

Table S1. Landsat images for land-use/land-cover (LULC) classification and detecting changes from 1990 to 2020.

Satellite	Sensor	Resolution (m)	Path/Row	Acquisition Date	Cloud cover (%)
Landsat 5	TM	30 x30	166/053	18 December 1990	0
Landsat 5	TM	30 x30	166/054	20 January 1990	0
Landsat 5	TM	30 x30	166/055	20 January 1990	0
Landsat 5	TM	30 x30	167/053	27 January 1990	0
Landsat 5	TM	30 x30	167/054	25 December 1990	0
Landsat 5	TM	30 x30	166/053	14 January 2000	0
Landsat 5	TM	30 x30	166/054	15 February 2000	0
Landsat 5	TM	30 x30	166/055	14 January 2000	0
Landsat 5	TM	30 x30	167/053	22 December 2000	0
Landsat 5	TM	30 x30	167/054	05 January 2000	0
Landsat 5	TM	30 x30	166/053	25 January 2010	3
Landsat 5	TM	30 x30	166/054	25 January 2010	0
Landsat 5	TM	30 x30	166/055	11 December 2010	0
Landsat 5	TM	30 x30	167/053	02 December 2010	0
Landsat 5	TM	30 x30	167/054	18 December 2010	0
Landsat 8	OLI	30 x30*	166/053	06 December 2020	1
Landsat 8	OLI	30 x30	166/054	21 January 2020	0.1
Landsat 8	OLI	30 x30	166/055	05 January 2020	0.4
Landsat 8	OLI	30 x30	167/053	26 December 2020	0
Landsat 8	OLI	30 x30	167/054	29 February 2020	0

Table S2. LULC classes and their descriptions.

LULC Class	Description
Bare land	Open areas with little or no vegetation cover, including barren lands, rocky or sandy areas, seashores, and landfill sites.
Built-up	Areas with built-up land (including those under construction) for public services, administration, transportation, industry, commercial or mixed uses, and residences
Cropland	The land is allocated to the cultivation, including rain-fed or irrigated vegetables.
Forest	Land covered by forest (both natural and planted) comprising > 0.5 ha reaching a height of more than two meters with a canopy cover of more than 20% [74]
Grassland	The land is utilized for grazing and pasture.
Shrubland	Land with shrubs/bushes canopy cover $\leq 10\%$ or combined bush cover and shrubs $\leq 10\%$ [74].
Waterbody	Rivers, streams, drainages, lakes, reservoirs, swamp areas, and ponds

N.B: Forest and shrub classes that do not meet the area and canopy cover conditions were determined using predefined references and expert knowledge of the study area.

Table S3. Estimated soil erodibility (K) value for soil classes.

Soil class	DOMSOI	% of the area covered	K-value
Chromic Vertisols	Vc	2	0.8
Eutric Nitisols	Ne	10	0.3
Eutric Regosols	Re	8	0.8
Calcaric Regosols	Rc	21	0.9
Calcic Xerosols	Xk	2.6	0.4
Cambic Arenosols	Qc	0.04	0.8
Dystric Cambisols	Bd	13.3	0.4
Eutric Cambisols	Be	4	1
Haplic Xerosols	Xh	33.4	0.4
Haplic Yermosols	Yh	0.4	0.8
Humic Cambisols	Bh	5.3	0.3

Table S4. The C-factor values for LULC classes.

LULC Class	C Factor
Bare land	0.1
Built-up	0.2
Cropland	0.25
Forest	0
Grassland	0.1
Shrubland	0.01
Waterbody	0

Table S5. The slope classes with the P-factor values for erosion control practices.

Slope (%)	Conservation Support Practice (P) Factor ¹		
	Contouring	Strip Cropping	Terracing
0–7.0	0.55	0.27	0.1
7.0–11.3	0.6	0.3	0.12
11.3–17.6	0.8	0.4	0.16
17.6–26.8	0.9	0.45	0.18
>26.8	1	0.5	0.2

Table S6. Total and average soil loss per district and the contribution to annual soil loss, mean rainfall, and slopes in 1990.

District Name	% of the area covered a	Total soil loss (Mt y ⁻¹)	Mean erosion (t ha ⁻¹ y ⁻¹)	% of annual soil loss	Mean rainfall (mm y ⁻¹)	Mean slope (%)
Jarso	2	0.1	23	2	707	25
Kombolcha	2	0.1	22	1	776	25
Meta	3	0.4	59	5	932	30
Haro Maya	2	0.2	23	2	853	12
Goro Gutu	2	0.3	56	3	812	26
Gursum	3	0.2	17	2	618	13
Kersa	2	0.2	36	2	870	17
Deder	2	0.2	36	3	1012	30
Babile	20	1	17	11	512	9
Kurfa Chele	1	0.1	37	1	874	21
Bedeno	4	0.4	38	5	887	27
Girawa	6	1	32	6	787	21
Malka Balo	6	1	70	12	854	22
Golo Oda	16	3	60	29	728	13
Fedis	5	0.2	13	2	679	7
Midega Tola	3	0.2	20	2	598	11
Meyu Muleke	15	1	26	12	623	12
Chinaksen	6	0.3	18	3	600	14
Total	100	9	33	100	687	15

Table S7. Total and mean soil loss per district and the contribution to annual soil loss, mean rainfall, and slopes in 2000.

District Name	% of the area covered	Total soil loss (Mt y ⁻¹)	Mean erosion (t ha ⁻¹ y ⁻¹)	% of annual soil loss	Mean rainfall (mm y ⁻¹)	Mean slope (%)
Jarso	2	0.3	54	2	663	25
Kombolcha	2	0.3	56	2	726	25
Meta	3	1	172	9	903	30
Haro Maya	2	0.2	28	1	801	12
Goro Gutu	2	0.4	87	3	785	26
Gursum	3	0.3	29	2	575	13
Kersa	2	0.3	61	2	842	17
Deder	2	1	146	7	964	30
Babile	20	2	27	11	457	9
Kurfa Chele	1	0.2	65	1	838	21
Bedeno	4	1	97	7	825	27
Girawa	6	1	63	7	734	21
Malka Balo	6	2	120	13	769	22
Golo Oda	16	2	52	17	598	13
Fedis	5	0.2	16	1	627	7
Midega Tola	3	0.4	38	3	536	11
Meyu Muleke	15	1	26	8	497	12
Chinaksen	6	0.5	27	3	538	14
Total	100	14	50	100	610	15

Table S8. Total and mean soil loss per district and the contribution to annual soil loss, mean rainfall, and slopes in 2010.

District Name	% of the area covered	Soil loss (Mt y ⁻¹)	Mean erosion (t ha ⁻¹ y ⁻¹)	% of Annual Soil Loss	Mean rainfall (mm y ⁻¹)	Mean slope (%)
Jarso	2	0.2	36	2	764	25
Kombolcha	2	0.2	38	2	831	25
Meta	3	1	117	7	988	30
Haro Maya	2	0.2	22	1	897	12
Goro Gutu	2	0.1	25	1	853	26
Gursum	3	0.2	27	2	648	13
Kersa	2	0.2	44	2	932	17
Deder	2	0.4	63	3	1029	30
Babile	20	2	26	13	511	9
Kurfa Chele	1	0.1	45	1	917	21
Bedeno	4	1	73	7	894	27
Girawa	6	1	51	7	795	21
Malka Balo	6	2	107	13	806	22
Golo Oda	16	3	59	22	647	13
Fedis	5	0.2	17	2	696	7
Midega Tola	3	0.4	42	3	591	11
Meyu Muleke	15	1	30	10	554	12
Chinaksen	6	0.4	23	3	627	14
Total	100	12	44	100	672	15

Table S9. Total and mean soil loss per district and the contribution to annual soil loss, mean rainfall, and slopes in 2020.

District Name	% of the area covered	Total soil loss (Mt y ⁻¹)	Mean erosion (t ha ⁻¹ y ⁻¹)	% of Annual Soil Loss	Mean rainfall (mm y ⁻¹)	Mean slope (%)
Jarso	2	0.3	42	2	739	25
Kombolcha	2	0.1	27	1	799	25
Meta	3	1	184	12	963	30
Haro Maya	2	0.1	21	1	881	12
Goro Gutu	2	1	103	4	789	26
Gursum	3	0.2	26	2	633	13
Kersa	2	0.3	65	3	899	17
Deder	2	1	146	9	1034	30
Babile	20	2	30	16	518	9
Kurfa Chele	1	0.1	42	1	933	21
Bedeno	4	1	63	6	923	27
Girawa	6	1	34	5	826	21
Malka Balo	6	1	77	11	846	22
Golo Oda	16	1	30	12	675	13
Fedis	5	0.2	18	2	716	7
Midega Tola	3	0.2	22	2	620	11
Meyu Muleke	15	1	16	6	575	12
Chinaksen	6	0.3	16	3	611	14
Total	100	11	39	100	683	15

Table S10. Error matrix of LULC classification accuracies for (a)1990, (b) 2000, (c) 2010, and (d) 2020, in percent (%).

Classified Data ¹	Reference Data							Total	UA	CE
	Bare land	Built-up	Cropland	Forest	Grassland	Shrubland	Waterbody			
(a)										
Bare land	59	9	2	0	0	0	0	70	84	16
Built-up	2	41	0	0	0	0	0	43	95	5
Cropland	2	0	85	2	1	0	0	90	94	6
Forest	1	0	0	66	0	1	0	68	97	3
Grassland	0	0	0	0	26	1	0	27	96	4
Shrubland	1	0	3	2	3	83	0	92	90	10
Waterbody	0	0	0	0	0	0	30	30	100	0
Total	65	50	90	70	30	85	30	390		
PA	91	82	94	94	87	98	100		OA	93
OE	9	18	6	6	13	2	0			
(b)										
Bare land	61	4	2	0	0	0	0	67	91	9
Built-up	0	43	1	0	0	0	0	44	98	2
Cropland	4	3	85	0	1	0	0	93	91	9
Forest	0	0	0	67	0	3	0	70	96	4
Grassland	0	0	0	0	29	0	0	29	100	0
Shrubland	0	0	2	3	0	82	0	87	94	6
Waterbody	0	0	0	0	0	0	30	30	100	0
Total	65	50	90	70	30	85	30	397		
PA	94	86	94	96	97	96	100		OA	95
OE	6	14	6	4	3	4	0			
(c)										
Bare land	65	1	0	0	0	0	0	66	98	2
Built-up	0	44	0	0	0	0	0	44	100	0
Cropland	0	2	88	0	1	2	0	93	95	5
Forest	0	0	0	68	0	7	1	76	89	11
Grassland	0	0	0	0	27	0	0	27	100	0
Shrubland	0	3	2.00	2	2	76	0	85	89	11
Waterbody	0	0	0	0	0	0	29	29	100	0
Total	65	50	90	70	30	85	30	397		
PA	100	88	98	97	90	89	97		OA	95
OE	0	12	2	3	10	11	3			
(d)										
Bare land	60	0	0	1	0	0	0	61	98	2
Built-up	1	47	1	0	0	0	0	49	96	4
Cropland	3	0	88	0	0	1	0	92	96	4
Forest	0	0	0	66	0	3	0	69	96	4
Grassland	0	0	0	0	28	1	0	29	97	3
Shrubland	1	3	1	3	2	80	0	90	89	11
Waterbody	0	0	0	0	0	0	30	30	100	0
Total	65	50	90	70	30	85	30	399		
PA	92	94	98	94	93	94	100		OA	95
OE	8	6	2	6	7	6	0			

¹The diagonal values in the italics-down error matrix tables represent reference points accurately classified for each LULC class, while off-diagonal entries represent misclassified points that conform to individual classes.

Table S11. Area of LULC change (km²) relative to the 1990–2000 period.

LULC Class	Bare land	Built-up	Cropland	Forestland	Grassland	Shrubland	Waterbody	1990
Bare land	1,007	6	1,011	12	4	107	0	2,148
Built-up	7	1	17	1	0	3	0	29
Cropland	890	23	9,324	493	2	1,506	1	12,240
Forestland	50	3	847	1,288	1	327	2	2,518
Grassland	39	1	50	1	6	14	0	111
Shrubland	383	20	5,770	736	16	1,060	2	7,986
Waterbody	0	0	1	1	0	1	6	8
2000	2,377	54	17,019	2,532	30	3,018	10	25,040
2000–1990	229	26	4778	14	–81	–4968	2	

Table S12. Area of LULC change (km²) relative to the 2000–2010 period.

LULC Class	Bare land	Built-up	Cropland	Forestland	Grassland	Shrubland	Waterbody	2000
Bare land	1,092	7	993	7	7	271	0	2,377
Built-up	6	3	15	4	0	26	0	54
Cropland	1,300	34	12,034	588	20	3,042	0	17,019
Forestland	6	5	778	928	1	814	0	2,532
Grassland	5	0	7	1	3	14	0	30
Shrubland	124	6	1,478	351	12	1,048	0	3,018
Waterbody	0	0	3	1	1	3	3	10
2010	2,534	55	15,308	1,879	43	5,217	3	25,040
2010–2000	158	0.3	–1,711	–653	13	2,199	–7	

Table S13. Area of LULC change (km²) relative to the 2010–2020 period.

LULC Class	Bare land	Built-up	Cropland	Forestland	Grassland	Shrubland	Waterbody	2010
Bare land	790	24	1116	10	15	579	1	2534
Built-up	4	7	22	6	0	15	0	55
Cropland	598	59	9219	422	57	4950	4	15308
Forestland	3	7	433	996	1	437	3	1879
Grassland	3	0	7	1	6	26	0	43
Shrubland	76	43	1721	651	24	2698	6	5217
Waterbody	0	0	0	0	0	0	3	3
2020	1474	139	12518	2086	101	8705	16	25040
2020–2010	–1061	84	–2790	207	58	3488	13	

Table S14. LULC changes and associated soil erosion rates (in t ha⁻¹ yr⁻¹).

	Bare land	Built-up	Cropland	Forest	Grassland	Shrubland
1990–2000						
Bare land	1	–3	5	–3	–3	–4
Built-up	1	0	4	–0.5	0.4	1
Cropland	–6	–8	1	–19	–9	–8
Forest	5	0.2	17	0	0.4	1
Grassland	3	–1	6	–1	0	1
Shrubland	4	–0.5	4	–2	–0.3	0.1
2000–2010						
Bare land	–0.4	–2	5	–4	–3	–3
Built-up	2	0	6	–0.3	0.1	0.6
Cropland	–5	–6	–0.5	–16	–11	–5
Forest	5	0.2	16	0	1	2
Grassland	10	–3	32	–0.7	–0.1	0.7
Shrubland	3	–1	10	–1.4	–1	–0.1
2010–2020						
Bare land	–0.1	–2	5	–1	–11	–3
Built-up	1	0	4	–0.4	0.3	1
Cropland	–5	–7	–0.1	–21	–30	–12
Forestland	2	0.2	11	0	1	1
Grassland	3	–1	8	–1	0	1
Shrubland	3	–8	8	–2	–1	0

Reference

74. Woldemariam, G.W.; Tibebe, D.; Mengesha, T.E.; Gelete, T.B. Machine-Learning Algorithms for Land Use Dynamics in Lake Haramaya Watershed, Ethiopia. *Model. Earth Syst. Environ.* **2021**, *8*, 3719–3736. <https://doi.org/10.1007/s40808-021-01296-0>.