United Nations
Convention to Combat Desertification
United for land

UNCCD Science-Policy Interface (SPI) work programme (2022-2024)

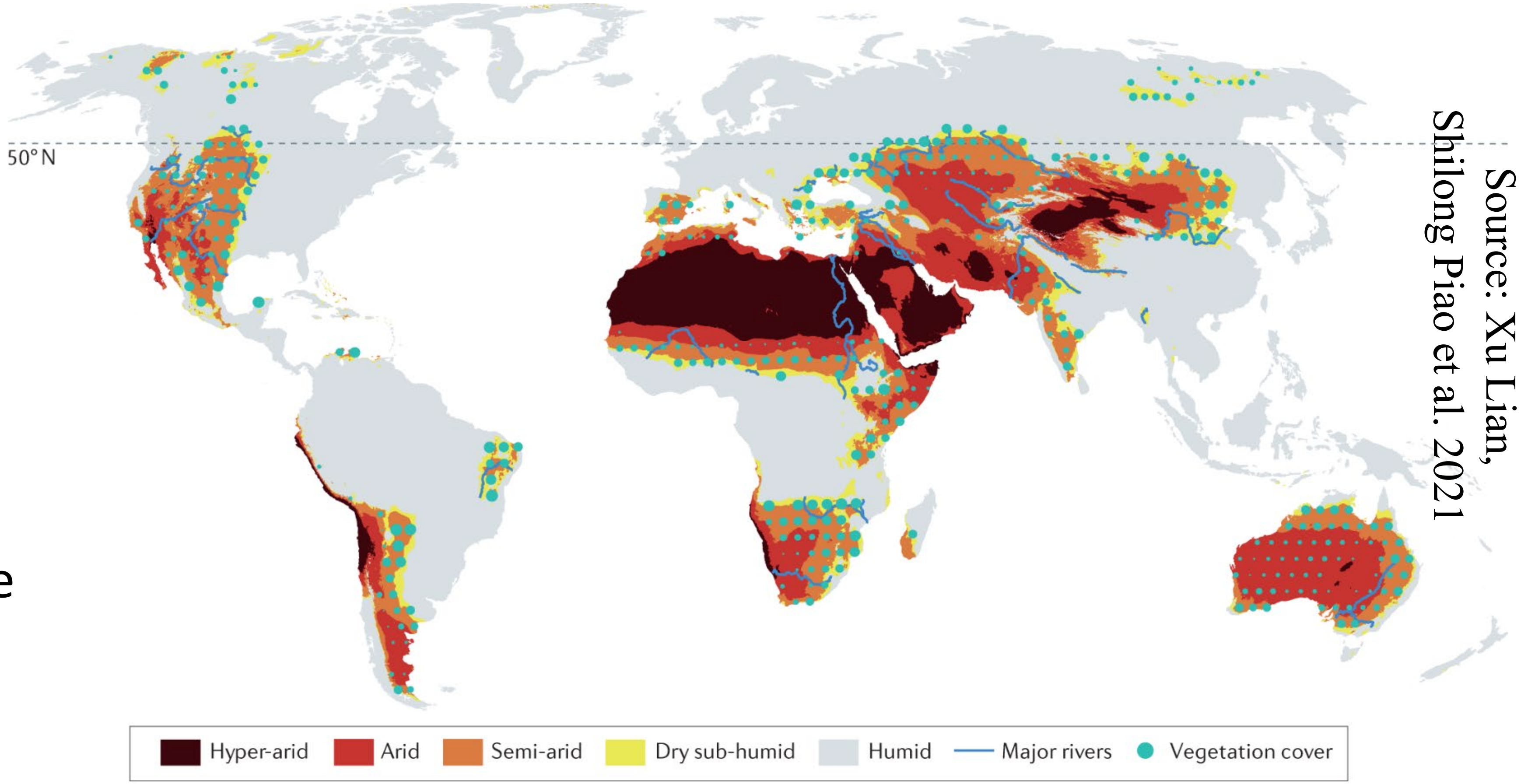
Thematic assessment objective 2 tends and projections on aridity and it s Impacts

NEASPEC Expert Meeting
19-20 June 2023

Global dryland

Drylands are vital ecosystems which cover almost **47% of the Earth's surface**, hosting **39% of the global population**.

Drylands is defined by aridity a long-term average moisture conditions of the land.

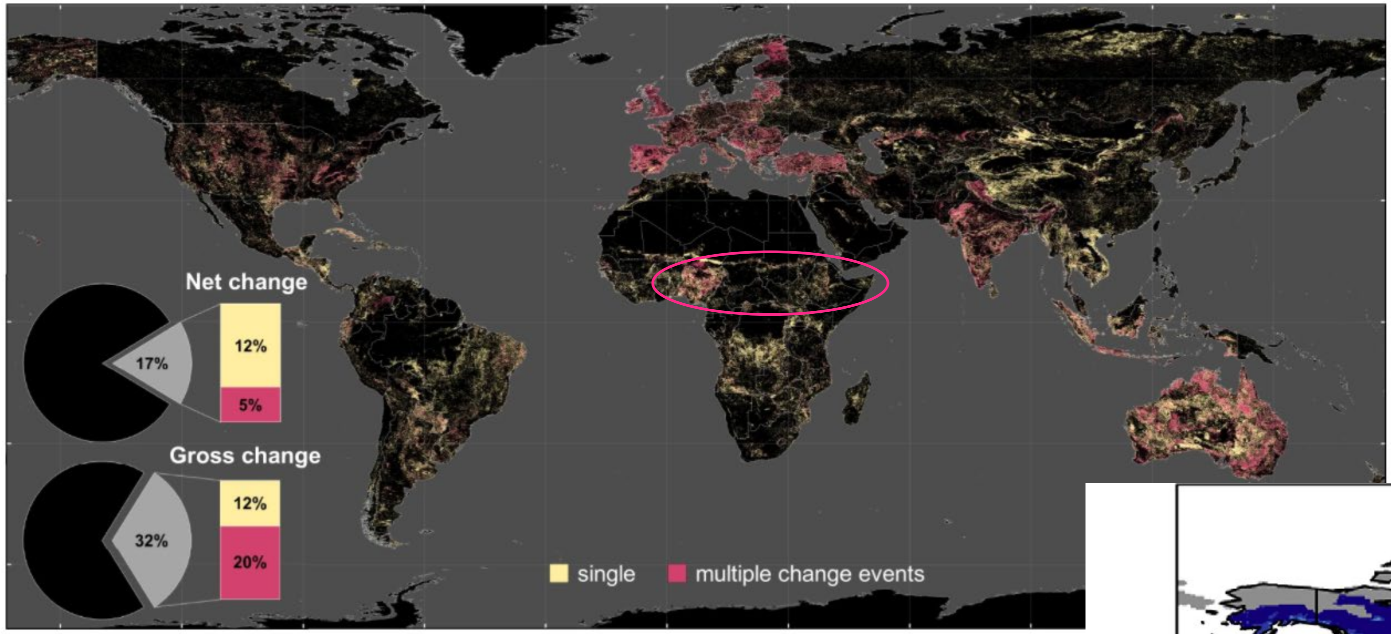


Source: Xu Lian, Shilong Piao et al. 2021

Water is the limiting factor for land productivity and ecosystem functioning in drylands. It is therefore at the center of economic growth and human well-being.

Fig. 1: Spatial extent of global land use/cover change.

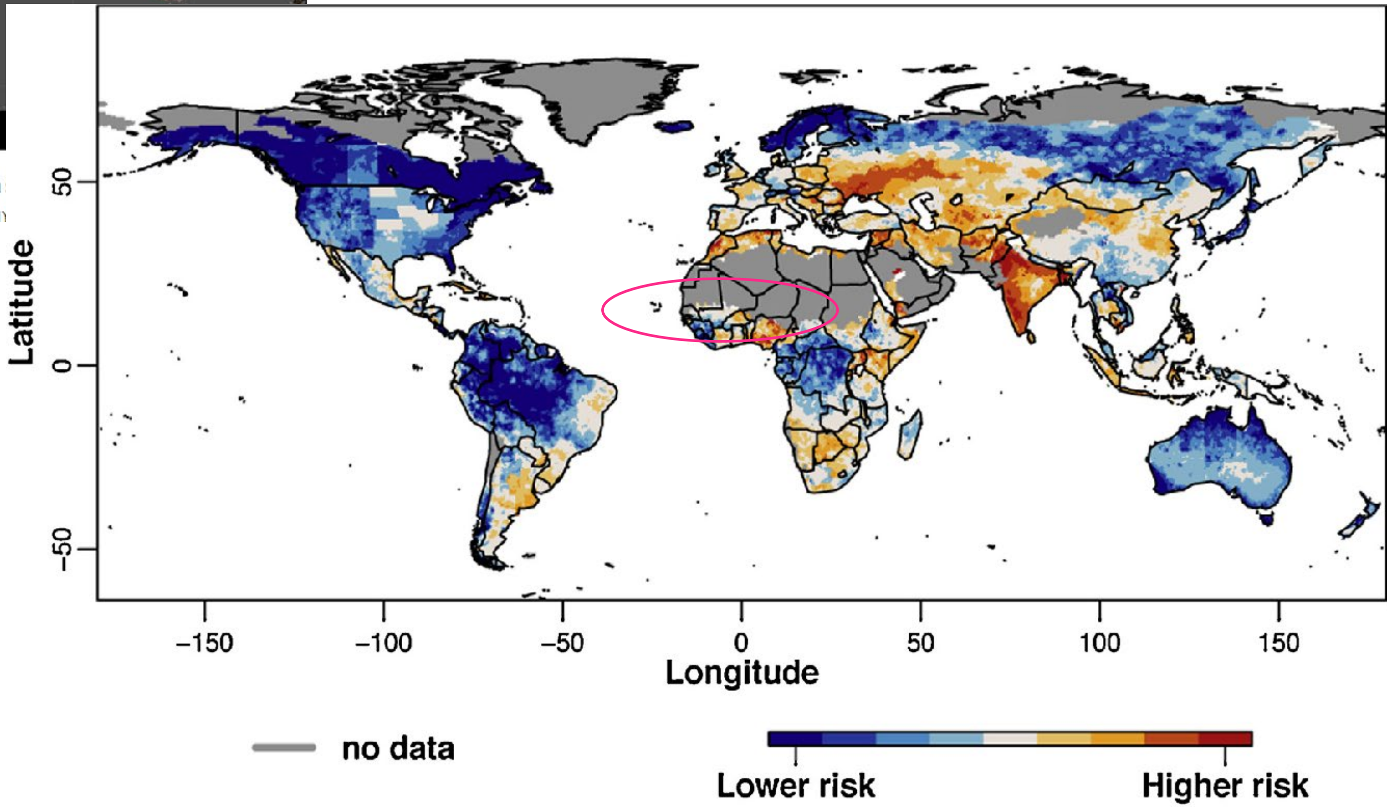
From: Global land use changes are four times greater than previously estimated



Share of the total land surface without (net change) and with consideration of multiple changes (gross change) between
categories (urban area, cropland, pasture/rangeland, forest, unmanaged grass/shrubland, non-/sparsely vegetated land)

• Land cover change and land degradation

- Healthy land has a natural capacity to hold, store and filter water.
- Land degradation and land cover change disrupt the water cycle and hydrological functions.



Drought risk and water stress (Carrão et al. 2016).

Aridity is an expression on the long-term state of water deficiency, which measures "**the degree to which a climate lacks effective, life- promoting moisture**" (American Meteorological Society, 2000).

Aridity index (AI) a numerical indicator calculated by comparing the long-term average of climate water supply known as precipitation (P) to the long-term average of climatic water demand known as potential evapotranspiration (PET), as the ratio P/PET with which drylands are classified as six subtypes.

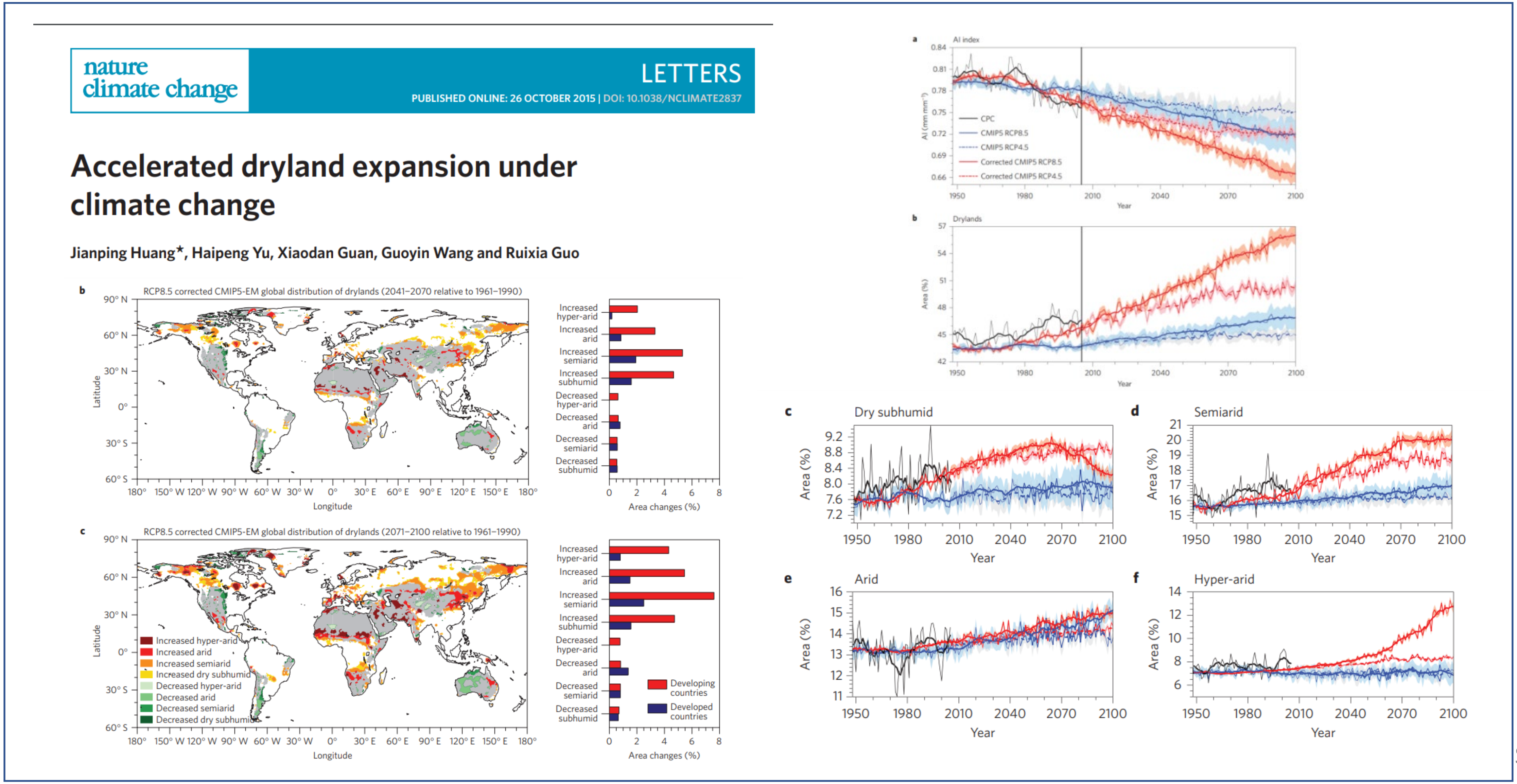
Drought refers **to periods of time with water imbalance** substantially below average moisture conditions, usually covering large areas, during which limitations in water availability result in negative impacts for various components of natural systems and economic sectors.

Source: Xu Lian, Shilong Piao et al. 2021

Climate Type	Aridity Index
Dryland Subtypes	
Hyper-arid	AI < 0.05
Arid	0.05 ≤ AI < 0.2
Semi-arid	0.2 ≤ AI < 0.5
Dry Subhumid	0.5 ≤ AI < 0.65
Non-Drylands	
Humid	AI ≥ 0.65
Cold	PET < 400mm

Source: JRC, 2018 2021

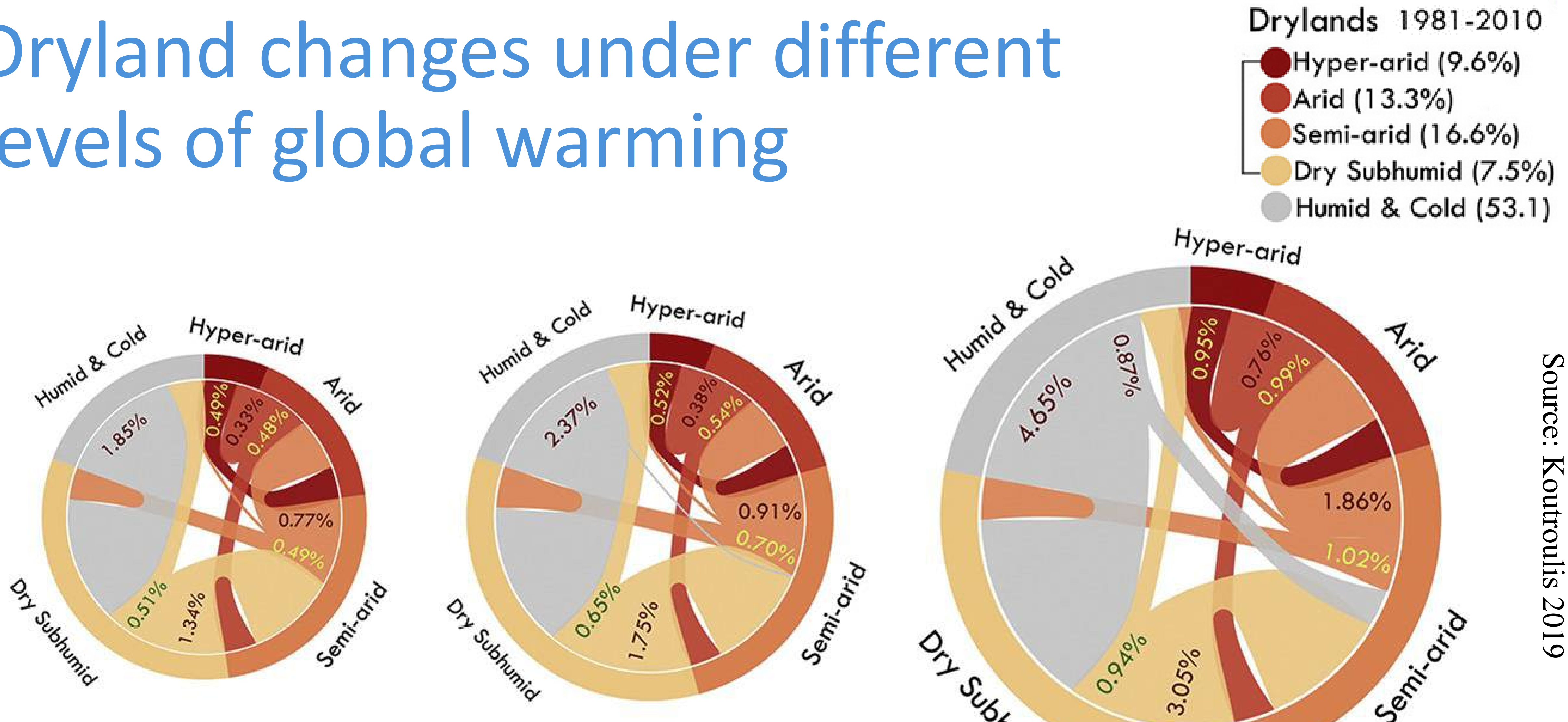
- The IPCC has reported that **drylands have expanded. Warming rates** have been **twice as high in drylands** as compared to humid lands.



Historical trends of the Aridity of Asia

- The results reveal that the largest expansion of drylands has occurred in semi-arid regions since the early 1960s.
- This expansion of semi-arid regions accounts for more than half of the total dryland expansion.
- The area of semi-arid regions in the most recent 15 years studied (1990–2004) is 7 % larger than that during the first 15 years (1948–1962) of the study period;
- this expansion totaled 0.4 × 106 and 1.2 × 106 km2 within the American continents and in the Eastern Hemisphere, respectively.

Dryland changes under different levels of global warming



+1.5°C

4.30% global land to drier types

2.02% global land to wetter types

+2°C

5.45% global land to drier types

2.48% global land to wetter types

+4°C

11.20% global land to drier types

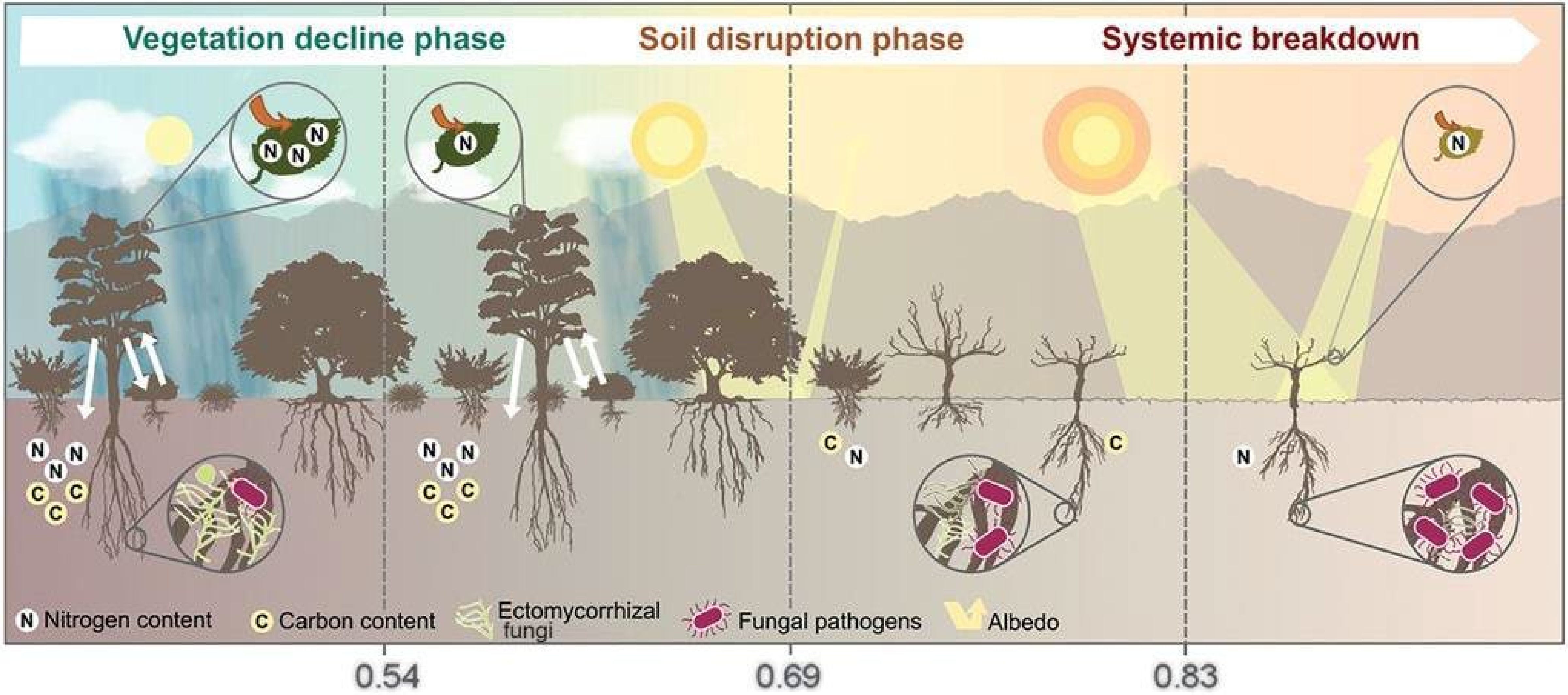
4.24% global land to wetter types

Source: Koutroulis 2019

What do these aridity trends portend for drylands?

- **The drylands could increase by an additional 7% of the global land surface by 2100.**
- With rapid climate change and population growth, anthropogenic **water demand in drylands is projected to increase by ~270% by the 2090s**, exacerbating current water resource scarcity.
- Up to **1.9 billion people could *avoid* living in drylands by keeping to 1.5 °C vs 4 °C.**

What will this mean for land?



As aridity increases >>>>>>>>

Source: Berdugo et al. 2020

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Review Article | Published: 09 March 2021

Multifaceted characteristics of dryland aridity changes in a warming world

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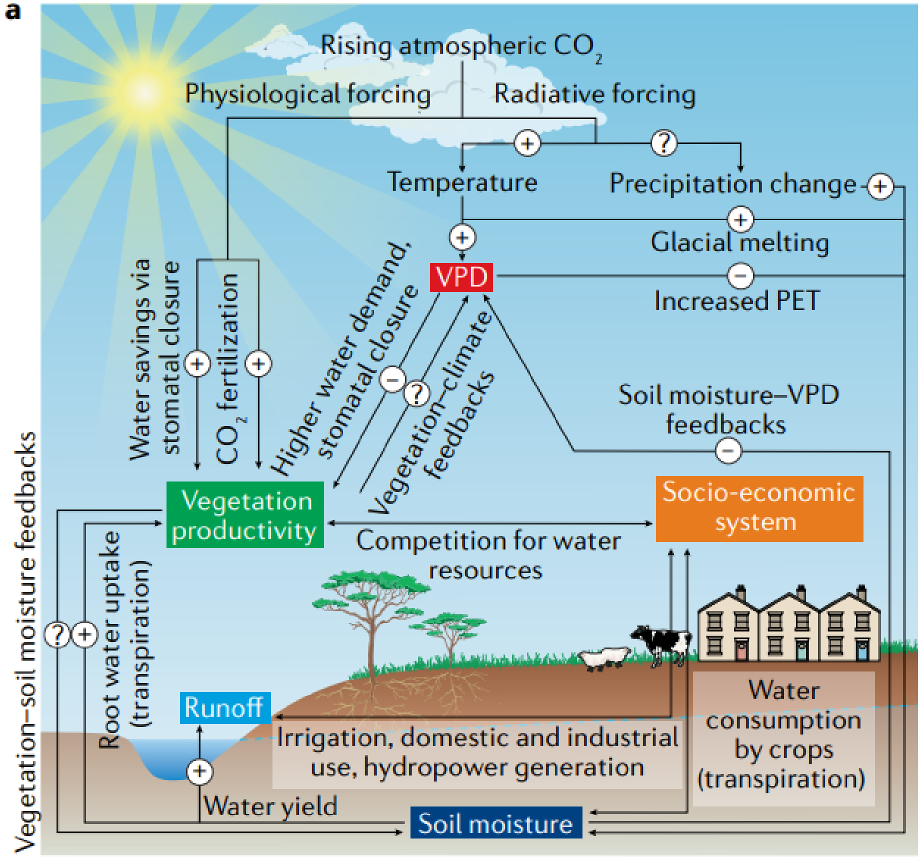


<u>Aridity has numerous specific perspectives</u>:

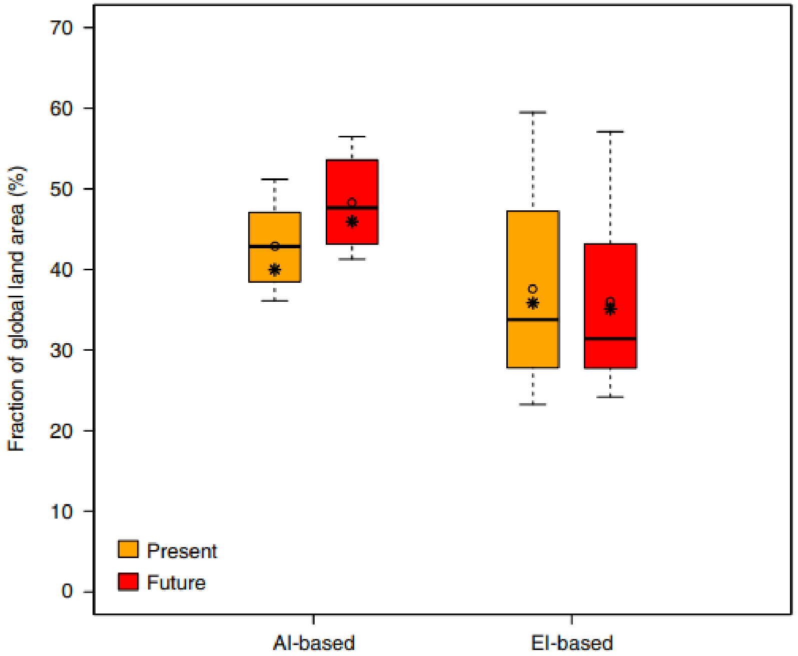
1) **atmospheric aridity** describes high atmospheric demand for water, and is measured by vapour pressure deficit or relative humidity;
2) **soil moisture** (or agricultural) aridity describes a state of soil moisture stress;
3) **hydrological aridity** describes a deficit of surface runoff;
4) **ecological aridity** describes a state of insufficient moisture to support vegetation growth, and is often related to reduction (or reduced capacity) of plant photosynthesis

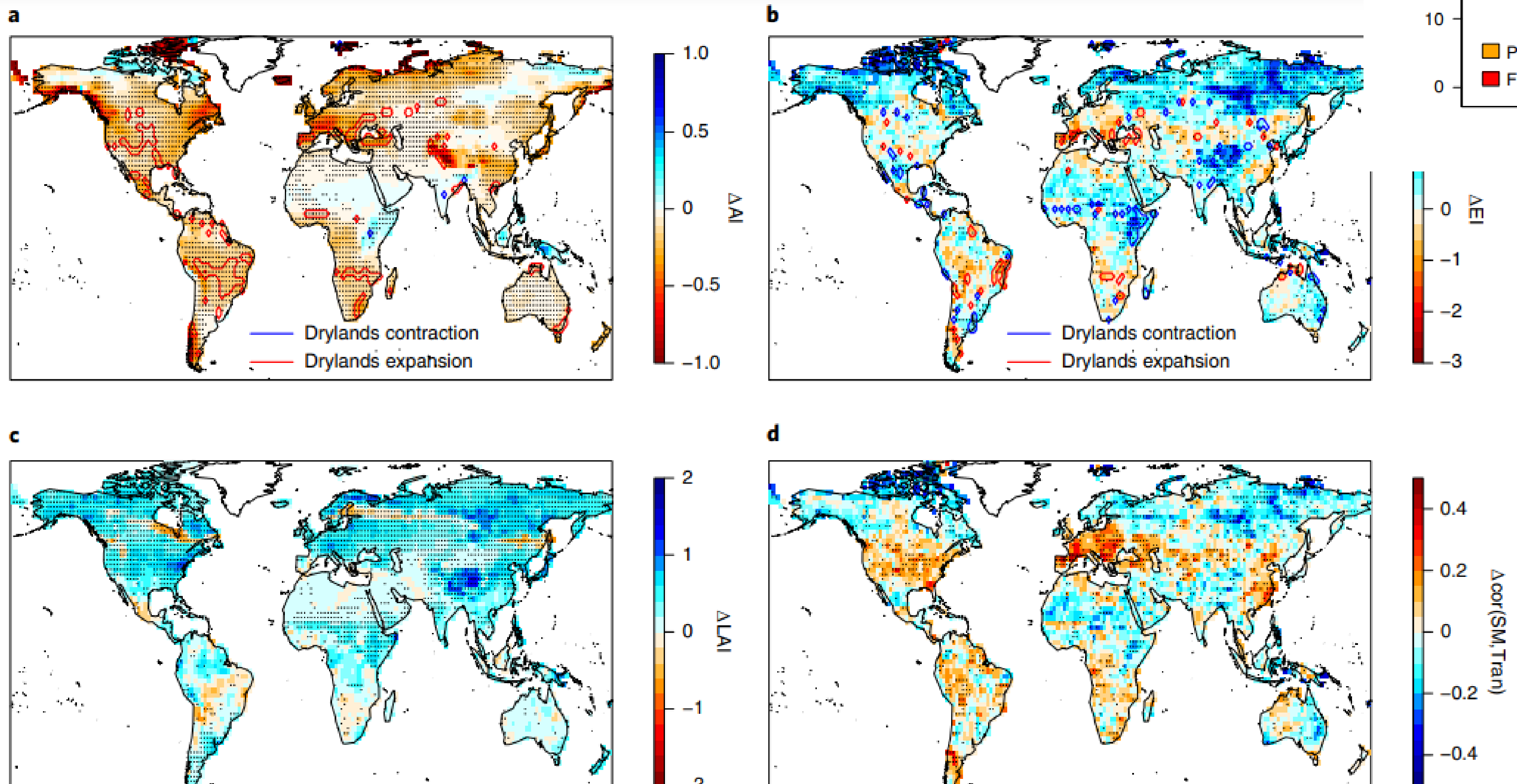
Although aridity means an excess of water demand over available supply for all Earth System processes, **both the demand and supply sides differ substantially among these Perspectives**.

nature climate change
ARTICLES
https://doi.org/10.1038/s41558-021-01007-8

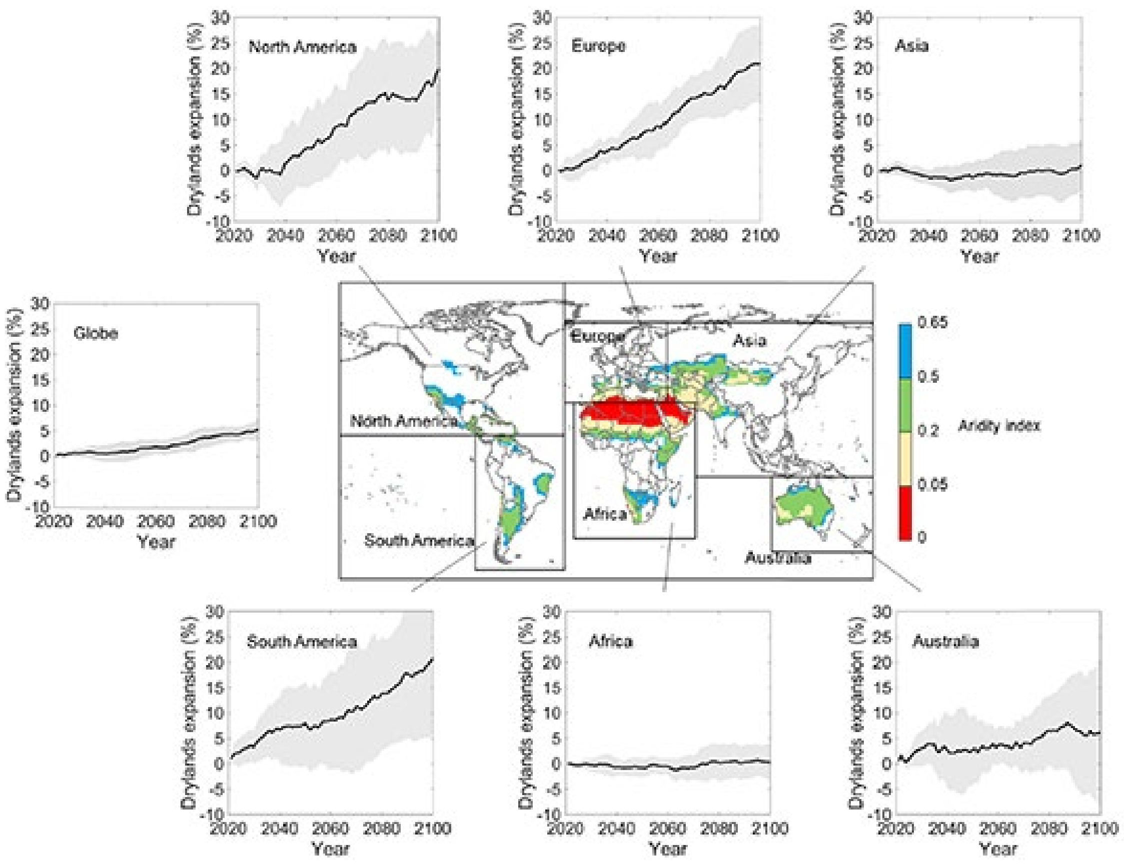
No projected global drylands expansion under greenhouse warming

Alexis Berg[1] and Kaighin A. McColl[1,2]



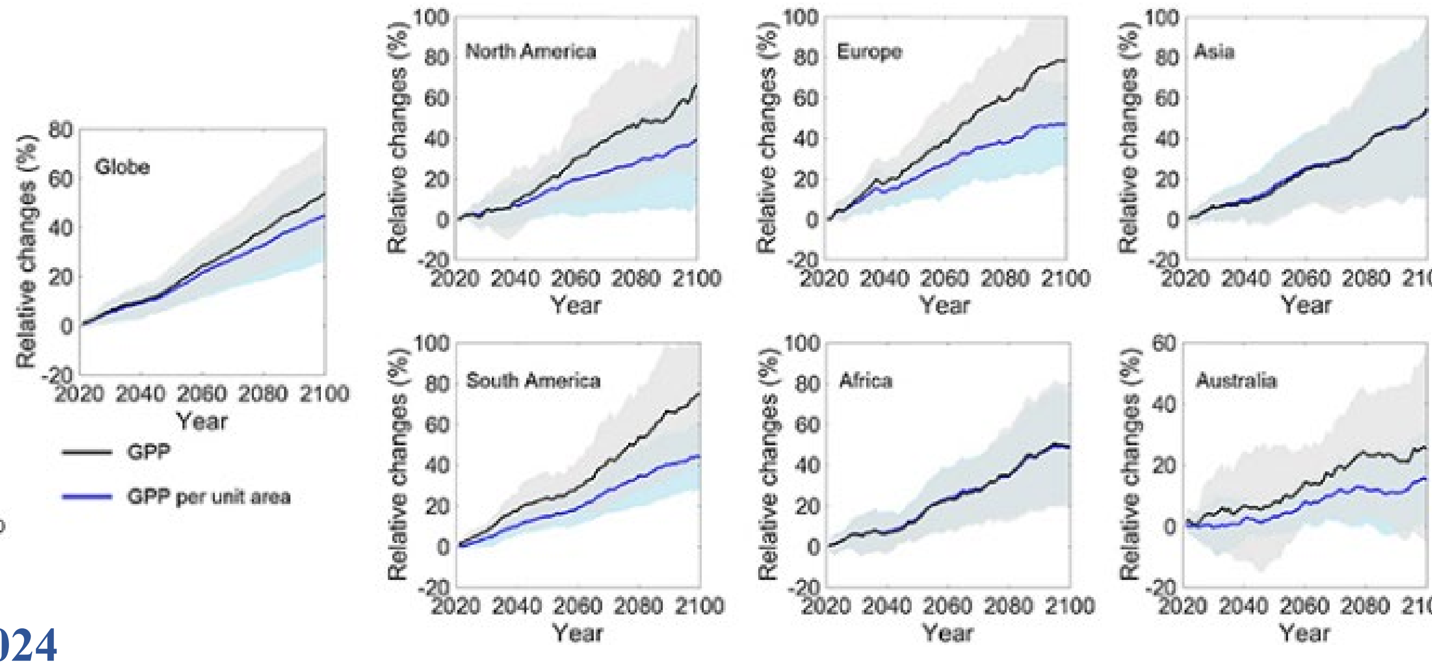


Overestimated global dryland expansion with substantial increases in vegetation productivity



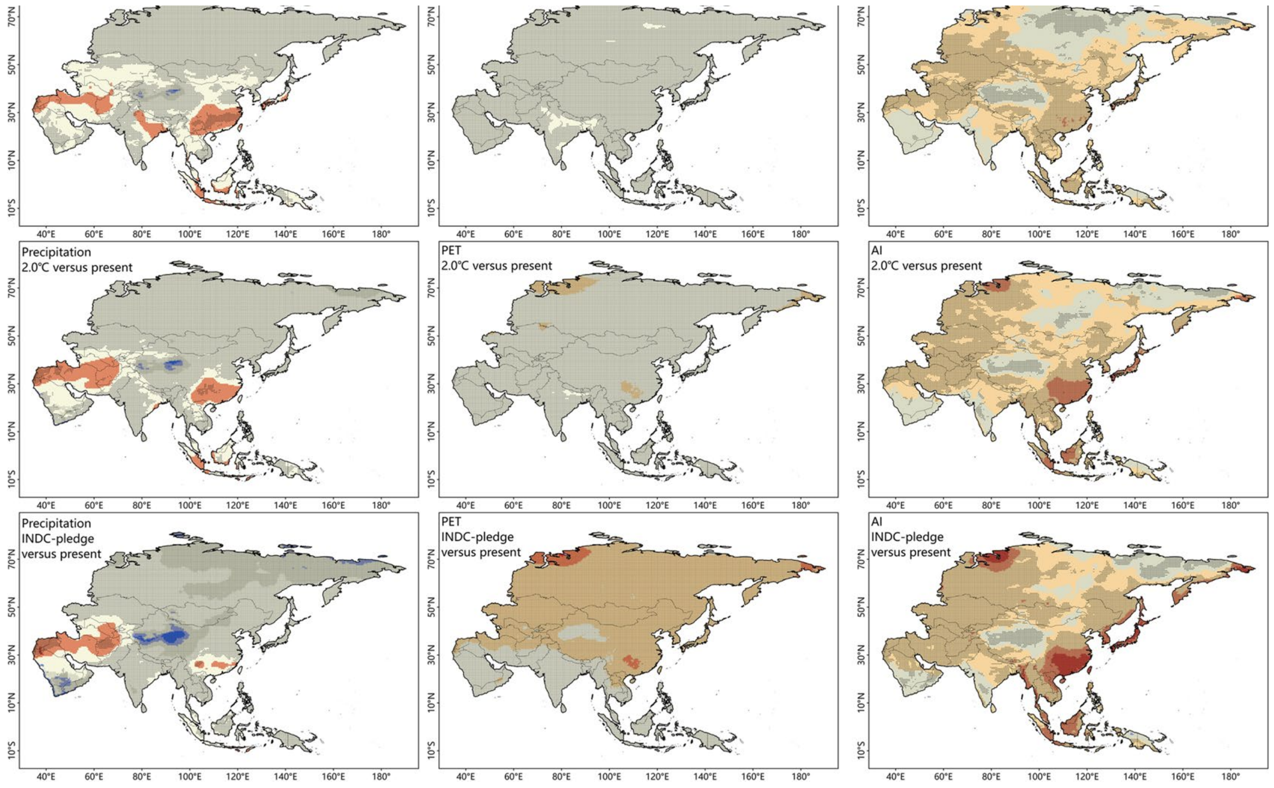
Fertilization effects of elevated CO2 for vegetation growth, no expansion trend of Asia and Africa,

An observed GPP increase in all regions , as natural vegetation improvement

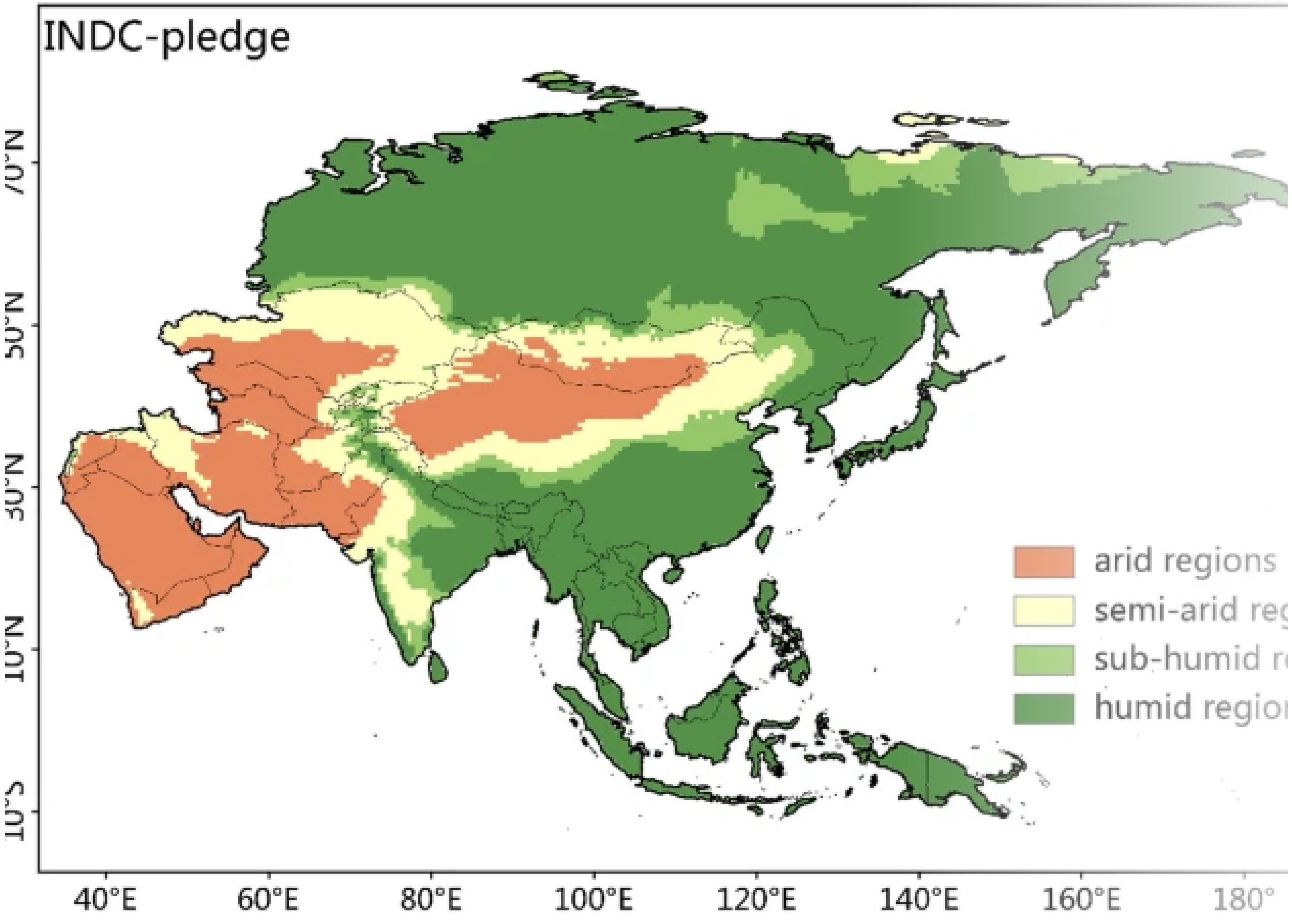


Ziwei Liu et al 2023 Environ. Res. Lett. 18 054024

Asia Aridity projections



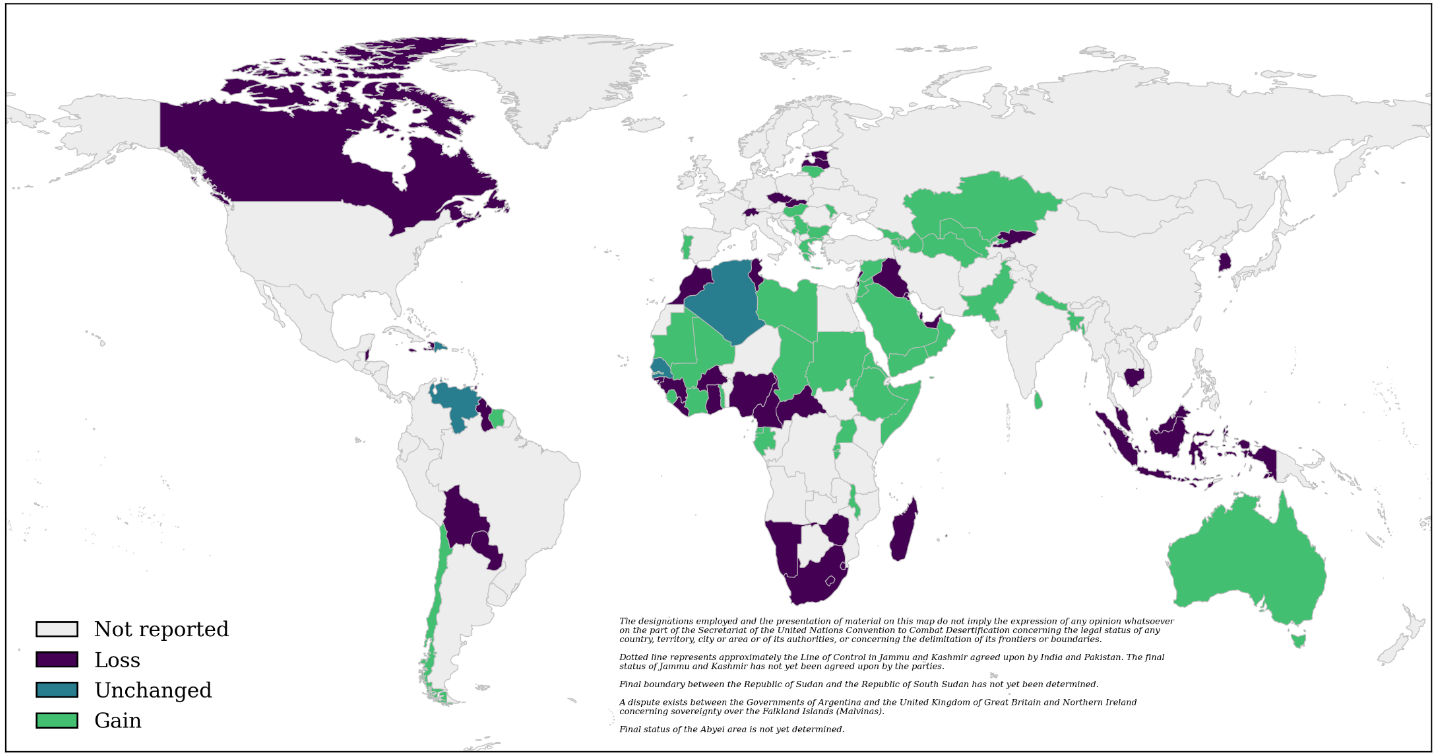
Projected Asia dryland change



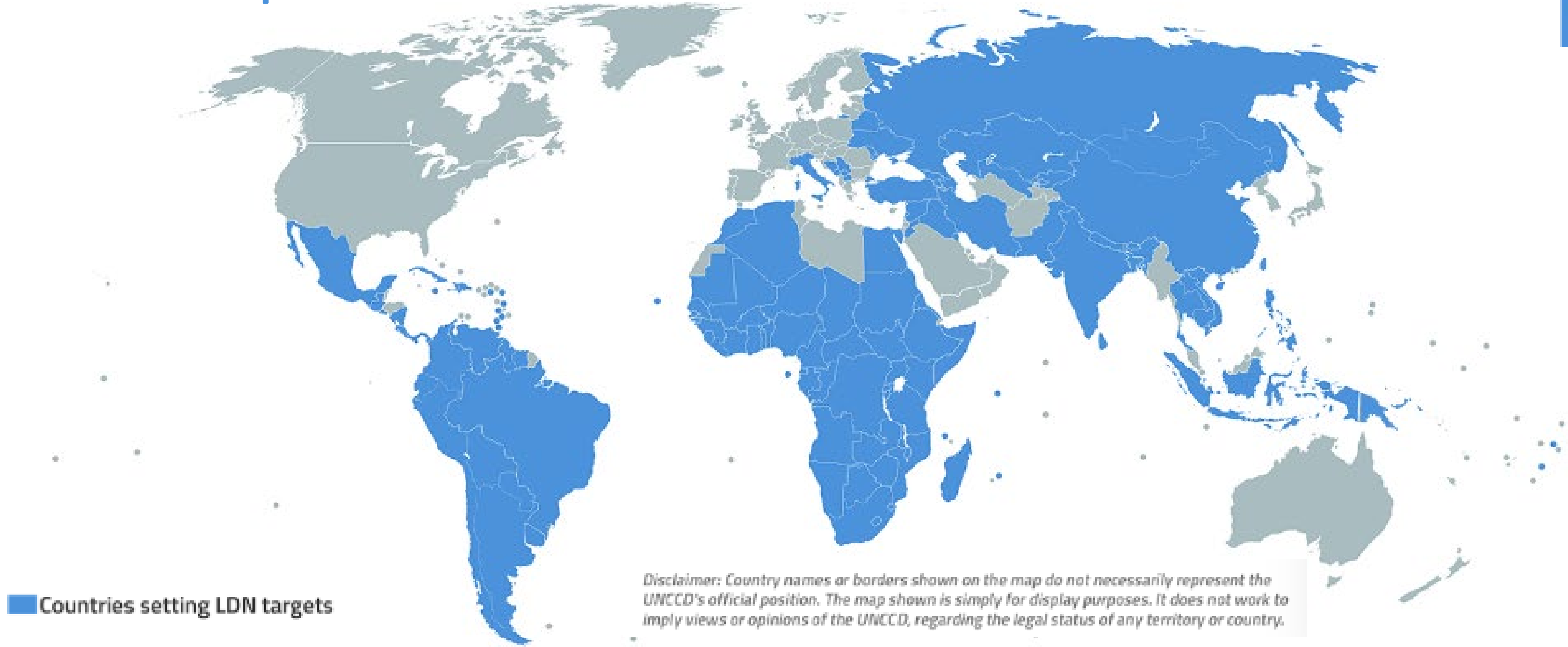
- Humid region will contract, and the arid region and arid/humid transition zones will expand.
- Compared with the present period, arid/humid region switch is projected to occur in a land area of 2512.8×10^3 km^2 over Asia under INDC pledge scenario.
- Under 2.0 °C and 1.5 °C scenarios scenario, a decrease in the changes in the area of arid/humid regions by more than half would be expected.

Natural vegetation Improvement

- **The proportion of degraded land for all land reported by country Parties increased from 14.7 per cent in the baseline period to 18.9 percent in the reporting period with a total area of degraded land equal to more than 11.8 million km^2 in 2019.**
- UNCCD PRASE4 2023 in proce



Restoration efforts- human contributions –LDN Implementation



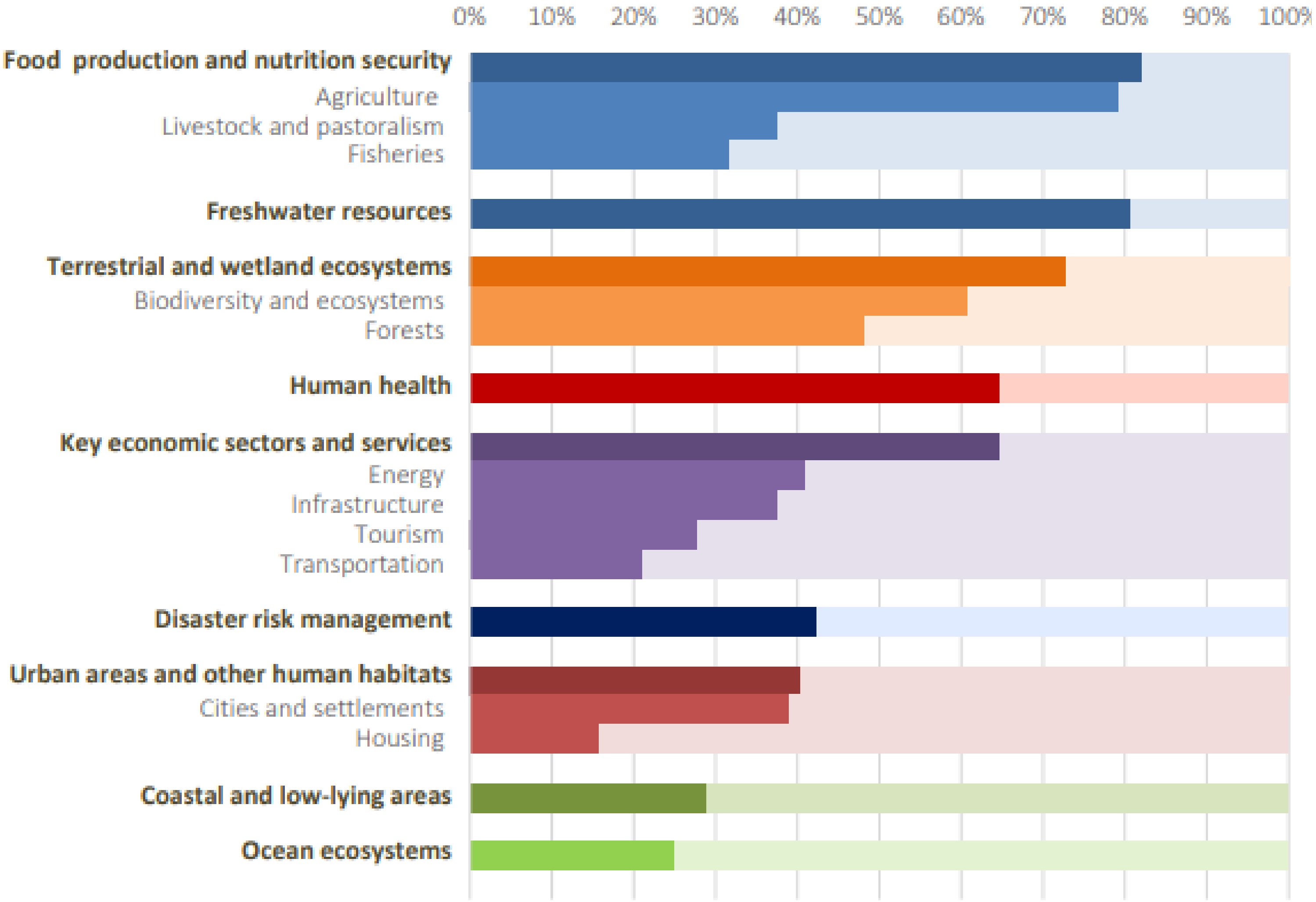
United Nations
Convention to Combat Desertification

128 countries have committed to set LDN targets so far

86 countries have officially validated their targets

51 countries targets adopted by their governments

Share of adaptation components of NDCs referring to specific adaptation priority areas and sectors



- As of July 2021,
- **More than 80%** of 164 Nationally Determined Contributions (NDCs) representing 191 countries referring to land-based activities for climate mitigation and/or adaptation.

Land-based actions for domestic quantitively mitigation measures in nationally determined contributions for Paris agreement

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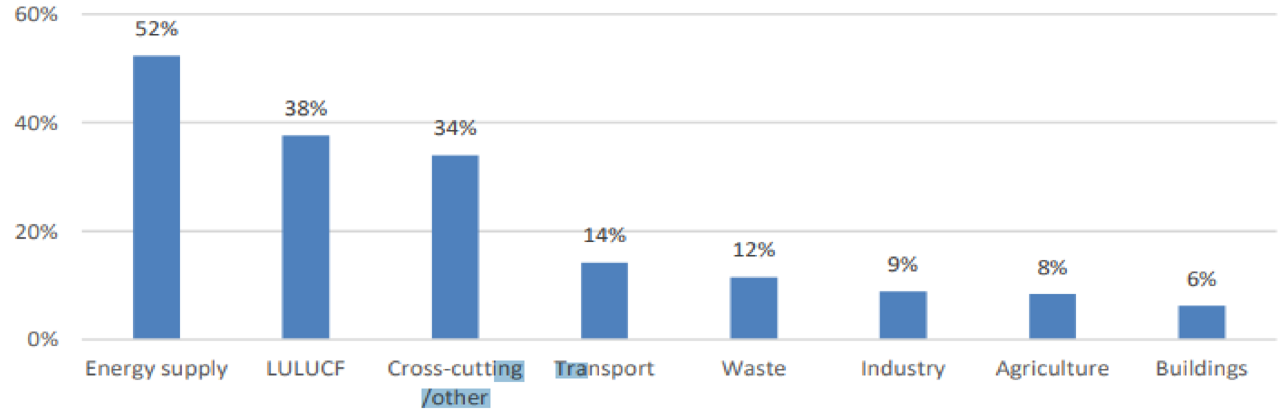
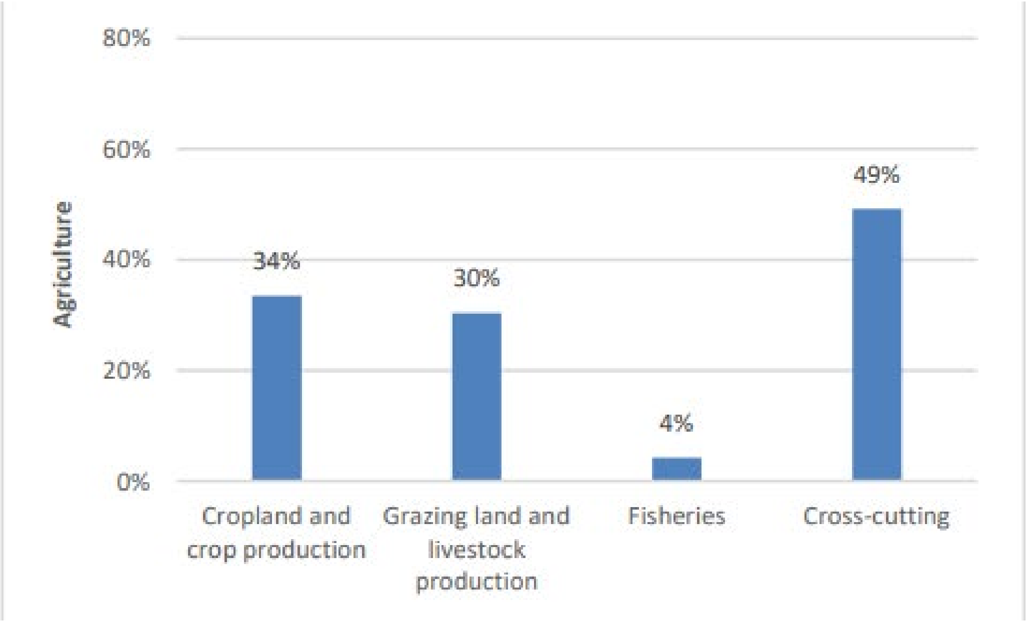
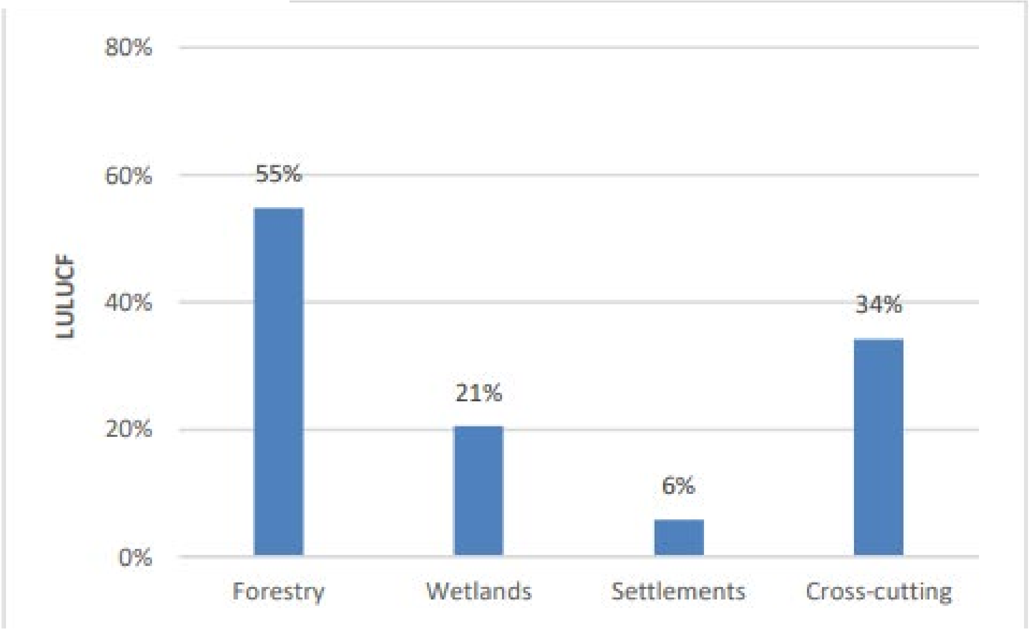
Share of Parties providing quantitative mitigation targets specific to priority areas or sub-areas in nationally determined contributions





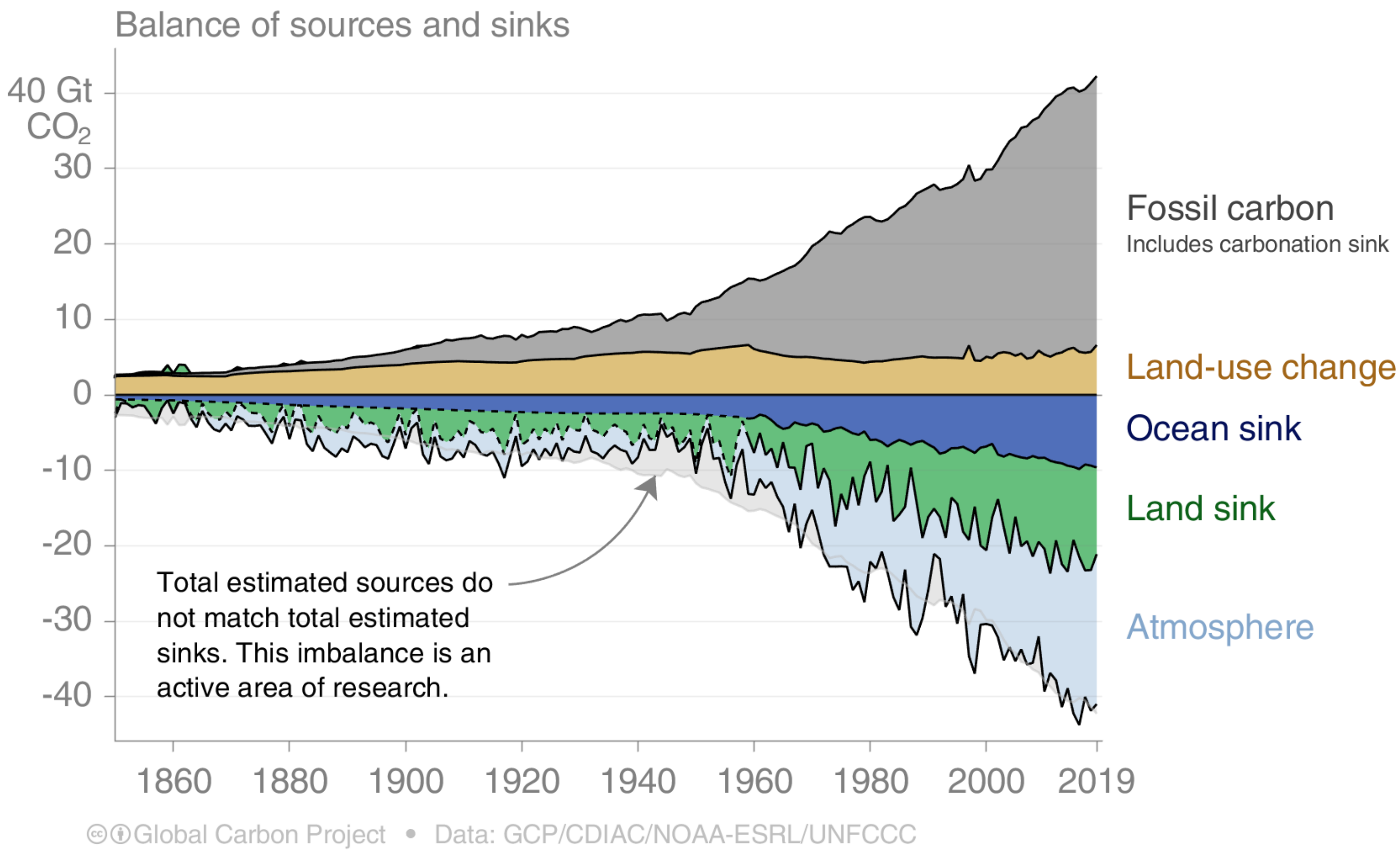


FCCC/PA/CMA/2021/8/Add.2

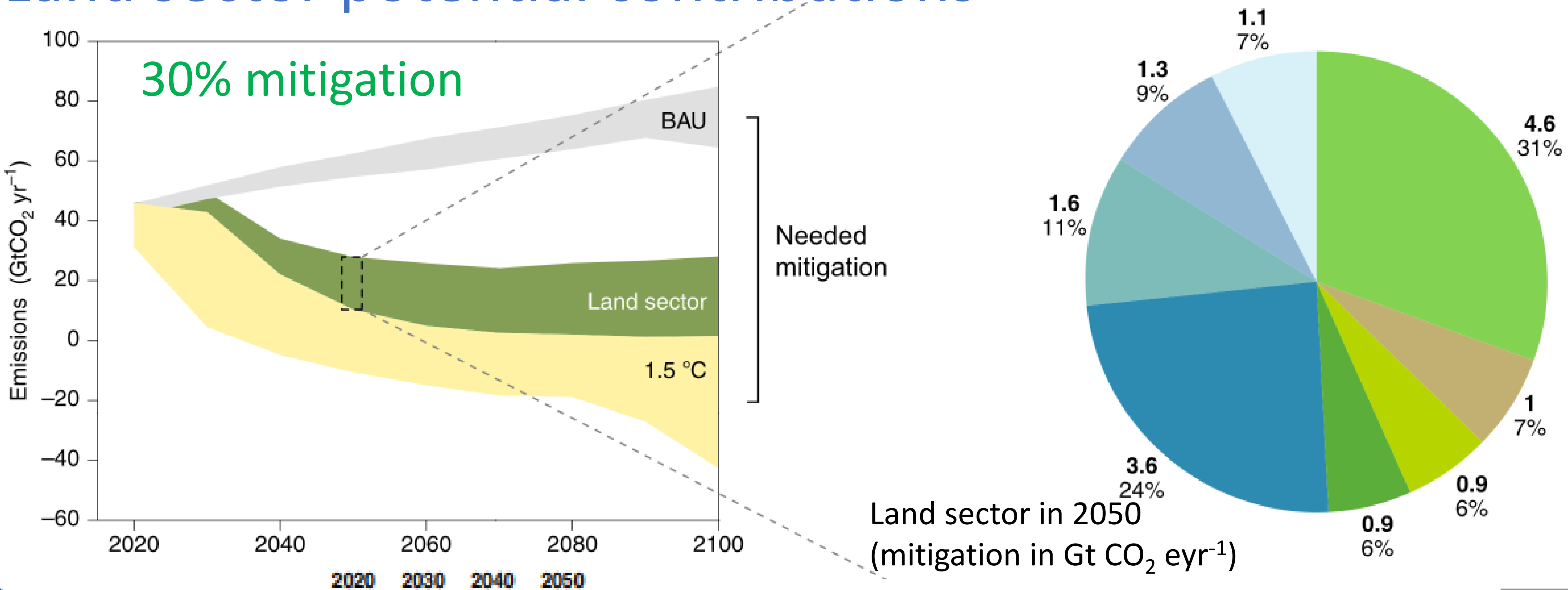
Land: Carbon Sink or Source ?

- Terrestrial ecosystems remove **about 30 % the carbon dioxide (CO_2)** emitted by human activities each year through natural response and land management

- Due to CO_2 fertilization, and longer growing seasons, temperature and precipitation raising and management
- But their effectiveness is slowing the accumulation of carbon dioxide is declining.
- Future net increases in land CO_2 emissions are projected to counteract increased removals



Land sector potential contributions



	2020	2030	2040	2050
Reduce emissions from deforestation and degradation, conversion of coastal wetlands, and peatland burning[18] (95% emissions reduction by 2050 compared to 2018)	25%	70%	90%	95%
Reduce emissions from agriculture[16,21] (25% emissions reduction by 2050 compared to BAU)	0%	0%	15%	25%

Shift to plant-based diets[45] (50% adoption in global population by 2050)	5%	20%	35%	50%
Reduce food waste[45] (50% reduction in total food waste by 2050 compared to BAU)	20%	30%	45%	50%
	10%	30%	45%	50%

Restore forests, coastal wetlands and drained peatlands[18]	9	45	90
Improve forest management and agroforestry[18]	4	20	40
Enhance soil carbon sequestration in agriculture and apply biochar[17,45]	3	16	32
Deploy BECCS[17,35]	0	11	22

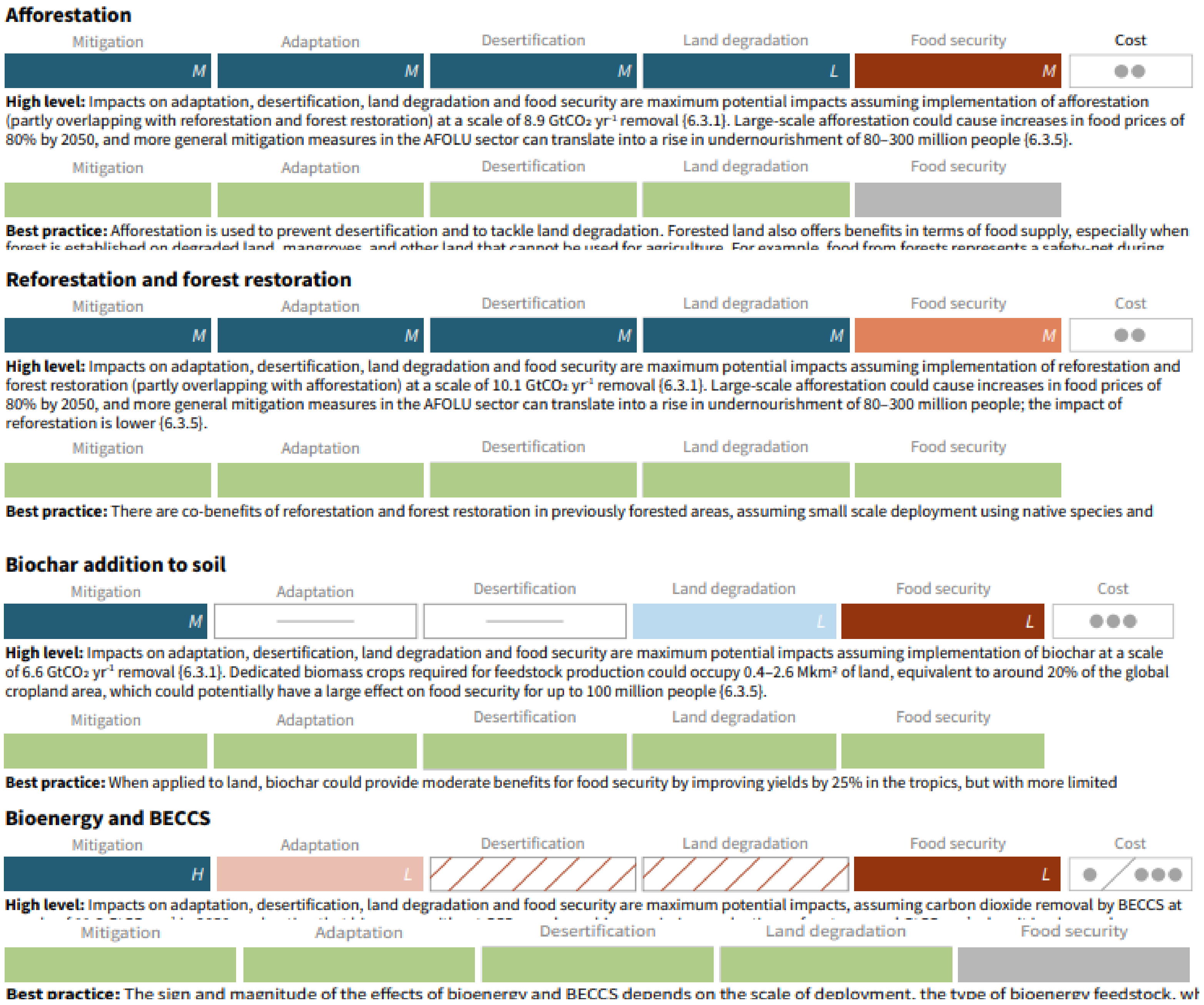
Roe, S. eat al 2019 IIASA NATURE CLIMATE CHANGE | VOL 9 | NOVEMBER 2019 | 817–828

Three Response options (IPCC-SRCL)-restoration

Restore plant biodiversity

Restore soil Carbon

Co-development with renewable energy



Afforestation

Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
M	M	M	L	M	●●

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation (partly overlapping with reforestation and forest restoration) at a scale of 8.9 $GtCO_2\ yr^{-1}$ removal {6.3.1}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people {6.3.5}.

Mitigation	Adaptation	Desertification	Land degradation	Food security

Best practice: Afforestation is used to prevent desertification and to tackle land degradation. Forested land also offers benefits in terms of food supply, especially when forest is established on degraded land, mangroves, and other land that cannot be used for agriculture. For example, food from forests represents a safety-net during

Reforestation and forest restoration

Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
M	M	M	M	M	●●

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of reforestation and forest restoration (partly overlapping with afforestation) at a scale of 10.1 $GtCO_2\ yr^{-1}$ removal {6.3.1}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people; the impact of reforestation is lower {6.3.5}.

Mitigation	Adaptation	Desertification	Land degradation	Food security

Best practice: There are co-benefits of reforestation and forest restoration in previously forested areas, assuming small scale deployment using native species and

Biochar addition to soil

Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
M	—	—	L	L	●●●

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of biochar at a scale of 6.6 $GtCO_2\ yr^{-1}$ removal {6.3.1}. Dedicated biomass crops required for feedstock production could occupy 0.4–2.6 Mkm^2 of land, equivalent to around 20% of the global cropland area, which could potentially have a large effect on food security for up to 100 million people {6.3.5}.

Mitigation	Adaptation	Desertification	Land degradation	Food security

Best practice: When applied to land, biochar could provide moderate benefits for food security by improving yields by 25% in the tropics, but with more limited

Bioenergy and BECCS

Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
H	L			L	● / ●●●

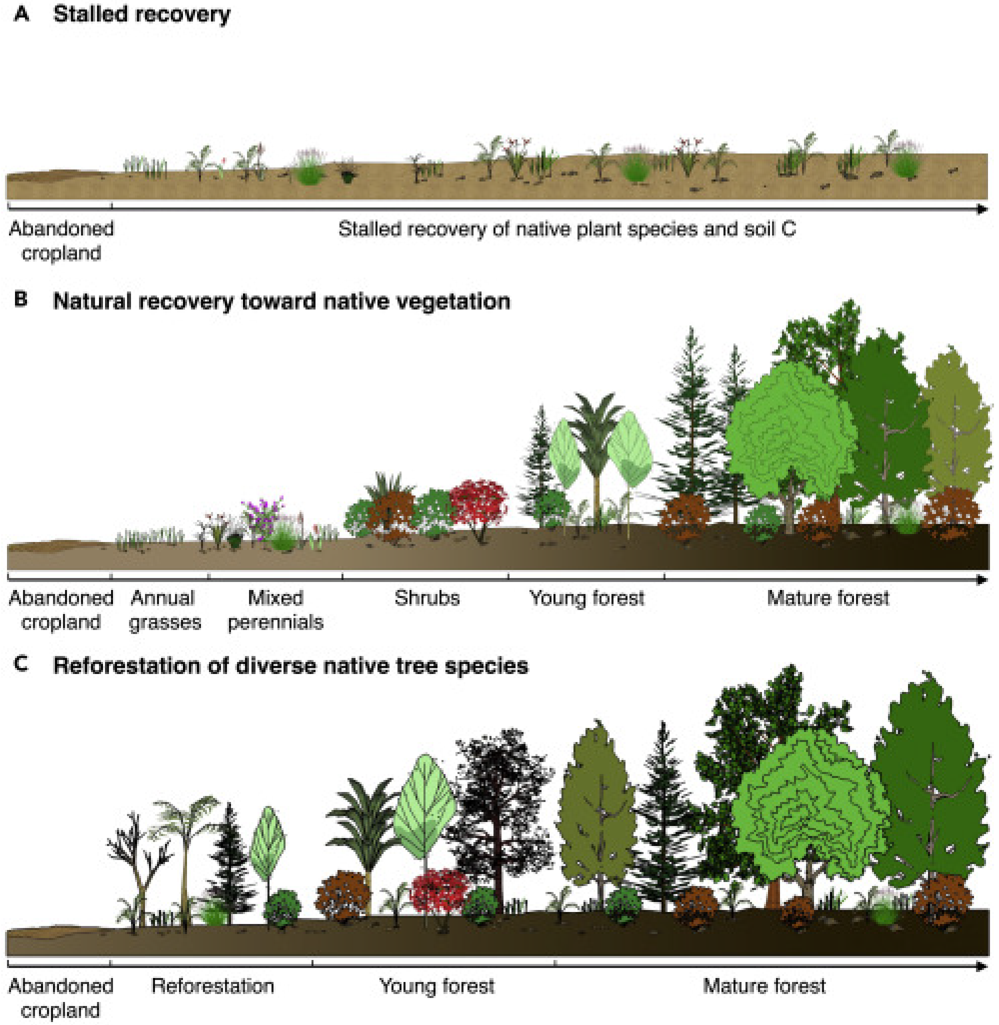
High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts, assuming carbon dioxide removal by BECCS at

Mitigation	Adaptation	Desertification	Land degradation	Food security

Best practice: The sign and magnitude of the effects of bioenergy and BECCS depends on the scale of deployment, the type of bioenergy feedstock, wh

Passive and active ways to restore degraded land

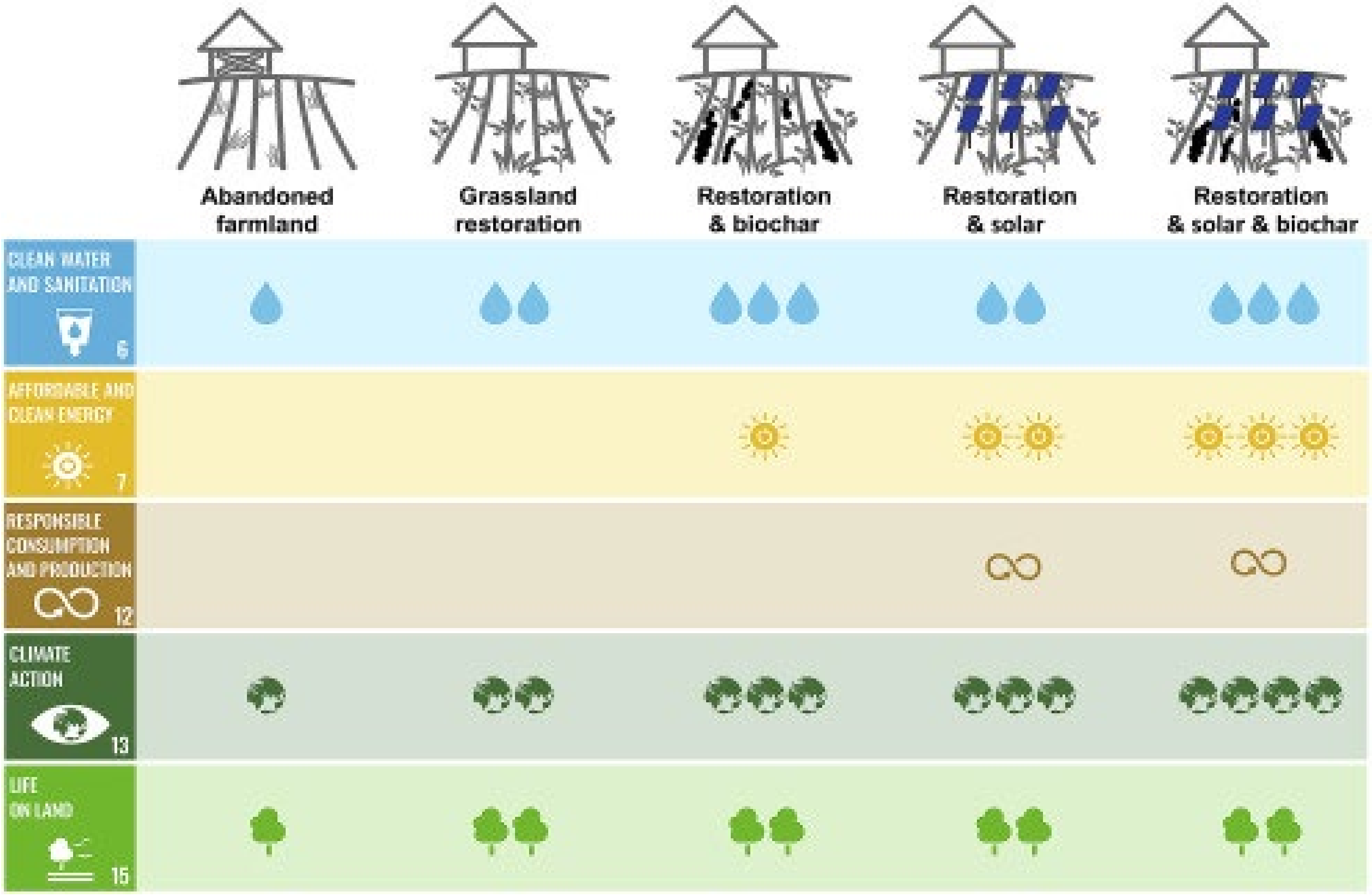
- Land only has ~75% of plant diversity and 50% of plant productivity nearly a century after abandonment.
- Rates of soil organic C sequestration on restored grasslands, shrublands, or forests are 92%–215% higher than those under natural recovery.



Yang,Y eat al 2020 Restoring Abandoned Farmland to Mitigate Climate Change on a Full Earth, One EarthVolume 3, Issue 2, 21 August 2020, Pages 176-186 https://doi.org/10.1016/j.oneear.2020.07.019

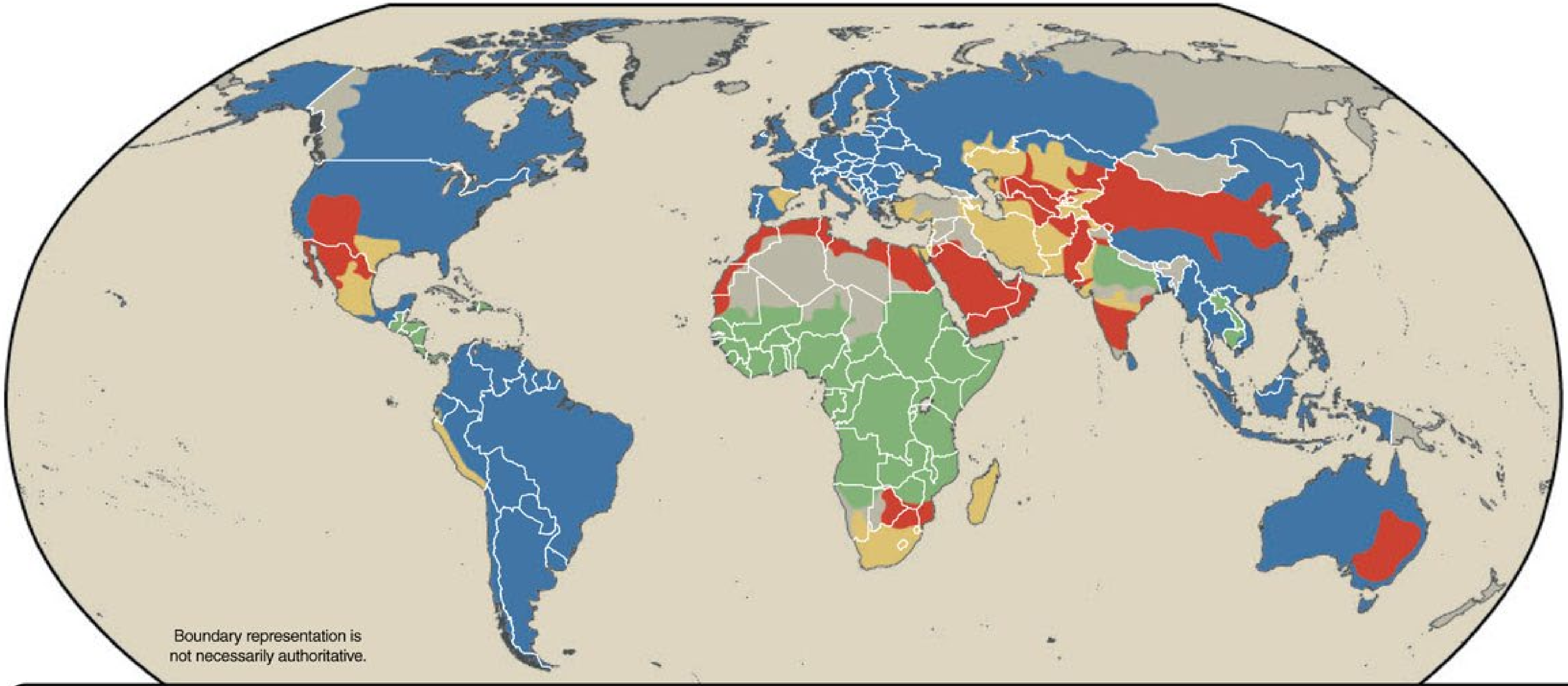
Integrated Restoration contributes more to SDGs

Worldwide abandoned cropland and pastureland (which have not been converted to forest or urban areas) at 385–472 million ha, which is about 26%–31% of global cropland areas (1,500 million ha).



- Yang,Y eat al 2020 , One EarthVolume 3, Issue 2, 21 August 2020, Pages 176-186

Projected Global Water Scarcity, 2025



Physical water scarcity: More than 75% of river flows are allocated to agriculture, industries, or domestic purposes. This definition of scarcity — relating water availability to water demand — implies that dry areas are not necessarily water-scarce.

Approaching physical water scarcity: More than 60% of river flows are allocated. These basins will experience physical water scarcity in the near future.

Economic water scarcity: Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.

Little or no water scarcity: Abundant water resources relative to use. Less than 25% of water from rivers is withdrawn for human purposes.

Not estimated

Historical trend of land degradation in dryland

- Desertification area has increased over the past several decades, especially in dryland areas.

- Source: Burrell et al., 2018, Gichenje and Godinho, 2018, Hellden and Tottrup, 2008.

- Land degradation has reduced 23 % of the terrestrial ecosystem productivity,
- but 3 Pg C yr^{-1} could be stored up by restoring the degraded land.

- Source: Arora, 2019

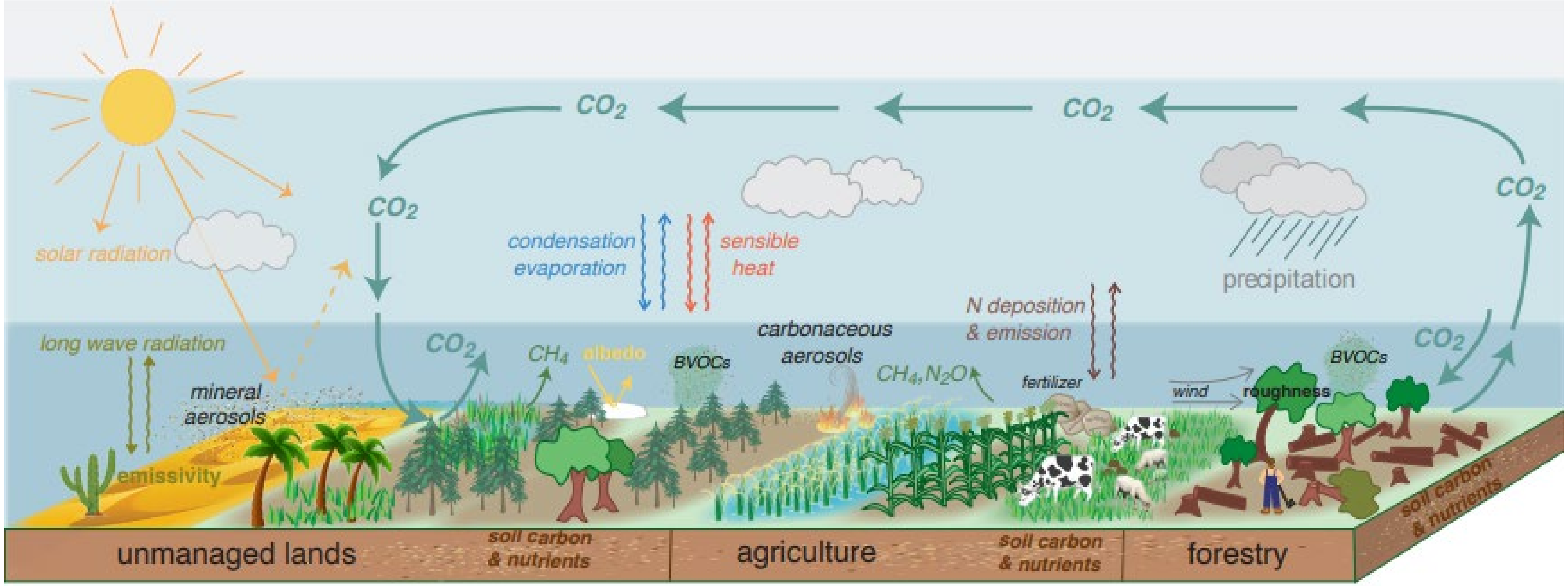
[Li, Saibo. 2023]()

What is Land

The terrestrial portion of the biosphere that comprises

- the natural resources (soil, near surface air, vegetation and other biota, and water),
- basic processes that fundamentally sustain the supply of food, bioenergy and freshwater, and the delivery of multiple other ecosystem services and biodiversity.

(Henry et al. 2018, adapted from FAO 2007; UNCCD 1994).



ecosystem-Climate interaction

Source: IPCC SRCCL Technical Summary (2019)

Potential options for adoption to climate change

Sector wise adaptation options	Climate extremes			
	Drought/drying	Increased rainfall/flooding	Warming/heatwaves	Wind speed/storminess
Crops	• Drought resistant varieties • Intercropping • Crop diversification • Crop residue retention • Weed management • Water harvesting • Hydroponic farming • Alternate wetting and drying	• Changes in sowing time • Promotion of alternative crops • Floating agricultural systems • Improved drainage • Improved extension services	• Heat resistant varieties • Alteration of cropping calendar and activities • Pest control • Crop surveillance • Irrigation	• Wind resistant crops • Agroforestry
Livestock	• Supplementary feeding • Change in stocking rate • Altered grazing and rotation of pasture	–	• Housing and shade provision • Change to heat-tolerant breeds	–
Water	• Water budgeting • Water conservation via mulching • Water recharge techniques • Leak reduction • Education for sustainable water use	• Flood forecasting • Early warning systems • Insurance	• Sustainable water use • Water conservation • Cover cropping	–

IPCC2007, 2014a

Climate Change 2001-2017

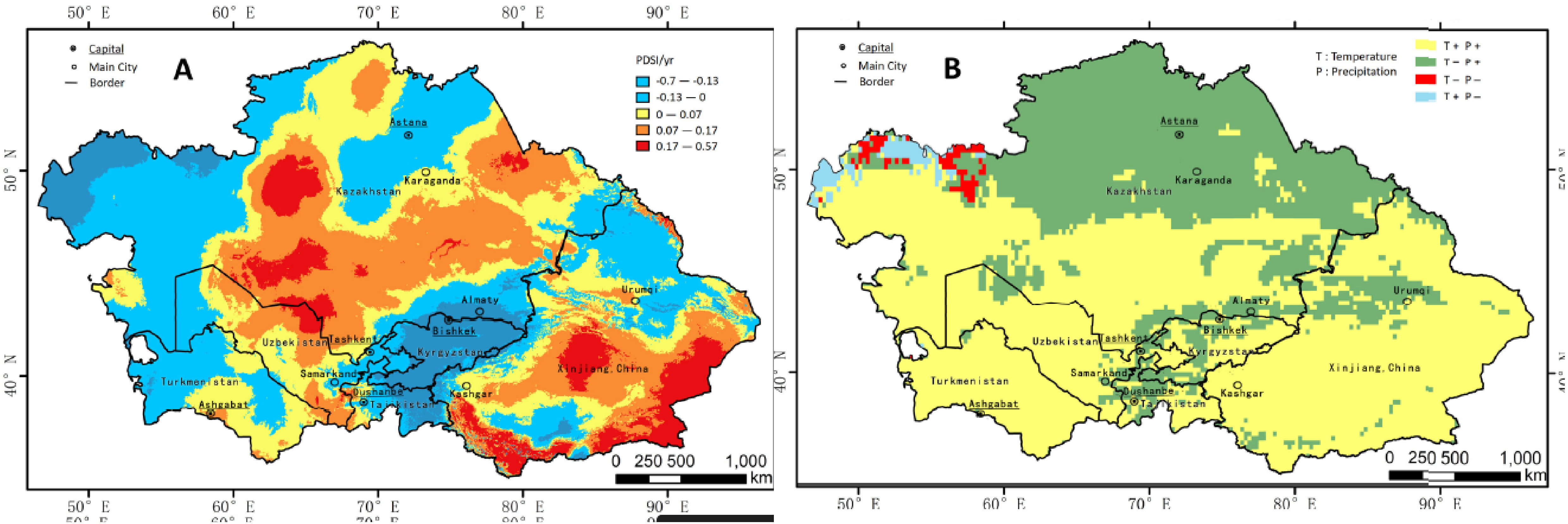


Figure 10. Spatial pattern of climate change in Central Asia from 2001 to 2017. (**A**) Change in the PDSI, PDSI/yr indicates the slope of the change in the annual average PDSI. (**B**) Temperature-precipitation change zoning map. +/− indicates that the slope of the change in the annual average temperature or annual precipitation is greater or less than 0.

Source: Yunfeng Hu and Yang Hu 2019 **Land Cover Changes and Their Driving Mechanisms in Central Asia from 2001 to 2017 Supported by Google Earth Engine**

Land cover change and surface water bodies change

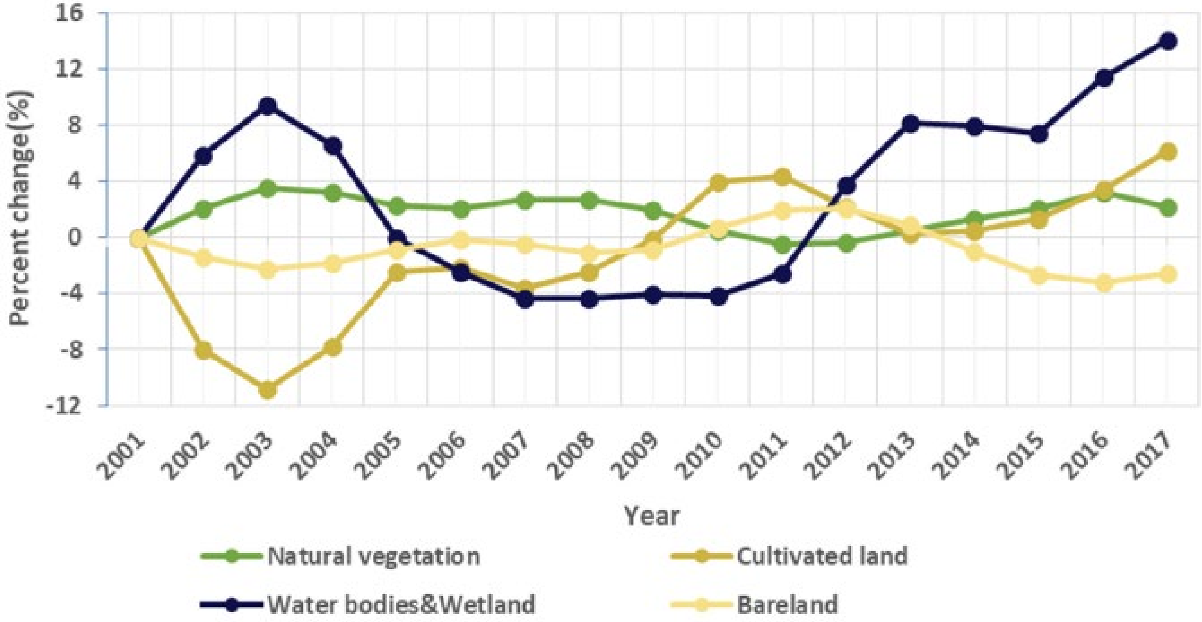


Figure 7. Rate of land area change for various land cover types in the study area from 2001 to 2017. The rates indicate the rate of change of area in a certain year relative to 2001.

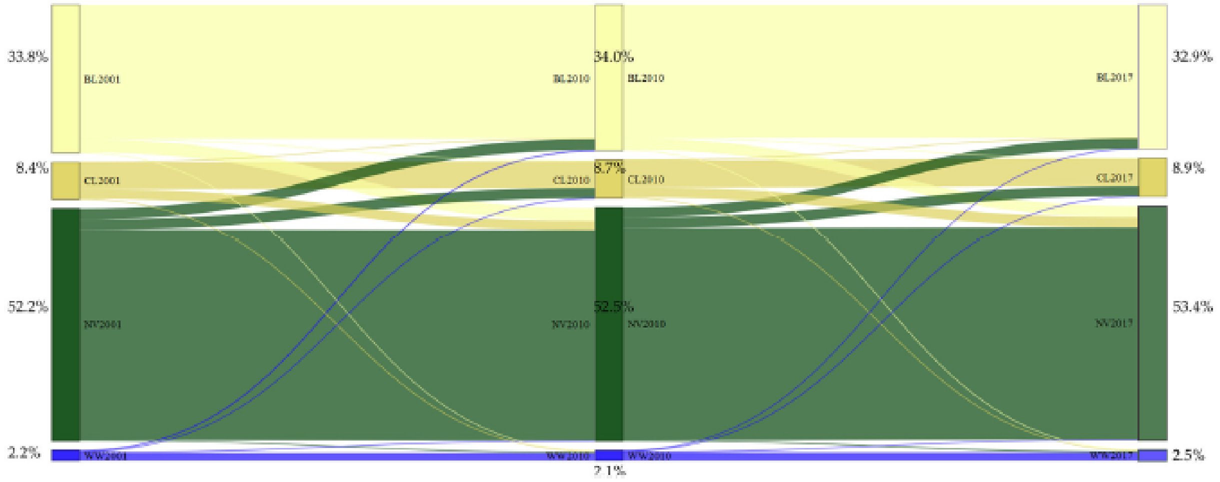
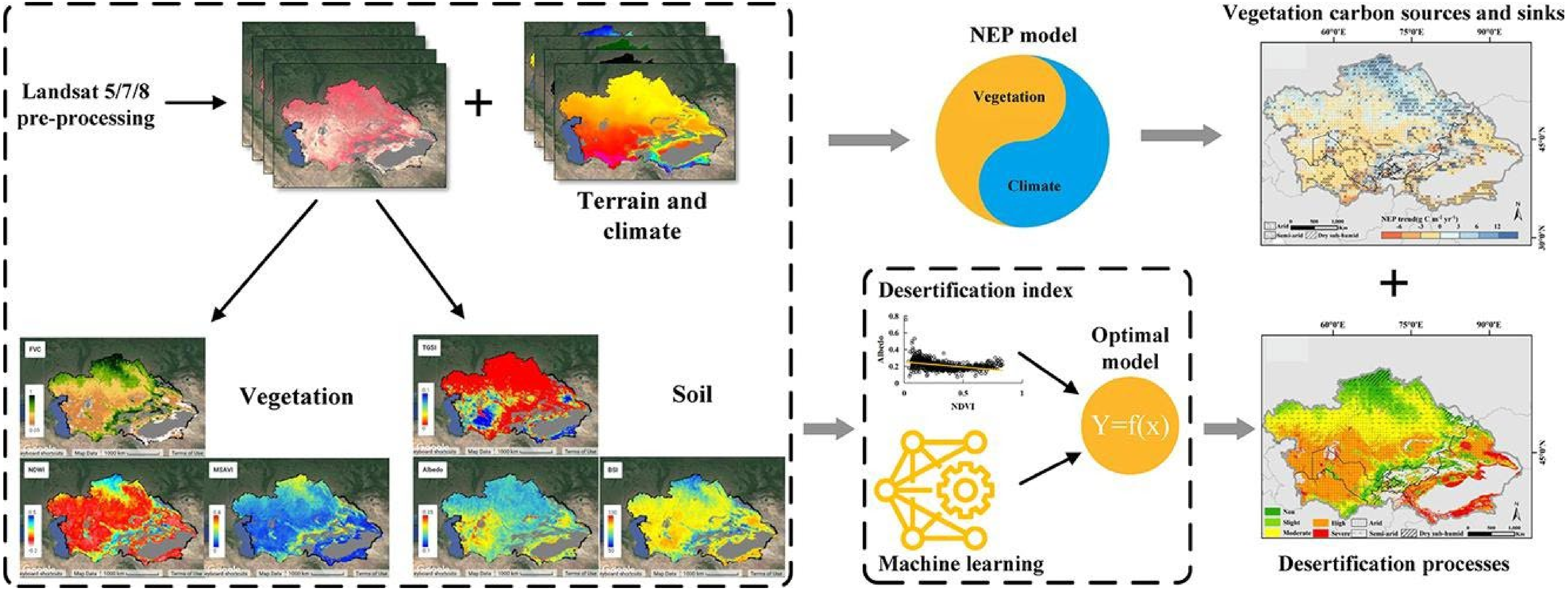


Figure 8. Sankey plot showing changes from one land use land cover class to another between 2001, 2010 and 2017. The numbers beside boxes indicate the percentage of the area of the land cover type based on the total study area. BL: Bareland, CL: Cropland, NV: Natural vegetable, WW: Water bodies&Wetland.

Source: Yunfeng Hu and Yang Hu 2019 **Land Cover Changes and Their Driving Mechanisms in Central Asia from 2001 to 2017 Supported by Google Earth Engine**

Central Asia: Desertification process and Biomass Carbon



[Li, Saibo. 2023 Desertification process and its effects on vegetation carbon sources and sinks vary under different aridity stress in Central Asia during 1990–2020]()

Desertification process and Biomass Carbon Dynamics in Central Asia

Desertification area has decreased by 8.58 % (341,643 km^2) from 1990 to 2020.

- ➢severe and slight: decreased by 62.42 % and 32.11 %,
- ➢moderate and high: increased by 24.6 % and 13.11 %,

- Net ecosystem production (NEP):

- ➢Trends: increase at a rate of 0.54 g C m^{-2} yr^{-1} during 1990–2020,
- ➢Area passed the *t*-test ($p < 0.05$): Kazakh Steppe, Kazakh Uplands, and the edge of Tianshan Mountains.
- ➢Restored 61.08×10^3 t carbon, accounting for 59.61 % of the total net change of NEP,

- but the fragile ecological environments in the existing desertification areas have been further aggravated.

Central Asia

- Anthropogenic induced land degradation and its related **soil carbon loss in the past created a carbon sink capacity** that now could be filled by carbon sequestration through restoration and adaptive sustainable land management practice.

- With current temperatures raising and precipitation increasing patterns and CO_2 fertilization effects, it might suggest **a narrow window time up** to mid of this century,2050s, most favorable to ecosystem restoration and carbon farming, when the glacier melting run flow is not get turning point of reduction.

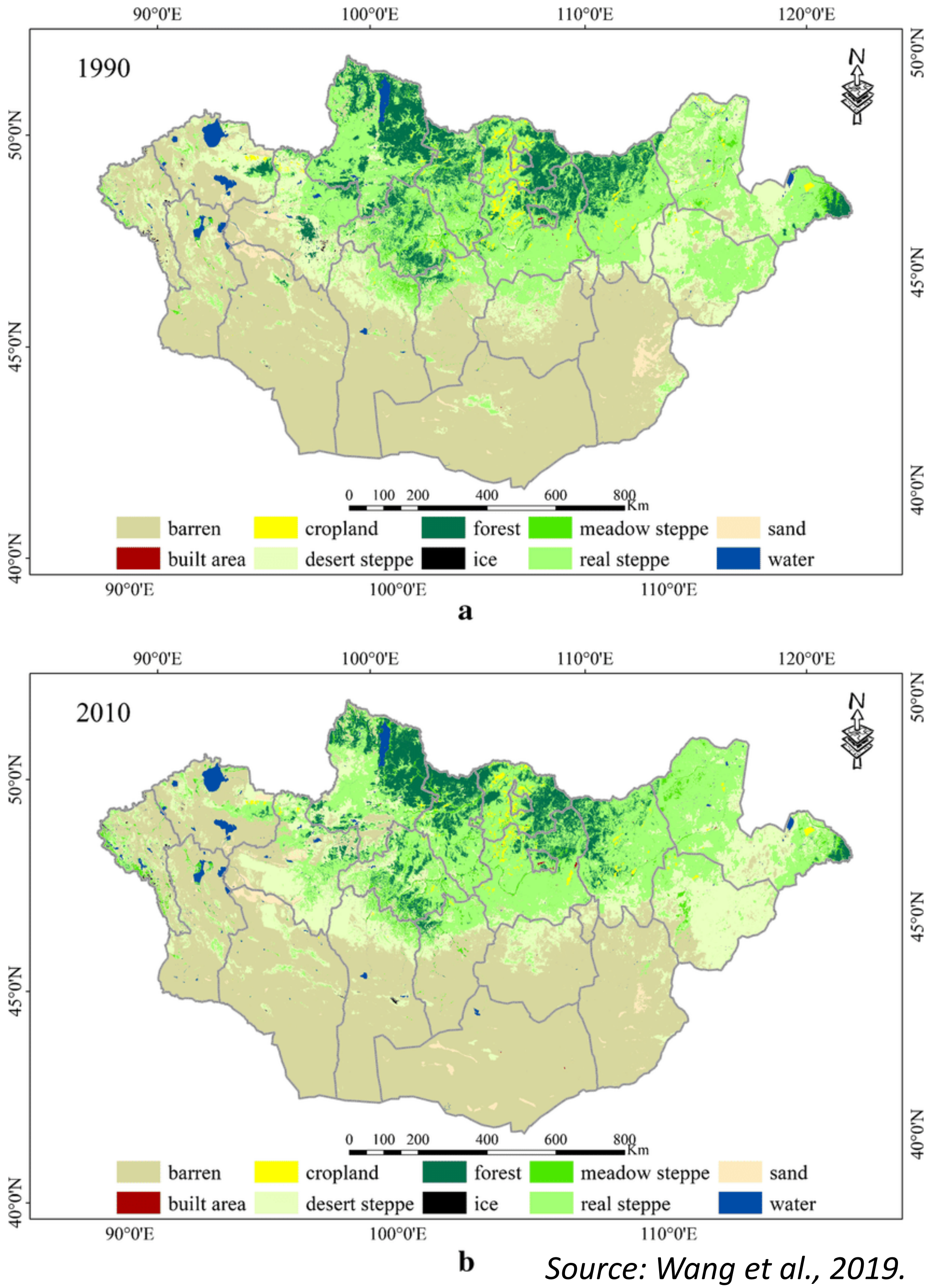
- With ecosystem restoration and carbon sequestration, the region may create and contribute to climate change mitigation.
- **buffering feedback to climate change**

Land Use of Mongolia

Figure: Barren and grassland were the dominant land cover types, comprising 48.68% and 42.85%, respectively, followed by forest (6.63%), water (1.14%), cropland (0.60%), ice (0.07%), and built area (0.03%). The distribution of barren was relatively concentrated, mainly in Southern and Western Mongolia.

Table: Rate of vegetation cover in Mongolia.

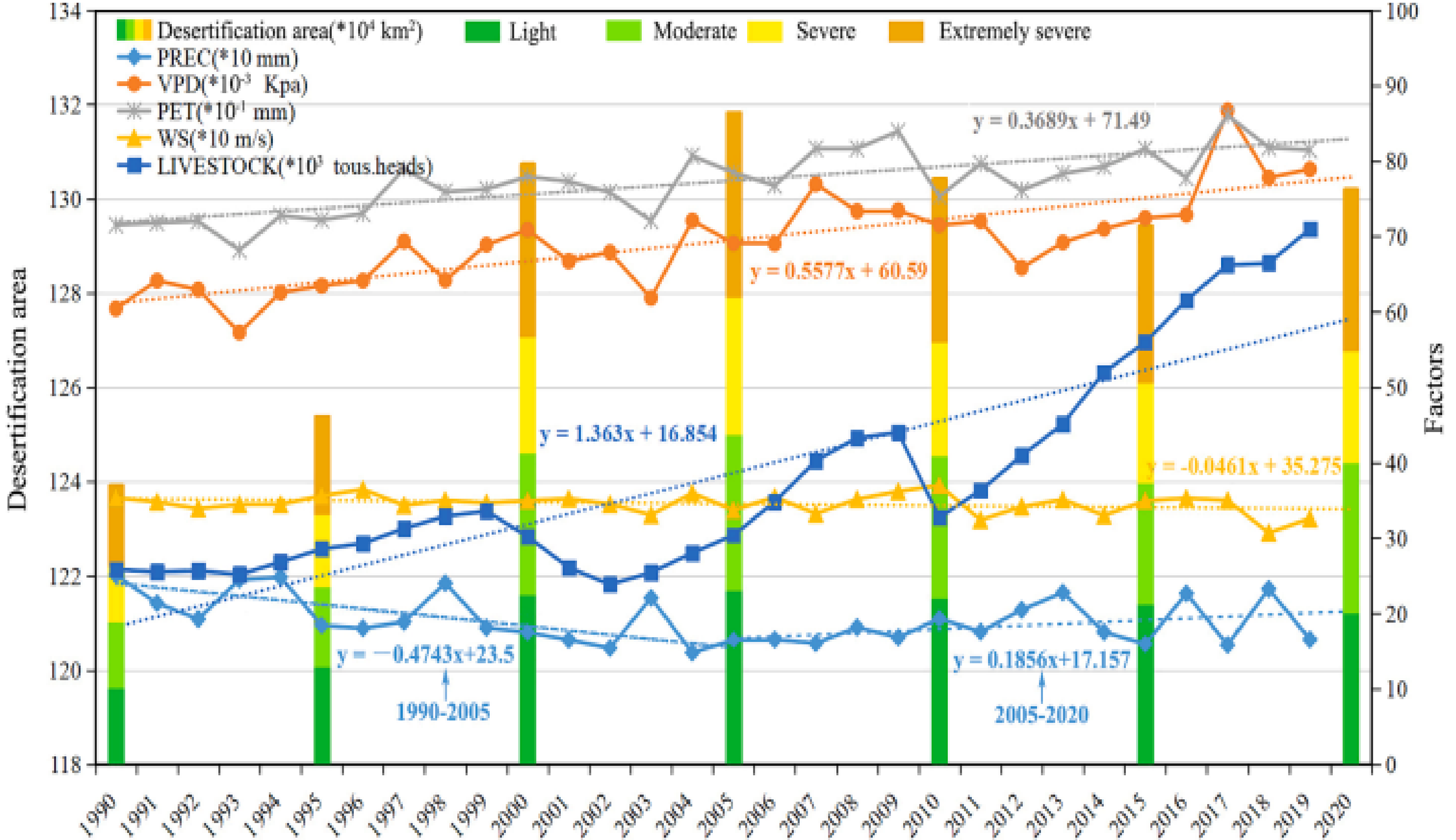
Level	Landscape description	Vegetation cover (%)
Light	Local vegetation is degraded, and patchy sandy areas appear (5–25%)	50–70
Moderate	Vegetation is scattered, and degraded land accounts for 25–50%	10–50
Severe	The degraded area exceeds 50%. Vegetation is sparse	1–10
Extremely severe	Vegetation cover is < 10%. Mobile sandy soil is widely distributed	< 1



Source: Wang et al., 2019.

Variations in Desertification Area in Mongolia

Variations in desertification area, annual mean precipitation, vapor pressure deficit, potential evapotranspiration, wind speed, and livestock number in Mongolia during 1990–2020. Different colors indicate the proportions of different desertified land areas in separate histograms.

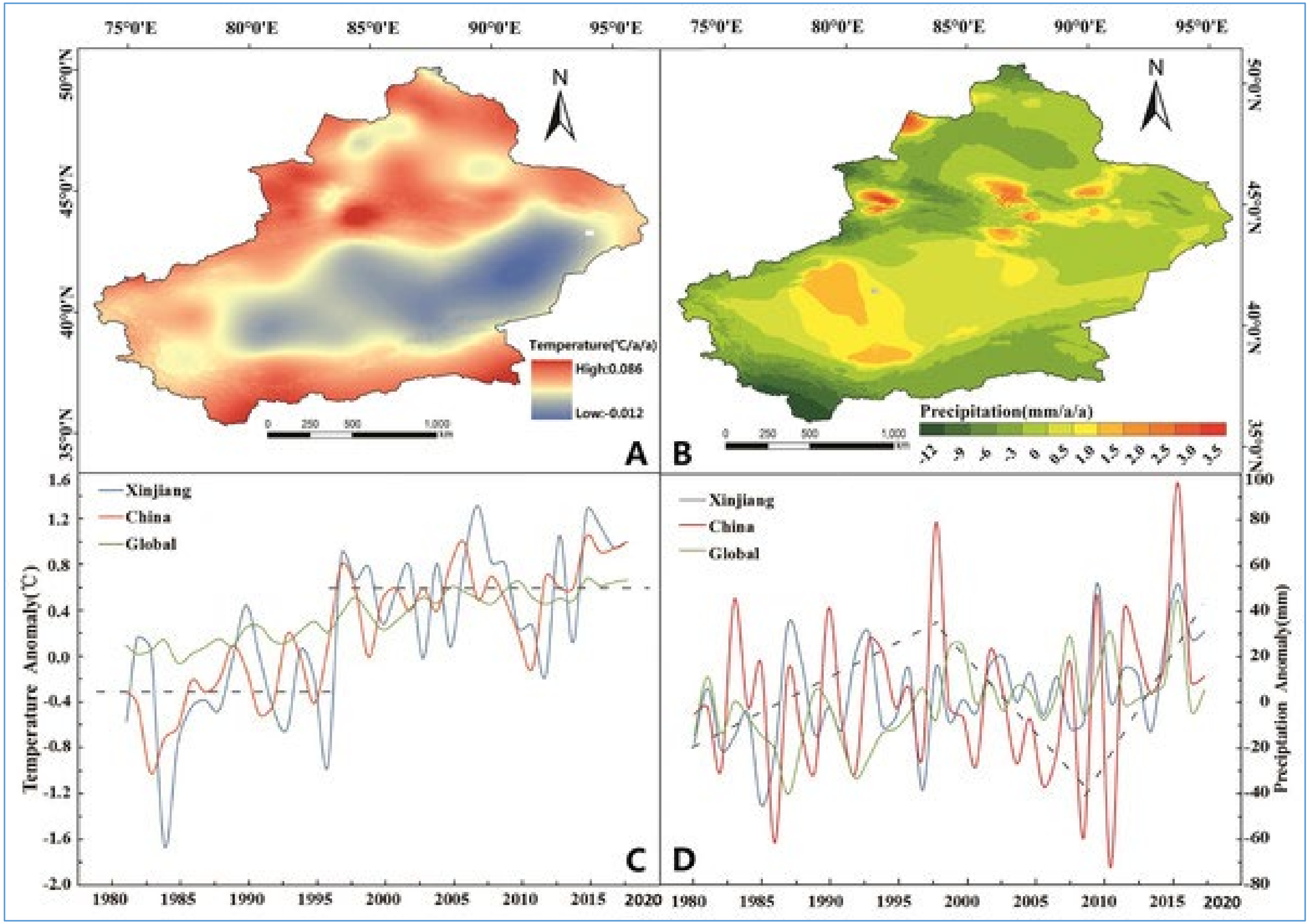


Source: Meng et al.,2021

Spatiotemporal Changes in Temperature and Precipitation of Xinjiang

Figure: The spatiotemporal changes in temperature and precipitation during 1981–2018.

(A) Trend of temperature in Xinjiang. (B) Trend of precipitation in Xinjiang. (C) Annual temperature anomalies of Globe, China and Xinjiang. (D) Annual precipitation anomalies of Globe, China and Xinjiang

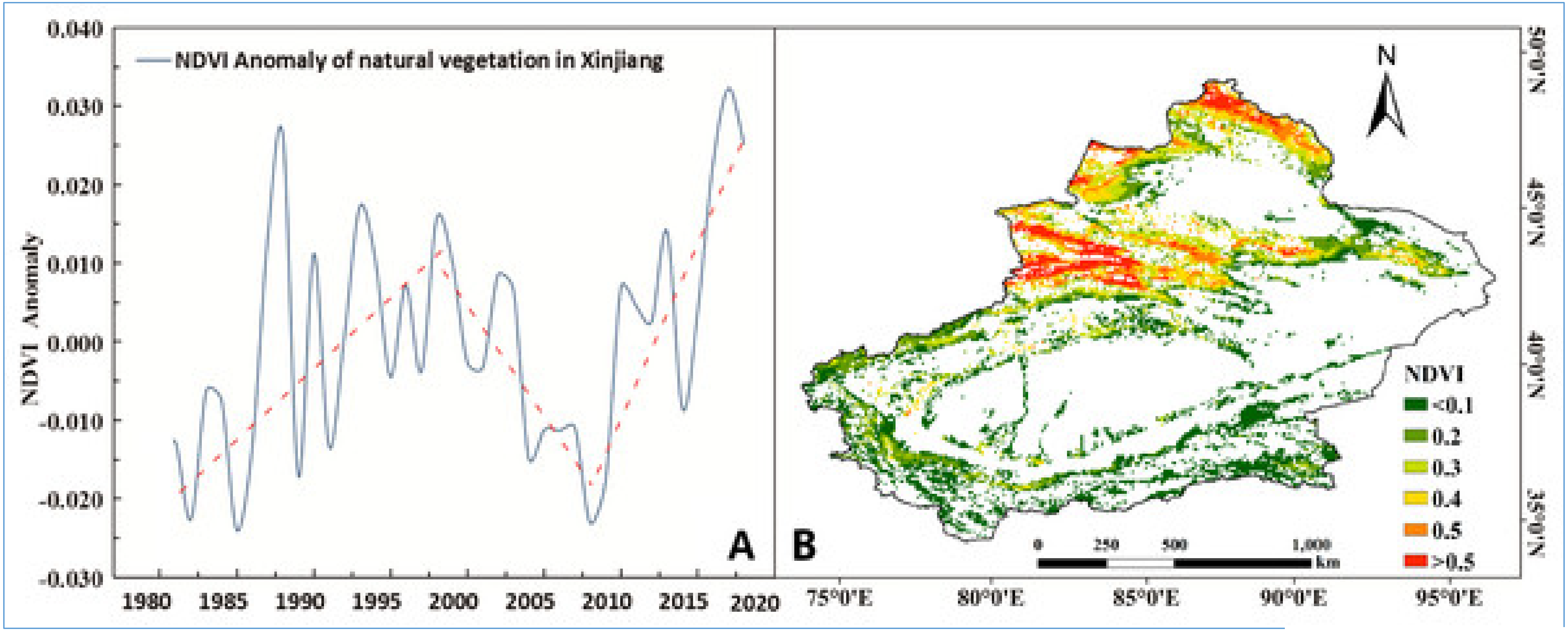


Sources: Zhuang et al., 2020

Spatiotemporal NDVI Changes in Xinjiang

Figure: Spatiotemporal changes in the annual NDVI in Xinjiang from 1981 to 2018.

(A) Anomalies in the annual NDVI of natural vegetation in Xinjiang. (B) Distribution of the natural NDVI in Xinjiang.



Sources: Zhuang et al., 2020

- The **magnitude of the projected aridity trends and the regional variations needs further assessment**.

- A clearer understanding is necessary of **what the changes in aridity will mean for impact risk**.

- An evaluation of **adaptation approaches to reduce associated risk** can provide Parties with **guidance on how to respond to these increased impact risks**.

SPI Objective 2 of the SPI work programme

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Table 1

Objectives and deliverables of the Science-Policy Interface work programme 2022–2024

Objective	*Deliverable*
2. Provision of science-based evidence on the historical regional and global aridity trends and future projections that may contribute to expanding drylands and affected populations and the adaptation approaches that reduce risks to environmental, social and economic systems.	A technical report, based on a review of existing synthesis reports and the primary literature, which provides (a) science-based evidence on the existing approaches for the quantification and assessment of hydro-climate aridity; (b) the determination of its regional and global changes and future projections; (c) the resulting historical changes and future projections in impact risk, including from extreme heat events, drought and dust storms as well as higher risk of desertification, water scarcity, soil erosion, vegetation loss, wildfire damage and food supply disruptions; and (d) an evaluation of adaptation approaches that can reduce associated risk.
	Provision of scientific assistance to the secretariat and the Global Mechanism to support decisions on the technical feasibility of initiatives focused on building resilience to the effects of drought.

✓ Framing of the SPI Objective to define the focus and scope

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- **Science-based evidence** on the historical regional and global aridity trends and future projections that may contribute to expanding drylands and affected populations and the adaptation approaches that reduce risks to environmental, social and economic systems.
- **Focus: physical aridity trends** (hydro-climate aridity) trends, projections and impacts

Sections of the SPI Obj. 2 technical report

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a) **Science-based evidence on the existing approaches for the quantification and assessment of hydro-climate aridity**
b) Determination of its regional and global changes and future projections;
c) the resulting historical changes and future projections in impact risk, including from extreme heat events, drought and sand & dust storms as well as higher risk of desertification, water scarcity, soil erosion, vegetation loss, wildfire damage and food supply disruptions; and
d) an evaluation of adaptation approaches that can reduce associated risk

General Assembly Proclaims 12 July International Day of Combating Sand and Dust Storms,

SEVENTY-SEVENTH SESSION ON 8 JUNE 2023

- Aiming to Raise Awareness about Importance for Health, Sustainability
- Promote sustainable land use and managing
- Enhancing food security and resilience to climate change and sustainable livelihood

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Thank you!

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