Global Agriculture and Environmental Issues Landscape

Prepared for the David and Lucile Packard Foundation

September 2013

CEA California Environmental Associates

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Project Overview

- In the summer of 2013, the Packard Foundation asked CEA to conduct a landscape review of leading agriculture and environment issues, and to evaluate the importance of each issue, in terms of both environmental and human well-being impacts.

- Specifically, this inquiry was designed to answer the following questions:
  - Which agriculture and environment issues are most serious and urgent?
  - Where in the world are these leading issues most severe?
  - What are the potential implications of a business-as-usual scenario?
  - What are the solutions that are most promising?
  - Who is working on these issues?
  - What role might philanthropy play in addressing these issues?

Review of Environmental Issues Associated with Agriculture

- CEA analyzed 10 reports (presented in appendix) and interviewed several experts to understand how leading experts and institutions categorize and prioritize environmental issues associated with agriculture.
- Issues that were consistently ranked at the top of the list included: Water Quantity; Climate and Air Pollution; and Biodiversity and Habitat Loss.

Environmental Issues Associated with Agriculture	UNEP, Environmental Food Crisis 2009	UNEP, Global Environmental Outlook, 2012	Foley et al, 2011	FAO Statistical Yearbook 2013	MSCI Industry Food Report	WWF 2050 Criteria	TruCost, Natural Capital at Risk	Millennium Ecosystem Report, 2005	Foresight, Future of Food and Farming	WRI Great Balancing Act 2013
Water Quantity	X	X	X	X	X	X	X	X	X	X
Climate and Air Pollution[1]		X	X	X	X	X	X	X	X	X
Biodiversity and Habitat Loss[2]	X	X	X	X	X	X	X	X	X	X
Water Pollution[3]	X	X	X	X		X	X	X	X	X
Soil quality[4]		X		X		X	X		X	
Biodiversity of Agriculture[5]	X	X		X				X		
Pesticides and Toxins		X				X				
GMOs		X								
Waste					X					
Invasives										

Notes:

[1] Includes direct GHG emissions from agriculture, GHG emissions from land use change, and air pollution.

[2] Includes habitat loss and biodiversity impacts from land use change.

[3] Includes eutrophication, nitrate pollution, and toxicity.

[4] Includes soil erosion, salinization, acidification, and desertification.

[5] Includes ongoing impact of agricultural practices to on-farm biodiversity (e.g., genetic erosion).

Key
- **Highest Priority**
- **High Priority**
- **Important Issue**

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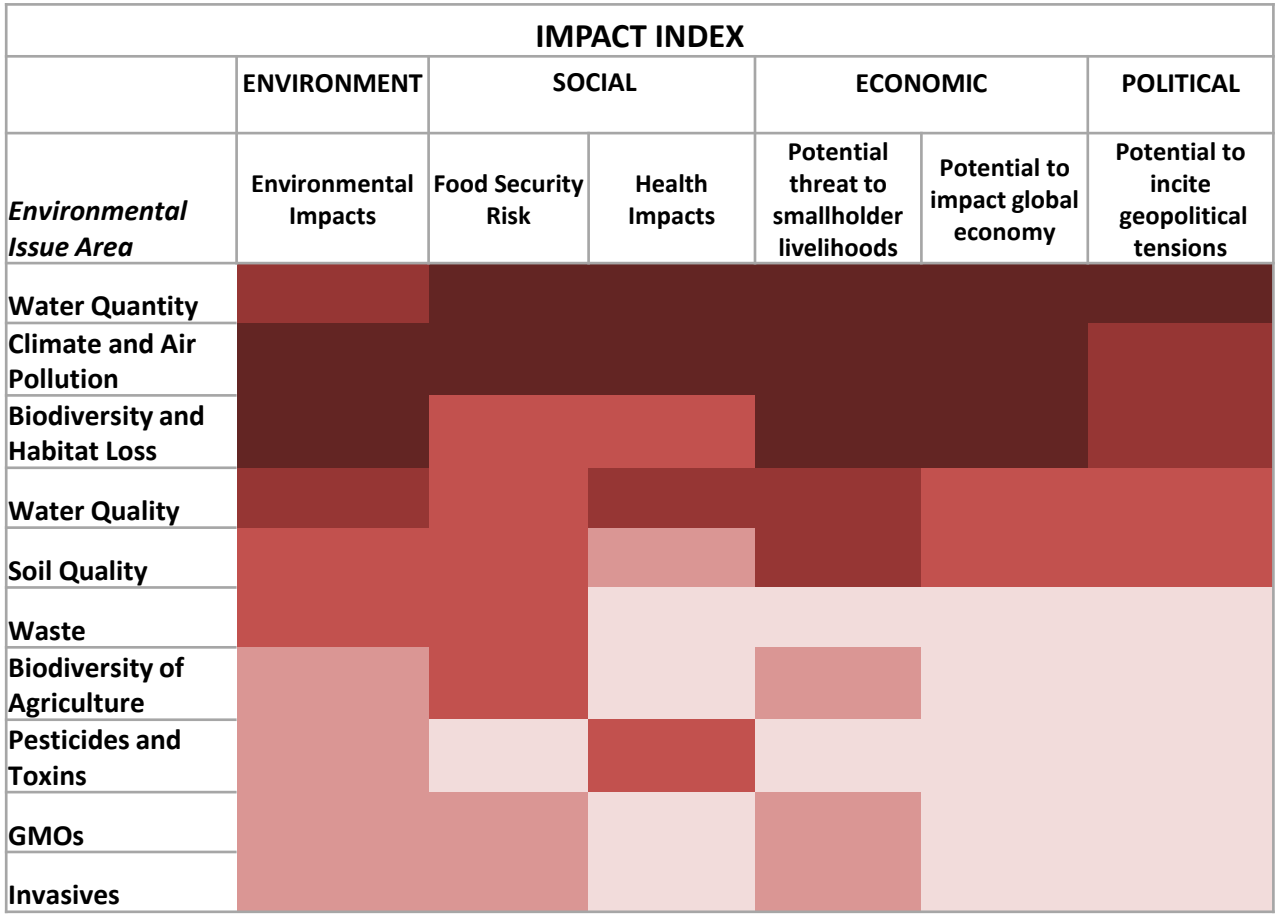
Heat Map of Environmental Issue Areas

CEA assessed each issue in terms of its respective environmental, social, and economic impact. Issues were assigned scores based on whether impacts are relatively localized (1-2, lowest severity), are more regional (3-4, moderate severity), or potentially global in their scope (4-5, highest severity). Based on this ranking, the most severe issues are: Water Quantity; Climate and Air Pollution; and Biodiversity and Habitat Loss.



Note: For this report, the term 'smallholder' refers to subsistence farmers who lack economic competitiveness and involvement in the market. Smallholders operate small-scale, low input farms in low-income countries.

Framing Questions for Deep Dive Investigations

DEEP DIVE INVESTIGATIONS

WATER QUANTITY	CLIMATE AND AIR POLLUTION	BIODIVERSITY AND HABITAT LOSS

SHALLOW DIVE INVESTIGATIONS

WATER QUALITY	SOIL QUALITY	AGRICULTURAL DEVELOPMENT

- Based on an initial scan of global threats through both a literature review and expert interviews, CEA conducted a deeper investigation for the three most urgent environmental issues associated with agriculture: Water Quantity; Climate and Air Pollution; and Biodiversity and Habitat Loss.

- CEA also conducted further research through “shallow dive” investigations on the next most pressing issues: Water Quality and Soil Quality, in addition to providing a brief landscape review on the broader context of agricultural development.

- Through each of these investigations, CEA examined the issue’s association with agriculture, the most severe geographic hotpots, potential solution sets, and key initiatives and funders in the field.

DEEP DIVE INVESTIGATIONS

- WATER QUANTITY
- CLIMATE AND AIR POLLUTION
- BIODIVERSITY AND HABITAT LOSS

SHALLOW DIVE INVESTIGATIONS

- WATER QUALITY
- SOIL QUALITY
- AGRICULTURAL DEVELOPMENT

CEA's Impressions of the Field: Water Quantity

Agriculture is the single largest user of freshwater globally, accounting for 70 percent or more of freshwater withdrawals. While water stress itself is local, its impacts can be global due to the embedded water of globally traded commodities (e.g., food prices can spike globally as a result of a drought in a major producing country). Most experts agree that water quantity will remain one of the foremost environmental and national security threats in the coming decades. By 2050, global water demand is projected to increase by over 50 percent. Water stress can have significant ecological impacts on both terrestrial and aquatic systems by reducing streamflow, increasing evapotranspiration, and introducing saltwater into aquifers. Around the world, water is underpriced (or not priced at all), over-allocated, and requires more effective management.

The stakes are high. Hundreds of millions of people depend on access to water for agricultural production (which is the source of their livelihoods), some of the world's greatest breadbaskets are threatened by aquifer depletion, massive riverine ecosystems are becoming severely degraded, growing urban populations are increasing demand for water, and the transnational nature of some of the world's major rivers are adding to geopolitical tensions. Regional agricultural collapse, mass migration, and major global commodity price spikes are possible.

Solutions exist. There is tremendous potential to use agricultural water more efficiently. The problem can be addressed through technology (e.g., better irrigation systems, rain water harvesting, conservation agriculture practices, improved water storage, reuse of wastewater, drought-resistant seed varieties), markets (e.g., water pricing, payment for ecosystem services, supply chain management), and policies (e.g., better irrigation planning, better water allocations, crop zoning, preferential lending for farmers who grow climate-appropriate crops, water metering and rights, headwater and inflow protections). State and regional planning and irrigation districts are as important or more important than federal policy in most countries.

Globally, there is substantial funding, but little targets the heart of the problem. Most foundations in this field are focused on drinking water and sanitation. Those that have an environmental or agricultural bent seem primarily focused on technological solutions, which alone don't create effective incentive structures. Corporations have become significant players, but tend to engage in project work in places where they have corporate assets. Aid organizations, national governments and multi-laterals are major funders, but historically have looked to solve the problem though infrastructure; though some seem to now be shifting towards policy reform.

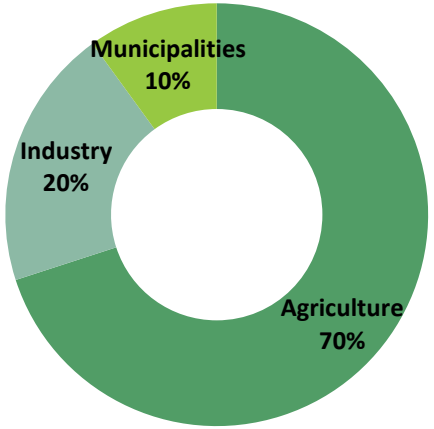
Agriculture, population growth, and economic development are driving the global demand for water to unprecedented levels

Globally, agriculture is the world's largest user of water, accounting for 70 percent of freshwater withdrawals throughout the world. In developing countries, the ratio is even more pronounced, with the agricultural sector accounting for as much as 90 percent of total water use. While water stress itself is local, its impacts ripple across political borders due to the embedded water of globally traded agricultural commodities (e.g., food prices can spike globally as a result of a drought in a major producing country).

Irrigated agriculture has driven the global expansion and intensification of freshwater depletion. The world now produces large quantities of food in arid regions – such as the Middle East, Central Asia, and the Western U.S. – which depend heavily on irrigation to meet agricultural demands. Water stress can have significant ecological impacts on both terrestrial and aquatic systems by reducing streamflow, increasing evapotranspiration, introducing saltwater into aquifers, and driving land cover change to expand land for food production. Further, regional economic collapse, and potentially population migration and international conflict can be catalyzed by aquifer depletion or extreme water-related weather events (e.g. flood and drought), which are often exacerbated by poor watershed management.

Most experts agree that water quantity will remain one of the foremost environmental and national security threats, particularly given its interconnections with the "food-water-energy" nexus. By 2050, global water demand is projected to increase by roughly 55 percent. In addition to depleting aquifers, climate change promises to shift current rainfall patterns and reduce snowpack, which will add to the destabilization. Given competing demands for industrial and municipal uses, there may be little opportunity to expand allocations for agricultural use. The net result is an expectation of further water stress and groundwater depletion globally.

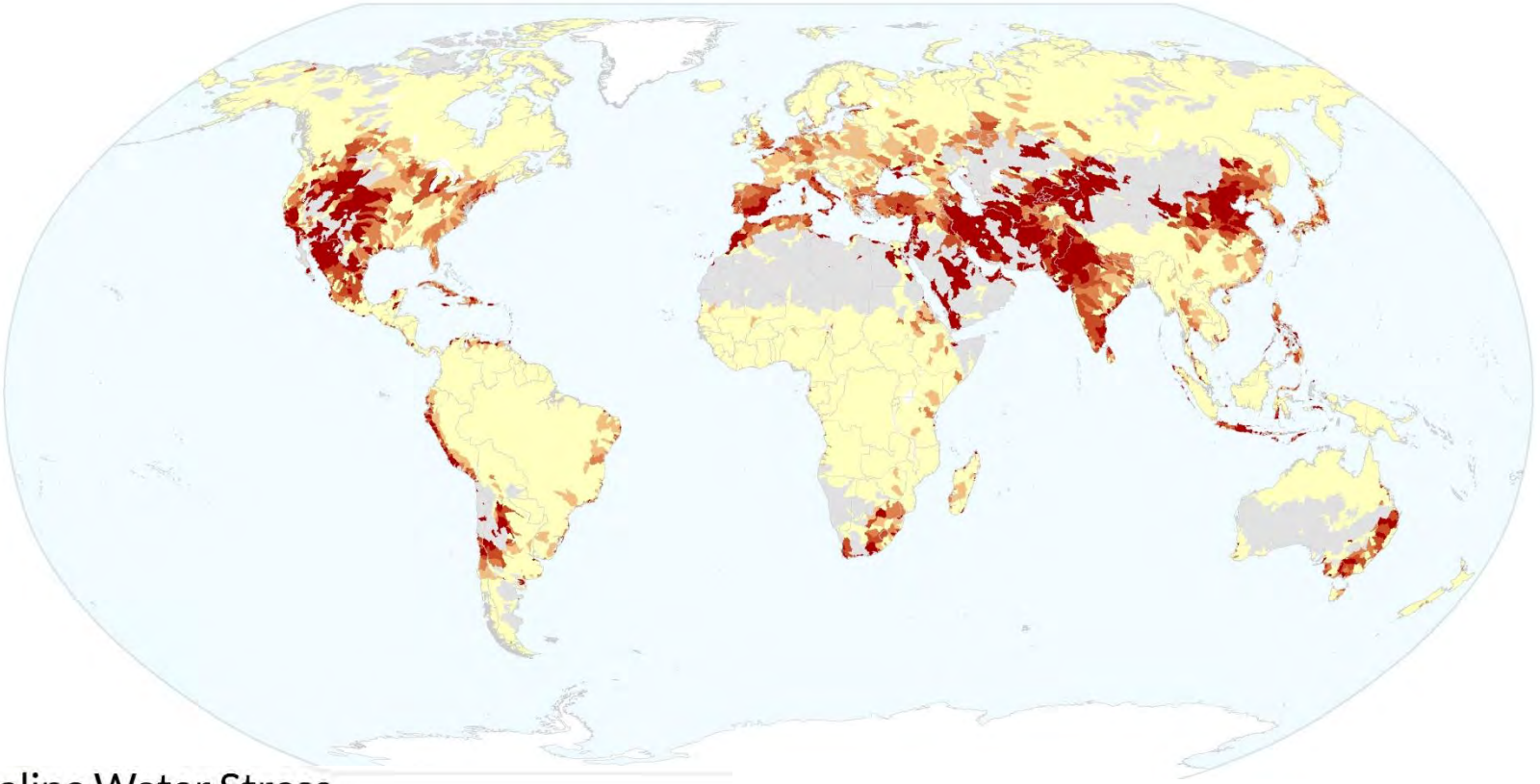
Global water use by sector



Sources: UN World Water Assessment Program, 2012; WWF, Water Risk Filter, 2012; Richter et al, 2013, "Tapped out: how can cities secure their water future?" Water Policy (5): 355-363.

Baseline Water Stress

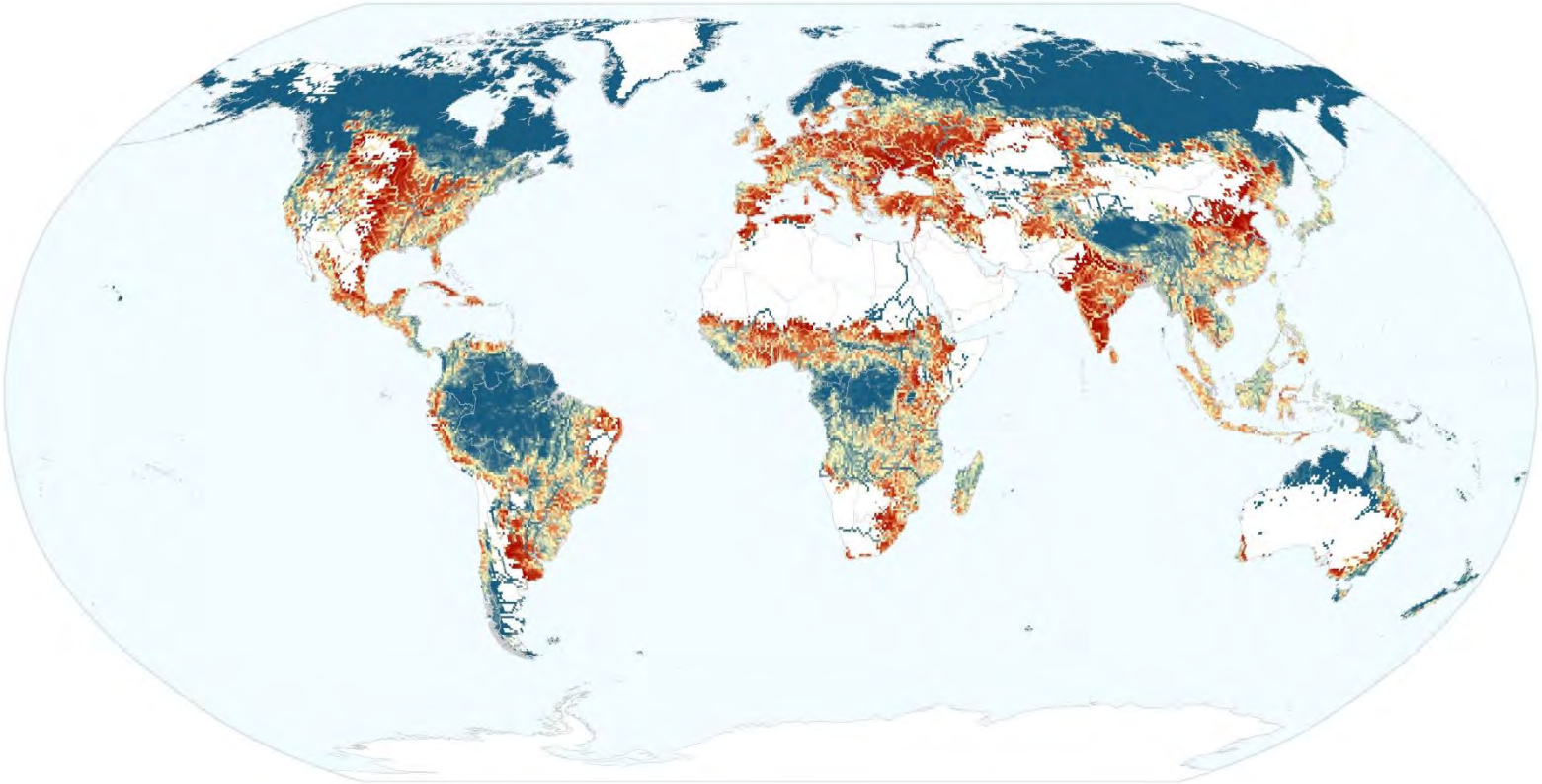
This map shows the ratio of water withdrawals to available flow. Higher stress values indicate greater competition among users (agricultural, industrial, and municipal).



Data Source: World Resources Institute/Aqueduct; http://aqueduct.wri.org/

Agricultural Water Stress

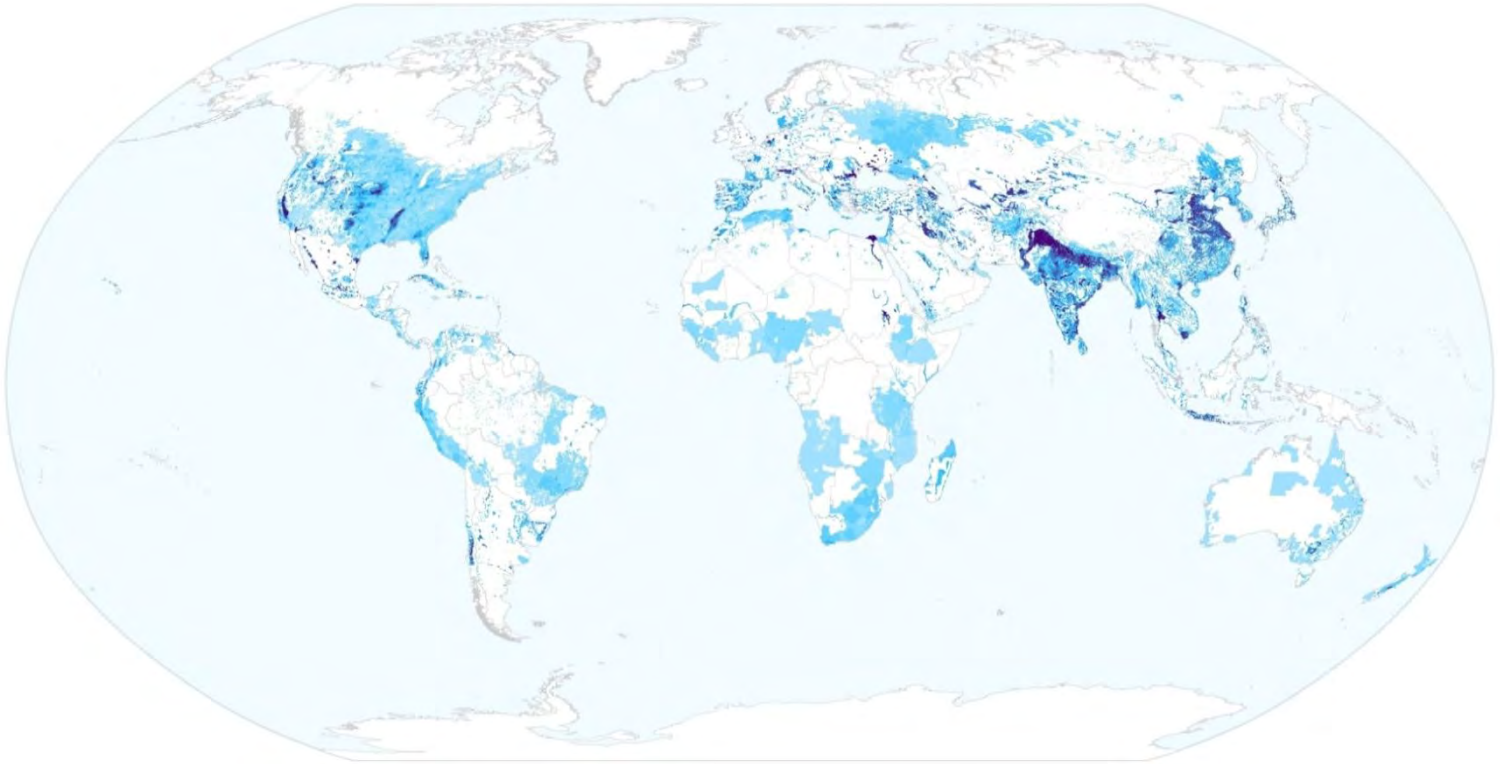
This map shows the ratio of discharge to cropland area as a way of estimating the burden that crop production places on renewable water supplies. Red areas (those with less water available per area of cropland) implies a higher potential for competition between agriculture and other sectors, or a higher potential for insufficient water availability for agricultural uses.



The results are expressed in units of million m^3 annual discharge per km^2 cropland area per year, such that the lowest values indicate places with the highest human water stress levels. Therefore, driver scores were inverted (i.e., 1-original score) following standardization to be consistent with the polarity of other drivers. Data from the year 2000.

Distribution of Irrigated Areas

This map shows the percentage of land under irrigation (percentage of area in each grid cell). The high dependence on irrigation of the major agricultural regions in India, China, and other parts of Southeast Asia is evident.



Occurrence of Irrigated Areas

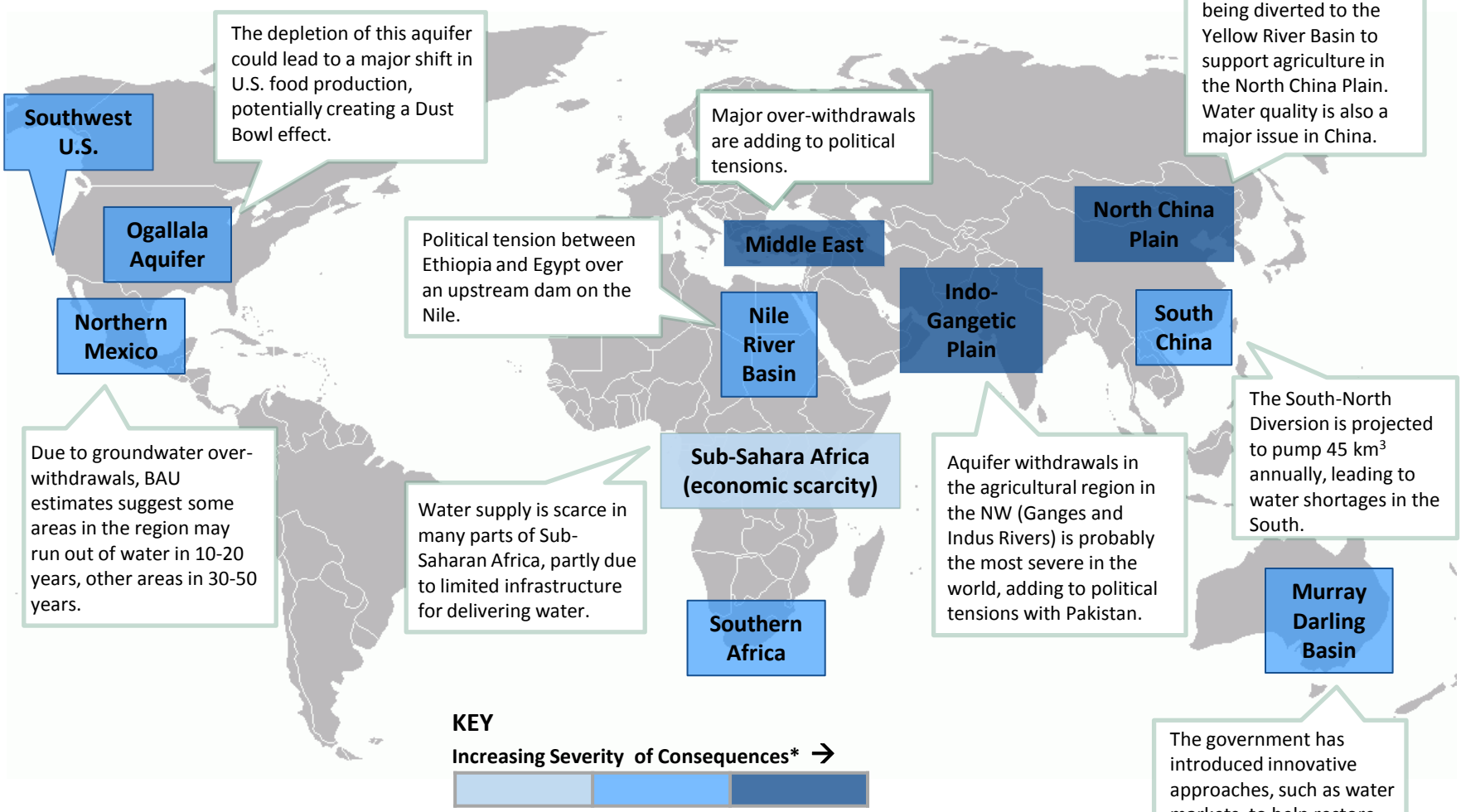
Percentage of 5 arc-minute grid cells

- 0 - 0.1
- 0.1 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 35
- 35 - 50
- 50 - 75
- 75 - 100

Data Source: FAO FGGD: Land Degradation Assessment in Drylands; http://geonetwork3.fao.org/fggd/

Water Quantity: Geographic Hotspots

Water scarcity has resulted in a wide range of hotspots globally. The most intense consequences are likely to be seen in China, India, and the Middle East given the convergence of environmental pressures and political tensions.



*For this issue area, a high severity of consequences indicates critical implications for food security and/or geopolitical relations.

Source: CEA synthesis of literature and expert interviews, conducted June 2013 to August 2013.

Continued expansion of water use and the absence of efforts to reduce water demand have left freshwater sources heavily depleted.

INDO-GANGETIC PLAINS

- India's drive to boost food production for its 1.3B population has been largely successful, yet increased intensity from the agricultural sector has led to overexploitation of groundwater resources, especially in the breadbasket of northwestern India. Government subsidies have also incentivized increased cotton and sugar production, even in unsuitable dry land areas.
- The rate of withdrawal in the Upper Ganges is roughly 50 times more than the natural recharge rate.
- Experts warn that the significant drop-offs in groundwater could lead to massive forced migration, political upheaval, and economic disruption.
- Two CEA interviewees described the situation as such:
  - "There is a real train wreck happening in India, where the population is exploding and underlying water resources are diminishing."
  - "In terms of water quantity, there is hardly a grimmer scene than in India and Pakistan."

OGALLALA AQUIFER

- The Ogallala Aquifer is a fossil aquifer, meaning it has extremely slow replenishment rates. While there are sections of the High Plains with too much surface water (e.g., Nebraska), depletion of the aquifer increases in severity towards the south (e.g., Kansas and Texas).
- Some estimates project that the Ogallala Aquifer could dry up in as little as 25 years.

NORTH CHINA PLAIN

- The country's breadbasket, the North China Plain, has extremely high water stress due to agricultural demand. The Chinese government is building a $65B water transfer system, the South-North Diversion, to channel water northward along three routes. Experts suggest that the central route may be most problematic, as it could reach the Himalayan headwaters, disturbing flows into India and Pakistan, potentially leading to serious geopolitical concerns.

SOUTH CHINA

- South China currently has low water stress, yet it is likely to be exacerbated by the South-North Diversion.
- As a whole, experts warn that the growing population in China – as in India – will magnify water demands as the burgeoning middle class seeks more water and energy-intensive foods, such as meat.

AFRICA and MIDDLE EAST

- Ethiopia's Grand Renaissance Dam project, intended to generate electricity and water supply on the Blue Nile, has raised serious alarm among Egyptian officials.
- In Palestine, aquifers are depleted to the extent that they may run dry within a decade. The capital of Yemen, Sana'a, may become the first capital in the world to run out of viable water, as its aquifers and streams run dry.
- In the Sahel, on the other hand, experts suggest that the region could dramatically improve its agricultural productivity by improving irrigation infrastructure and accessing untapped groundwater reserves.

Source: CEA synthesis of literature and expert interviews, conducted June-August 2013.

Water Quantity: Potential Solutions

SECTOR	APPROACH
MARKETS	• Water funds: a Payments for Ecosystem Service (PES) strategy in which downstream users pay for upstream watershed conservation in order to ensure a regular, clean supply of water; most effective when downstream urban users are water stressed and willing to pay. Often requires policy/regulatory support to formalize and scale the market. • Corporate supply chain approaches to improve watershed management and establish efficiency targets • Business models to expand the reuse of treated wastewater • Water pricing to incentivize more efficient use of agricultural water • Irrigation management schemes with water user associations
POLICY	• Water metering: simple water metering is the basis for any water rights or trading scheme, and can lead to better efficiency by itself • Water rights: are the foundation of most rational allocation and trading systems, but require sufficient institutional capacity; Australia has successful models • Water allocation between sectors based on careful monitoring and scientific analysis, including for environmental flows • Clear understanding of the linkages between ground water and surface water: these resources are often treated as separate entities, rather than as an inter-related management policy • Regulation of individual groundwater allocations by capping electricity usage at pumps • Preferential lending for farmers who grow crops appropriate for the local climate • Promotion of dietary shifts away from water-intensive food products • Headwater and inflow protections
TECHNICAL/ ON FARM	• Drip irrigation • Mulching and reduced tillage to reduce on-field loss of irrigation water • Water storage and transport improvements to reduce off-field evaporation • Crop varieties which are more water-efficient (e.g. drought/flood-resistant varieties) • Rainwater harvesting for agricultural uses • Reuse of wastewater for irrigation • Scheduling irrigation by using satellite pictures to examine evapotranspiration • Remote sensing technology to estimate water levels in wells

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Approach, Geography, and Partners
Bill and Melinda Gates Foundation	• **Investment Size:** $74M during 2006-2013. Direct agriculture-water investments are currently suspended, partly due to internal staff realignment • **Approach:** Strong focus on micro-irrigation products and service delivery models. $10.2 M project to research water management technologies in parts of African and India. • **Geography:** India and Sub-Saharan Africa • **Partners:** International Development Enterprises (iDE), International Water Management Institute (IWMI), Kickstarter, Professional Assistance for Development Action (PRADAN, India), International Food Policy Research Institute (IFPRI), Stockholm Environment Institute
Howard G. Buffett Foundation	• **Investment Size:** $150M over ten years (2006-2016) for its Global Water Initiative (GWI) • **Approach:** From 2006-2011, GWI focused on water and sanitation. Based on an external review in 2011, the foundation realigned GWI to focus on water security through sustainable agriculture development. GWI funds advocacy and research through regional programs to improve agriculture water management policies, research, investments, and knowledge. • **Geography:** West Africa, East Africa, Central America, and U.S. (Ogallala, MS, CO River basins) • **Partners:** CARE, International Institute for Environment and Development (IIED), Catholic Relief Services, EDF, IUCN, and Lake Partners Strategy Consultants
Skoll Global Threats Fund	• **Investment Size:** $1.5M in 2013, with plans to increase to $3M/year over next 3-5 years • **Approach:** Seeks to improve the quality and accessibility of water data to provide better information to decision makers including governments and corporations to farmers. • **Geography:** South Asia • **Partners:** Friends of the Earth Middle East, World Resources Institute (WRI), Global Environment and Technology Foundation, Inter-American Development Bank, and Woodrow Wilson Center for International Scholars

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Approach, Geography, and Partners
Walton Family Foundation	• **Investment Size**: $14.5M in 2012 • **Approach:** Aims to improve the quantity and timing or river flows for instream purposes, both basin-wide and in priority tributaries of the CO River Basin. • **Geography:** Colorado River Basin • **Partners:** TNC, EDF, Pronatura Noroeste AC, Trout Unlimited, Western Resource Advocates
S.D. Bechtel, Jr. Foundation	• **Investment Size:** $16M in 2012 • **Approach:** Focused on improving water management in California to enhance the state's environmental and economic health, by advancing efforts at the intersection of research and policy. • **Geography:** California • **Partners:** Stanford University's Water in the West Program, Audubon California, TNC, PRBO Conservation Science, Trout Unlimited, American Rivers
Pisces Foundation	• **Investment Size:** $1.5M annually • **Approach:** Supports water efficiency and groundwater reform in California, as well as the expansion of a new national water program focused on water efficiency and green infrastructure • **Geography:** California and U.S. national water policy • **Partners:** California Water Foundation, NRDC, National Fish and Wildlife Foundation
Cynthia and George Mitchell Foundation	• **Investment Size**: Approximately $600k/year • **Approach:** Seeks to advance scientific understanding of water issues in Texas, with the goal of informing effective policy approaches and allocating sufficient water resources for human and environmental needs. • **Geography:** Texas • **Partners**: Greater Edwards Aquifer Alliance, Texas A&M Foundation, Surfrider Foundation

Other Key Collaborations, Initiatives, and Partnerships

- Corporations are showing increased interest in water, primarily due to its interconnections with their supply chains. Most companies tend to engage in discrete projects in locations where they operate, with clear opportunity to yield reputational benefits. Key corporations active in this field include: Coca-Cola, PepsiCo, Dow Chemical, DuPont, General Electric, Goldman Sachs, General Mills, Unilever, Nestle, FEMSA Foundation, SABMiller, Lloyd's, Swiss Re, Levi Strauss.
- National governments are often the largest funders of domestic water initiatives. Some seem open to innovative water management policies, though most are focused on infrastructure projects.

Private companies and governments (examples)	Sample Projects
The Coca-Cola Company	• Coca-Cola has invested $247M into 386 projects through its Community Water Partnership (CWP) program over the past 5 years. Within CWP, 42% of projects types are for watershed protection and water for productive use; 33% are clean drinking water and sanitation initiatives; and 25% are education-oriented. • As one of its many partnerships, Coca-Cola works with WWF on watershed protection globally. During 2006-2012, Coca-Cola worked with WWF in 7 priority watersheds. During the next phase of its partnership with WWF, it will work in 11 key river basins through 2020. The company considers its supply chains, future expansion, and other business opportunities in selecting these locations, while WWF considers the conservation value of these places. • CEA Interview quote: "We can do cost-benefit calculations, but framing water quantity as a risk issue is more compelling for businesses. They are willing to spend a lot of money when their very existence is threatened."
Australian Government	• The Australian Government's $12B *Water for the Future* commitment supports healthy rivers, helps communities adjust to a future with less water, and helps restore the Murray Darling Basin. As part of this program, the government is purchasing water entitlements for the environment within the Murray Darling and has committed $5B to recover water for the environment through the Sustainable Rural Water Use and Infrastructure Program. • Urban-rural partnerships – through which cities pay farmers for a range of sustainable water management practices – can provide dual benefits by stabilizing the water supply for cities and providing a strong price signal that incentivizes conservation for farmers.

Other Key Collaborations, Initiatives, and Partnerships

- Although the food crisis of 2008 mobilized the aid community, the global financial crisis has subsequently depressed funding from traditional aid donors, including USAID and DFID.
- Multinationals continue to seek public-private partnerships to leverage funding and to promote the integration of market principles in government sector reform.

Aid and Multinationals	Overview of Approach and Sample Projects
Global Environmental Facility	• In 2011, GEF partnered with TNC, Inter-American Development Bank, and FEMSA Foundation to launch a $27 million partnership for the Latin American Water Funds. The partnership seeks to protect 7 million acres of watersheds in Ecuador, Colombia, Peru, Brazil, Mexico, and other countries, primarily through payment transfers between urban and rural areas for good practices at the farm level. • This partnership builds upon TNC's existing water fund work. In 2000, the organization created the first water in Quito, Ecuador in partnership with the public and private sectors.
USAID	• In 2013, USAID released the Agency's first global Water and Development Strategy to provide a clear roadmap for USAID's approach to water programming. The plan includes two strategy objectives: a) to improve health outcomes through water and sanitation initiatives, and b) to manage water for agriculture to enhance food security. For the latter objective, the Agency will focus primarily on technical and market-based approaches to achieve crop yield increases in rainfed areas, as well as to increase irrigated agriculture in select countries.
2030 Water Resources Group	• The 2030 Water Resources Group (WRG) is an independent entity which is currently hosted under the IFC and works solely at the invitation of governments. It provides a forum for mobilizing actors from the public and private sectors, civil society, academia, and finance institutions. Its objective is to support governments in implementing sustainable water sector policies that also advance national economic growth plans.
World Bank	• The World Bank recently launched the second phase of the Water Partnership Program (WPP), a multi-donor trust fund established in 2009. Supported by the governments of the Netherlands, Denmark, and UK, the WPP has provided $11.5B in World Bank financing in over 60 countries. In Phase II, the WPP anticipates investing largely in climate adaptation and water management projects in urban areas, with an initial program budget of $40M.

Key NGO Stakeholders

NGO	Primary Initiatives, Geography , and Effort
World Resources Institute	• **Initiative:** The Aqueduct Water Risk Atlas measures and maps water risk along 12 key indicators in 15,000 catchments around the world. The Aqueduct Alliance, which was founded by General Electric and Goldman Sachs, is a network of companies and organizations that provide support for the Aqueduct Project. • **Geography:** Global • **Effort:** 7 staff (2 directors, 1 Senior Fellow, 3 Senior Associates, 1 Associate)
The Nature Conservancy	• **Initiative:** TNC is engaging in market-based approaches to freshwater conservation. Two primary initiatives are the Latin American Water Funds Partnership (PES) and water markets with impact investors, the latter is currently in the design phase. • **Geography:** Latin American and the U.S. • **Effort:** 19 freshwater experts (junior staff figures not available)
WWF	• **Initiative:** Similar to WRI's Aqueduct Atlas, the WWF Water Risk Filter provides global maps of water risk to support companies in assessing water-related risks for their operations, suppliers, or growth plans. • **Geography:** Global • **Effort:** n/a
International Water Management Institute	• **Initiative:** A research center of CGIAR, IWMI focuses on water and land management challenges faced by poor communities in the developing world. • **Geography:** Global • **Effort:** Staff of 350, divided between work on 4 themes: Water Quantity, Productive Water Use, Water Quality, and Water and Society
Stockholm International Water Institute	• **Initiative:** SIWI provides policy research to inform decision-making for smart water policy and sustainable development. • **Geography:** Global • **Effort:** 26 water program staff
International Food Policy Research Institute	• **Initiative:** Through its policy reports and analysis, IFPRI seeks to improve water use efficiency in developing countries, as well as to improve water quality, reduce degradation on irrigated land, and increase food and water security for the poor. • **Geography:** Global • **Effort:** 3 staff focusing on water policy; dozens of other researchers focusing on agriculture/water cross-cutting issues

Additional Resources

- **Reports and Databases**
  - "A Comprehensive Assessment of Water Management in Agriculture," IWMI, 2007
  - "Charting Our Water Future: Economic frameworks to inform decision making," McKinsey and Company, 2009
  - AgWATER Solutions Project: $10M project funded by BMGF and led by IWMI; conducted landscape review of water technology and the environment in Africa and India
  - CEO Water Mandate: Special initiative of UN Secretary-General; its website features research, reports, and tools to inform companies about understanding global water challenges

- **Conferences**
  - World Water Week: Hosted by Stockholm International Water Institute; held in August/September
  - Water for Food Conference: Hosted by Water for Food Institute at the University of Nebraska; held in May
  - UN World Water Day: Coordinated by UNESCO to promote global water cooperation; held on March 22nd

- **Consultants**
  - Julie Wroblewski
    - Consulted to BMGF on water management in agriculture program
    - Current program officer for Global Water Initiative at Howard G. Buffet Foundation
    - Has a strong sense of funding landscape, program strategies, and implementation partners
    - Email: Julie.Wroblewski@gatesfoundation.org
    - Phone: 310-595-4239

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CEA's Impressions of the Field: Climate and Air Pollution

Agriculture is a major contributor to global greenhouse gas emissions, especially when its role in deforestation is considered. Agriculture accounts for about ten percent of global greenhouse gas emissions (~4.6 Gt CO_2e yr^{-1}). In addition, agriculture is thought to drive roughly 80 percent of deforestation globally. When land use change emissions are included, along with those from the agricultural supply chain, the sector accounts for about 20% of global emissions (~10.6 Gt CO_2e yr^{-1}). In terms of the direct emissions from production, four countries (China, India, US, and Brazil) account for 40 percent of all emissions. And three commodities alone – beef, dairy, and rice – account for over 60 percent of agricultural emissions. Since deforestation associated with agriculture is a major element of the emissions, any mitigation intervention needs to be evaluated for the impact it might have on future land use.

Global food production will increase about 70% by 2050, and emissions will roughly follow suit. Though yields are still increasing for most crops, additional conversion of natural habitat is likely. Further, increasing demand for input-intensive and carbon intensive foods (such as meat and dairy) is growing quickly in many parts of the world, and at the same time, climate change has the potential to greatly diminish agricultural productivity in some regions. Sustainable agriculture practices need to be embraced on existing lands in order to keep their soils from degrading.

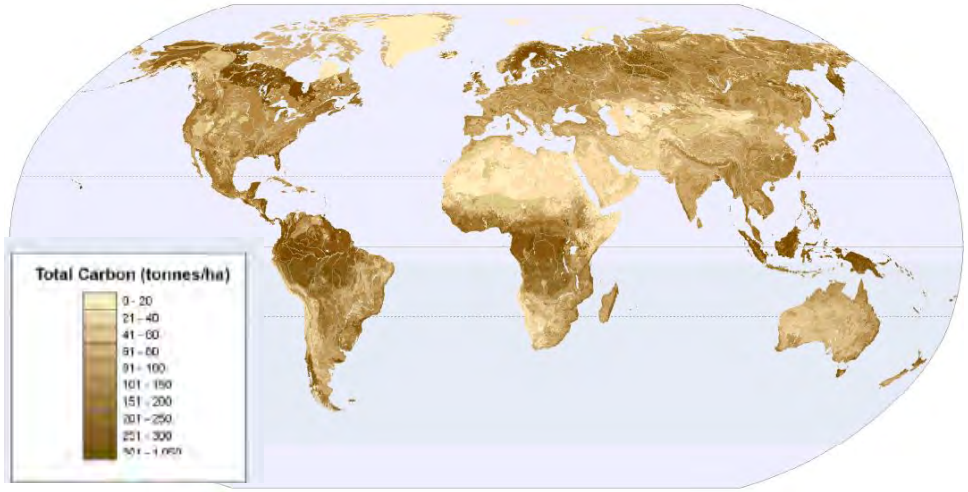
The technical potential to mitigate emissions from the agricultural sector is high. However, it depends on changing the practices of hundreds of millions of farmers spread across the globe. Leading technical options include: 1) improve pasture management, especially in Latin America, to decrease enteric methane emissions, increase soil carbon sequestration, and reduce forest conversion, 2) improve nutrient management, especially in China, 3) introduce mid-season drainage in irrigated rice systems across Southeast Asia, and 4) expand agriculture onto degraded lands (to protect high-carbon lands).

Furthermore, national governments have shied away from mitigation efforts because of a fear of decreasing productivity and an overarching commitment to food security. Though many funders of all kinds are focused on deforestation, there is much less investment at the intersection of agriculture and climate.

Source: Alexandratos and Brunisma, 2012, "Global Agriculture Towards 2030/2050; FAOStat 2010.

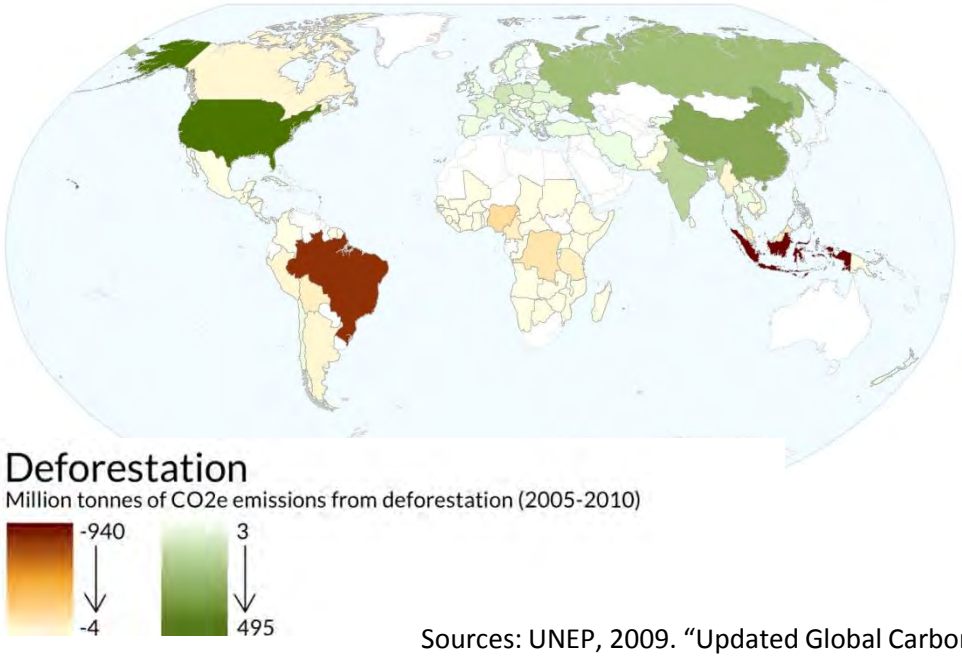
Global map of carbons stocks and deforestation trends

A. Carbon stocks in terrestrial ecosystems (T/ha)



A. The planet's terrestrial ecosystems store over 2,000 GT of carbon in their above/below-ground biomass and in the soil. As this map highlights, carbon stocks are especially dense in tropical ecosystems.

B. CO2e emissions from deforestation (MT CO2e)

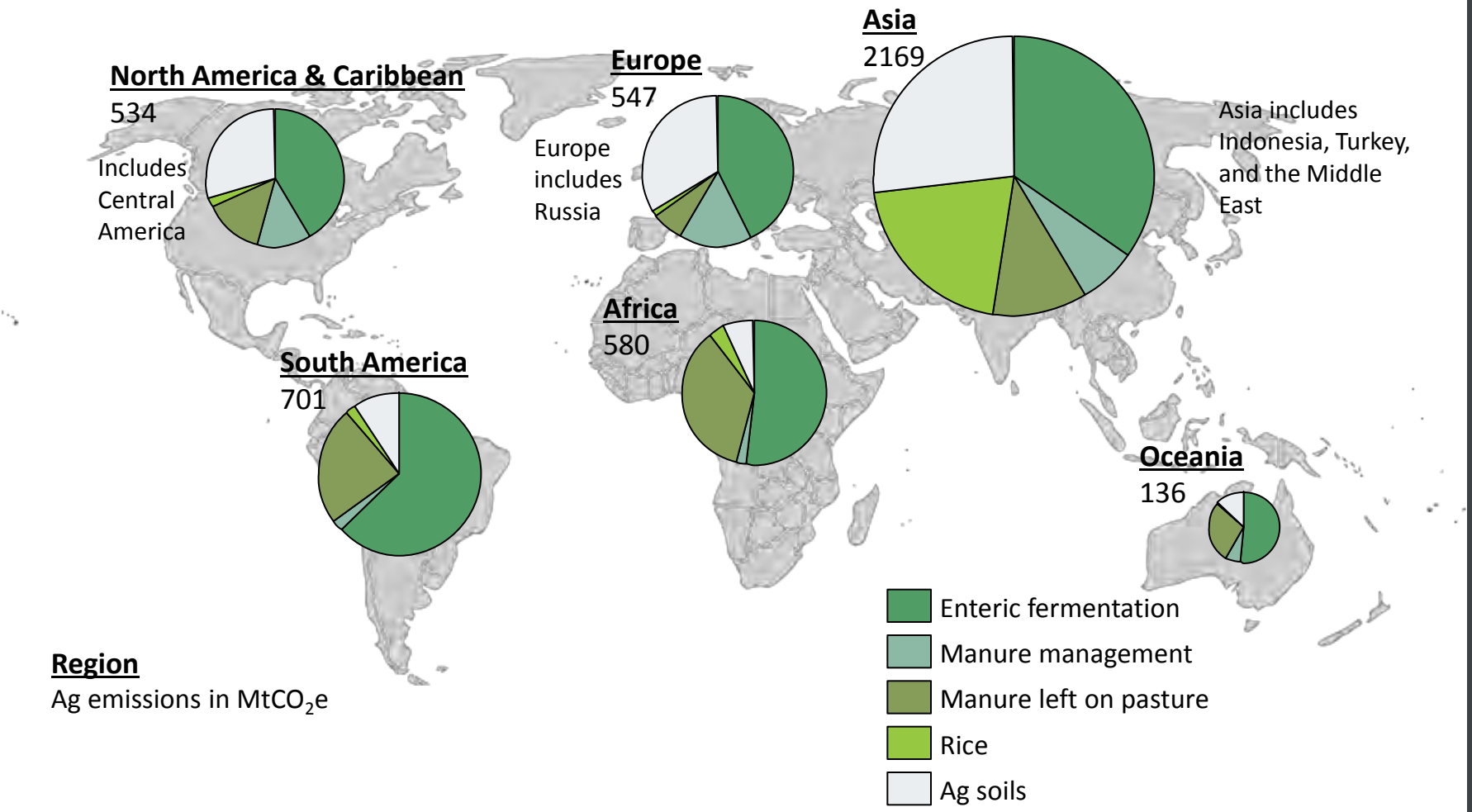


B. Indonesia and Brazil showed the sharpest increases in CO_2e emissions from deforestation during 2005-2010. The Congo Basin is at risk of future development as are the Peruvian, Columbian, and Bolivian parts of the Amazon. The U.S., China, Russia, and India followed an afforestation trend over the same time period.

Sources: UNEP, 2009. "Updated Global Carbon Map"; EDGAR v. 4.2; FAO Forest Resource Assessment, 2010.

Distribution of agricultural emissions

Asia, which possesses 60% of the world's population and 30% of its land area, accounts for 45% of global agricultural emissions. China, India, Brazil and the U.S. are top emitters. (Emissions from land use change are not included in the analysis.)



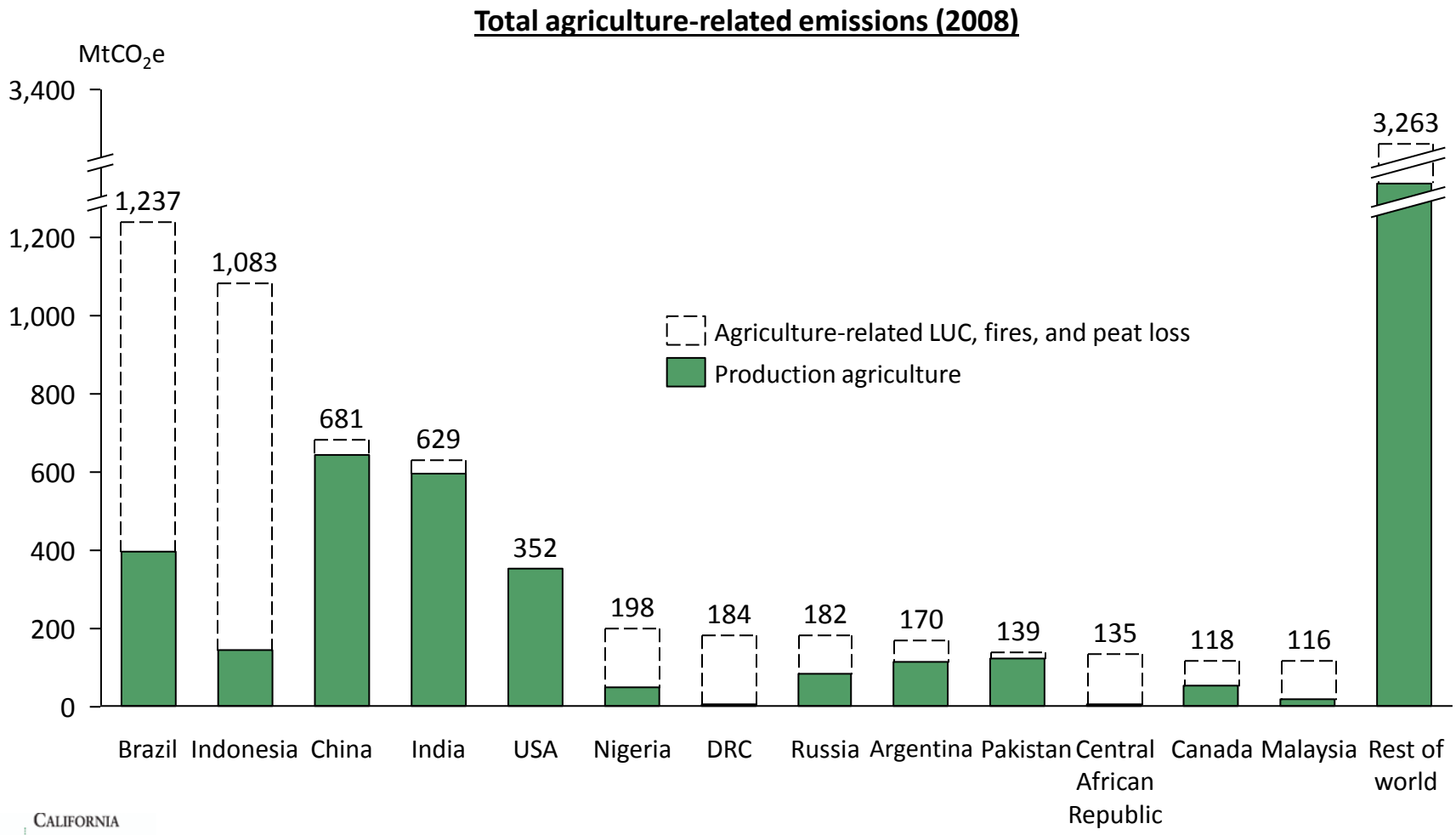
Note: Area of pie charts scaled to regional emissions.

Source: FAOStat data from 2010.

Ag soils includes synthetic fertilizers, manure applied to crops, field application of crop residues, and nitrous oxide from cultivated organic soils.

Distribution of emissions from agriculture and forestry

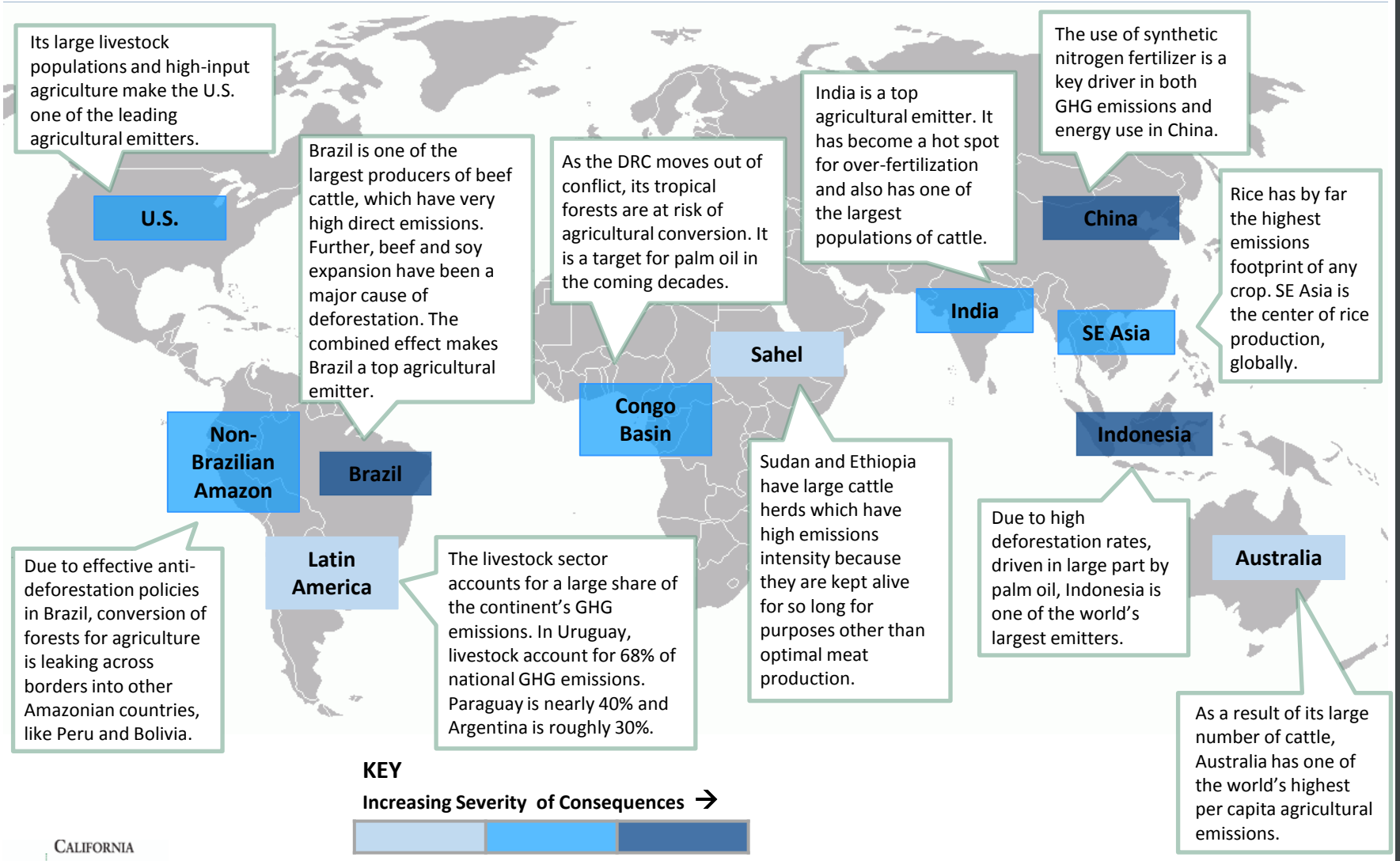
Factoring in agriculturally-driven land use change alters the calculus of which countries have the highest agricultural emissions, with tropical countries, particularly Indonesia and Brazil, rising to the fore.



Source: CEA analysis using FAOStat 2010, UN 2012, EDGAR v4.2

Climate and Air Pollution: Geographic Hotspots

Pollution hotspots are dispersed geographically, yet three countries in particular - Brazil, Indonesia, and China - emerge distinctly as the world's top agricultural emitters.



*For this issue area, a high severity of consequences indicates high GHG emissions potential.

Source: CEA synthesis of literature and expert interviews, conducted June 2013 to August 2013; EDGAR v4.2.

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Geography, and Approach
ClimateWorks Foundation	• **Investment Size**: $17.3M for CLUA in 2012 • **Geography:** China, EU, India, US, and Latin America • **Approach**: Core funder of CLUA; focuses on forest policy in Brazil and Indonesia as well as international mechanisms to reduce deforestation
Gordon and Betty Moore Foundation	• **Investment Size:** ~$8.7M for CLUA • **Geography:** Amazon Basin • **Approach:** Core funder of CLUA; conserves Amazonian forests by maintaining protected area systems, addressing deforestation challenges in frontier economies, and establishing national/subnational policies for REDD
Ford Foundation	• **Investment Size**: $2.1M in 2011 for climate/ag grants; ~$7.9M for CLUA • **Geography:** Brazil, Mexico, Central America, and Indonesia • **Approach**: Core funder of CLUA; strong focus on indigenous rights in land use and development
Margaret A. Cargill Philanthropies	• **Investment Size:** ~$6M for forest carbon grants • **Geography:** Brazil, Indonesia, Mexico, Central America, other unnamed tropical countries • **Approach:** CLUA affiliate; core focus on REDD+ to support alternative livelihoods
Rockefeller Foundation	• **Investment Size:** $4M for forest carbon grants • **Geography:** Africa and Asia • **Approach:** Food security and climate intersection through programs to promote climate resilience practices in agricultural development in Africa and Asia
Fundo Vale	• **Investment Size**: ~$10M for forest carbon grants • **Geography:** Brazilian Amazon • **Approach:** CLUA affiliate; research-oriented with deforestation risk modeling focus
Skoll Foundation	• **Investment Size:** ~$1M for forest carbon grants in 2011 • **Geography:** Tropical forests in Amazon, Central Africa, and Southeast Asia • **Approach:** Work with entrepreneurs in communities to improve land management and slow deforestation
Waterloo Foundation	• **Investment Size:** Not available • **Approach:** Supports projects that protect tropical rain forests, primarily through avoided deforestation • **Geography:** Tropics

Other Key Collaborations, Initiatives, and Partnerships

Sector	Stakeholders and Sample Projects
Private	• **Corporations**: Starbucks, Mars, Olam International, Citi, Credit Suisse, Rabobank, HSBC, Ikea, Swiss Re, Sodexo, Woolworths Limited, and Body Shop • **Sample Project:** Mars partnered with the World Agroforestry Center (ICRAF) through the "Visions for Change: Sustainable Cocoa Communities" project. The initiative conducts research to explore climate change adaptation and mitigation opportunities, develop improved cocoa varieties, and secure markets.
National Governments	• **Governments:** Norway, Netherlands, Denmark, Japan, Spain, Australia, New Zealand, and Brazil • **Sample Projects:** In 2010, the Norwegian Government committed $1B to reduce forest and peat related emissions in Indonesia. In 2009, the Brazilian Government created the Amazon Fund to raise donations to prevent, monitor, and combat deforestation in the Amazon Biome. New Zealand led the founding of the Global Research Alliance on Agricultural Greenhouse Gases, and committed $45 million in funding from 2010 to 2016 (see more on GGA, below).
Aid	• **Aid Organizations:** USAID, DFID, AusAID, German Agency for International Cooperation, GEF Trust Fund • **Sample Project:** For the period 2010-2014, a total of $4.25 billion has been pledged for the GEF Trust Fund, of which roughly $1.35 billion is expected to be used for climate mitigation projects.
Multilaterals	• **Multilaterals:** World Bank; IFC; Global Research Alliance on Agricultural Greenhouse Gases; Convention on Biological Diversity; CGIAR Climate Change, Agriculture, and Food Security; CGIAR World Agroforestry Center; UN Framework Convention on Climate Change; UN-REDD; and UN Forum on Forests • **Sample Project:** The Global Research Alliance on Agricultural Greenhouse Gases, which launched in 2009, includes a network of 35 countries researching ways to produce more food without increasing GHG emissions. It focuses on the rice, croplands, and livestock sectors, and the cross-cutting themes of soil carbon, nutrient cycling, and measurement issues.
NGOs	• **NGOs:** Conservation International, The Nature Conservancy, WWF, EDF, World Resources Institute, Greenpeace, EcoAgriculture Partners, IFPRI, Rainforest Alliance, Rainforest Action Network, and IUCN • **Sample Project**: WWF has convened several multi-stakeholder roundtables to unite producers and buyers on improving practices within commodity supply chains. The objective of the roundtables is to establish independent certification schemes with production standards. Current roundtable issue areas include: sustainable palm oil, cotton, sugar cane, soy, forestry, biofuels, and beef.

DEEP DIVE INVESTIGATIONS

- WATER QUANTITY
- CLIMATE AND AIR POLLUTION
- BIODIVERSITY AND HABITAT LOSS

SHALLOW DIVE INVESTIGATIONS

- WATER QUALITY
- SOIL QUALITY
- AGRICULTURAL DEVELOPMENT

CEA's Impressions of the Field: Biodiversity and Habitat Loss

Agriculture is the world's largest driver of species loss, genetic erosion, and habitat conversion. No other human activity has physically altered the planet more than agriculture: crops and pasture cover nearly 40 percent of the Earth's terrestrial surface. Recently, agricultural expansion has been greatest in the tropics, with particularly high deforestation rates seen in the Amazon and Indonesia, responding to growing global demand for livestock, soy, and palm oil. While habitat loss is the most direct way in which agriculture impacts biodiversity, given the massive footprint of agriculture, the manner in which production is conducted also matters a lot. An agricultural system that include migration corridors, multiple crop rotations, riparian buffers, pollinator habitat, and that limit chemical inputs will be much more wildlife-friendly than high-input, mono-cropping systems. GMOs, while potentially important from a food security perspective, threaten natural genetic stocks and biodiversity.

The contribution of biodiversity to human livelihoods has historically been under-valued. Biodiversity and intact habitats provide key ecosystem services — such as pollination, air and water purification, nutrient cycling, and drought and flood control— which are necessary for protecting human health and economic livelihoods. The expansion of agriculture can threaten the provision of these services. Historically, these functions have not been measured, valued, or considered in planning and prioritization of national governments and multilaterals.

Progress in this field is challenging because industrial agriculture is profitable while habitat and biodiversity benefits accrue over time to diffuse populations. Strong land use protections and policies are needed to control habitat loss; governance is key. Market-based approaches (e.g., payment for eco-system services and natural capital accounting) can compensate for habitat protection and better farming practices, but though they are appealing and slowly making progress, they are not yet at scale. Traditional conservation agriculture practices are vital, but too often not seen to be in the near-term economic interest of the producers. Consumer-driven certifications (e.g., organics, Rainforest Alliance) have to-date provided little demand for these practices.

Agricultural expansion into sensitive habitat has led to extensive impacts on biodiversity and ecosystem services

In total, agriculture occupies nearly 40 percent of terrestrial surface, with pastures covering roughly 3.4 billion ha (26 percent of ice-free land) and croplands covering 1.5 billion ha (12 percent of ice-free land). Globally, agriculture has cleared or converted roughly 70 percent of the original extent of grassland, 50 percent of the savanna, 45 percent of the temperate deciduous forest, and 27 percent of the tropical forest biome. The cumulative activities of the agricultural sector represent one of the principal drivers of biodiversity and habitat loss.

In recent decades, agricultural expansion has occurred disproportionately in the tropics, where approximately 80 percent of new croplands annually replace forests, a critical source of biodiversity and ecosystem services. Habitat loss has immediate local and regional level impacts, and it can also have more widespread effects on global eco-system functions, such as changing weather patterns or changing the resiliency of large landscapes. Scientific knowledge recognizes that a diverse mix of species is integral to ecosystem health, yet tipping points are not well understood (i.e., little is known about how much biodiversity can be lost before the resilience of ecosystems is compromised).

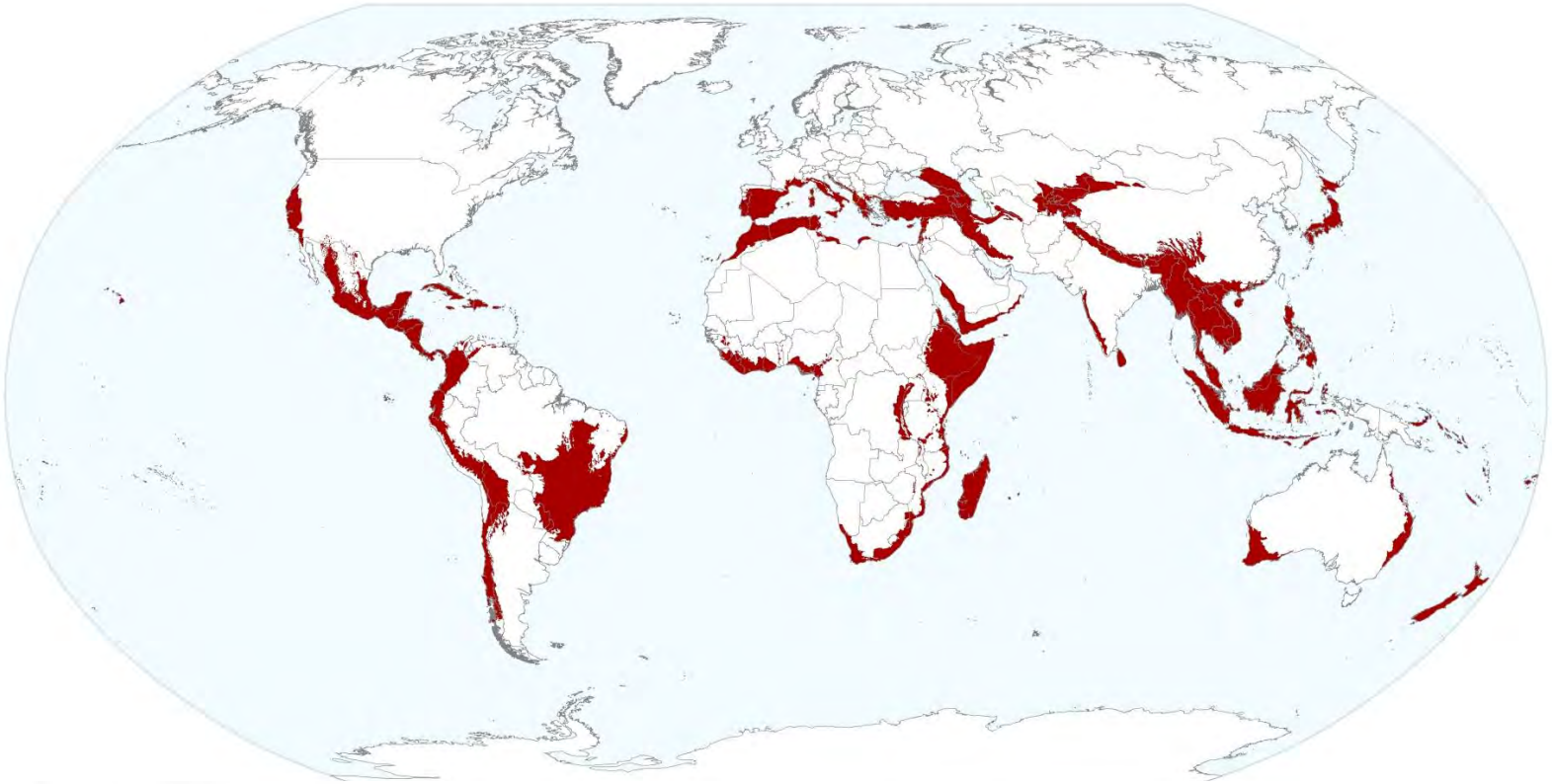
In recent years, biodiversity in the agricultural landscape has attracted increased attention given its contribution to the resiliency of agricultural systems, and therefore both food security and economic health. In July 2013, sixteen global agricultural and conservation leaders gathered in Rio to launch *Bridging Agriculture and Conservation*, an initiative aimed at addressing the role of agricultural and biodiversity in achieving the Rio+20 Sustainable Development Goals.

Through partnerships such as the World Bank's WAVES Program, several national governments have also demonstrated their commitment to implementing natural capital accounting into their national accounts. Though the concept of natural capital has been in existence for more than 30 years, the recent adoption of the System for Environmental-Economic Accounts has propelled finance ministries and ministries of the environment to more closely consider the impact of natural capital to national income. Several countries, including Botswana, Colombia, Madagascar, and the Philippines have developed work plans for implementing natural capital accounting. Still, these programs have not yet reached scale for wide impact. The focus on natural capital valuation is part of a larger global trend by the conservation community to raise the prominence of biodiversity conservation within broader economic growth and development agendas.

Sources: Foley et al., 2011. "Solutions for a Cultivated Planet," Nature 478: 337-342; Phalan et al., 2013. "Crop Expansion and Conservation Priorities in Tropical Countries," PLoSOne 8 (1): 1-13; World Bank, 2013, "Waves Partnership."

Map of Global Biodiversity Hotspots

This map shows biodiversity hotspot areas, as defined by Conservation International. CI's hotspots are areas of the world with large number of endemic plant species (each hotspot must contain at least 1,500 species of vascular plants) and where *less than 30 percent* of the original habitat remains. Based on this quantitative framework, CI has identified 34 biodiversity hotspots, which are home to over 50 percent of the world's plant species and 42 percent of all terrestrial vertebrate species.



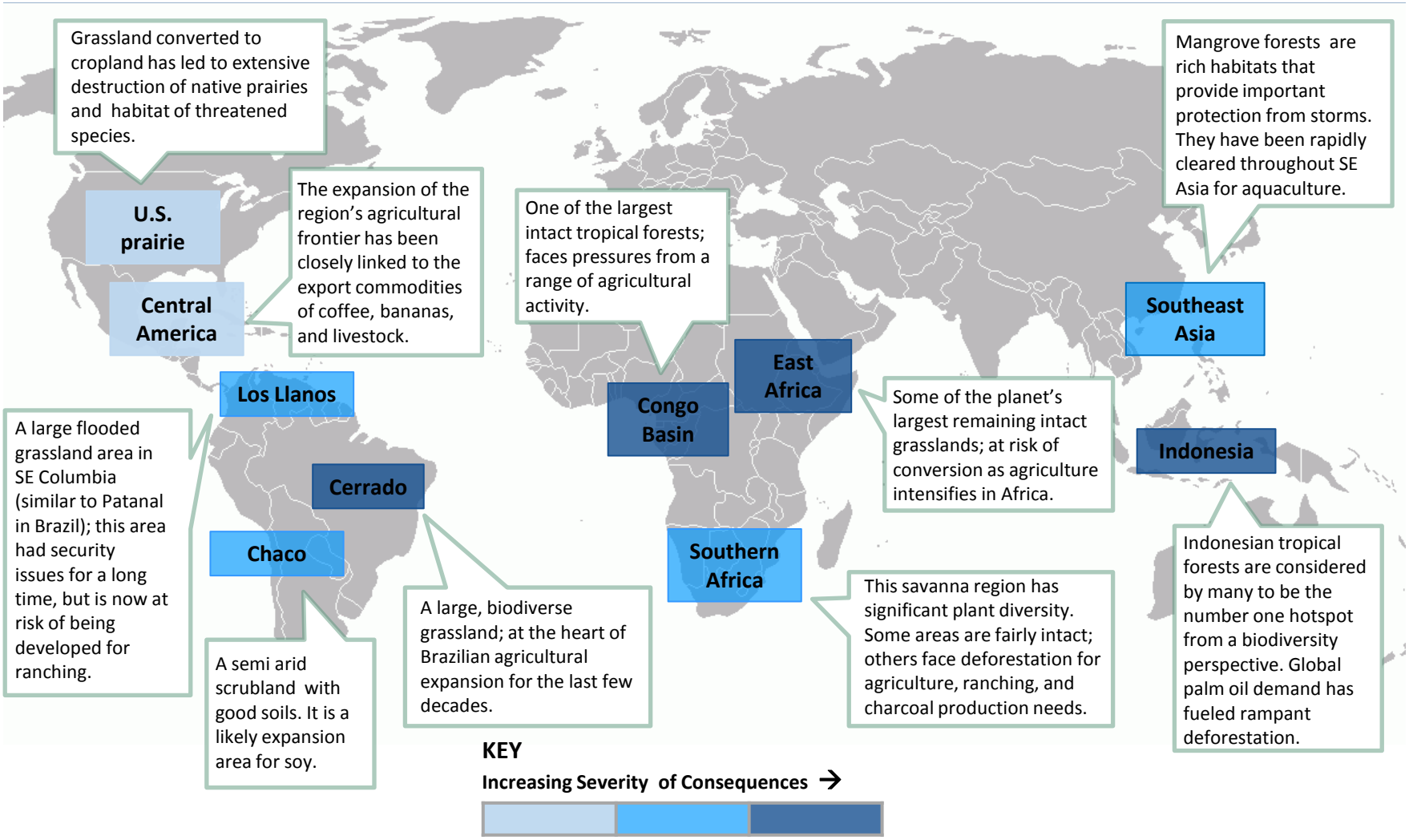
Biodiversity Hotspots

Hotspot Area

Data Source: Conservation International; http://www.conservation.org/where/priority_areas/hotspots/Pages/hotspots_main.aspx

Biodiversity and Habitat Loss: Geographic Hotspots

Experts point to Indonesia as the world's leading biodiversity hotspot. Other threatened biodiverse areas which are ripe for agricultural expansion include the Cerrado in Brazil, Congo Basin, and East Africa.



*For this issue area, a high severity of consequences indicates high potential for habitat conversion and/or a reduction in species richness or abundance.

Source: CEA synthesis of literature and expert interviews, conducted June 2013 to August 2013.

Biodiversity and Habitat Loss: Geographic Hotspots

GRASSLANDS

- 70% cleared or converted by agriculture*
- Threatened geographies: Chaco (NW Bolivia, Western Paraguay, and Northern Argentina); U.S. Prairie
- Grassland soil is very fertile, with potential to cultivate a wide range of crops. However, poor agricultural practices can exhaust the soil, leaving the land barren.
- Experts worry that the Chaco and Los Llanos are very suitable for commercial agriculture and are poised to experience rapid habitat conversion.
- In the U.S., less than 5% of the original prairie remains.

SAVANNAS

- 50% cleared or converted by agriculture*
- Threatened geographies: Cerrado (Brazil) Southern Africa, East Africa.
- The Brazilian Cerrado accounts for 21% of the country's land area. The region contributes 70% of the country's livestock production and is also an important production center for soy.

WETLANDS

- Threatened geographies: SE Asia (Malaysia, Indonesia)
- The agricultural development of wetlands often increases pollution inputs, removes natural filtering functions, and decreases other ecosystem services.

TROPICAL FORESTS

- 45% of temperate deciduous forest cleared or converted by agriculture. 27% of tropical forest biome cleared or converted by agriculture.*
- Threatened geographies: Indonesia, Congo Basin, Brazil
- Roughly 12-15 million hectares of forest are lost annually, with 87% of deforestation occurring in just 15 countries.
- Although the Brazilian government has shown leadership in developing sustainable forestry policies, experts are concerned that deforestation is leaking across borders to other Amazonian countries.
- Experts also point to the Congo Basin as facing worrisome trajectory, on the verge of development as Brazil experienced in the 1970s.

MANGROVES

- Mangrove forests have declined by 30-50% during the past half century.
- Threatened geographies: SE Asia (Thailand, Indonesia, Vietnam, Malaysia) due to expanding aquaculture; Africa (Nigeria, Mozambique, Madagascar) for fuel wood demand.
- Remaining intact forests are located in Brazil, Benin, and Bangladesh.
- Studies have found that mangroves are among the most carbon dense forests in the tropics, and that they are valuable for protecting against storms and sea level rise.

Sources: CEA synthesis of literature and expert interviews, conducted June-August 2013.

* Foley et al, 2011. "Solutions for a Cultivated Planet," Nature 478: 337-342; Phalan et al, 2013. "Crop Expansion and Conservation Priorities in Tropical Countries," PLoSOne 8 (1): 1-13;

Biodiversity and Habitat Loss: Potential Solutions

SECTOR	APPROACH
MARKETS	• Develop certification programs to drive consumer demand for more sustainable foods (e.g., organic shrimp certification in Vietnam demands that farms maintain 50% mangrove cover) • Create networks that link producers, retailers, and consumers who value food quality standards and support farmers who practice more sustainable approaches to agriculture (e.g. Rainforest Alliance certified coffee) • PES: provide remuneration for communities that protect key habitat providing ecological services (e.g. coastal communities that preserve mangrove forests, which provides a storm buffer)
POLICY	• Establish property rights surrounding land use • Implement and enforce national land use policies to stabilize the agricultural frontier through land use and infrastructure planning, regulation of large international land acquisitions, and protected areas • Support PES schemes and/or international agreements that protect land and water rights for parties that maintain biodiversity, including indigenous communities and small-scale farmers • Ban the use of particular pesticides with severe and known threats to biodiversity • Fund research in areas with objectives beyond increasing agricultural production – e.g. those that optimize biological processes, including soil management and pest and disease control • Influence agricultural bills to prevent perverse subsidies • Redirect agricultural expansion to suitable degraded lands
TECHNICAL/ ON FARM	• Educate farmers about traditional biodiversity-friendly agricultural practices, including: integrated pest and disease management, multi-cropping farming systems, diversified crop rotations with nitrogen-fixing legumes, no-till direct planting, and year-round organic cover • Protect functional ecological groups: this includes species that collectively provide ecosystem services such as soil formation, cycling of nutrients, and pollination • Use agroforestry systems for timber and fuelwood to prevent degradation of forests • Apply mixed crop-livestock systems: livestock provide manure and draught power, while crops residues serve as livestock feed • Increase aquaculture productivity to prevent expansion into vulnerable habitat (e.g. mangrove forests)

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Approach, Geography, and Partners
Gordon and Betty Moore Foundation	• **Investment Size:** $32M for Andes-Amazon Initiative in 2012 • **Approach:** The Andes-Amazon Initiative seeks to maintain the ecological function and representative biodiversity of the Amazon Basin through protected areas and reduced deforestation. • **Geography:** Amazon Basin • **Partners:** IFPRI, TNC, Conservation Strategy Fund, Consultative Group on Biological Diversity, WWF, Wildlife Conservation Society, Amazon Conservation Society
MacArthur Foundation	• **Investment Size:** $176M, ten-year commitment for entire conservation and sustainable development (encompasses areas beyond the scope of agriculture) • **Approach:** In addition to protecting protect biodiversity in its three key geographies, the Foundation also works globally to incorporate environmental and social considerations into commodities markets, including timber, palm oil, cotton, and soy • **Geography:** Gates Lakes of East Central Africa, the Greater Mekong, and the Andes (region-specific work) and global-level for cross-cutting issues • **Partners:** Conservation International, Conservation Strategy Fund, Amazon Watch
The Christensen Fund	• **Investment Size:** $10M in 2012 (includes grants for 'cultural' diversity) • **Approach:** Makes place-based investments in regions with significant cultural and biological diversity • **Geography:** African Rift Valley, Central Asia and Turkey, SW U.S. and NM, Melanesia, and N. Australia • **Partners:** Consultative Group on Biological Diversity, Slow Food International, Bioversity International
Swift Foundation	• **Investment Size:** $1.1M for biodiversity-related grants in 2012 • **Approach:** Support indigenous peoples in linking biological and cultural diversity in agricultural landscapes • **Geography:** Columbia, Ecuador, Peru, Northwest British Columbia • **Partners:** EarthRights International, Land is Life, Global Greengrants Fund

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Approach, Geography, Partners, and Grantmaking Orientation
Bill and Melinda Gates Foundation	• **Investment Size:** Three-year $10M grant to CI for 'Vital Signs Program' • **Approach:** Vital Signs is developing a system to provide near-real time data for monitoring ecosystem services in agricultural landscapes, in order to inform decision-making on agricultural development. • **Geography:** Currently in Tanzania, Ethiopia, Ghana; planned future expansion in Africa • **Partners:** Conservation International, Columbia University Earth Institute, and Council for Scientific and Industrial Research
blue moon fund	• **Investment Size:** $1.3M for biodiversity/habitat protection grants in 2011 • **Approach:** Works in high-biodiversity areas on three continents to protect threatened habitats and livelihoods, particularly those threatened by climate change. The Foundation seeks to leverage market mechanisms and advance initiatives with potential for long-term sustainability. • **Geography:** China, Greater Mekong sub-region, Himalayas, Chesapeake-Appalachia, Gulf Coast, Andes Amazon, Eastern Amazon, and Mesoamerica • **Partners:** Wildlife Conservation Society, Amazon Watch, Conservation International
Rockefeller Foundation	• **Investment Size:** $1.2M for two grants to protect mangrove ecosystems • **Approach:** Though its work with the Asian Cities Climate Change Resilience Network to enhance urban sustainability, it has supported the integration of mangrove conservation into local urban development plans. • **Geography:** Asia • **Partners:** Institute for Social and Environmental Transition (Vietnam); Mercy Corps (Indonesia)

Other Key Collaborations, Initiatives, and Partnerships

- **Corporations:** The Walt Disney Company, Chiquita, Starbucks, Credit Suisse, Nestle, Rio Tinto, HeidelbergCement, Rabobank, Citi, Wal-Mart, and Woolworths Holdings
- **Bilaterals:** The largest biodiversity bilateral donors were U.S. (7.5%) and Germany (5%) during 2001-2008
- **Aid agencies:** USAID, Canadian International Development Agency, Japanese Ministry of Foreign Affairs, Norwegian Agency for Development Cooperation, and GEF
- **Multilaterals:** CITES, UNEP, UNDP, UN Statistical Commission, and FAO

Examples	Stakeholders and Sample Projects
Business and Biodiversity Offsets Program	• BBOP is an alliance of more than 75 companies, governments, financial institutions, and conservation NGOs that develop best practice standards for biodiversity offsets and conservation banking.
Chiquita	• Chiquita has partnered with Rainforest Alliance to invest in certification and reduce its pesticide use by 80 percent, which has allowed the company to maintain access to the European market for certified bananas.
Global Environment Facility	• GEF is the world's largest public funder of biodiversity conservation; it was responsible for 22% of biodiversity aid spending during 2001-2008. In 2012, GEF launched the Biodiversity for Food and Nutrition Project, a $35M project which is researching the role of agricultural biodiversity in good nutrition and in coping with predicted impacts of climate change. The multi-country project is currently taking place in Brazil, Kenya, Sri Lanka, and Turkey.
World Bank	• The World Bank has provided 19% of global biodiversity aid. Its chief biodiversity initiative is Wealth Accounting and the Valuation of Ecosystem Services (WAVES), which is a global partnership that seeks to incorporate the value of natural resources into national accounts to measure and plan for economic growth. Implementing countries, to date, include: Botswana, Colombia, Costa Rica, Madagascar, and the Philippines.
Zoological Society of London	• ZSL launched the Sustainable Palm Oil Platform, a resource center to promote sustainable practices among stakeholders in the palm oil supply chain. The platform provides tools for improving the monitoring and protection of High Conservation Value Areas in and around palm oil plantations. ZSL also has projects focused on mangroves.

Source: Waldron et al, 2013. "Targeting global conservation funding to limit immediate biodiversity declines." PNAS 110 (29): 12144-12148.

Key NGO Stakeholders

*** Indicates that NGO also works on deforestation**

NGO	Primary Initiatives, Effort, and Geography
WWF*	• **Initiative:** WWF works to address drivers of biodiversity loss by engaging in field-based projects, policy initiatives, capacity building, and education work at both the local and international levels. Through its Amazon Initiative, WWF invested over $30M on conservation activities in the region to create 20 million hectares of protected areas since 2002. • **Geography:** Global, focused on 35 priority places identified by the organization • **Effort:** n/a
Conservation International*	• **Initiative:** CI is working to develop measurement and valuation tools for ecosystem services and to get these included in accounting systems of national governments. In the biodiversity corridors of the Atlantic Forest and Cerrado of Brazil, CI partnered with Monsanto to encourage more biodiversity-friendly practices in the company's supply chain. • **Geography:** Global, with work concentrated in 34 biodiversity hotspots • **Effort:** n/a
Greenpeace*	• **Initiative:** Greenpeace is campaigning for zero deforestation, globally, by 2020. In Indonesia, it launched a major campaign in 2008 to target Unilever, the world's largest consumer of palm oil. The campaign forced Unilever to call for a moratorium on additional forest clearance and to conduct an environmental audit of its Indonesian suppliers. Additionally, Greenpeace protects biodiversity-rich habitats at risk of conversion within the organization's key geographies. For instance, the organization is working to protect forests of the Congo Basin for critically endangered species, including gorillas, elephants, bonobos, and okapis. • **Geography:** Primarily Amazon, Congo, and Indonesia • **Effort:** n/a
Blue Ventures	• **Initiative:** Blue Ventures is advancing a PES scheme to finance the conservation of 43,000 ha of mangroves in Madagascar. Foundation support has been provided by Rockefeller and Waterloo. Although it is not an official member of the Business and Biodiversity Offsets Program, Blue Ventures offers offsets to businesses and other clients. • **Geography:** Madagascar • **Effort:** 12 staff

Key NGO Stakeholders

*** Indicates that NGO also works on deforestation**

NGO	Primary Initiatives, Effort, and Geography
IUCN*	• **Initiative:** In addition to its place-based research of biodiversity hotspots around the world. the IUCN is partnering with the International Fund for Agricultural Development and Bioversity International to bridge the global agriculture and conservation agendas, using biodiversity as a critical link. In 2012, the IUCN World Conservation Congress issues a "Call to Action for Agriculture and Conservation to Work Together." IUCN is continuing to work with its partners for a paradigm shift in agriculture and biodiversity conservation. • **Geography:** Global • **Effort:** Staff of 1,000 in 45 offices
Rainforest Alliance*	• **Initiative:** The Rainforest Alliance uses market mechanisms to curb drivers of deforestation and environmental destruction, including agricultural expansion, cattle ranching, and timber extraction. It uses its Alliance Certified™ seal and Rainforest Alliance Verified™ mark to connect businesses with consumers for products adhering to defined sustainability standards. • **Geography:** Central America, South America, Central Africa, and Indonesia • **Effort:** n/a
World Resources Institute*	• **Initiative:** Through its People and Ecosystems Program, WRI is working with governments, businesses, and multilaterals to integrate ecosystem services into public- and private-sector policy processes. The program links ecosystem service mapping, economic valuation, and scenario planning with a range of policy options aimed at maintaining ecosystem services. • **Geography:** Global • **Effort:** Staff of 9
Bioversity International	• **Initiative:** Bioversity International is a research organization that focuses on the use and conservation of agricultural biodiversity in smallholder farming systems. Its specific areas of research include: agrobiodiversity and ecosystem services, commodity systems and genetic resources, conservation policy reform, forest genetic resources, and nutrition diversity. • **Geography:** Global • **Effort:** 300 staff

Additional Resources

❑ Reports and Databases

- "Targeting global conservation funding to limit immediate biodiversity declines," PNAS, 2013
- "Global Biodiversity Outlook," Convention on Biological Diversity, 2010
- "Achieving Food Security in the Face of Climate Change," CGIAR, 2012
- "Evidence from Major Assessment Reports on Sustainable Agriculture and Climate Change," CGIAR, 2012
- "Biodiversity for Food and Agriculture: Contributing to food security and sustainability in a changing world," FAO, 2010

❑ Conferences

- CITES: 65th Meeting of the CITES Standing Committee; to be held July 7-11, 2014 in Switzerland
- IUCN World Conservation Congress: During this meeting, the IUCN Members Assembly involves governments and NGOs to make joint decisions on biodiversity and conservation issues.
- International Day for Biological Diversity: Sponsored by the UN to increase understanding and awareness of biodiversity issues; held on May 22nd

DEEP DIVE INVESTIGATIONS

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SHALLOW DIVE INVESTIGATIONS

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CEA's Impressions of the Field: Water Quality

As the single largest user of freshwater, agriculture is one of the leading contributors to water quality impairment. Contaminated agricultural runoff, including nitrogen, phosphorus, and pesticides, can degrade both surface and groundwater resources. Excess manure also poses serious threats to water quality, particularly in areas where the volume of manure from confinement agriculture surpasses local fertilizer needs. In the U.S. alone, livestock production generates upwards of 1 billion tons of manure per year and contributes half of the total phosphorus entering U.S. waters. In urban areas, there are multiple sources of freshwater pollution including industrial waste and sewage. But globally, agriculture is the leading contributor.

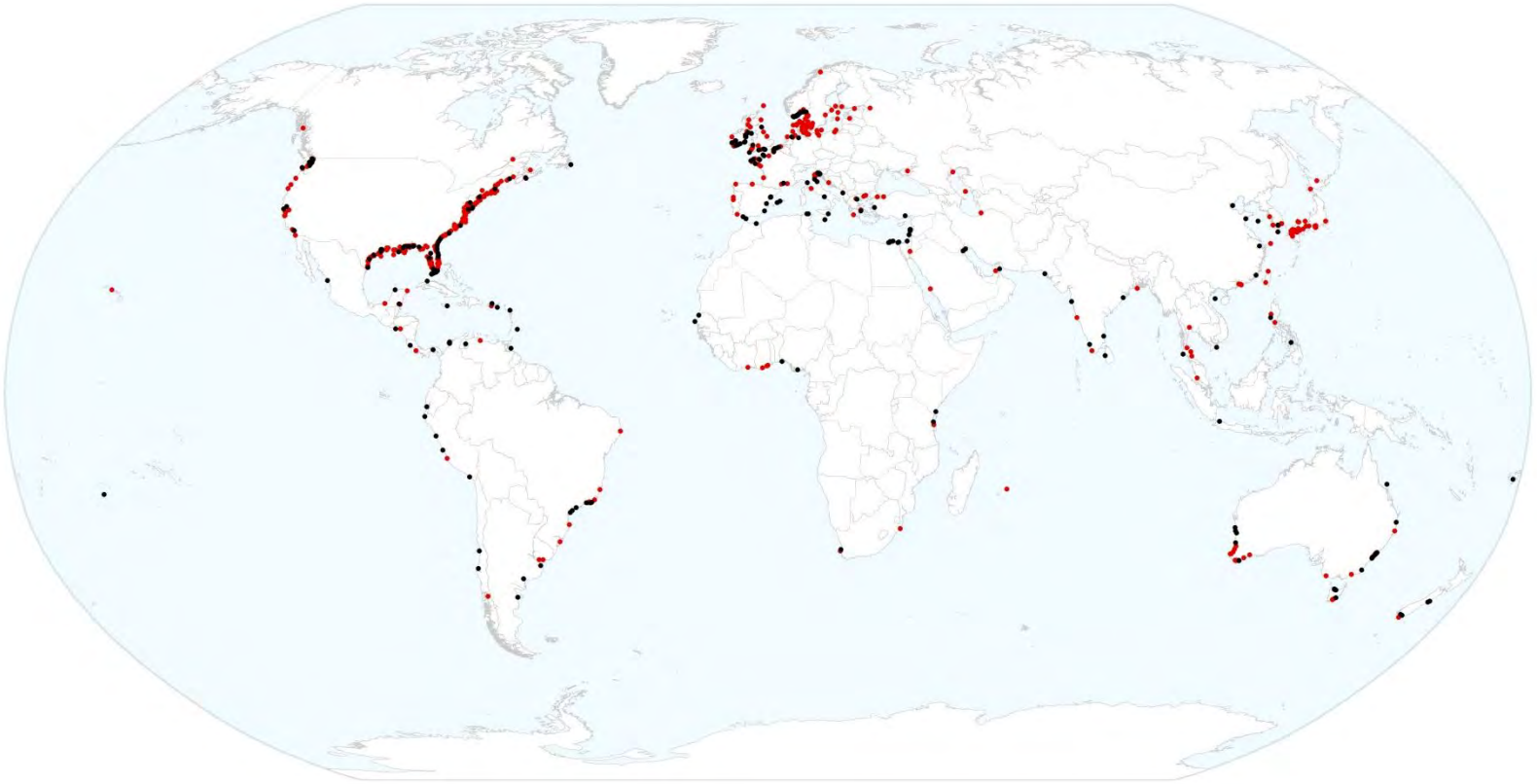
Water quality solutions vary by scale, often require minimal technical innovation, and can carry ancillary benefits that also positively affect water quantity. At the farm-level, precision irrigation and more targeted application of fertilizer results in less nutrient inputs and agricultural runoff. Other organic or sustainable conservation methods, such as crop rotation and less intensive tillage practices, decrease the need for chemical inputs. At the basin-level, water quality trading programs can provide market-based incentives for nutrient reduction, while national governments can establish enforceable water quality standards (although non-point source polluters are not usually enforced). Innovative policies and market mechanisms are key to creating effective incentives for farmers to protect water quality, but have tended to be elusive.

Most foundations working on water quality have made place-based investments, primarily for policy and advocacy purposes in areas like the Chesapeake Bay and Mississippi River Basin. Few foundations are working on the agriculture-water quality intersection at the international level. Rather, international water quality funding tends to focus on public health and safe drinking water initiatives. Corporate engagement also tends to be relatively limited. While some agencies have incorporated water quality as a core focus of their water strategies (e.g., USAID Water Program Strategy 2013-2018), most aid organizations, multilaterals, and development banks have actively promoted new fertilizer technologies, many of which may impair water quality. As the global population expands and the demand for food continues to grow, nutrient pollution associated with agriculture is expected to worsen in many areas of the world. According to the Millennium Ecosystem Assessment, human-created nitrogen inputs are projected to rise 50 percent by 2050. Producing enough food for a world of 9 billion while simultaneously maintaining water quality standards is an issue that merits more global attention.

Source: IUCN, 2013. "IUCN Red List of Threatened Species: Major Threats"; Environmental Working Group, 2012, "Troubled Waters: Farm Pollution Threatens Drinking Water"; UNEP, 2010, "Clearing the Waters: A Focus on Water Quality"; WRI, 2008, "Eutrophication and Hypoxia in Coastal Areas: A Global Assessment of the State of Knowledge"

Distribution of Hypoxic Zones and Eutrophication

The World Resources Institute has identified 415 eutrophic and hypoxic coastal systems worldwide. The Gulf of Mexico and Baltic Sea are the most well-known hypoxic areas. Limited data, particularly in Asia, suggest that coastal water pollution may be a concern in other undocumented areas with intensive farming practices. Agriculture is a leading source of water pollution in China.



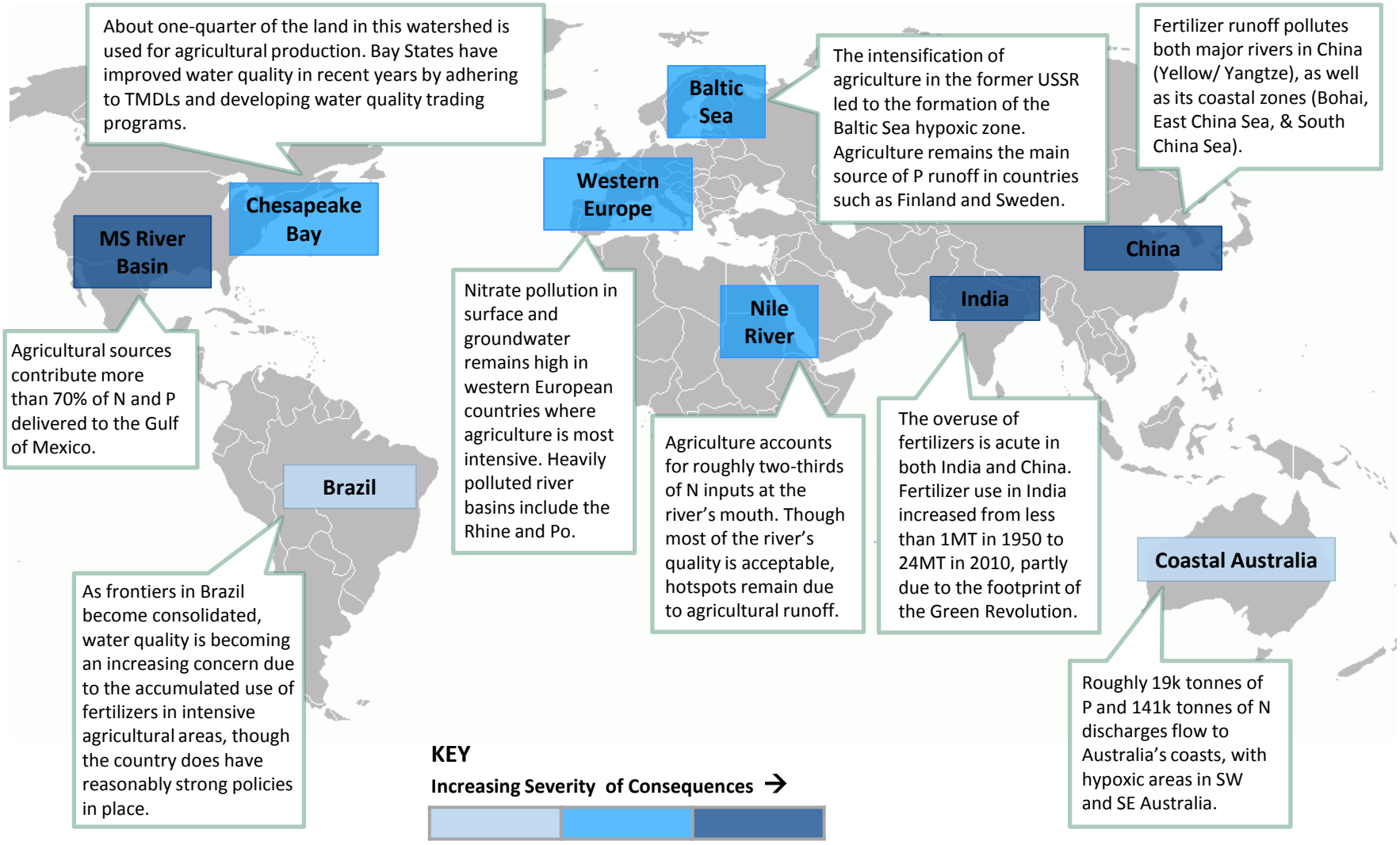
Hypoxia and Eutrophication

- Hypoxic (oxygen-depleted "dead" zones)
- Eutrophic (sites that experience other symptoms of eutrophication, including algal blooms, species loss, and impacts to coral reef assemblages)

Data Source: World Resources Institute; http://www.wri.org/project/eutrophication

Water Quality: Geographic Hotspots

Agriculture has lead to severe water quality impairment in the MS River Basin, as well as in India and China.



*For this issue area, a high severity of consequences indicates high potential for pollution of surface and/or groundwater due to agricultural activities.

Source: CEA synthesis of literature and expert interviews, conducted June 2013 to August 2013.

CEA California Environmental Associates

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Approach, Geography, and Partners
Walton Foundation	• **Investment Size:** $14.8M for MS River Basin grants in 2012 • **Approach:** Seeks to address Gulf Dead Zone challenges by reducing nutrient runoff using national agricultural and food policy levers (i.e., federal Farm Bill). • **Geography:** MS River Basin • **Partners:** EDF, Audubon, National Wildlife Federation, and The Nature Conservancy
McKnight Foundation	• **Investment Size:** $8.5M in 2012 • **Approach:** Reduce agricultural pollution in the Midwest and promote cross-boundary policy coordination in the MS River corridor • **Geography:** US Midwest (MS River Basin) • **Partners:** CERES, Environmental Working Group, American Farmland Trust, and The Nature Conservancy
Keith Campbell Foundation	• **Investment Size**: $5.1M in 2011 • **Approach:** Supports policy, advocacy, and enforcement to improve water quality at the watershed-level • **Geography:** Chesapeake Bay, U.S. Atlantic Coastal bays, and U.S. Pacific Coast region • **Partners:** EDF, Chesapeake Bay Foundation, and Trout Unlimited
Linden Trust for Conservation	• **Investment Size:** Committed $2M between 2007-2012; leveraged by additional $1.5M from co-funders • **Approach:** Advancing cap-and-trade approach through federal, state, and municipal work to limit nutrient pollution, using the Chesapeake Bay as a national model. • **Geography:** Chesapeake Bay • **Partners:** WRI, NRDC, EDF, Chesapeake Bay Foundation
blue moon fund	• **Investment Size:** ~$1M for water quality related grants in 2011 • **Approach:** Supports policy and advocacy to reduce agricultural pollution in Chesapeake Bay watershed • **Geography:** Chesapeake-Appalachia • **Partners:** Ceres, Chesapeake Bay Foundation, Chesapeake Bay Trust, and EDF
The Christensen Fund	• **Investment Size:** $475,000 in 2012 for water quality related grants • **Approach:** Makes place-based investments in regions with significant cultural and biological diversity. • **Geography:** African Rift Valley, Central Asia and Turkey, SW U.S. and NM, Melanesia, and N. Australia • **Partners:** Consultative Group on Biological Diversity, Slowfood International, Biodiversity International

Other Key Collaborations, Initiatives, and Partnerships

Sector	Stakeholders and Sample Projects
Private	• **Corporations:** Dow Chemical Company, Syngenta, Coca-Cola, and Soybean Growers Association • **Sample Project:** Dow Chemical entered a $10 million, five-year partnership with TNC to incorporate the value of natural capital into the company's business strategy. TNC assessed the company's dependency on ecosystem services, such as clean water for treating its plants.
National Governments	• **Governments:** Netherlands, Belgium, Denmark, Finland, Norway, Sweden, Australia, Indonesia, and U.S. • **Sample Project:** The Netherlands implemented the Mineral Accounting System, which forces farmers to monitor N and P flows, and taxes those farms whose nutrient surplus exceeds the established level. Through the Nitrate Directive, the EU also limits the amount of manure which can be spread on farmland, in order to limit manure application near waterways vulnerable to eutrophication.
Aid	• **Aid Organizations:** Swedish International Development Cooperation Agency (Sida), AUSAid, USAID, GEF • **Sample Projects:** During World Water Week in Stockholm in September 2013, USAID and Sida launched 'Securing Water for Food: A Grand Challenge for Development,' a prize program which seeks to identify and develop technologies and business models that improve water sustainability for food security purposes. The two aid partners will commit $25M for projects focusing on saltwater intrusion, particularly in coastal aquifers and estuarine environments; water capture and storage; and water efficiency and reuse.
Multilaterals	• **Multilaterals/Development Banks**: World Bank, Asian Development Bank, UNEP, UNDP • **Sample Project**: The Asian Development Bank funded a project to assess the potential for agriculture nutrient trading in the Chao Lake Basin, the most polluted lake in China. ADB is now working with WRI and the Chinese government to develop policy guidelines on mitigating nonpoint source pollution, using Chao Lake as the pilot basin for this initiative. ADB is also promoting the development of 'eco-compensation' schemes in China to provide economic incentives for watershed protection, which are funded primarily by the central government.
NGOs	• **NGOs**: WRI, EDF, Chesapeake Bay Foundation, CERES, Environmental Working Group, The Nature Conservancy, WWF, Stockholm International Water Institute, International Fertilizer Development Center (IFDC) • **Sample Projects**: • WRI has actively worked on water quality and nutrient trading in the U.S. - Chesapeake Bay, Gulf of Mexico, Puget Sound, and Long Island Sound. In China, WRI has performed economic analyses to determine cost curves for pollution reduction policies. • IFDC developed the Fertilizer Deep Placement (FDP) technology which uses fertilizer briquettes placed directly below the soil surface (instead of broadcasting). The deliberate placement and slow release of N has resulted in reduced fertilizer use and run-off, improved crop yields, and increased farm incomes. IFDC has implemented the technology successfully in Bangladesh and is now expanding in Africa with support of USAID.

DEEP DIVE INVESTIGATIONS

- WATER QUANTITY
- CLIMATE AND AIR POLLUTION
- BIODIVERSITY AND HABITAT LOSS

SHALLOW DIVE INVESTIGATIONS

- WATER QUALITY
- **SOIL QUALITY**
- AGRICULTURAL DEVELOPMENT

CEA's Impressions of the Field: Soil Quality

Though soil degradation is a natural process, human activities have rapidly accelerated the soil quality decline. Roughly 40% of soil used for agriculture around the world is classified as either degraded or seriously degraded, and experts estimate that soil loss is between 10 to 40 times the rate of its natural replenishment. Primary activities leading to global soil degradation include overgrazing (35%), deforestation (30%), and agricultural management (28%). Soil degradation processes include wind and water erosion, desertification, salinization, acidification, and nutrient mining.

The role of soil quality has been historically under-appreciated, even though soil resources are closely inter-related with globally important issues such as food security, energy and water demands, carbon sinks, and climate change. Since degraded soils have vastly diminished water retention capacity, reductions in soil quality may also exacerbate water quantity disputes in countries such as China, India, and Pakistan. In addition to negatively impacting biological productivity and ecosystem services, the decline of soils can lead to harmful social consequences, including forced migration and reduction in smallholders' income.

As the world attempts to feed a growing population from diminishing land resources with declining soil quality, the potential for social and political conflict is evident. Most of the world's poorest soils overlap directly with the economic poorest countries, several of which are also projected to experience the sharpest population growth rates. Soil quality and food security issues are especially acute in Africa, which has highly weathered soils with poor nutrient storage capacity and response rates to fertilizers.

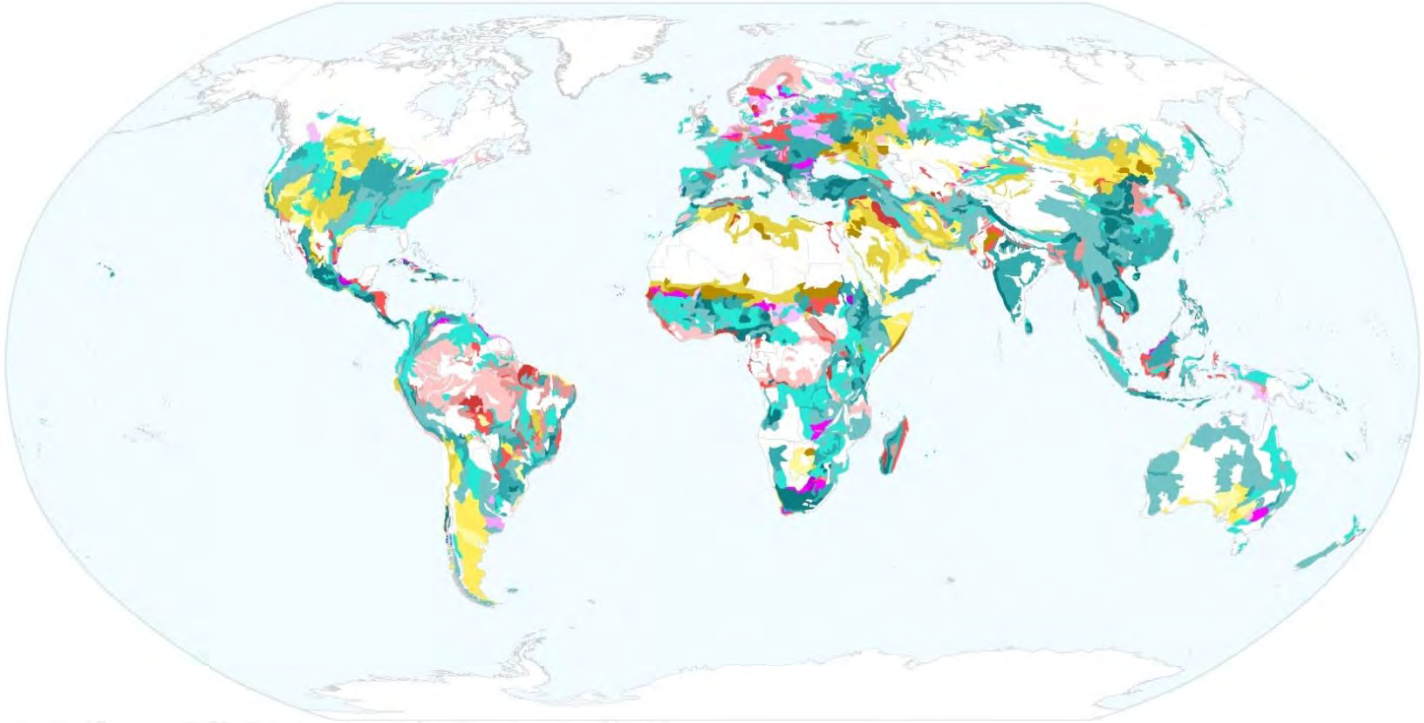
Techniques for improving soil quality are well-known and require little technology. Solutions for addressing comprehensive soil management should take a systems approach. Basic practices such as crop rotations, no-till, green manures, and organic amendments can improve soil quality – particularly when coupled with sound water management, informed fertilizer application, and farmer education on general stewardship practices.

Most philanthropic activity focusing on soil quality alone has taken place in Africa through the Gates Foundation and Rockefeller Foundation, with their support of the Alliance for a Green Revolution in Africa. Few funders focus exclusively on soil quality; other activities fall within the broader agricultural development context, with soil as a peripheral issue. Private sector engagement is limited since most companies attempt to address the issue through seed and technology inputs. National governments and multilaterals are involved in important research efforts, including global soil mapping projects.

Source: FAO, 2013, "State of the World's Land and Water Resources for Food and Agriculture; AGRA, 2013, "Soil Health Program Brochure"

Severity of Human-Induced Soil Degradation

This map indicates areas where human activities have led to soil degradation, measured through chemical deterioration, wind erosion, physical deterioration, and water erosion.



Severity of Human-induced Soil Degradation

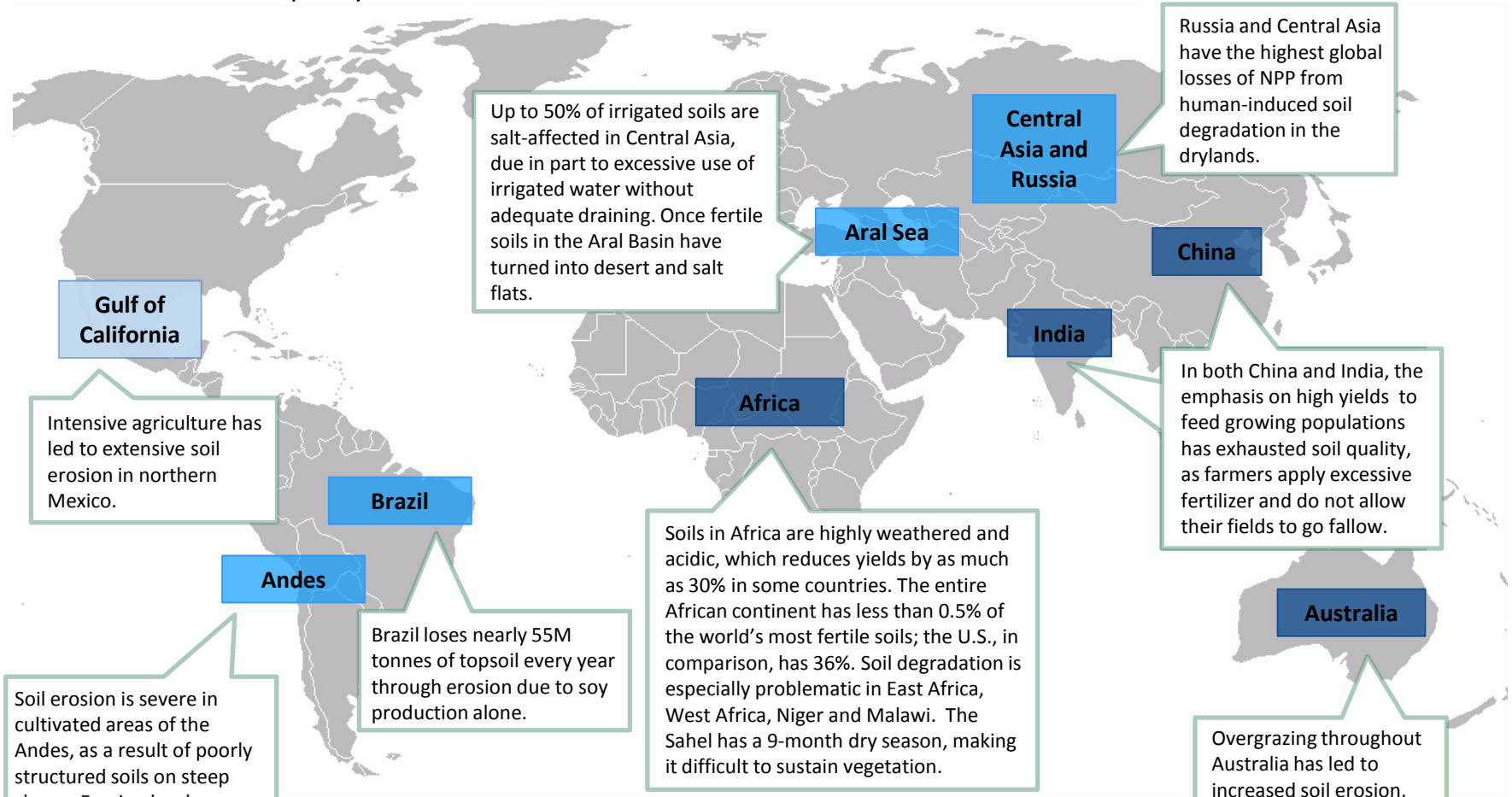
Chemical deterioration severity	Wind erosion severity	Physical deterioration severity	Water erosion severity
low	low	low	low
medium	medium	medium	medium
high	high	high	high
very high	very high	very high	very high

Low: The terrain has somewhat reduced agricultural suitability, but is suitable for use in local farming systems. Restoration to full productivity is possible by modifications of the management system. Original biotic functions are still largely intact.
Medium: The terrain has greatly reduced agricultural productivity, but is still suitable for use in local farming systems. Major improvements are required to restore productivity. Original biotic functions are partially destroyed.
High: The terrain is non reclaimable at farm lever. Major engineering works are required for terrain restoration. Original biotic functions are largely destroyed.
Very High: The terrain is unreclaimable and beyond restoration. Original biotic functions are fully destroyed.

Data Source: International Soil Reference and Information Centre (ISRIC) Global Assessment of Human-induced Soil Degradation (GLASOD); http://www.isric.org/projects/global-assessment-human-induced-soil-degradation-glasod

Soil Quality: Geographic Hotspots

Experts uniformly point to Africa as having naturally poor soils, while intensive agricultural activity has exhausted soil quality in India, China, and Australia.



*For this issue area, a high severity of consequences indicates vulnerability to decreased production capacity due to degraded soil conditions.

Source: CEA synthesis of literature and expert interviews, conducted June 2013 to August 2013.

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Approach, Geography, and Partners
Bill and Melinda Gates Foundation	• **Investment Size:** $164.5M for AGRA Soil Health Program • **Approach:** Working to improve smallholder soil fertility and productivity by improving access to, and effectiveness of, fertilizers and by building applied research capacity for new fertilizers. • **Geography:** Sub-Saharan Africa • **Partners:** Alliance for a Green Revolution in Africa (AGRA)
Rockefeller Foundation	• **Investment Size:** $15M for AGRA Soil Health Program • **Approach:** See Gates Foundation, above • **Geography:** Sub-Saharan Africa • **Partners:** Alliance for a Green Revolution in Africa
Howard G. Buffett Foundation	• **Investment Size:** $2.5M in 2011 for direct soil-related grants • **Approach:** Supports research aimed at improving soil health and nitrogen fixation in order to increase productivity and farm income. • **Geography:** Sub-Saharan Africa, Latin America, and the U.S. • **Partners:** N2Africa Initiative, Gates Foundation, Michigan State University, and Wageningen University

Other Key Collaborations, Initiatives, and Partnerships

Sector	Stakeholders, Approach, and Sample Projects
Private	• **Corporations:** Terra Global Capital, PepsiCo • **Sample Project:** PepsiCo has partnered with USAID and the World Food Program (WFP) to work with 10,000 smallholders in Ethiopia, with the objective of doubling chickpea production by improving soil management and irrigation. Increasing chickpea production is part of PepsiCo's business plan to increase revenue from nutritional products to $30B by 2020. A portion of the chickpea supply is also used by WFP as a ready-to-use-food product for humanitarian purposes. • **Interview Quote:** "The private sector is not as engaged in this field, since biological solutions tend to be cheaper than commercial agricultural products. A holistic approach to soil and water conservation is not a solution you can buy out of a bag."
National Governments	• **Governments:** Norway, Germany, Australia, Kenya, Brazil, U.S., Italy, China • **Sample Project:** Scientific and agricultural research agencies in the aforementioned countries are involved in leading the Global Soil Map Project, which seeks to create a new digital soil map of the world to better inform decision-making. The project is an initiative of the International Union of Soil Sciences, with contributions from numerous academic and research centers. The first stage of the project started in Sub-Saharan Africa through an $18M grant awarded to the International Center for Tropical Agriculture from the Gates Foundation and AGRA.
Aid	• **Aid Organizations:** USAID, DFID, AUSAid, and GEF • **Sample Project:** GEF sponsors the Collaborative Partnership on Forests (CPF) with FAO, UNEP, UNFF, and fourteen countries. The aim of the project is to improve forest management practices and raise awareness of the soil-water-forest nexus . Roughly 8 percent of the world's forests are designated for soil and water conservation.
Multilaterals	• **Multilaterals/Development Banks:** World Bank, FAO Global Soil Partnership, UNEP Global Partnership on Nutrient Management, CGIAR World Agroforestry Center, CGIAR Research Program on Dryland Systems, UN Convention to Combat Desertification, UN Forum on Forests, and International Fund for Agriculture Development • **Sample Project:** CGIAR World Agroforestry Center's Evergreen Agriculture Program is an approach to integrate perennials such as trees into crop and livestock systems. The practice has been implemented throughout Africa; interest is also growing in South Asia and Australia. The three principles are to: use minimum or zero tillage; permanently cover the soil with crop residues; and rotate/diversify crops to replenish soil nutrients.
NGOs	• **NGOs:** WRI, WWF, NRDC, Alliance for Green Revolution in Africa, Programa Campesino a Campesino, International Fertilizer Development Center, Global Partnership for Landscape Restoration, IUCN, World Vision, EcoAgriculture Partners, and Earth Institute • **Sample Project:** Researchers at Columbia University's Earth Institute are developing a portable field-level soil test which will allow extension workers to provide immediate, on-site feedback on which nutrients are limiting crop yields.

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SHALLOW DIVE INVESTIGATIONS

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CEA's Impressions of the Field: Agricultural Development

The on-going challenge of food security is far from a result of insufficient food production; rather, it is intertwined with political and economic inequities that lead to uneven distribution. Roughly 270 million farms in non-OECD countries operate on less than 2 ha of land and are pre-commercial, meaning they lack access to stable financing, markets, and productivity-boosting technologies. The millions of farmers disconnected from markets face an uncertain future, caught in a potentially perpetuating cycle of social, economic, and environmental degradation. The situation of the world's poorest is made even more vulnerable by destabilizing forces such as extreme weather events associated with climate change and food price spikes. There is a tremendous amount of funding for agricultural development, focused on improving the capacity of these low-productivity agricultural systems.

The field of agricultural development today is largely focused on creating enabling institutions and production efficiencies to feed the world and promote more inclusive growth. Involvement in this field spans a wide range of activities, from technical crop-specific research focused on increasing yields and developing drought-resistant varieties to policy advocacy aimed at securing access to land, water, infrastructure, and financing for smallholders.

As a share of total development aid, foreign aid for agriculture is roughly six percent. Agricultural aid reached a peak of 23 percent in 1980 and faced a downward trend through 2006. While the financial crisis initially led to depressed funding levels from aid organizations, the food crisis of 2008 renewed attention on aid for agricultural development and food security. Following the L'Aquila Summit in 2009, the G-20 committed $20 billion over three years to agricultural development, on top of their assistance for emergency food aid and nutrition programs. It is unclear, however, what portion of the $20 billion commitment was actually new or double-counted against previous funding commitments.

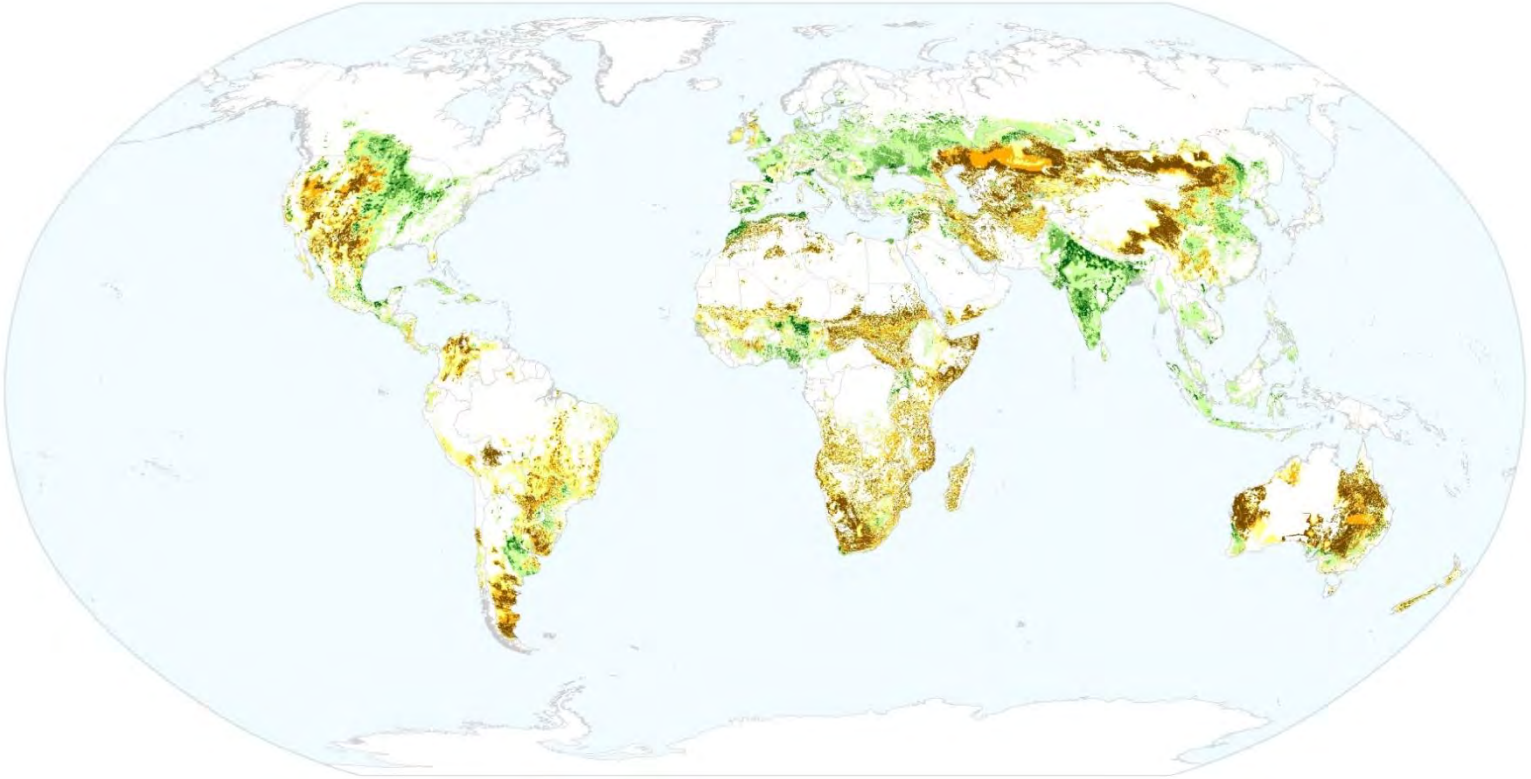
Multilateral development agencies contribute the majority of funding for smallholder development. According to a 2010 analysis that mapped trends in international donor flows to smallholder agricultural development, multilaterals accounted for 75% of funding. Foundations contributed roughly 7% of smallholder funding, with the Gates Foundation providing 90% of this amount.

The philanthropic sector is currently engaged in a range of approaches to promote synergies with the public and private sectors for agricultural development. Foundation initiatives include incorporating smallholder farmers into commercial agricultural value chains, building climate change resilience into agricultural development programs, and providing technical assistance and financing to improve smallholders' access to capital.

Sources: FSG Social Impact Advisors, 2010. "Smallholder Farmer Development: International Donor Funding Trends."

Global Cropland and Pasture Cover

This map depicts the extent of cropland and pasture cover. Pastures cover about 26 percent of Earth's ice-free land (3.4B ha), while croplands cover roughly 12 percent of ice-free land (1.5B ha). Of total crop production, 62 percent is allocated to human food, 35 percent to animal feed, and 3 percent for bioenergy crops and other industrial products.



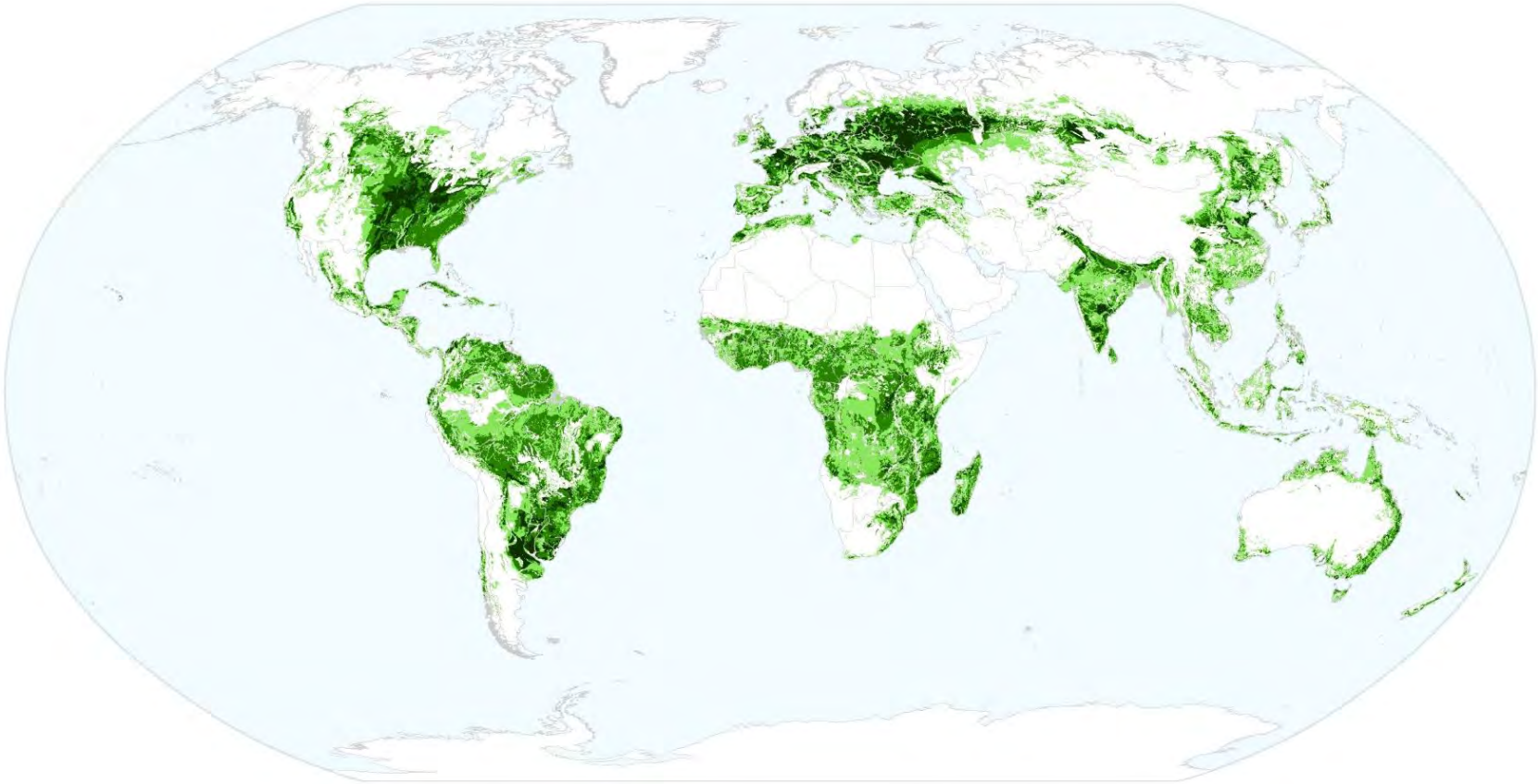
Percent Cropland & Pasture

- 30% - 70% Cropland
- 70% - 90% Cropland
- >90% Cropland
- 30% - 70% Pasture
- 70% - 90% Pasture
- >90% Pasture

Data Source: EarthStat.org (U-MN and McGill University LUGE labs)

Suitability of Land for Pasture and Rainfed Crops

This map shows the combined suitability of currently available land for pasture and rainfed crops.



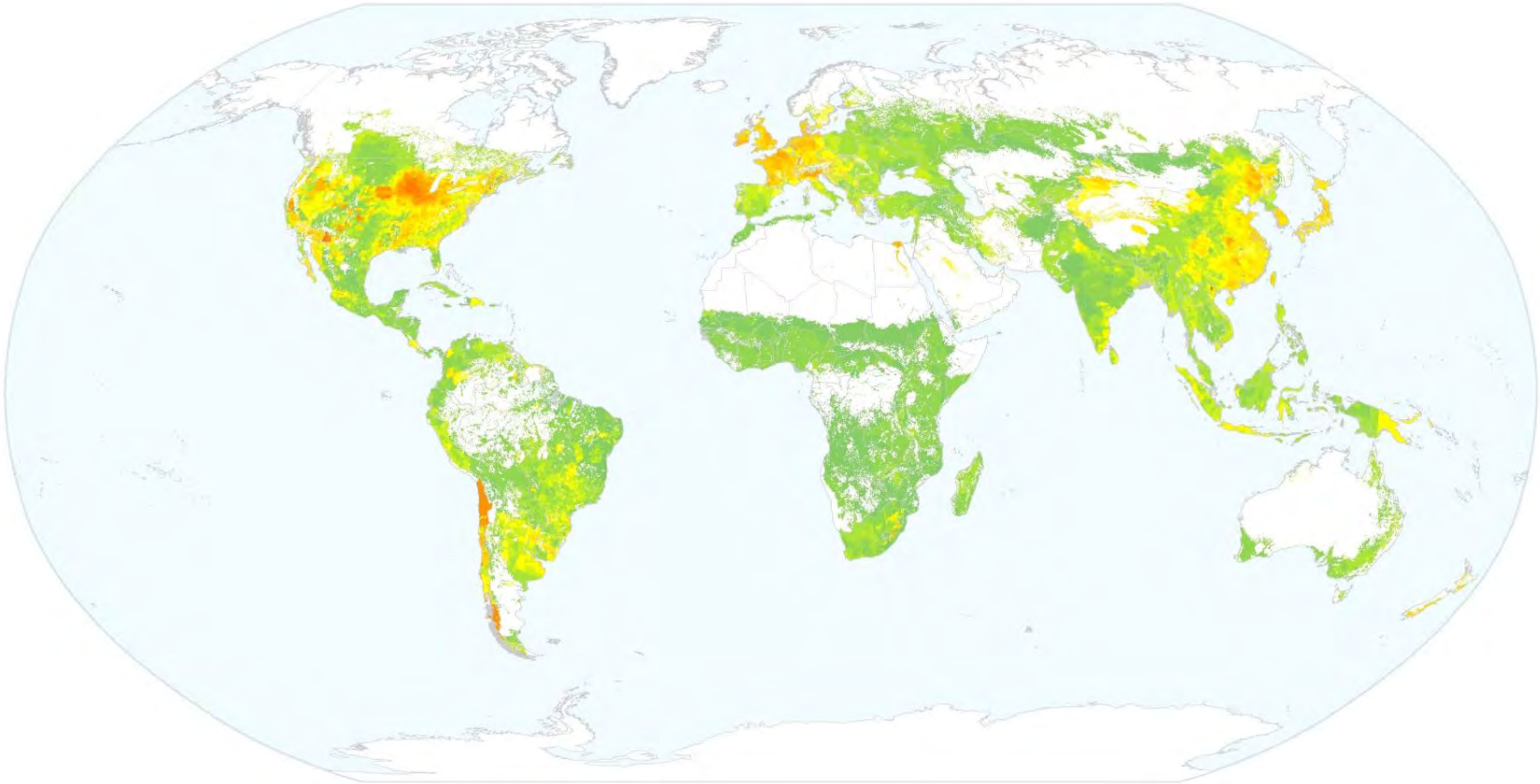
Suitability of global land area for pasture and rainfed crops (low input level)

- Land suited for rainfed crops and pasture possible
- Land well suited for rainfed crops and pasture possible
- Prime land for rainfed crops and pasture possible

Data Source: FAO FGGD: Food Insecurity, Poverty and Environment Global GIS Database; http://geonetwork3.fao.org/fggd/

Average Yield of Cereal Grain Production

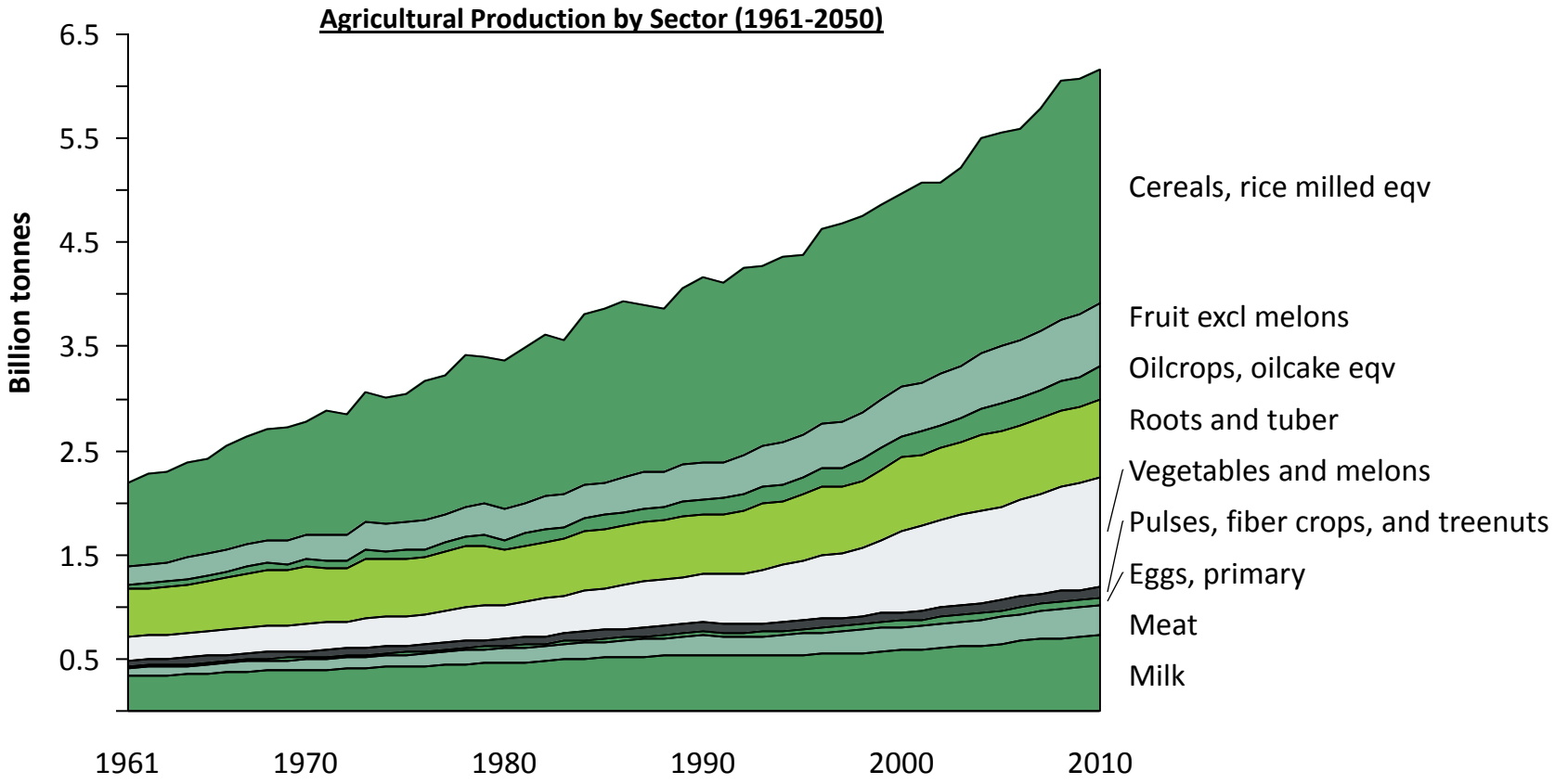
This map shows average cereal yields (in tonnes per hectare), including wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains.



Data Source: Navin Ramankutty, LUGE (Land Use and the Global Environment) lab; http://www.geog.mcgill.ca/~nramankutty/Datasets/Datasets.html

Global agricultural production has nearly tripled in the past 50 years

- Global cereal production (the largest production sector) has nearly doubled since 1960.
- Fruit, vegetable, egg, and meat production have all increased by more than 250%, while oilcrop production has quintupled over the same period.
- The global average of per capita food availability is adequate for the world's population to be well-fed; however, factors such as limited agricultural infrastructure and weak access to markets continue to contribute to food insecurity.

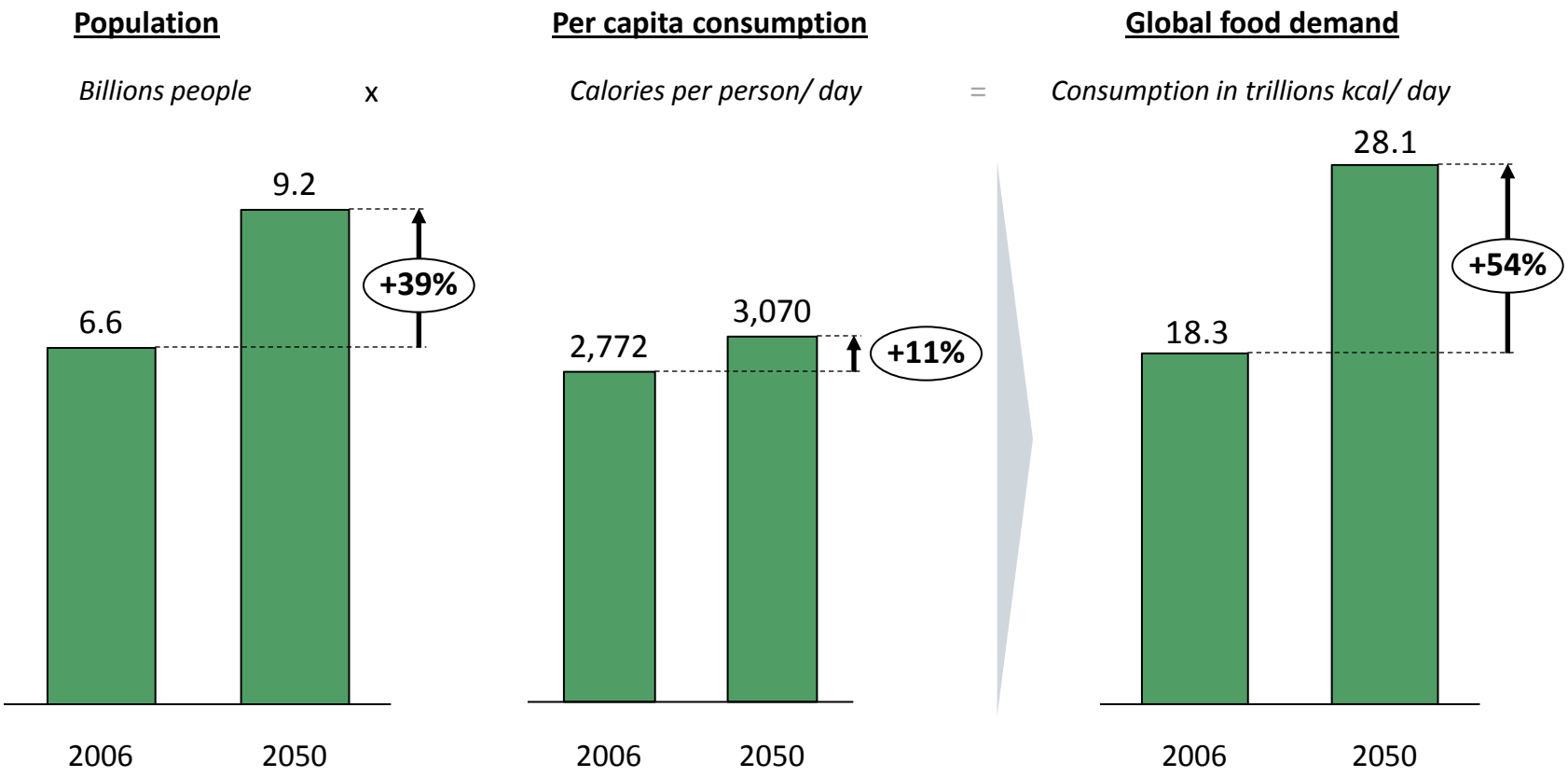


'Other' includes oilcrops, pulses, spices, stimulants, sugar crops, treenuts, and vegetable oils.

Source: FAOStat 2010.

Food demand may increase another 50 percent in the first half of the century

- Both population and food demand are projected to grow significantly by 2050.
- While total population is expected to climb above 9 billion by 2050, food demand is expected to outstrip population growth as rising incomes drive per capita consumption higher, particularly for meat consumption.

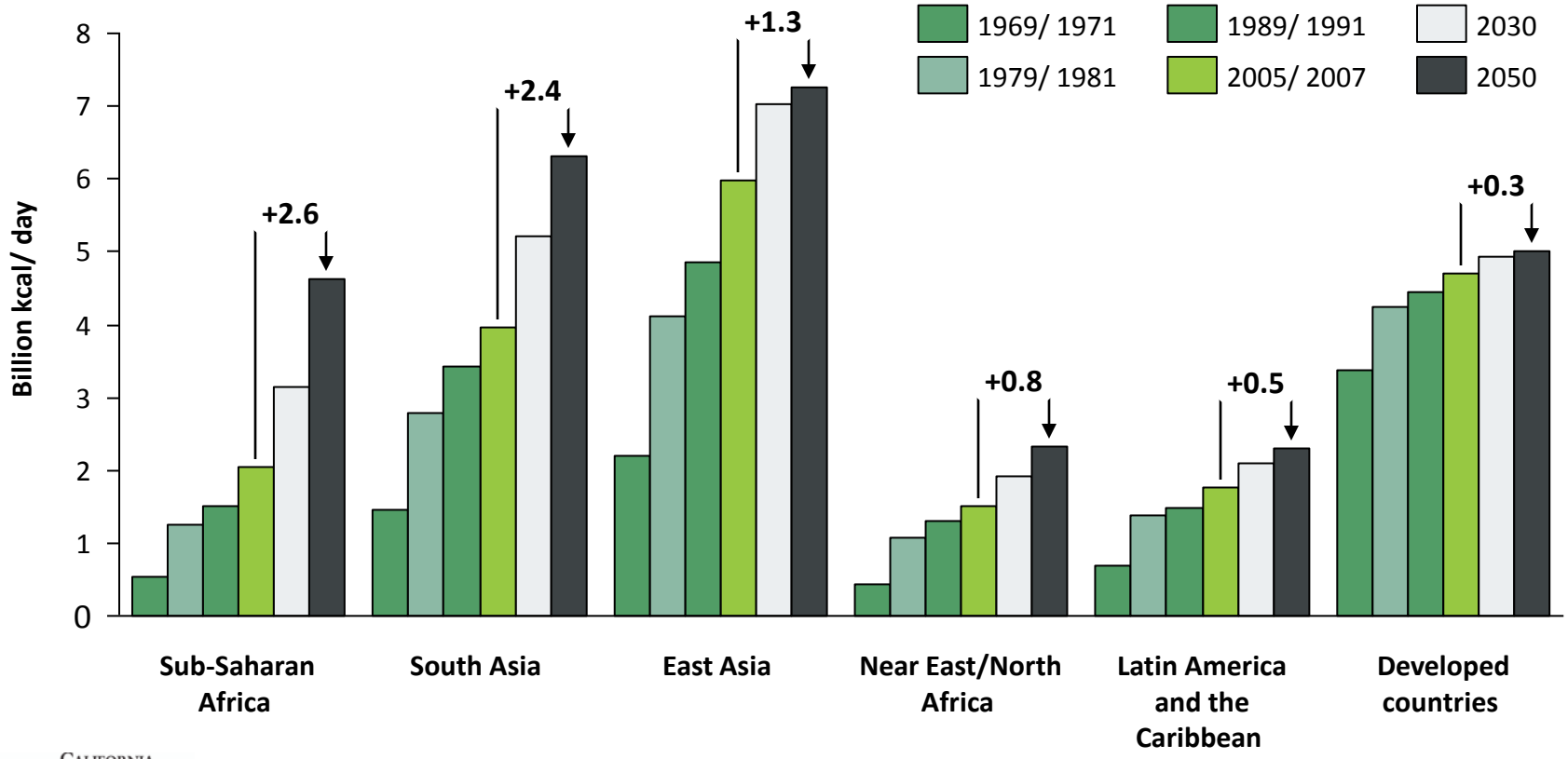


Note: The effects of climate change are not incorporated into this projection.
Source: Alexandratos and Brunisma, 2012, "Global Agriculture Towards 2030/2050"; Tweeten 2008.

Future demands in food consumption overlap with areas of high population growth and poverty: Sub-Saharan Africa and South Asia

- Between now and 2050, global food demand is expected to increase by 125% in Sub-Saharan Africa and by 85% in South Asia. Together, these two regions account for nearly two thirds of expected consumption growth.
- Consumption demand has plateaued in the developed world and is slowing in Latin America and East Asia.

Food demand by region, 1970-2050



Source: Alexandratos and Brunisma, 2012, "Global Agriculture Towards 2030/2050"; Tweeten 2008.

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Approach, Geography, and Partners
Bill and Melinda Gates Foundation	• **Investment Size:** $2 billion to date • **Approach:** Supports smallholder livelihoods through work in five key areas: agricultural research and development, agricultural policies, livestock, access and market systems, and strategic partnerships and advocacy • **Geography:** Sub-Saharan Africa and South Asia • **Partners:** Alliance for a Green Revolution in Africa, TechnoServe, UN World Food Program, and IFPRI
Howard G. Buffett Foundation	• **Investment Size:** $44M in 2012 for food security portfolio • **Approach:** Supports technical assistance and research efforts surrounding soil health, impacts of climate change on crop suitability, and seeds requiring less irrigation and fertilizer • **Geography:** Africa and Latin America • **Partners:** International Center for Tropical Agriculture, International Maize and Wheat Improvement Center, Catholic Relief Services, and Texas A&M AgriLife Research Center
Gatsby Charitable Foundation (U.K.)	• **Investment Size:** $10.9M in 2011 • **Approach:** Partners with the public and private sectors to advance East Africa's economic competitiveness by addressing value chain constraints in the agricultural sector. • **Geography:** East Africa • **Partners:** Rockefeller Foundation, DFID, Norwegian Agency for Development Cooperation, Tanzania Ministry of Agriculture, and Kilimo Trust
Ford Foundation	• **Investment Size:** $5.5M during 2009-2012; ranged from low of $250,000 in 2012 to high of $2.1M in 2011 • **Approach:** Promotes rights of poor rural families through two programs: Expanding Community Rights over Natural Resources, and Climate Change Responses that Strengthen Rural Communities. • **Geography:** Global • **Partners:** IMAZON, African Center for Economic Transformation, Oxfam, and Association for Nature and Sustainable Development

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Approach, Geography, and Partners
Acumen	• **Investment Size:** $5M for agriculture projects in 2012; $20.5 million for 12 projects during 2008-2012 • **Approach**: Invests in hybrid seed varieties, access to financing for smallholder farmers, mobile-technology to ensure fair pay for crops, and micro-irrigation. Provides patient long-term debt or equity investments to early-stage companies that hold promising potential for scale. • **Geography:** India, Pakistan, West Africa, and East Africa • **Partners:** Gulu Agricultural Development Company, NSP Microfinance Bank, and Microdrip
Rockefeller Foundation	• **Investment Size:** $4.2M in 2012 • **Approach:** Works on food security through four key areas: improving access to high-yielding seeds; promoting soil health and productivity; building more efficient agricultural markets; and promoting policies aimed at increasing agricultural productivity • **Geography:** Sub-Saharan Africa and South Asia • **Partners:** KickStart International, International Institute of Tropical Agriculture, Conservation International, and Gorakhpur Environmental Action Group
William and Flora Hewlett Foundation	• **Investment Size:** $2.8M during 2008-2011 • **Approach:** Through its Global Development Program, the Foundation has funded policy initiatives to improve access to agricultural markets for farmers in developing countries. • **Geography:** Global • **Partners:** AGree, Oxfam, Aspen Institute, and International Policy Council on Agriculture, Food, and Trade
MacArthur Foundation	• **Investment Size:** $2.45M in 2012 • **Approach:** Supports policy and research initiatives for smallholder development in its key geographies. • **Geography:** Andes, Great Lakes region of East Central Africa, and Greater Mekong • **Partners:** USAID, Conservation International, EcoAgriculture Partners, and Green Belt Movement
W.K. Kellogg Foundation	• **Investment Size:** $560,000 during 2012-2013 • **Approach:** Focuses on technical assistance and policy advocacy to improve smallholder productivity and rural livelihoods. • **Geography:** Latin America and Caribbean (primarily Mexico and Brazil). • **Partners:** AGree, Earth Institute, and Fundacion Avanza Campeche

Key Funder Collaborations, Initiatives, and Partnerships

Foundation Funders	Investment Size, Approach, Geography, and Partners
Clinton Foundation	• **Investment Size:** Pass-through foundation; investment size undetermined • **Approach**: Works with smallholder farmers in Rwanda and Malawi to improve water management, soil quality, and crop yields. Announced partnership with Dutch Government in July 2013 for $3M Climate Smart Agriculture Program. • **Geography:** Malawi and Rwanda • **Partners:** Receives financial support from the Salida Capital Foundation for Malawi and from the Hunter Foundation for Rwanda.
Syngenta Foundation	• **Investment Size:** Not available • **Approach:** Seeks to help smallholders become more professional growers by providing technical assistance, access to inputs, and linking smallholders to markets. • **Geography:** Developing countries, primarily in Africa and Asia • **Partners:** Kilimo Salama, Farmforce, Kenyan Horticultural Crop Development Authority, USAID, and Vietnamese Plant Protection Research Institute
Agropolis Foundation (France)	• **Investment Size:** Not available • **Approach:** Supports high-level research and international partnerships for agricultural sciences and sustainable development research. Also hosts a collaboaration for foundation funders of agrobiodiversity. (Most recent meeting held in September 2013.) • **Geography**: Global • **Partners:** Danone Research, CGIAR Consortium, and Embrapa

Other Key Collaborations, Initiatives, and Partnerships

Sector	Stakeholders and Sample Projects
Private	• **Corporations:** Monsanto, Jain Irrigation, Novus International, DuPont, Rabobank, and Syngenta • **Sample Project:** DuPont committed $6.3M to establish a regional technology hub in South Africa, which will serve the continent. The hub will apply breeding technologies to create and disseminate seed varieties with improved resistance to drought, insects, and disease.
National Governments	• **National Governments:** Nearly every national government works on agricultural development through its agricultural ministries, extension agencies, and economic development boards. • **Sample Project:** Recognizing the importance of rice to its national economy, the Vietnamese government has collaborated with the International Rice Research Institute since 1963, to conserve the genetic diversity of rice and breed new varieties. Vietnam is now the world's second largest rice exporter; its production has increased every year since the 1980s.
Aid	• **Aid Organizations:** USAID, DFID, German Agency for Technical Cooperation, Japan International Cooperation Agency, and Global Environment Facility • **Sample Project:** Feed the Future represents the U.S. contribution of $3.5B towards the global pledge of $20B, as part of the L'Aquila Joint Statement on Food Security. Feed the Future, administered by USAID, currently works in 19 target countries to increase agricultural productivity, boost harvests and incomes of smallholders, improve agricultural research and development, disseminate agricultural technologies, and advance climate-smart agriculture.
Multilaterals	• **Multilaterals/Development Banks**: World Bank, Inter-American Development Bank, Asian Development, African Development Bank**,** CGIAR Institutes (e.g., World Agroforestry Center, International Crops Research Institute for the Semi-Arid Tropics, International Center for Agricultural Research in the Dry Areas, and International Rice Research Institute), International Foundation for Agricultural Development, UNEP, UNESCO, FAO Committee on World Food Security, and Global Agriculture and Food Security Program • **Sample Project:** The CGIAR consortium consists of 15 independent centers engaged in a wide range of research issues focused on making a scientific contribution to agricultural development for the world's poor. In 2010, it established a multi-donor trust fund to harmonize funding. Approximately 60 donors—including 35 national governments, the World Bank and Gates Foundation—contribute to the CGIAR Fund.
NGOs	• **NGOs:** IUCN, Oxfam, AGree, WRI, Alliance for a Green Revolution in Africa, Technoserve, International Food Policy Research Institute, Heifer International, WWF, Conservation International, International Water Management Institute, and African Agricultural Technology Foundation • **Sample Project:** Through a $47M grant from the Gates Foundation, TechnoServe is working to double the coffee incomes of 182,000 smallholder coffee farmers in East Africa by improving coffee quality and linking high-quality producers to buyers.

APPENDICES

Appendix A:
Data sources and Interviewees

10 Reports Used for Issue Scan

Report Reference
FAO (2013). FAO Statistical Yearbook 2013: World food and agriculture. FAO: Rome, Italy.
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WWF (2012). The 2050 Criteria: A Guide to Responsible Investment in Agricultural, Forest, and Seafood Commodities. Washington, DC: WWF.

List of Interviewees

EXPERT NAME AND AFFILIATION	EXPERT NAME AND AFFILIATION
Amon Anderson, Acumen	Jurgenne Primavera, IUCN
Andrew Noble, International Water Management Institute	Karen Villholth, International Water Management Institute
Bob Winterbottom, World Resources Institute	Lijin Zhong, World Resources Institute
Braulio Dias, Convention on Biological Diversity	Mindy Selman, World Resources Institute
Charles Godfray, Oxford University	Pedro Sanchez, Columbia University
Charles Iceland, World Resources Institute	Peter Bosshard, International Rivers
Chris Reij, World Resources Institute	Peter DeWees, World Bank
Craig Hanson, World Resources Institute	Peter Rogers, Harvard University
David Cleary, The Nature Conservancy	Ricardo Salvador, Union of Concerned Scientists
Dennis Garrity, World Agroforestry Center	Robert Lenton, Water for Food Institute, U. of Nebraska
Gawain Kripke, Oxfam America	Roman Czebiniak, Center for Biological Diversity
Greg Koch, The Coca-Cola Company	Sarah Scherr, EcoAgriculture Partners
Hal Mooney, Stanford University	Steven Kovach, USAID
Jan Willem Erisman, Energy Research Center of Netherlands	Stewart Maginnis, IUCN
Jon Foley, University of MN, Institute on the Environment	Thomas Lovejoy, Heinz Center
John Reganold, Washington State University	Walter Falcon, Stanford University
Julie Wroblewski, Gates Foundation/Buffett Foundation	Will Turner, Conservation International

Select Interview Summaries

Academic Interviewee	• You have to look first at those resources that have a link with agriculture (water, soils, land). • Globally, the biggest issue with water and agriculture is salinity (from insufficient drainage); it can really reduce yields and even put land out of production; remediation is very expensive. Pakistan/Indus Basin and Aral Sea are a hotspots. • Water quantity and water quality should be given equal priority, they are wholly inter-related. • It all boils down to not enough incentives to use water more efficiently. Lots to be done here. • There are pockets of good and bad examples everywhere, no one region has it figured out.
NGO Interviewee	• Small ball: do we care about GMOs. Big ball: who owns what. • Child labor is a serious issue if SE Asia where the practice is very diffuse. In Africa it is concentrated around cocoa and tea. In Latin America its large plantation crops (e.g., bananas). In SE Asia it can be found everywhere from large scale production (e.g., cotton) down to subsistence crops. • Production doesn't go to feed hungry people, it goes to feed fuel and livestock. We can definitely produce enough food with small scale eco-agricultural systems, if we are focused on feeding people. • "It's hard to overemphasize how important water is."
NGO Interviewee	• We can't just think about food production. We need a whole systems view. Multifunctionality of ag lands needs to be supported (e.g., ag lands role in watershed protection, biodiversity protection, ghg reductions, not just food production). Too many funders have too narrow of an approach. • Everyone looks at land use change, but she would prioritize areas that have high population density, high agricultural dependency, and environmental degradation (e.g., highlands of east Africa, small holders in India and SE Asia, China, Andes); especially those with irrigation dependency. These areas are under extreme social and environmental stress and need to increase production. • In Northern Mexico, Eastern Europe and Egypt we see all of the problems of industrial agriculture without the last generation of technological innovation.

Select Interview Summaries

NGO Interviewee	• Approximately 90% of the world's large dams (over 15 meters) have been built for irrigation. About half of these are in China (~20,000). Irrigation dams have had a massive ecological impact, have led to the collapse of river systems. • One major leg of China's effort to divert the Yangtze River to the Yellow River is primarily driven by the agricultural needs of the North China Plain. • India may be reaching its hydrological limits; nearing crisis mode; serious social tensions around water. • Land grabs are largely water grabs.
NGO Interviewee	• TNC's top priorities are: habitat conversion (biodiversity), water quantity, and water quality. Soils, managing ag lands for wildlife, and food security are second. Direct GHG emissions from agriculture production are rising quickly. • Indonesia is THE hotspot with respect to biodiversity. • They are looking as much at grasslands as at forests; "forests suck up all of the oxygen in the room." They are very focused on the Cerrado in Brazil. • Top of their list of areas vulnerable for agriculture conversion is the Guinea Savanna (East Africa), Congo Basin, Chaco (N. Argentina, NE Paraguay, SE Bolivia), the Llanos (grasslands/wetlands in SE Columbia). • Sees land grabbing as a red herring.
Academic Interviewee	• Stresses the need to focus on sustainable intensification. • Stresses the need for integrated policy-making. Policies driving food production, energy, water supply, land use, oceans and biodiversity need closer coordination.
NGO Interviewee	• The interviewee's organization has identified ecosystems (land use change and over extraction of wild fish stocks), climate (direct GHG emissions from ag), and water consumption by ag as the three top ecological threats from agriculture. Water pollution and soil degradation would be next. • "The Congo Basin is a future crisis area – it's on the verge the way Brazil was in the 1970s. Few foundations are working in Central Africa, yet half the world's growth in the next 40 years will be in Sub-Sahara Africa." • Sees an urgent need to address the demand side: shifting diets away from ruminants, decreasing food waste, reducing population, and reducing biofuels.

Alternative approaches

While we applied an environmental lens in considering the leading impacts from agriculture, many of the experts we spoke with also offered alternative constructs for thinking about the environmental and social impacts of agriculture.

Smallholder/Commercial

"CGIAR and foundations that have historically invested in East Africa have singlehandedly focused on smallholder agriculture … You cannot ignore the interface between smallholder and commercial agriculture. Although it poses some risks, the expansion and intensification of commercial agriculture could open up economic opportunities for smallholders, including improving infrastructure and bringing new actors to the market."

"Ignoring commercial agriculture can end up just displacing smallholders."

"If your model is around production intensification and you have a big population that can't do that, you marginalize a whole population."

Integrated eco-system management

"Sorry, Gates Foundation, World Bank, and IFC – the solution is not just fertilizers and new seeds. First of all, most farmers can't afford these inputs and even if they could, distribution channels aren't in place. Classic conservation agriculture practices (e.g. residue management, agro-forestry) are a strong solution because they also provide ancillary benefits, like raising groundwater levels."

"Agro-ecological systems are the most productive for smallholders."

"Most people in agriculture believe in sustainable intensification, which often translates to a high-tech model. While this aspect is a part of the solution, it's distracting to only use the frame of sustainable intensification; you cannot ignore broader ecosystem management."

Contest for resources

"Nowhere is the constraint technical. This is a contest about who controls the resources - the best land, water rights, mineral rights, even marginal lands."

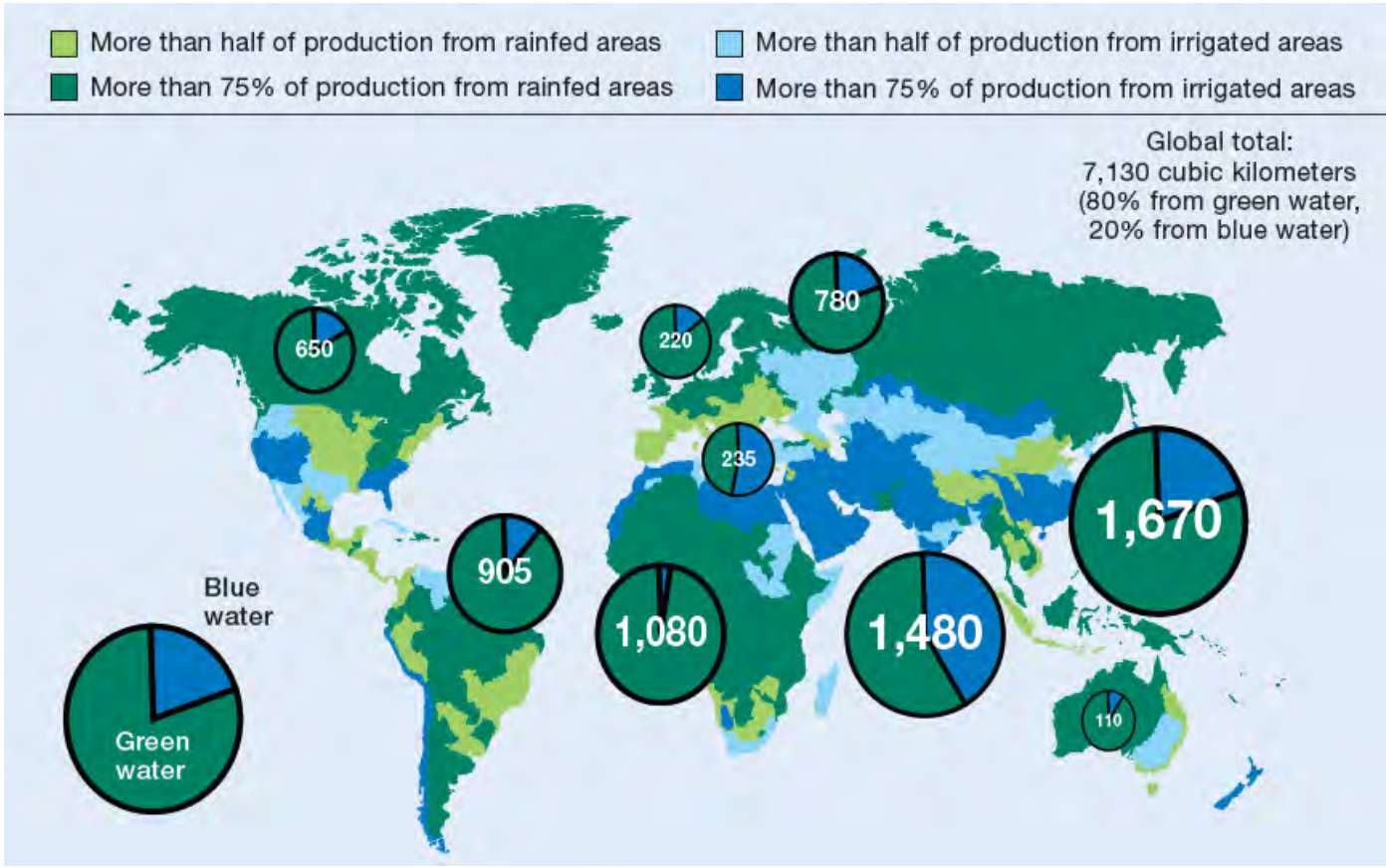
"There is tremendous opportunity for productive, integrated, low-impact agriculture, but to get there small scale producers need to have access to land, rents, financing, and markets"; lots of work to be done on the political economy side of the equation, outside of production.

Appendix B:
Additional information on water quantity

Despite limited natural availability, the world still attempts to grow food in dry areas.

- Arid regions – including the Middle East, Central Asia, and the Western U.S. – rely heavily on irrigation to meet agricultural production demands.
- South and East Asia have experienced large-scale irrigation development, while less irrigation development has occurred in Latin America and Sub-Saharan Africa.

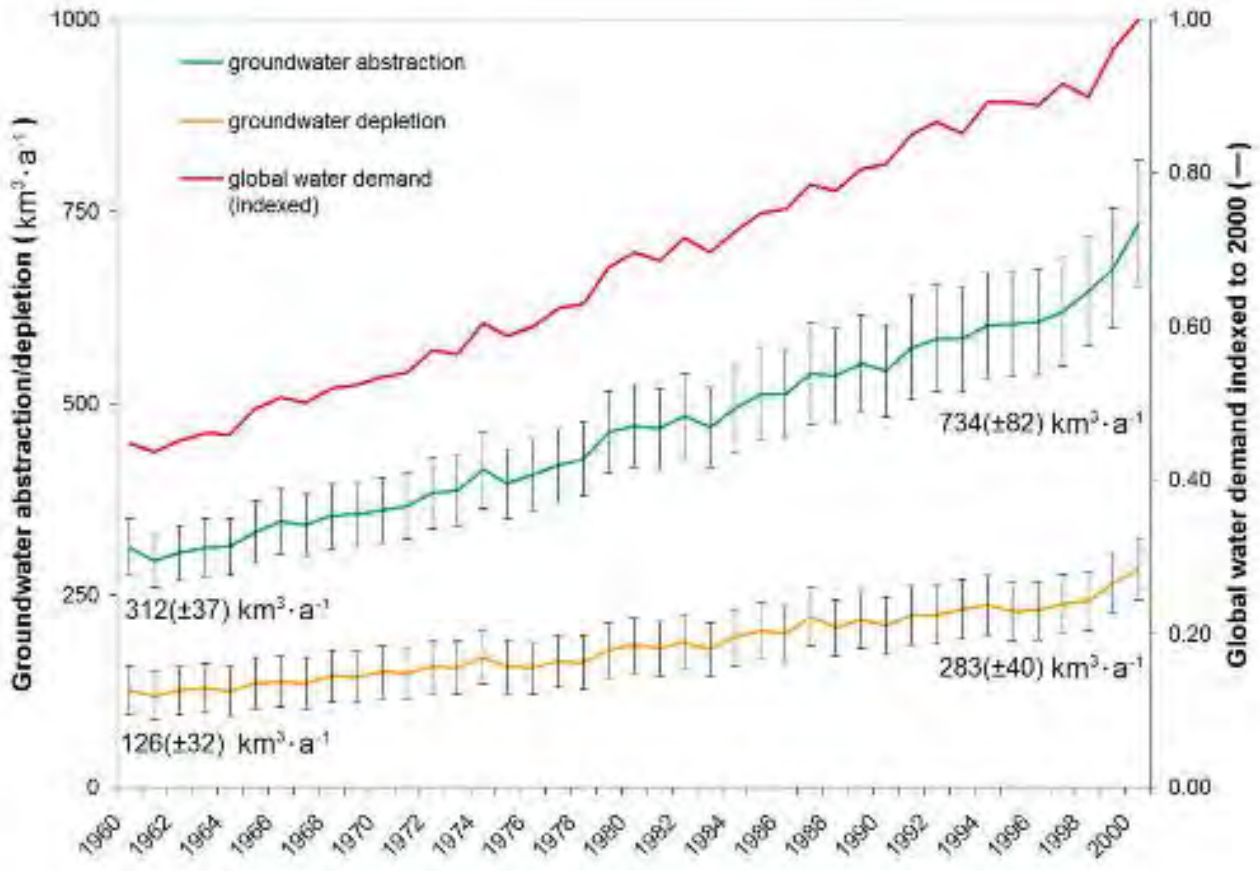
Regional variation in evapotranspiration in rainfed and irrigated agriculture



Note: Production refers to gross value of production. The pie charts indicate total crop water evapotranspiration in km^3.
Source: IWMI, 2007, "Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture."

Global annual groundwater depletion

- In regions with frequent water stress and large aquifer systems, groundwater is often used as an additional water source. If groundwater abstraction exceeds the natural groundwater recharge for extensive areas and long times, overexploitation or depletion occurs.
- Global ground water depletion (recharge minus abstractions) increased from 126 km^3 in 1960 to 283 km^3 in 2000 in sub-humid and arid areas.

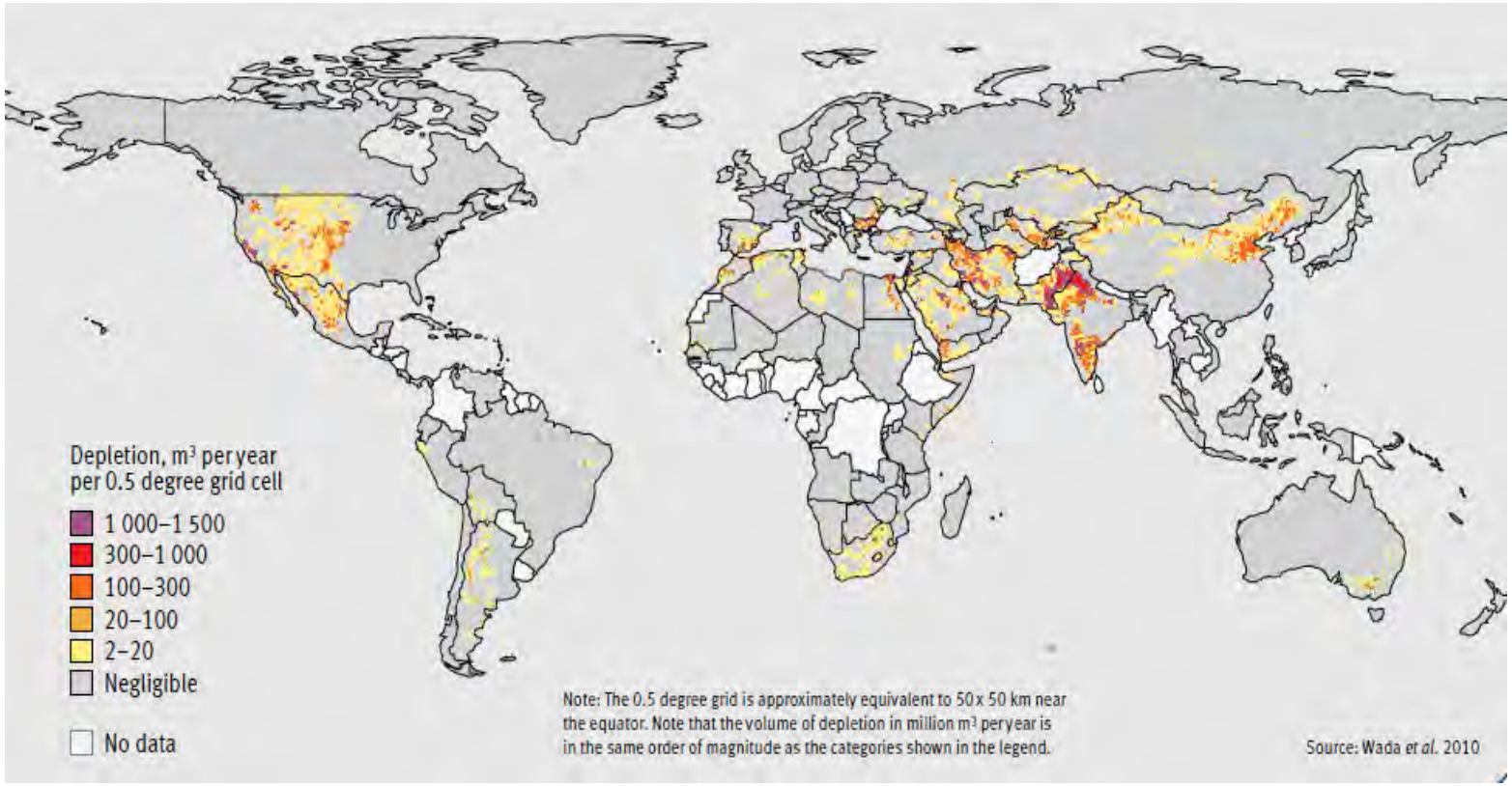


Source: Wada et al, "Global depletion of groundwater resources," Geophysical Research Letters, 2010.

Global annual groundwater depletion

- Experts estimate that 16-33% of agricultural withdrawals are non-renewable, globally.
- Geographic hotspots for groundwater depletion include: Northeast Pakistan, Northwest India, Northeast China, Yemen, Iran, South Africa, Southeast Australia, Southeast Spain, Northern Mexico, San-Joaquin Aquifer, and the Ogallala Aquifer. Many of these areas are major agricultural regions.
- The Middle East alone lost 117M acre feet of freshwater, an amount which fills the Dead Sea, between 2003-2009. At least 60% of this loss is due to groundwater depletion, mainly for irrigation purposes.

Global depletion of groundwater resources (2000)

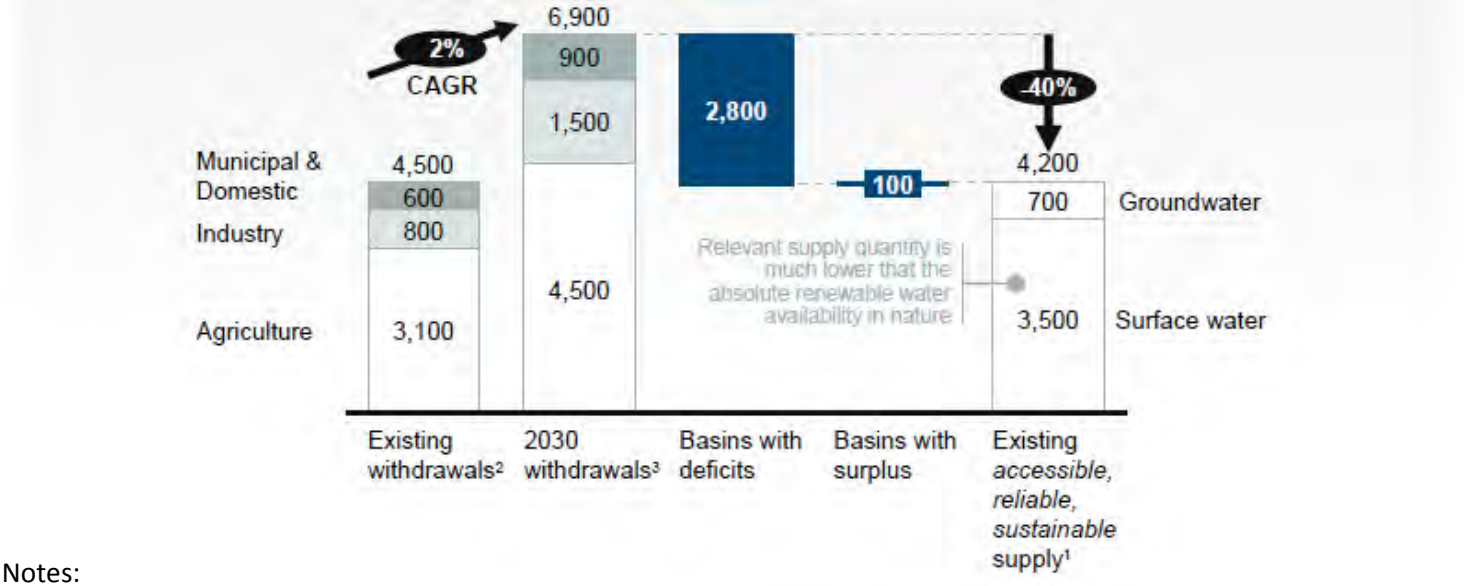


Source: Wada et al, 2010, "Global depletion of groundwater resources," Geophysical Research Letters.

Future demand for water is inextricably connected to agricultural production and economic development.

- Assuming no efficiency gains, agricultural withdrawals are projected to expand from 3,100 billion m^3 today to 4,500 billion m^3 by 2030.
- Projected withdrawals in 2030 among agricultural demand centers include: India (1,195 billion m^3), Sub-Saharan Africa (820 billion m^3), and China (420 billion m^3).

Aggregated global gap between existing accessible, reliable[1] supply and 2030 water withdrawals, assuming no efficiency gains (Billion m^3, 154 basins/regions)



Notes:

[1] Existing supply which can be provided at 90% reliability, based on historical hydrology and infrastructure investments scheduled through 2010; net of environmental requirements.

[2] Based on 2010 agricultural production analyses from IFPRI.

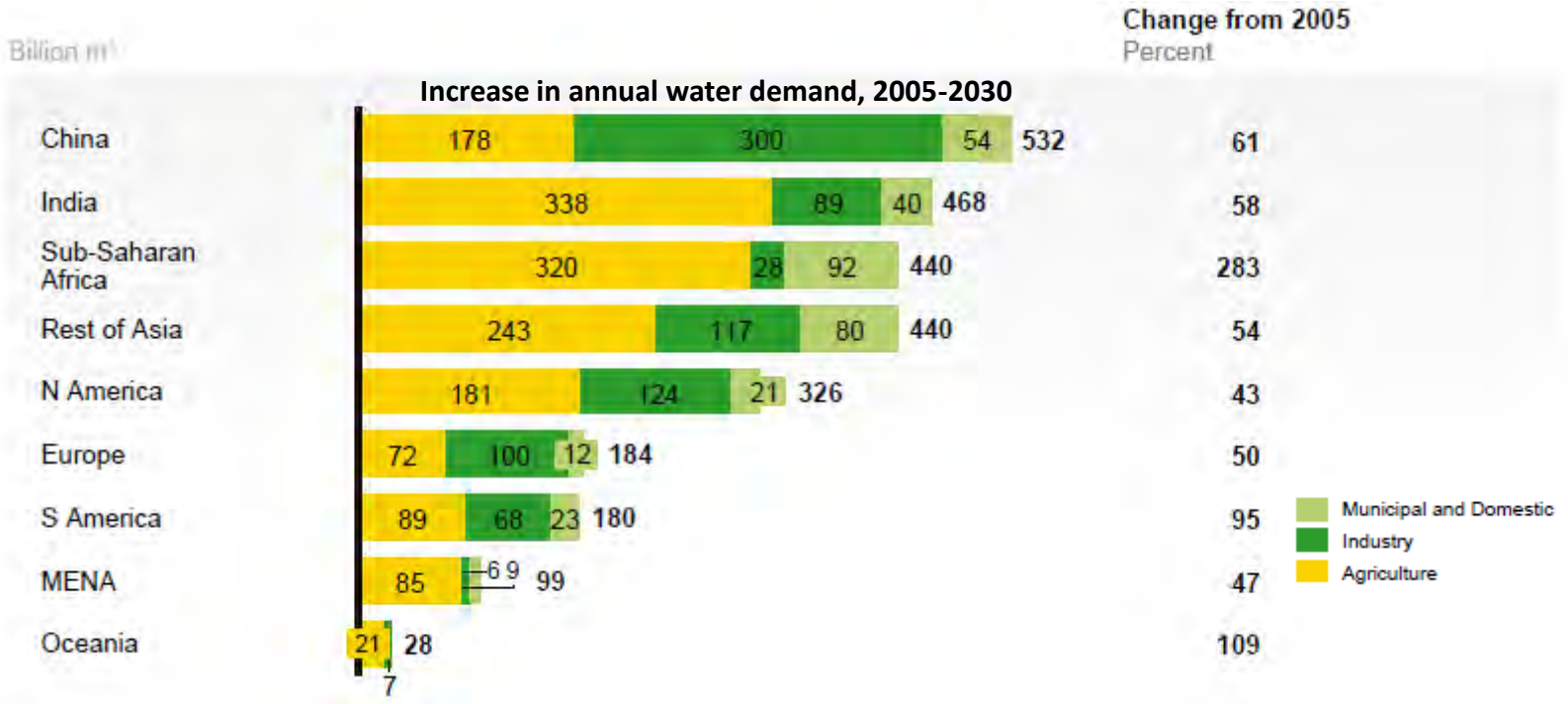
[3] Based on GDP, population projections and agricultural production projections from IFPRI; considers no water productivity gains between 2005-2030.

Source: Water 2030 Global Water Supply and Demand model; agricultural production based on IFPRI IMPACT-WATER base case.

Four countries/regions alone – China, India, Sao Paulo state, & South Africa will account for 42% of projected global water demand in 2030.

Experiences in these countries encapsulate key themes of the global water challenge, including:

- The role of agriculture as a key demand driver for water
- The nexus between food, water, and energy
- Sustainable growth in arid and semi-arid regions
- Competing demands for multiple uses within a river basis

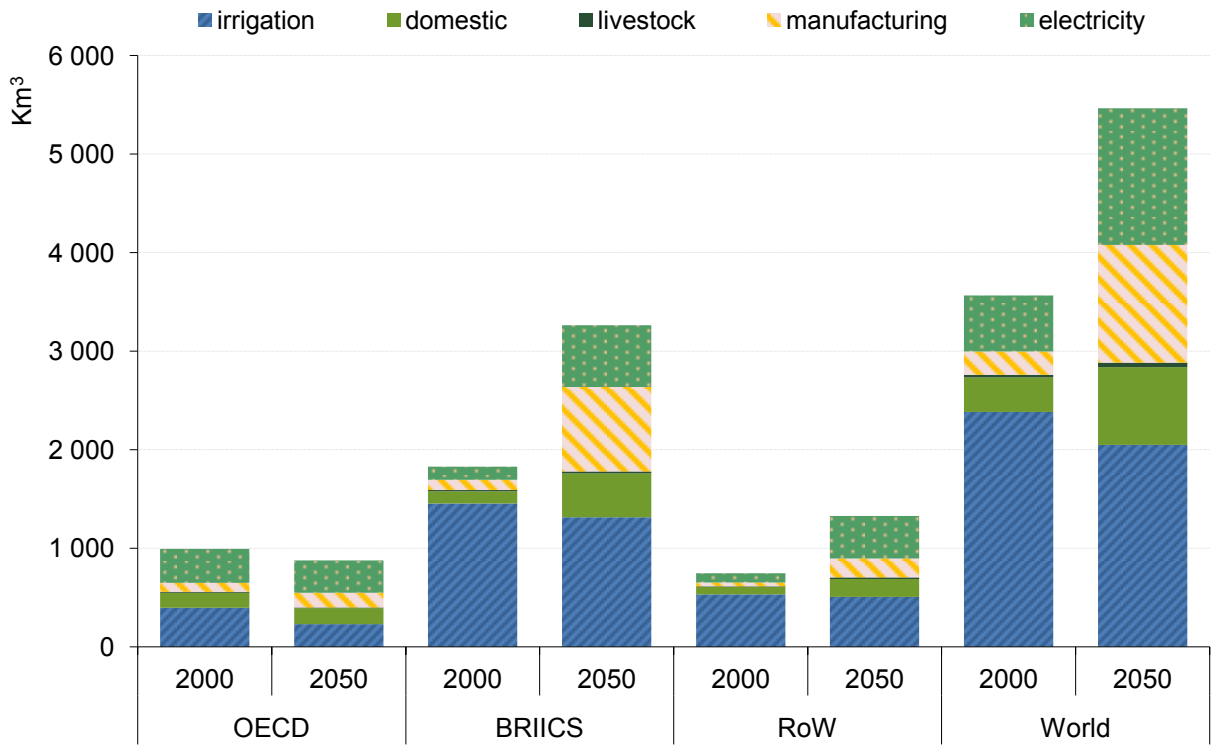


Source: Water 2030 Global Water Supply and Demand model; agricultural production based on IFPRI IMPACT-WATER base case.

Baseline scenarios suggest little opportunity for increasing future irrigation water, which may lead to groundwater depletion.

- Global water demand is projected to increase by approximately 55% by 2050. Competing demands from manufacturing and the energy sectors limit the possibility of increasing irrigation water.
- Environmental consequences of these competing demands may include: increased groundwater depletion, saltwater intrusion in aquifers, diminished agricultural and urban water supplies, drying out of wetlands, and less water to dilute pollutant inputs.

Global Water Demand: Baseline Scenario, 2000 and 2050



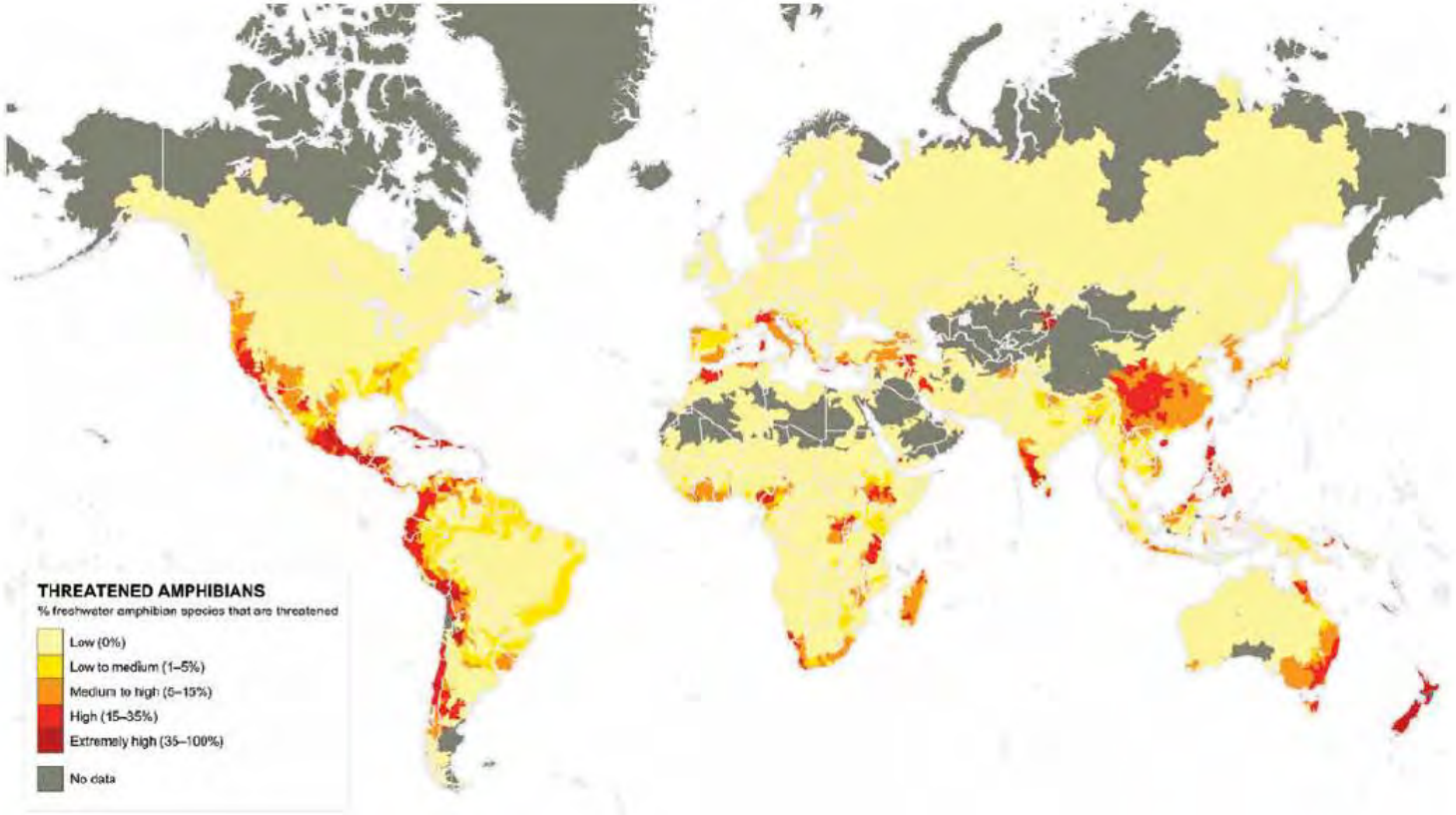
Note: BRIICS: Brazil, Russia, India, Indonesia, China, South Africa. RoW: Rest of the world.

Source: OECD, "OECD Environmental Outlook to 2050: The Consequences of Inaction," 2012.

Water Quantity and Biodiversity Loss

Several thousand species depend on water-rich areas and reliable environmental flows for their survival. According to the Millennium Ecosystem Assessment, biodiversity decline has been most severe in freshwater systems, out of all global ecosystems. Thus, biodiversity is a 'stakeholder' among competing users for the world's limited freshwater resources and appears on track to face a continued downward trend as global water demands increase.

Threatened Amphibians (% freshwater amphibian species that are threatened), 2010



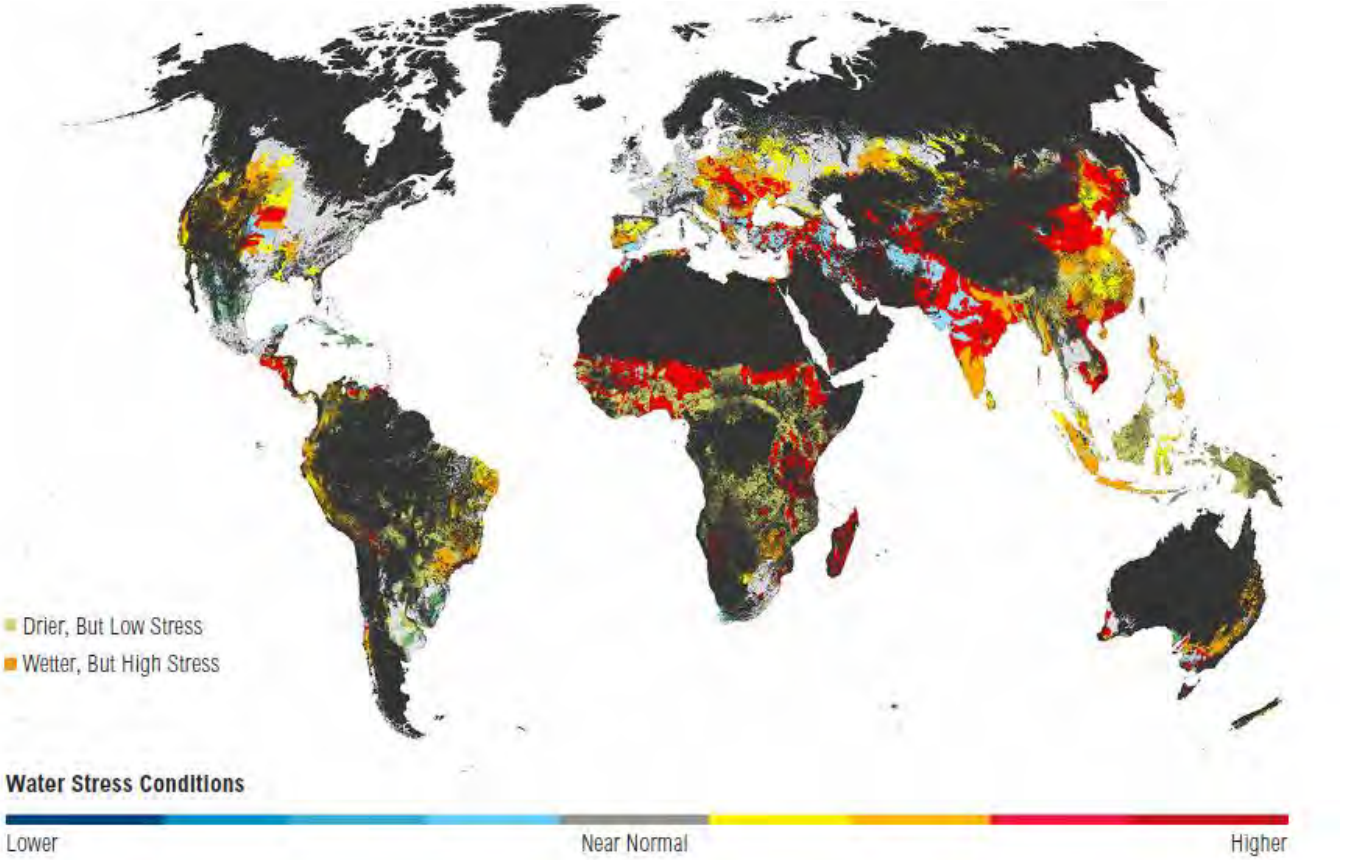
Note: 'Threatened amphibians' measures the percentage of freshwater amphibian species classified by IUCN as threatened. Higher values indicate more fragile freshwater ecosystems and may be more likely to be subject to water withdrawal and discharge regulations.

Source: WRI, "Aqueduct Global Maps 2.0," 2012; Wetlands International, "Biodiversity Loss and the Global Water Crisis," 2010.

Incorporating climate impacts, water stress is projected to increase in many agricultural areas by 2025.

The impacts of climate change are projected to significantly increase water stress in key food-producing areas, including India, China, sub-Saharan Africa, and the U.S. Midwest.

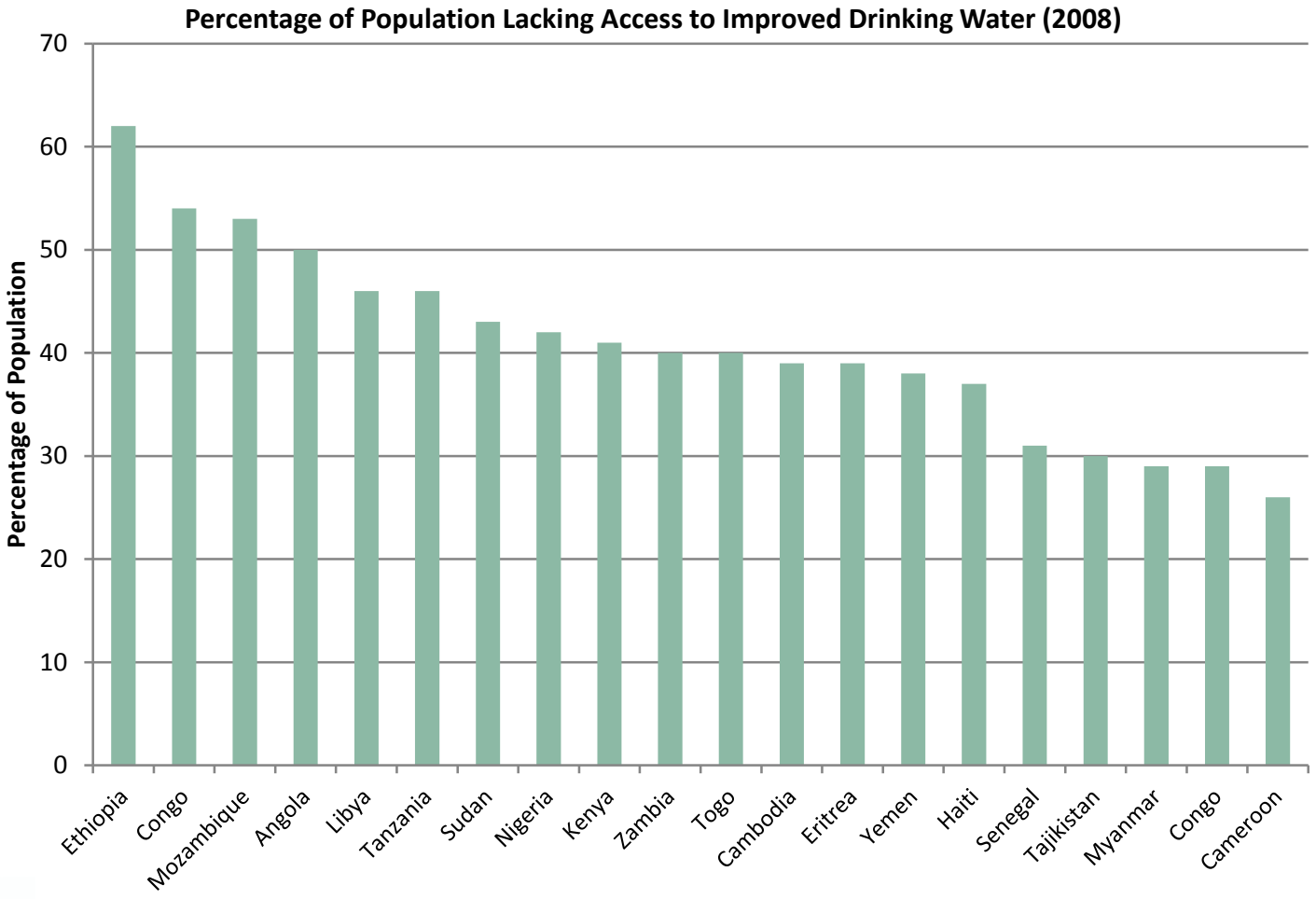
Projected Water Stress Conditions in 2025 (Based on IPCC Scenario A1B)



Source: WRI Aqueduct, 2012; water stress data from The Coca-Cola Company. Cropped areas from Ramunkutty et al, 2008, "Farming the Planet: Geographic distribution of global agricultural lands in the year 2000."

Social impacts to water quantity include water access, water rights, and drinking water safety.

Access to improved drinking water is especially acute in Africa, often due to infrastructure and governance issues. Among the top 20 countries with the worst access to improved public drinking water, 16 countries are in Africa.



Source: Yale Environmental Performance Index, 2012.

USAID Historical Water Funding and Beneficiaries Reached

During 2008-2011, USAID allocated approximately 40 percent of its water funding to Sub-Saharan Africa; 25 percent to the Middle East and North Africa; and 23 percent to Asia Pacific.

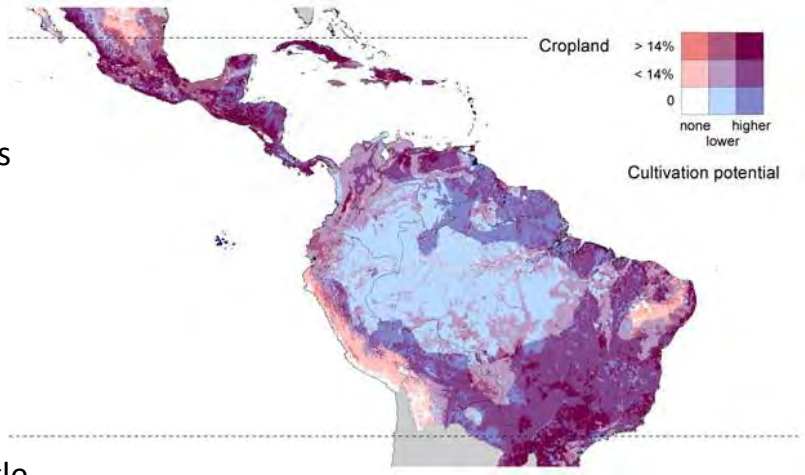
	Total 2011			Total 2008-2011			Average 2008-2011		
	Funding Amount (million USD)	# of Beneficiaries		Funding Amount (million USD)	# of Beneficiaries		Funding Amount (million USD)	# of Beneficiaries	
		Water Supply	Sanitation		Water Supply	Sanitation		Water Supply	Sanitation
Sub-Saharan Africa	186	1,176,021	548,745	715	5,208,559	3,542,712	179	1,302,140	885,678
Asia Pacific	52	1,516,705	604,881	406	7,642,087	3,051,601	101	1,910,522	762,900
Central Programs	15	60,514	40,465	72	60,514	40,465	18	15,129	10,116
Europe and Eurasia	2	50,193	0	13	180,278	1,986	3	45,070	497
Latin America and Caribbean	18	140,086	116,586	94	2,179,219	505,711	24	544,805	126,428
Middle East and N. Africa	86	880,982	614,589	449	4,929,554	5,293,100	112	1,232,389	1,323,275
Other	2	0	0	5	0	0	1	0	0
Total	360	3,824,501	1,925,266	1,754	20,200,211	12,435,575	438	5,050,053	3,108,894

Appendix C:
Additional information on climate

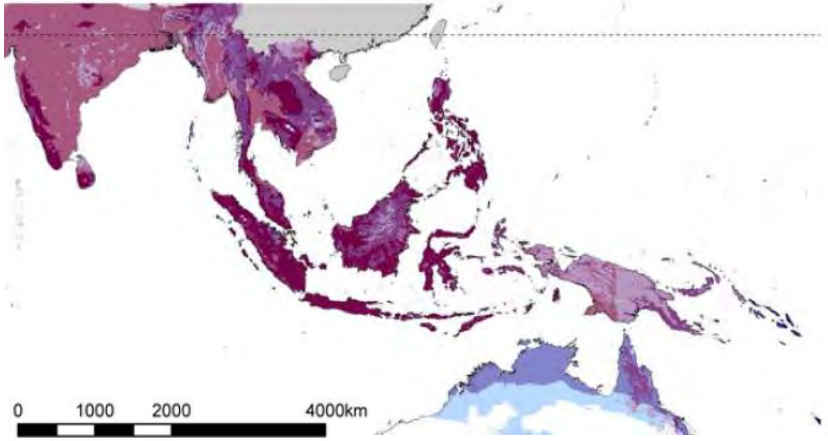
Areas of High Cultivation Potential in Tropical Countries

- A recent analysis suggests that High Biodiversity Wilderness Areas and Frontier Forests may be vulnerable to future agricultural conversion.
- According to this analysis, areas with high cultivation potential include: the Congo Basin, savanna woodlands in the Sahel and East Africa, land on the fringes of the Amazon Basin, Paraguayan Chaco, and northern Australia.
- In these maps, red shades indicate cropland extent in the year 2000. Purple shades indicate land which is suitable for one or more crops and which is already cultivated. Areas with high cultivation potential but little current cropland are shown in blue. This analysis did not consider land conversion to cattle pasture.

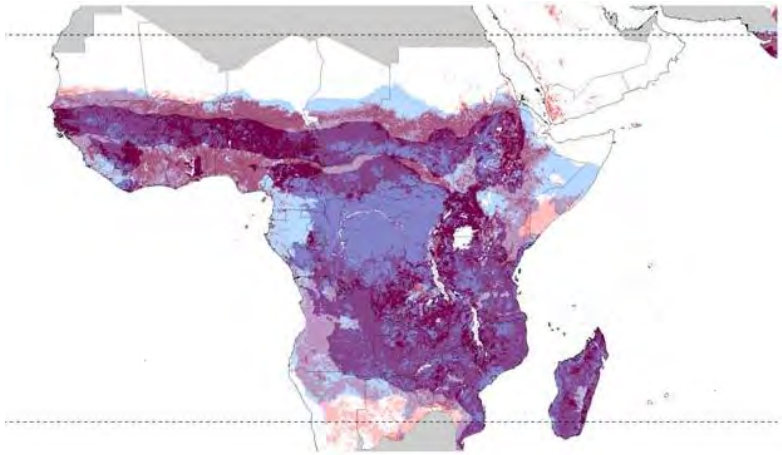
Neotropical countries



Tropical Asia/Australia



Tropical Africa

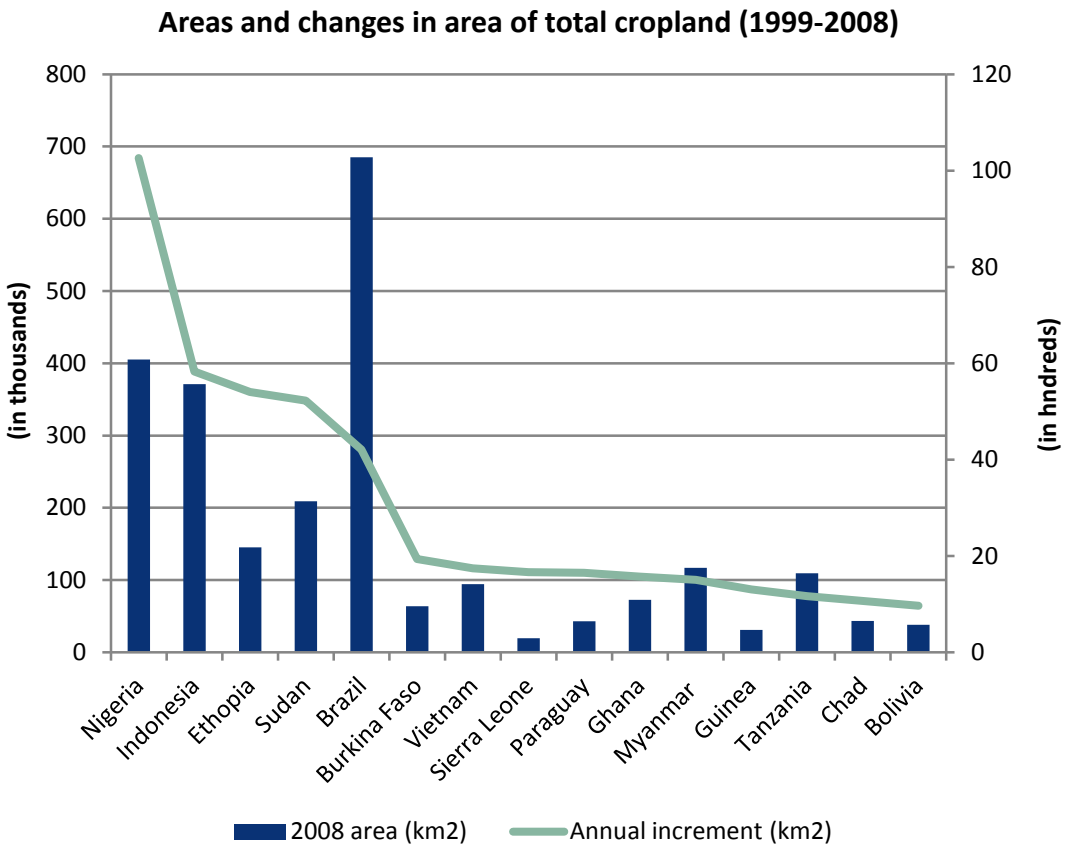


Source: Phalan B, Bertzky M, Butchart SHM, Donald PF, Scharlemann JPW, et al. (2013) Crop Expansion and Conservation Priorities in Tropical Countries. PLoS ONE 8(1): 1-13.

Appendix D:
Climate impacts on agriculture

Recent Cropland Expansion by Country

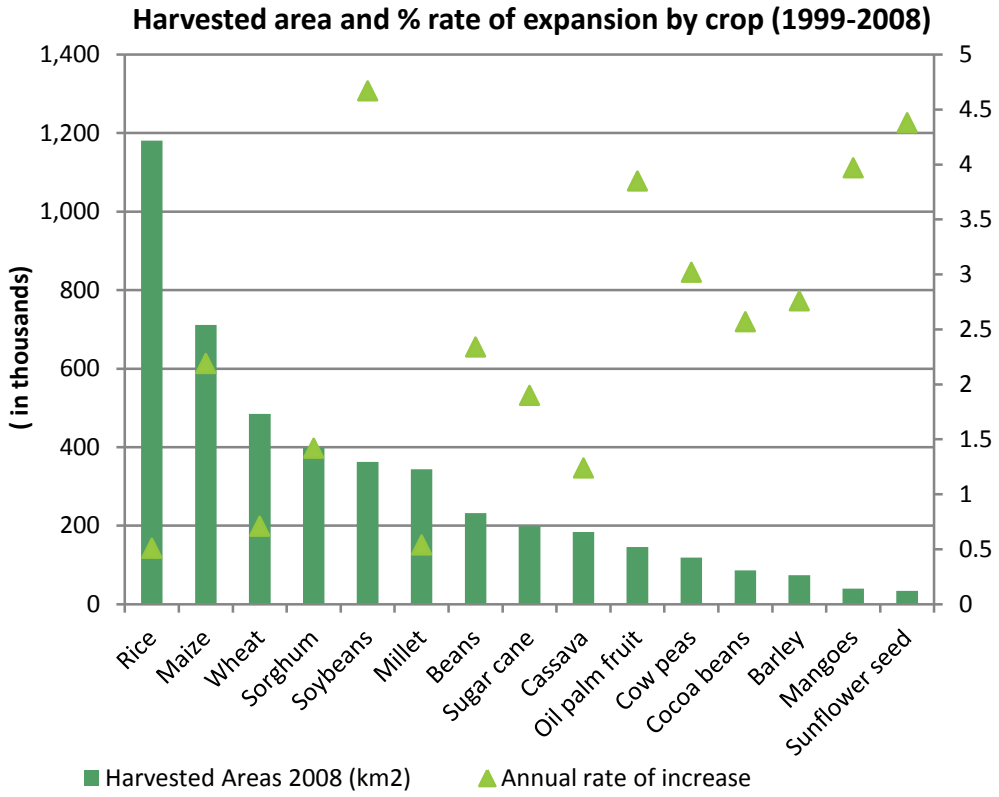
- The recent expansion of annual crops has occurred primarily in the tropics, across much of South America, Africa, and tropical Asia.
- Cropland in tropical countries expanded at an annual rate of 48,000 km^2 during 1999-2008.
- Nigeria, Indonesia, Ethiopia, Sudan, and Brazil added the greatest area of new cropland during this period, in terms of absolute increase in arable cropland.



Source: Phalan B, Bertzky M, Butchart SHM, Donald PF, Scharlemann JPW, et al. (2013) Crop Expansion and Conservation Priorities in Tropical Countries. PLoS ONE 8(1): 1-13.

Recent Expansion by Crop in Tropical Countries

- Rice was the single crop grown over the largest area in tropical countries, while wheat was grown over the largest area globally, during 1999-2008. Rice, maize, and wheat were the top three crops with the greatest harvested area in absolute terms, both in tropical countries and at the global level.
- Soybeans and oil palm, which are drivers of biodiversity loss, were among the fast expanding crops in harvested area in tropical countries during this period. Soybeans have been identified as a major cause of biodiversity loss in the Brazilian Cerrado savannas, and oil palm is considered the greatest biodiversity threat in Southeast Asia.



Source: Phalan B, Bertzky M, Butchart SHM, Donald PF, Scharlemann JPW, et al. (2013) Crop Expansion and Conservation Priorities in Tropical Countries. PLoS ONE 8(1): 1-13.

Summary of Climate Change Impacts on Agricultural Productivity

- Changes in temperature and precipitation may have comparatively minimal impacts on agriculture in the near-term (e.g. 2050). However, large reductions in agricultural productivity are projected over longer term horizons (e.g. 2080).

- Based on baseline global warming figures, agricultural productivity is projected to decline globally by 3% in the presence of carbon fertilization benefits, and by 16% without any carbon fertilization benefits by 2080.

- Global losses in agricultural productivity may be even higher than many current models predict, given that the models do not account for extreme climate events—such as droughts and floods—or agricultural losses related to rising sea levels.

- The IPCC suggests that changes in the frequency and intensity of extreme climate events may have even more serious impacts on food than the projected increases in mean temperature and precipitation.

- Overall, developing countries have higher vulnerability given the dominance of agriculture in their economy. Countries closest to the equator also appear to be at significant risk for experiencing productivity declines.

- The two largest developing countries, China and India, have diverging forecasts: on an aggregate basis, China may experience neutral or even positive effects to its agricultural productivity, whereas India is slated to face severe productivity losses without a reduction in global GHG emissions.

Source: Cline, 2007, "Global Warming and Agriculture: Impact Estimates by Country."

Increased temperatures are expected to decrease agricultural productivity, with the most significant impacts seen in the developing world.

- Agricultural productivity (output per hectare) is projected to decline by 16% globally without carbon fertilization benefits, and by 3% in a scenario with carbon fertilization benefits.
- Developing countries are projected to experience a productivity loss of roughly 25% without carbon fertilization, and a loss of 10-15% with carbon fertilization.

Percent change in agricultural output potential, 2005-2080

Region	Without Carbon Fertilization	With Carbon Fertilization
World		
Output weighted	-16	-3
Population weighted	-18	-6
Median by country	-24	-12
Industrial countries	-6	8
Developing countries	-21	-9
Median	-26	-15
Africa	-28	-17
Asia	-19	-7
Middle East and North Africa	-21	-9
Latin America	-24	-13

Notes:
1. Assumes overall warming of 3.3°C, based on doubling of atmospheric carbon concentration in 2080 from 2008 levels.
2. Assumes temperature increase of roughly 4.4°C weighting by farm area and 5°C weighting by land area (given that land areas warm more than the oceans).
3. Assumes precipitation increase of 3 percent by 2080 globally.

Source: Cline, 2007, "Global Warming and Agriculture: Impact Estimates by Country"

While individual countries fare differently, the general trend is that nearly all countries are projected to experience productivity declines.

Climate change impacts are expected to lead to productivity reductions in nearly all countries, whether based on economic (Ricardian) or agronomic (crop) models.

Percent change in agricultural output potential, 2005-2080

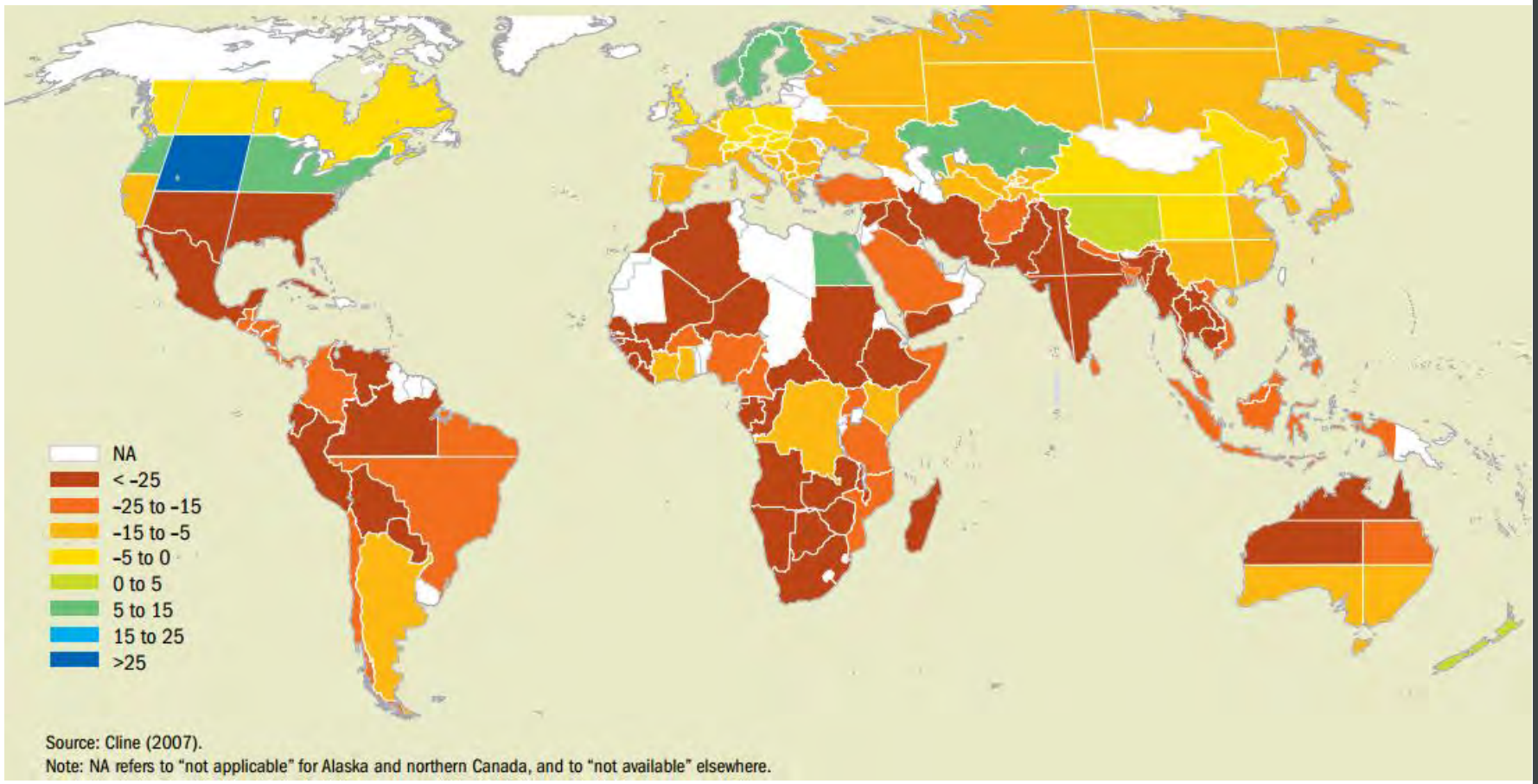
Geography	Ricardian model[1]	Crop Model[2]	Weighted average, Without Carbon Fertilization	Weighted average, With Carbon Fertilization
Argentina	-4	-18	-11	2
Brazil	-5	-29	-17	-4
United States	5	-16	-6	8
Southwest plains	-11	-59	-35	-25
India	-49	-27	-38	-29
China	4	-13	-7	7
South central	-19	-13	-15	-2
Mexico	-36	-35	-35	-26
Nigeria	-12	-25	-19	-6
South Africa	-47	-20	-33	-23
Ethiopia	-31	-31	-31	-21
Canada	0	-4	-2	12
Spain	-4	-11	-9	5
Germany	14	-11	-3	12
Russia	0	-15	-8	6

Notes: Ricardian models statistically infer the contribution of temperature and precipitation to agricultural productivity by analyzing the relationship of land price to climate. Crop models relate output to land quality, climate, fertilizer inputs, and other agricultural inputs.

Source: Cline, 2007, "Global Warming and Agriculture: Impact Estimates by Country"

Assuming no CF benefits, agricultural productivity is likely to decline most significantly in Africa, Latin America, and South Asia.

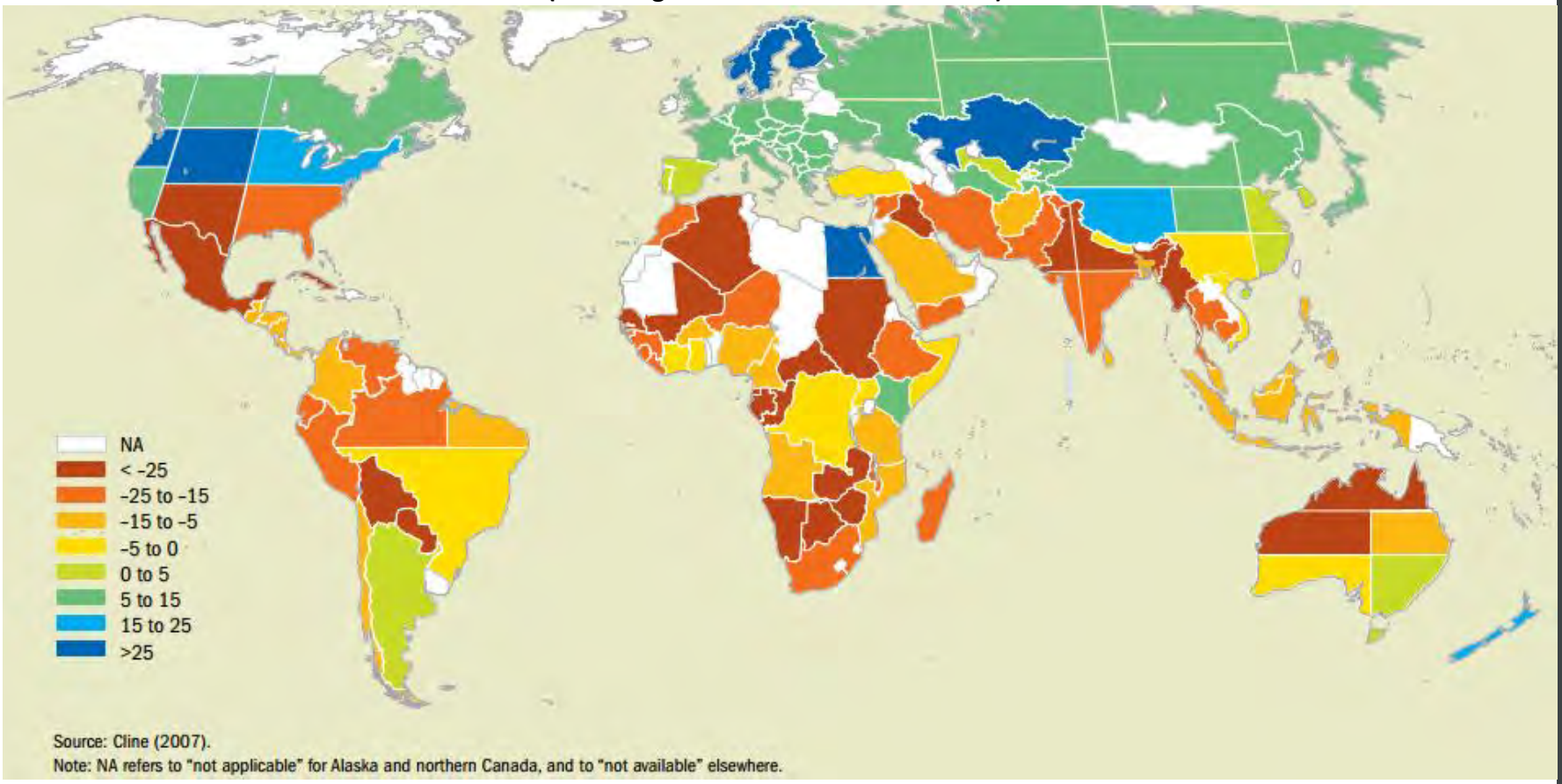
Climate-induced percentage change in agricultural productivity between 2003 and the 2080s (assuming no carbon fertilization benefits)



Source: Cline, 2007, "Global Warming and Agriculture: Impact Estimates by Country"

Assuming CF benefits, global impact is less severe and productivity may increase in countries at higher latitudes.

Climate-induced percentage change in agricultural productivity between 2003 and the 2080s (assuming carbon fertilization benefits)



Source: Cline, 2007, "Global Warming and Agriculture: Impact Estimates by Country"

Appendix E:
Additional information on biodiversity and habitat loss

Global Status and Distribution of Mangroves

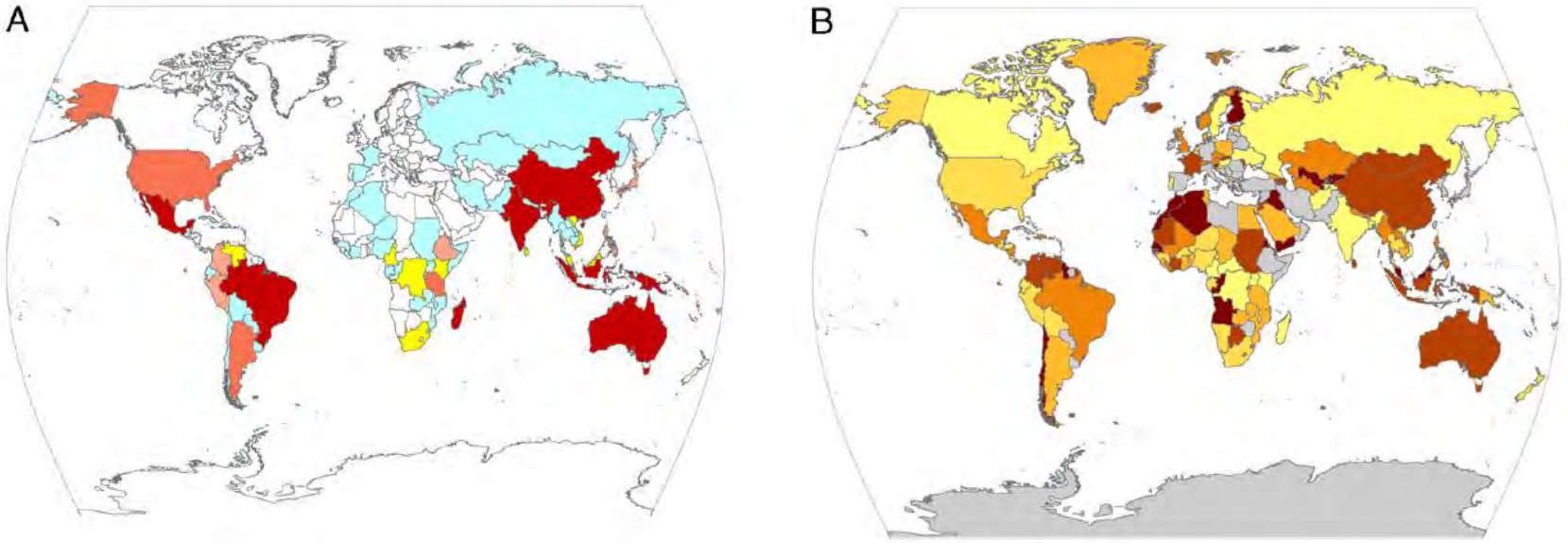
- Approximately 75 percent of world's mangroves are found in 15 countries alone. Only 6.9 percent of the world's mangroves are protected under the existing protected areas network (IUCN I-IV).
- The distribution of mangroves is primarily limited to the tropical and subtropical regions; the largest percentage of mangroves is found between 5° N and 5° S latitude.

The 15 most mangrove-rich countries					
Rank	**Country**	**Area (ha)**	**% of global total**	**Cumulative %**	**Region**
1	Indonesia	3,112,989	22.6	22.6	Asia
2	Australia	977,975	7.1	29.7	Oceania
3	Brazil	962,683	7.0	36.7	South America
4	Mexico	741,917	5.4	42.1	North/Central America
5	Nigeria	653,669	4.7	46.8	Africa
6	Malaysia	505,386	3.7	50.5	Asia
7	Myanmar	494,584	3.6	54.1	Asia
8	Papua New Guinea	480,121	3.5	57.6	Oceania
9	Bangladesh	436,570	3.2	60.8	Asia
10	Cuba	421,538	3.1	63.9	North/Central America
11	India	368,276	2.7	66.6	Asia
12	Guinea Bissau	338,652	2.5	69.1	Africa
13	Mozambique	318,851	2.3	71.4	Africa
14	Madagascar	278,078	2.0	73.4	Africa
15	Philippines	263,137	1.9	75.3	Asia

Sources: Spalding, M, 2011. "World Atlas of Mangroves." Hoboken: Taylor and Francis; Giri, C., 2011. "Status and distribution of mangrove forests of the world using earth observation satellite data." Global Ecology and Biogeography 20 (1): 154-159.

Global conservation funding and biodiversity

- A recent study, partly funded by the MacArthur Foundation, found that the 40 most severely underfunded countries (for biodiversity conservation spending) contain 32 percent of all threatened mammalian diversity.
- The top three countries listed in the bottom quartile of relative funding and in the top quartile of threatened biodiversity (measured through a model produced by the authors) were: Chile, Malaysia, the Solomon Islands, and Venezuela.
- Map A shows the levels of threatened biodiversity by country, with white and blue showing very low and low threatened diversity, respectively; yellow: medium diversity; and red: high diversity, with darker shades shows higher values of diversity.
- Map B shows underfunding levels from a predictor model produced by the study authors. Darker colors indicate worse levels of underfunding for conservation.

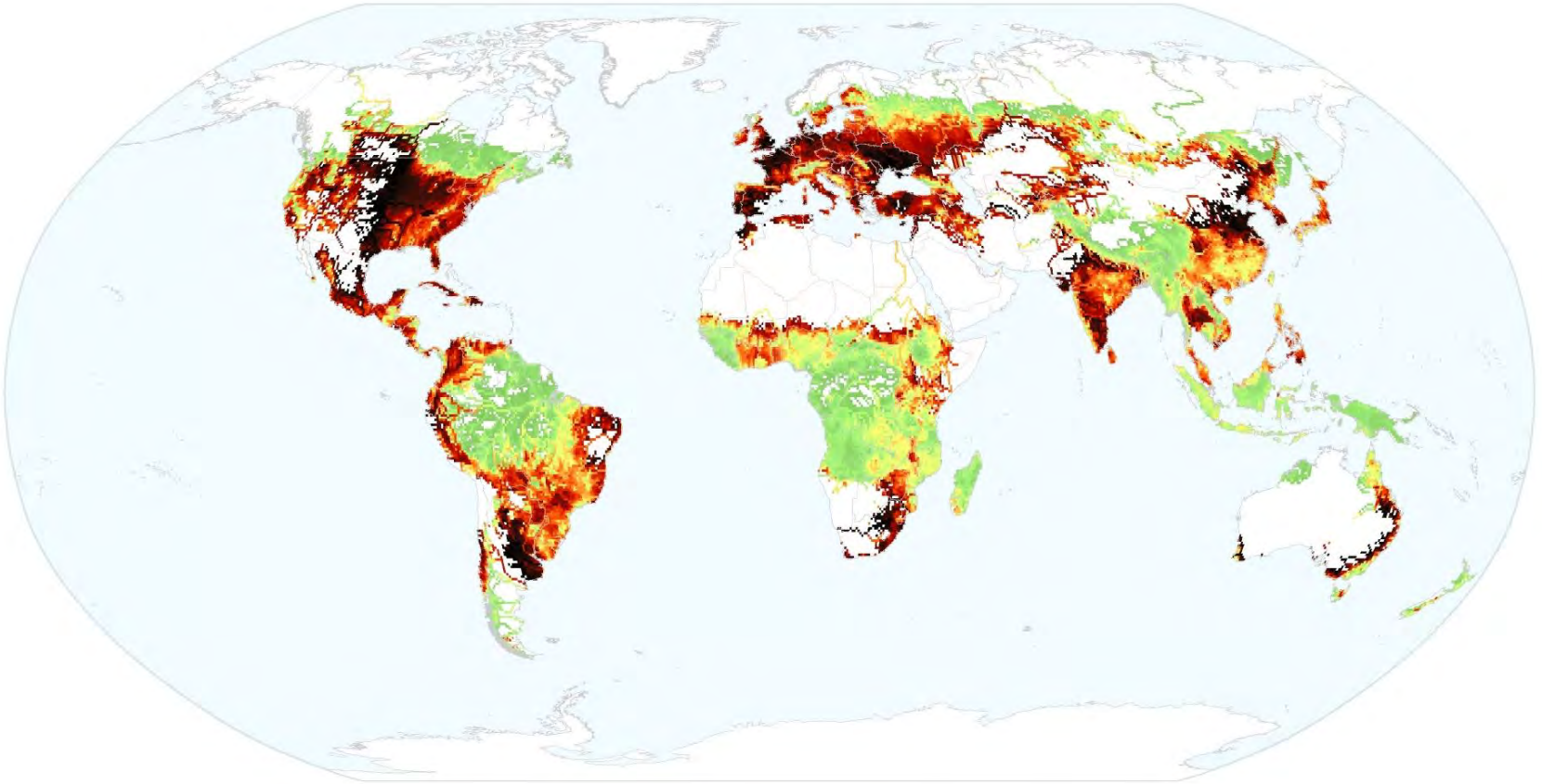


Source: Waldron et al, 2013. "Targeting global conservation funding to limit immediate biodiversity declines." PNAS 110 (29): 12144-12148.

Appendix F:
Additional information on water quality

Distribution of Pesticide Loading

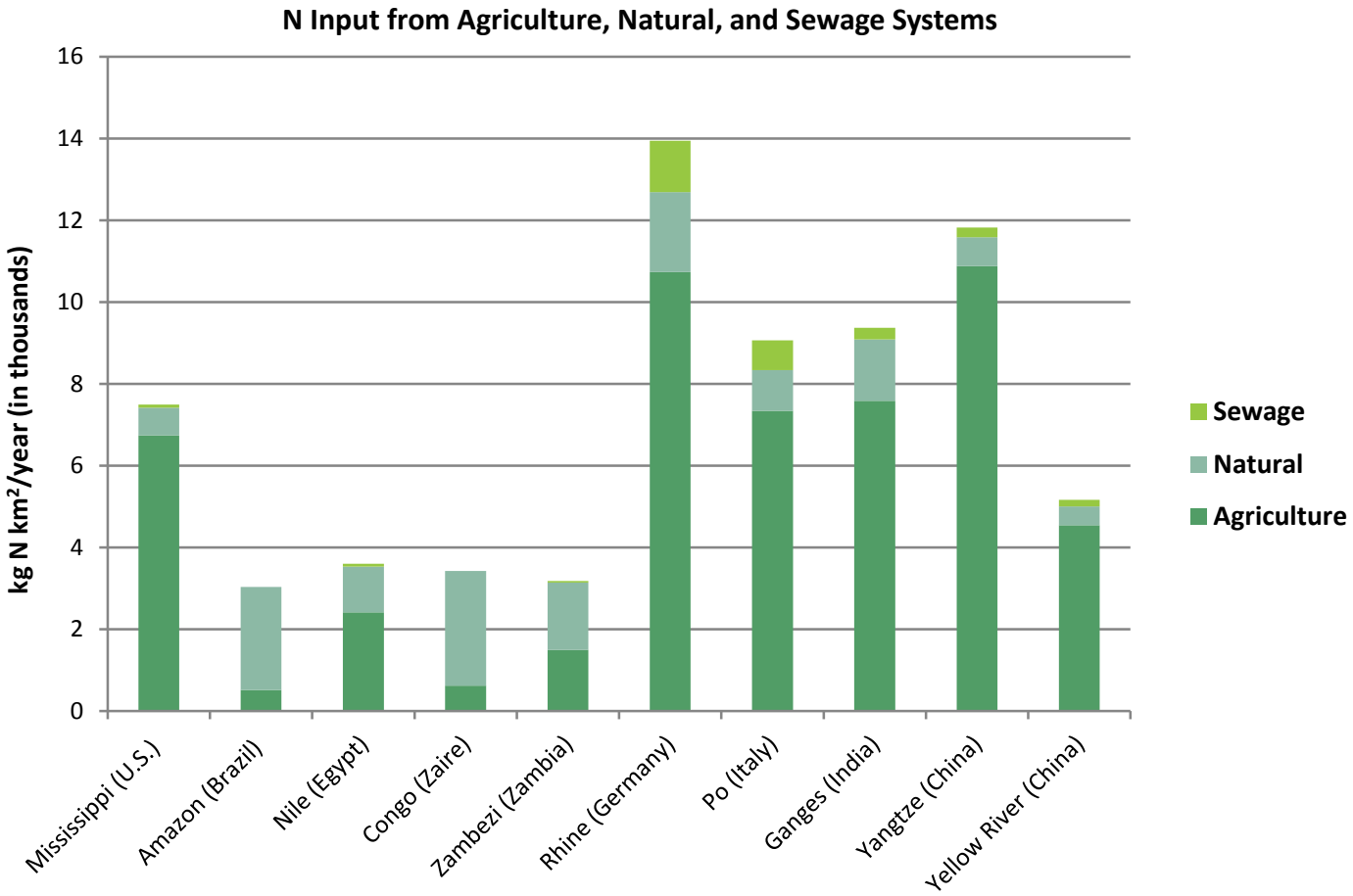
This map indicates the level of pesticide loading, estimated based on country-level data on pesticide application to croplands.



Data Source: Rivers in Crisis; http://www.riverthreat.net/

Nitrogen Inputs at River Mouth for Ten Selected Rivers

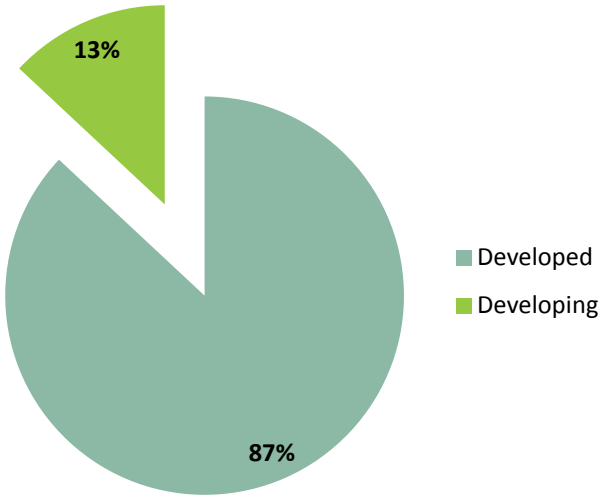
A study which examined the global nitrogen pollution of surface waters found that agriculture is a dominant contributor to the N load at the river mouth in large river basins with high levels of agricultural activity, including: the Mississippi, Ganges, Yellow, Yangtze, Rhine, and Po.



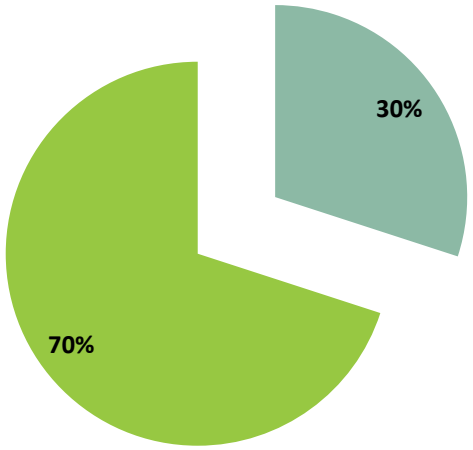
Source: van Drecht et al, 2001. "Global N Pollution of Surface Waters," The Scientific World 1: 632-641.

Global Fertilizer Consumption: Regional Shares

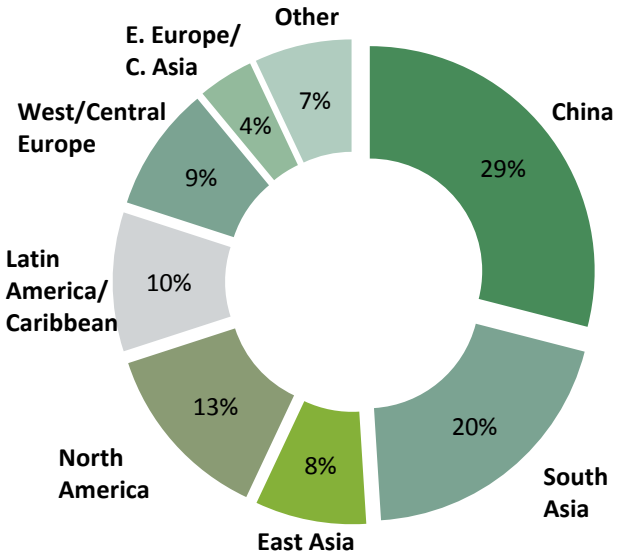
Consumption in 1960/1961 (30 MT)



Consumption in 2010/2011 (173 MT)



2010/2011 Consumption by Region



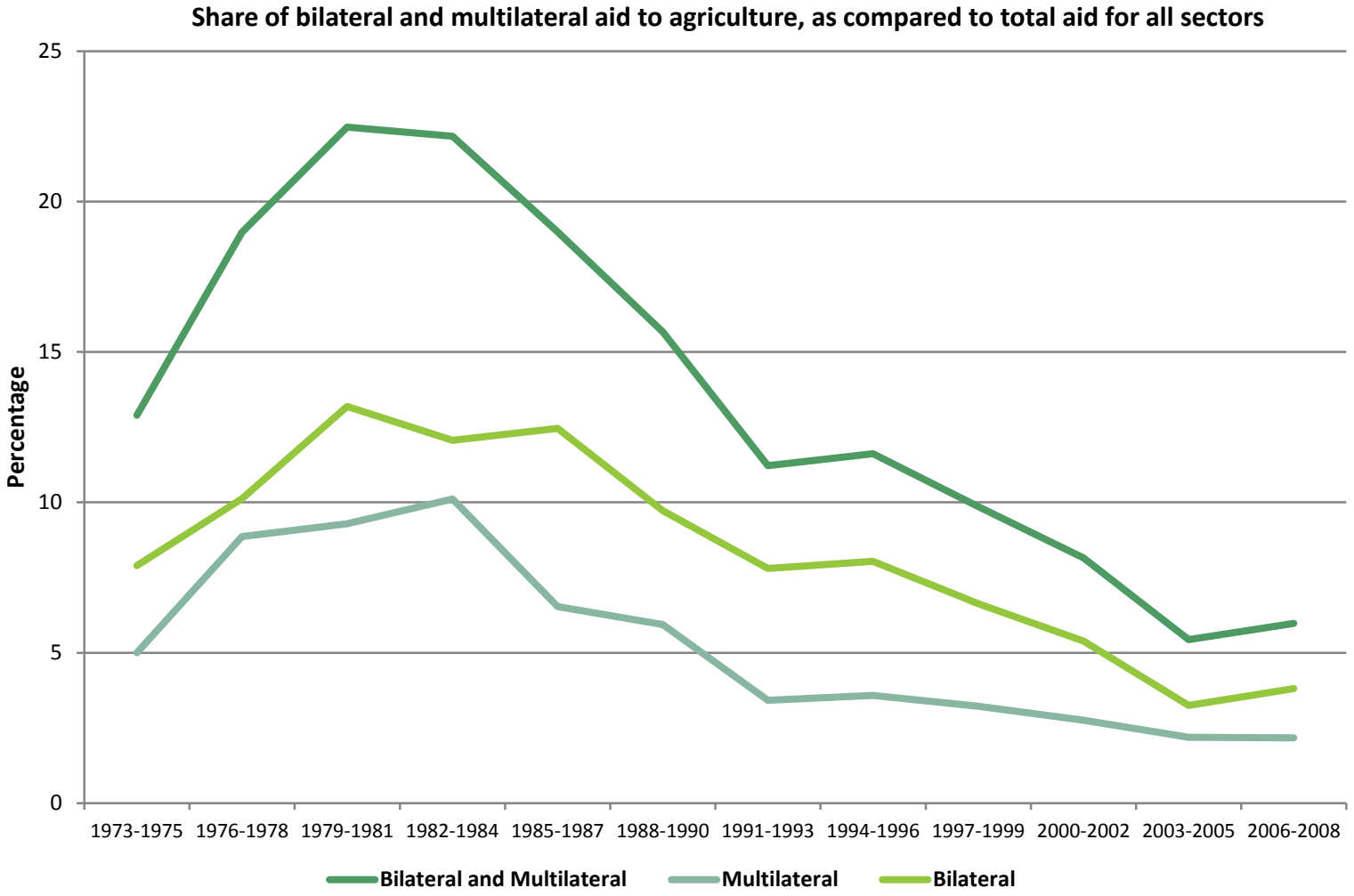
Developing countries, particularly in Asia, have accounted for the majority of growth in demand for fertilizers, over the past five decades.

Source: International Fertilizer Associations, 2013. "Fertilizer Indicators."

Appendix F:
Additional information on agriculture development funding

Pattern of Foreign Aid for Agriculture

Of total development aid from multilateral and bilateral sources, the share to agriculture peaked at 23% in 1979-1981, an increase which was potentially influenced by the 1974 world food crisis. The proportion decreased continuously starting in the mid-1980s, then increased slightly in 2006-2008 to 6 percent.

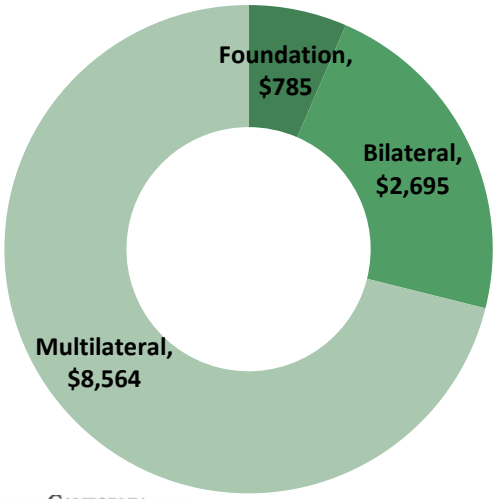


Note: Figures based on OECD/DAC database.
Source: IFPRI, 2011. "Foreign Aid to Agriculture: Review of Facts and Analysis."

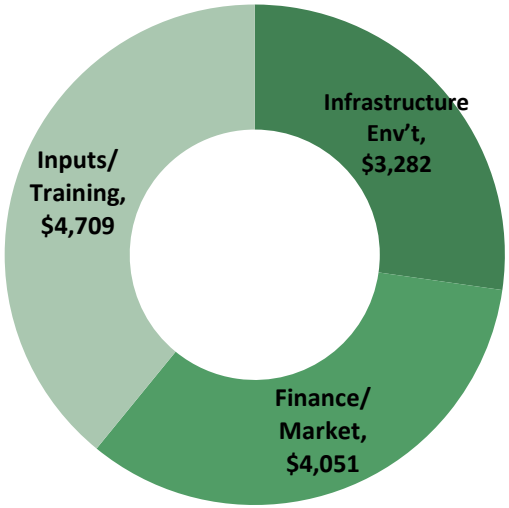
Funding Trends for Smallholder Agriculture

- A global analysis that mapped trends in international donor flows to smallholder agricultural development identified $12 billion in funding for more than 1,700 smallholder-focused projects (including multi-year commitments). Of the $120B in total development aid for one-year disbursements in 2009, approximately 5.4% ($6.5B) was allocated for agricultural development and 2.2% ($2.6B) for smallholder development.
- The study characterized the following trends:
  - **Funder Type:** Multilaterals contributed close to 75% of funding for smallholder development. Bilaterals contributed 22% of smallholder funding, while foundations contributed 7 percent. The Gates Foundation alone provided 90 percent of foundation funding in Africa.
  - **Focus of Funding:** There is a relatively even spread of funding across project types at the global level. However, regional variations remain: for instance, inputs/training accounted for half of funding in Africa, while the focus in Asia tended to be on infrastructure and environment projects.
  - **Investment Region:** Africa received more than 50% of smallholder aid, while Asia received 34 percent.

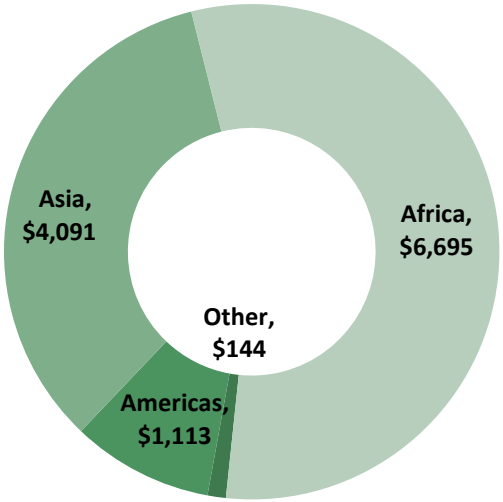
Funder Type ($M)



Funding Focus ($M)



Investment Region ($M)

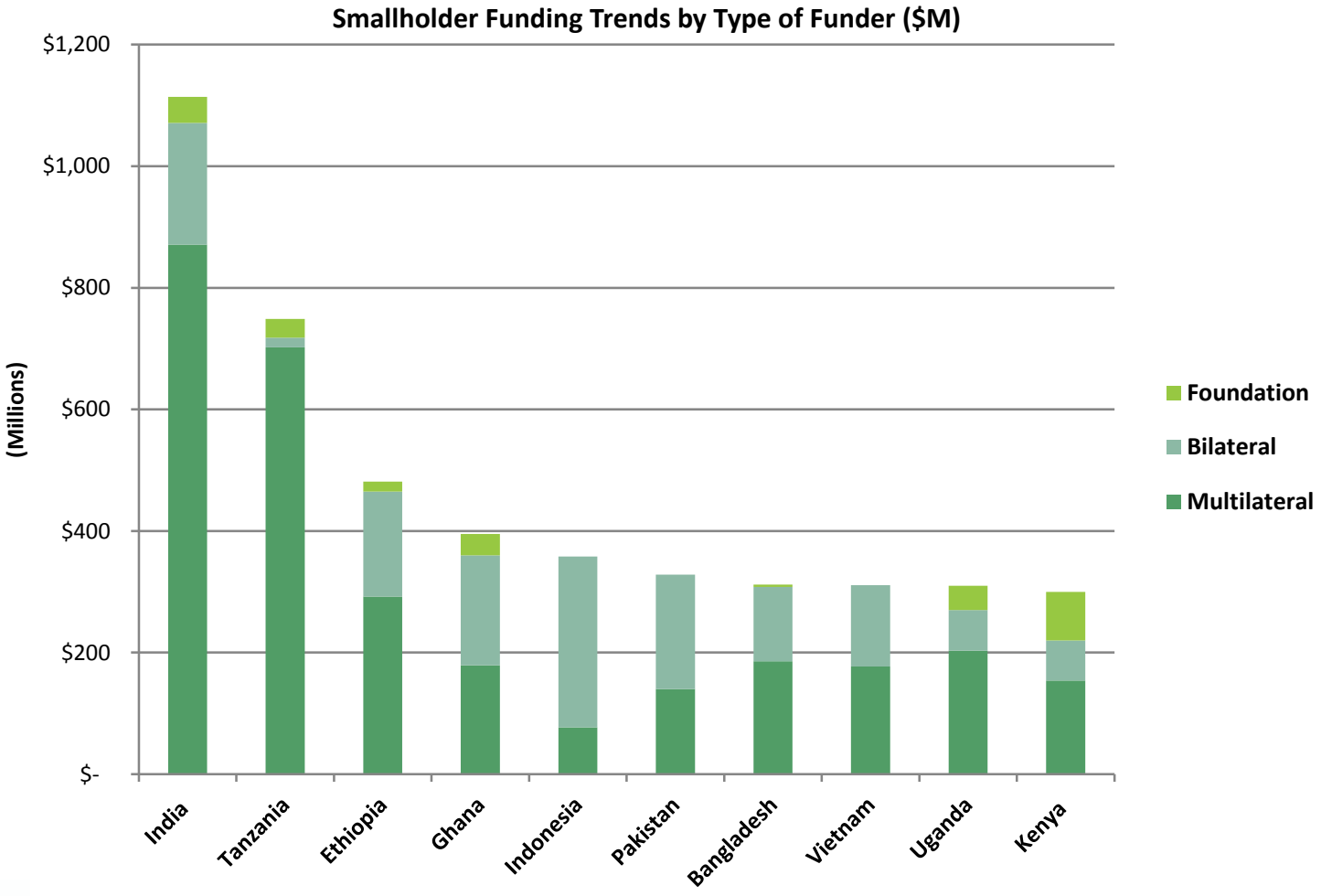


*The analysis, conducted in 2010, includes commitments from the year 2009 forward. (New commitments made after 2009 are excluded.)

Sources: FSG Social Impact Advisors, 2010. "Smallholder Farmer Development: International Donor Funding Trends."

Smallholder Funding Trends by Type of Funder, for Top Ten Countries

Ten countries alone were recipients of nearly 40% of the $12B in global funding for smallholder development. In India, the majority of projects were multilateral-funded and focused on irrigation and water management. Among the top ten countries, foundation funding was greatest in Kenya.



Sources: FSG Social Impact Advisors, 2010. "Smallholder Farmer Development: International Donor Funding Trends."