56	82.86	83.33	85.71	81.08	85.71	90.91	85.71	84.21	91.43	83.33	85.71
FC	80.00	80.00	80.00	80.00	83.78	88.57	84.21	91.43	85.71	85.71	88.57	88.57
BL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC	80.56	82.86	81.08	85.71	80.56	82.86	81.08	85.71	82.35	80.00	84.85	80.00
WB	79.41	77.14	80.00	80.00	90.91	85.71	87.88	82.86	85.29	82.86	88.24	85.71
Overall A.	80.57		82.86		84.57		86.29		85.14		85.71	

Mohattrai

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	80.56	82.86	81.08	85.71	83.33	85.71	85.71	85.71	86.11	88.57	86.11	88.57
CL	84.21	91.43	79.49	88.57	83.33	85.71	86.11	88.57	84.21	91.43	84.21	91.43
FC	81.08	85.71	82.86	82.86	82.86	82.86	86.49	91.43	88.24	85.71	88.57	88.57
BL	75.86	62.86	86.67	74.29	76.47	74.29	76.47	74.29	83.33	71.43	86.21	71.43
SC	75.68	80.00	78.95	85.71	77.78	80.00	77.78	80.00	80.56	82.86	78.95	85.71
WB	81.82	77.14	93.33	80.00	81.82	77.14	87.50	80.00	83.33	85.71	85.29	82.86
Overall A.	80.00		82.86		80.95		83.33		84.29		84.76	

Dhanusa

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	82.86	82.86	85.71	85.71	85.71	85.71	86.11	88.57	88.57	88.57	88.24	85.71
CL	80.56	82.86	82.86	82.86	83.78	88.57	80.56	82.86	82.05	91.43	82.05	91.43
FC	83.33	85.71	88.57	88.57	86.11	88.57	88.57	88.57	88.57	88.57	91.18	88.57
BL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC	78.38	82.86	76.32	82.86	78.38	82.86	83.33	85.71	85.29	82.86	83.33	85.71
WB	90.32	80.00	87.50	80.00	90.00	77.14	87.50	80.00	87.50	80.00	90.63	82.86
Overall A.	82.86		84.00		84.57		85.14		86.29		86.86	

Siraha

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	82.35	80.00	85.29	82.86	88.24	85.71	83.78	88.57	88.57	88.57	88.24	85.71
CL	78.38	82.86	81.08	85.71	81.58	88.57	81.08	85.71	84.21	91.43	82.05	91.43
FC	83.78	88.57	86.11	88.57	88.24	85.71	88.57	88.57	88.57	88.57	90.91	85.71
BL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC	80.00	80.00	82.86	82.86	81.08	85.71	81.82	77.14	85.71	85.71	82.86	82.86
WB	90.32	80.00	87.88	82.86	87.50	80.00	84.85	80.00	87.50	80.00	85.29	82.86
Overall A.	82.29		84.57		85.14		84.00		86.86		85.71	

Saptari

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	80.00	80.00	80.56	82.86	80.56	82.86	81.08	85.71	88.57	88.57	91.18	88.57

CL	80.56	82.86	83.33	85.71	83.78	88.57	81.58	88.57	82.05	91.43	83.33	85.71
FC	83.33	85.71	83.33	85.71	90.91	85.71	87.88	82.86	88.24	85.71	86.49	91.43
BL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC	75.00	77.14	79.41	77.14	81.08	85.71	84.85	80.00	83.33	85.71	83.33	85.71
WB	84.38	77.14	84.85	80.00	87.50	80.00	85.29	82.86	90.32	80.00	84.38	77.14
Overall A.	80.57		82.29		84.57		84.00		86.29		85.71	

Sunsari

Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	85.29	82.86	83.33	85.71	83.33	85.71	83.78	88.57	85.71	85.71	88.89	91.43
CL	76.92	85.71	81.58	88.57	81.58	88.57	80.00	91.43	80.00	91.43	79.49	88.57
FC	83.78	88.57	88.57	88.57	91.18	88.57	88.24	85.71	91.18	88.57	93.75	85.71
BL	79.41	77.14	82.35	80.00	82.86	82.86	82.35	80.00	83.33	85.71	80.56	82.86
SC	76.47	74.29	81.82	77.14	82.35	80.00	82.86	82.86	85.71	85.71	86.11	88.57
WB	83.33	85.71	81.08	85.71	81.08	85.71	83.33	85.71	82.35	80.00	85.71	85.71
SA	87.10	77.14	87.50	80.00	90.32	80.00	93.55	82.86	87.10	77.14	87.10	77.14
Overall A.	81.63		83.67		84.49		85.31		84.90		85.71	

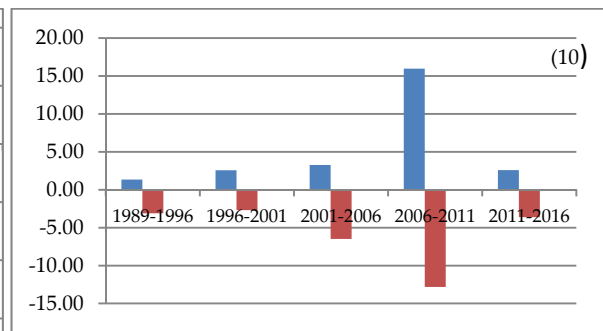
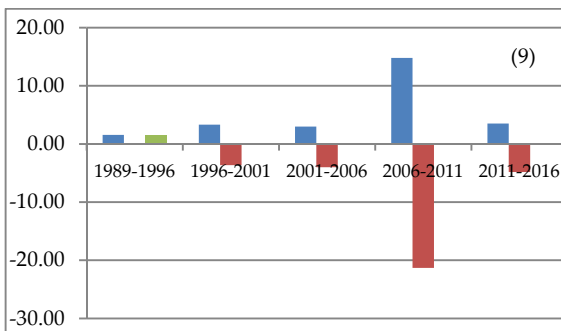
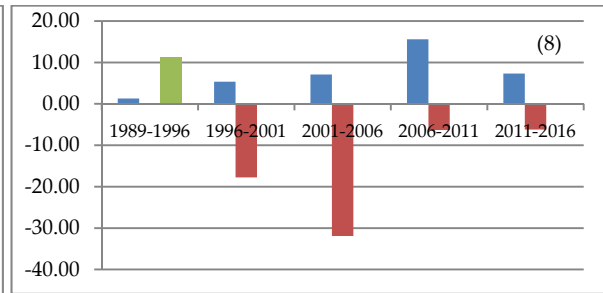
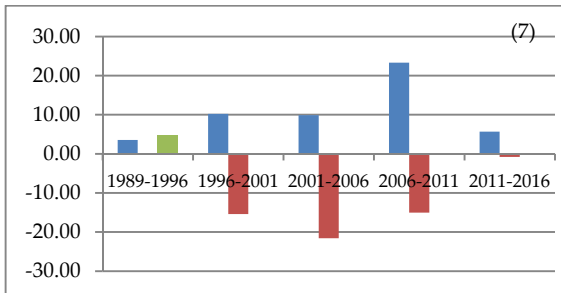
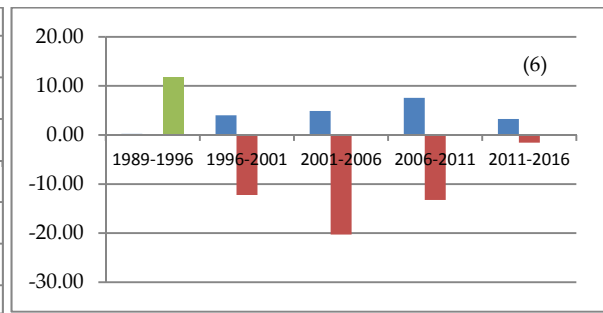
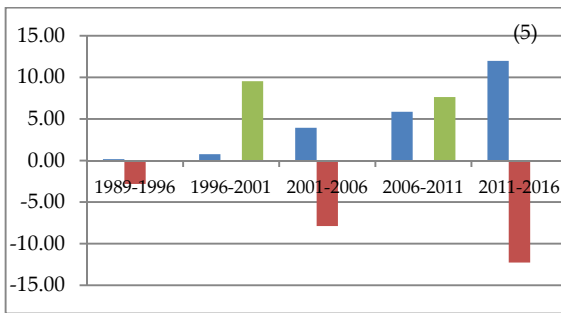
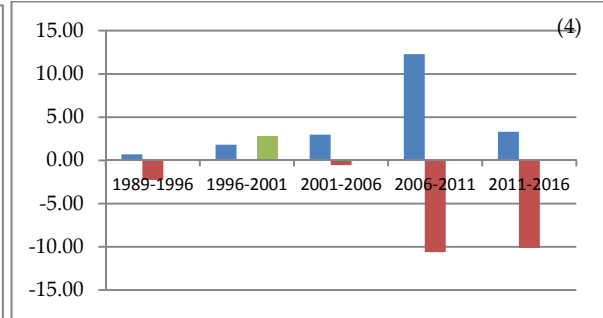
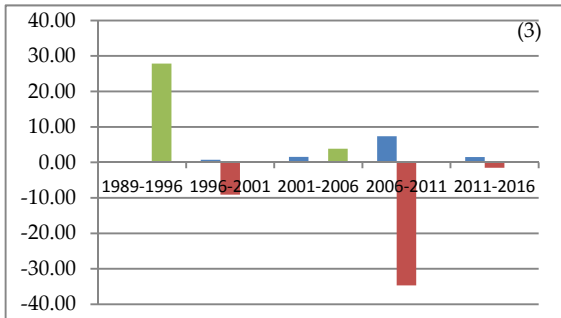
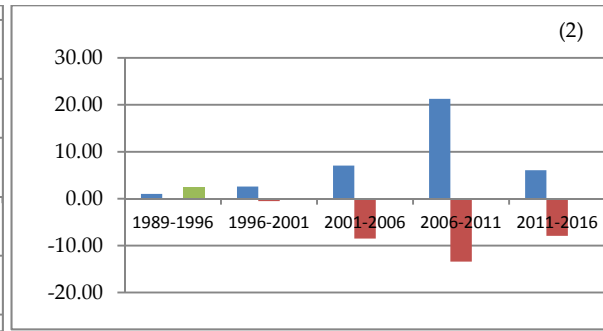
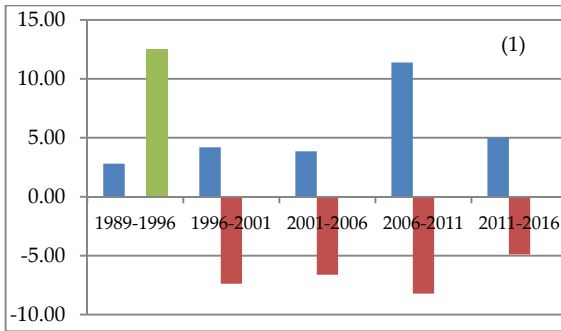
Morang

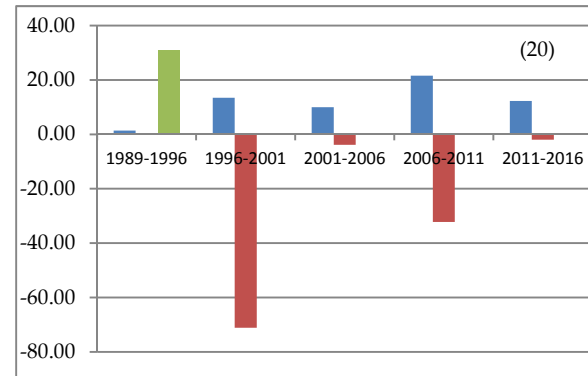
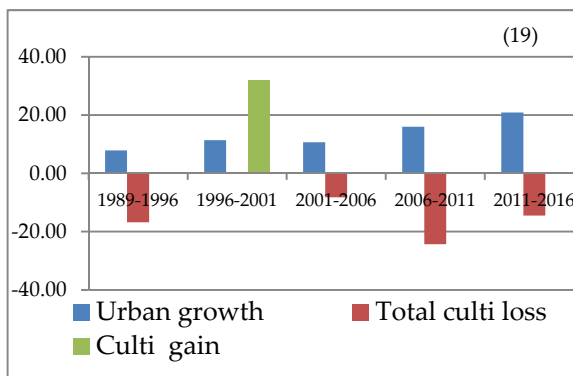
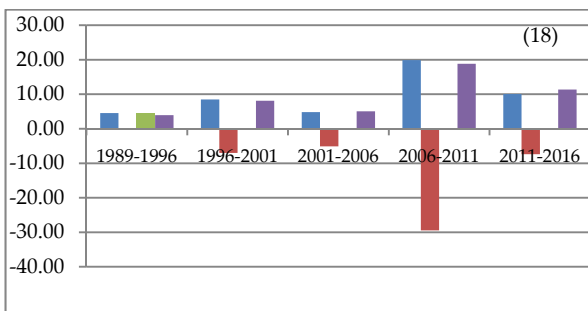
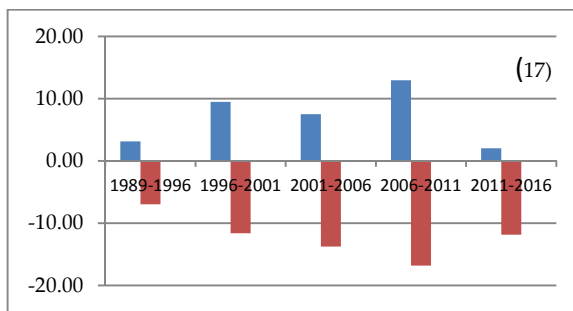
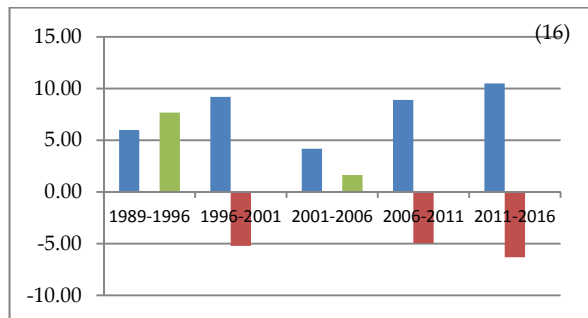
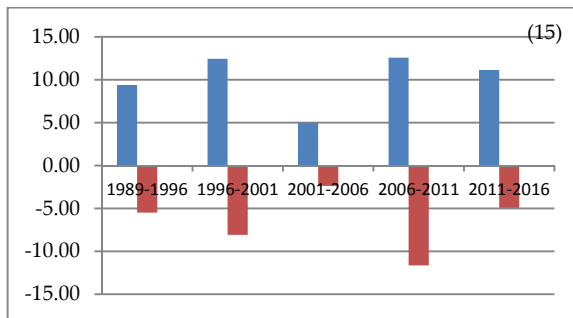
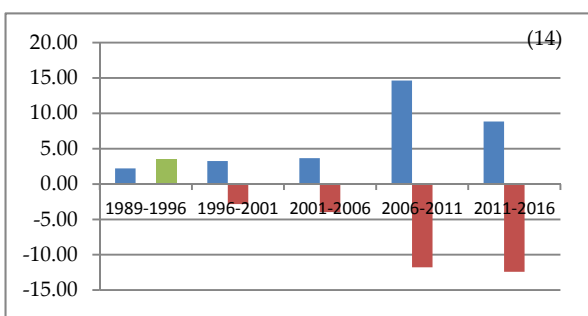
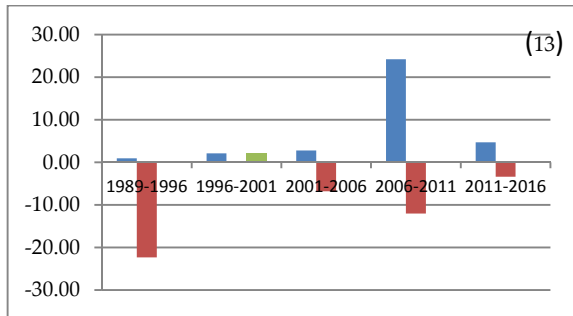
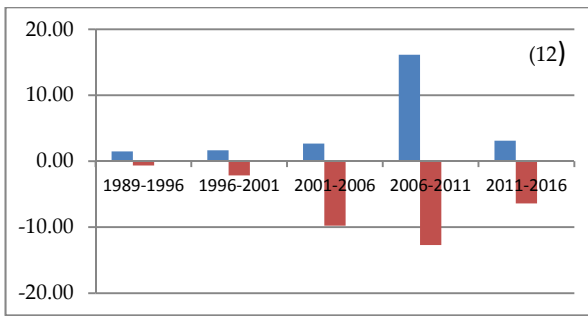
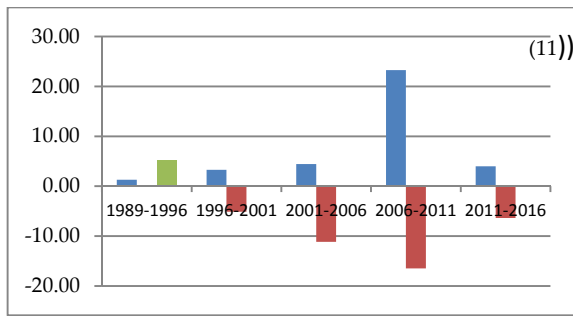
Year	1989		1996		2001		2006		2011		2016	
	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.	PA.	UA.
UB	84.85	80.00	82.86	82.86	87.88	82.86	85.71	85.71	85.71	85.71	88.57	88.57
CL	81.58	88.57	81.58	88.57	81.58	88.57	83.78	88.57	88.89	91.43	91.43	91.43
FC	82.86	82.86	85.71	85.71	88.57	88.57	82.86	82.86	88.57	88.57	88.57	88.57
BL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC	81.08	85.71	81.82	77.14	82.35	80.00	82.86	82.86	85.29	82.86	85.71	85.71
WB	84.38	77.14	85.29	82.86	85.71	85.71	84.85	80.00	85.71	85.71	85.71	85.71
Overall A.	82.86		83.43		85.14		84.00		86.86		88.00	

Note: U/B (Urban /Built-up), CL (Cultivated Land), VC (Vegetation Cover), BL (Barren Land), SC (Sand cover), WB (Water body), SA (Swamp Area) and TF (Tea Farming).

Supplementary information S2: District level area of urban growth and loss of cultivated land (km²) in the Tarai region

Figure S2. Area of urban growth and loss of cultivated land (km²) in the Tarai region for six observation periods between 1989 and 2016, by district: (1) Kanchanpu; (2) Kailali; (3) Bardiya; (4) Banke; (5) Dang; (6) Kapilbastu; (7) Rupandehi; (8) Nawalparasi; (9) Chitwan; (10) Parsa; (11) Bara; (12) Rautahat; (13) Sarlahi; (14) Mahottra; (15) Dhanusa; (16) Siraha; (17) Saptari; (18) Sunsari; (19) Morang; (20) Jhapa.





Supplementary information S3: District-level LULC statistics.

Table S3: District-level LULC statistic of the Tarai region, by district and land-cover classification year (1989-2016)

Kanchanpur							Kailali						
LULC	1989	1996	2001	2006	2011	2016	LULC	1989	1996	2001	2006	2011	2016
U/B	4.95	7.76	11.94	15.80	27.19	32.22	U/B	4.94	5.97	8.55	15.61	36.87	42.92
CL	547.75	560.29	552.91	546.28	538.06	533.17	CL	968.03	970.49	969.97	961.49	948.08	940.16
VC	937.30	914.71	911.89	918.96	902.90	904.08	VC	2030.62	2031.28	2021.88	2019.94	1992.10	2016.92
BL	9.62	7.62	8.52	8.53	9.03	5.42	BL	63.08	52.71	55.81	57.66	60.55	34.86
SC	87.41	96.42	108.32	104.14	119.75	130.34	SC	175.72	179.06	190.09	194.10	204.99	214.13
WB	28.21	28.49	21.60	21.43	18.27	10.04	WB	38.76	41.54	34.64	32.28	38.66	31.87
SA	1.30	1.25	1.35	1.40	1.33	1.27	SA	1.80	1.90	2.00	1.88	1.70	2.10
Total	1616.54	1616.54	1616.54	1616.54	1616.54	1616.54	Total	3282.95	3282.95	3282.95	3282.95	3282.95	3282.95

Bardiya							Banke						
LULC	1989	1996	2001	2006	2011	2016	LULC	1989	1996	2001	2006	2011	2016
U/B	6.53	6.81	7.52	9.08	16.45	17.96	U/B	6.82	7.53	9.34	12.32	24.61	27.91
CL	707.15	735.00	725.90	729.77	695.07	693.53	CL	613.31	611.04	613.91	613.36	602.74	592.61
VC	1140.85	1118.93	1125.14	1118.63	1148.84	1149.34	VC	1161.74	1161.98	1159.11	1159.43	1165.28	1158.04
BL	3.09	3.09	4.17	4.10	3.96	4.58	BL	0.16	0.16	0.19	0.18	0.18	0.20
SC	104.88	107.04	107.15	110.82	109.51	107.13	SC	76.91	79.65	75.57	68.84	57.11	65.19
WB	35.38	26.92	27.85	25.68	24.30	25.51	WB	21.05	19.62	21.88	25.85	30.07	36.04
SA	2.00	2.10	2.15	1.80	1.75	1.83	Total	1879.99	1879.99	1879.99	1879.99	1879.99	1879.99
Total	1999.88	1999.88	1999.88	1999.88	1999.88	1999.88							

Dang							Kapilbastu						
LULC	1989	1996	2001	2006	2011	2016	LULC	1989	1996	2001	2006	2011	2016
U/B	6.54	6.70	7.45	11.39	17.26	29.23	U/B	4.91	5.15	9.15	14.03	21.60	24.87
CL	883.82	881.00	890.54	882.66	890.29	878.02	CL	1015.54	1027.35	1015.12	994.84	981.60	980.02
VC	2001.61	2003.74	2000.53	2002.10	2006.16	2004.42	VC	578.95	569.95	574.66	583.91	592.90	590.06
BL	9.11	9.00	11.17	11.14	11.04	11.02	BL	0.04	0.03	0.03	0.03	0.03	0.13
SC	132.18	130.70	118.99	120.02	98.08	93.44	SC	32.98	33.64	40.19	43.66	39.94	43.80
WB	25.26	27.38	29.84	31.21	35.69	42.38	WB	16.40	12.55	9.53	12.35	12.77	11.85
Total	3058.52	3058.52	3058.52	3058.52	3058.52	3058.52	SA	3.11	3.25	3.26	3.11	3.09	1.21
							Total	1651.93	1651.93	1651.93	1651.93	1651.93	1651.93

Rupandehi							Nawalparasi						
LULC	1989	1996	2001	2006	2011	2016	LULC	1989	1996	2001	2006	2011	2016
U/B	16.34	19.90	30.11	40.02	63.35	69.02	U/B	8.54	9.84	15.17	22.27	37.86	45.17
CL	997.97	1002.77	987.36	965.77	950.73	949.94	CL	991.21	1002.34	984.57	952.66	946.35	940.13
VC	247.28	245.64	243.82	250.91	250.54	249.03	VC	988.46	988.33	984.07	997.34	1002.66	1003.30
BL	0.14	0.06	0.05	0.03	0.03	0.04	BL	4.83	3.35	3.13	2.66	2.68	3.83
SC	27.91	23.83	33.10	37.35	29.47	29.71	SC	96.59	86.74	112.89	119.73	109.98	107.80
WB	16.27	13.74	11.49	11.84	11.82	8.2	WB	61.52	60.08	50.88	56.64	52.23	53.50
SA	00	00	00	00	00	00	SA	4.84	5.30	5.26	4.66	4.22	2.25
Total	1305.93	1305.93	1305.93	1305.93	1305.93	1305.93	Total	2155.97	2155.97	2155.97	2155.97	2155.97	2155.97

	Chitawan							Parsa					
LULC	1989	1996	2001	2006	2011	2016	LULC	1989	1996	2001	2006	2011	2016
U/B	11.79	13.34	16.66	19.66	34.44	37.96	U/B	12.74	14.09	16.66	19.92	35.89	38.48
CL	686.78	688.29	684.65	680.65	659.34	654.51	CL	582.13	579.02	576.33	569.84	557.03	553.42
VC	1372.57	1380.28	1382.24	1376.95	1386.89	1396.97	VC	732.35	731.92	745.18	742.92	736.29	739.45
BL	0.25	0.23	0.23	0.23	0.23	0.23	BL	0.03	0.03	0.03	0.03	0.01	0.04
SC	114.83	106.80	110.76	112.82	111.34	107.19	SC	80.58	83.63	70.47	73.14	76.87	73.07
WB	56.5	53.77	48.18	52.42	50.47	45.85	WB	1.94	1.09	1.09	3.92	3.67	5.31
Total	2242.72	2242.72	2242.72	2242.72	2242.72	2242.72	Total	1409.77	1409.77	1409.77	1409.77	1409.77	1409.77

	Bara							Rautahat					
LULC	1989	1996	2001	2006	2011	2016	LULC	1989	1996	2001	2006	2011	2016
U/B	13.37	14.65	17.92	22.36	45.61	49.59	U/B	15.05	16.62	18.34	21.18	38.29	41.37
CL	718.49	723.62	718.51	707.35	690.88	684.51	CL	654.27	653.61	651.46	641.68	628.98	622.58
VC	475.64	472.01	478.5	476.05	466.55	464.3	VC	286.24	288.00	287.87	291.84	280.30	279.19
SC	60.14	61.70	56.81	63.55	67.72	69.70	SC	34.75	59.52	59.89	65.35	69.41	55.19
WB	7.67	3.32	3.58	6.00	4.55	7.20	WB	52.29	24.84	25.04	22.54	25.61	44.27
Total	1275.31	1275.31	1275.31	1275.31	1275.31	1275.31	Total	1042.59	1042.59	1042.59	1042.59	1042.59	1042.59

	Sarlahi							Mahottari					
LULC	1989	1996	2001	2006	2011	2016	LULC	1989	1996	2001	2006	2011	2016
U/B	14.39	15.32	17.44	20.22	44.45	49.15	U/B	10.10	12.30	15.55	19.22	33.86	42.71
CL	893.56	871.23	873.41	866.61	854.61	851.23	CL	697.77	701.20	698.37	694.40	682.61	670.19
VC	279.22	301.57	295.24	293.42	270.16	264.91	VC	223.65	219.11	221.21	221.17	217.67	221.51
SC	42.85	60.19	61.56	77.53	87.41	76.91	BL	0.02	0.02	0.02	0.02	0.02	0.02
WB	38.60	20.29	20.95	11.83	11.98	26.41	SC	65.54	67.08	64.85	64.77	64.72	63.97
Total	1268.61	1268.61	1268.61	1269.61	1268.61	1268.61	WB	7.74	5.11	5.81	5.23	5.93	6.41
							Total	1004.81	1004.81	1005.81	1004.81	1004.81	1004.81

	Dhanusa							Siraha					
LULC	1989	1996	2001	2006	2011	2016	LULC	1989	1996	2001	2006	2011	2016
U/B	17.70	27.07	39.51	44.48	57.04	68.17	U/B	13.47	19.46	28.66	32.83	41.73	52.22
CL	788.70	783.21	775.13	772.76	761.12	756.19	CL	828.32	836.00	830.78	832.43	827.47	821.17
VC	274.92	274.75	278.82	274.99	276.82	276.23	VC	202.26	189.9	195.15	191.65	191.07	188.4
SC	105.04	102.58	94.81	95.60	92.14	85.89	SC	93.43	92.99	85.52	83.64	79.28	76.67
WB	8.30	7.04	6.39	6.84	7.54	8.18	WB	8.50	7.63	5.87	5.43	6.43	7.52
Total	1194.66	1194.66	1194.66	1194.66	1194.66	1194.66	Total	1145.98	1145.98	1145.98	1145.98	1145.98	1145.98

	Saptari							Sunsari					
LULC	1989	1996	2001	2006	2011	2016	LULC	1989	1996	2001	2006	2011	2016
U/B	9.77	12.91	22.41	29.91	42.87	44.90	U/B	16.07	20.60	29.11	33.92	53.82	63.87
CL	862.73	855.77	844.16	830.41	813.61	801.78	CL	776.90	781.41	774.43	769.33	739.85	732.46
VC	212.28	218.31	222.65	250.49	236.94	263.03	VC	235.37	241.29	243.76	240.99	236.83	245.96
SC	151.45	160.56	153.64	138.59	157.61	121.87	BL	0.14	0.15	0.12	0.16	0.20	0.19
WB	49.40	38.23	42.93	37.06	35.82	54.65	SC	100.61	98.98	88.58	106.29	126.33	83.05
SA	2.37	2.21	2.21	1.53	1.16	1.77	WB	52.86	43.74	50.52	39.01	43.13	75.72
Total	1288.00	1288.00	1288.00	1288.00	1288.00	1288.00	SA	19.53	15.30	14.96	11.78	1.31	0.24

							Total	1201.48	1201.48	1201.48	1201.48	1201.48	1201.48
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	Morang							Jhapa					
LUL C	1989	1996	2001	2006	2011	2016	LUL C	1989	1996	2001	2006	2011	2016
U/B	14.78	22.65	34.05	44.73	60.72	81.59	U/B	12.35	13.71	27.12	37.09	58.65	70.91
CL	1196.0 4	1179.2 4	1211.0 8	1202.8 5	1178.5 0	1164.0 1	CL	1259.3 4	1290.3 4	1219.2 7	1215.4 3	1183.2 5	1181.2 7
VC	528.85	518.44	487.43	486.52	485.72	491.39	VC	189.80	170.88	184.12	183.18	178.55	184.52
SC	78.93	116.07	99.46	99.42	99.29	89.61	SC	48.01	73.77	121.26	107.88	103.82	104.50
WB	33.07	15.36	20.05	18.63	27.96	26.78	WB	71.72	34.40	28.61	33.33	50.26	39.77
SA	3.60	3.50	3.20	3.11	3.06	2.88	TF	22.26	20.38	23.10	26.58	28.96	22.52
Total	1855.26	1855.26	1855.26	1855.26	1855.26	1856.26	Total	1603.49	1603.49	1603.49	1603.49	1603.49	1603.49

Note: U/B (Urban /Built-up), CL (Cultivated Land), VC (Vegetation Cover), BL (Barren Land), SC (Sand cover), WB (Water body), SA (Swamp Area) and TF (Tea Farming).

Supplementary information S4: District-level urban growth rate

Table S4. District-level urban growth rate of Tarai region (in %) for six observation periods between 1989 and 2016

	Districts	1989-1996	1996-2001	2001-2006	2006-2011	2011-2016
1	Kanchanpur	8.08	10.8	6.46	14.42	3.69
2	Kailali	2.97	8.66	16.5	27.23	3.28
3	Bardiya	0.6	2.1	4.14	16.24	1.83
4	Banke	1.48	4.83	6.38	19.93	2.68
5	Dang	0.34	2.25	10.52	10.3	13.88
6	Kapilbastu	0.7	15.51	10.69	10.78	3.03
7	Rupandehi	3.11	10.46	6.41	11.99	1.79
8	Nawalparasi	2.18	10.84	9.37	13.99	3.86
9	Chitawan	1.89	4.98	3.6	15.05	2.04
10	Parsa	1.52	3.65	3.91	16.04	1.44
11	Bara	1.37	4.57	4.96	20.8	1.75
12	Rautahat	1.49	2.07	3.1	16.15	1.6
13	Sarlahi	0.93	2.76	3.19	23.97	2.11
14	Mahottari	3.12	5.29	4.72	15.23	5.23
15	Dhanusa	7.57	9.18	2.52	5.65	3.9
16	Siraha	6.36	9.46	2.91	5.42	5.03
17	Saptari	4.59	14.71	6.7	8.66	0.95
18	Sunsari	4.03	8.26	3.31	11.73	7.73
19	Morang	7.6	10.06	6.27	7.14	7.87
20	Jhapa	1.57	19.58	7.35	11.63	3.17