

## Supplementary Data

**Table S1. Satellite Imageries details**

Study Region	Row/Path	Year	2000	2010	2020
		Sensor	TM	TM	OLI
Lahore	149/038	Date	14, 30 May	11 June	22 June
			12, 28 April	26, 10 May	05, 21 May
			11 March	8, 24 April	3, 19 April
				03 march	2, 18 March
Peshawar	151/036 151/037	Date	13 June	16 June	04, 20 June
			12, 28 May	03, 24 May	03, 19 May
			10 April	06 April	05 March
			09, 25 March	05 March	
Swat	151/035 151/036	Date	06 June	04, 18 June	04, 20 June
			12, 28 May	24 May	03, 19 May
			10 April	06 April	10 April
			09, 25 March	05 March	

### REDD+ Project

Reducing Emissions from Deforestation and Forest Degradation (REDD+) is an initiative to reduce deforestation and carbon emissions from forest ecosystems in developing countries. The REDD+ also includes the conservation of forests, sustainable forest management, and enhancing carbon stocks to facilitate developing countries in climate change mitigation [1, 2]. The REDD+ activities can be validated and monitored through the Measuring, Reporting, and Verification (MRV) system, the central part of the REDD+ mechanism, which ensures proper forest inventories and carbon estimation by national baselines or reference levels (RLs) [3-5].

### LULC Class divisions

- (i) Cultivated land (growing crops. Paddy fields, irrigated upland, rain-fed upland, vegetable land, cultivated pasture, greenhouse land, mainly planted with crops rarely with fruit trees or other trees, tea garden, coffee garden, and other economic cropland are included in this category).
- (ii) Vegetation (lands covered with trees, the maximum density of which occupies over 30%. Deciduous broadleaf forest, evergreen broadleaf forest, deciduous, coniferous forest, evergreen coniferous forest, mixed forest, and sparse woodland, the most excellent density covers 10%-30%, are included in this category, also surrounded by natural grass with a cover density of over 10%).
- (iii) Water bodies (covered by biogas or hygrophite plants and shallow water or wet soils. Inland marsh, lake marsh, river floodplain wetland, forest/shrub wetland, peat bogs, mangrove, salt marsh, etc.).
- (iv) Artificial surfaces (All kinds of habitation in urban and rural areas, industrial and mining, transportation facilities, etc.).
- (v) Bare land (land with a lower than 10% cover density): desert, sand, gravel ground, bare rocks, saline, alkaline lands, etc.).
- (vi) Permanent snow (covered by permanent snow, glacier, and icecap.)

**Table S2: Land use transitions 2000-2010 (Provinces)**

		Cultivated land	Vegetation	Water bodies	Artificial Surfaces	Bare Land	Permanent Snow and Ice
<b>KPK</b>	Cultivated land	25315.7	530.5	46.8	46.3	19	NA
	Vegetation	640.8	27126.4	118.4	3.5	1262.7	189.2
	Water bodies	64.4	150.4	473.5	0.7	37.5	1.4
	Artificial Surfaces	36.0	7.1	1.02	619.5	0.4	NA
	Bare Land	203.8	4105.8	55.7	0.6	10095.4	138.3
	Permanent Snow and Ice	NA	541.6	0.18	NA	159.4	5024.3
<b>Punjab</b>	Cultivated land	135144.2	231.8	267.5	265.6	104.9	NA
	Vegetation	843.8	18261	540.2	11.2	1594.1	NA
	Water bodies	538.6	475.6	1360.7	3	81.1	NA
	Artificial Surfaces	248.7	7.2	1.6	3578.8	9.7	NA
	Bare Land	350.1	2327.3	154.9	6.6	43120.9	NA

**Table S3: Land use transitions 2000-2020 (Sites)**

		Cultivated land	Vegetation	Water bodies	Artificial Surfaces	Bare Land	Permanent Snow and Ice
<b>Peshawar</b>	Cultivated land	405.4	157.5	8.6	57.9	0.7	NA
	Vegetation	103.8	834.1	3.3	19.01	56.5	NA
	Water bodies	0.82	7.58	13.0	0.11	1.5	NA
	Artificial Surfaces	6.3	14.07	0.7	44.4	5.7	NA
	Bare Land	7.9	381.8	9.8	208.5	258.3	NA
	Permanent Snow and Ice	NA	NA	NA	NA	NA	NA

<b>Swat</b>	Cultivated land	930.6	147.17	6.75	30.67	0.31	NA
	Vegetation	48.3	1984.86	4.02	5.07	112.81	29.66
	Water bodies	2.2	8.22	3.96	0.04	1.18	0.47
	Artificial Surfaces	0.79	0.06		21.44		NA
	Bare Land	0.63	543.85	1.96	0.25	515.43	34.82
	Permanent Snow and Ice	NA	30.82	NA	NA	36.19	799.89
<b>Lahore</b>	Cultivated land	503.2	86.5	12.6	157.9	3.8	NA
	Vegetation	97.6	134.31	1.26	150.13	173.04	NA
	Water bodies	5.8	10.31	4.93	23.33	11.84	NA
	Artificial Surfaces	0.8	19.13	4.42	283.11	143.11	NA
	Bare Land	8.2	152.75	0.81	299.3	330.58	NA
		NA	NA	NA	NA	NA	NA

**Table S4: LULC Transition Probabilities Kpk and Punjab 2000-2020**

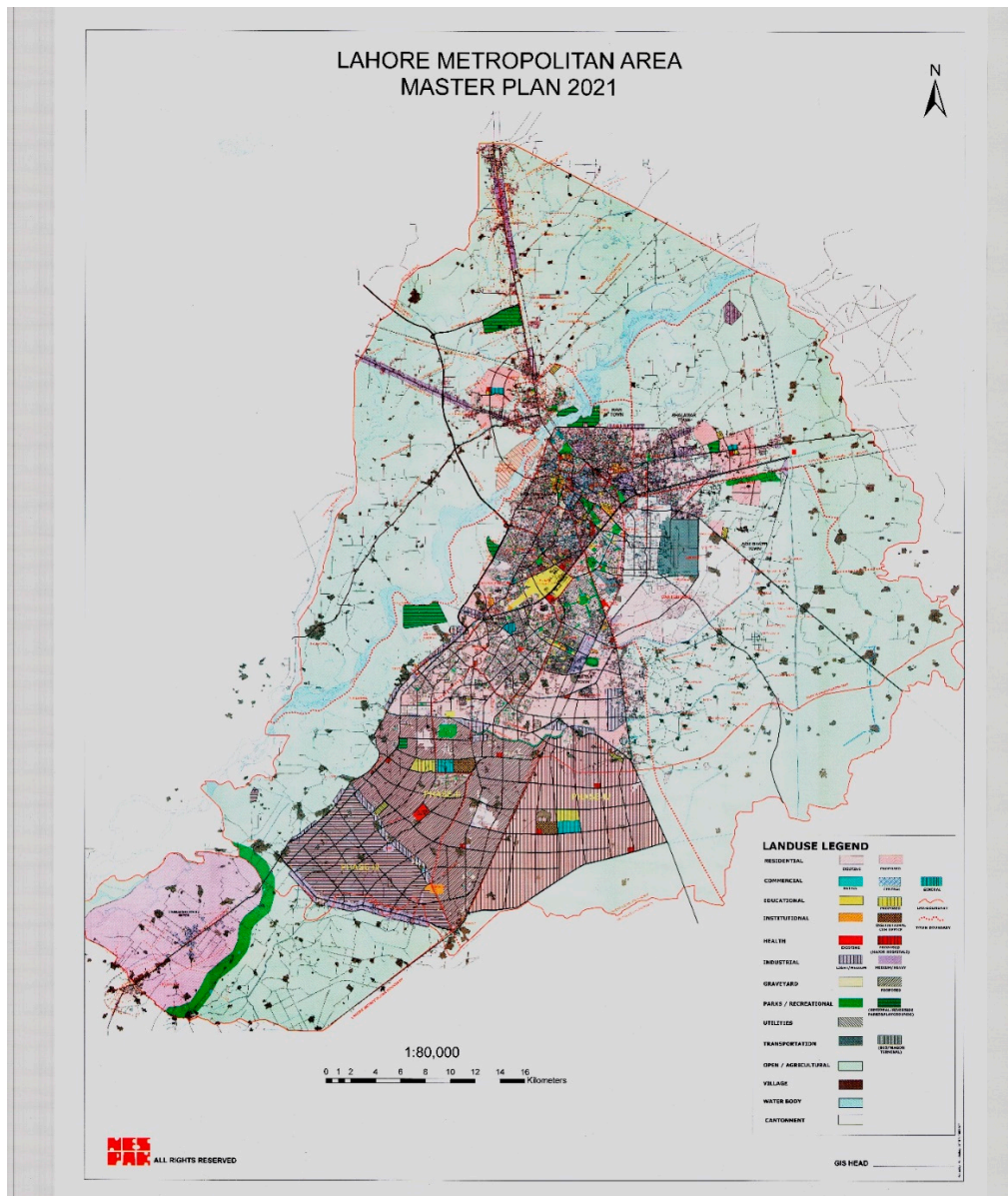
<b>KPK</b>		Cultivated land	Vegetation	Water bodies	Artificial Surfaces	Bare Land	Permanent Snow and Ice
	Cultivated land	0.9588	0.0235	0.0025	0.0152	0	0
	Vegetation	0.0206	0.9058	0.0068	0.0008	0.0611	0.0049
	Water bodies	0.0447	0.0836	0.8269	0.0005	0.0437	0.0006
	Artificial Surfaces	0.0539	0.0045	0.0005	0.9408	0.0003	0
	Bare Land	0.0059	0.1921	0.0015	0	0.7939	0.0066
	Permanent Snow and Ice	0	0.0469	0	0	0.0224	0.9307
<b>Punjab</b>		Cultivated land	Vegetation	Water bodies	Artificial Surfaces	Bare Land	NA

	Cultivated land	0.9834	0.0009	0.0153	0.0003	0.0001	NA
	Vegetation	0.0162	0.9794	0.0027	0.0014	0.0002	NA
	Water bodies	0	0	1	0	0	NA
	Artificial Surfaces	0.0352	0.146	0.0006	0.8181	0	NA
	Bare Land	0	0	0	0	1	NA

**Tabel S5: LULC gain and loss over Kpk and Punjab 2000-2020**

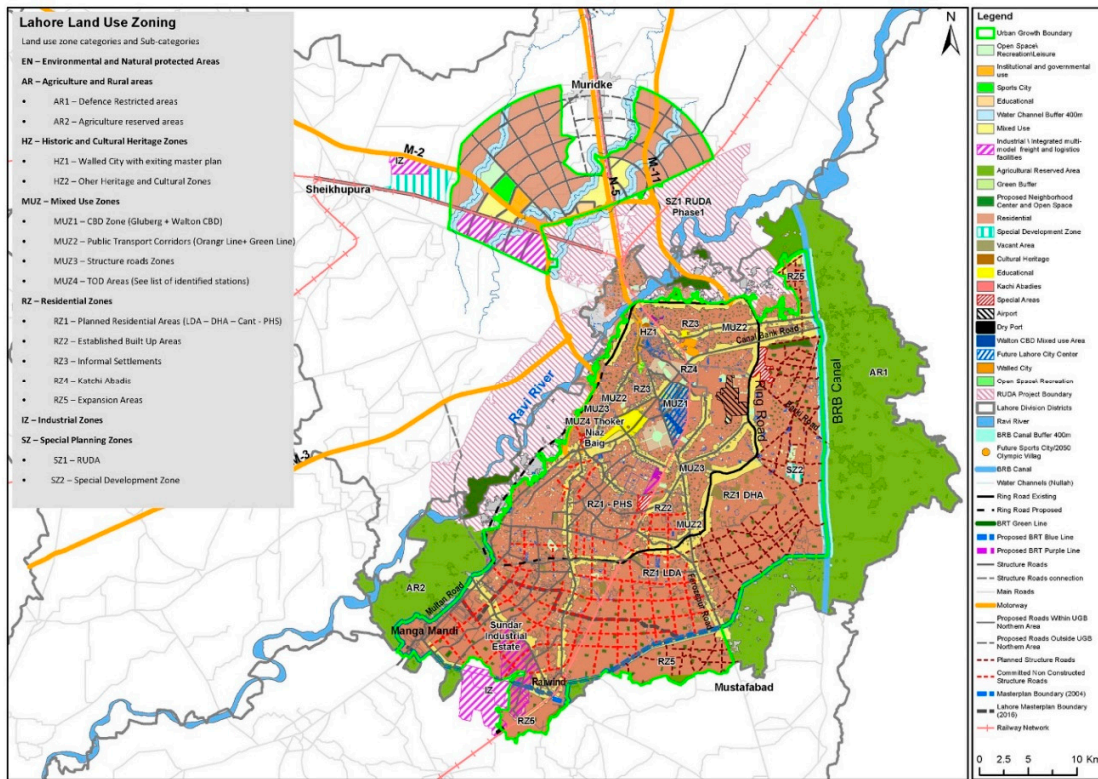
KPK						
	Cultivated Land	Vegetation	Water Bodies	Artificial Surfaces	Bare Land	Permanent Snow and Ice
Losses	1282.5	2796.4	219.3	74.9	4848	755.1
Persistence	24674.2	26541.1	508.4	589.2	9750.1	4969.3
Gains	1040	5716.6	333.7	506.9	2035.4	343.6
Punjab						
Losses	3647.2	4592.4	1126.4	619.1	4352.6	NA
Persistence	132359.3	16655.5	1332.2	3226.9	41605	NA
Gains	3285.1	4179.1	2507.7	1757.6	2608.3	NA

Figure S1 (a). Lahore Metropolitan area master Plan 2021



[https://lda.gov.pk/website/images/Integrated\\_Master\\_Plan\\_of\\_Lahore.jpg](https://lda.gov.pk/website/images/Integrated_Master_Plan_of_Lahore.jpg)

Figure S1 (b). Lahore Metropolitan area master Plan 2050



[https://lda.gov.pk/website/images/scnerio\\_master\\_plan\\_lahore\\_18\\_04\\_2022\\_full.jpg](https://lda.gov.pk/website/images/scnerio_master_plan_lahore_18_04_2022_full.jpg)

## References

1. Fry, I. Reducing emissions from deforestation and forest degradation: opportunities and pitfalls in developing a new legal regime. *Rev. Eur. Community Int. Environ. Law* **2008**, *17*, 166-182.
2. UNFCCC. *Factsheet: Reducing Emissions from Deforestation in Developing Countries: Approaches to Stimulate Action*. 2011. Available from: [http://unfccc.int/files/press/backgrounders/application/pdf/fact\\_sheet\\_reducing\\_emissions\\_from\\_deforestation.pdf](http://unfccc.int/files/press/backgrounders/application/pdf/fact_sheet_reducing_emissions_from_deforestation.pdf) (accessed on).
3. Page, P. *Report of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention on the first part of its fifteenth session, held in Bonn from 15 to 24 May 2012*; 2012.
4. Herold, M.; Skutsch, M. Monitoring, reporting and verification for national REDD+ programmes: two proposals. *Environ. Res. Lett.* **2011**, *6*, 014002.
5. Skutsch, M.M.; Torres, A.B.; Mwampamba, T.H.; Ghilardi, A.; Herold, M. Dealing with locally-driven degradation: A quick start option under REDD+. *Carbon Balance Manag.* **2011**, *6*, 1-7.