- Mitigation and adaptation
- Methane

Black Carbon

Climate Active Pollutants = CAP

Intersting because it is a good way to act on a component that is **relatively quickly responding** in terms of climate time scale.

Greenhouse gas	Atmospheric survival time
CO_2	100-1000 years
CH_4	10 years
N_2O (laughing gas)	150 years
Black Carbon, CAP	5 years

Black Carbon is very bad for women and children's health and it is a climate active gas.

Black Carbon is generally generated by partial combustion of organic matter.

CO-BENEFITS: what is good for climate is good for health.

Health and climate change: policy responses to protect public health

Nick Watts, W Neil Adger, Paolo Agnolucci, Jason Blackstock, Peter Byass, Wenjia Cai, Sarah Chaytor, Tim Colbourn, Mat Collins, Adam Cooper, Peter M Cox, Joanna Depledge, Paul Drummond, Paul Ekins, Victor Galaz, Delia Grace, Hilary Graham, Michael Grubb, Andy Haines, Ian Hamilton, Alasdair Hunter, Xujia Jiang, Moxuan Li, Ilan Kelman, Lu Liang, Melissa Lott, Robert Lowe, Yong Luo, Georgina Mace, Mark Maslin, Maria Nilsson, Tadj Oreszczyn, Steve Pye, Tara Quinn, My Svensdotter, Sergey Venevsky, Koko Warner, Bing Xu, Jun Yang, Yongyuan Yin, Chaoqing Yu, Qiang Zhang, Peng Gong*, Hugh Montgomery*, Anthony Costello*

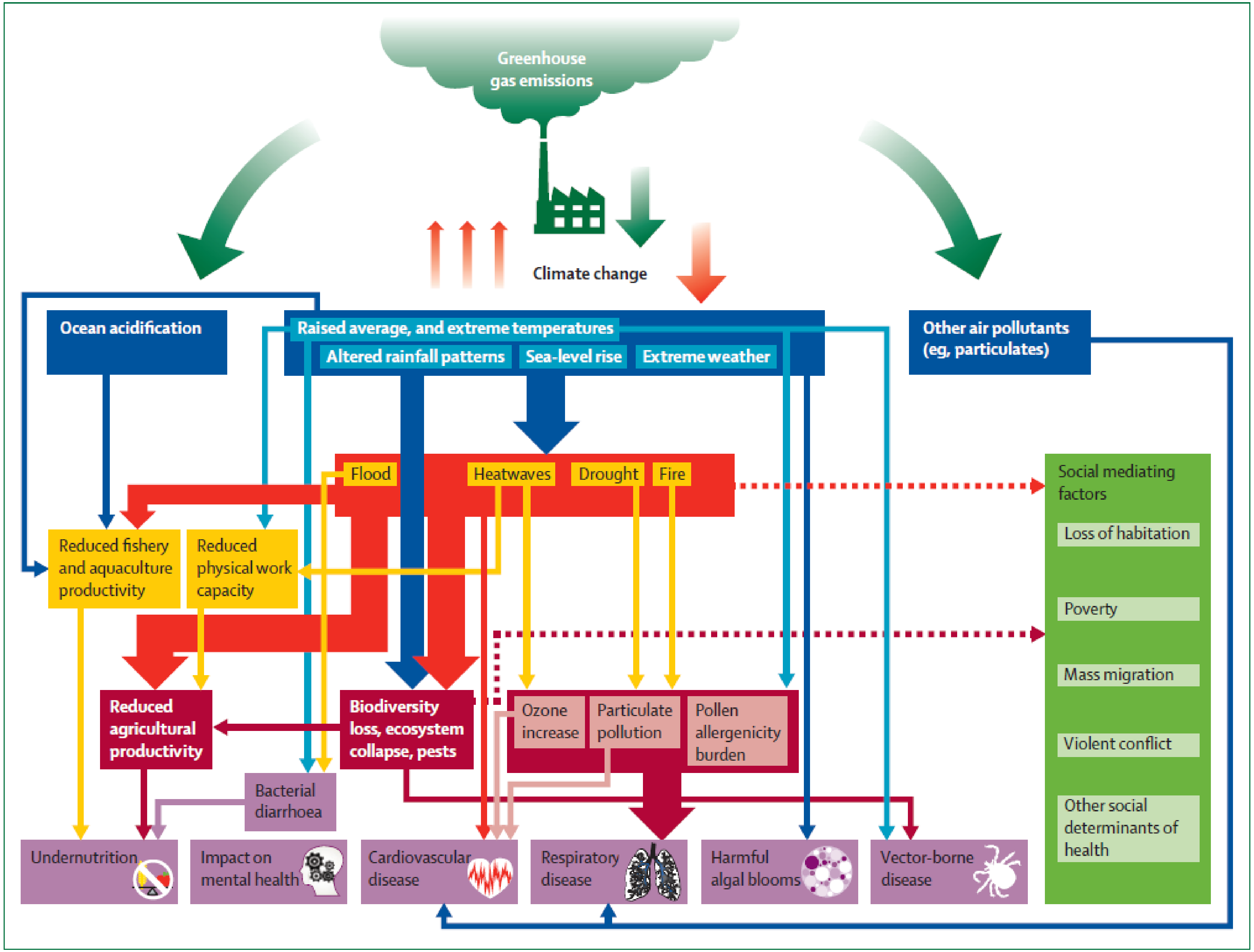


Figure 1: An overview of the links between greenhouse gas emissions, climate change, and health
The causal links are explained in greater detail in the section about climate change and exposure to health risks.

Health and climate change: policy responses to protect public health

Nick Watts, W Neil Adger, Paolo Agnolucci, Jason Blackstock, Peter Byass, Wenjia Cai, Sarah Chaytor, Tim Colbourn, Mat Collins, Adam Cooper, Peter M Cox, Joanna Depledge, Paul Drummond, Paul Ekins, Victor Galaz, Delia Grace, Hilary Graham, Michael Grubb, Andy Haines, Ian Hamilton, Alasdair Hunter, Xujia Jiang, Moxuan Li, Ilan Kelman, Lu Liang, Melissa Lott, Robert Lowe, Yong Luo, Georgina Mace, Mark Maslin, Maria Nilsson, Tadj Oreszczyn, Steve Pye, Tara Quinn, My Svensdotter, Sergey Venevsky, Koko Warner, Bing Xu, Jun Yang, Yongyuan Yin, Chaoqing Yu, Qiang Zhang, Peng Gong*, Hugh Montgomery*, Anthony Costello*

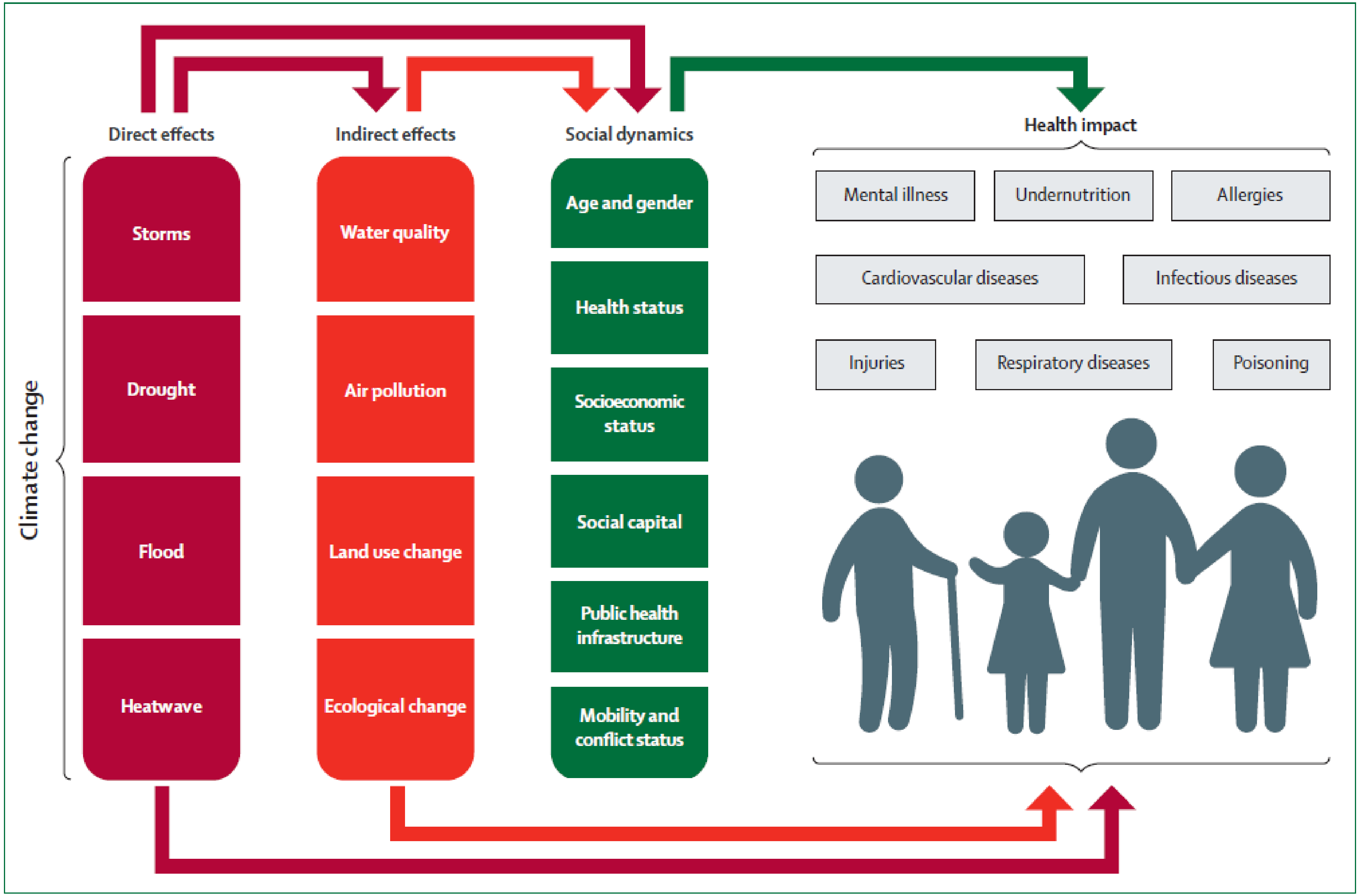
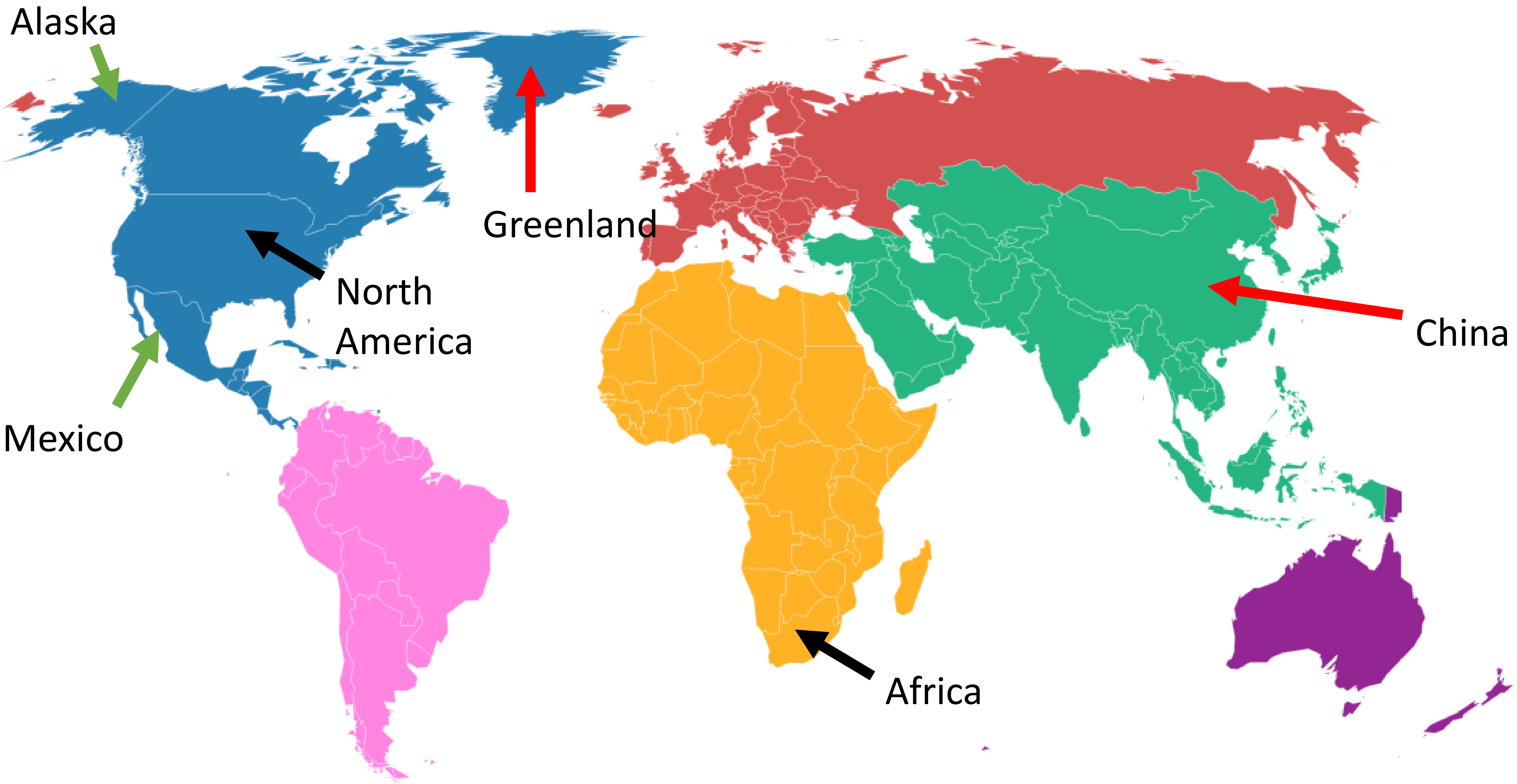


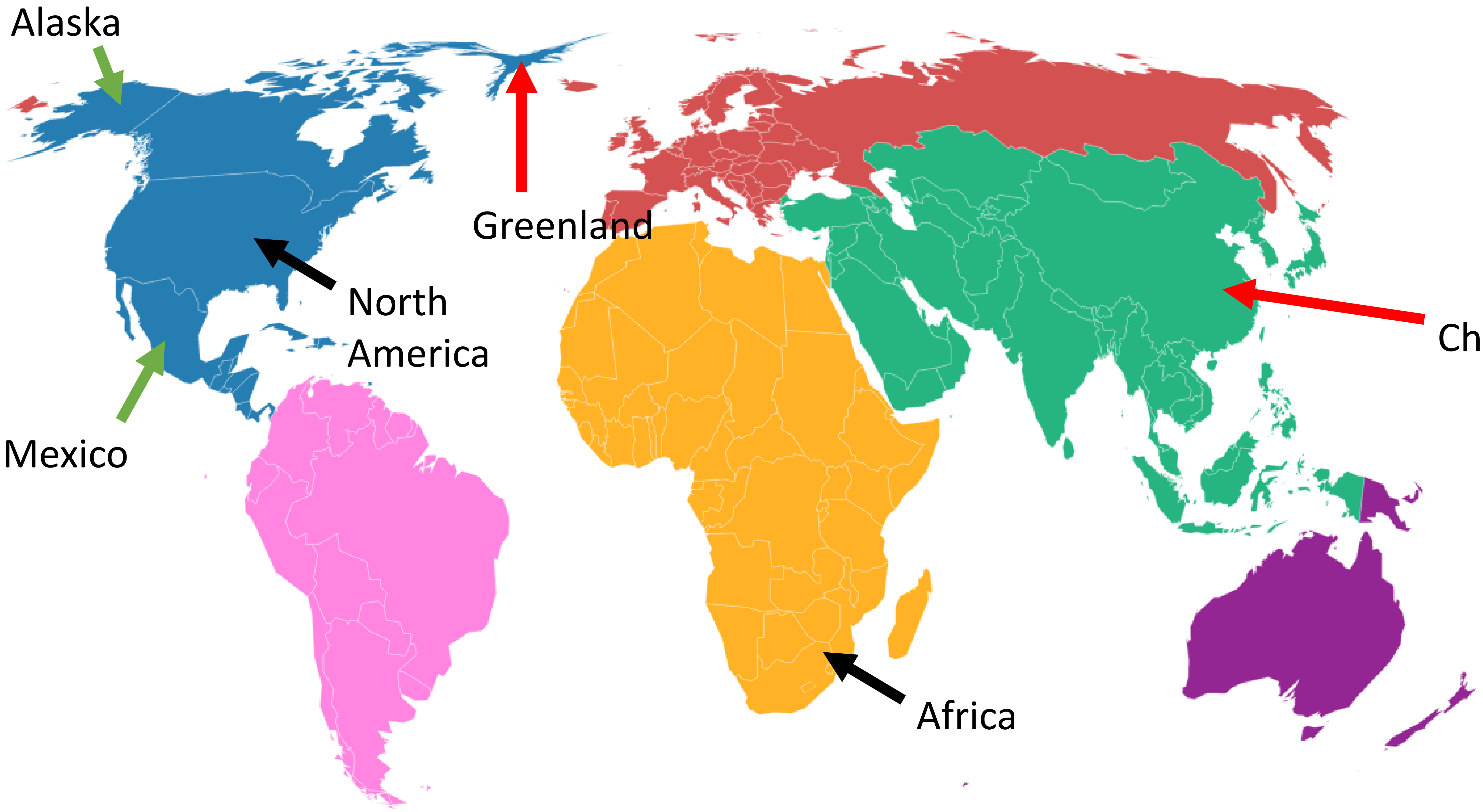
Figure 2: **The direct and indirect effects of climate change on health and wellbeing**
There are complex interactions between both causes and effects. Ecological processes, such as impacts on biodiversity and changes in disease vectors, and social dynamics, can amplify these risks. Social responses also ameliorate some risks through adaptive actions.

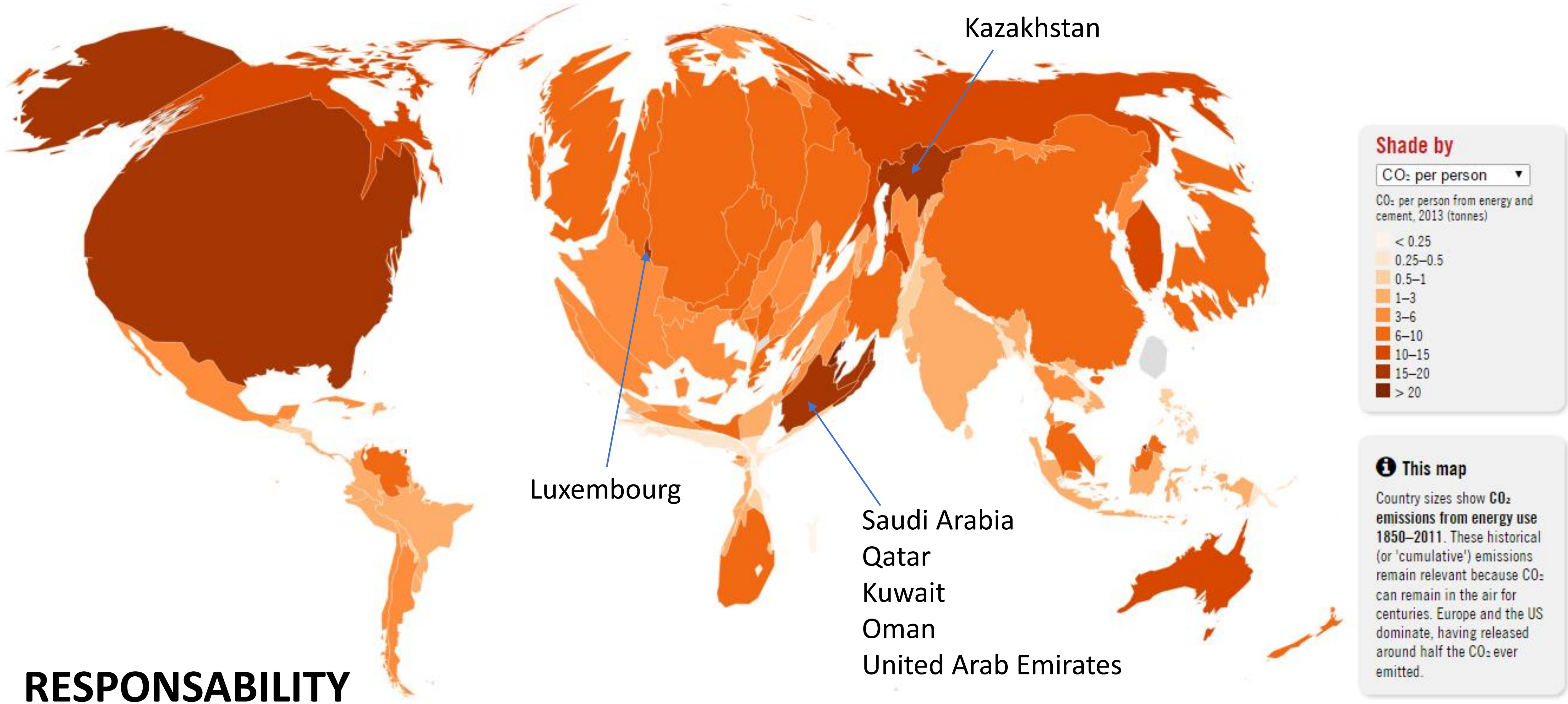
General Introduction – how we usually look at the map



www.carbonmap.org

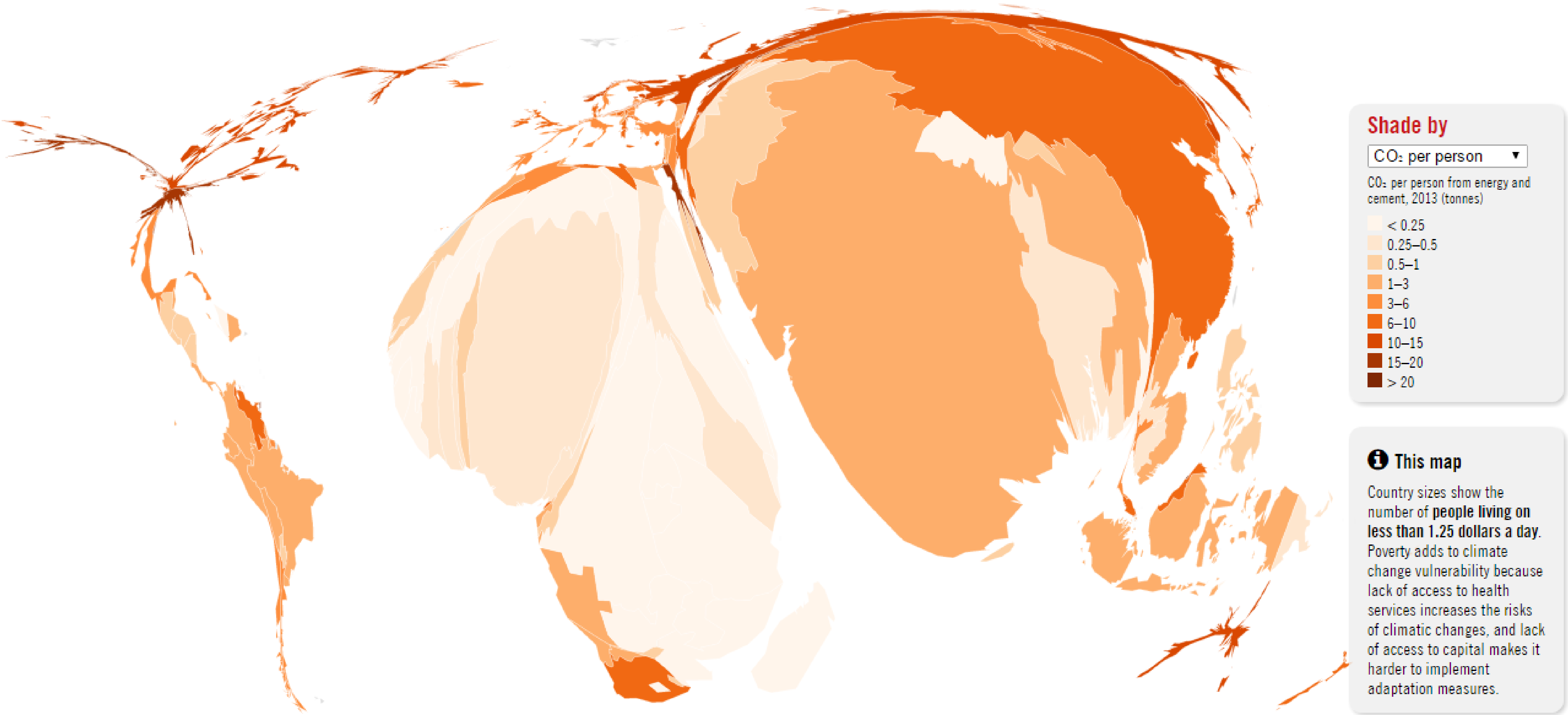
General Introduction – proportionally to the area





<u>RESPONSABILITY</u>

How countries have contributed to emissions and northern are dominating

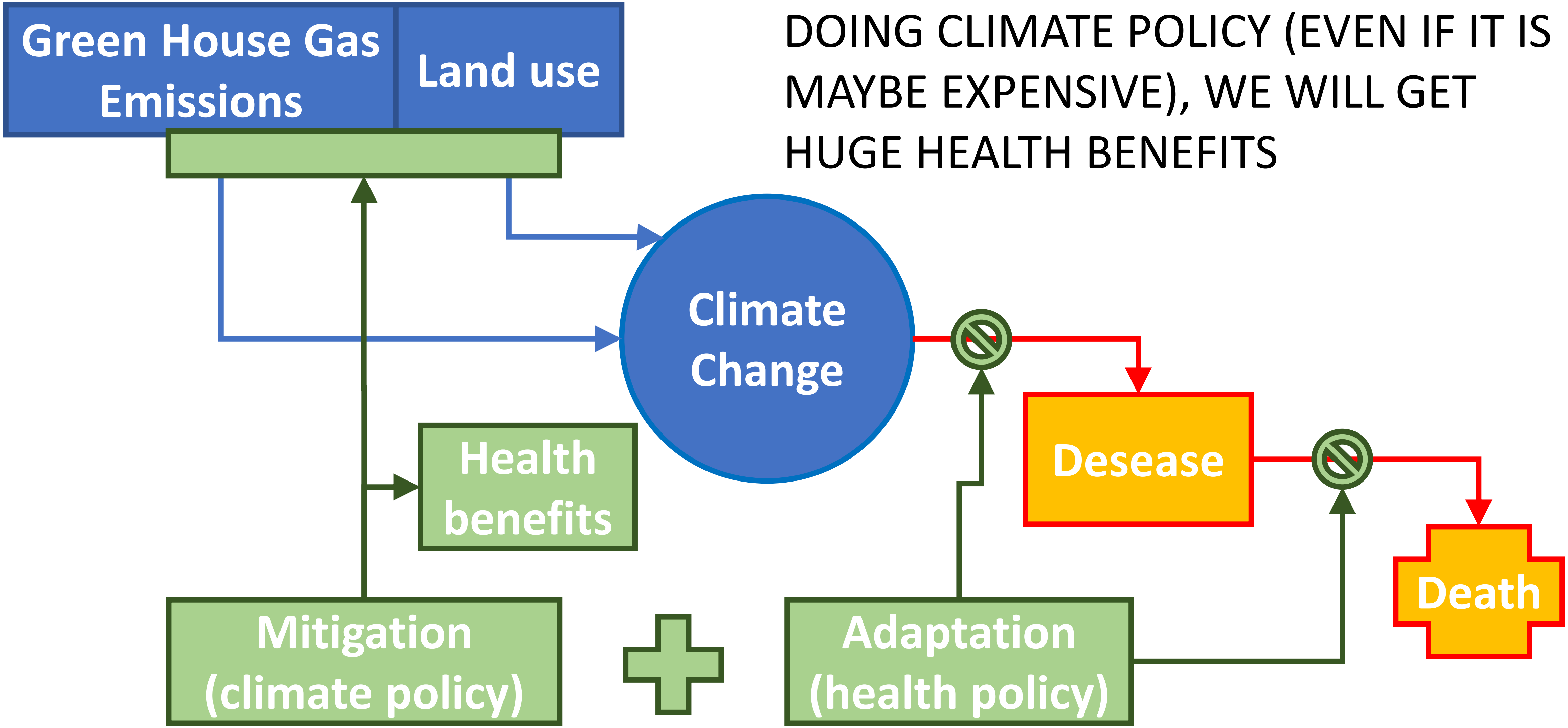


Poverty and similar results if you consider health

- We fear that the gain in development that we have achieved could be reversed by climate change

Policy goal	Climate policy term	Health policy term
Measures to counter the root causes of a problem	Mitigation	Primary prevention
Measures to address a problem as early as possible	Adaptation after early warming	Seconary prevention (diagnoses of early stage diseases, screening)
Measures to manage the inflicted damage	Adaptation	Tertiary prevention (tratement and reahabilitation)

THE BEAUTY OF MITIGATION, BY DOING CLIMATE POLICY (EVEN IF IT IS MAYBE EXPENSIVE), WE WILL GET HUGE HEALTH BENEFITS



https://cop23.com.fj/mitigation-adaptation-resilience/

Mitigation: Slowing the rate of global warming

The nations of the world are committed by the Paris Agreement to reduce global emissions of greenhouse gases by 40% by 2030. **Each nation has filed its own plan to reduce emissions in its own territory, known as Nationally Determined Contributions.** But this commitment will not stop global warming; it will only reduce the rate at which the earth is warming. Top policy makers and corporate leaders must think about how to meet the Paris Agreement's targets from a legislative, technological, business, and even political perspective. In other words, there is no silver bullet to overcome increasing global temperatures. More ways must be found to reduce greenhouse gases in the earth's atmosphere. **Decision makers at all levels need to recommit to finding ways to reduce even further the greenhouse gases that are released into the atmosphere.**

Adaptation: Taking steps to live with the effects of global warming

Our economies, our well-being, and in some cases, our abilities to continue living on the land we occupy will depend on how well we adapt to climate change. **Adaptation can take many forms. Some communities may decide to build dikes, levees or sea walls to hold back water; others may want to move people and economic activity out of flood-prone areas. Farmers may choose to grow crops that are more suitable to warmer temperatures than the crops they are growing now, or that are more resistant to periods of drought.** Communities that have never had to consider saving water may have to develop systems to hold rain water or mountain runoff for periods of drought. And many communities, particularly in the developing world or in tropical climates, may have to adjust their building codes so that homes, schools and public buildings can withstand more severe weather events.

Resilience: Nations need to become more resilient to the effects of climate change

Resilience means the key economic and social systems are climate-proofed for the future. It is not a question of if, but when: When the next storm hits, how prepared will you be? This issue is being addressed by communities around the world who are seeking—and finding—ways to be more resilient following a major natural disaster. **Nations need to become more resilient to the effects of climate change.** For example, flooding is the most costly and frequent natural disaster in many places around the world. The adoption of policy mandates that will provide flood insurance for high-risk areas is one answer. Those mandates can raise awareness among citizens and give peace of mind to those who need to be financially protected. But **insurance** against flood and storm damage can be prohibitive for the private sector alone, particularly in developing countries where housing construction may be relatively weak and many people don't have the means to acquire it. Private and public partnerships can help mitigate some of the worst effects of natural disasters amplified by climate change by pooling resources and coming up with solutions that address what happens before, during, and after an extreme weather event. Resources can be made available to strengthen homes and other structures to better withstand extreme storms. And infrastructure for temporary evacuation and sheltering of vulnerable populations can be developed. But it is not just about extreme weather. Climate change is slow and inexorable, but the exact nature of the effects can be unpredictable. With rising temperatures around the globe comes more responsibility from the top down. How we consume our natural resources and integrate more proactive and continuous community planning will be instrumental in how resilient we are.

CO-BENEFITS

EXAMPLES

1. Reduce transport by car = less emission and fitter population

2. Clean fuels = less emissions and reduce risk of disease for women

- Around 3 billion people cook and heat their homes using open fires and simple stoves burning biomass (wood, animal dung and crop waste) and coal.
- Over 4 million people die prematurely from illness attributable to the household air pollution from cooking with solid fuels.
- More than 50% of premature deaths due to pneumonia among children under 5 are caused by the particulate matter (soot) inhaled from household air pollution.
- 3.8 million premature deaths annually from non-communicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer are attributed to exposure to household air pollution.

https://thevision.com/habitat/bicicletta-ecologica-inquinamento/

https://www.pinbike.it/

HABITAT

LA BICICLETTA NON INQUINA, È ECONOMICA E PRODUCE RICCHEZZA. PERCHÉ CI OSTINIAMO A USARE L'AUTO?

DI SILVIA GRANZIERO 17 APRILE 2019

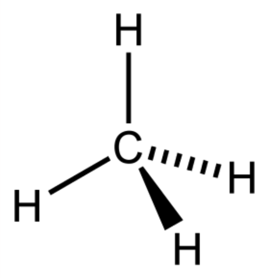
Share Tweet

Oggi è uno dei mezzi che usiamo per combattere il surriscaldamento globale. Eppure la bicicletta fu inventata nel 1817 per ovviare alla moria di cavalli dovuta alla carestia dell'"anno senza estate" – il 1816 – causata dall'esplosione di un vulcano in Indonesia, che l'anno prima offuscò il cielo sconvolgendo gli equilibri termici facendo precipitare la temperatura media del pianeta. Oggi la bici è uno dei nostri migliori alleati per limitare le emissioni inquinanti prodotte dalle auto.

In Europa tra il 2000 e il 2016 la concentrazione di polveri sottili nell'aria ha registrato un calo graduale. Considerando che il trasporto su strada è una delle sue principali cause e che il volume dei passeggeri è rimasto costante, ciò significa che sta migliorando la sostenibilità dei mezzi di trasporto. La strada verso l'obiettivo europeo delle zero emissioni nette entro il 2050 è lunga, ma diventa più facile seguirla se è vero che per i *millenial* l'automobile non sembra più avere l'attrattiva di uno *status symbol*. E, tra ingorghi e i semafori, non è nemmeno più l'emblema della velocità. Tuttavia, a gennaio di quest'anno, sulla base dei dati del ministero dello Sviluppo Economico, in Italia si è calcolato un aumento del 3,5% delle emissioni dovute a benzina e gasolio rispetto a gennaio 2018. Secondo i dati del rapporto della *European Environment Agency* sulla qualità dell'aria in Europa, il nostro Paese l'anno scorso è risultato tra i peggiori a livello europeo per superamento (sia giornaliero che annuale) dei limiti del PM10 . È urgente trovare un equilibrio tra il bisogno di spostarsi in città e la volontà che queste diventino luoghi in cui sia sano (e piacevole) vivere.

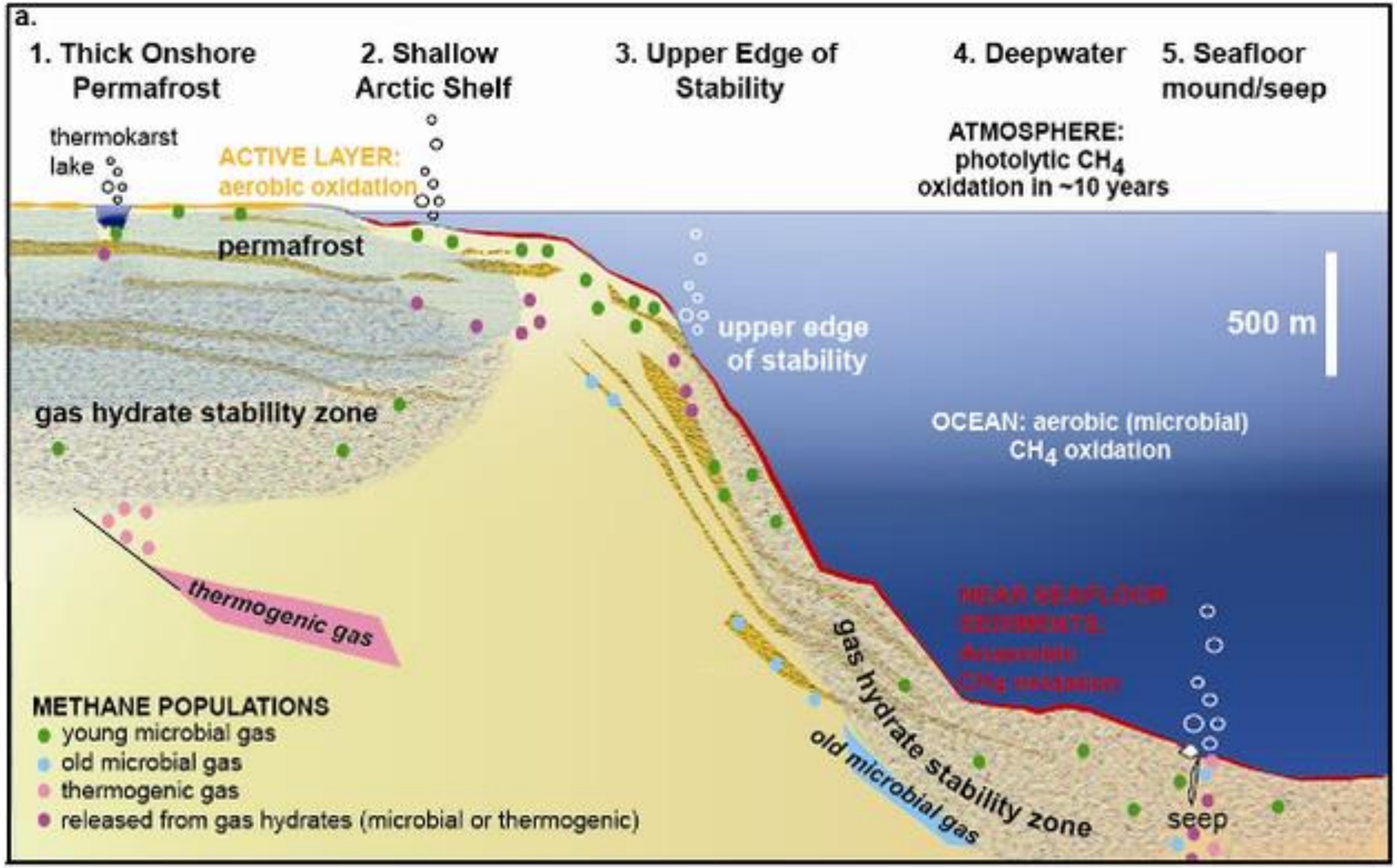
Greenouse gas	Atmospheric survival time
CO_2	100-1000 years
CH_4	10 years
N_2O (laughing gas)	150 years
Black Carbon, CAP	5 years

METHANE (CH_4)



- Methane **is the primary component of natural gas**, a common fuel source.
- If methane is allowed to leak into the air before being used—from a leaky pipe, for instance—**it absorbs the sun's heat**, warming the atmosphere. For this reason, it's considered a greenhouse gas, like carbon dioxide.
- While methane doesn't linger as long in the atmosphere (10 years) as carbon dioxide (100-1000 years), it is initially far **more devastating to the climate** because of how effectively it absorbs heat. After its release, **methane is 84 times more potent than carbon dioxide**. Both types of emissions must be addressed if we want to effectively reduce the impact of climate change.

…BUT ENCREASED BY CLIMATE CHANGE



Ruppel, Nature Knowledge, Hydrates/Climate, April 2011

Schematic cross-section from a high-latitude ocean margin nature International weekly journal of science

Home | News & Comment | Research | Careers & Jobs | Current Issue | Archive | Audio & Video | F

News & Comment > News > 2019 > May > Article

NATURE | NEWS

Mysterious Siberian crater attributed to methane

Build-up and release of gas from thawing permafrost most probable explanation, says Russian team.

Katia Moskvitch

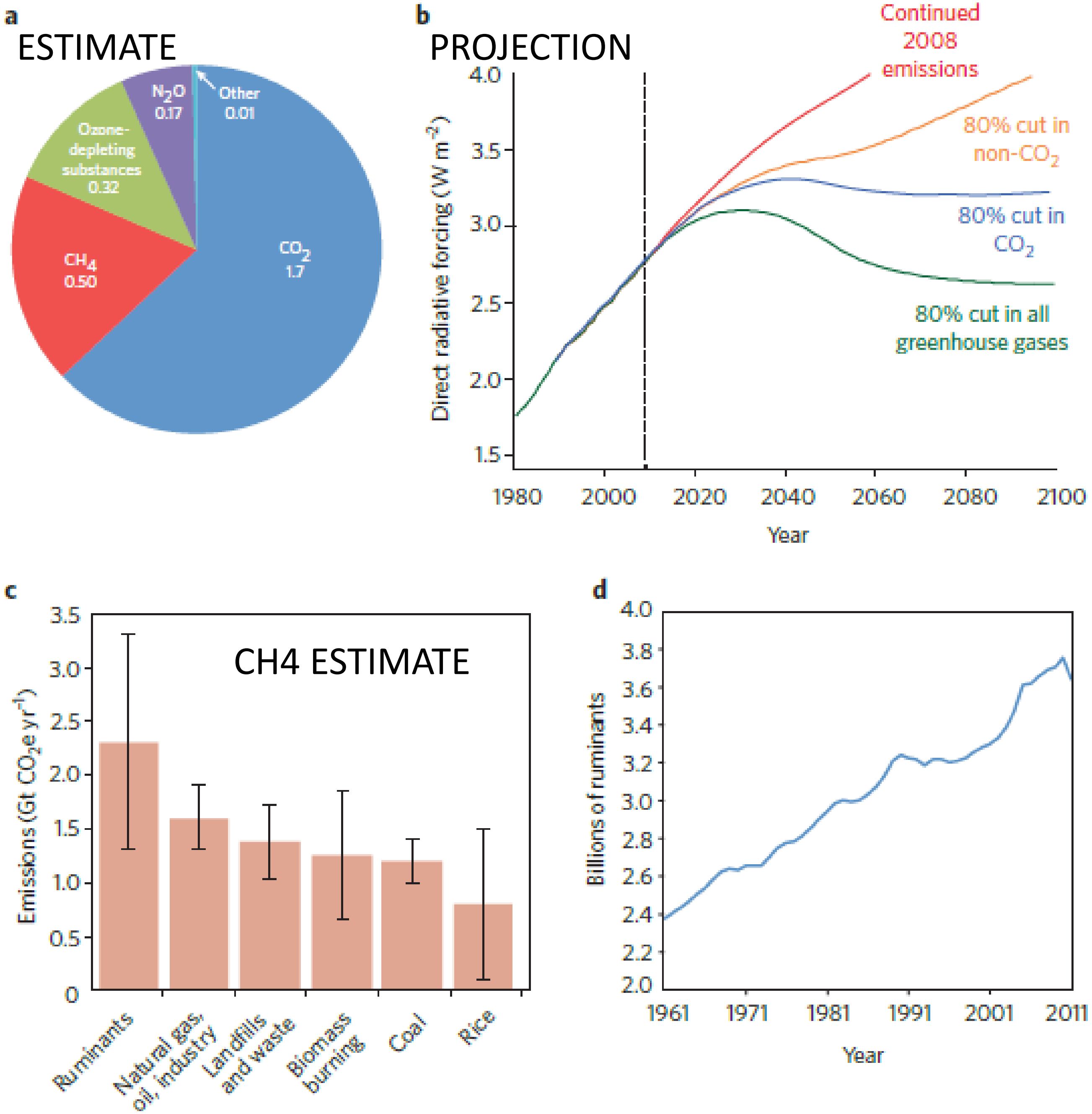


Figure 1 | Compound- and sector-specific emissions of greenhouse gases, associated radiative forcing and global ruminant numbers over the past 50 years. **a**, Estimates of direct radiative forcing in 2008 for CO_2 and non-CO_2 greenhouse gases from anthropogenic sources. **b**, Projections of radiative forcing in four different scenarios: constant future emissions at 2008 levels (red); 80% reduction in only non-CO_2 emissions (orange), 80% reduction in only CO_2 emissions (blue), and **80% reductions in both non-CO_2 and CO_2 emissions (green)**. **c**, Estimated annual **anthropogenic emissions from major sources of methane** in recent years. Error bars represent 1 standard deviation. **d**, **Global ruminant numbers from 1961 to 2011.**

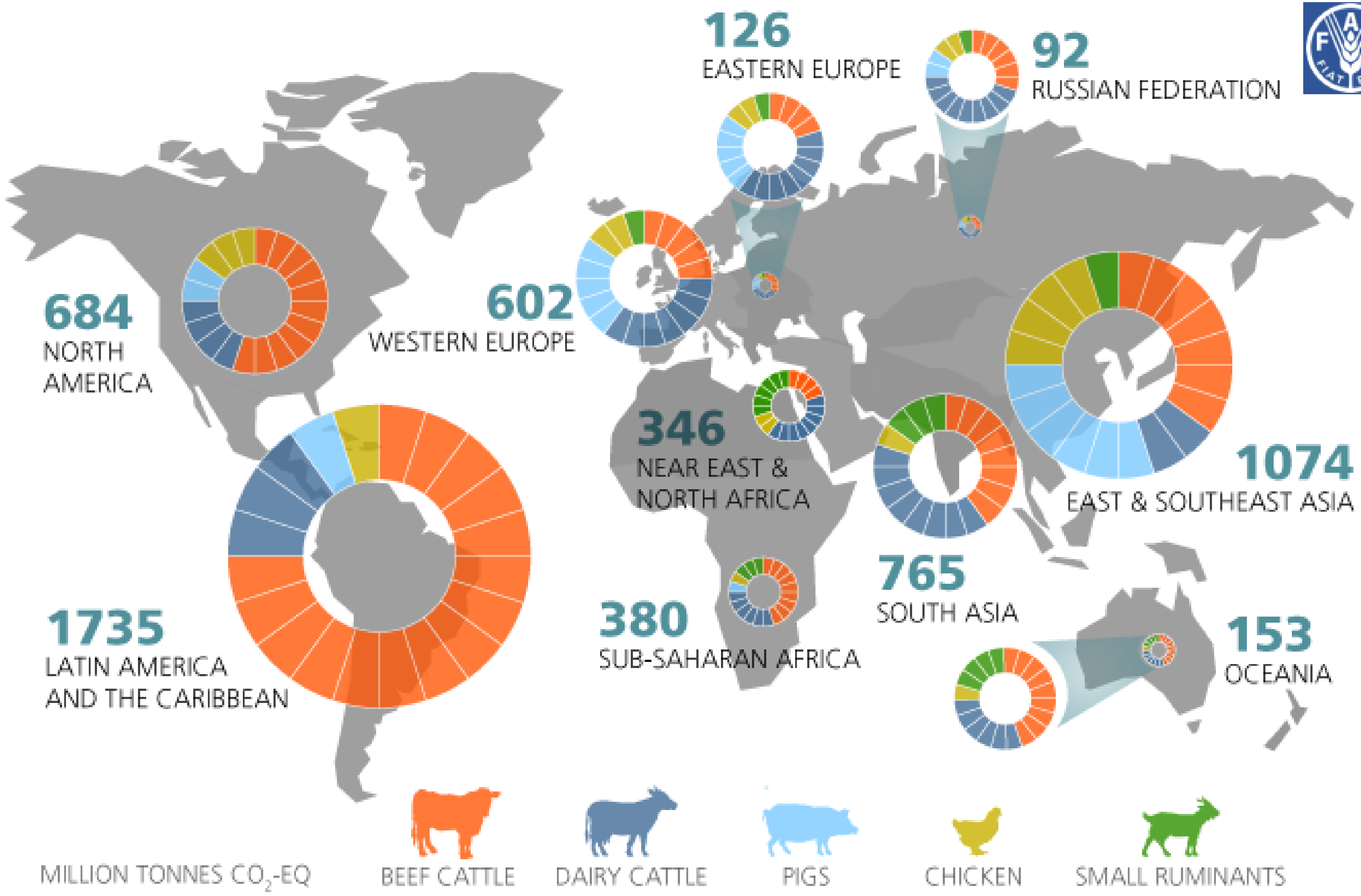
opinion & comment

COMMENTARY:

Ruminants, climate change and climate policy

William J. Ripple, Pete Smith, Helmut Haberl, Stephen A. Montzka, Clive McAlpine and Douglas H. Boucher

Food and Agriculture Organization of the United Nations



Greenhouse gas emissions from ruminant meat production are significant. Reductions in global ruminant numbers could make a substantial contribution to climate change mitigation goals and yield important **social and environmental co-benefits**.

Although a main focus of climate policy has been to reduce fossil fuel consumption, large cuts in CO2 emissions alone will not abate climate change.

Annual meat production worldwide is growing rapidly, and without policy changes is projected to more than double from 229 million tonnes in 2000 to 465 million tonnes in 2050.

opinion & comment

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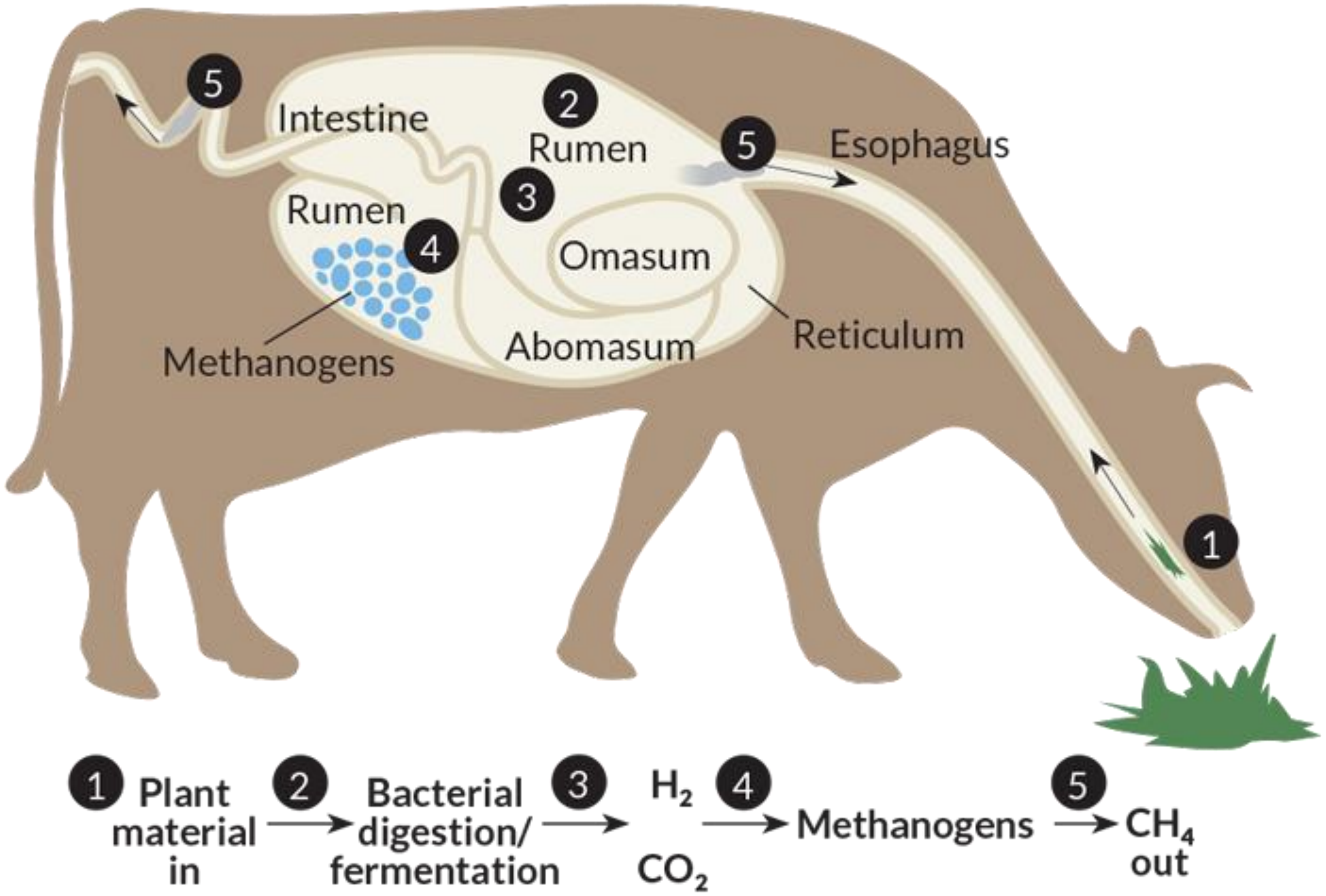
NEWS IN FOCUS

Cattle farming, shown here in northern Brazil, is emission-intensive and often accompanies large-scale deforestation.

CLIMATE CHANGE

Eat less meat: UN climate-change panel tackles diets

Report on climate change and land comes amid accelerating deforestation in the Amazon.



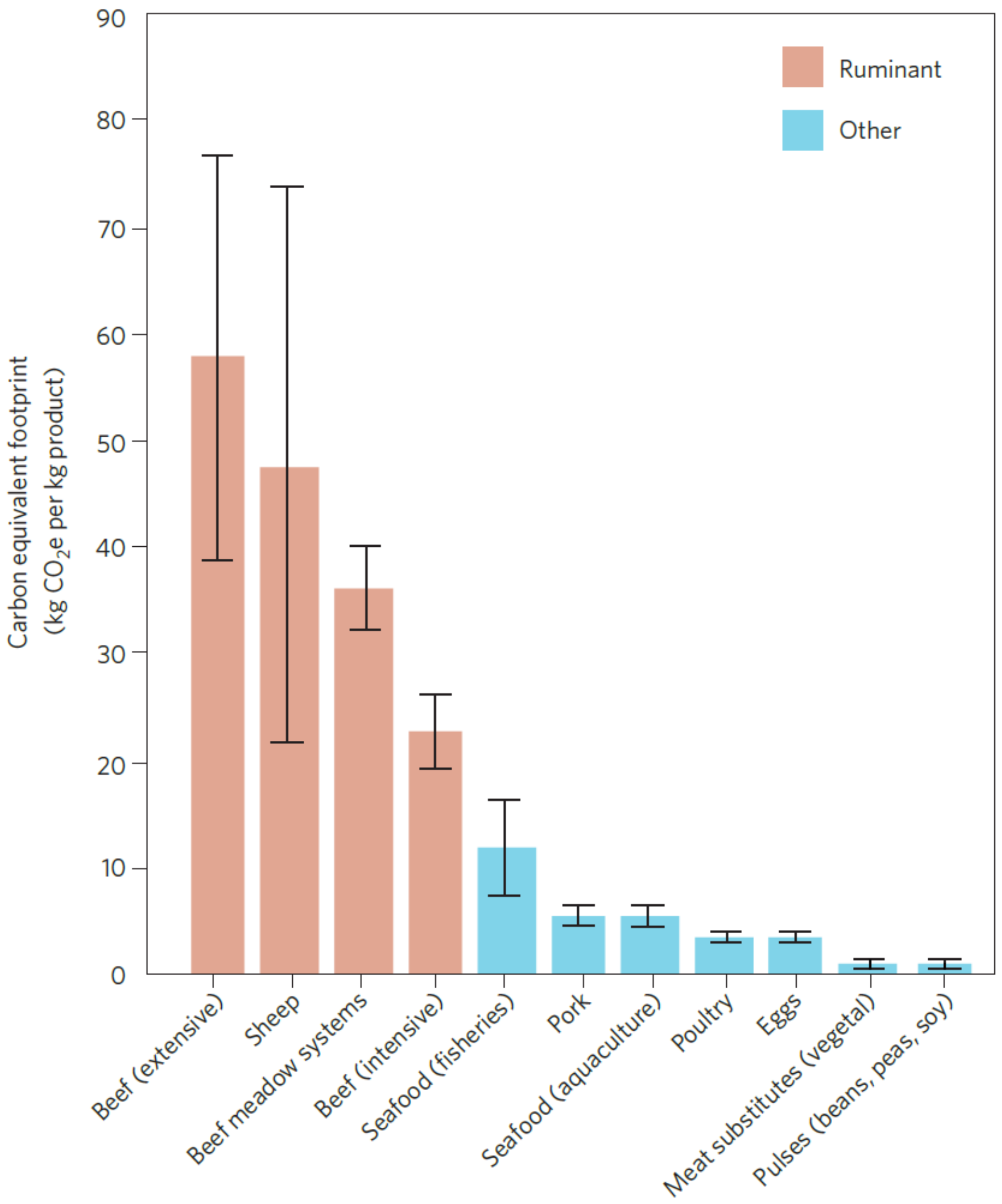
Thanks to a multichambered stomach and helpful microbes, cattle can digest food that humans cannot. The largest chamber, the rumen, is a fermentation vat that breaks down cellulose. Microbes soak up the resulting hydrogen, producing methane (CH_4), which the cow releases.

Science News: Vol. 188, No. 11, November 28, 2015, p. 22

GREENER COWS These cows at the Ellinbank Dairy Research Centre in Victoria, Australia, wear backpacks that measure their methane output.

Different approaches are under study to reduce bovine methane emissions. Most try to change the chemistry or microbial makeup of the rumen.

Method	How it works	Advantages	Disadvantages
Nitrate additive	Promotes formation of ammonia instead of methane	Highly effective in some experiments	Nitrate toxicity for some cows
Plant extract additive	Alters the chemistry of the rumen	Natural	Cost concerns; may affect taste of feed
Increasing concentrates	Substitutes feed that relies less on fermentation	Increases milk production in dairy cows; already available	Can be expensive; environmental cost if transportation needed
Synthetic additive	Blocks enzyme that drives last step of methane formation	In one experiment, methane dropped 30 percent and cows gained weight	Rumen may adapt, reducing effectiveness over time
Vaccine	Antibodies to methanogens	Easy to use	Potential for cows to accumulate hydrogen; effectiveness unknown
Selective breeding	Cows require less feed for same growth	Cumulative and permanent	Changes are slow; may affect other traits, such as health or fertility



when full life cycle analysis including both direct and indirect environmental effects from '**farm to fork**' for enteric fermentation, manure, feed, fertilizer, processing, transportation and land-use change are considered. **Non-ruminant meats such as those from pigs and poultry (and marine fisheries) have a lower carbon equivalent footprint, although they still average 3–10 times greater than high-protein plant foods.** Pigs and poultry also consume feed that could otherwise be more efficiently consumed directly by humans.

Influencing human behaviour is one of the most challenging aspects of any large-scale policy, and **it is unlikely that a large-scale dietary change will happen voluntarily without incentives**.

Implementing a **tax** or emission trading scheme on livestock's greenhouse gas emissions could be an economically sound policy that would modify consumer prices and affect consumption patterns. **A tax has recently been successfully modelled for the European Union with tax rates proportional to the average greenhouse gas emissions per unit of food sold**, although social justice, equity and food access issues need to be carefully considered. Such demandside **mitigation** measures have more social and environmental co-benefits than supply-side measures. **For an effective and rapid response, we need to increase awareness among the public and policymakers** that what we choose to eat has important consequences for climate change.

The Washington Post
Democracy Dies in Darkness

CLIMATE SOLUTIONS

How New Zealand plans to tackle climate change: Taxing cow burps

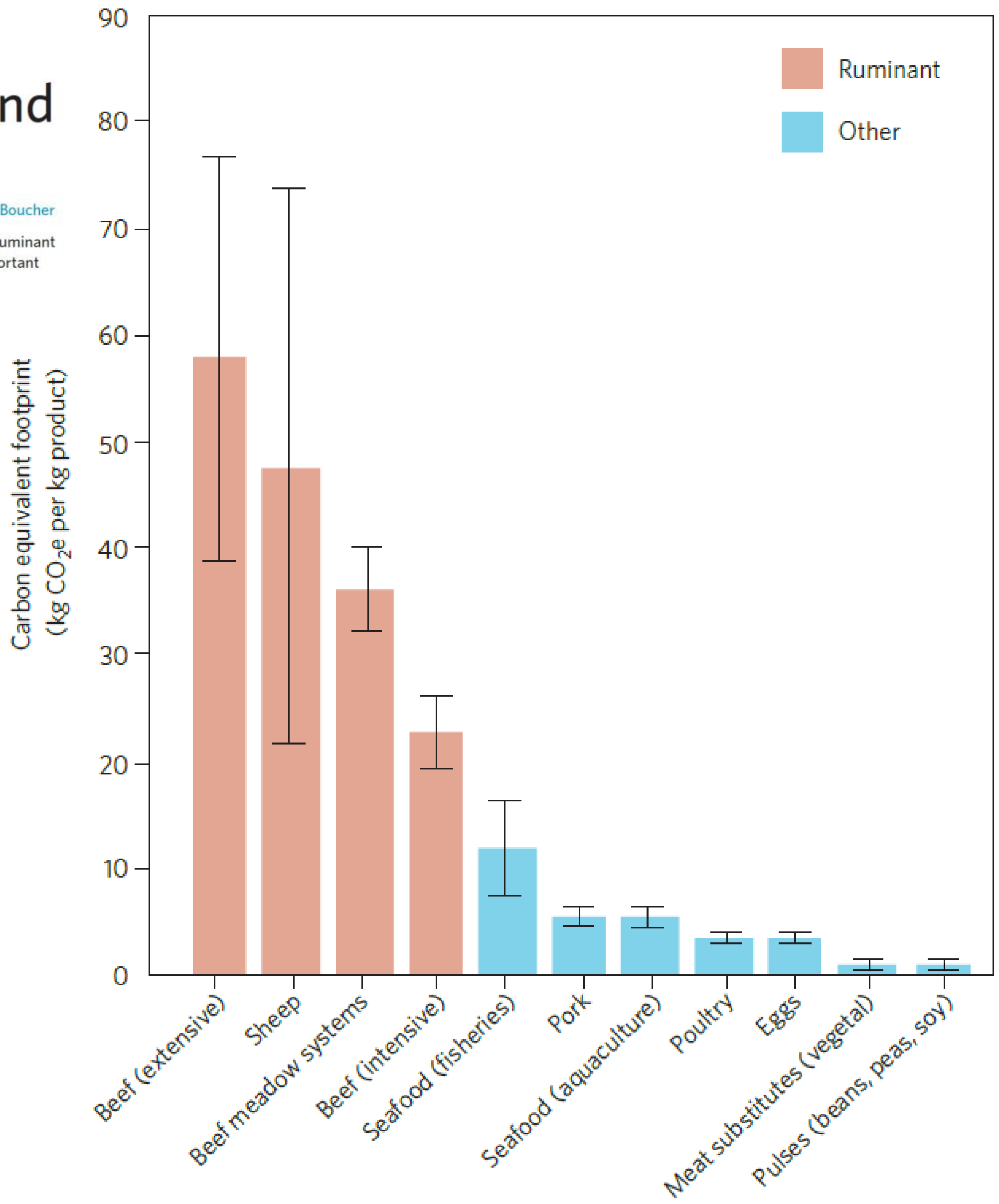
opinion & comment

COMMENTARY:

Ruminants, climate change and climate policy

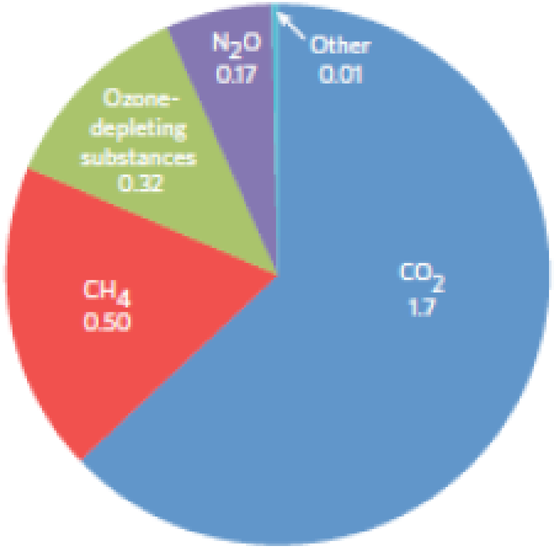
William J. Ripple, Pete Smith, Helmut Haberl, Stephen A. Montzka, Clive McAlpine and Douglas H. Boucher

Greenhouse gas emissions from ruminant meat production are significant. Reductions in global ruminant numbers could make a substantial contribution to climate change mitigation goals and yield important social and environmental co-benefits.



Although policymakers strive to reduce fossil fuel emissions, the livestock sector has generally been exempt from climate policies and little is being done to alter patterns of production and consumption of ruminant meat products[5,10]. Annual meat production worldwide is growing rapidly, and without policy changes is projected to more than double from 229 million tonnes in 2000 to 465 million tonnes in 2050[4]. The greenhouse gas footprint of consuming ruminant meat is, on average, 19–48 times higher than that of high-protein foods obtained from plants (Fig. 2), when full life cycle analysis including both direct and indirect environmental effects from 'farm to fork' for enteric fermentation, manure, feed, fertilizer, processing, transportation and land-use change are considered. Non-ruminant meats such as those from pigs and poultry (and marine fisheries) have a lower carbon equivalent footprint, although they still average 3–10 times greater than high-protein plant foods (Fig. 2). Pigs and poultry also consume feed that could otherwise be more efficiently consumed directly by humans.

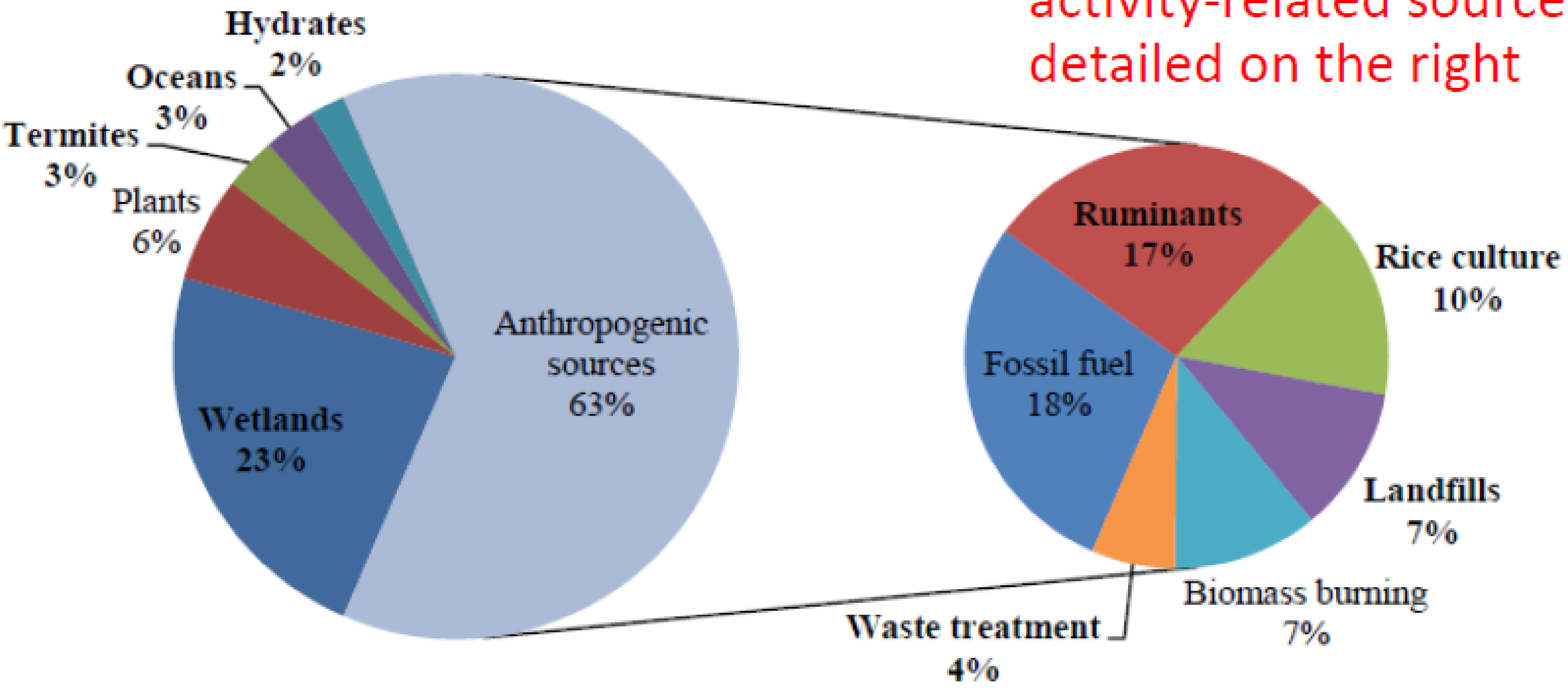
- **Social impact**
- **Economic and political actions**
- **Three gases (carbon dioxide or CO2, methane or CH4 and nitrous oxide or N2O) account for about 98 % of the global annual emissions of greenhouse gases (GHGs).**
- **Atmospheric methane**, the second most important greenhouse gas after carbon dioxide, and is responsible for about 20% of the global warming effect since pre-industrial times



Digestion stems from methanogenesis, a process in which microorganisms synthesise methane. This process takes place in most environments (soil (Gutknecht et al., 2006), including permafrost (Li et al., 2020), and water (Martinez-Cruz et al., 2017)). Together with other processes (such as nitrification and denitrification), methanogenesis influences atmospheric chemistry (Gutknecht et al., 2006).

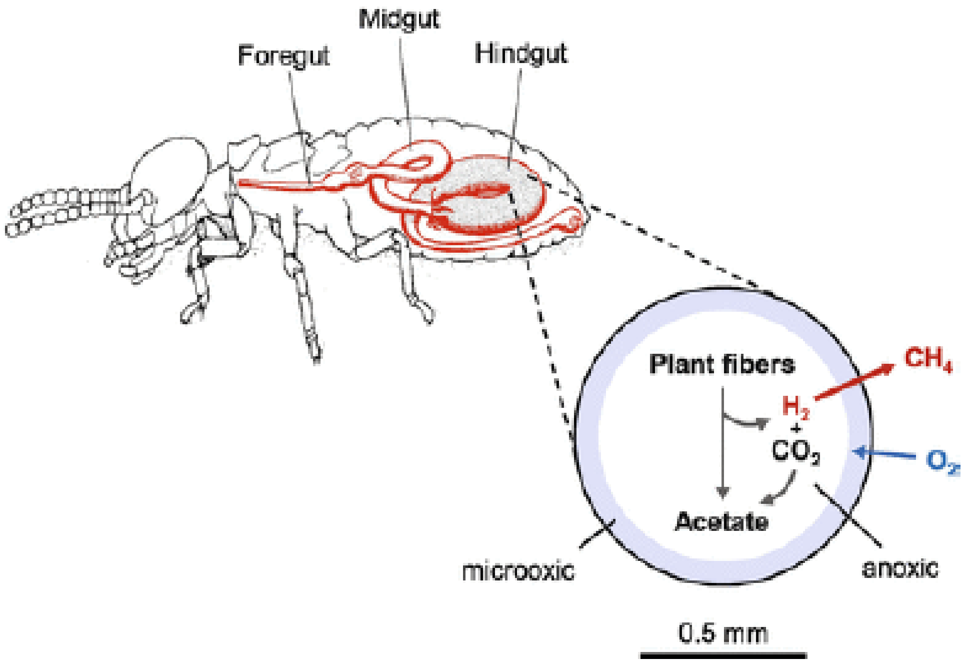
Global sources of atmospheric CH4

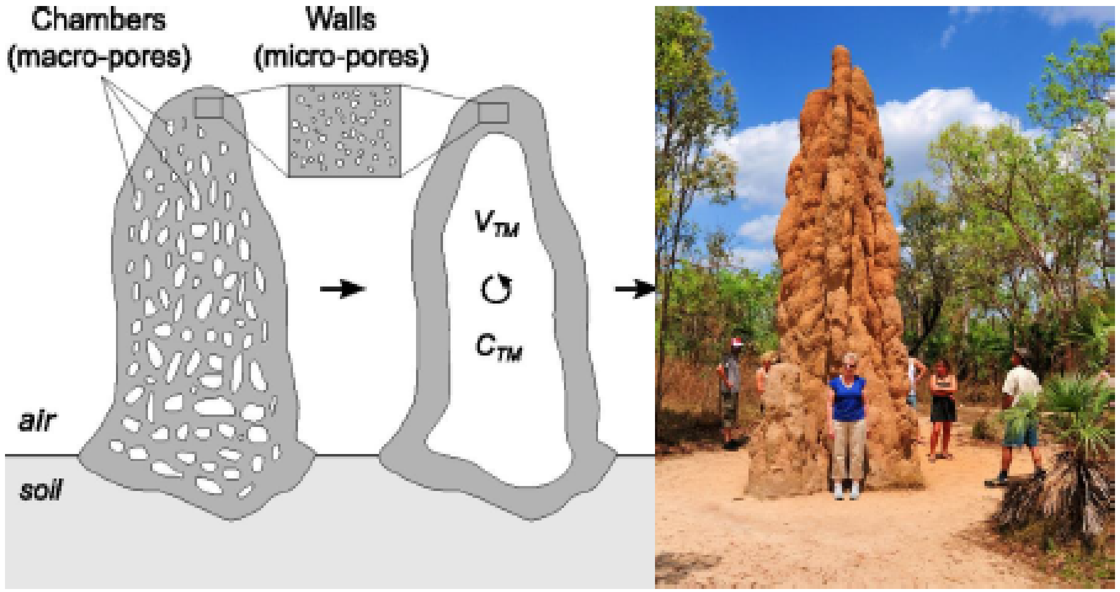
- Natural CH4 sources
- estimate of anthropogenic activity-related sources as detailed on the right



Adapted from IPCC (2001) and Conrad (2009)

Methanogenesis in the Digestive Tracts of Insects and Other Arthropods





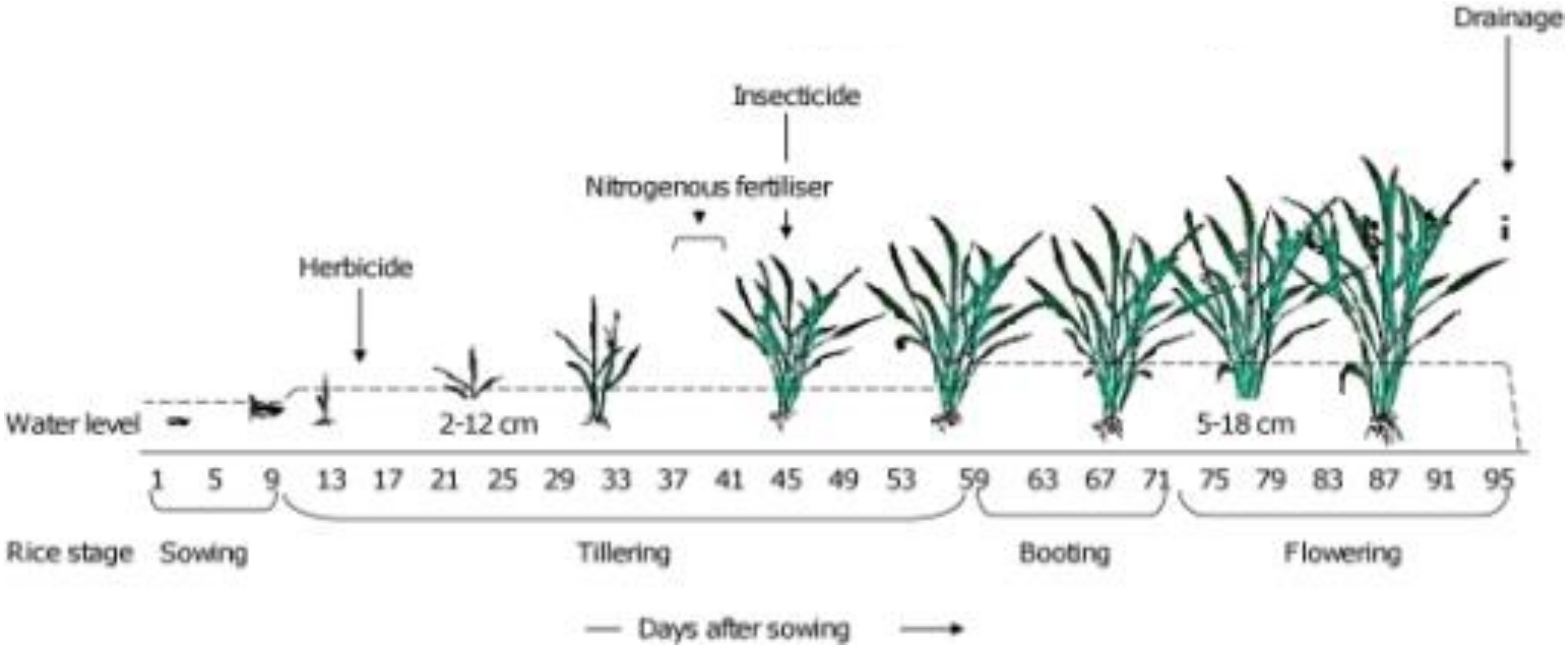
https://doi.org/10.1007/978-3-319-53114-4_13-1

https://doi.org/10.1073/pnas.1809790115

Rice paddies are one of the largest anthropogenic methane source and produce 7–17% of atmospheric methane. Warm waterlogged soil and exuded nutrients from rice roots provide ideal conditions for methanogenesis in paddies with annual methane emissions of 25–100-million tonnes.

1) NEW TECHNOLOGIES

2) GOOD PRACTISES



pone-0021713-g002: Timeline for rice growth, maintenance and application. The dashed horizontal line indicates the water level that was maintained during various stages of rice crop and drainage 10–14 days before harvest.

Simple changes to farming practices in China have slashed the amount of methane released from rice fields.

Farmers normally flood rice fields throughout the growing season, meaning that methane is produced by microbes underwater as they help to decay any flooded organic matter.

Draining paddy fields in the middle of the rice-growing season stopped most of the methane release from the field.

Only 1% of Chinese farmers drained their paddies halfway during the rice-growing season in 1980, but around 80% of them have been routinely using this approach since 2000.

Given that most farmers outside China continuously flood their rice fields, the researchers say that simply shifting towards the practice of mid-season drainage could significantly reduce global paddy-derived methane emissions.

WORLD RESOURCES INSTITUTE

Working Paper

Installment 8 of "Creating a Sustainable Food Future"

WETTING AND DRYING: REDUCING GREENHOUSE GAS EMISSIONS AND SAVING WATER FROM RICE PRODUCTION

TAPAN K. ADHYA, BRUCE LINQUIST, TIM SEARCHINGER, REINER WASSMANN, AND XIAOYUAN YAN

PRIMARY RICE GREENHOUSE GAS MITIGATION STRATEGIES

Three principal strategies exist for mitigating GHG emissions from rice. The first is to increase rice yields. Increasing yields avoids increases in emissions from land-use change and from rice area expansion. If they are high enough, yield increases could even lead to reductions in rice area, reducing methane emissions as well as emissions from land-use change. 1

Second, better management of rice straw, the non-grain portion of rice plants, can hold down emissions. Methane emissions increase when fresh (non-composted) rice straw is added to flooded fields, particularly if not plowed in until just before planting. Yet rice straw burning, which occurs in some regions, also creates methane and other greenhouse gases, as well as local air pollution. Strategies that reduce emissions include incorporating rice straw into fields well before new production seasons, and removing rice straw from fields to use for other productive purposes, such as growing mushrooms, energy, or biochar.[18] 2

In this paper, we focus on the third strategy for mitigating GHG emissions from rice: reducing or interrupting periods of flooding. We focus on this strategy for its water savings potential and because among the three strategies, it could reduce emissions most dramatically. In addition, 3

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Systems for reducing flooding and emissions during the crop-growing season fall into four categories:

1

- **DRY SEEDING.** Most paddy rice production in Asia follows the traditional pattern of transplanting seedlings grown in nursery areas into already flooded paddies. But direct seeding of rice is growing in Asia and probably now accounts for a quarter of all rice production there.[21] Farmers in the United States use direct seeding because it requires less labor.[22] Direct seeding can occur in flooded fields or through drilling seeds into dry fields. If it occurs in flooded fields (wet seeding), it is unlikely to reduce methane emissions,[23] but if it occurs in dry fields (dry seeding), it reduces emissions because it shortens the flooding period by roughly a month.[24]

2

- **SINGLE MID-SEASON DRAWDOWN.** Studies have shown that a single drawdown during the crop production season, sufficient to allow oxygen to penetrate the soils, substantially lowers GHG emissions. Typically, this kind of drawdown must occur for 5–10 days to generate methane benefits.[25] Most farmers in China, Japan, and South Korea already practice this drawdown to increase yields.

3

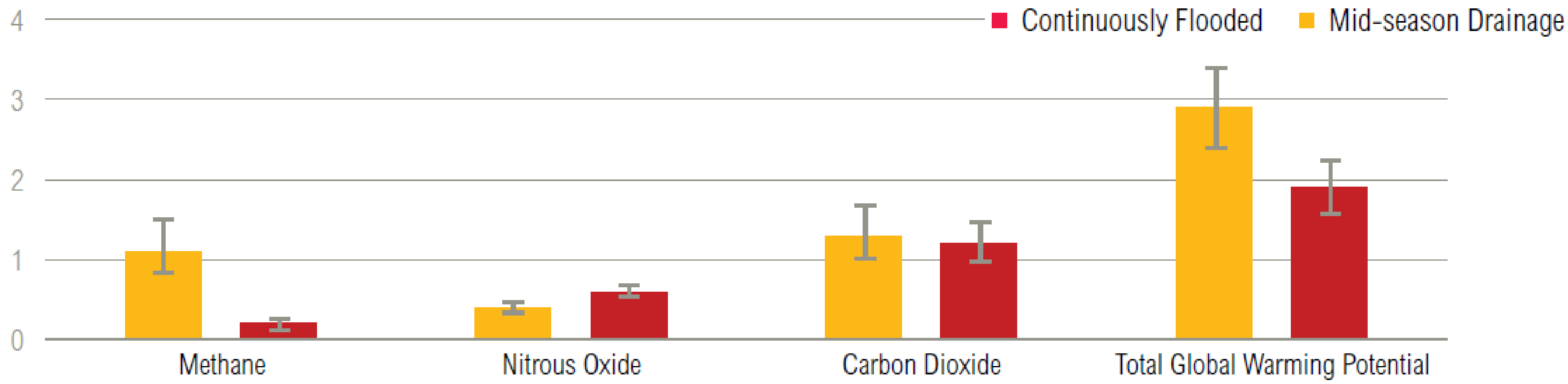
- **ALTERNATE WETTING AND DRYING (AWD).** This practice involves repeatedly flooding a farm field, typically to a water depth of around 5 centimeters, allowing the field to dry until the upper soil layer starts to dry out (typically when the water level drops to around 15 centimeters below the soil surface), and then reflooding the field. This cycle can continue from 20 days after sowing until 2 weeks before flowering.[26] This approach is also known as "controlled irrigation" or "multiple irrigation," depending on country and research context. Because each drying cycle sets back the generation of methane-producing bacteria, AWD achieves even larger reductions in methane than only one drawdown. AWD can be practiced along a continuum, with the frequency of drawdowns ranging from more to less frequent, although the level of methane reductions will depend on how stringently it is practiced.

4

- **AEROBIC RICE PRODUCTION.** Like AWD, this system involves adding irrigation water only when needed. It avoids standing water, aiming instead to keep soils moist. This system can drastically reduce—or nearly eliminate—methane production. In general, however, aerobic rice production has lower yields than rice produced through traditional methods or the three methods listed above. Still, as our case study from China shows, some farmers are maintaining high yields by constructing raised beds and ditches, which limit standing water to furrows.

All of these systems will reduce methane emissions. Various studies have found reductions in GHG emissions from direct seeding in dry fields of 30 percent or more.[27] IPCC guidance provides that a single drawdown will reduce whatever emissions would otherwise occur by 40 percent, and multiple drawdowns by 48 percent.[28] However, these figures are averages. Evidence from the United States (described below) indicates that AWD could reduce emissions by as much as 90 percent.[29] There is also evidence that combining different water-saving approaches can have additive benefits for mitigation. For example, studies combining dry seeding with AWD have found emissions reductions of 90 percent.[30]

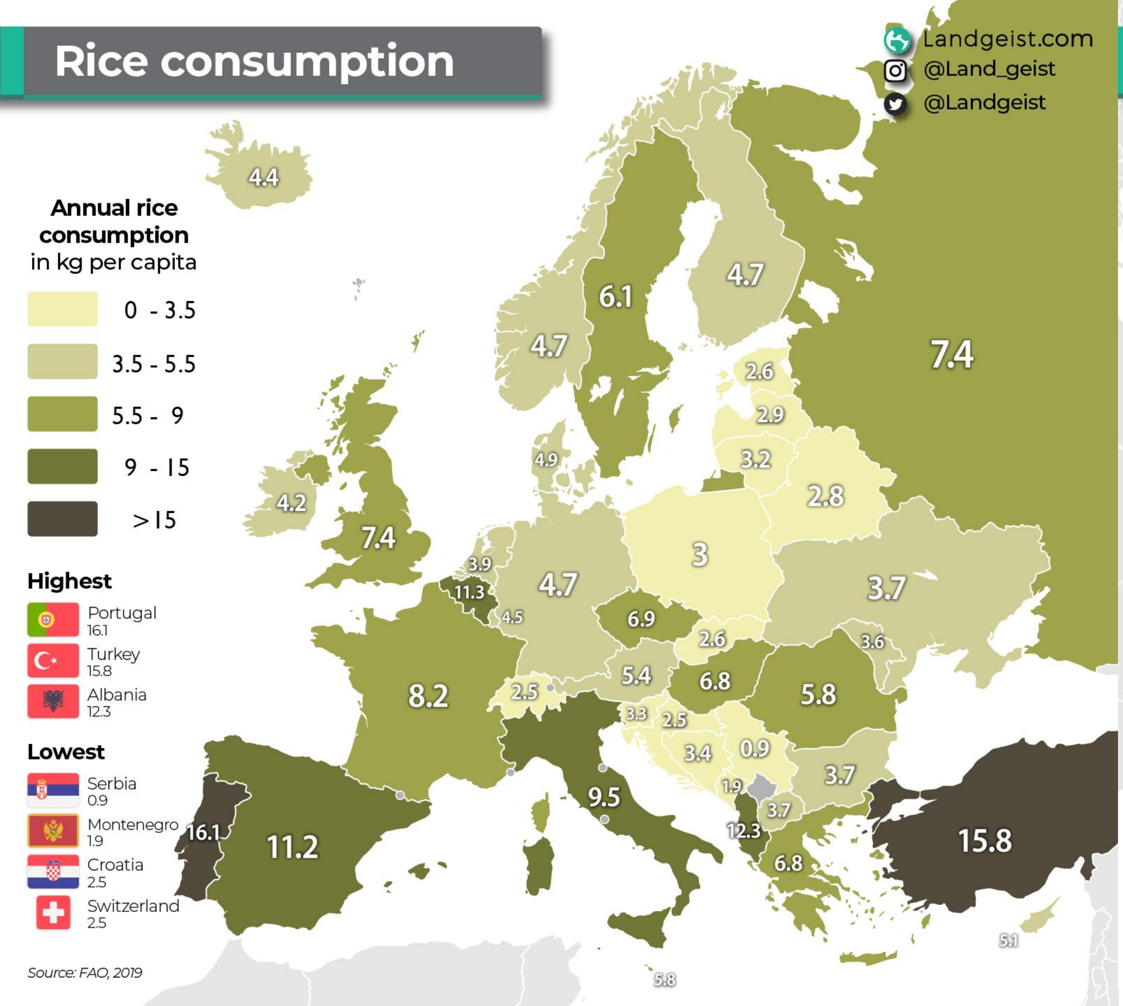
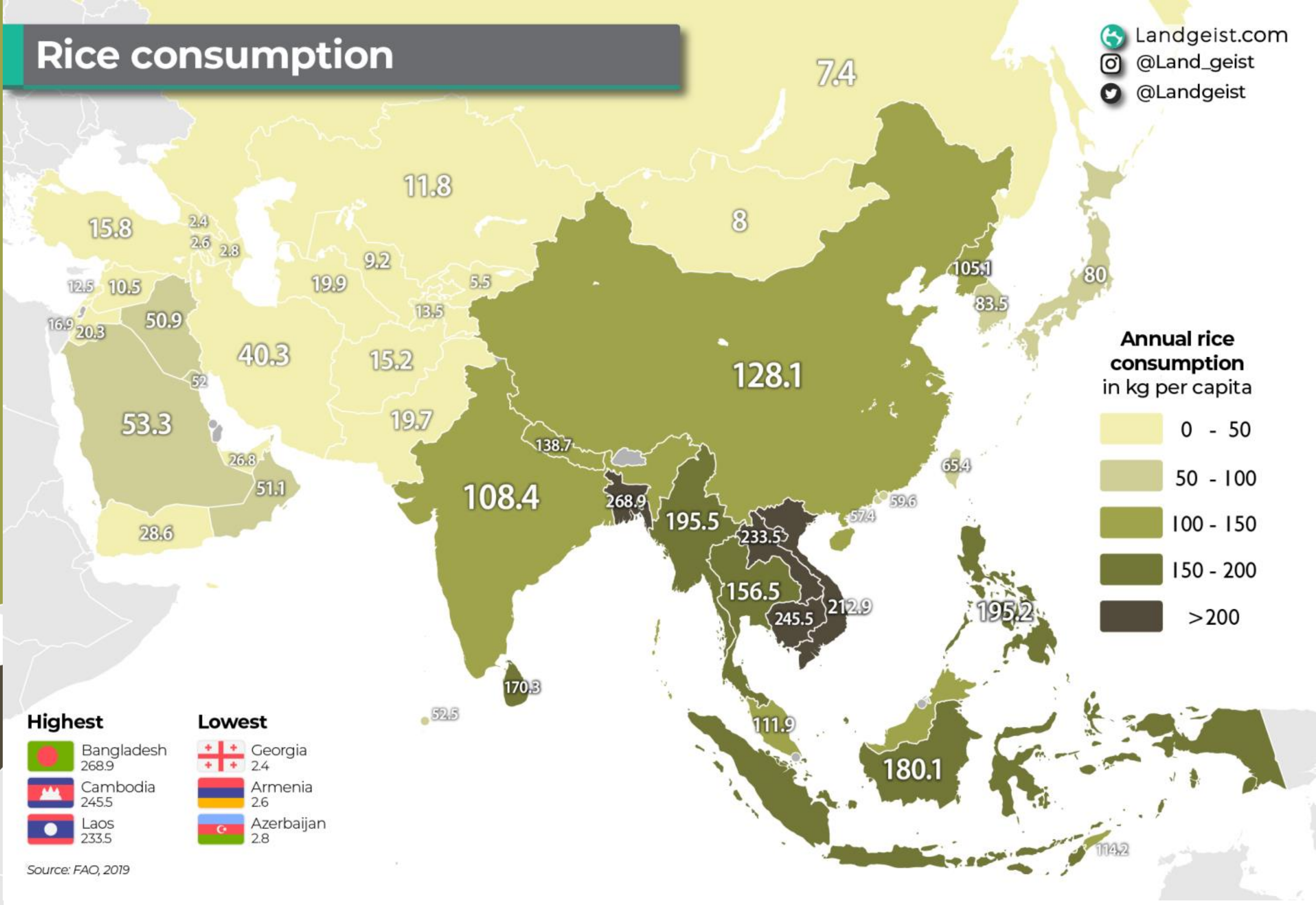
Figure 1 | **Mid-season Drainage Reduces Greenhouse Gas Emissions from Rice Production in Punjab By One-Third (Tons of CO_2e per hectare)**



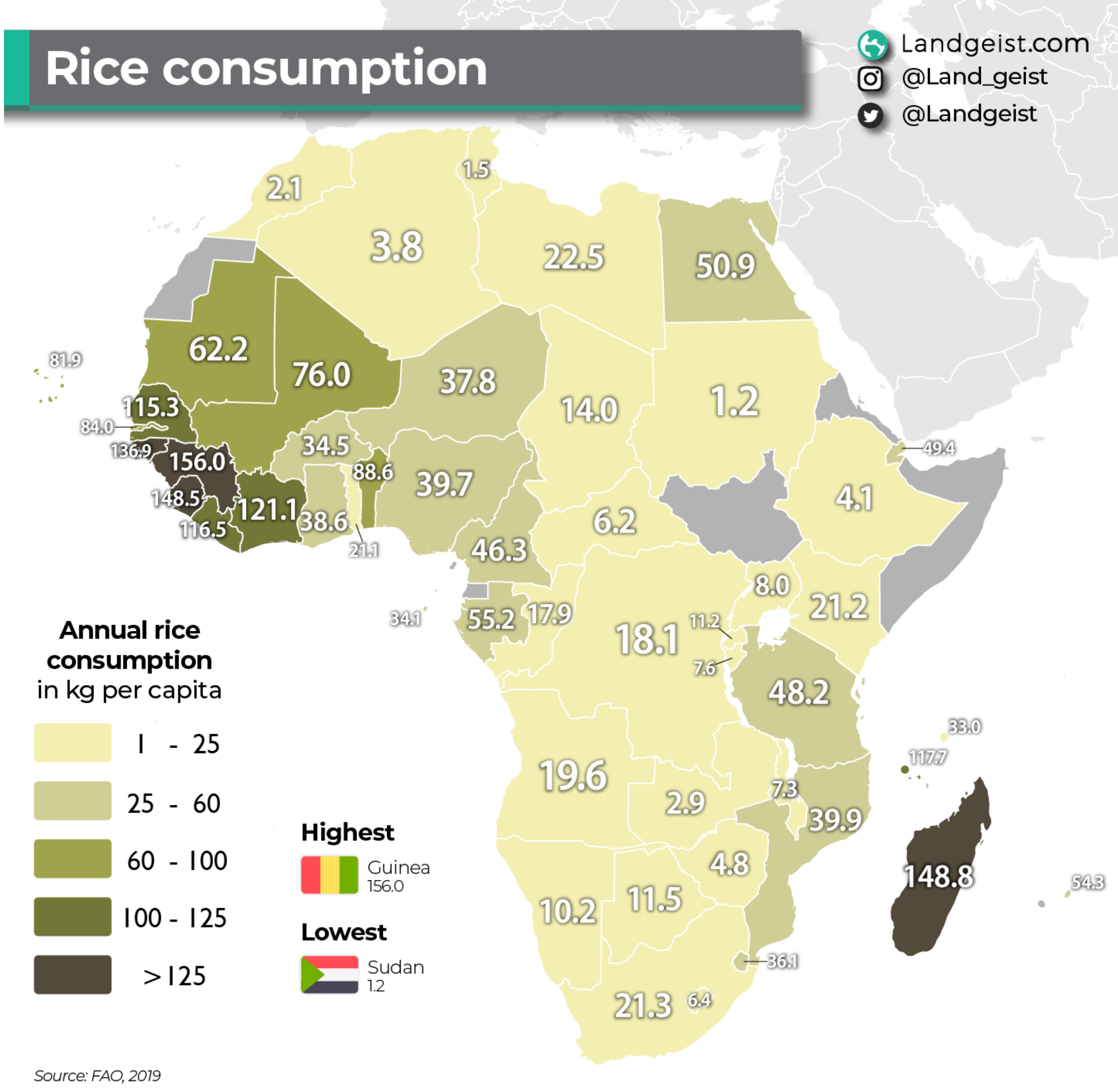
Source: Pathak et al. (2012).

Note: Solid bars show state-wide averages. Error bars represent one standard deviation.

CGIAR = Consultative Group for International Agricultural Research)

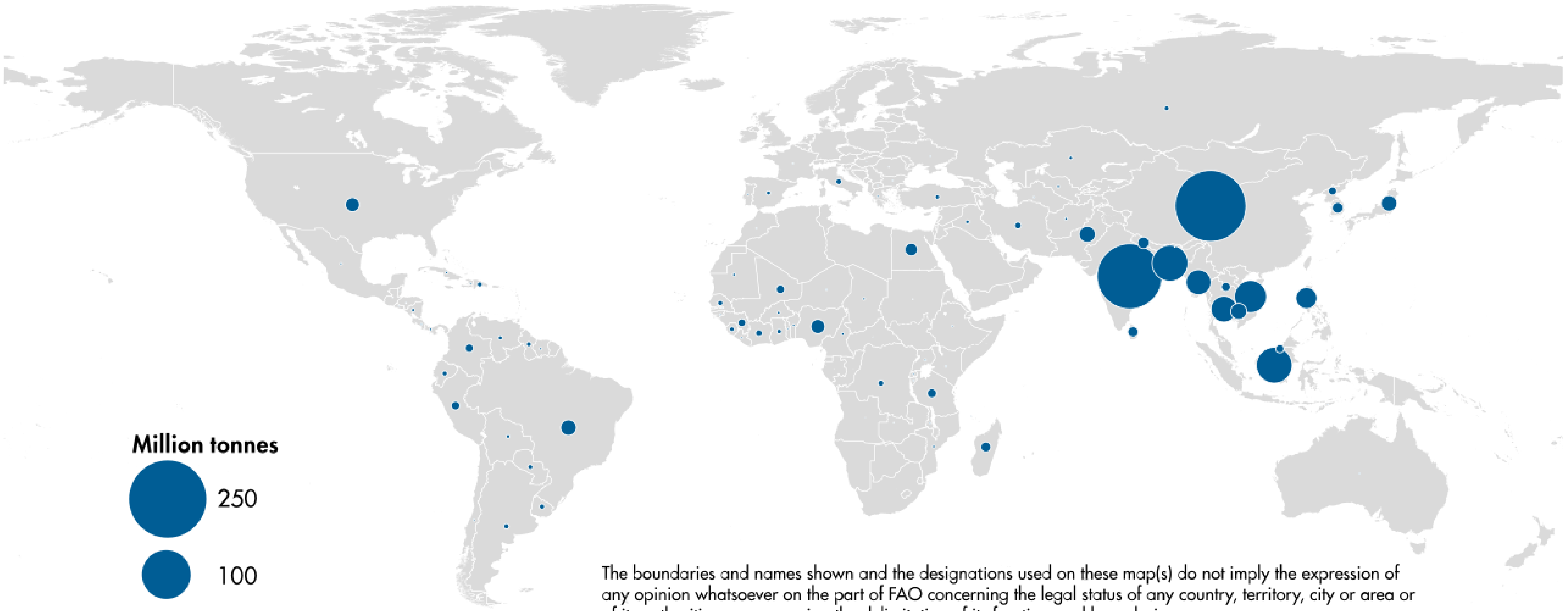

Rice consumption
Landgeist.com
@Land_geist
@Landgeist
Annual rice consumption in kg per capita
0 - 3.5
3.5 - 5.5
5.5 - 9
9 - 15
>15
Highest
Portugal 16.1
Turkey 15.8
Albania 12.3
Lowest
Serbia 0.9
Montenegro 1.9
Croatia 2.5
Switzerland 2.5
Source: FAO, 2019
4.4
6.1
4.7
4.7
7.4
2.6
2.9
3.2
2.8
4.9
4.2
7.4
3.9
11.3
4.7
3
3.7
4.5
6.9
2.6
3.6
8.2
2.5
5.4
6.8
5.8
3.3
2.5
3.4
0.9
3.7
9.5
1.9
3.7
12.3
16.1
11.2
6.8
15.8
5.1
5.8

Rice consumption
Landgeist.com
@Land_geist
@Landgeist
Annual rice consumption in kg per capita
0 - 50
50 - 100
100 - 150
150 - 200
>200
Highest
Bangladesh 268.9
Cambodia 245.5
Laos 233.5
Lowest
Georgia 2.4
Armenia 2.6
Azerbaijan 2.8
Source: FAO, 2019
7.4
11.8
8
15.8
2.4
2.6
2.8
9.2
19.9
5.5
12.5
10.5
13.5
105.1
80
83.5
16.9
20.3
50.9
40.3
15.2
128.1
52
53.3
19.7
138.7
26.8
65.4
51.1
108.4
268.9
59.6
195.5
57.4
233.5
28.6
156.5
212.9
245.5
195.2
170.3
52.5
111.9
180.1
114.2

Rice consumption
39.9
114.9
103.6
53.2
55.8
75.5
37.5
41.6
4.5
11.8
16.7
13.3
Highest
Guyana
114.9
Lowest
Paraguay
4.5
Annual rice consumption in kg per capita
0 - 20
30 - 50
50 - 80
>80
Landgeist.com
@Land_geist
@Landgeist
Source: FAO, 2019



Rice consumption
Landgeist.com
@Land_geist
@Landgeist
2.1
1.5
3.8
22.5
50.9
81.9
62.2
76.0
37.8
14.0
1.2
115.3
84.0
136.9
156.0
34.5
88.6
39.7
49.4
148.5
116.5
121.1
38.6
21.1
46.3
6.2
4.1
34.1
55.2
17.9
18.1
11.2
8.0
21.2
7.6
48.2
33.0
117.7
19.6
2.9
7.3
39.9
148.8
54.3
10.2
11.5
4.8
36.1
21.3
6.4
Annual rice consumption in kg per capita
1 - 25
25 - 60
60 - 100
100 - 125
>125
Highest
Guinea
156.0
Lowest
Sudan
1.2
Source: FAO, 2019

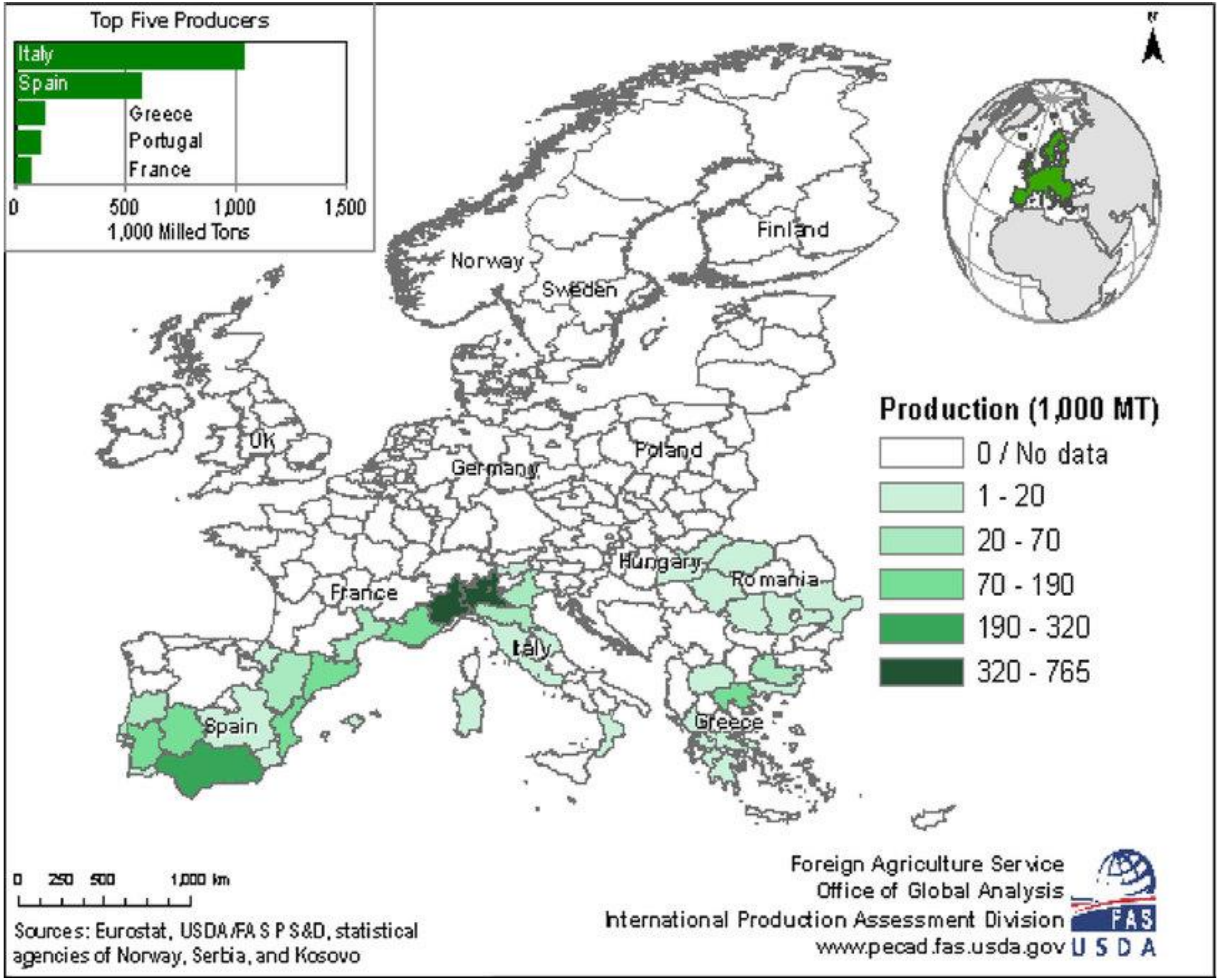
PRODUCTION OF RICE (2019)



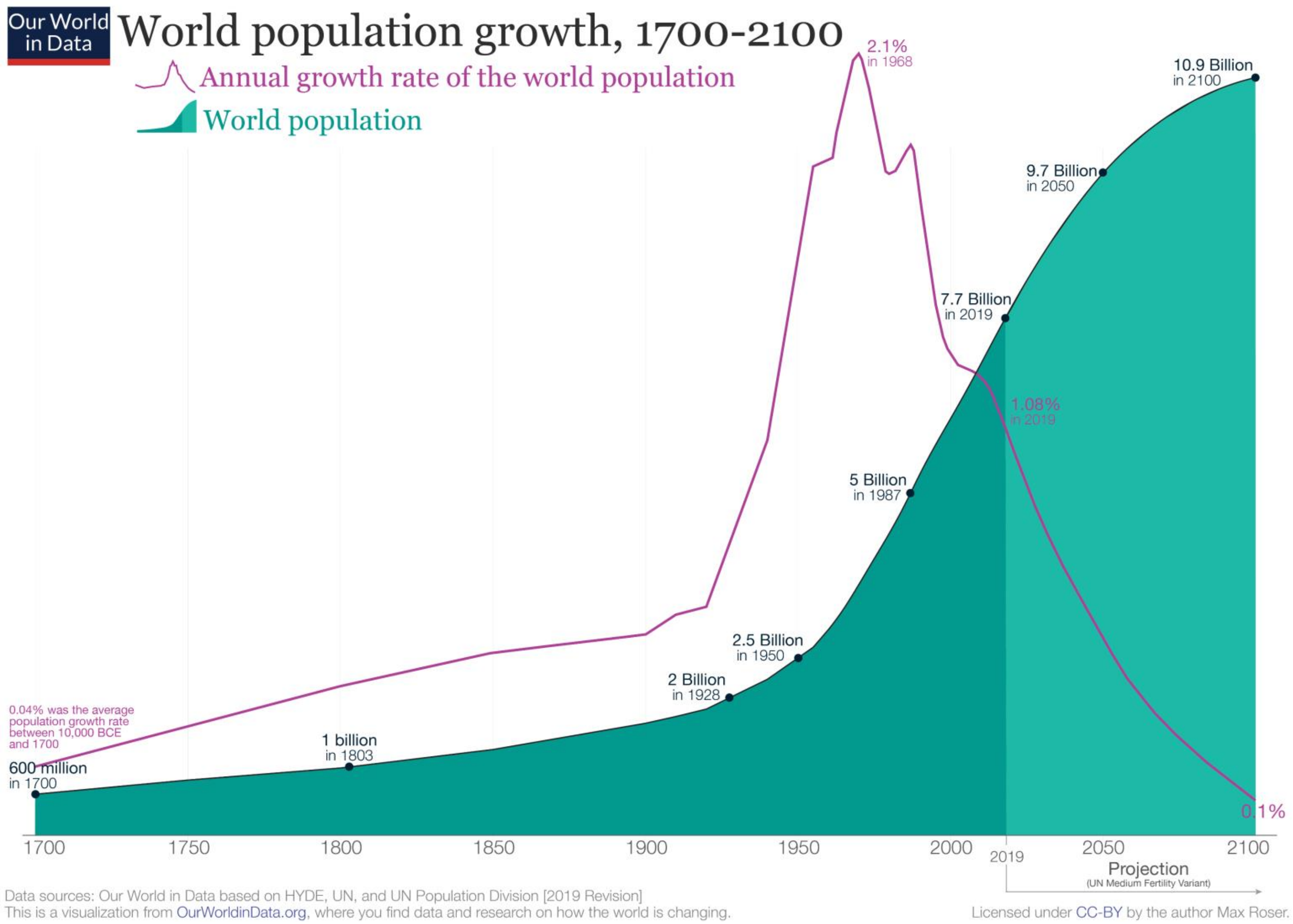
The boundaries and names shown and the designations used on these map(s) do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries.
Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.
Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.
Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

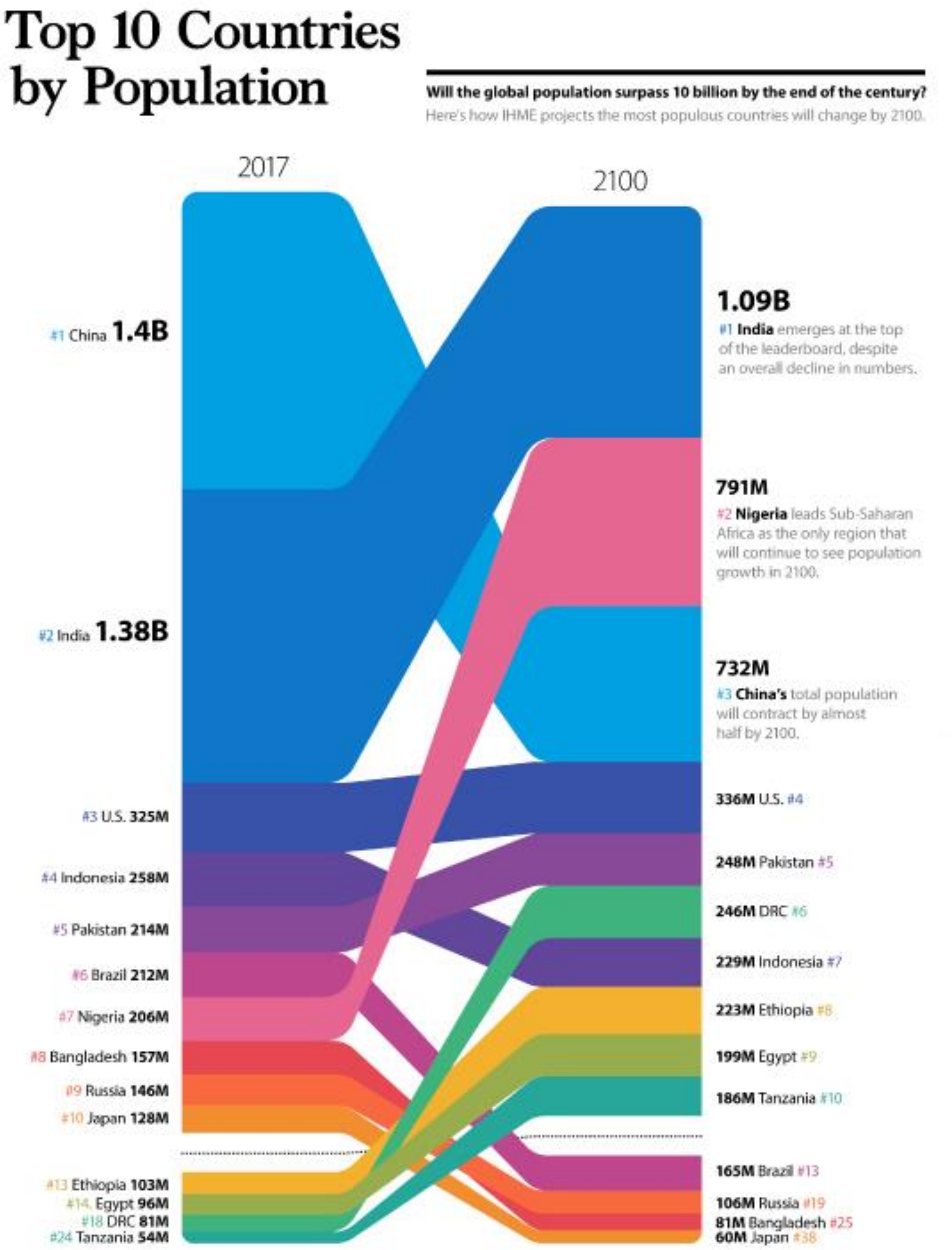
Source: FAOSTAT

https://doi.org/10.4060/cb4477en-map13
FAO. 2021. World Food and Agriculture – Statistical Yearbook 2021. Rome.



Top Five Producers
Italy
Spain
Greece
Portugal
France
0
500
1,000
1,500
1,000 Milled Tons
Norway
Sweden
Finland
UK
Germany
Poland
Hungary
Romania
France
Italy
Spain
Greece
Production (1,000 MT)
0 / No data
1 - 20
20 - 70
70 - 190
190 - 320
320 - 765
0 250 500 1,000 km
Sources: Eurostat, USDA/FAS PS&D, statistical agencies of Norway, Serbia, and Kosovo
Foreign Agriculture Service
Office of Global Analysis
International Production Assessment Division
www.pecad.fas.usda.gov
FAS
USDA


Our World in Data
World population growth, 1700-2100
Annual growth rate of the world population
World population
2.1% in 1968
10.9 Billion in 2100
9.7 Billion in 2050
7.7 Billion in 2019
1.08% in 2019
5 Billion in 1987
2.5 Billion in 1950
2 Billion in 1928
1 billion in 1803
600 million in 1700
0.04% was the average population growth rate between 10,000 BCE and 1700
0.1%
1700
1750
1800
1850
1900
1950
2000
2019
2050
2100
Projection
(UN Medium Fertility Variant)
Data sources: Our World in Data based on HYDE, UN, and UN Population Division [2019 Revision]
This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing.
Licensed under CC-BY by the author Max Roser.


Top 10 Countries by Population
Will the global population surpass 10 billion by the end of the century?
Here's how IHME projects the most populous countries will change by 2100.
2017
2100
#1 China 1.4B
#2 India 1.38B
#3 U.S. 325M
#4 Indonesia 258M
#5 Pakistan 214M
#6 Brazil 212M
#7 Nigeria 206M
#8 Bangladesh 157M
#9 Russia 146M
#10 Japan 128M
#13 Ethiopia 103M
#14 Egypt 96M
#18 DRC 81M
#24 Tanzania 54M
1.09B
#1 India emerges at the top of the leaderboard, despite an overall decline in numbers.
791M
#2 Nigeria leads Sub-Saharan Africa as the only region that will continue to see population growth in 2100.
732M
#3 China's total population will contract by almost half by 2100.
336M U.S. #4
248M Pakistan #5
246M DRC #6
229M Indonesia #7
223M Ethiopia #8
199M Egypt #9
186M Tanzania #10
165M Brazil #13
106M Russia #19
81M Bangladesh #25
60M Japan #38

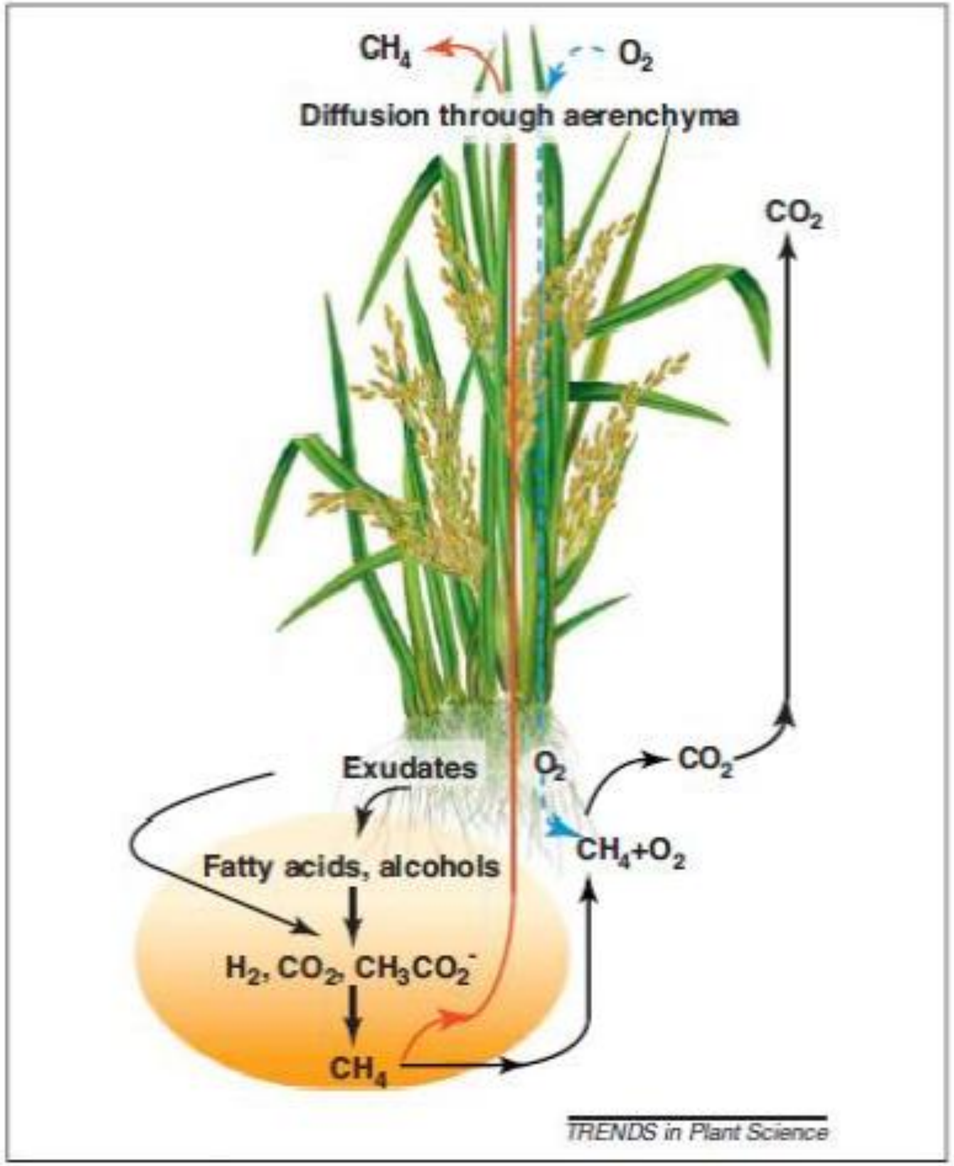
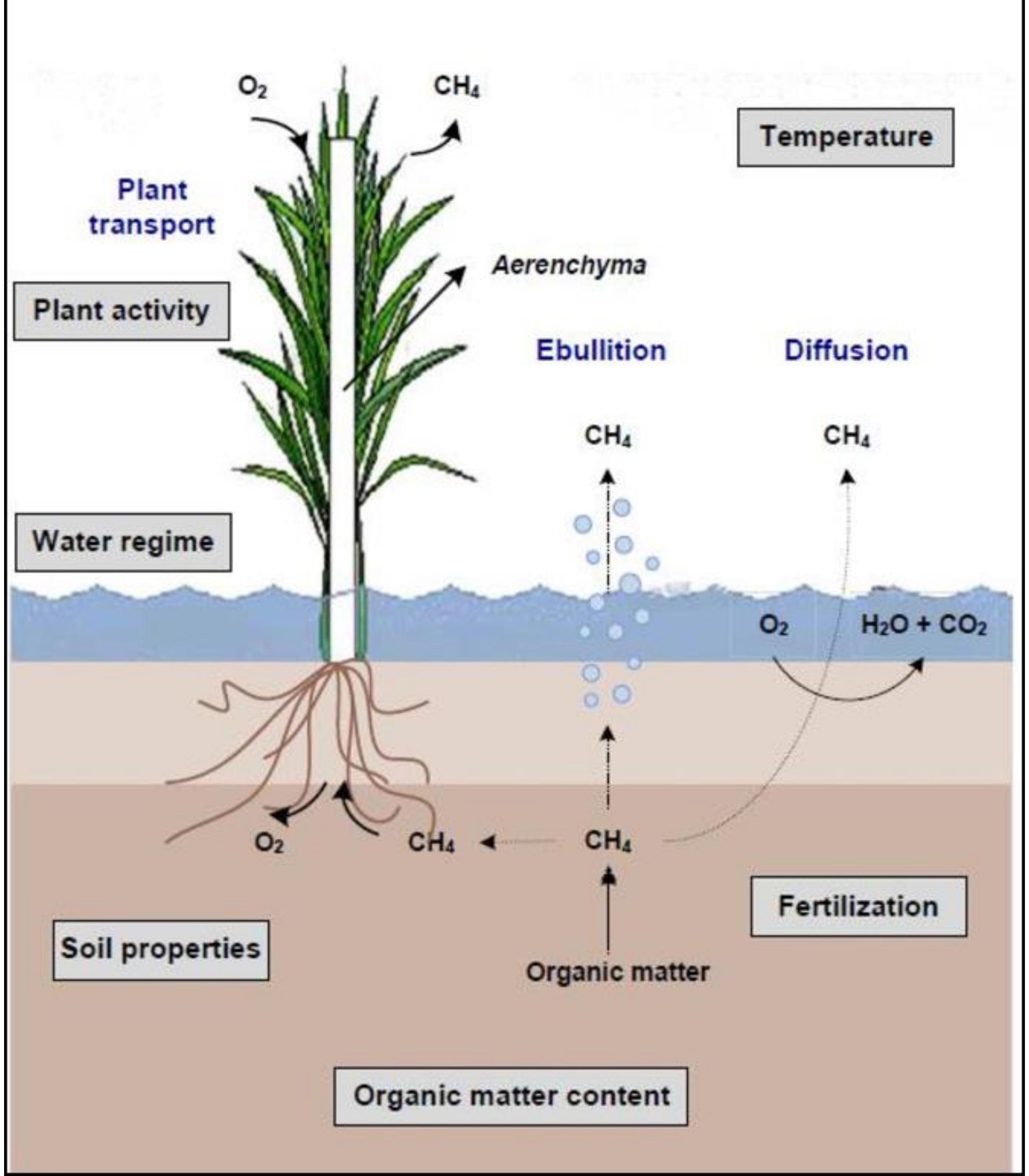


Figure 1. CH_4 production, transport and consumption in the rice rhizosphere. Reactions within the shaded ellipse indicate the microbial transformations of root exudates into methane. The blue and red arrows show the diffusion of CH_4 and O_2 through the plant aerenchyma.

- This scenario will be exacerbated by an expansion in rice cultivation needed to meet the escalating demand for food in the coming decades

- Change metabolite allocation for the reduction of methane

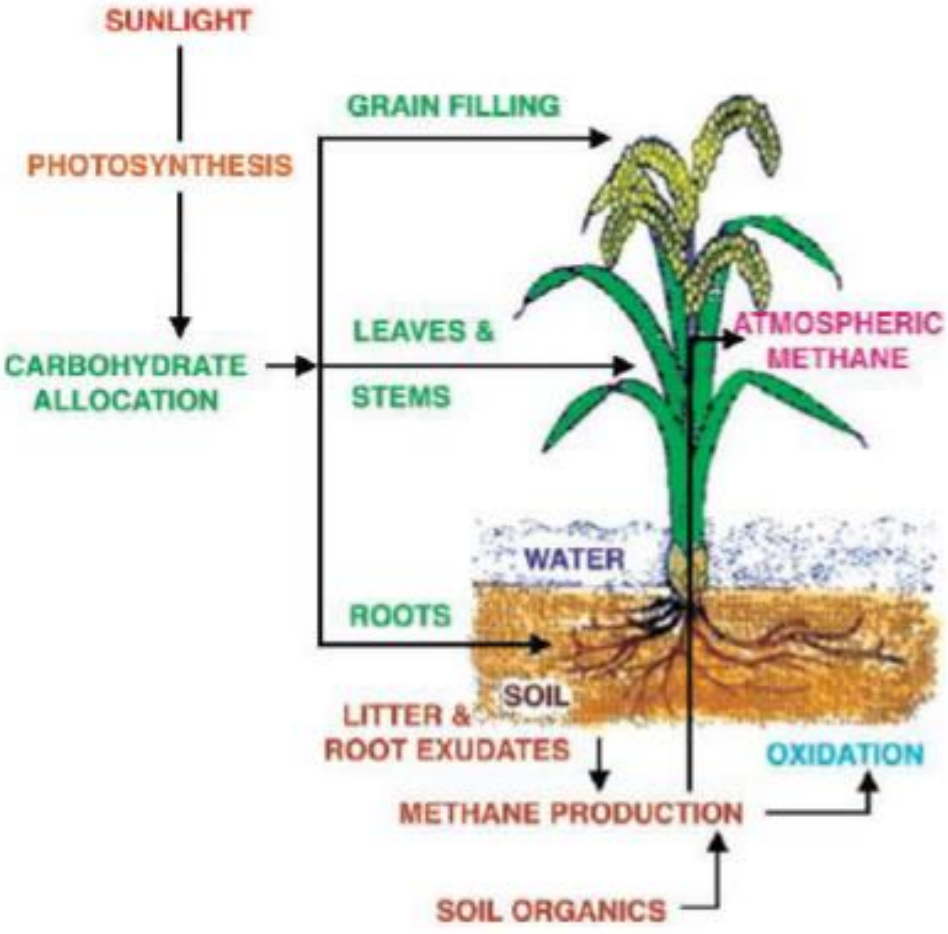


O2
CH4
Temperature
Plant transport
Aerenchyma
Plant activity
Ebullition
Diffusion
CH4
CH4
Water regime
O2
H2O + CO2
O2
CH4
CH4
Fertilization
Soil properties
Organic matter
Organic matter content

Photosynthate allocations in rice plants: Food production or atmospheric methane?

Ronald L. Sass*† and Ralph J. Cicerone‡

- Diagram representing the climate-plant-soil components of the processes of rice grain production and methane emission.



- Rice is the staple food for nearly 50% of the world's peoples, many in Asia. The world per capita rice consumption in 1990 was 58 kg / yr of milled rice. This represents 23% of the average world per capita caloric intake and 16% of the protein intake

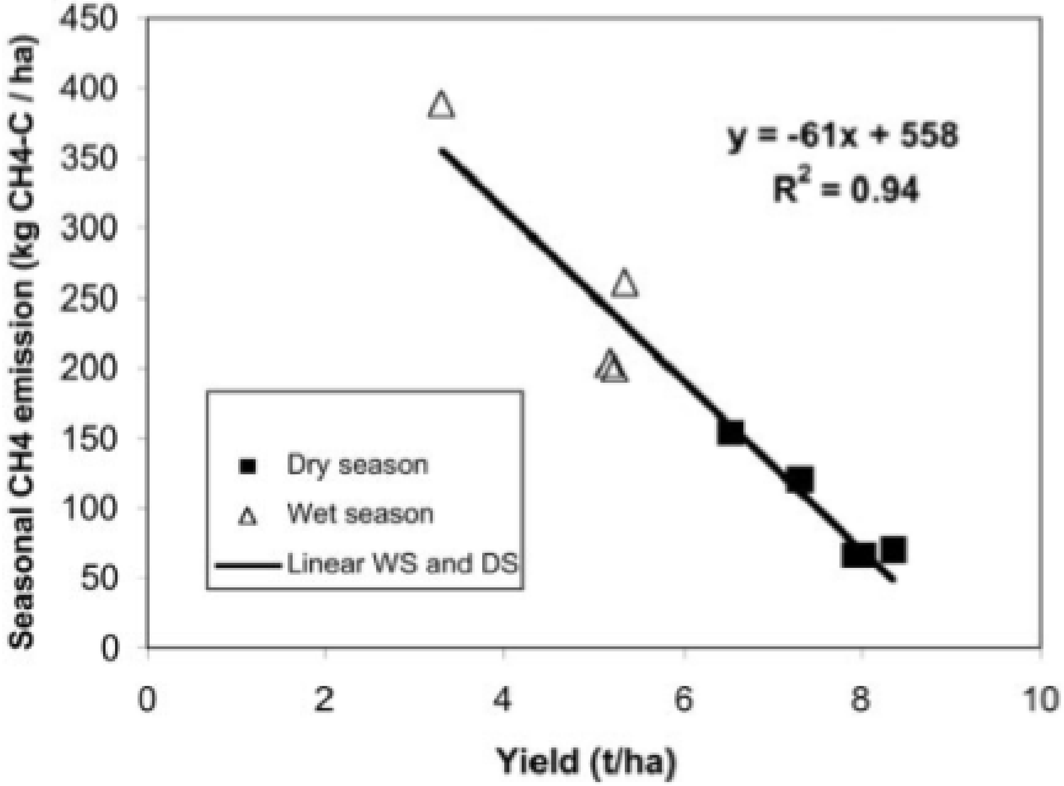


Fig. 1. Seasonal methane emission as a function of grain yield at Maligaya, Philippines, 1994–1998 (data from ref. 13, treatment T1).

- An inverse relationship exists between a rice plant's capacity to store photosynthetically fixed carbon as grain and seasonally emitted methane

Optimizing grain yields reduces CH_4 emissions from rice paddy fields

H. A. C. Denier van der Gon, M. J. Kropff, N. van Breemen, R. Wassmann, R. S. Lantin, E. Aduna, T. M. Corton, and H. H. van Laar

Optimizing grain yields reduces CH_4 emissions from rice paddy fields

H. A. C. Denier van der Gon[†‡], M. J. Kropff[§], N. van Breemen[†¶], R. Wassmann[||], R. S. Lantin[**], E. Aduna[**], T. M. Corton[††], and H. H. van Laar[§]

- carbon that could not be allocated to rice grain is an issue
- excess carbon is then available to soil bacteria for the production and emission of additional methane

Biotechnology for methane mitigation

LETTER

doi:10.1038/nature14673

Expression of barley SUSIBA2 transcription factor yields high-starch low-methane rice

J. Su[1,2*], C. Hu[1,2*], X. Yan[2*], Y. Jin[2,3], Z. Chen[1], Q. Guan[1], Y. Wang[1], D. Zhong[1], C. Jansson[4], F. Wang[1], A. Schnürer[5] & C. Sun[2]

- First high-starch low-methane-emission rice reported.
- Generated via transcription factor technology.

What is SUSIBA2?

- Sugar signalling in barley 2 (SUSIBA2) is a plant-specific transcription factor

How do you test SUSIBA2 localization?

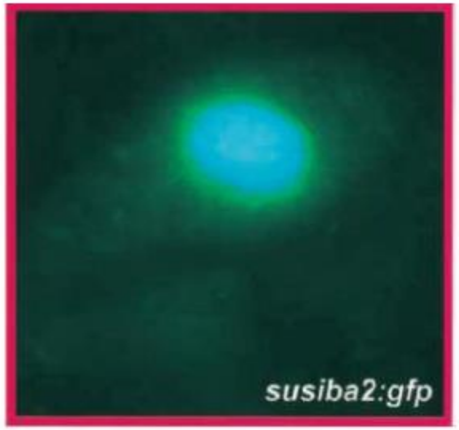


Figure 11. Nuclear Localization of the SUSIBA2:GFP Fusion Protein.

What is the advantage of working with a transcription factor?

What is SUSIBA2?

- Sugar signalling in barley 2 (SUSIBA2) is a plant-specific transcription factor

- What are plant source and sink organs?
- How is carbon stored and transported in general in plants?