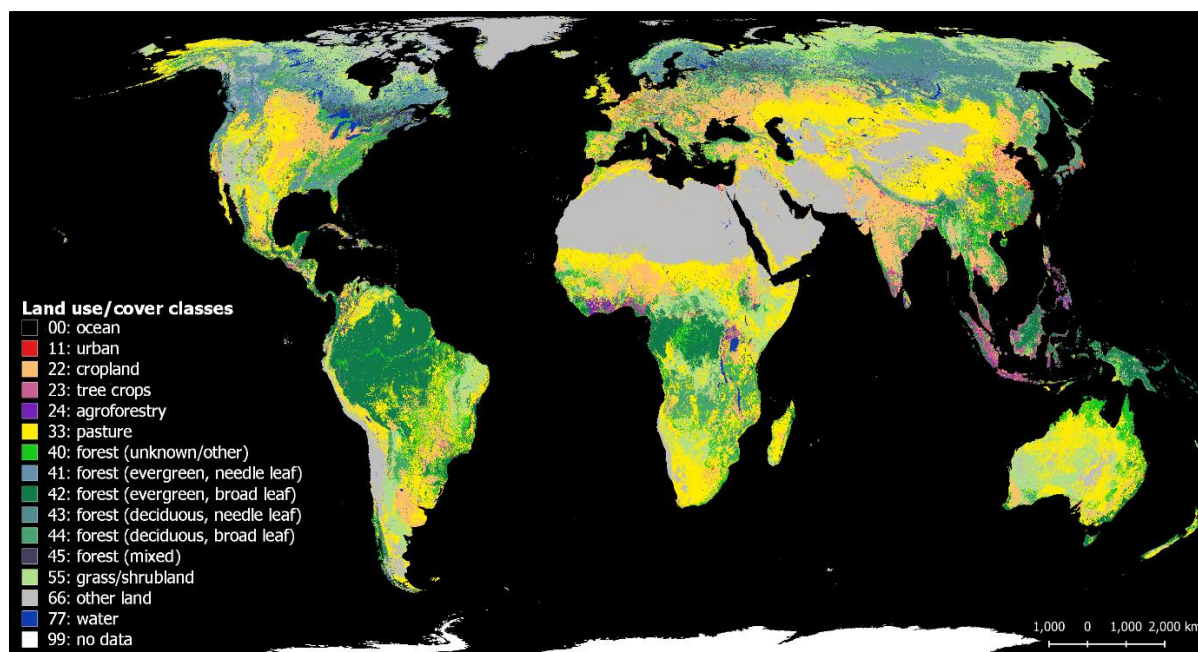


HILDA+ Global Land Use Change version 3.0

Note that this is an unpublished beta version.

Specifications vGLOB-3.0_geotiff



Exemplary map: HILDA+ land use/cover (states) 2023

Specifications of vGLOB-3.0

Data set Land Use/Cover states (1) and transitions (2)

Thematic classes **1) Land Use/Cover categories (*states*)**

00 ocean
11 urban
22 annual crops
23 tree crops
24 agroforestry
33 pasture/rangeland
40 forest (unknown/other)
41 forest (evergreen, needle leaf)
42 forest (evergreen, broad leaf)
43 forest (deciduous, needle leaf)
44 forest (deciduous, broad leaf)
45 forest (mixed)
55 unmanaged grass/shrubland
66 sparse/no vegetation
77 water
99 no data

2) Transitions between Land Use/Cover categories (*transitions*)
with 4-digit codes (XXYY, where XX is LULC category of previous year and YY is LULC category of reference year)

e.g.

1111 urban (stable)
 1122 urban to annual crops
 1123 urban to tree crops
 1124 urban to agroforestry
 1133 urban to pasture
 1140 urban to forest (unknown/other)
 1141 urban to forest (evergreen, needle leaf)
 1142 urban to forest (evergreen, broad leaf)
 1143 urban to forest (deciduous, needle leaf)
 1144 urban to forest (deciduous, broad leaf)
 1155 urban to shrub/grassland
 1166 urban to other land
 ...
 etc.

_eckert4 (equal-area projection)

Format	GeoTIFF
Projection	EPSG:54012 - World_Eckert_IV
Spatial coverage/extent	--18000000, 9000000, 18000000, -9000000
Temporal coverage	1960-2023
Spatial resolution	1 km
Temporal resolution	1 year

_wgs84 and netCDF (latitude longitude; Unit: degree)

Format	GeoTIFF, or netCDF
Projection	EPSG:4326 - WGS 84
Spatial coverage/extent	-180, 90, 180, -90
Temporal coverage	1960-2023 in the netCDF: 1900-2023, with extrapolated trends before 1960
Spatial resolution	0.01°
Temporal resolution	1 year

General/ data basis for change allocation procedure

-
- **HILDA+ period 1960-2023:** land use/cover and transitions are based on
 - **reported (and extrapolated) FAO land use** (forest, cropland, pasture area) and population estimates
 FAO, 2025. FAOSTAT Land Use, last update: September 18, 2025, Food and Agriculture Organization of the United Nations (FAO), <https://www.fao.org/faostat/en/#data/RL> (accessed 15.10.25)
 FAO, 2024. FAOSTAT Annual population, last update: December 31, 2024, Food and Agriculture Organization of the United Nations (FAO), <https://www.fao.org/faostat/en/#data/OA> (accessed 15.10.25)
 - **remote sensing-based maps of class area fractions** (harmonisation of multiple EO-based land cover products, see table below)
 - data-derived (from ESA CCI LC, AAFC, Australia DLCD, CORINE, LULC India, MoFor Indonesia, NLCD USA), country-specific **mean gross land use transition matrices**
 - **Base map 2020:** built from ESA World Cover (10m) and additional Global Pasture Watch livestock densities for 2020, and calibrated to FAO forest, cropland and pasture data from 2020, used as starting point for annual change allocation

Land use/cover classes and their definitions

- **Urban**: Artificial surfaces, urban and built-up areas, including urban parks and sports areas, green spaces, industrial, deposits, extractions sites (mining etc.)
- **Annual crops**: Crops that complete their life cycle within one year/growing season (technically all cropland which was not classified as tree crops or agroforestry).
- **Tree crops**: Crops produced by trees, including the following FAO crop categories:
Almonds, with shell; Apples; Apricots; Areca nuts; Apricots; Avocados; Cashew nuts with shell; Cashewapple; Cherries; Cherries, sour; Chestnut; Coconuts; Cocoa, beans; Coffee, green; Dates; Figs; Grapefruit (inc. pomelos); Grapes; Gums, natural; Hazelnuts, with shell; Jojoba seed; Kapok fibre; Kapok fruit; Kapokseed in shell; Karite nuts (sheanuts); Kiwi fruit; Kola nuts; Lemons and limes; Mangoes, mangosteens, guavas; Oil palm fruit; Oil, coconut (copra); Oil, olive, virgin; Oil, palm; Oil, palm kernel; Olives; Oranges; Peaches and nectarines; Pears; Pepper (piper spp.); Persimmons; Pistachios; Quinces; Rubber, natural; Tangerines, mandarins, clementines, satsumas; Tung nuts; Vanilla; Walnuts, with shell.
- **Agroforestry**: Crops grown among trees (mixture of cropland and tree cover)
- **Pasture/rangeland**: Managed herbaceous plants (cover $\geq 10\%$) including managed grasslands (e.g. prairies, steppes, savannah, mosaics with tree/shrubs): grasslands or meadows used for e.g. livestock grazing or hay production with different intensities
- **Forest**: Trees with $> 5\text{m}$ height (cover $\geq 10\%$) including forest plantation, trees on seasonally or permanently flooded areas, including mangroves
- **Unmanaged grass/shrubland**: Natural herbaceous plants (cover $\geq 10\%$) including grasslands (e.g. prairies, steppes, savannah, mosaics with tree/shrubs) or natural shrub cover ($\geq 10\%$), including permanently or regularly flooded areas (wetlands), (herbaceous) wetlands
- **Sparse/no vegetation**: Bare areas, sparse vegetation (2-10 %), snow and ice, rocks, sand, mudflats

Spatial datasets used for cropland mapping in HILDA+ version 3.0

Dataset	Variables used in this study	Spatial coverage/ resolution	Reference time	References
SDPT 1.0	Tree crops	82 countries/ scale varies by country	2015	(Harris et al., 2019)
Lesiv et al. Forest management	- Oil palm plantations - Agroforestry	Global/ 100m	2015	(Lesiv et al., 2022)
Descals et al. Oil palm map	- Industrial oil palm plantations - Smallholder oil palm plantations	Global/ 10m	2019	(Descals et al., 2021)
SPAM 2010	Tree crops: banana, cocoa, coconut, coffee, oil palm, plantain, tropical and temperate fruit	Global/ 5 arc min (~10km)	2010	(Yu et al., 2020)
Agroforestry maps	Tree cover on agricultural land	Global/30 arc sec (~1km)	2000, 2010	(Zomer et al., 2016)

Cropland-related land use categories tree crops, agroforestry and annual crops were derived from a combination of remote sensing-based spatial datasets and crop production statistics (tree crops defined as above) from the FAO (FAO, 2022). Fractional information from the spatial data was used for a potential reallocation of HILDA+ version 1.0 land use categories cropland, pasture/rangeland, grass/shrubland or forests (not matching ESA CCI forest categories).

Descals, A., Wich, S., Meijaard, E., Gaveau, D.L.A., Peedell, S., Szantoi, Z., 2021. High-resolution global map of smallholder and industrial closed-canopy oil palm plantations. *Earth Syst. Sci. Data* 13, 1211–1231. <https://doi.org/10.5194/essd-13-1211-2021>

FAO, 2025. FAOSTAT Production, crops and livestock products [Dataset], last update: June 11, 2025, Food and Agriculture Organization of the United Nations (FAO), <http://www.fao.org/faostat/en/#data/QCL> (accessed 15.10.25).

Harris, N., Goldman, E.D., Gibbes, S., 2019. "Spatial Database of Planted Trees Version 1.0." Technical Note. Washington, DC: World Resources Institute. Available online at: <https://www.wri.org/publication/spatial-database-planted-trees>. [WWW Document].

Lesiv, M., Schepaschenko, D., Buchhorn, M., See, L., Dürauer, M., Georgieva, I., Jung, M., Hofhansl, F., Schulze, K., Bilous, A., Blyshchyk, V., Mukhortova, L., Brenes, C.L.M., Krivobokov, L., Ntie, S., Tsogt, K., Pietsch, S.A., Tikhonova, E., Kim, M., Di Fulvio, F., Su, Y.-F., Zadorozhniuk, R., Sirbu, F.S., Panging, K., Bilous, S., Kovalevskii, S.B., Kraxner, F., Rabia, A.H., Vasylyshyn, R., Ahmed, R., Diachuk, P., Kovalevskiy, S.S., Bungnamei, K., Bordoloi, K., Churilov, A., Vasylyshyn, O., Sahariah, D., Tertyshnyi, A.P., Saikia, A., Malek, Ž., Singha, K., Feshchenko, R., Prestele, R., Akhtar, I. ul H., Sharma, K., Domashovets, G., Spawn-Lee, S.A., Blyshchyk, O., Slyva, O., Ilkiv, M., Melnyk, O., Sliusarchuk, V., Karpuk, A., Terentiev, A., Bilous, V., Blyshchyk, K., Bilous, M., Bogovyk, N., Blyshchyk, I., Bartalev, S., Yatskov, M., Smets, B., Visconti, P., McCallum, I., Obersteiner, M., Fritz, S., 2022. Global forest management data for 2015 at a 100 m resolution. *Sci. Data* 9, 199. <https://doi.org/10.1038/s41597-022-01332-3>

Yu, Q., You, L., Wood-Sichra, U., Ru, Y., Joglekar, A.K.B., Fritz, S., Xiong, W., Lu, M., Wu, W., Yang, P., 2020. A cultivated planet in 2010 – Part 2: The global gridded agricultural-production maps. *Earth Syst. Sci. Data* 12, 3545–3572. <https://doi.org/10.5194/essd-12-3545-2020>

Zomer, R.J., Neufeldt, H., Xu, J., Ahrends, A., Bossio, D., Trabucco, A., van Noordwijk, M., Wang, M., 2016. Global Tree Cover and Biomass Carbon on Agricultural Land: The contribution of agroforestry to global and national carbon budgets. *Sci. Rep.* 6, 29987. <https://doi.org/10.1038/srep29987>

Spatial land use/cover datasets used for HiLDA+ land use change (version 3.0) and their specifications (thematic, spatial and temporal coverage), **updated and new datasets displayed in bold**.

Dataset and reference	Content	Spatial coverage	Temporal coverage	Spatial resolution	Data type
Global datasets					
Copernicus LC100 https://land.copernicus.eu/global/products/lc	LCCS 22 classes	global	2015-2019	100 m	raster
ESA CCI Land Cover http://maps.elie.ucl.ac.be/CCI/viewer/download.php	LCCS 22 classes	global	1992-2019	300 m	raster
ESA WorldCover https://esa-worldcover.org/en/data-access	11 LULC classes	global	2020-2021	10 m	raster
Esri Land cover: Sentinel-2 10-Meter Land Use/Land Cover https://livingatlas.arcgis.com/landcover/	LCCs 9 classes	global	2017-2024	10 m	raster
GLAD UMD VCF https://glad.umd.edu/dataset/long-term-global-land-change	tree canopy, bare ground, short vegetation	global	1982-2016	0.05 deg	raster
GLC2000 http://forobs.jrc.ec.europa.eu/products/glc2000/glc2000.php	LCCS 22 classes	global	2000	1 km	raster
GLCNMO https://globalmaps.github.io/glcnmhtml	LCCS 22 classes	global	2003 2008, 2013	30 arc sec 15 arc sec	raster
Global Human Settlement Layer (GHSL) https://ghslsys.jrc.ec.europa.eu/datasets.php	built-up area (fractional)	global	1975, 1990, 2000, 2014	1 km	raster
Global Urban Footprint (GUF) https://www.dlr.de/eoc/en/desktopdefault.aspx/tabid-11725/20508_read-47944/	built-up area (fractional)	global	2011/12	2.8 arc sec	raster
GlobCover http://due.esrin.esa.int/page_globcover.php	LCCS 22 classes	global	2005/2006, 2009	300 m	raster
Global Pasture Watch 2024 https://zenodo.org/records/13890401 https://zenodo.org/records/14933660 https://zenodo.org/records/14933641 https://zenodo.org/records/14933653	grassland classes (cultivated, natural, open shrubland); cattle, sheep and goat density	global	2000-2024; 2000-2022	30m	raster
Globeland30 http://www.globeland30.org	10 LULC classes	global	2000, 2010	30 m	raster
Gridded Livestock World v3 (GLW) http://www.fao.org/livestock-systems/en/	density of ruminants	global	2010	5 arc min	raster

Dataset and reference	Content	Spatial coverage	Temporal coverage	Spatial resolution	Data type
Hansen Global Forest Change https://storage.googleapis.com/earthenginepartners-hansen/GFC-2024-v1.12/download.html	tree cover (fractional) loss year/gain	global	2000-2024 (loss) 2000-2012 (gain)	30 m	raster
HYDE 3.3 (preliminary version, requested from authors 2022) https://www.pbl.nl/en/image/links/hyde	cropland, grazing land	global	1900-2019	5 arc min	raster
MODIS MCD12Q1 https://lpdaac.usgs.gov/products/mcd12q1v006/	IGBP 17 classes	global	2001-2024 (yearly)	500 m	raster
Ramankutty cropland (update) http://www.ramankuttylab.com/data.html	cropland	global	1900-2011	5 arc min	raster
Regional datasets					
AAFC Land Use Canada https://open.canada.ca/data/en/dataset/18e3ef1a-497c-40c6-8326-aac1a34a0dec	15 LULC classes	Canada	1990, 2000, 2010	30 m	raster
Australia DLCD V2.1 https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/83868	LCCS 22 classes	Australia	2002-2014	500 m	raster
CORINE https://land.copernicus.eu/pan-european/corine-land-cover/view	44 LULC classes with change layers	Europe (changing extent)	1990, 2000, 2006, 2012, 2018	100 m	raster
LULC classification of India https://daac.ornl.gov/cgi-bin/dsvviewer.pl?ds_id=1336	11 LULC classes (IGBP scheme)	India	1985, 1995, 2005	100 m	raster
Mapbiomas Brazil https://brasil.mapbiomas.org/colecoes-mapbiomas/	6+21+9 LULC classes	Brazil	1985-2024	30 m	raster
MoEF Indonesia http://webgis.dephut.go.id:8080/kemenuhut/index.php/en/feature/download	22 LULC classes	Indonesia	2000, 2003, 2006, 2009	300 m	raster
NLCD Land Cover (CONUS) https://www.mrlc.gov/data?f%5B0%5D=category%3Aland%20cover	16 LULC classes	U.S.	2001, 2006, 2011	30 m	raster
RCMRD Land Cover http://opendata.rcmr.org/search?tags=land%20cover	6 LULC classes with country-specific sub-classes	Botswana, Ethiopia, Lesotho, Malawi, Namibia, Rwanda, Tanzania, Uganda, Zambia	different years between 2000 and 2014	30 m	raster
South Africa Land Cover https://gee-community-catalog.org/projects/sa_nlc/	35/72 LULC classes	South Africa	1990, 2013-14	30 m	raster

* LULC = land use/land cover, LCCS = Land Cover Classification System, IGBP = International Geosphere-Biosphere Programme