CAMBIOSCOP
Carbon management towards low fossil carbon use

NEGEM

MAKE OUR PLANET GREAT AGAIN

Synergy of CAMBIOSCOP with the H2020 NEGEM project (Quantifying and deploying responsible negative emissions)

Pushing the biopump concept beyond borders for inducing negative emissions

(June 2020-March 2022)

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Negative emission technologies and practices (NETP): the concept

Negative emission: CO_2 removal to supplement emission reduction and permanently store carbon
(e.g. via BECCS, DACCS, afforestation/reforestation, soil C sequestration, biochar, etc)

Soil C sequestration potentials (Global and EU view)

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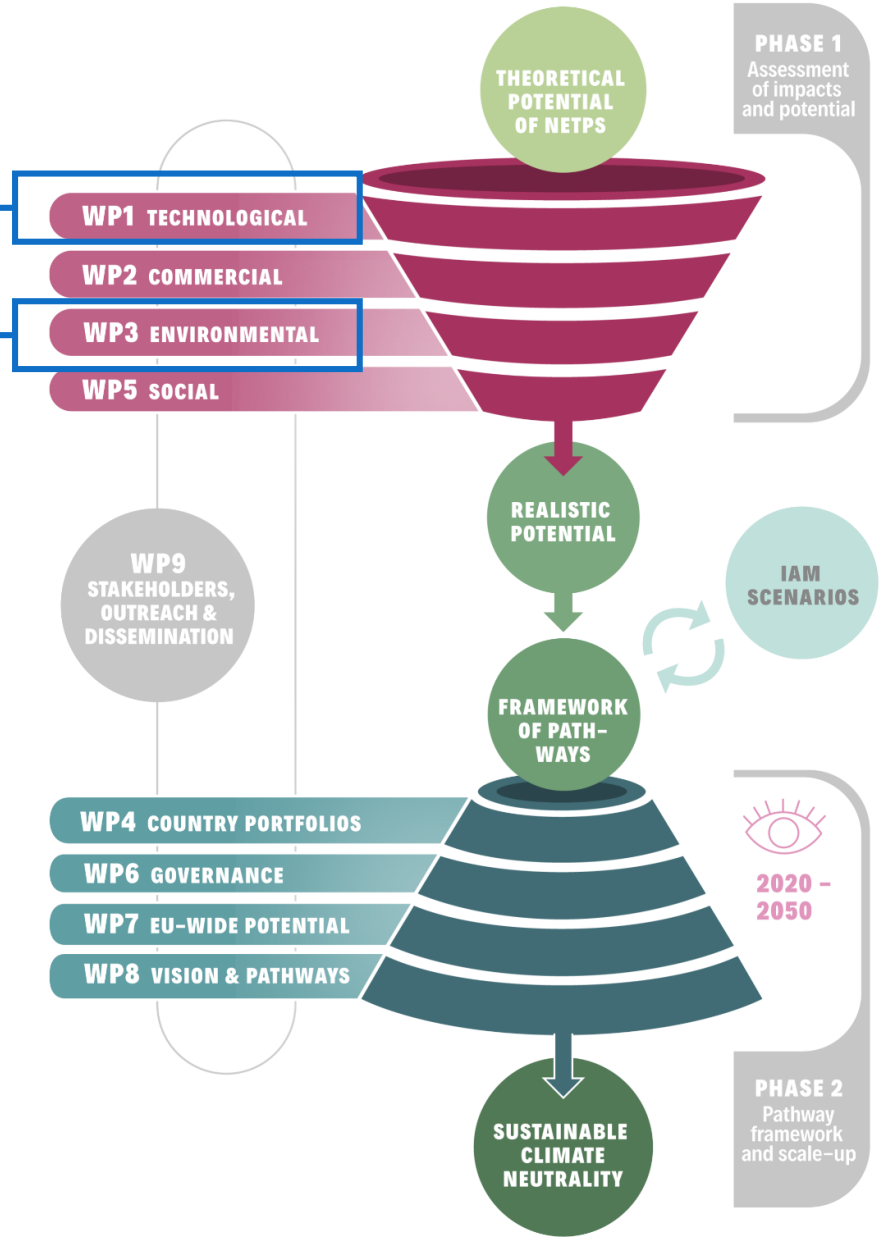


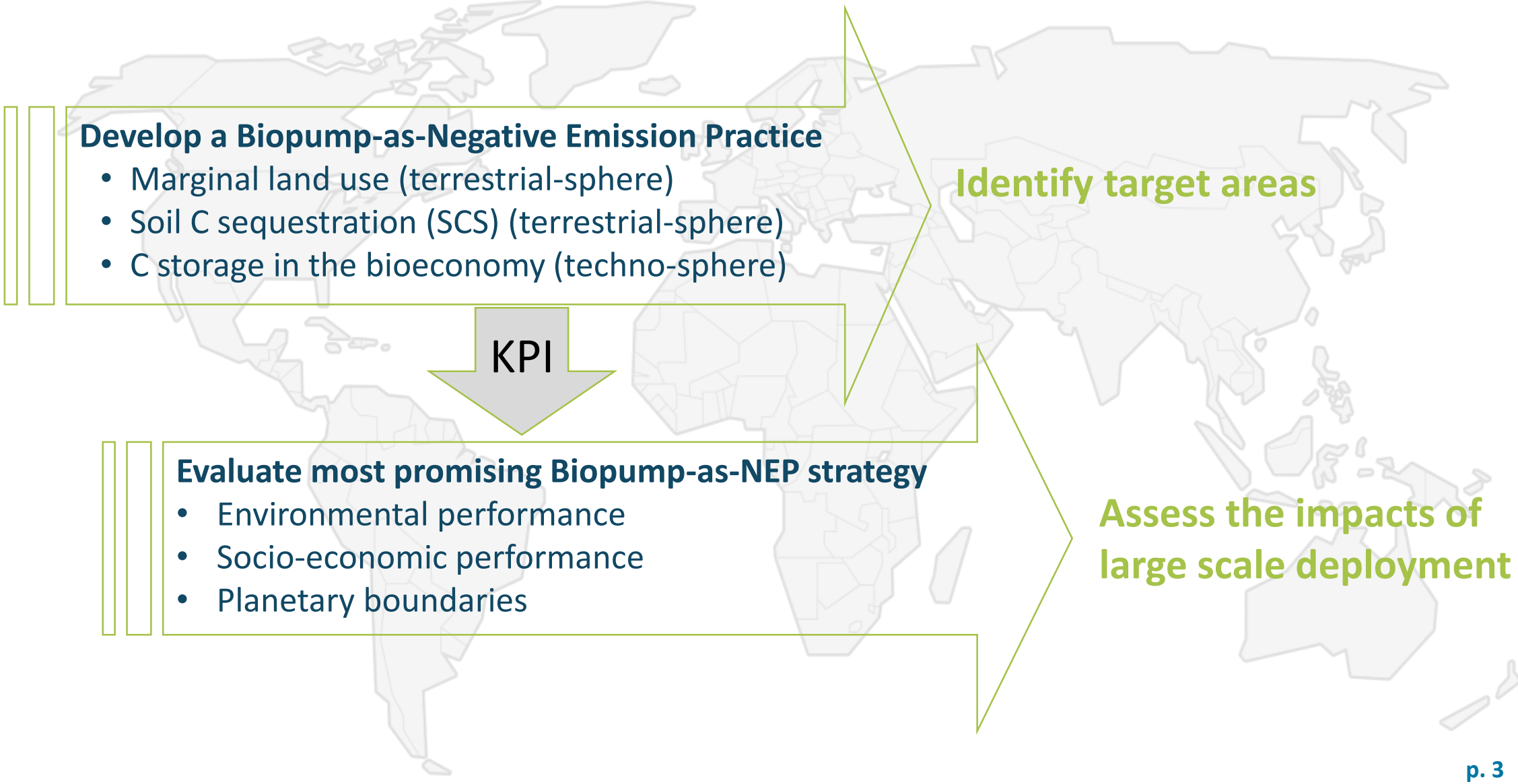
PHASE 1

Identify promising NETPs having significant real-world potential

PHASE 2

Create scalable NETP-pathways that contribute to climate neutrality and support Paris Agreement targets and in the context of SDGs.

Our overall working package objectives across scales



What is the biopump concept?

Cultivation

high soil C sequestration potential

+

can be grown in marginal land

C flow

Grasses

SRC

Oilseed

Orchard

Fibre

Bioeconomy

can be used as renewable feedstock

+

long-term C storage in bio-based products

Lignocellulose Starch Sugar Oil

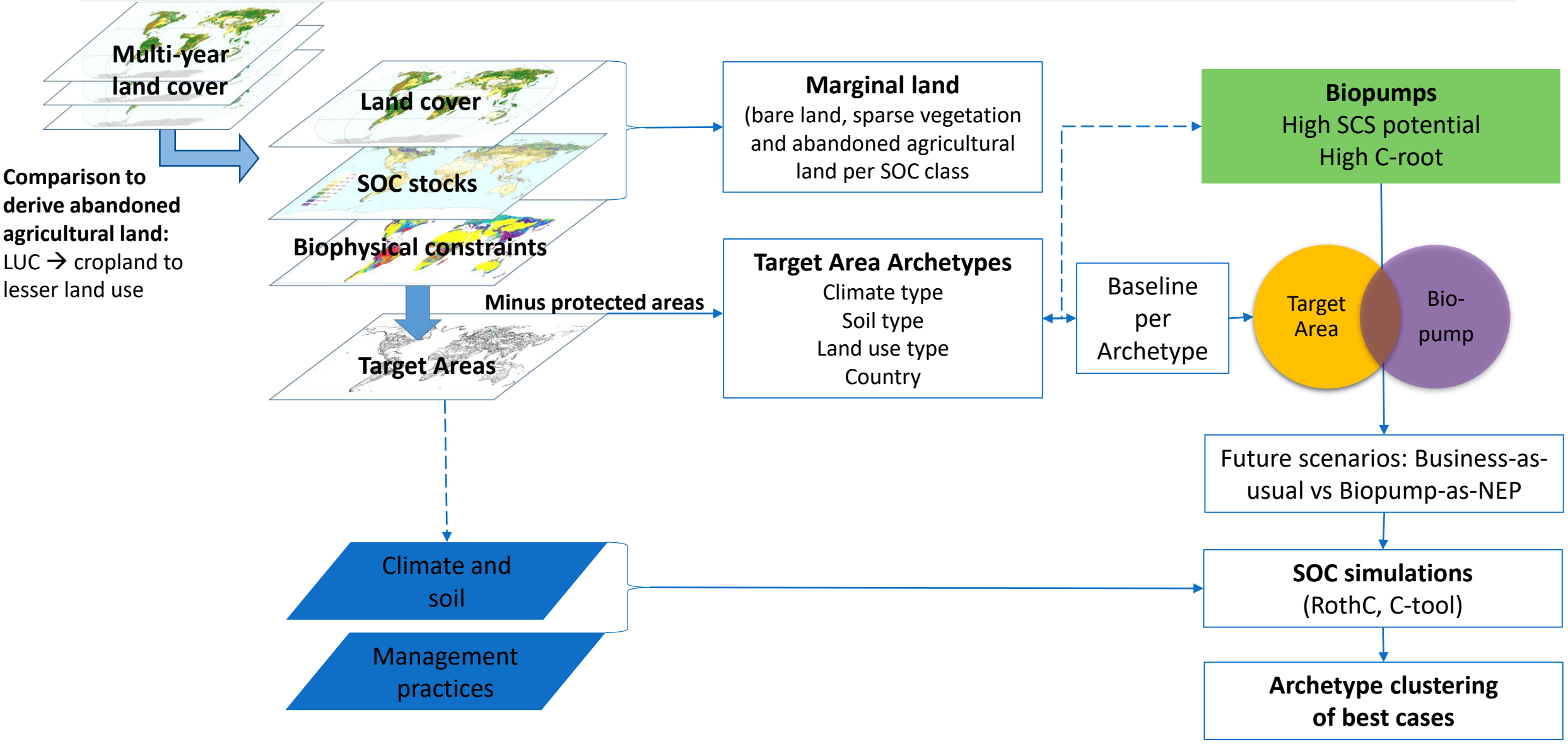
Textile / Building & Construction / Furniture
Automotive / Cellulose & Paper / Chemicals / Speciality
Food / Feed / Biofuels

What is marginal land suitable for biopumps?

Marginal land is any identifiable land area, whether **originally agricultural or non-agricultural**, including those in peri-urban areas, which is **currently unused or underutilised** due to and aggregation of economic, environmental or social limitations and/or human-induced degradation, and/or soil problems (among other biophysical limitations), but which is potentially suitable for temporary or long-term use for **sustainable biomass production,** that would **increase C sequestration in the soil** and throughout the **bioeconomy.**

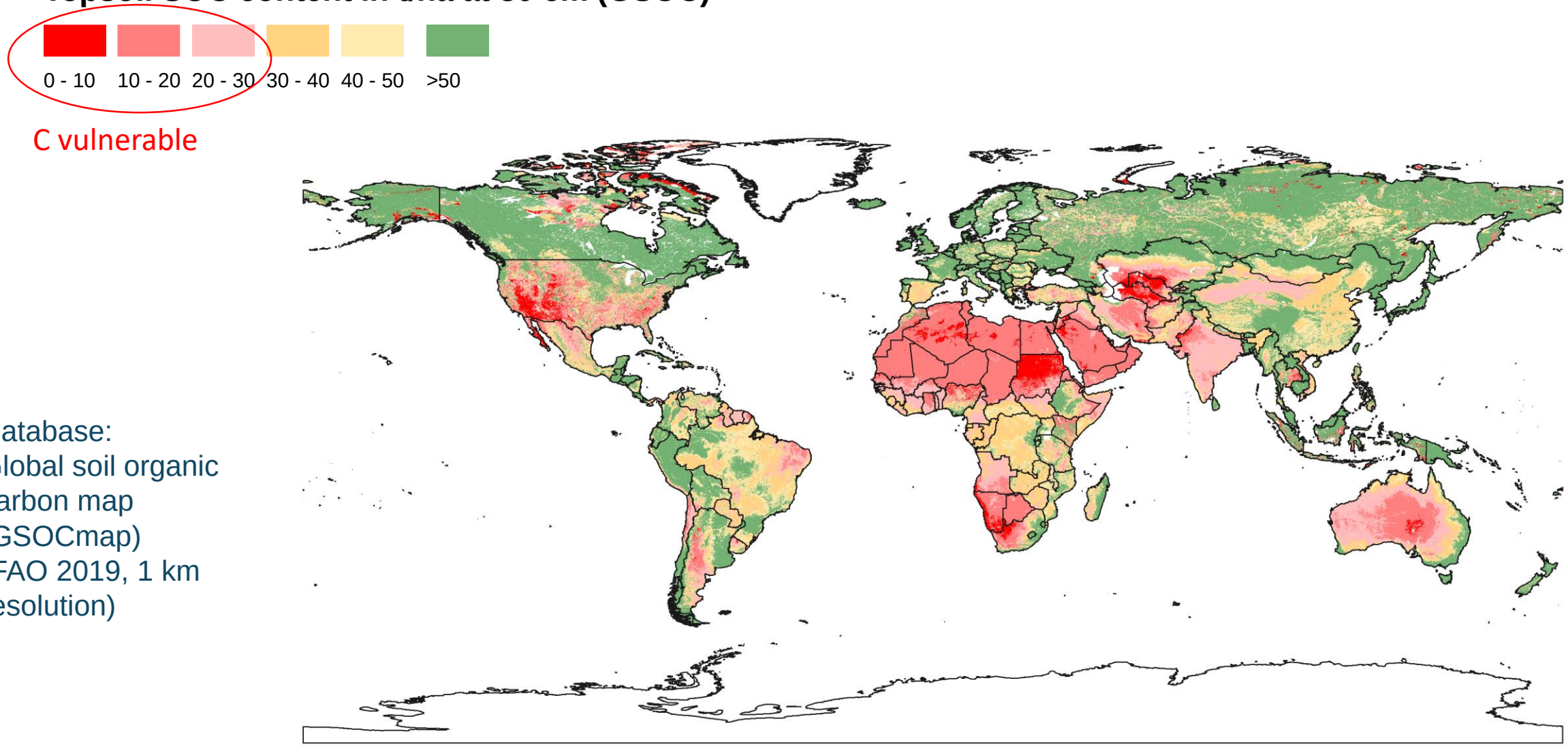
Sustainable production implies not negatively interfering with the current market (e.g. food security, disrupt value chains) or affect people's livelihoods".

Strategy for clustering target areas for biopumps



Identify global C vulnerable soils as C sink potentials

Topsoil SOC content in t/ha at 30 cm (GSOC)



C vulnerable

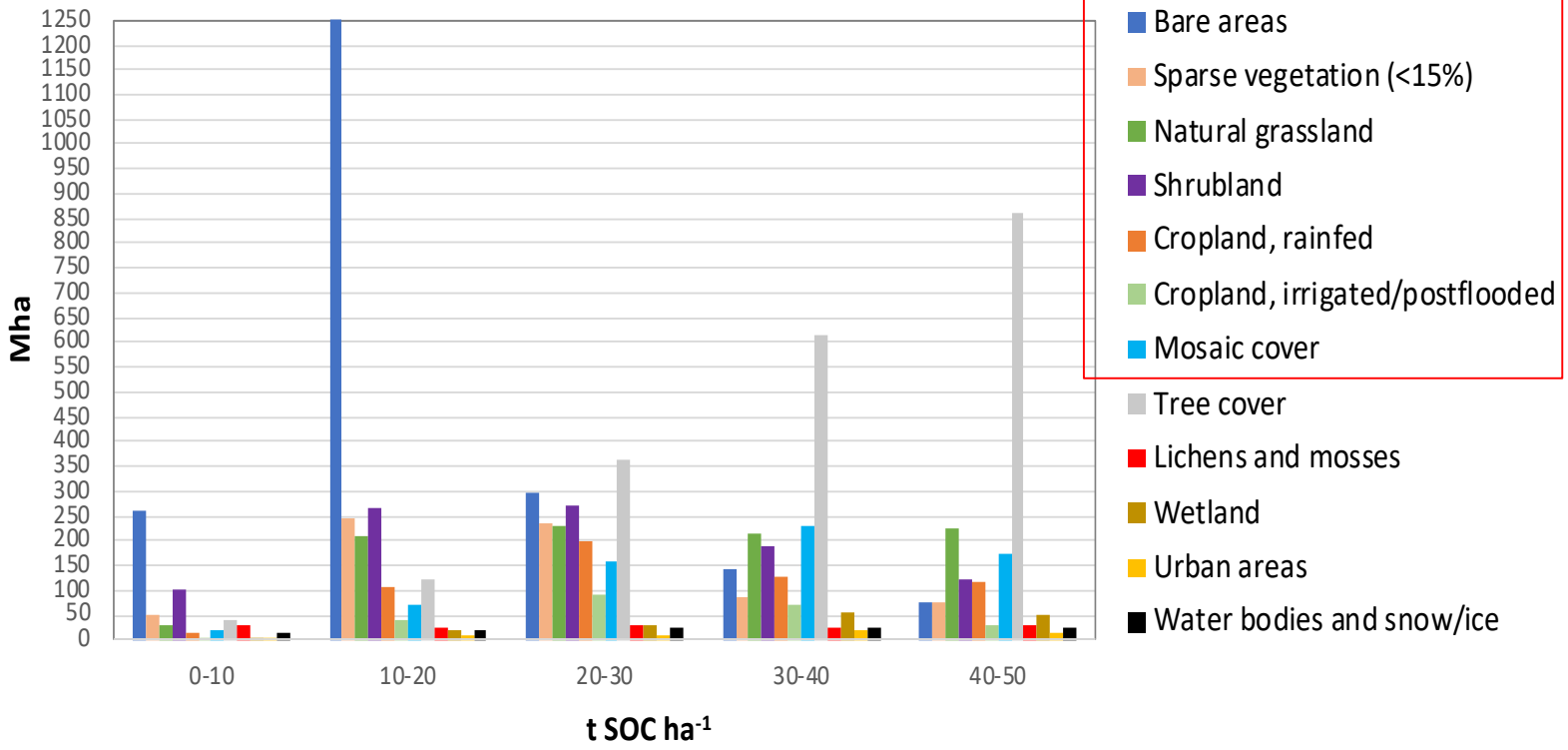
Database:
Global soil organic carbon map (GSOCmap)
(FAO 2019, 1 km resolution)

Identify marginal land

→ Used land cover (LC) of 2018, and compare with LC of 2010 to identify abandoned agricultural land
→ FAO Land Cover Classification System (LCCS3, 22 classes)

Abandoned agricultural land (CCI-LC 2010 vs 2018)
LUC from cropland to lesser land use

Database:
Global Climate Change Initiative Land Cover (CCI-LC) (ESA, 2018), 300 m resolution



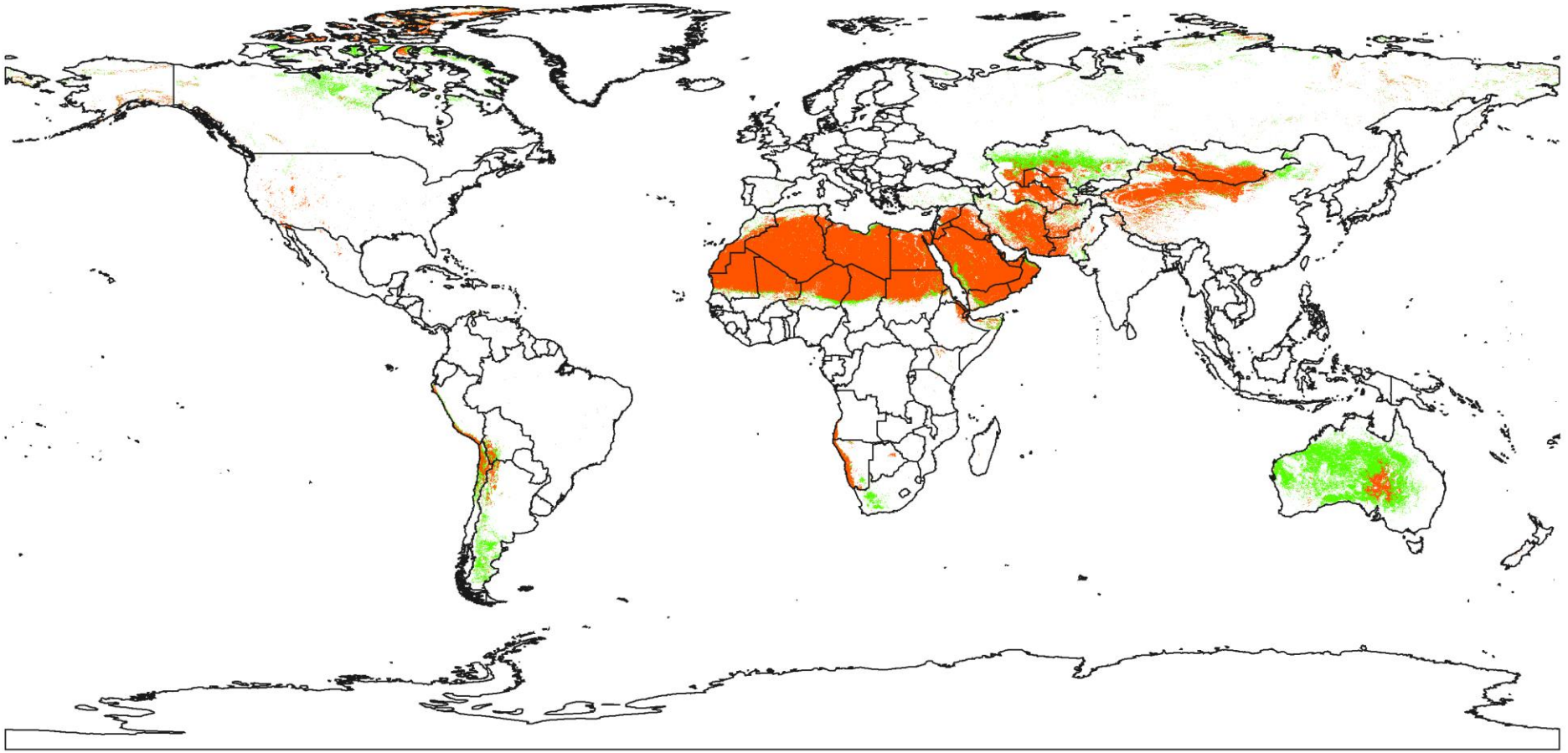
Land cover	Mha
Bare and sparse	2710
Grassland	908
Shrubland	949
Cropland	796
Mosaic	655
Tree cover	2002
Lichens and mosses	136
Wetland	153
Urban areas	54
Water bodies/snow/ice	102

Sparse vegetation and bare areas

Preliminary target areas (marginal land)

Sparse vegetation (tree, shrub, herbaceous cover) (<15%) → 685.1 Mha

Bare areas → 2 011 Mha



Database:
Global soil organic carbon map (GSOCmap) (FAO 2019, 1 km resolution)

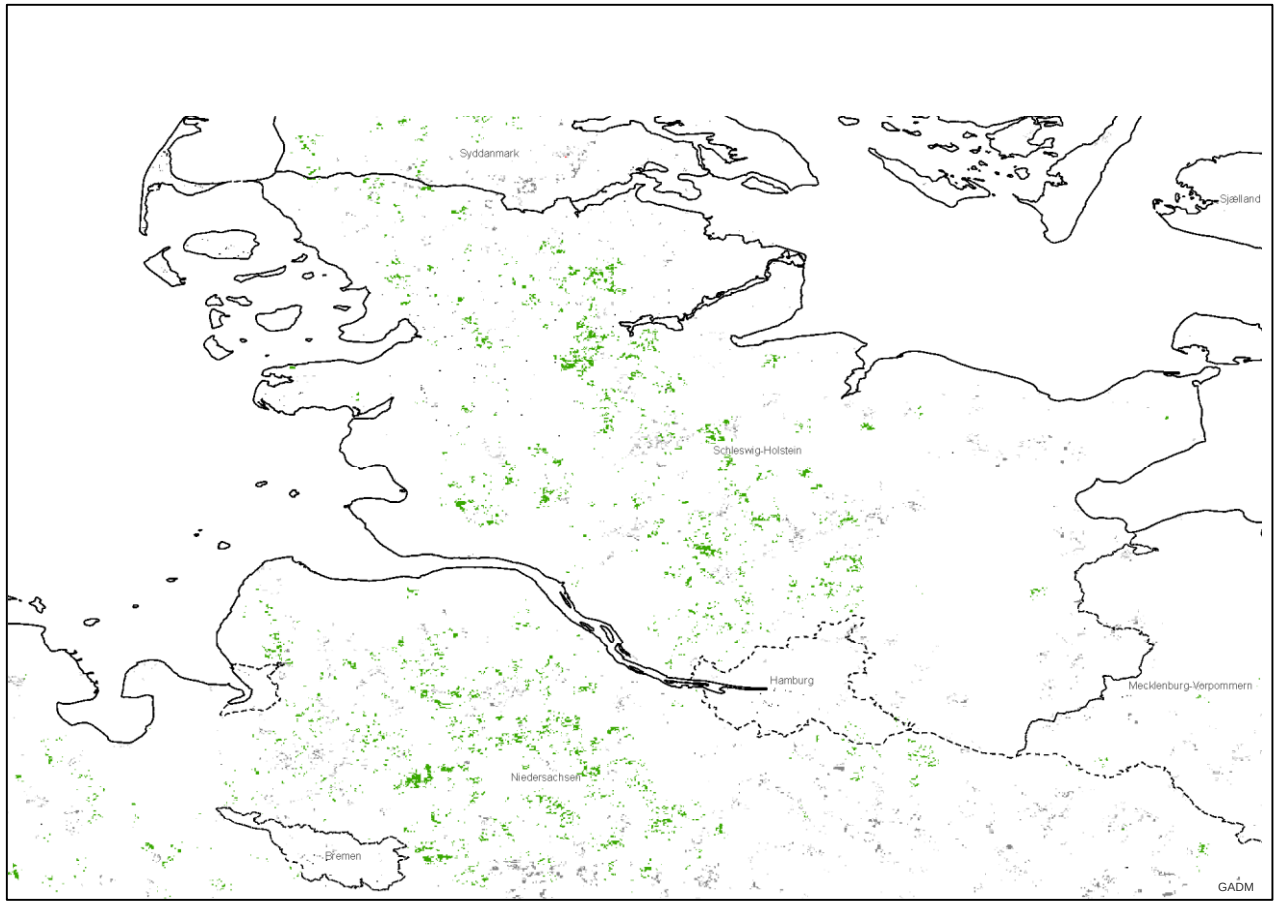
Identify abandoned agricultural land

Multi-year land cover (2010-2018) comparison to derive abandoned agricultural land

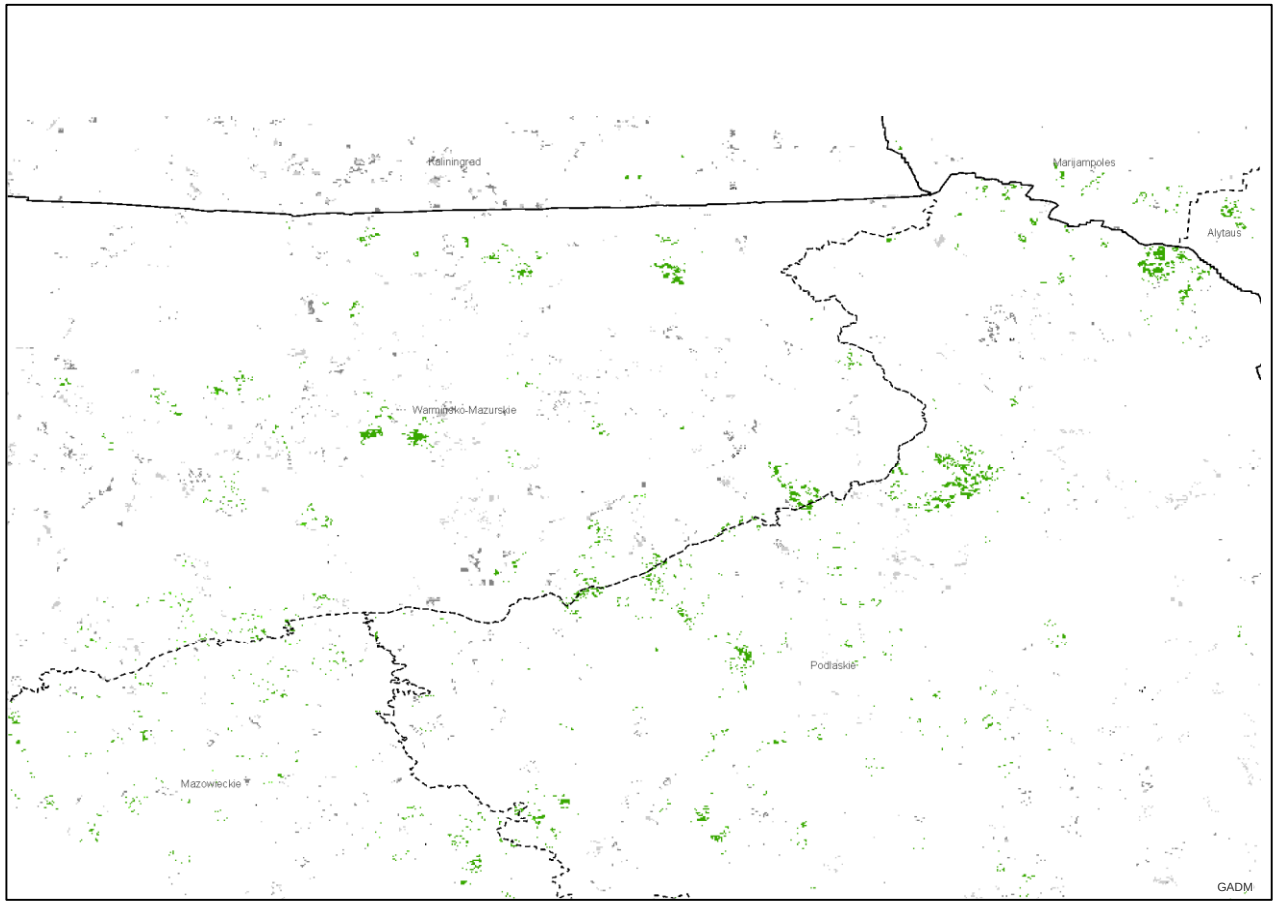
	pixels (300 · 300 m^2 = 9 ha)	Mha
No LUC	8 369 978 541	75 329.8
Non-cropland to other land use	24 235 664	218.1
Cropland to other land use (not abandonment)	2 834 677	25.5
Non-cropland to urban	613 580	5.5
Cropland to mosaic	133	0.001
Mosaic to semi-natural	434	0.004
Cropland to grassland	234 447	2.1
Cropland to sparse vegetation	36 734	0.3
Cropland to bare areas	15 140	0.1
Cropland to mosaic herbaceous	14 707	0.1
Cropland to shrubland	115 943	1.0
Abandonment		**3.76**

Abandoned agricultural land in 2010-2018 (LCCS3)

- No LUC
- Non-cropland to other land use
- Cropland to other land use (not abandonment)
- Non-cropland to urban
- Cropland to mosaic
- Mosaic to semi-natural
- Cropland to grassland
- Cropland to sparse vegetation
- Cropland to bare areas
- Cropland to mosaic herbaceous
- Cropland to shrubland



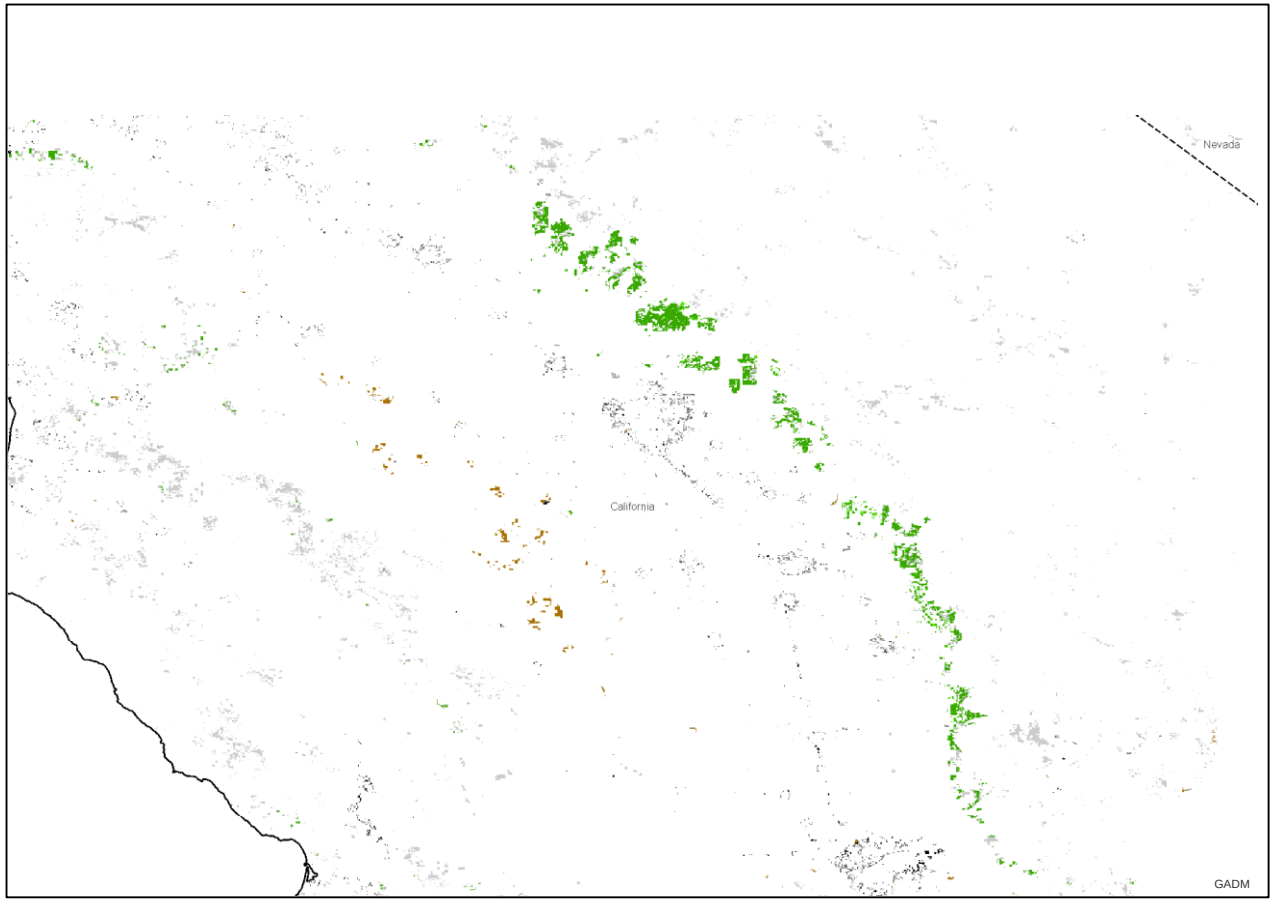
Germany-Denmark border



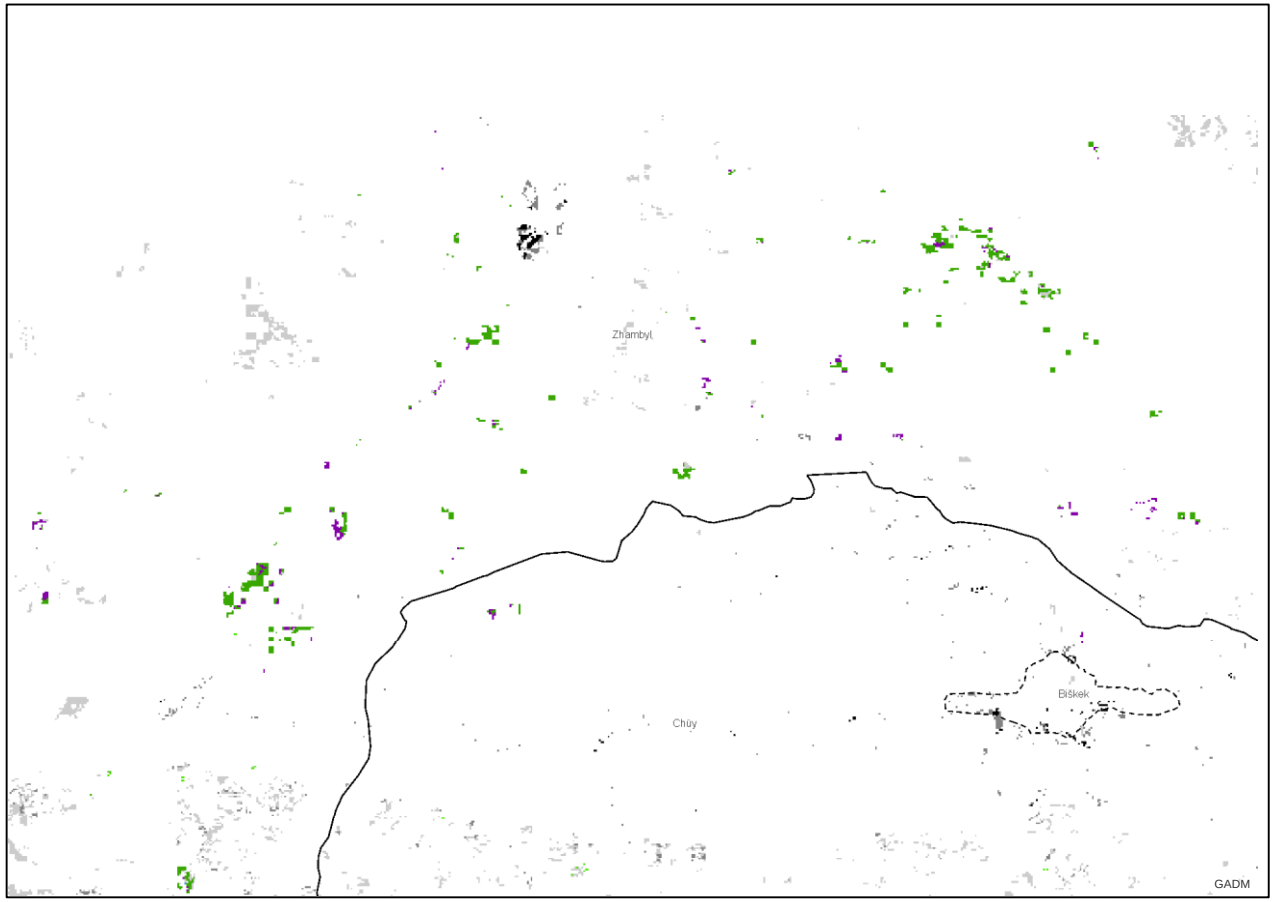
Poland-Kaliningrad border

Abandoned agricultural land in 2010-2018 (LCCS3)

- No LUC
- Non-cropland to other land use
- Cropland to other land use (not abandonment)
- Non-cropland to urban
- Cropland to mosaic
- Mosaic to semi-natural
- Cropland to grassland
- Cropland to sparse vegetation
- Cropland to bare areas
- Cropland to mosaic herbaceous
- Cropland to shrubland



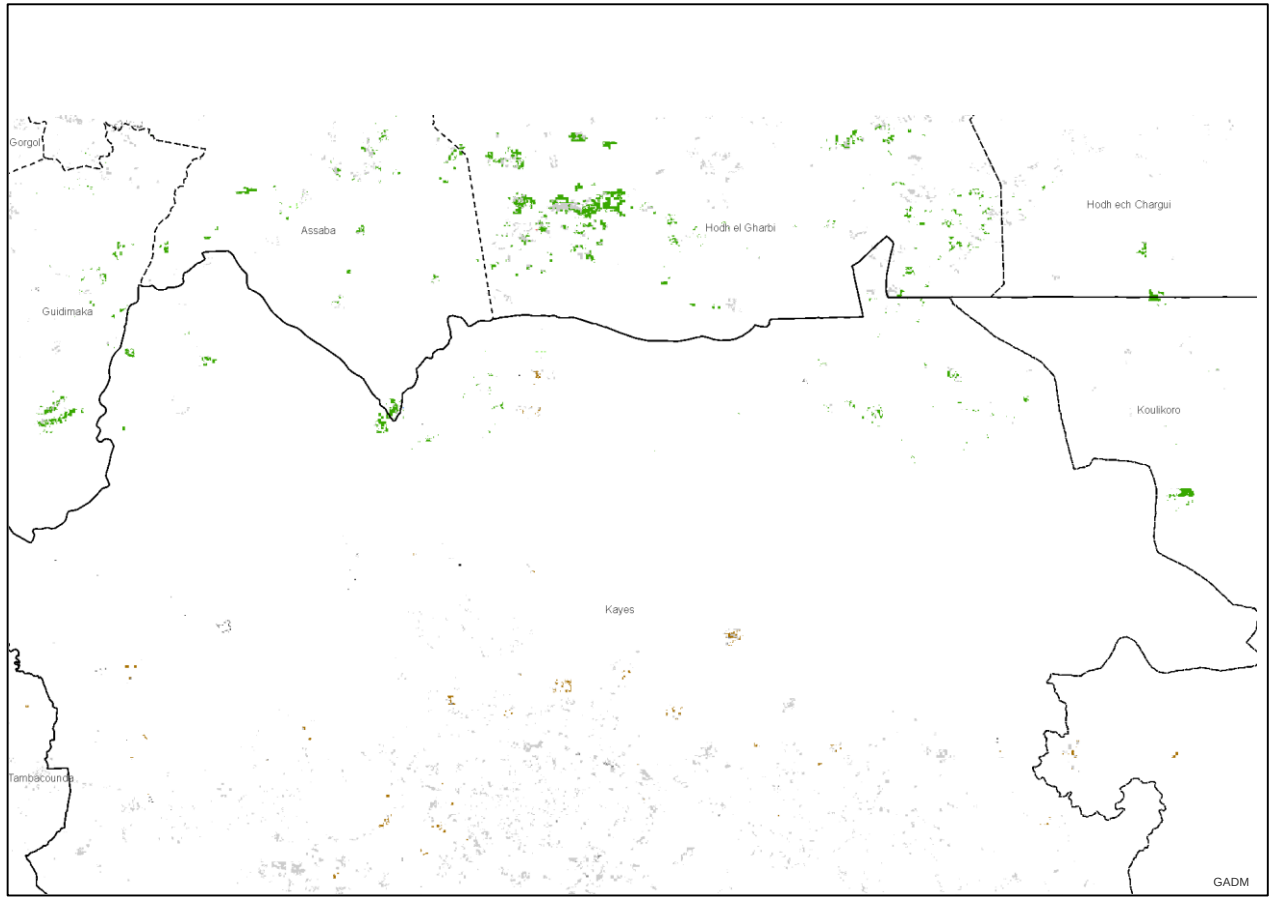
Centre California



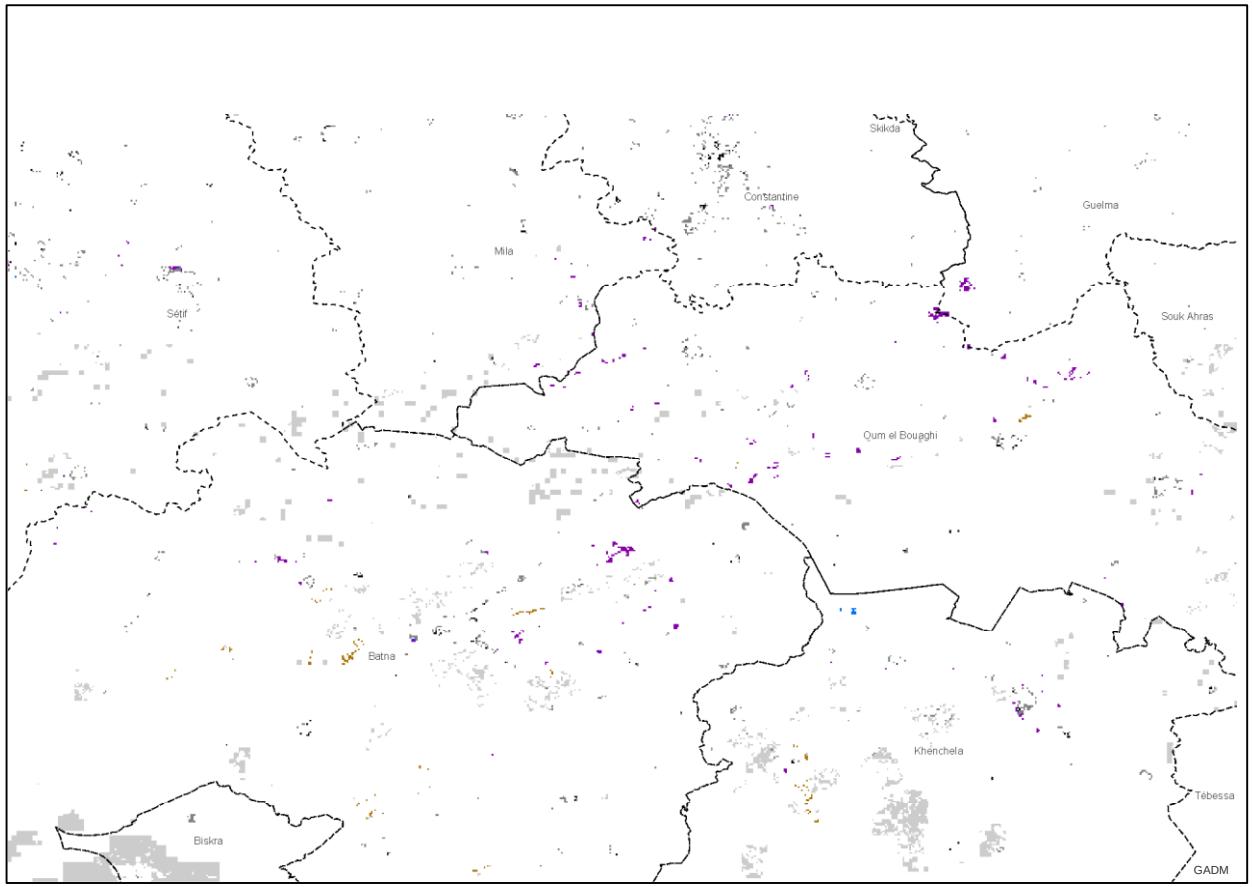
Kazakhstan-Kyrgyzstan border

Abandoned agricultural land in 2010-2018 (LCCS3)

- No LUC
- Non-cropland to other land use
- Cropland to other land use (not abandonment)
- Non-cropland to urban
- Cropland to mosaic
- Mosaic to semi-natural
- Cropland to grassland
- Cropland to sparse vegetation
- Cropland to bare areas
- Cropland to mosaic herbaceous
- Cropland to shrubland



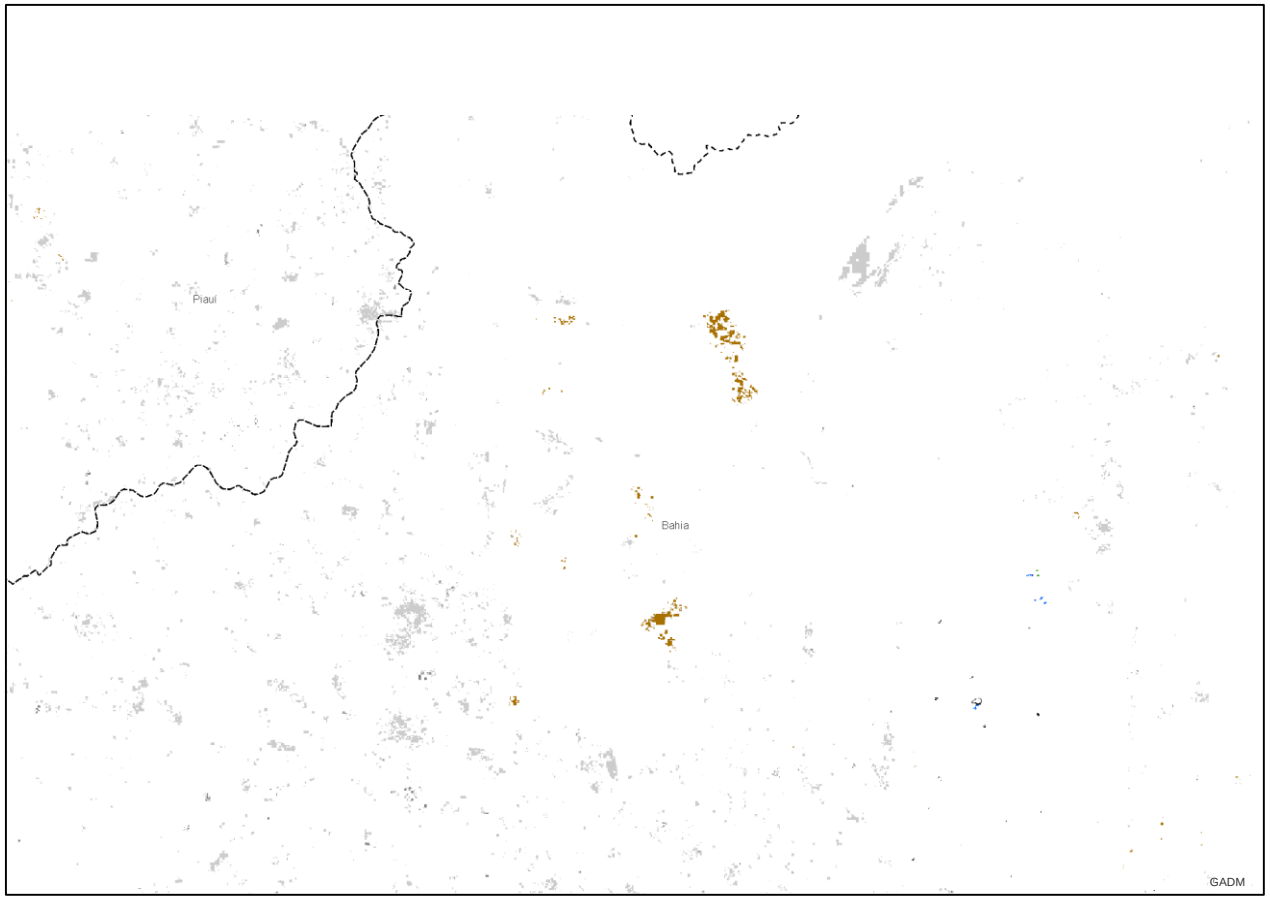
Mali-Mauritania border



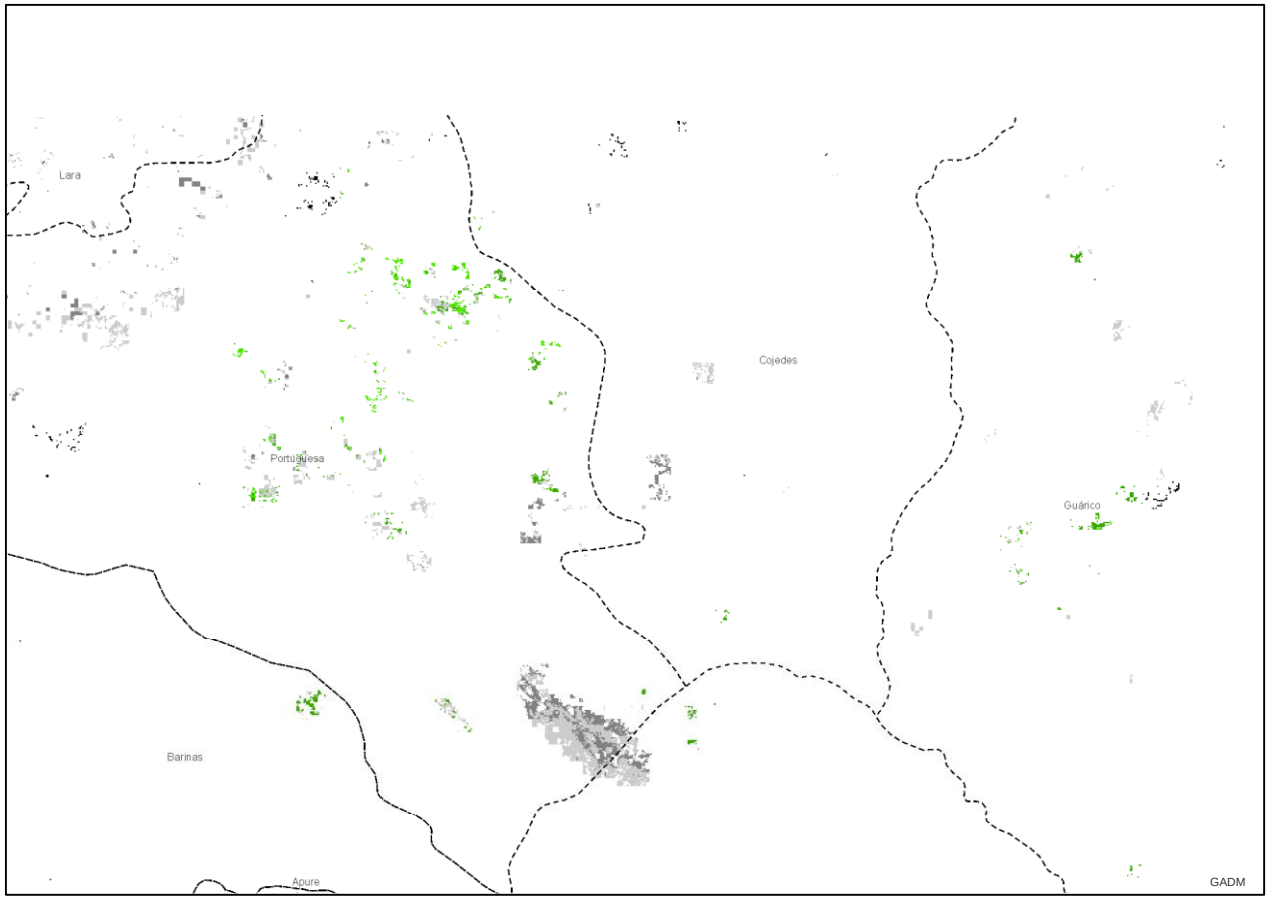
North-East Algeria

Abandoned agricultural land in 2010-2018 (LCCS3)

- No LUC
- Non-cropland to other land use
- Cropland to other land use (not abandonment)
- Non-cropland to urban
- Cropland to mosaic
- Mosaic to semi-natural
- Cropland to grassland
- Cropland to sparse vegetation
- Cropland to bare areas
- Cropland to mosaic herbaceous
- Cropland to shrubland



North of Bahia state, Brazil

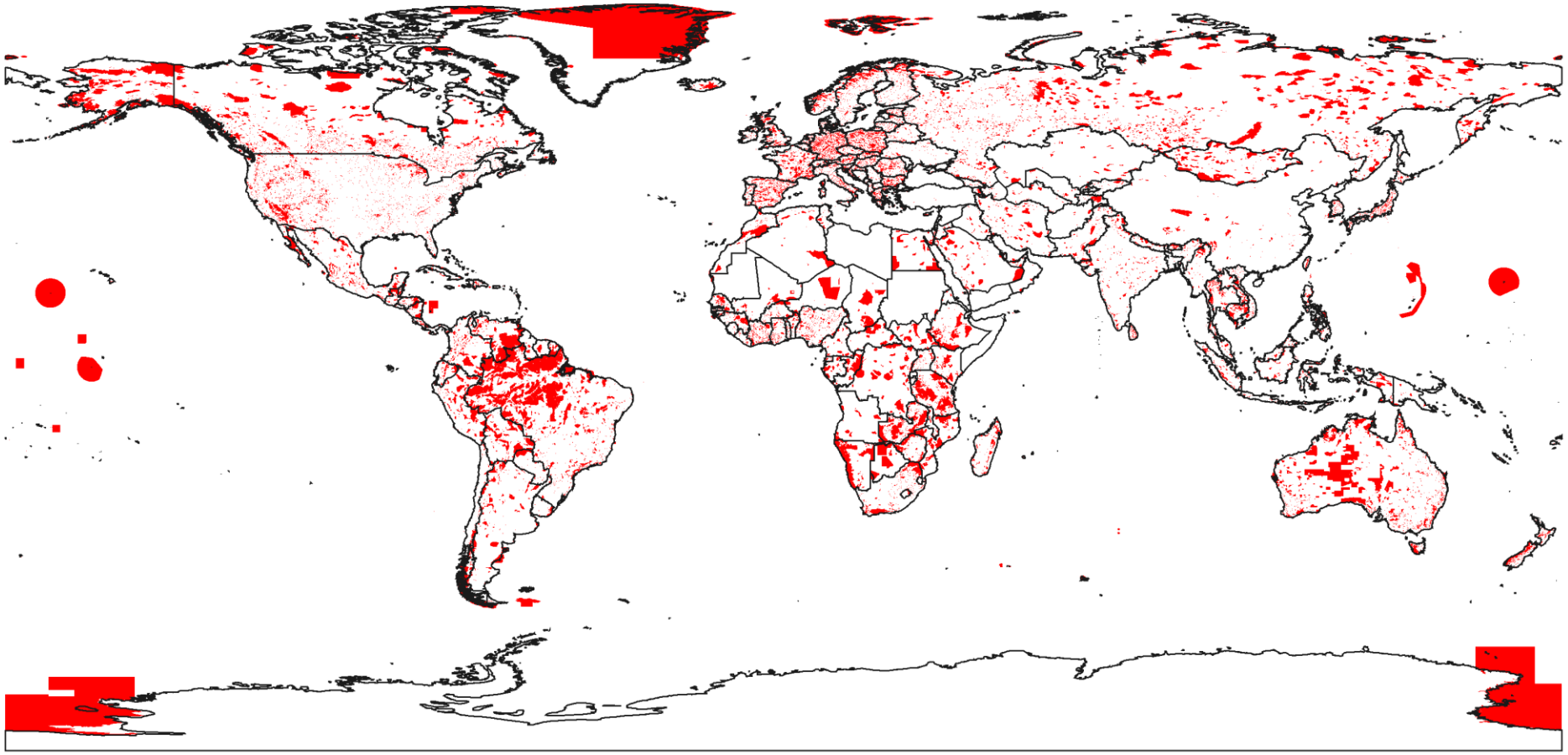


North-West Venezuela

Protected land areas

Protected land areas in 2016 (WDPA)

Protected areas



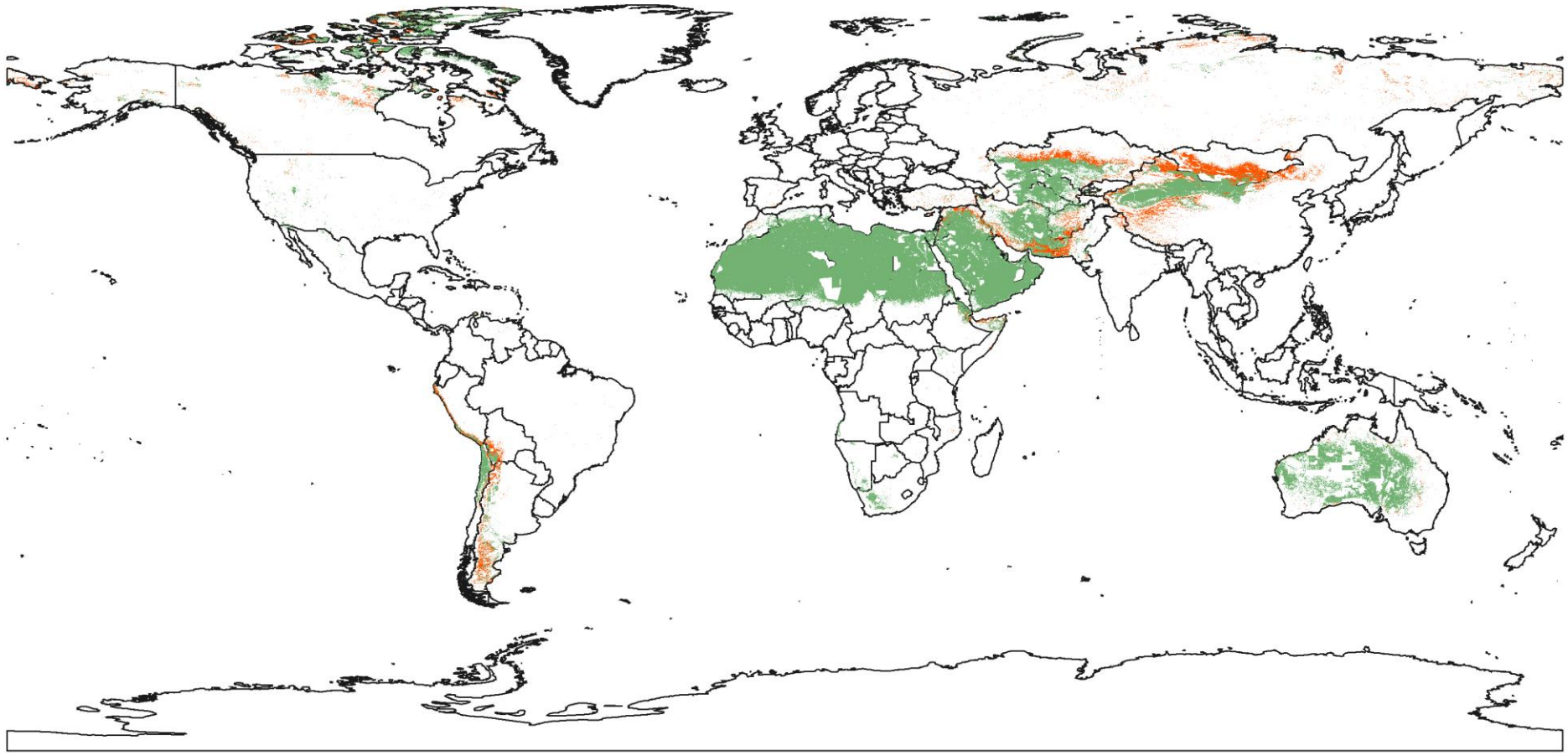
Database:
World database for protected areas (WDPA, 2016)

Preliminary result of marginal land

Bare + sparse + abandonned - protected

<30 tSOC/ha

<50 tSOC/ha



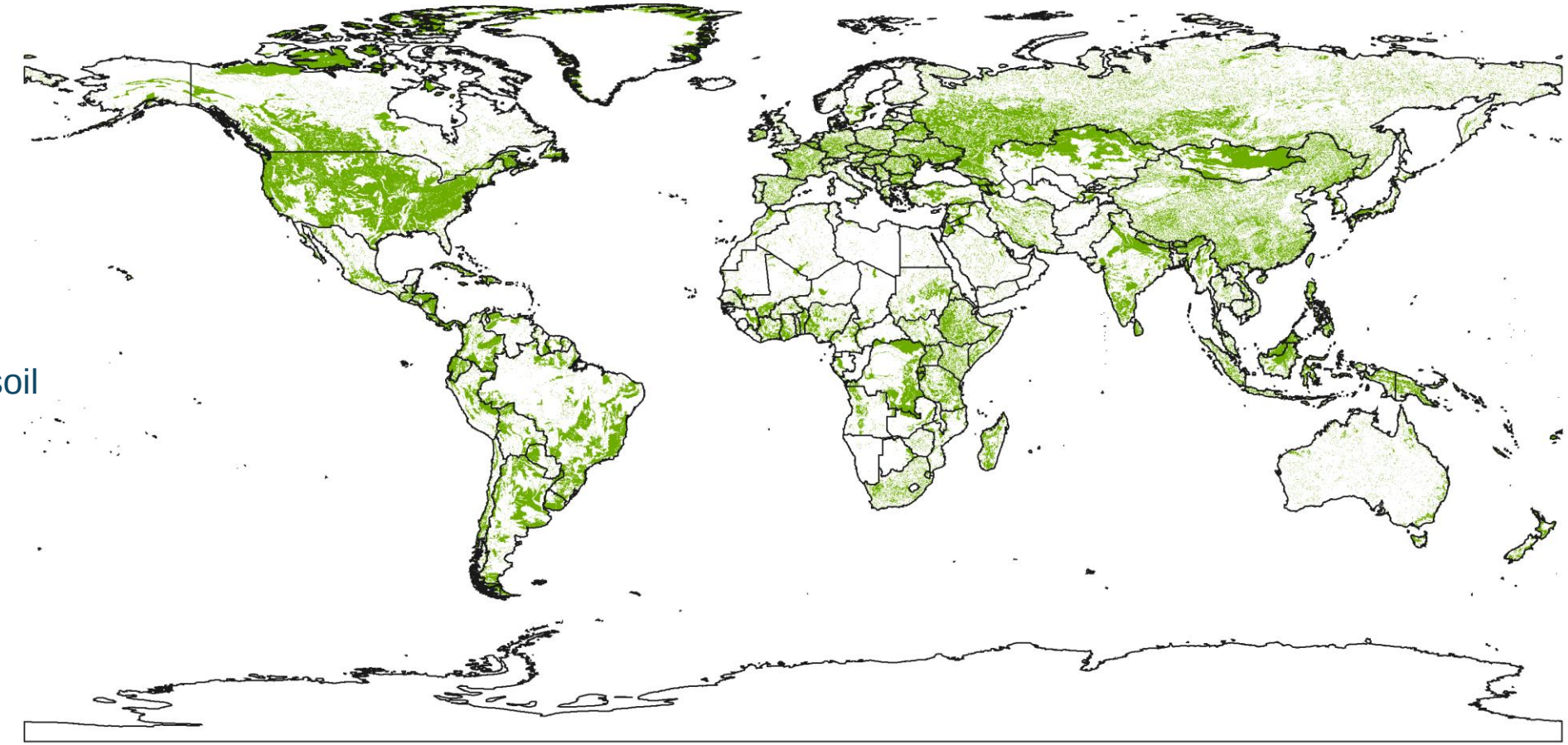
Constraints from soil characteristics

Biophysical soil constraints (HWSD)

Unsuitable

Suitable

Examples of soil criteria:
pH < 4.5 or pH > 8
>60% sand
Poor or excessive drainage
Salinity dS/m >15
Sodicity ESP ≥15%



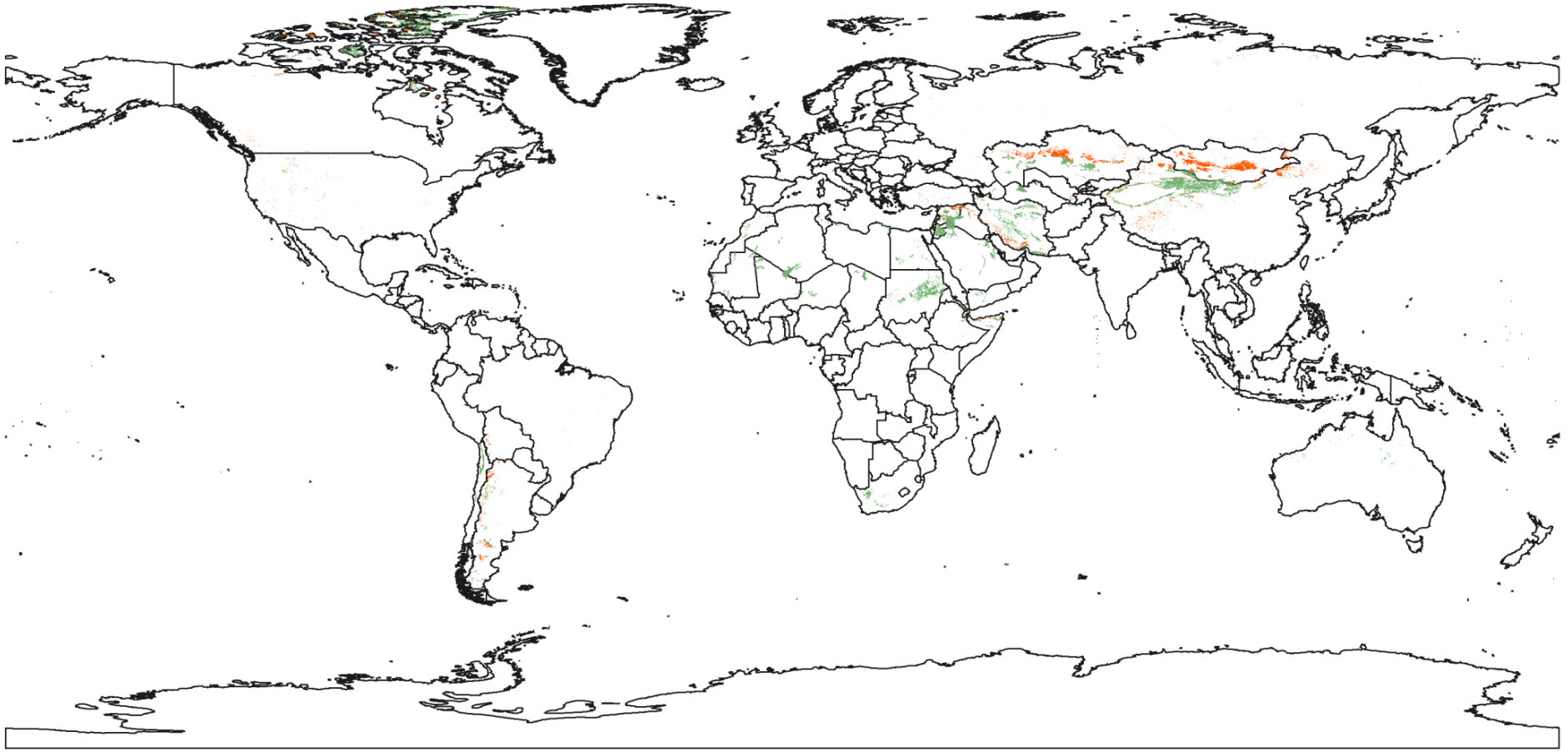
Database:
World harmonised soil database
(FAO/IISA, 2009)

Marginal land availability considering soil constraints of HWSD

Bare + sparse + abandonned - protected - biophysical soil constraints

<30 tSOC/ha

<50 tSOC/ha



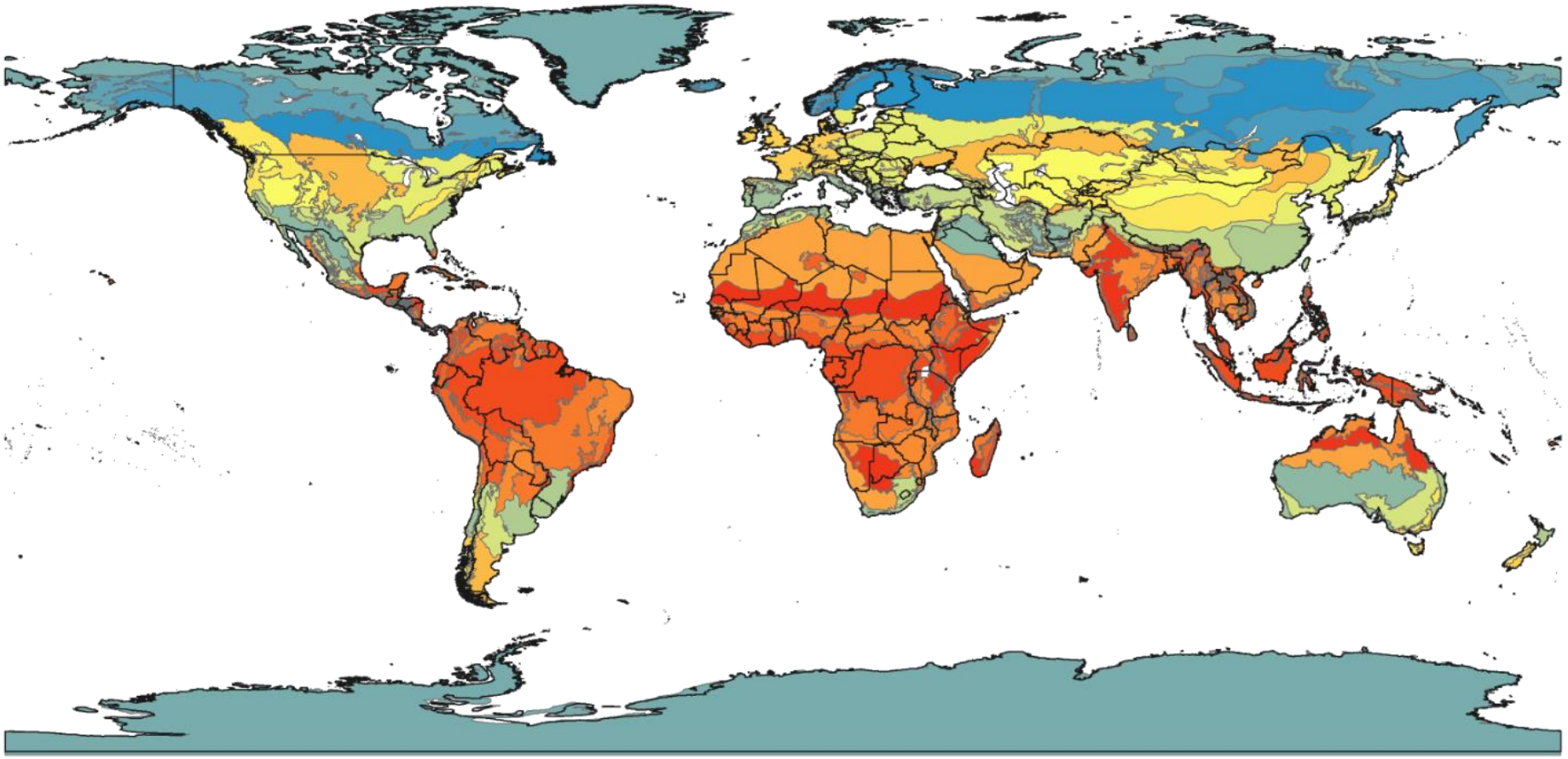
Consideration of climate zones for target area archetypes

FAO Global Ecological Zones

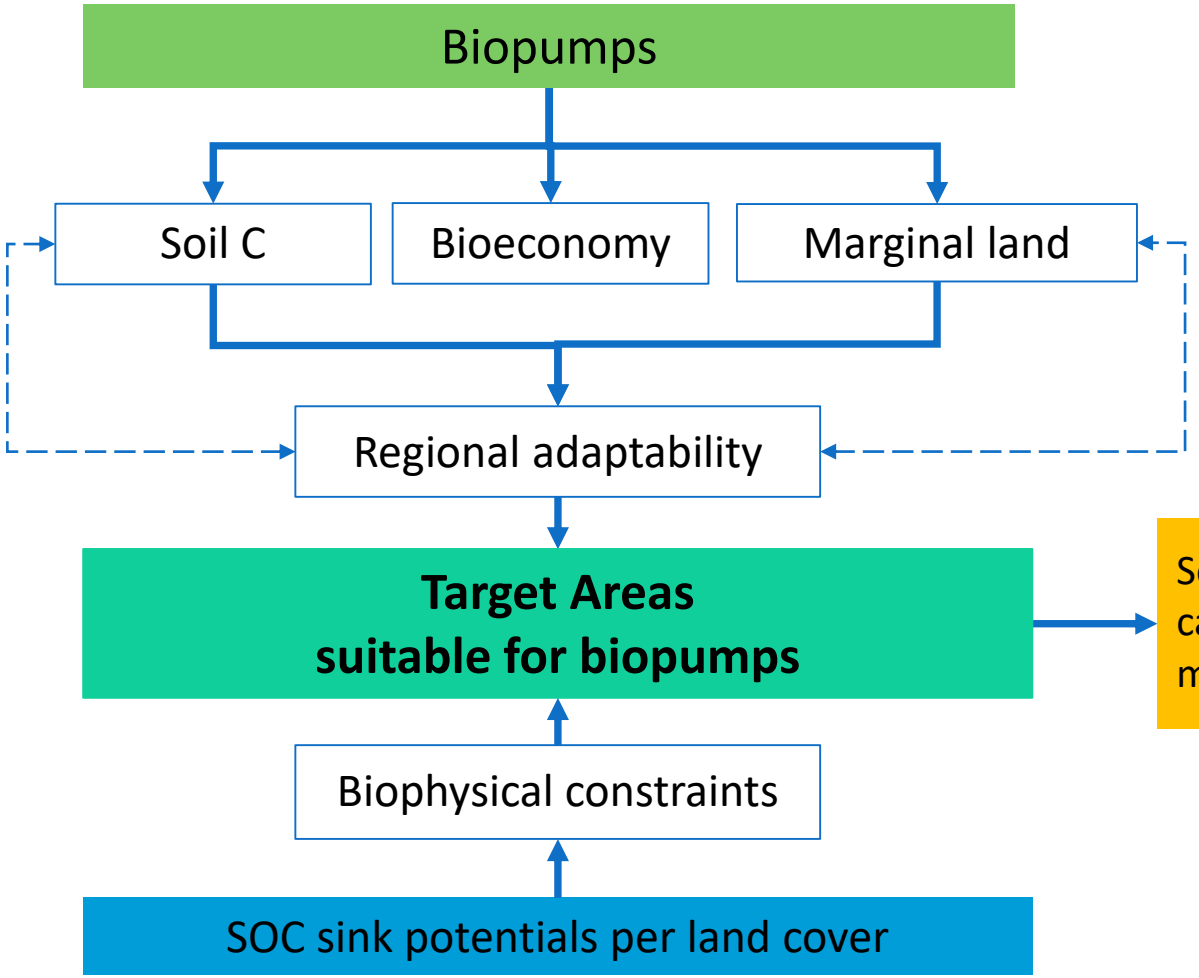
- Boreal coniferous forest
- Boreal mountain system
- Boreal tundra woodland
- Polar
- Subtropical desert
- Subtropical dry forest
- Subtropical humid forest
- Subtropical mountain system
- Subtropical steppe
- Temperate continental forest
- Temperate desert
- Temperate mountain system
- Temperate oceanic forest
- Temperate steppe
- Tropical desert
- Tropical dry forest
- Tropical moist forest
- Tropical mountain system
- Tropical rainforest
- Tropical shrubland

To be used to filter selected biopumps per GEZ and develop

Database:
Global Ecological Zones (GEZ)
(FAO, 2010)



Evaluation steps of biopumps suitable for target areas



Soil organic caron modelling

Phase 1: Semi-quantitative multi-criteria scoring and ranking (5 steps: re-scale, score, weight, normalise and rank)

Phase 2: Regional adaptability (e.g. under biophysical and agronomic constraints)

Biophysical criteria (Climate-Soil-Terrain) of marginal land mapping studies:
FAO (Eliasson 2007), JRC (Jones et al. 2012), H2020 MAGIC (Elbersen et al. 2020); APEC (Milbrandt and Ovenrend 2009)

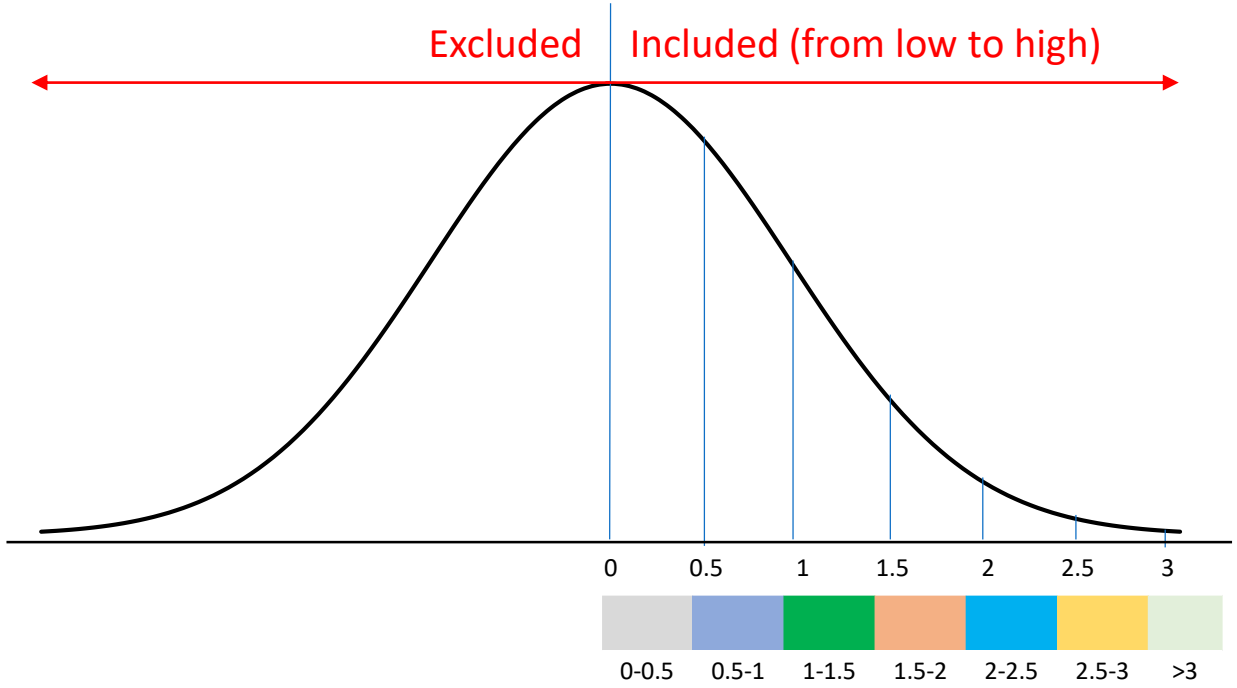
Phase 1: Multi-criteria analysis for the pre-selection

			Score	0	1	2	3	4
			Score meaning	very low	low	moderate	high	very high
			Re-Scaling	0 to 2	2 to 4	4 to 6	6 to 8	8 to 10
Criteria	**Criteria description**	**Weight**	Unit					
SOC changes	Top- (0-30 cm) + subsoil (x > 30 cm) **LUC attributes**. Transformation to perennials from previous annual crop, grassland, fallow, forest and short rotation coppice (excluded secondary or natural/primary forestry). **Climate zone attributes**: Tropical, Subtropical and Temperate	40%	t C ha^{-1} y^{-1}			MinMax Scalor [0;10]		
SOC stock potentials	Associated to a crop family from literature review	20%	n/a	Oilseed, vegetable, tuber	Fibre	Cereals, legume	Grasses, palm	Woody: orchad, shrub, SRC
Root C	Belowground C in the living roots or rhizome deposition partitioned to the soil.	25%	t C ha^{-1}			MinMax Scalor [0;10]		
Marginal land	**Abiotic stress tolerance** to grow on marginal land. **Climatic:** arid zones, cold climate, resistance to dry climates and extreme temperatures (droughts, heat stress or low temperature and frost), as well as has a high tolerance to excessive wetness. **Soil:** sandy soils with low SOM; heavy cracking clays (Vertisoils); soils with coarse texture (Arenosols, Regosols, and Vitric Andosols); soils with petric and stony phase, saline/sodic, acid sulphate soils **Other: low-input crops, marginal land properties**	20%	n/a	No stress tolerance	climatic tolerance but special soil texture preferences	climatic tolerance OR unfavourable/poor soil texture and chemical conditions	climatic tolerance AND unfavourable/poor soil texture and chemical conditions	climatic tolerance AND unfavourable/poor soil texture and chemical conditions AND low input AND remediation/Phyto sanitation properties
Economic yield	Higher yields/crop productivity (primary use) can be attractive for bioeconomic supply chains.	10%	t ha^{-1} y^{-1}			MinMax Scalor [0;10]		

Pre-liminary selection of biopumps

Normalisation: z-score

Ranking: subdivide values up to one-half of one standard deviation



Tropical	Subtropical	Temperate
Eucalyptus	Miscanthus (Silvergrass)	Miscanthus (Silvergrass)
Giant reed	Giant reed	Giant reed
Miscanthus (Silvergrass)	Reed canary grass	Willow
Reed canary grass	Eucalyptus	Reed canary grass
Ryegrass	Poplar	Ryegrass
Mulberry (blackberry)	Ryegrass	Poplar
Sea buckthorn	Mulberry (blackberry)	Switchgrass
Coffee	Switchgrass	Eucalyptus
Prosopis	Sea buckthorn	Mulberry (blackberry)
Brazil nut	Willow	Poplar-Willow
Elder	Acacia	Sea buckthorn
Guayule	Elder	Aritplex (Saltbush)
Poplar-Willow	Almond	Elder
Alder	Olive	Alder
Cordia	Guayule	Cordia
Willow	Poplar-Willow	Guayule
Poplar	Alder	Brazil nut
Kiwi	Cordia	Kiwi
Citrus	Brazil nut	Prosopis
Orange	Kiwi	Citrus
Guava	Prosopis	Orange
Switchgrass	Citrus	Peppermint
Sugar cane	Orange	Cup plant
Lichi (lychee)	Black locust	Jasmine
Mango	Peppermint	Rose-scented geranium
Peppermint	Cup plant	Sugar cane
Cup plant	Acerola	Acacia
Peach_palm_fruit	Jasmine	Jatropha
Cupuacu	Rose-scented geranium	Black locust
Rubber	Sugar cane	Oil palm
Jasmine	Jatropha	Guava
Rose-scented geranium	Oil palm	Tea
Oil palm	Guava	Peach_palm_fruit
Acerola	Tea	Tobacco (wild)
Annatto (Sinduri, achiot	Aritplex (Saltbush)	Annona
Tea	Peach_palm_fruit	Acerola
Annona	Tobacco (wild)	Almond
Acacia	Annona	Annatto (Sinduri, achiot
Jatropha	Annatto (Sinduri, achiot	Apricot
Black locust	Apricot	Blog-myrtle
Aritplex (Saltbush)	Blog-myrtle	Blueberries
Tobacco (wild)	Blueberries	Cashew nut
Almond	Cashew nut	Cocoa
Apricot	Cedar	Coffee
Blog-myrtle	Cocoa	Cupuacu
Blueberries	Coffee	Lichi (lychee)
Cashew nut	Cupuacu	Mango
Cocoa	Lichi (lychee)	Manilkara (Sapodilla)
Manilkara (Sapodilla)	Mango	Myrthe
Myrthe	Manilkara (Sapodilla)	Olive
Olive	Myrthe	Rubber
Stone_fruits	Rubber	Stone_fruits
Vineyard (grapes)	Stone_fruits	Vineyard (grapes)
Jojoba	Vineyard (grapes)	Jojoba
Plantain (Ribwort)	Jojoba	Plantain (Ribwort)
Wild sugarcane (africa	Plantain (Ribwort)	Wild sugarcane (africa
Opuntia	Wild sugarcane (africa	Maize
Bahiagrass, bread gras	Opuntia	Opuntia
Sunn hemp	Bahiagrass, bread gras	Bahiagrass, bread gras
Caper spurge	Sunn hemp	Sunn hemp
Cucumber	Caper spurge	Caper spurge
Loofah	Cucumber	Cucumber
Palm,Banana,others	Loofah	Loofah
Melon	Melon	Melon

Phase 2: Assess regional adaptability on marginal land

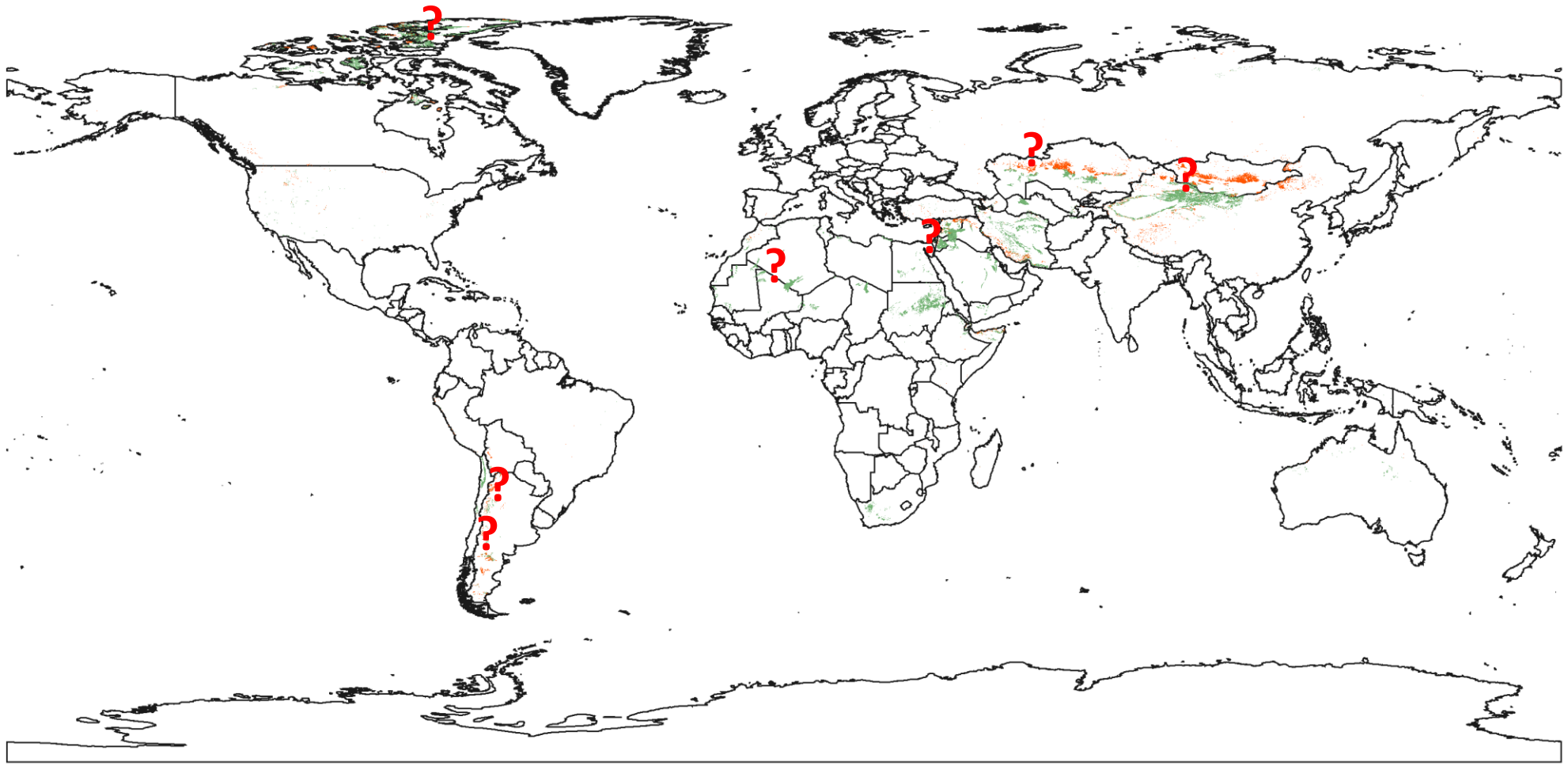
Criteria	Attributes	Constraint	Biopump 1	Biopump 2	Biopump n
Climatic	Low temperature	Polar/boreal			
	Dryness	LGP ≤60 days			
	Salinity	dS/m >15			
	Sodicity	ESP ≥15%			
	Natural toxicity / acid soils	Acidification potential upon drainage from high sulphur content			
Soil	Soil reaction	pH <4.5 or >8			
	Soil fertility	Severe: SOC in top soil (30 cm) <0.5% Sub-severe: SOC in top soil (30 cm) <0.75%			
	Unfavourable soil texture	Severe: >70% sand Sub-severe: >60% sand			
	Coarse fragments and surface stones	Rocky			
	Organic soils	>30% organic matter			
	Shallow rooting depth	<50 cm			
Terrain	Slope	Dominant slope >30%			
	Flooding risk	Waterlogged and/or flooded for a significant part of the year Alluvial soil in deserts			
Agronomic	Use of nutrients	kg ha^{-1} yr^{-1}			
	Water use efficiency	mm ha^{-1} yr^{-1}			

Notes. LGP: Length of Growing Period. P: Precipitation. PET: potential evapotranspiration. FC: field capacity. ESP: saturation with exchangeable sodium. dS: deciSiemens.

References: (Eliasson 2007), (Jones et al. 2012; Elbersen et al. 2020), (Milbrandt and Overend 2009), GAEZ/FAO problem lands (IIASA/FAO 2012), HWSD (FAO/IIASA 2009), GSOC (FAO, 2019)

Which biopumps and where do they increase SOC stock levels?

Are you exited to find out?



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Thank you!

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FAO LCCS3

Land cover classification system with 22 LC classes (red means excluded 100%)

10 Cropland, rainfed
20 Cropland, irrigated or post-flooding
30 Mosaic cropland (>50%) / natural vegetation (tree, shrub,herbaceous cover) (<50%)
40 Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) /cropland (<50%)
50 Tree cover, broadleaved, evergreen, closed to open (>15%)
60 Tree cover, broadleaved, deciduous, closed to open (>15%)
70 Tree cover, needleleaved, evergreen, closed to open (>15%)
80 Tree cover, needleleaved, deciduous, closed to open (>15%)
90 Tree cover, mixed leaf type (broadleaved and needleleaved)
100 Mosaic tree and shrub (>50%) / herbaceous cover (<50%)
110 Mosaic herbaceous cover (>50%) / tree and shrub (<50%)
120 Shrubland
130 Grassland
140 Lichens and mosses
150 Sparse vegetation (tree, shrub, herbaceous cover) (<15%)
160 Tree cover, flooded, fresh or brakish water
170 Tree cover, flooded, saline water
180 Shrub or herbaceous cover, flooded, fresh/saline/brakish water
190 Urban areas
200 Bare areas
210 Water bodies
220 Permanent snow and ice