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Changing Glaciers and Hydrology in Asia: Addressing Glacier Melt in the Region

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Agenda for Today

- Overview: scope, genesis, purpose, methods
- Results
  - Scientific knowledge
  - Vulnerabilities
  - Current activities
- Program concepts and approaches

Himalaya, Pheriche, Nepal. Photo by Dan Miller

Mountain ranges and river systems of High Asia. Map credit: Brian Melchior.

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About the Activity

- Sparked by USAID “Asia Future” dialogue about complex threats in ~15-year timeframe
- Focused on impacts of glacier melt
- Designed to coordinate and integrate information on
  - The science of glacier melt/retreat and impacts
  - Current vulnerabilities, especially related to natural resources and health
  - Current activities addressing glacier melt

- **Goal: Integration of information about the science, vulnerabilities, and current efforts to produce programmatic concepts and approaches that are cross-sectoral and produce multiple benefits.**

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A Timely Topic!

- Statement by the Intergovernmental Panel on Climate Change (IPCC 2007) warning of Himalayan glaciers melting by 2035 (not sourced correctly? transposed date?)
- Indian Ministry of Environment and Forests (2009) report asserting that "many" Himalayan glaciers are stable or have advanced
- Reports about retreat of individual glaciers
- IPCC (2010) retracts statement but reaffirms

> Widespread mass losses from glaciers and reductions in snow cover over recent decades are projected to accelerate throughout the 21st century, reducing water availability, hydropower potential, and changing seasonality of flows in regions supplied by meltwater from major mountain ranges…

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About the Project Team

- Implemented through a task order to the Environmental Health IQC – CDM the prime contractor
- Diverse, specialized knowledge
  - Glaciology
  - Health and population
  - Sociology
  - Geographic Information Systems (GIS)/geography
  - Environment/water
  - Agriculture
  - Disaster management/preparedness
- Integrated perspectives
  - USAID technical advisors
  - Project and activity managers, interdisciplinary technical lead
  - Sector specialists with USAID experience in cross-sectoral programs

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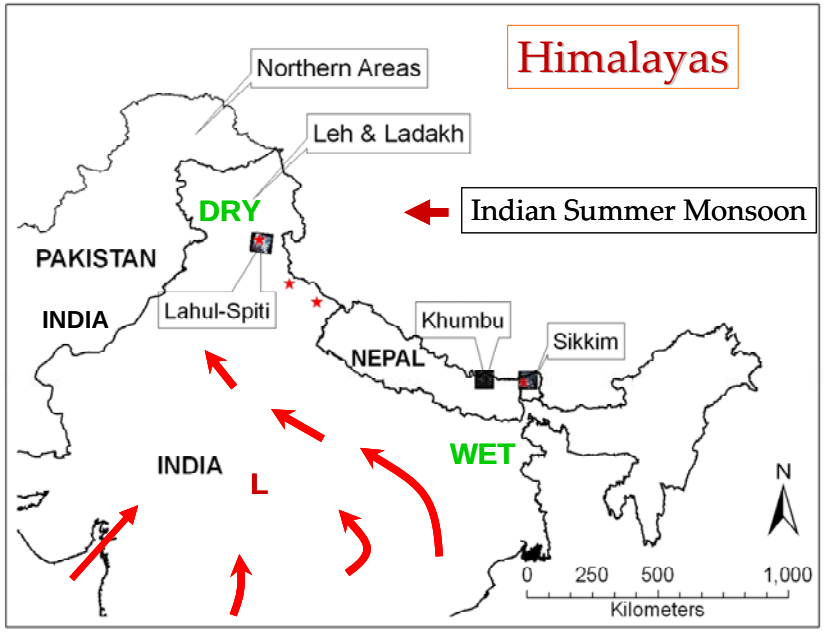
State-of-Knowledge Science Report: Findings

- Current, peer-reviewed science does not support dramatic statements about rapid melting/retreat of Himalayan glaciers
- Very few direct measurements of glacier volume or thickness exist, but are essential to accurate calculations of when a given glacier might disappear.
- Data on glacier melt are sparse, mostly of short duration, and biased (e.g., mostly lower elevations; may not account for slope, thickness, cover).
- Environmental hazards include glacier lake outburst floods (GLOFs)—both receding and advancing glaciers.
- Black carbon (soot) from fossil fuel burning (especially household cooking) theoretically accelerates melt rates, but in situ data are scarce.
- Catastrophic flooding from accelerated glacier melt is impossible, since glaciers melt very slowly.

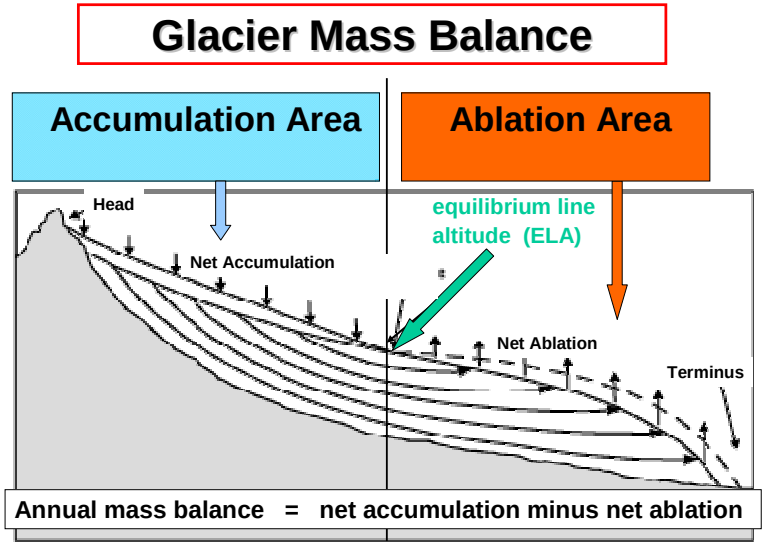
Conditions Are Different in the East (Himalaya Region) and the West (Karakoram and Hindu Kush)

- Climates: in the west, much drier and runoff at higher altitudes (i.e., more contribution from glacier melt but less water overall)
- Glacier conditions: west appears to show slower rates of retreat, less formation of pro-glacier lakes associated with flood hazard, and frequent observations of advancing glaciers.



Retreat of a Glacier's Terminus Is Not a Good Enough Measure of Glacier "Health"

- A glacier may be gaining more mass at the top than it is losing down valley.
- Measurements of both loss (melt, ablation) and accumulation (of snow and ice) are needed to determine whether a glacier is gaining or losing mass.



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Reason for Concern or Not?
Yes! Because

- We don't know enough – about aggregate trends in glacier melt, about interactions with other climate change impacts, or about societal impacts.
- Glacier melt is only one aspect of a complex hydrologic system (monsoons, snow, cyclones).
- Timing of water in the growing season is crucial; snow and ice provide water at different times from monsoons (and much is unknown about future changes).
- Perhaps the smallest amounts of glacier melt contribution correspond to the regions of the highest population: China, India and the Southeast Asia mainland. That is, *any* change in water supply has large implications.
- The Indus River has perhaps the largest ratio of melt water to population of any river system anywhere in the world. So more, less, or changes in timing of water supply are of concern here.
- "Now" actions to improve management, conservation, and efficient use of the water available will be crucially important to future, larger populations.

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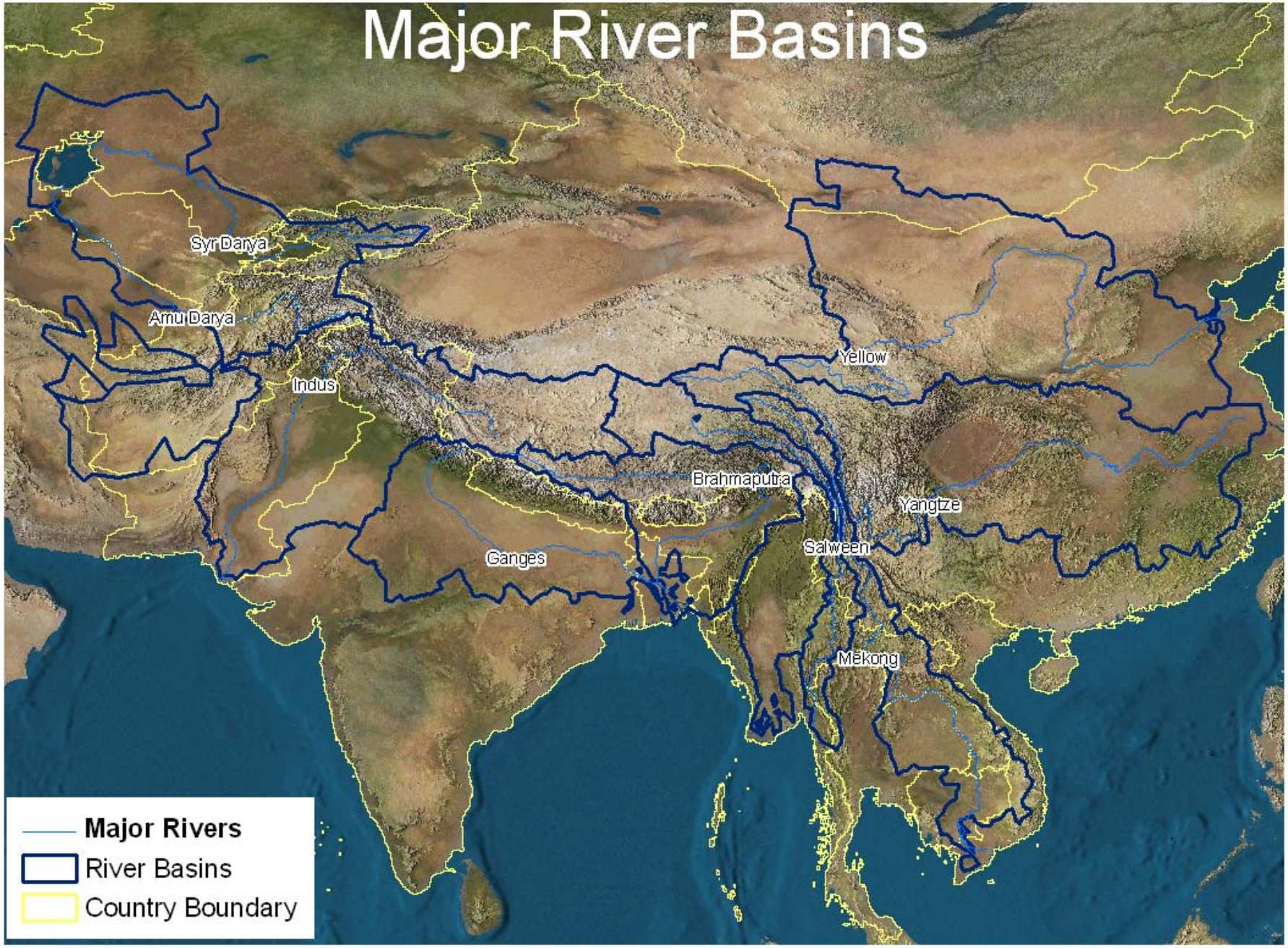
Vulnerability Maps: A Complementary Perspective

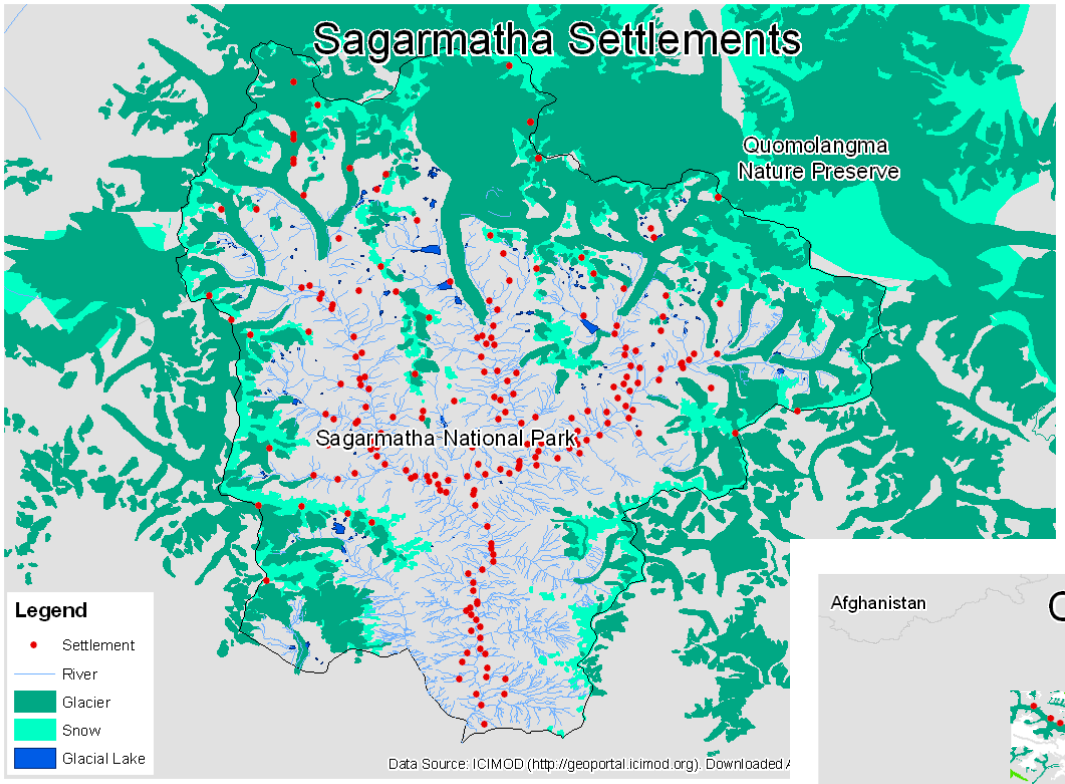
- The scientific perspective tells us what is known about glacier melt; the vulnerability perspective shows what and who could be affected by changes in glacier melt and the hydrologic system.
- If systems – both human and ecological – are already stressed, they are less able to be resilient in the face of changes.
- Existing vulnerabilities may include population pressures, poverty, ill health and malnutrition, air and water pollution, uncertain water supplies, and degraded environments.
- Programs and projects may target places where different vulnerabilities are particularly great or overlap.

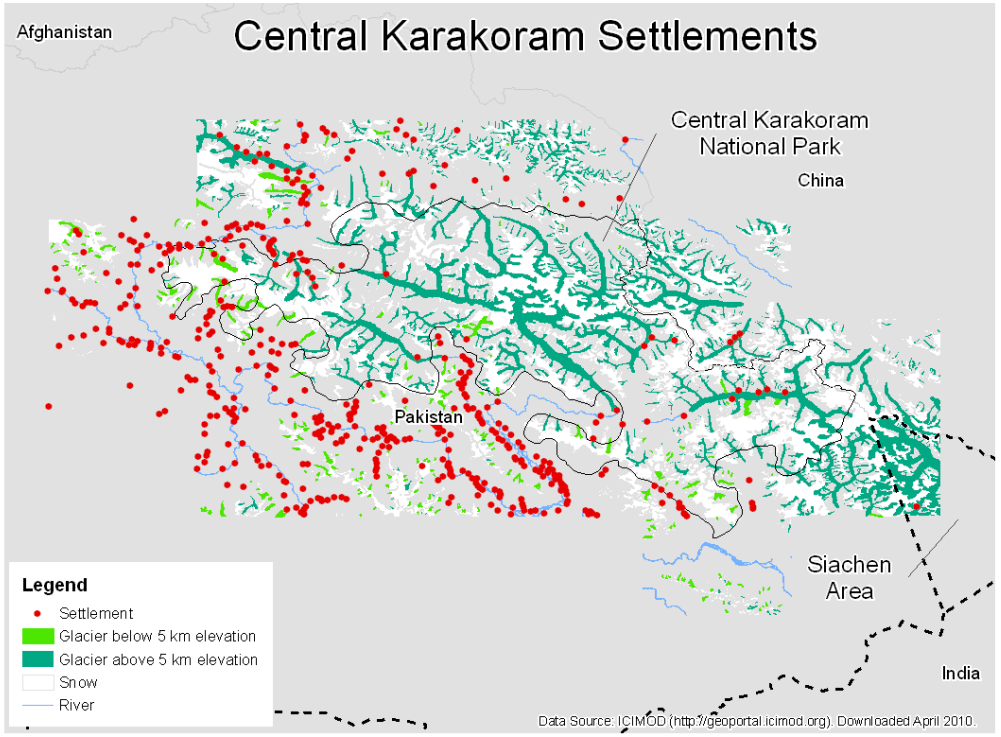
Vulnerability Maps: A Sample

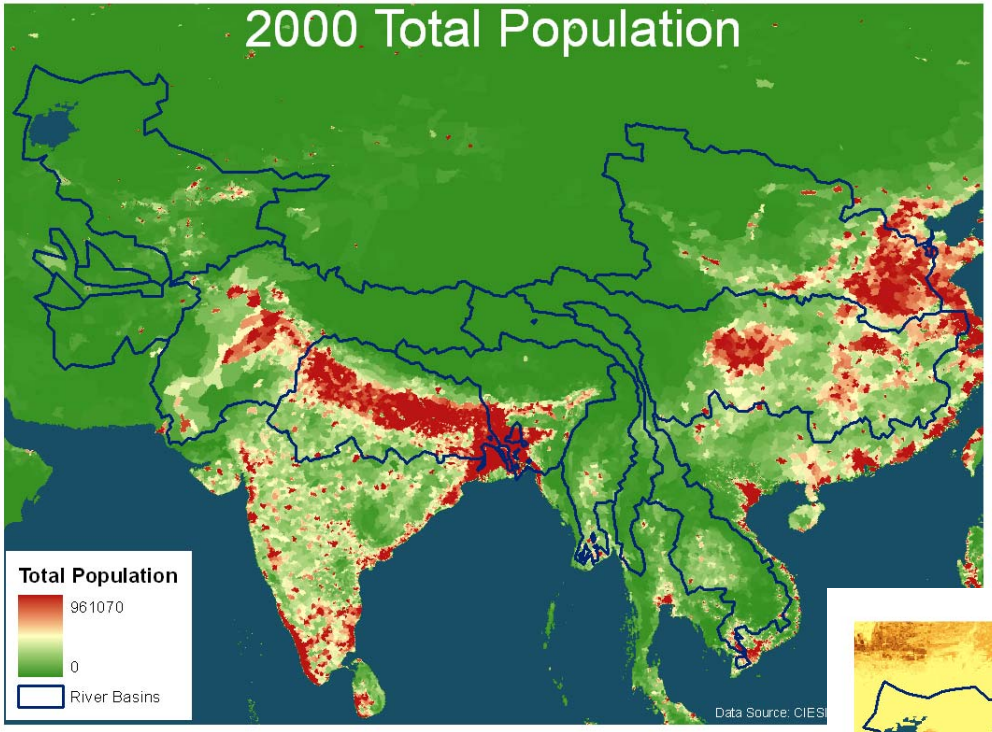
- The region—high mountains, plateaus, 9 river basins (Yellow, Yangtze, Mekong, Salween, Indus, Ganges, Brahmaputra, Syr Darya and Amu Darya Rivers)
- Glacier lakes
- Settlements

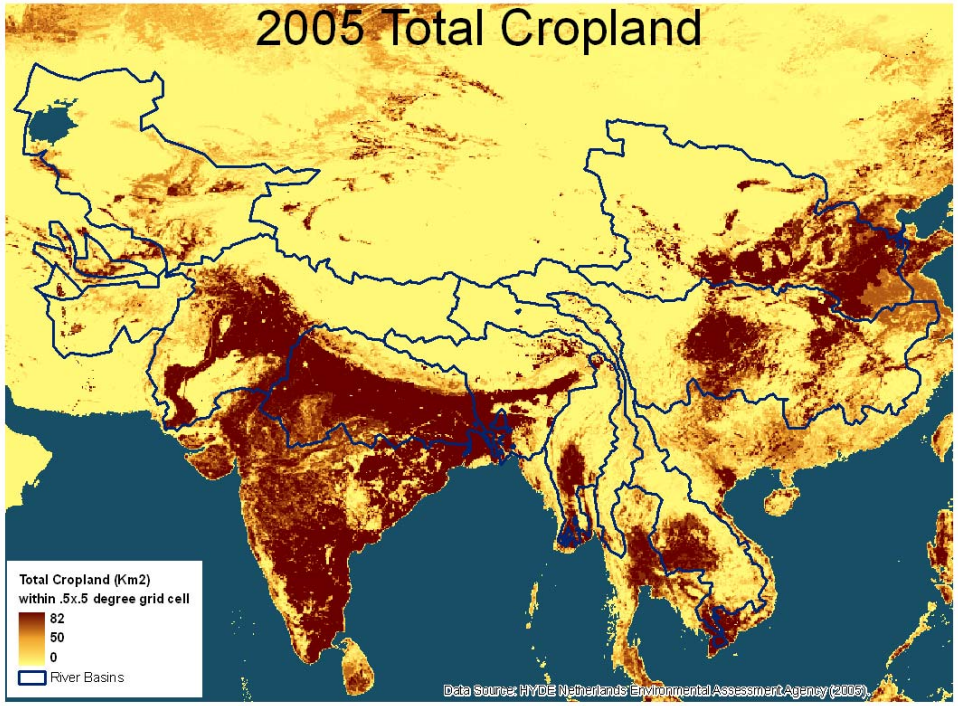
- Population and health vulnerabilities:
  - Total population/density
  - Hunger
  - Fertility rates
  - Infant mortality
  - Stunting
  - Black carbon emissions
- Natural resources vulnerabilities:
  - Cropland
  - Water stress
  - Biodiversity hotspots
  - Forest cover

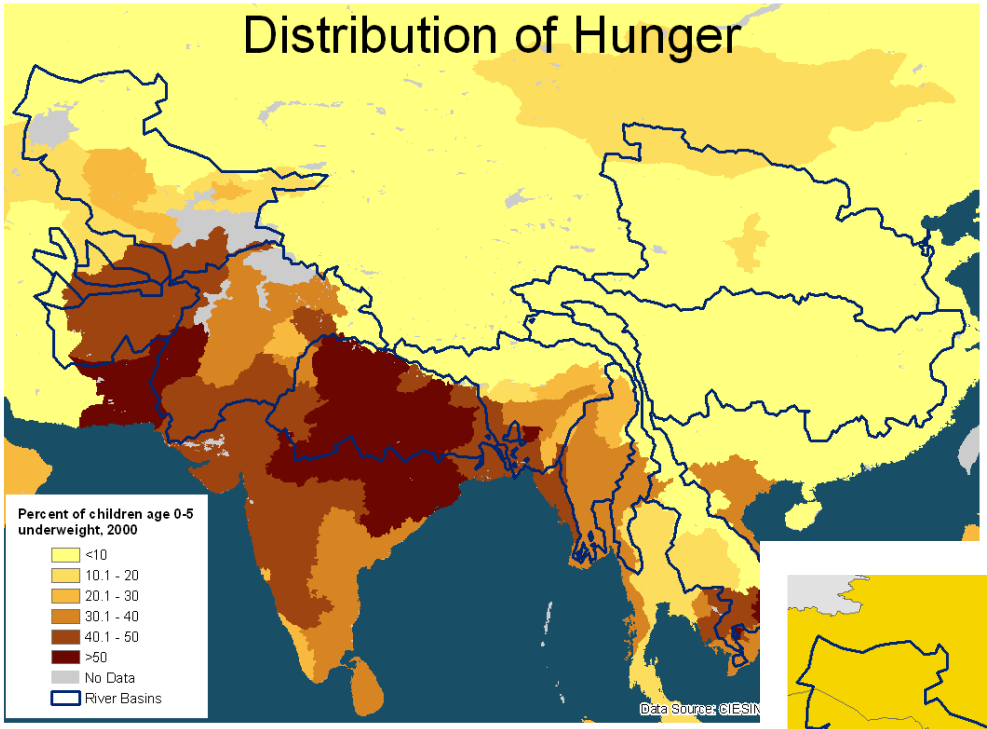

Major River Basins
Syr Darya
Amu Darya
Indus
Yellow
Brahmaputra
Yangtze
Salween
Ganges
Mekong
Major Rivers
River Basins
Country Boundary

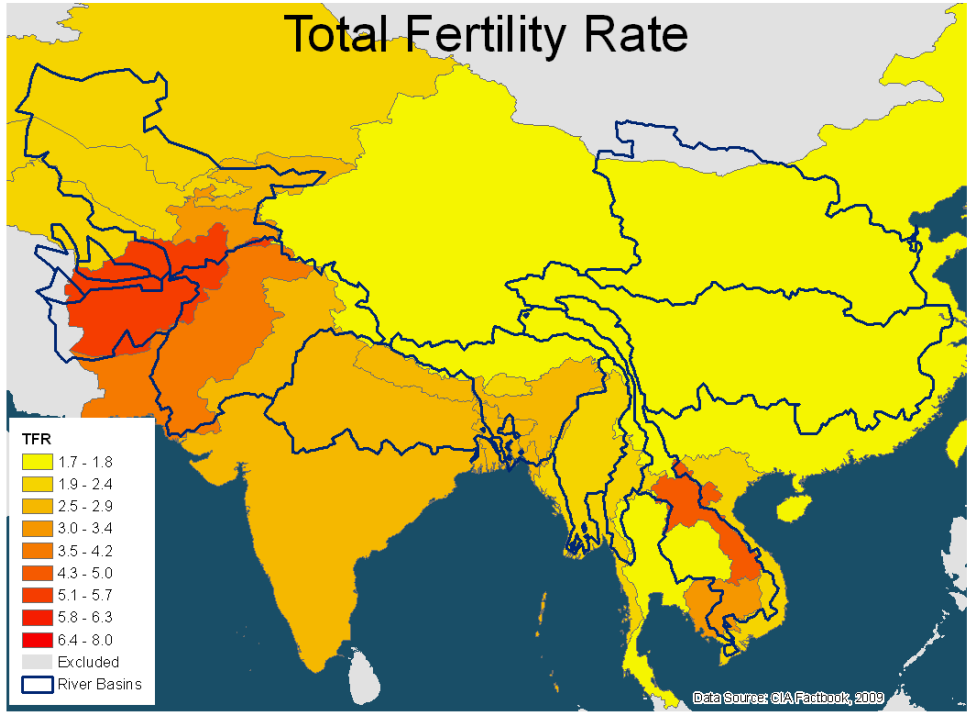

Sagarmatha Settlements
Quomolangma
Nature Preserve
Sagarmatha National Park
Legend
Settlement
River
Glacier
Snow
Glacial Lake
Data Source: ICIMOD (http://geoportal.icimod.org). Downloaded A

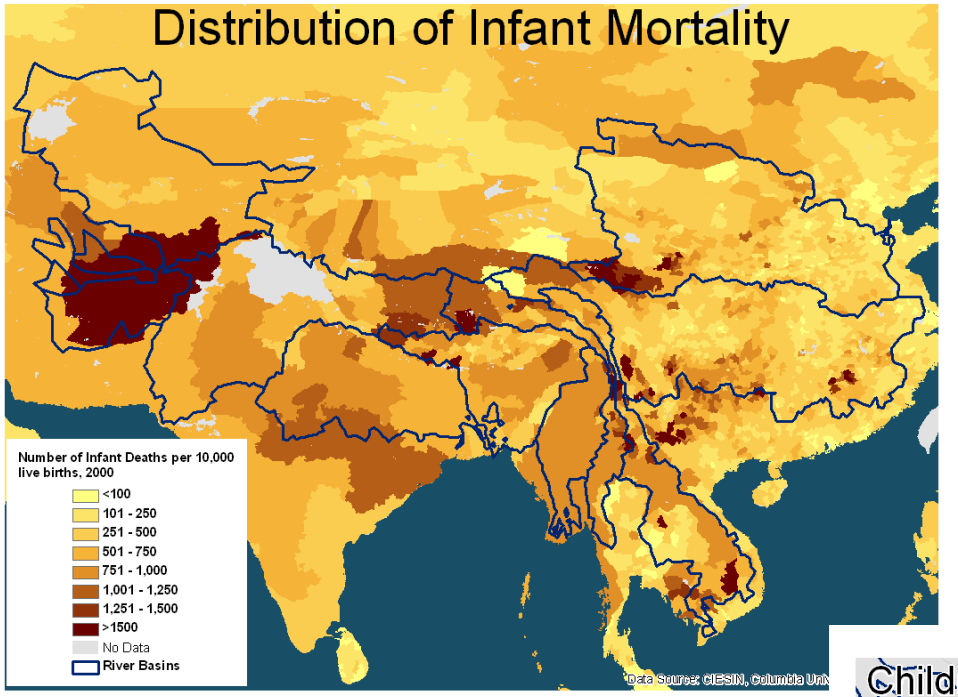

Afghanistan
Central Karakoram Settlements
Central Karakoram
National Park
China
Pakistan
Siachen
Area
India
Legend
Settlement
Glacier below 5 km elevation
Glacier above 5 km elevation
Snow
River
Data Source: ICIMOD (http://geoportal.icimod.org). Downloaded April 2010.

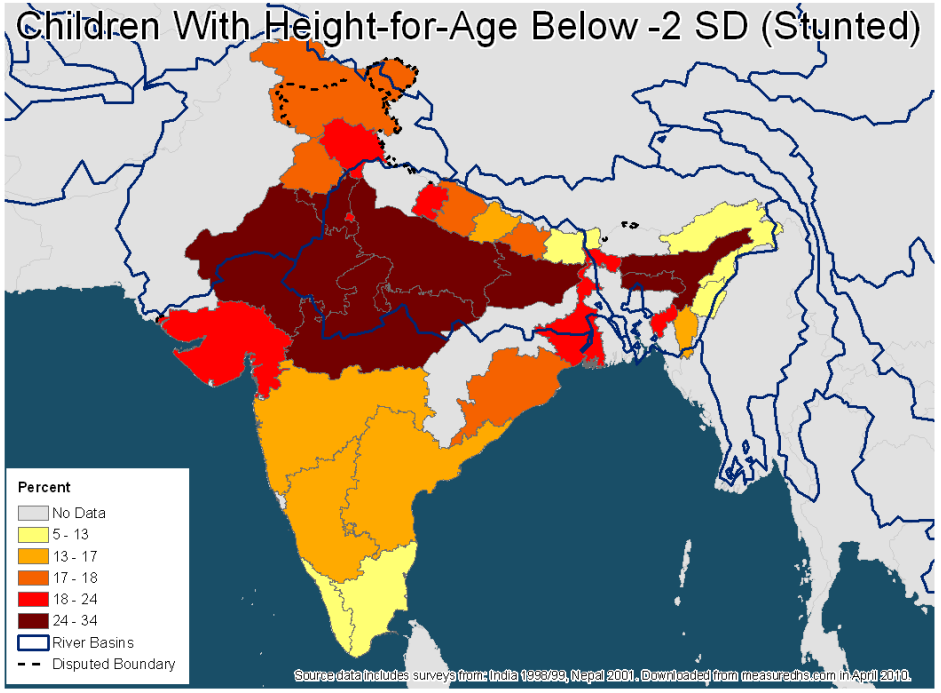

2000 Total Population
Total Population
961070
0
River Basins
Data Source: CIESI


2005 Total Cropland
Total Cropland (Km2)
within .5x.5 degree grid cell
82
50
0
River Basins
Data Source: HYDE Netherlands Environmental Assessment Agency (2005)

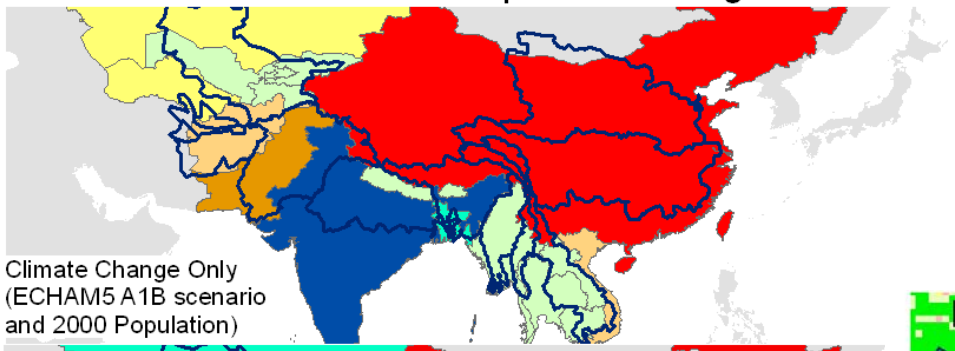

Distribution of Hunger
Percent of children age 0-5 underweight, 2000
<10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
>50
No Data
River Basins
Data Source: CIESIN


Total Fertility Rate
TFR
1.7 - 1.8
1.9 - 2.4
2.5 - 2.9
3.0 - 3.4
3.5 - 4.2
4.3 - 5.0
5.1 - 5.7
5.8 - 6.3
6.4 - 8.0
Excluded
River Basins
Data Source: CIA Factbook, 2009

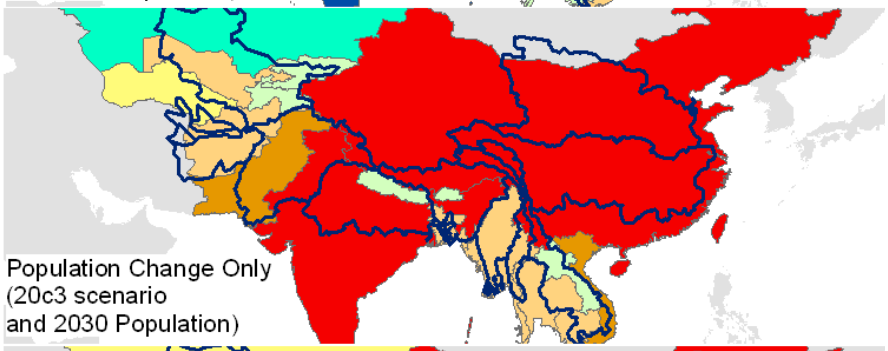

Distribution of Infant Mortality
Number of Infant Deaths per 10,000 live births, 2000
<100
101 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,500
>1500
No Data
River Basins
Data Source: CIESIN, Columbia Uni


Children With Height-for-Age Below -2 SD (Stunted)
Percent
No Data
5 - 13
13 - 17
17 - 18
18 - 24
24 - 34
River Basins
Disputed Boundary
Source data includes surveys from: India 1998/99, Nepal 2001. Downloaded from measuredhs.com in April 2010.

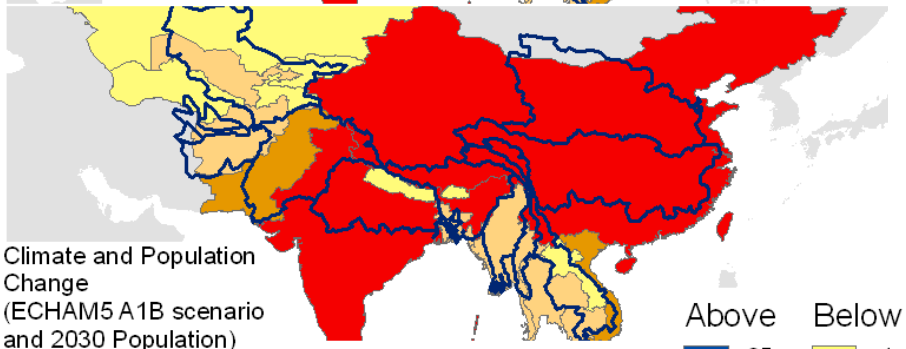
Future Population Thrust Above/Below 1000 m3/person Threshold for Climate and Population Change Scenario



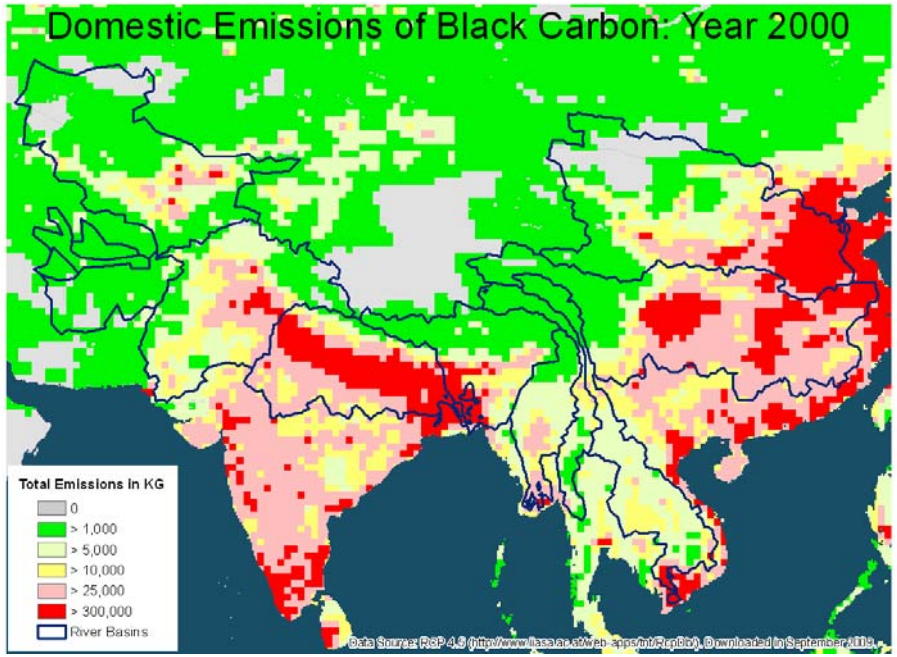
Climate Change Only
(ECHAM5 A1B scenario
and 2000 Population)



Population Change Only
(20c3 scenario
and 2030 Population)



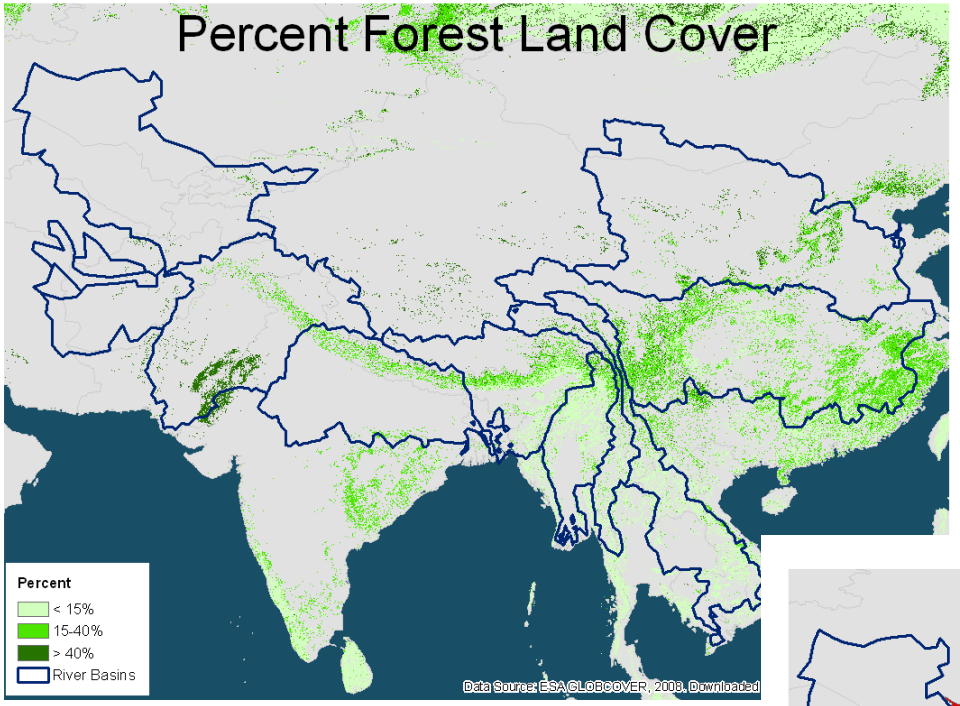
Climate and Population
Change
(ECHAM5 A1B scenario
and 2030 Population)

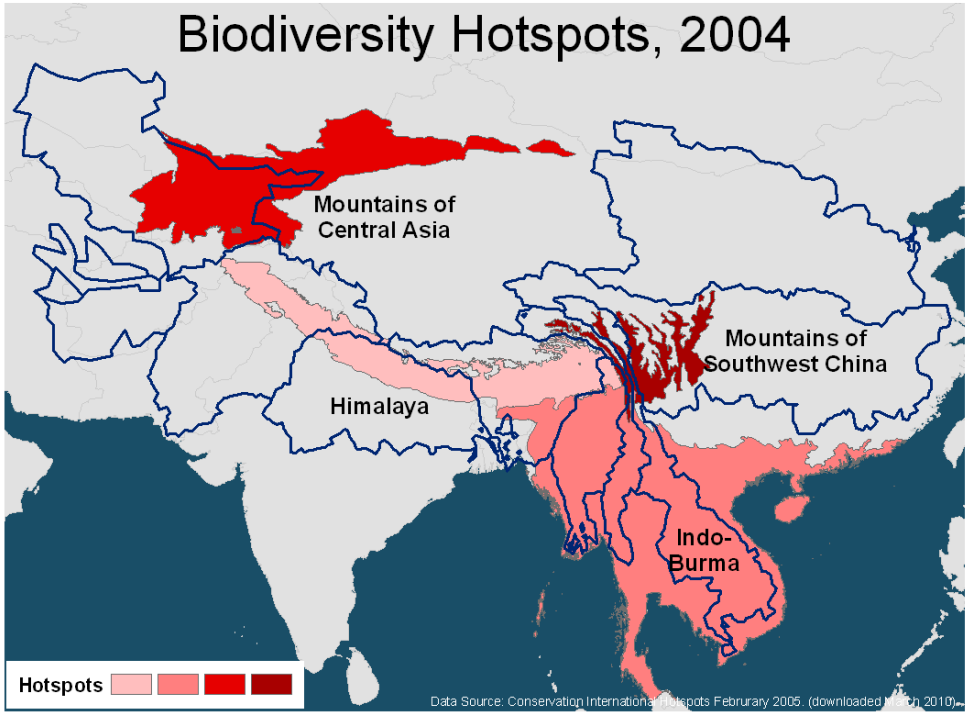


Above		Below	
	>25		< 1
	10 - 25		1 - 10
	1 - 10		10 - 25
	< 1		> 25

2030 Population (millions) thrust below (yellow/red) and above (blue/green) water stress threshold of 1000m3/person for population and climate change scenarios

Data Source: Assessment of Climate Change Impacts on Select U.S. Security Interests, CIESIN, 2007


Percent Forest Land Cover
Percent
< 15%
15-40%
> 40%
River Basins
Data Source: ESA GLOBCOVER, 2008, Downloaded


Biodiversity Hotspots, 2004
Mountains of Central Asia
Mountains of Southwest China
Himalaya
Indo-Burma
Hotspots
Data Source: Conservation International Hotspots Februrary 2005. (downloaded March 2010)

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Challenges

- Developing cross-sectoral approaches to complex problems
- Requiring co-benefits (approaches that are beneficial across sectors)
- Accounting for the diversity (climate, other environment, settlements, land use, etc.) in a vast region with many people
- Analyzing country differences and international relations
- Attributing any one cause (e.g., glacier melt/retreat) to impacts:
  - Changes in glacier melt are part of a complex hydrologic system.
  - Other existing conditions (pollution, inefficient irrigation, dams and other structures, land use, etc.) confound the analysis.
  - Social and economic changes (e.g., improved public health) may more than compensate for changed conditions for disease (e.g., increased disease vectors).
- Acting in the absence of enough information – the need for “no regrets” strategies.

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Ongoing Activities Related to Glacier Melt: Findings

- Over 80 governments and other organizations/contacts, ranging from agencies to researchers to NGOs
- Themes that emerged from the search:
  - Glacier monitoring (glacier inventories; monitoring glacier retreat/melt)
  - Glacier lake monitoring and glacier lake outburst flood (GLOF) risk
  - Downstream impacts of glacier melt including water management and agricultural issues
  - Black carbon studies and activity
  - Community-based/bottom-up adaptation with vulnerable mountain communities
- Lack of “on the ground” data/information about the people and environments of the region
- Little coordination among a fragmented group of organizations (e.g., China and India)

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Key Take-Aways for Health

- Upstream actions and choices can have a potentially huge effect on downstream communities.
- Communities need to be able to manage their water efficiently and effectively in order to avoid compromising water quantity and quality.
- Upstream programs pointed at water management and health messaging, including WASH, are likely cost-effective because of the numbers of people impacted downstream.
- High population levels and population density exacerbate water stress, poverty, and other human conditions that can increase vulnerability to impacts of glacier melt downstream in heavily populated areas.
- Finding innovative ways to integrate family planning services *and* messages about healthy timing and spacing of pregnancy into adaptation programs will prove to yield co-benefits.

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Addressing Glacier Melt: Three Concepts

Lack of Information and Data

Direct and Indirect Vulnerabilities

Black Carbon

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Three Program Concepts

1. Responding to the challenge of a lack of information
   - Focus on improving regional scientific cooperation on glaciers, snowpack and water resources in High Asia
   - Focus on strengthening monitoring capacity for climate and water resources in High Asia
2. Responding to direct and indirect vulnerabilities
   - Focus on improving the management of water resources
   - Focus on ecosystems
   - Focus on high-mountain communities
3. Responding by mitigation
   - Focus on reducing emissions of black carbon and other aerosols

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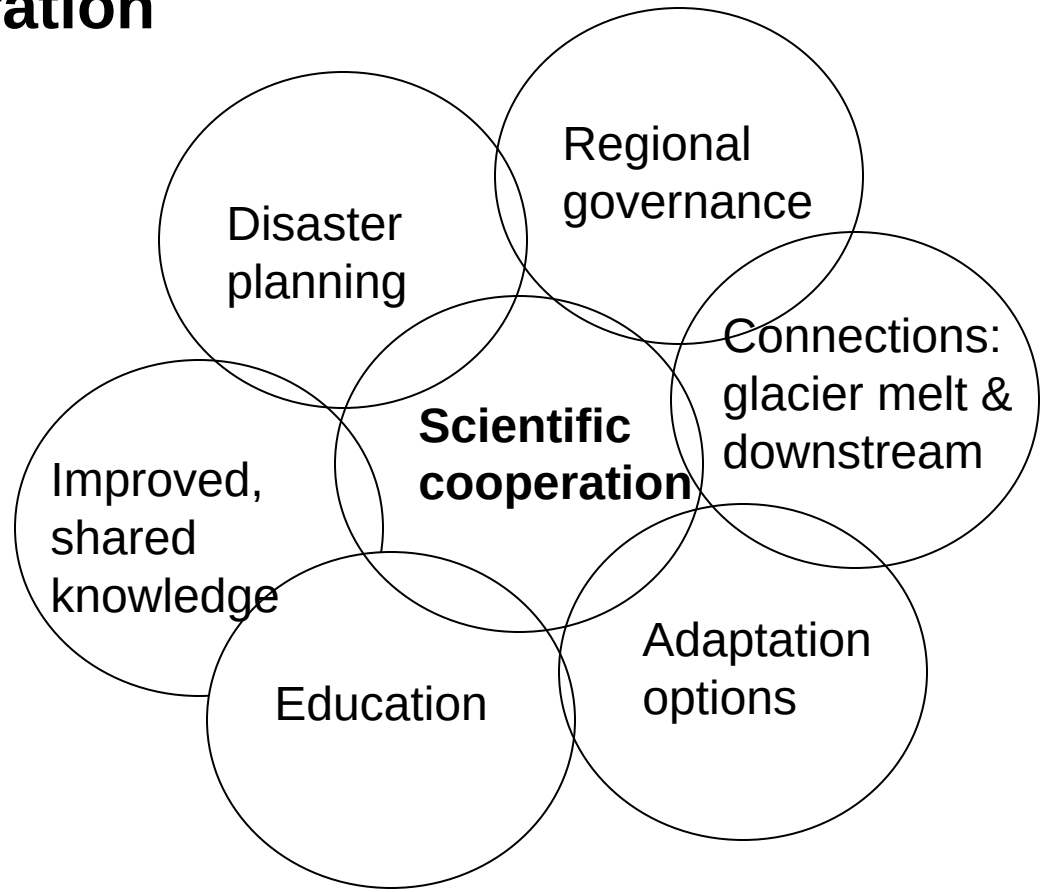
Focus on Improving Regional Scientific Cooperation

- Connections among excess glacier melt, snowpack changes, rain/monsoons, and water resource issues
- Partnerships with ICIMOD and other research organizations
- Data and technology sharing (e.g., GIS methods, satellite retrieval algorithms, climate and hydrology models)
- Coordinated in-situ research and measurement
- Involvement by and support for in-country scientists.

Objective: Improve scientific knowledge base re glaciers and climate change impacts

Co-Benefits: Integration Around Scientific Cooperation



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Focus on Strengthening Monitoring Capacity for Climate and Water Resources

Objective: Support development of a regional meteorological and hydro-logic monitoring network

- Across sectors, the lack of knowledge about glacier/hydrology changes and potential impacts on water supply & timing, poverty, food security, health, and potential disasters
- Regional meteorological and hydrologic monitoring network with spatial coverage adequate to characterize the region and provide data for models
- Monitoring of glacier mass balances, seasonal snow cover, black carbon on snow and ice surfaces, and the potential for glacier lake outburst floods
- Identifying of impacts and severity, monitoring of demographic patterns of water use.

Co-benefits: improved regional cooperation, use of students to build research capability, increased awareness of water issues and climate change, strengthened food security.

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Focus on Improving the Management of Water Resources

- Across sectors and at national, regional, and local levels, the long-term impact spans agriculture, health, family planning, empowerment of women, and governance

Objective: Build downstream resilience to future changes in high-altitude hydrology

- Improved water efficiency for agriculture, by far the largest water user
  - National-level policies to establish water rights and clear lines of authority (including community organizations)
  - Establish or strengthen Water User Associations (WUAs)
  - Provide centers for on-farm water-efficient crop production
- Reproductive health and family planning services
- WASH interventions directly linked to water management
- Improved forest-water management.

Current: Already-vulnerable people need to prepare for greater water stresses

Cross-Sectoral

-water

-agriculture

-forestry

-ecosystems/biodiversity

-health, including reproductive health and family planning (RH/FP)

-governance, including female participation

-economy, including industries

Focus on Management of Water Resources

-develop national policy

-increase capacity of regional institutions

-establish/strengthen WUAs, on-farm & forestry practices

-implement WASH interventions

-provide RH/FP services

Future: More-resilient people better able to adapt to changes in water supply

Co-Benefits

-integrated country-regional-local water basin management

-water-efficient crop production

-improved forest/ecosystem management

-better health, sanitation; smaller families

-strengthened governance & adaptive capacity

-higher economic returns to livelihoods

The Benefits of the Cross-Sectoral Approach → Co-Benefits

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Focus on Ecosystems

Objective: Healthier ecosystems, healthier people

- Across sectors and at national-regional-local levels, the causes of ill health may reside in degraded ecosystems (water scarcity, pollution, increased disease vectors, decreased productivity) – upstream and locally
- Addressing the web of ecological factors affecting human health
- Landscape (watersheds, forests, rangeland, etc.) conservation and management to lessen pollution, preserve predator-prey relationships, preserve plants that contribute to food security
- Ecosystem management to improve understanding of environmental-social interactions, manage vectors and habitats, and develop/maintain clean water sources and sanitation.

Co-benefits: enhanced water quality and green/blue water ratio, forest/rangeland regeneration, enhanced food security, disease prevention/reduced medical needs, increased labor productivity.

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Focus on high-altitude communities

Objective: Strengthen high-altitude, at-risk communities

- Across sectors, tailored to community needs, integrated through links with existing community organizations and groups
- For high-altitude communities, condition of glaciers (dangerous glacier lakes or small glaciers below ~5300 m) prompting disaster management planning
- Health, including surveillance for water quality/quantity problems, promotion of improved cook stoves
- Education, including informal literacy training for women and girls; information on reproductive health/family planning, water conservation, glacier risks and coping strategies
- Household and community water use/resource development, including efficient irrigation systems and improved drainage systems.

Co-benefits: preparation for potential disasters, improved health and family planning, literacy and awareness of environmental benefits and risks, and sustainable water use →higher coping & adaptive capacity.

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Focus on Reducing Emissions of Black Carbon and Other Aerosols

Objective: Reduce emissions, improve health

- Across sectors, climate change mitigation, and adaptation, health (respiratory illnesses), and air pollution
- Reduction of black carbon emissions from cook stoves, poor street design, industrial sources, fires
- Promotion of alternative fuels (biogas, solar lamps) and cook stoves
- Weather stations in schools to provide feedback on air pollution measurement via radio station reports

Co-benefits: improved resilience to changes in water supply and timing, integrated approach to household water use, hygiene and nutrition; food security based on sustainable water use, education, monitoring of air pollution.

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Conclusions

- Glacier melt is part of larger hydrologic and climate systems, so effective programs will be cross-sectoral and yield co-benefits.
- For this long-term issue, extending program timelines and explicitly coordinating cross-boundary projects should be considered.
- A crucial role USAID can plan is to link partners in the government and private sectors (including NGOs) to build capacity.
- USAID can spark synergies among new initiatives, such as Feed the Future, and vulnerabilities of glacier melt on water supply.
- Partnerships with forest user groups, water user associations, and other local groups will strengthen governance in civil society.
- “South-to-south” exchanges should be promoted (e.g., Peru-Nepal).
- In the midst of changing climate and uncertainties, greater emphasis on collecting indigenous knowledge will be crucial for adaptation.

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On Our Way

- Questions now?

- Questions later:

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Nomads on the Tibetan Plateau. Photo by Dan Miller.