Training Workshop on Climate Change Adaptation in Watersheds for Water, Food and Environmental Security, 15-18 October 2013 at SEARCA, College, Los Baños, Laguna

Understanding Changes in Watersheds due to Non-Climate Stressors: Influences of People, Land Use and Land Cover Change

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Introduction and Objectives

initiatives on **climate change adaptation** for water, food and environmental security in Southeast Asia

It aims to enable participants to:

1) understand the issues and challenges in watershed management in a changing climate in relation to water, food and environmental security;
2) analyze gaps toward sustainable watersheds in a changing climate for water, food, and environmental security; and
3) draw up an agenda for action towards sustainable watersheds for water, food and environmental security in a changing climate within their work contexts, be it in research, teaching, action programs and practices, and policies.

Management of watersheds and protection of water resources play a very important role for the attainment of water, food and environmental security

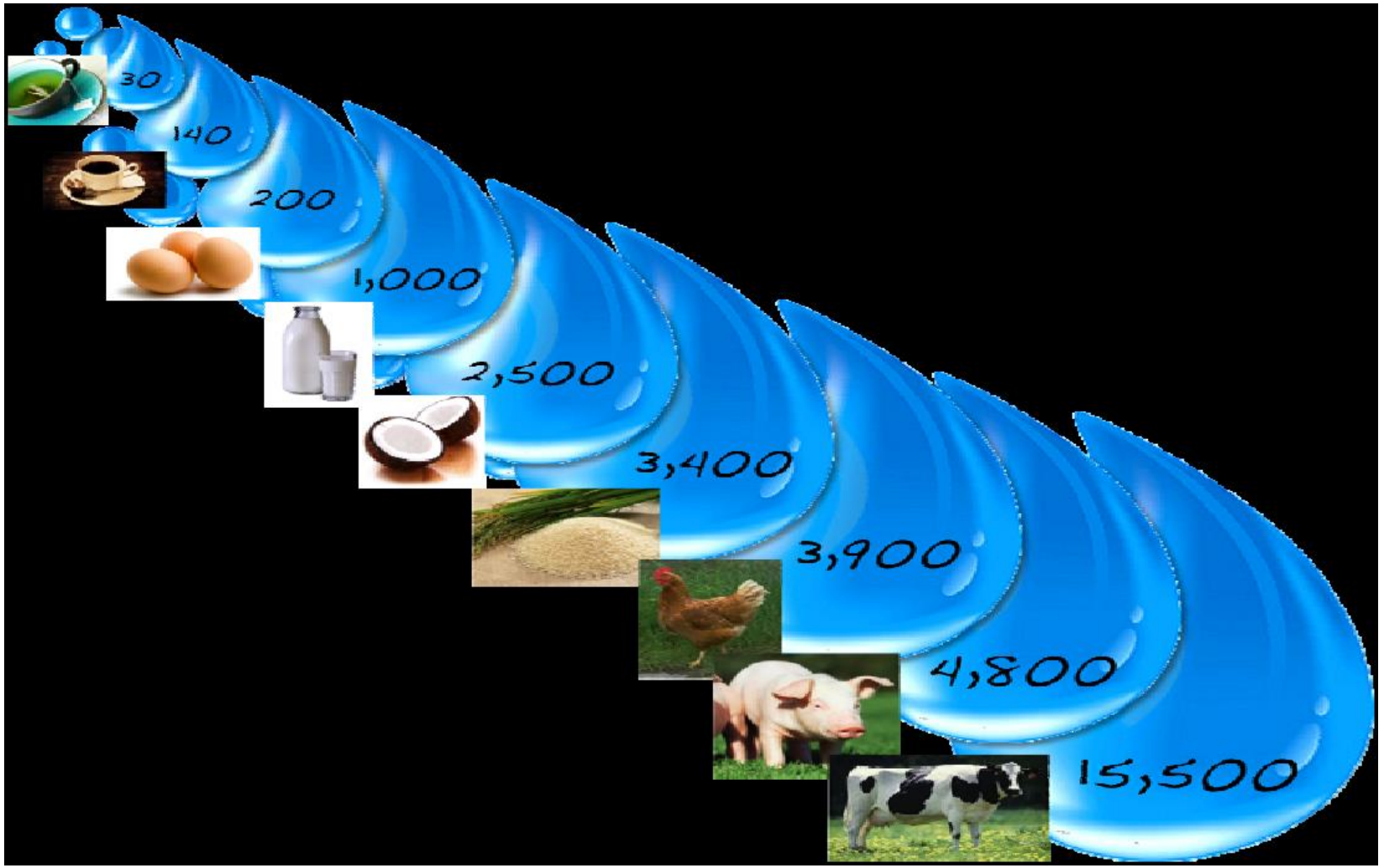
INTRODUCTION

- Country rich in water and environmental resources does not guarantee free from water, food and environmental securities due to excessive human pressures and interventions
- There is strong indication of relationship between land degradation and poverty in the form of vicious circle of poverty
- Efforts are being done through national programs to solve this linking the sustainable watershed management and community livelihoods

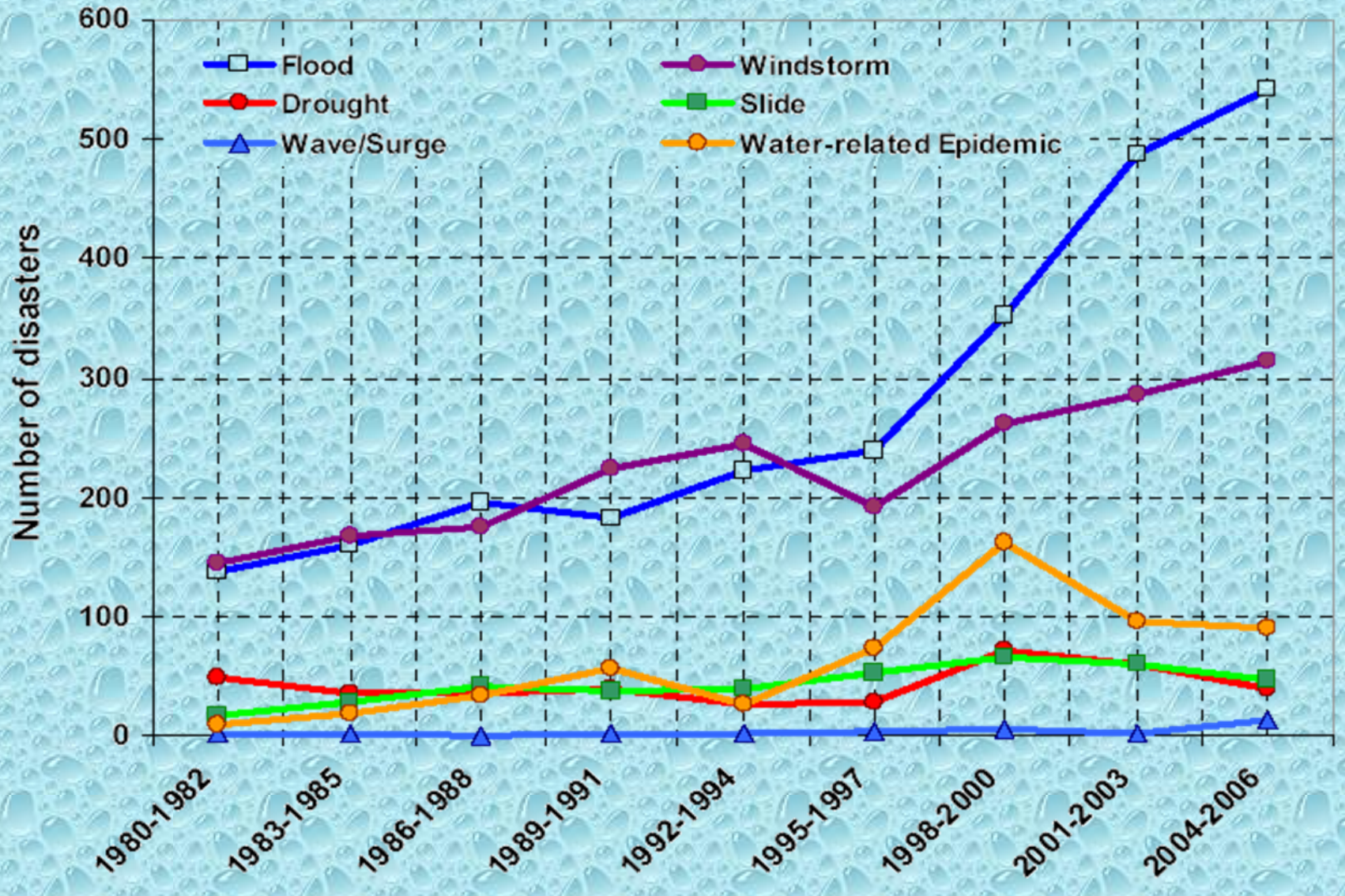
IPCC Report Calls Climate Changes Unprecedented
Randy Showstack (Eos, Oct.08, 2013)

Warming of the Earth's climate “is unequivocal and since the 1950s many of the observed changes are unprecedented over decades to millennia,” according to a new assessment report by the Intergovernmental Panel on Climate Change (IPCC). The 27 September summary for policy makers of IPCC's report “Climate Change 2013: The Physical Science Basis” also states that “**it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century**.”

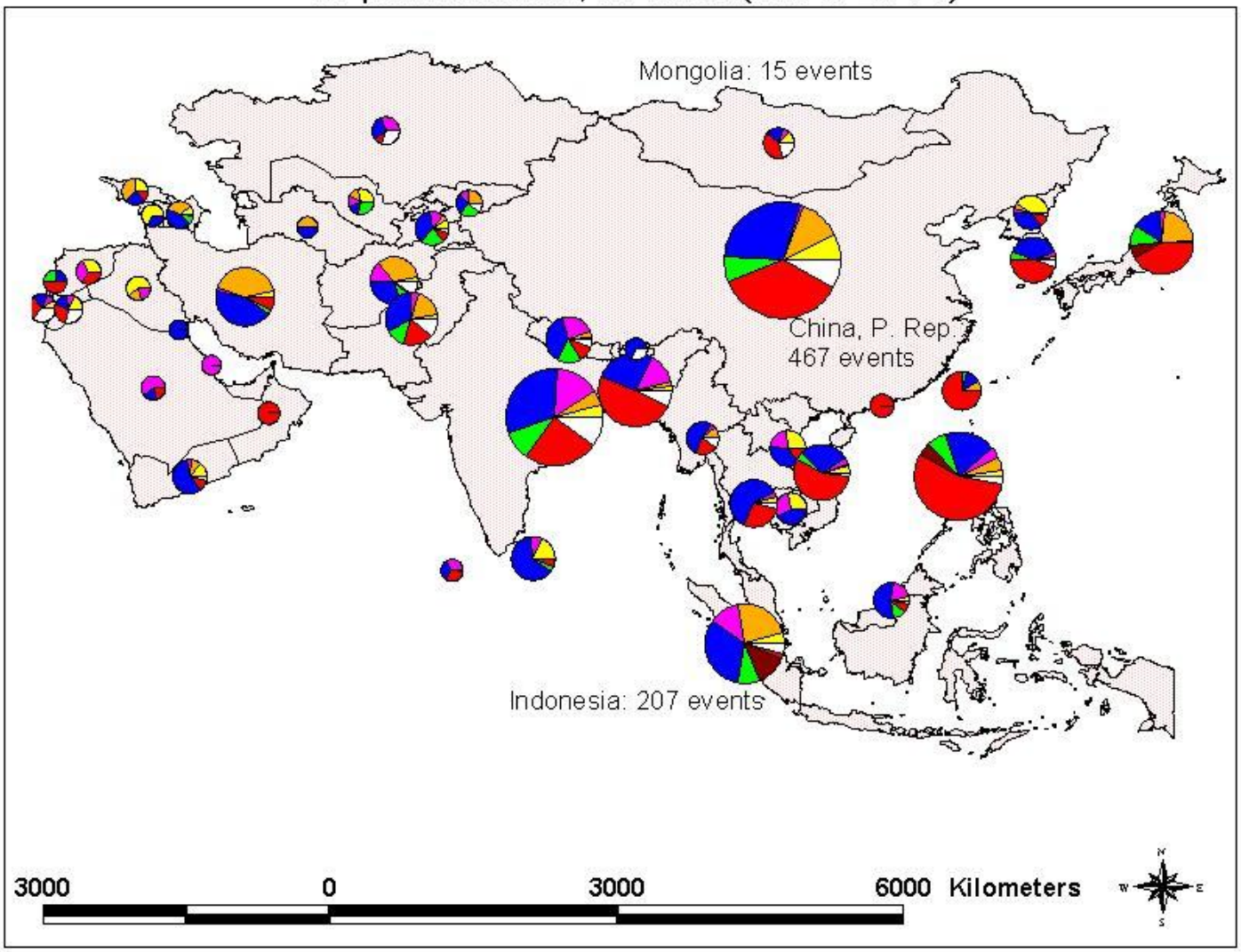
Global Water demand: ave. water footprint of various products



Trends of water related disasters



Distribution of natural disasters, by country and type of phenomena, in Asia (1975-2001)

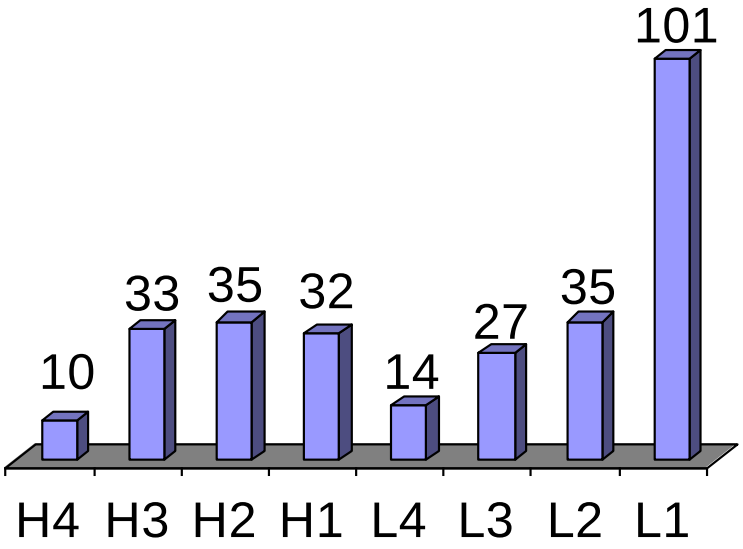


EM-DAT: The OFDA/CRED International Disaster Database
(http://www.cred.be ; email: cred@epid.ucl.ac.be)

Combination of Vulnerability Index and Level of Risk to Hazards

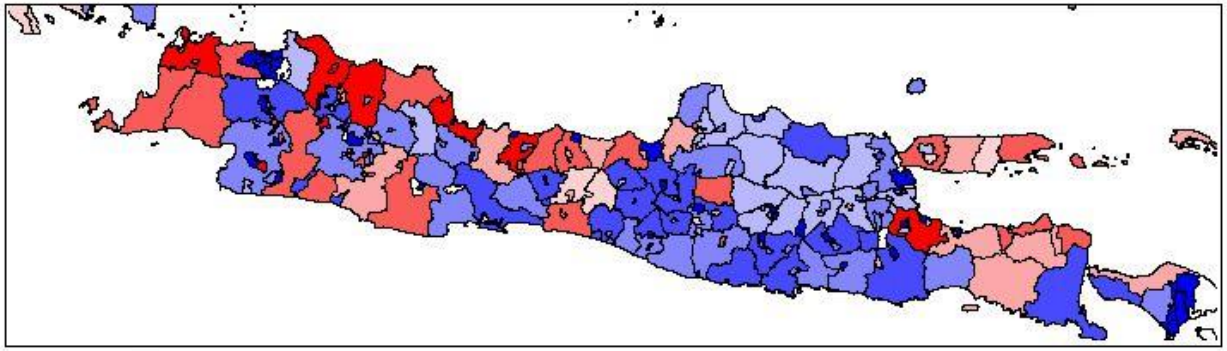
Jenis Bencana:

- Kekeringan
- Banjir
- Deman Berdarah
- Kebakaran Hutan



Legend :

- Less vulnerable and high risk to 1 hazards type
- Less vulnerable and high risk to 2 hazards types
- Less vulnerable and high risk to 3 hazards types
- Less vulnerable and high risk to 4 hazards types
- More vulnerable and high risk to 1 hazards type
- More vulnerable and high risk to 2 hazards types
- More vulnerable and high risk to 3 hazards types
- More vulnerable and high risk to 4 hazards types
- no data



Developed by Rizaldi Boer, Adi Rakhman, Kiki Kartikasari and Fitriyani
Data taken from www.data statistik_Indonesia.com, Murdiyarso et.al (2004) and Directorate of Plant Protection
Labarotory of Climatology, Departement of Geophysics and Meteorologi
Bogor Agricultural University
2007

Climates, Landscapes, and Civilizations Colin Schultz (2013)

Humans are now the dominant driver of global climate change. From ocean acidification to sea level rise, changes in precipitation patterns, and rising temperatures, global warming is presenting us with an uncertain future. However, this is not the first time human civilizations have faced a changing world. In the AGU monograph Climates, Landscapes, and Civilizations, editors Liviu Giosan, Dorian Q. Fuller, Kathleen Nicoll, Rowan K. Flad, and Peter C. Clift **explore how some ancient peoples weathered the shifting storms while some faded away**. In this interview, Eos speaks with Liviu Giosan about the decay of civilizations, ancient adaptation, and the surprisingly long history of humanity's effect on the Earth

Parts of Amazon on the verge of forest-to-grassland shift
Colin Schultz (2013)

The stability of the Amazon rainforest and the ecosystem's resilience to widespread deforestation may be much lower than previously thought. The **replacement of stands of trees with grassland changes evapotranspiration rates and atmospheric moisture convergence, which, in turn, reduce regional rainfall.** This feedback effect could drive further deforestation. Previous research indicated that a dramatic shift from forest to grassland could overtake the Amazon when the total deforested area hits 40% to 50% of the forest's current size. New research by Pires and Costa, however, found that the deforestation needed to trigger this equilibrium shift is much lower, closer to just 10%.

ISSUES AND CHALLENGES IN WATERSHED MANAGEMENT: Impacts on Water, food, and environmental security

Anthropogenic influences

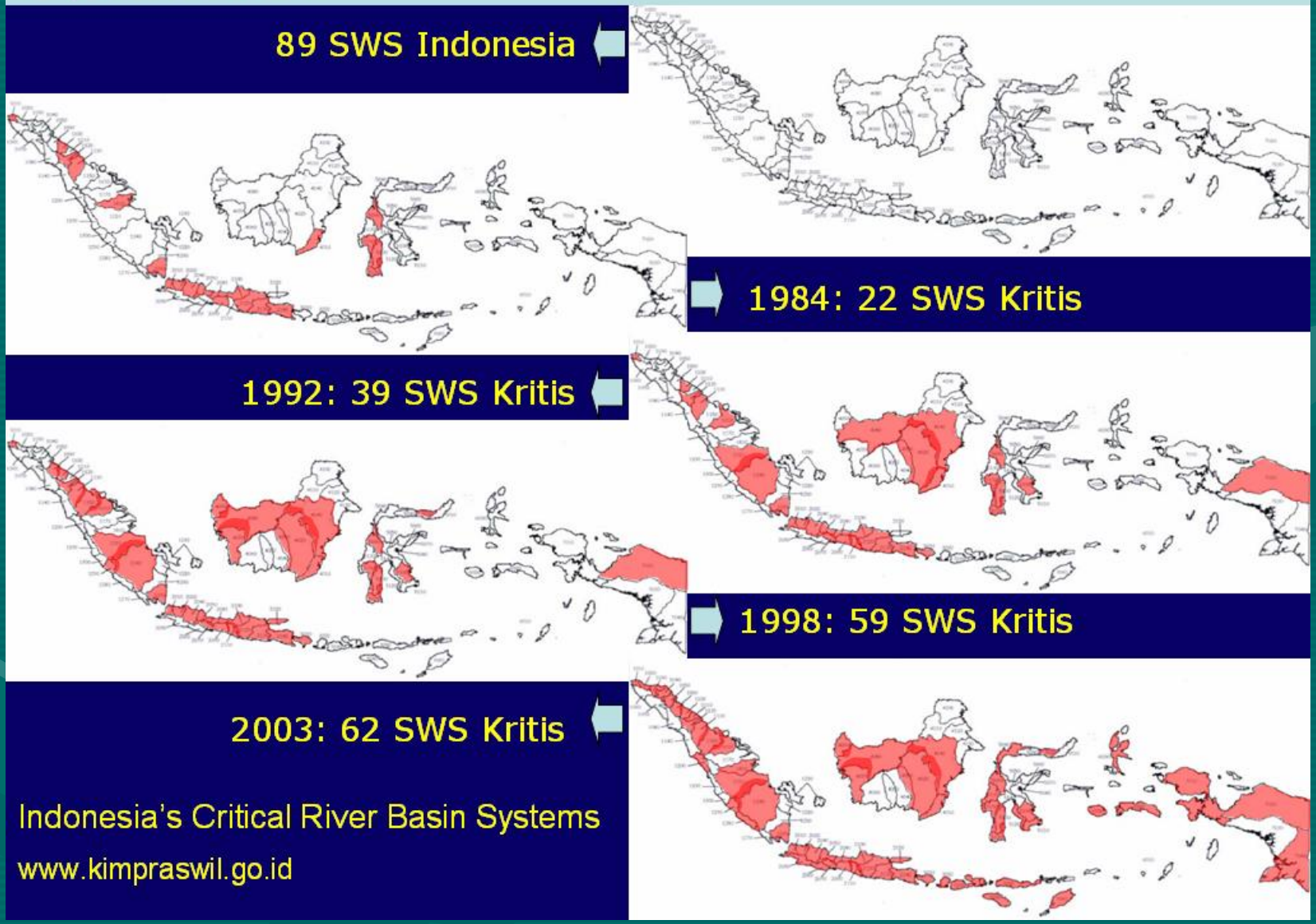
- ***From four million to forty million people in Java and Madura*** was the title of the Boeke report (1941) indicating the population increase from 1800 to 1930, when the first census of conducted in Java and Madura.
- It was reported that since old days, population density in Java had been very diverse, from 9 persons/km^2 to 880 person/km^2 in 1815 with average 35 person/km^2, and this average increased to 330 (1930) and 1000 (2000).
- This increase of population has severely affected the land uses and continuous changes in vegetation covers, with consequences in changes in hydrologic regimes and environmental qualities.

Population development in Greater Jakarta

No.	Year	Population of Greater Jakarta region		Population of DKI Jakarta	
		people	Growth rate (%)	People	Growth rate (%)
1	1971	8.307.492		4.546.492	
2	1980	11.916.227	43.43	6.503.227	43,04
3	1990	17.005.504	42,71	8.259.504	27,01
4	2000	20.963.722	23,27	8.363.722	1,26

Sumber : Studi Master Plan Integrasi Transportasi Jabodetabek , 2001

89 SWS Indonesia



1984: 22 SWS Kritis

1992: 39 SWS Kritis

1998: 59 SWS Kritis

2003: 62 SWS Kritis

Indonesia's Critical River Basin Systems

www.kimpraswil.go.id

Forest Degradation in Indonesia

- ✓ **40% of the forests existing in 1950 were cleared in the following 50 years. Forest cover fell from 162 million ha to 98 million ha.**
- ✓ **The rate of forest loss is accelerating. On average, about 1 million ha per year were cleared in the 1980s, rising to about 1.7 million ha per year in the first part of the 1990s, and down below 1 mil.ha/yr at present condition**
- ✓ **Forests have been almost entirely cleared in Sulawesi and are predicted to disappear in Sumatra by 2005 and Kalimantan by 2010 if current trends continue**

[FWI/GFW. 2002. The State of the Forest: Indonesia. Bogor, Indonesia: Forest Watch Indonesia, and Washington DC: Global Forest Watch].

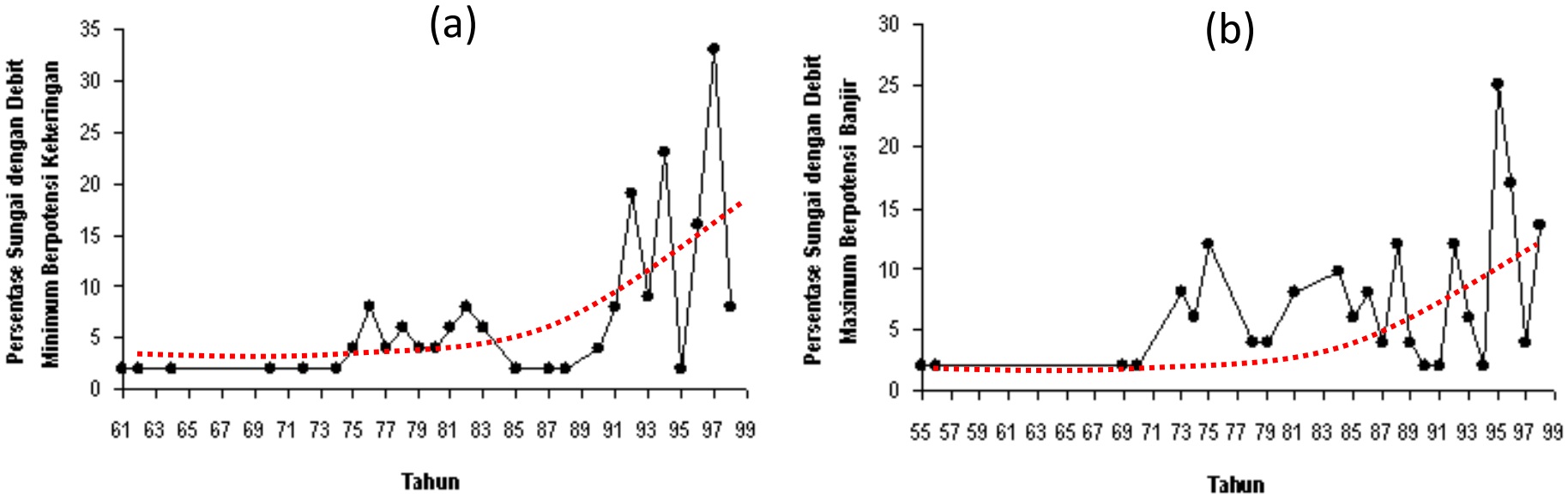
Rate of deforestation in Indonesia 1999 – 2005.

Year	Sumatr	Kalmnt	Sulws	Maluku	Papua	Jawa	Bali NT	Indon
1999-0	363,0	241,2	157,3	36,5	275,0	400,3	235,1	1.708,4
2000-1	259,5	212,0	154,0	20,0	147,2	118,3	107,2	1.018,2
2001-2	202,6	129,7	150,4	41,4	160,5	142,1	99,6	926,3
2002-3	339,0	480,4	385,8	132,4	140,8	343,4	84,3	1.906,1
2003-4	208,7	173,3	41,5	10,6	100,8	71,7	28,1	634,7
2004-5	335,7	234,7	134,6	10,5	169,1	37,3	40,6	962,5
Total	1.708,5	1.471,3	1.023,6	251,4	993,4	1.113,1	594,9	7.156,2

Sumber: Baplan-Dephut (2007)

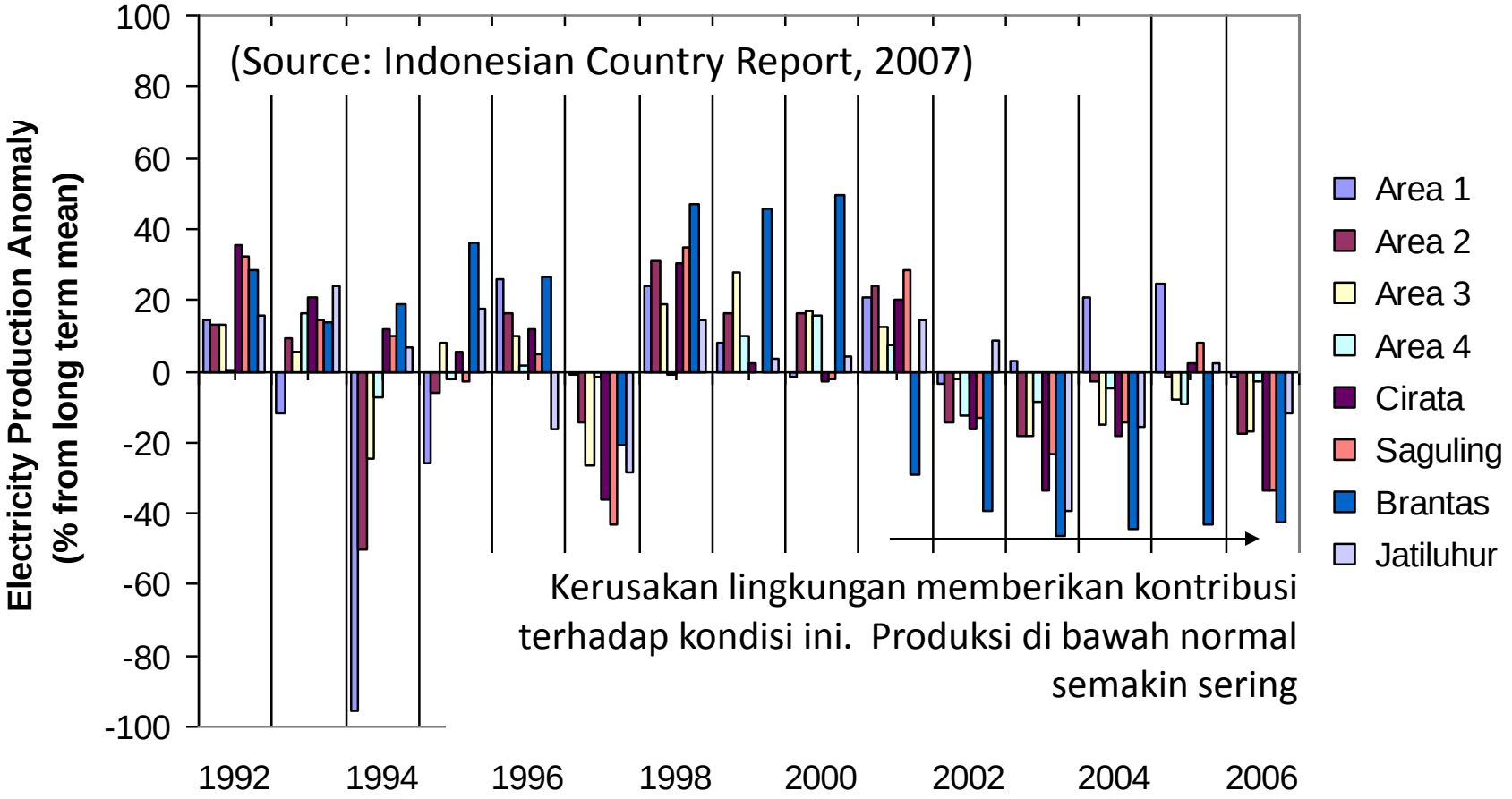

2 20 '98

Discharges of 52 rivers in Indonesia



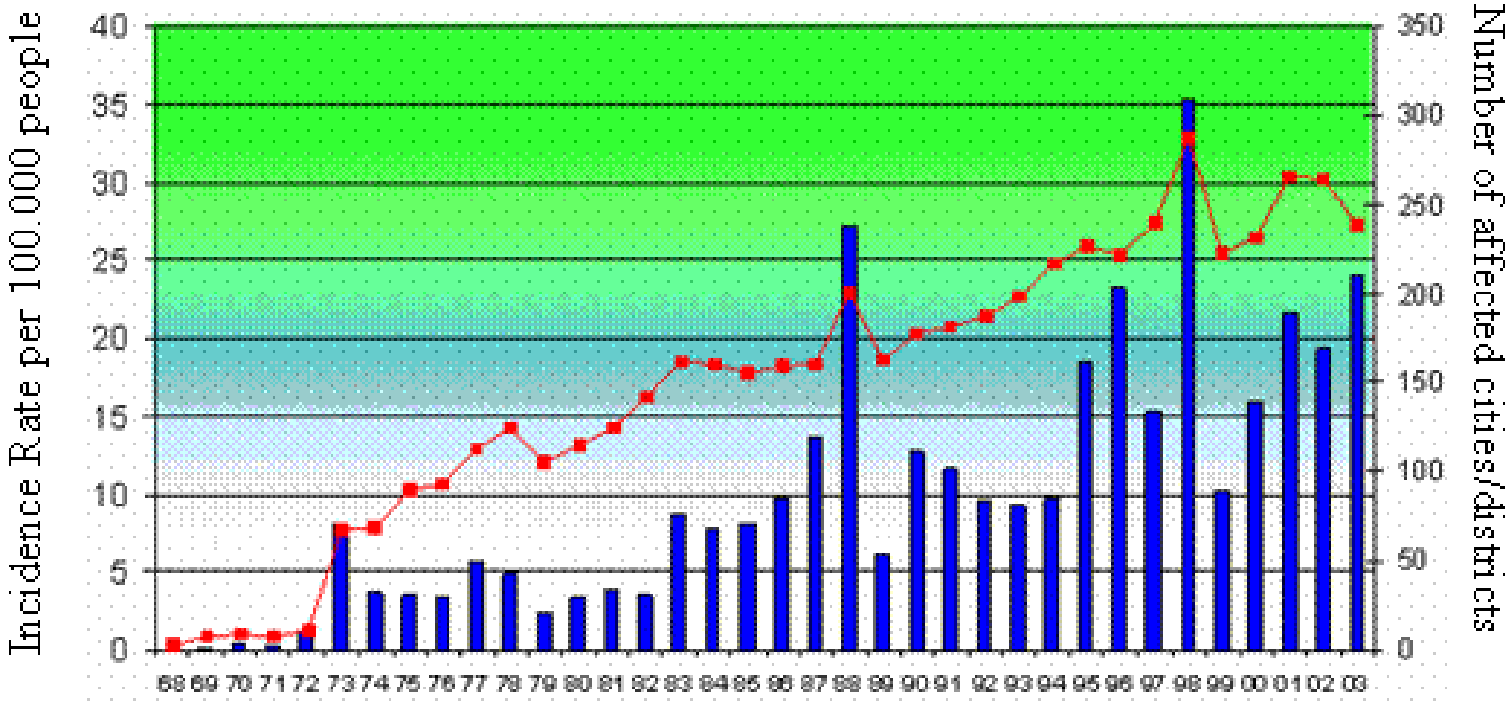
Persentase aliran sungai dengan debit rendah yang berpotensi menimbulkan risiko kekeringan (a) dan dengan debit tinggi yang berpotensi menimbulkan banjir (b) semakin meningkat (analyzed from Loebies, 2001).

Electric power generation



Penelitian Rajab et al. (2007) menunjukkan bahwa produksi listrik Saguling, Cirata, dan Jatiluhur menurun dengan laju 97, 65 dan 50 GWh per tahun (Rajab, 2007). Penurunan produksi semakin besar pada tahun-tahun El-Nino

Dengue haemoragic-fever



Kasus deman berdarah meningkat secara signifikan pada tahun-tahun La-Nina (Sumber: www.tempointeraktif.com)

At the Origin of the Problem

Human Societies → Economic Growth → Energy Consumption → Energy System Is C-based → GHG

Life Style

World Population

Factors/aspects involved:

- Biophysical: natural, ecological systems
- Socio-economic: behavioral, cultural, social systems
- Organizational & institutional: including legal aspects
- Political aspects

INDONESIAN CONTEXT:

- Population growth (annual rate of 1,49%, 2000-2010) reach up the Indonesia population in 2010 to about 236,7 million people

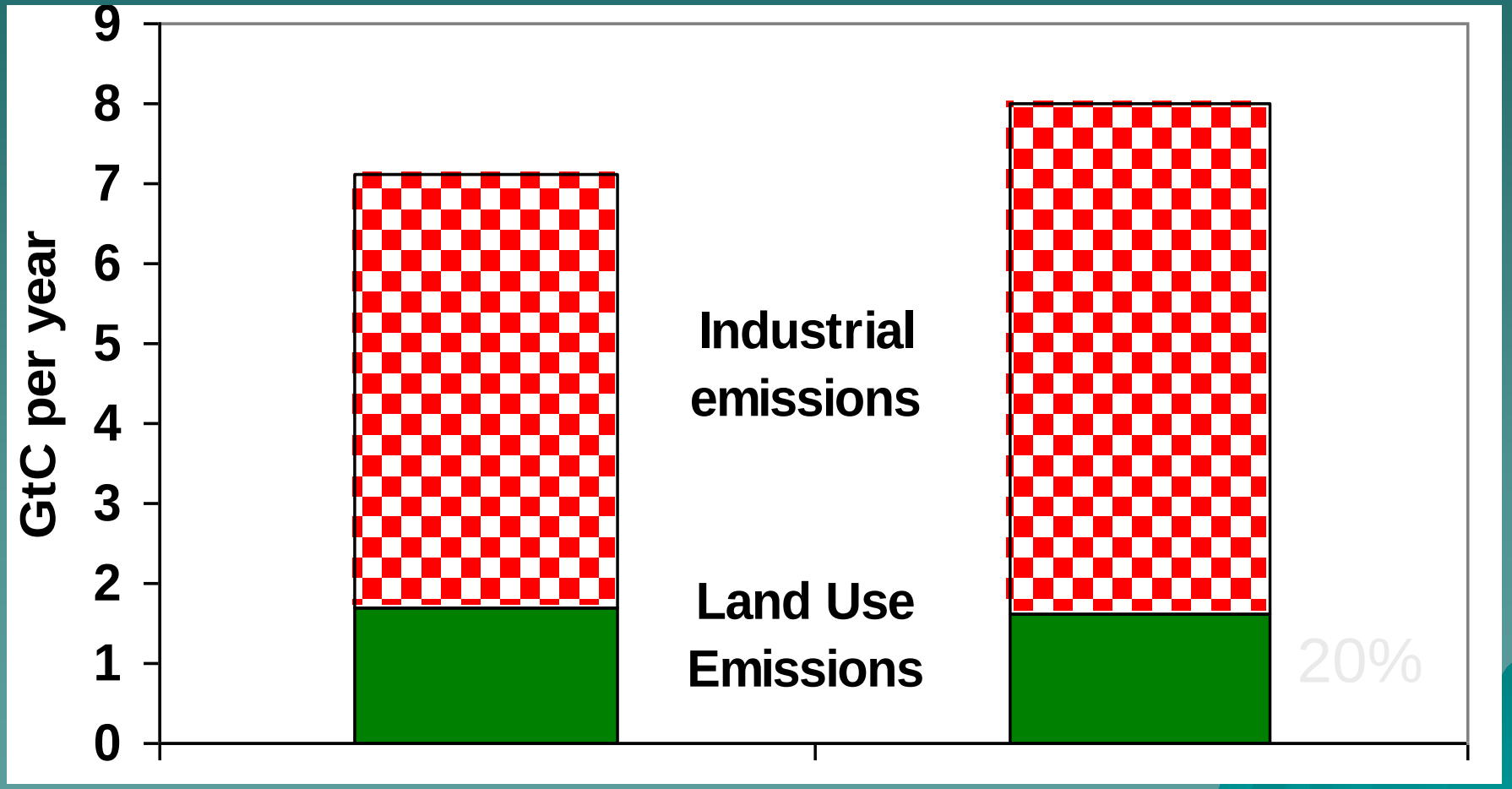
- **Increasing the needs of water.**
- **The increasing needs are ironically followed by the decreasing of water availability especially due to decreasing water quality.**

- These are caused by individuals and in grouped human behaviors and accelerated by the government policies which were actually expected to regulate the individuals and groups behavior to create the appropriate water supply-demand balance, but in facts many cases reversibly toward decreasing water supply.

Causes of Land Use Change

- Population growth
- Land tenure
- Government plans to “integrate” and “develop” forested areas
- Road/canal network throughout the region
- Colonization projects: rush of landless people to small scale, low tech agriculture
- Subsidized cattle ranching
- Destructive logging as a vector to subsequent deforestation
- Expansion of industrial rubber plantations
- ...etc.

17% of the global anthropogenic emissions are from land use change (2000-2006)



Global Carbon Project

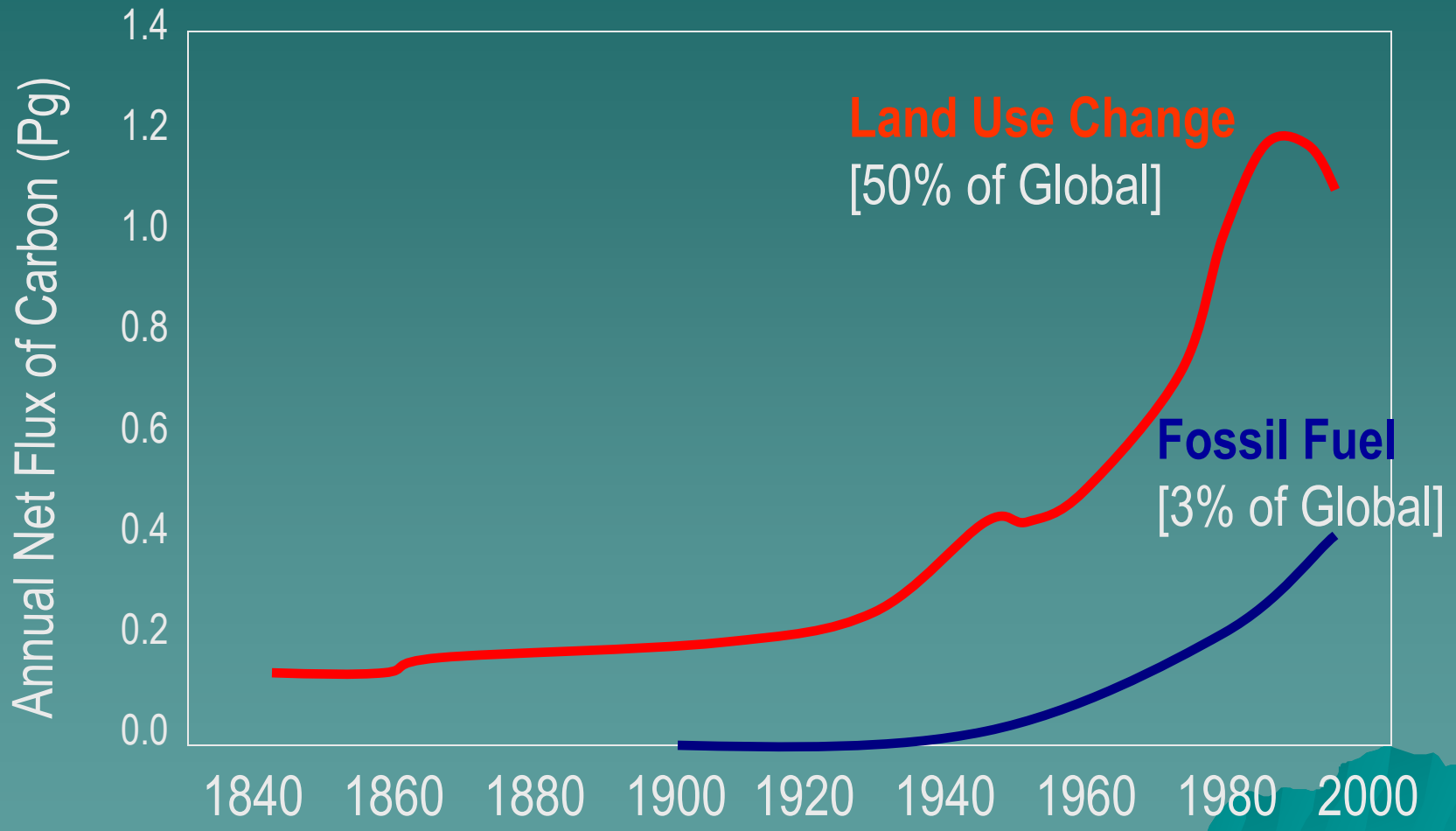
Earth System Science Partnership

GLOBAL CHANGE

IHDP

WCRP

Annual Net C Emissions in South and Southeast Asia (Pg)



Houghton and Hackler 1999

Global Carbon Project

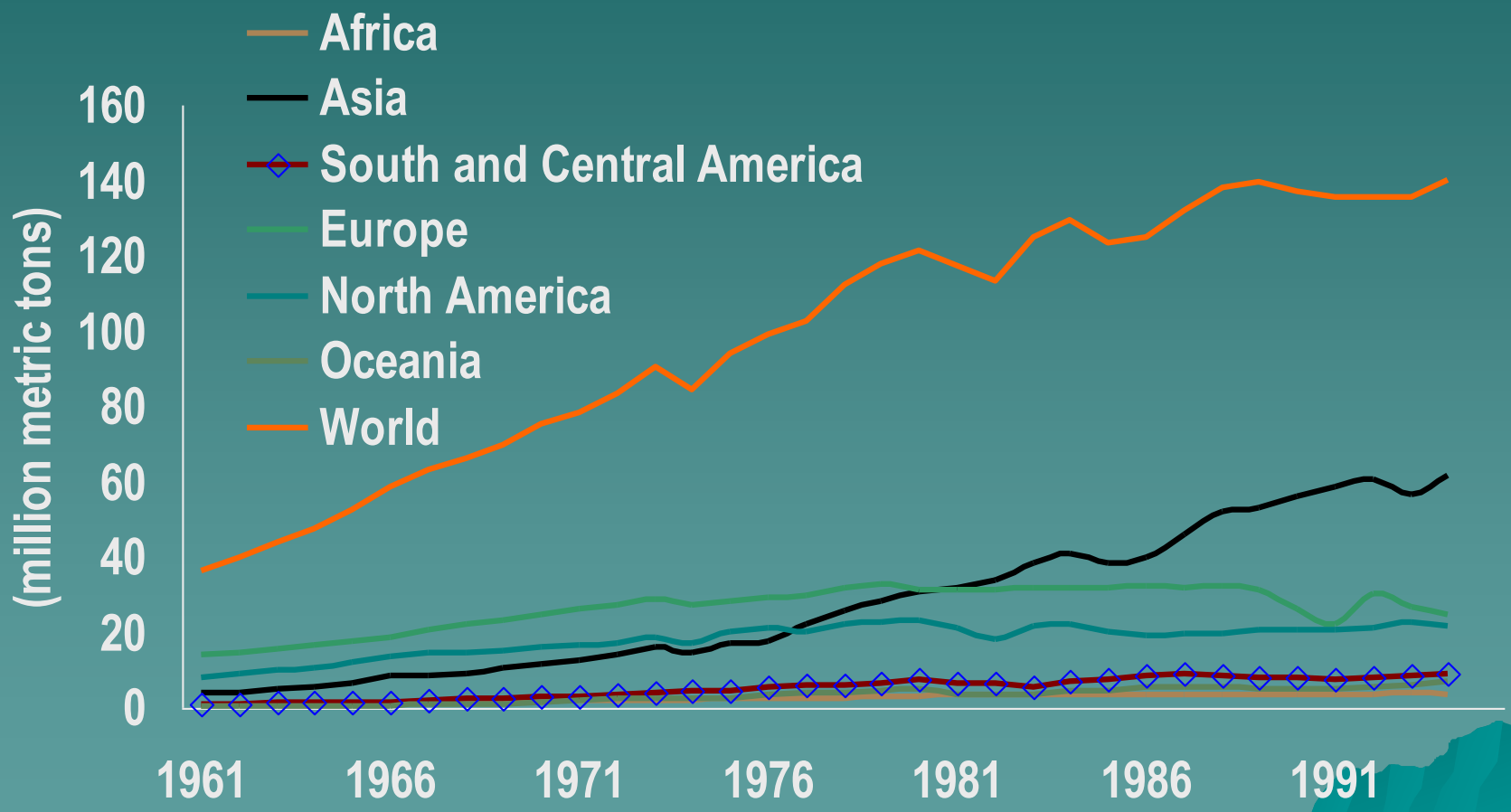
Earth System Science Partnership

GLOBAL CHANGE

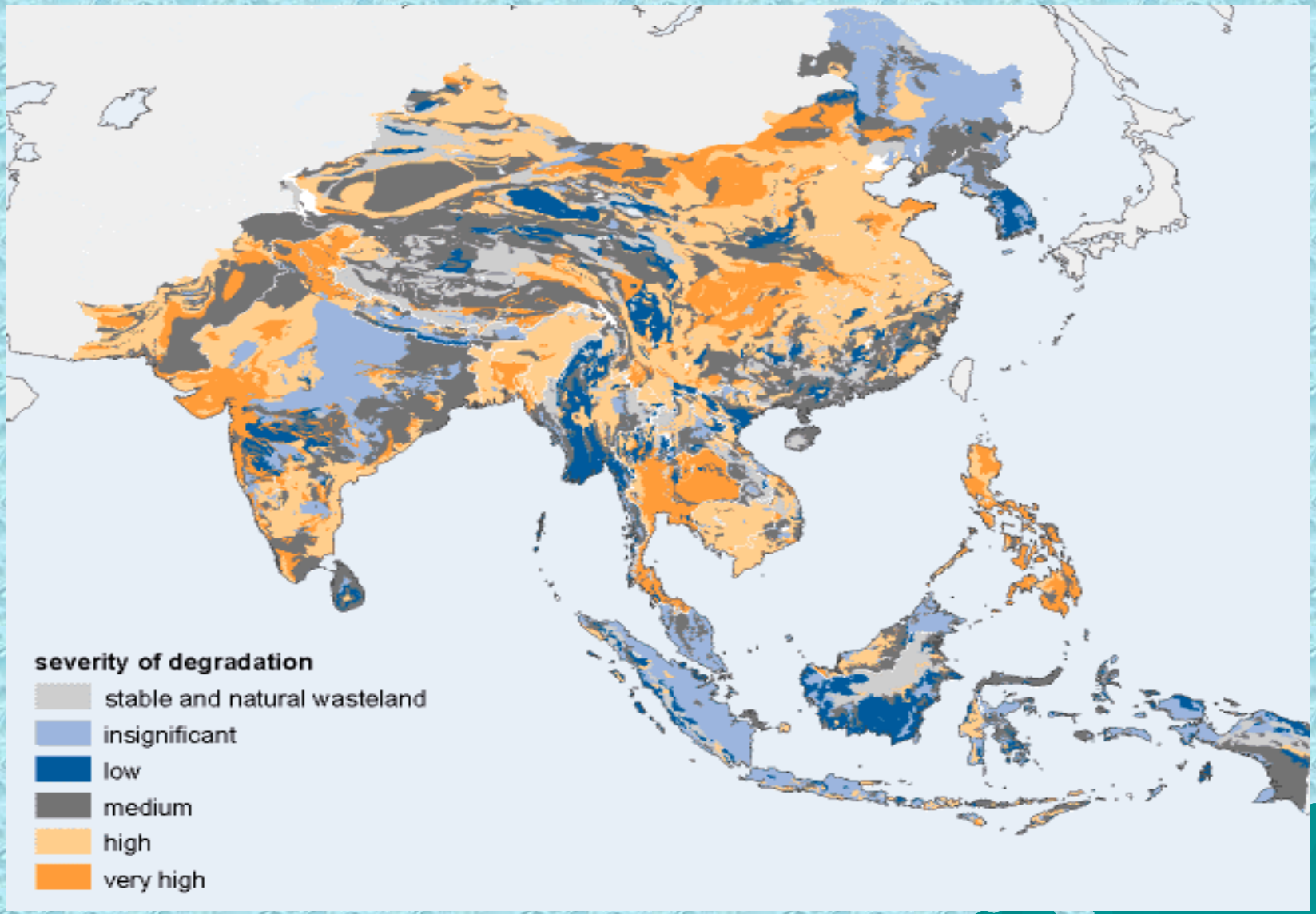
IHDP

WCRP Climate

More fertilizer: (N)
More food, but more pollution too



Severity of soil degradation in South and Southeast Asia



Source: ISRIC/UNEP/FAO 1997

Effects of built up areas

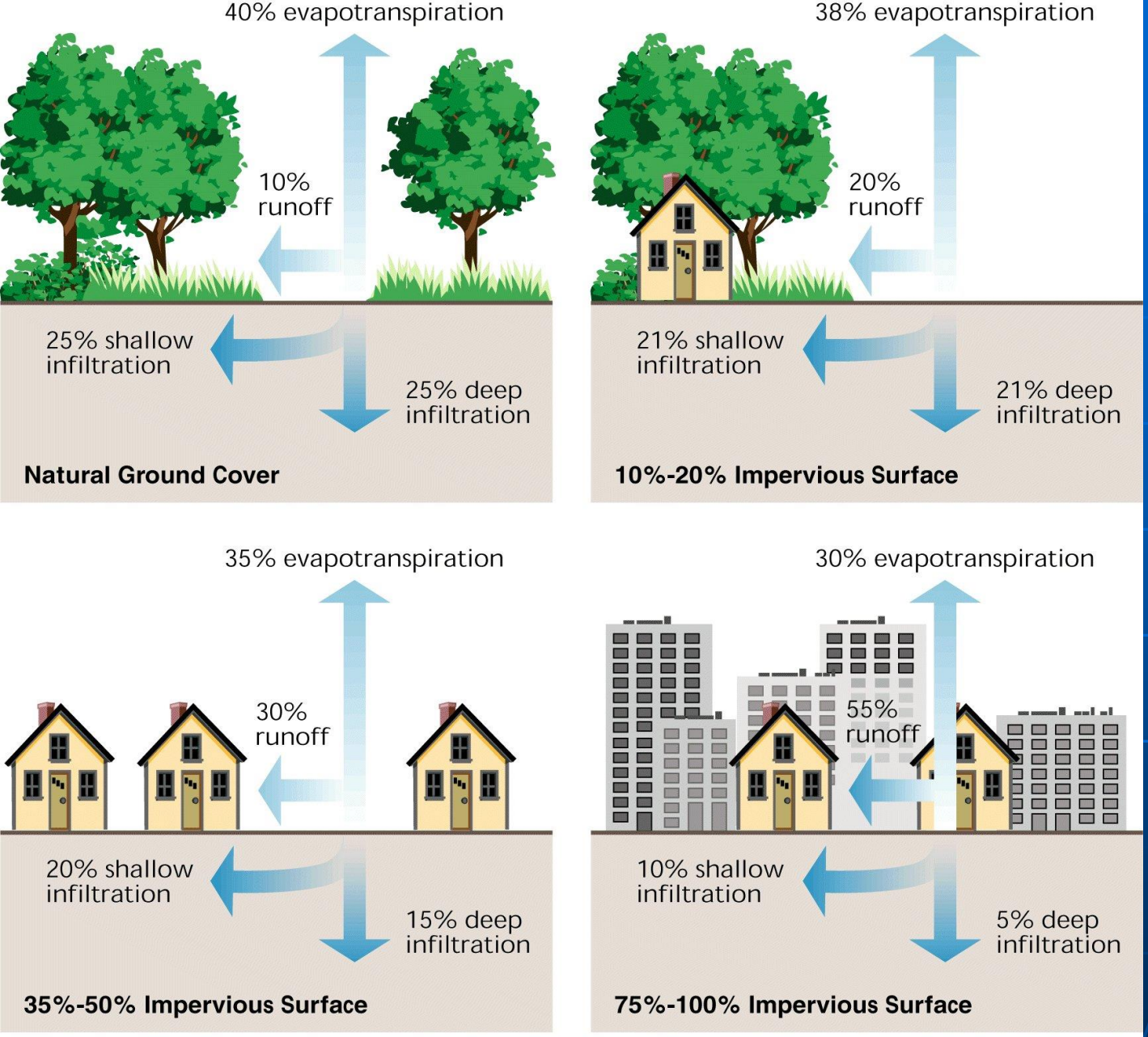


Fig. 3.21 -- Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
By the Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the U.S.)

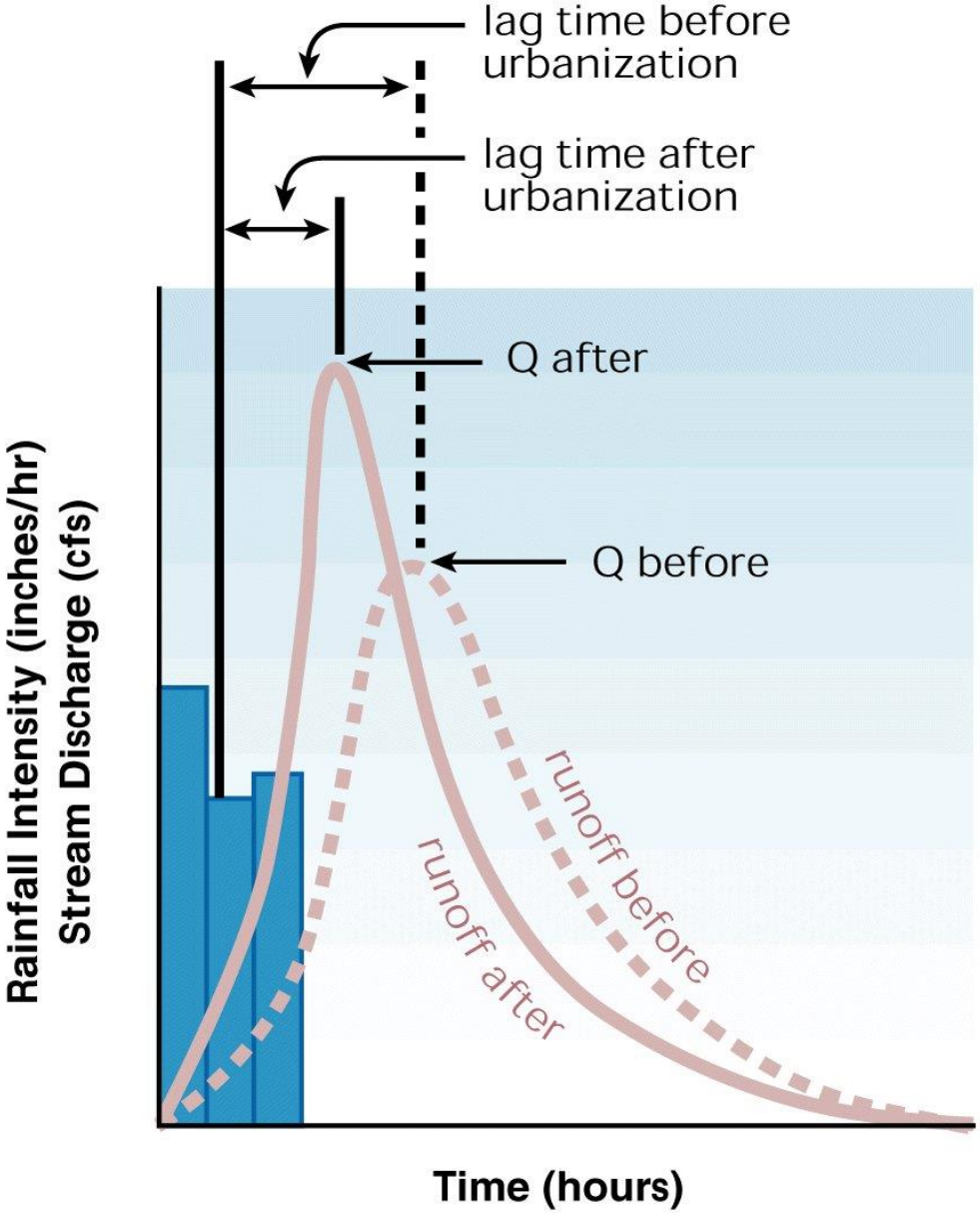
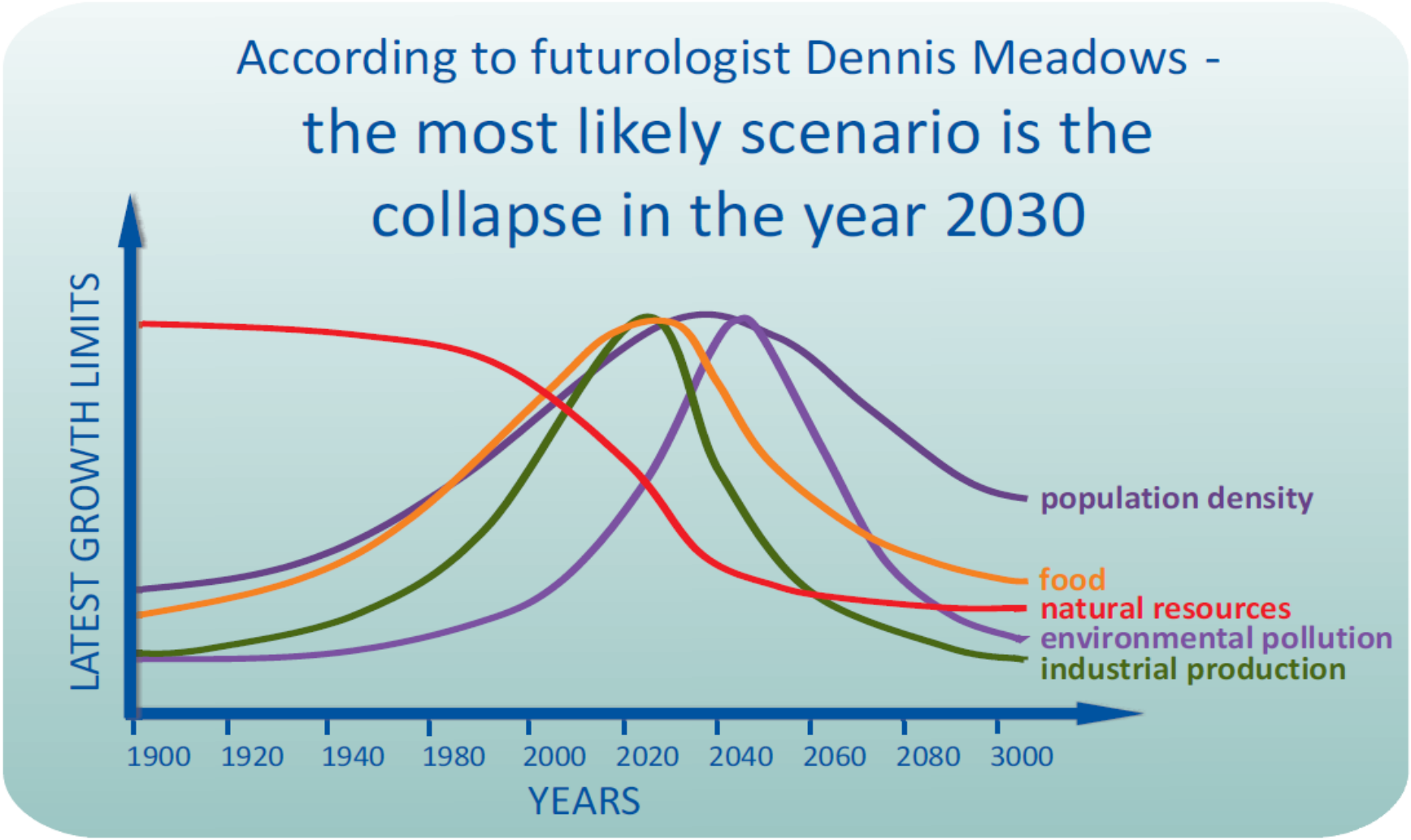


Fig. 1.15 -- A comparison of hydrographs before and after urbanization. The discharge curve is higher and steeper for urban streams than for natural streams.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).



The example of the scenarios of the future if the recent exploitation way of environment and resources use will not change [modified from Dennis L. Meadows - an American scientist and Emeritus Professor of Systems Management and coauthor of "Limits to growth : the 30-year update." (2004)]

„…to be sustainable humanity
must live within nature's carrying capacity"

"National natural capital accounting with the ecological footprint concept", Wackernagel at al. 1999 Ecological Econimics 29

TOWARD SUSTAINABLE WATERSHEDS

Definitions of watershed related terms

- Watershed is a topographically delineated area that is drained by a stream system. The watershed is a hydrologic unit that has been described and used both as a physical-biological unit and as a socio-economic and socio-political unit for planning and implementing resource management activities.
- Integrated watershed management (IWM) is the process of formulating and implementing a course of action involving natural and human resources in a watershed, taking into account the social, political, economic, and institutional factors operating within the watershed and the other relevant region, uplands and lowlands, to achieve specific objectives.
- The watershed approach is the application of IWM in the planning and implementation of resource management and rural development projects or as part of planning for specific resource sector such as agriculture, forestry, and/or mining that links both biophysical and socioeconomic contexts.

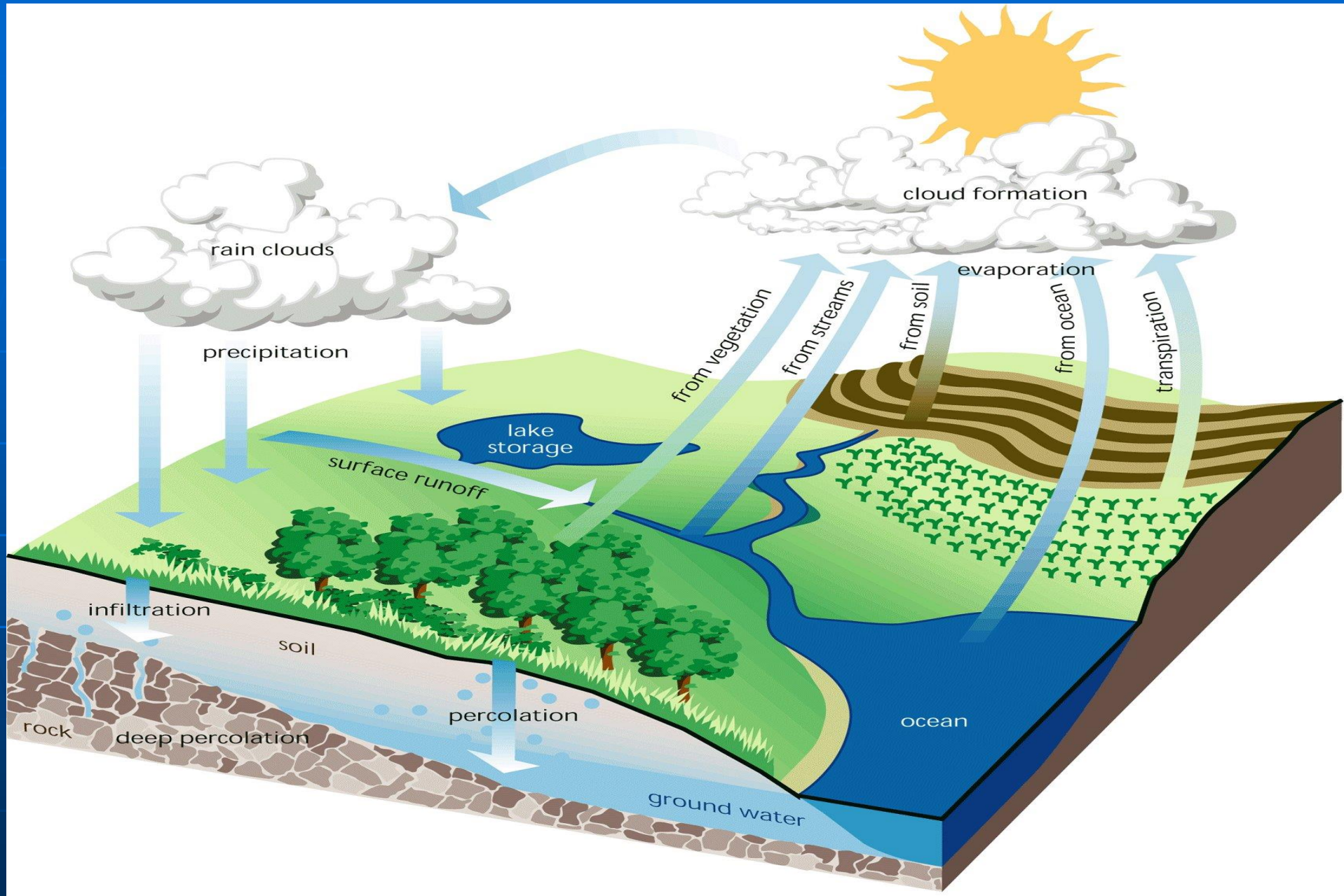


Fig. 2.2 -- The hydrologic cycle. The transfer of water from precipitation to surface water and ground water, to storage and runoff, and eventually back to the atmosphere is an ongoing cycle.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

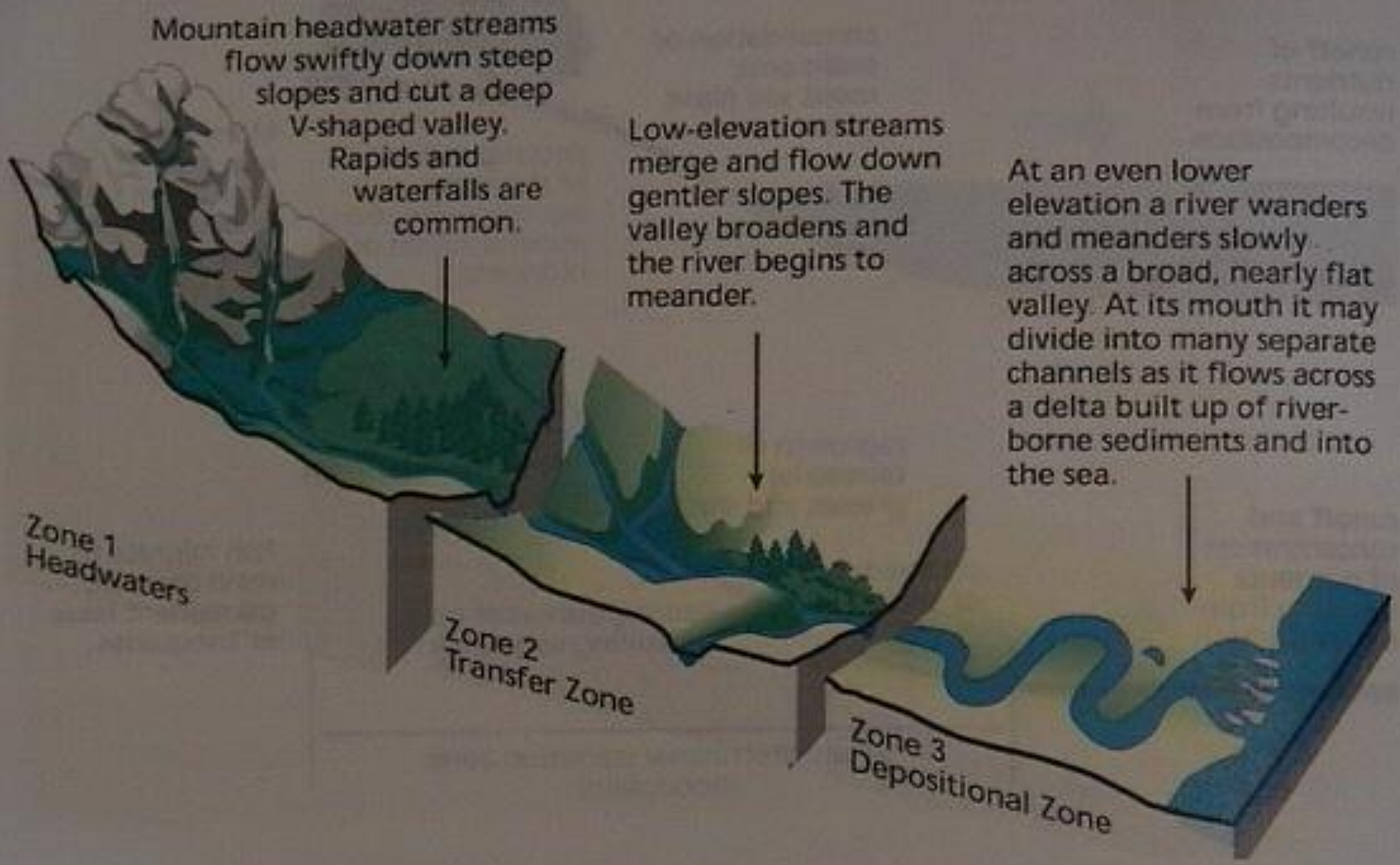


Figure 1.27: Three longitudinal profile zones. *Channel and floodplain characteristics change as rivers travel from headwaters to mouth.*
Source: Miller (1990). ©1990 Wadsworth Publishing Co.

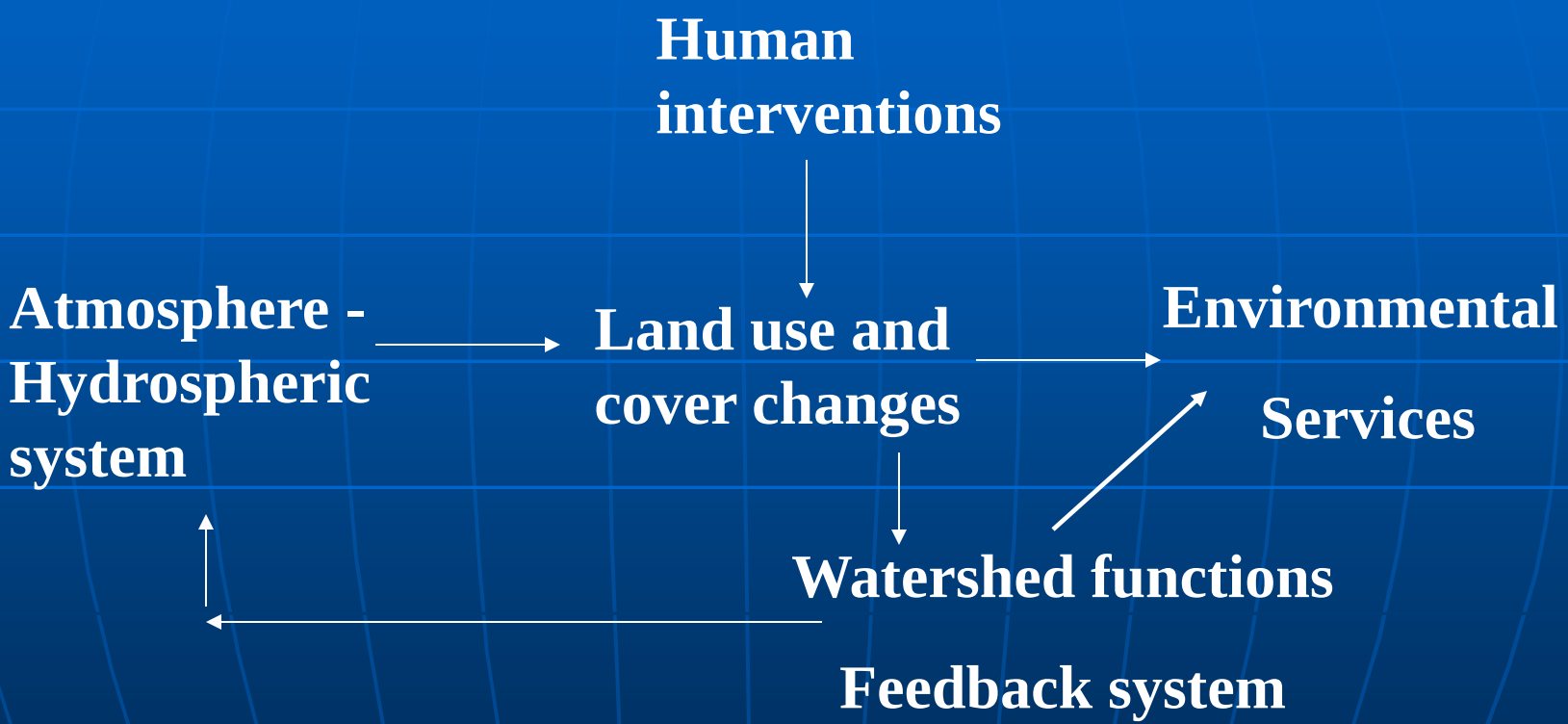
WATERSHED FUNCTIONS :

1. Collection function
2. Storage function
3. Transmission function: water flows
4. Chemical pathways function
5. Habitat function: biodiversity

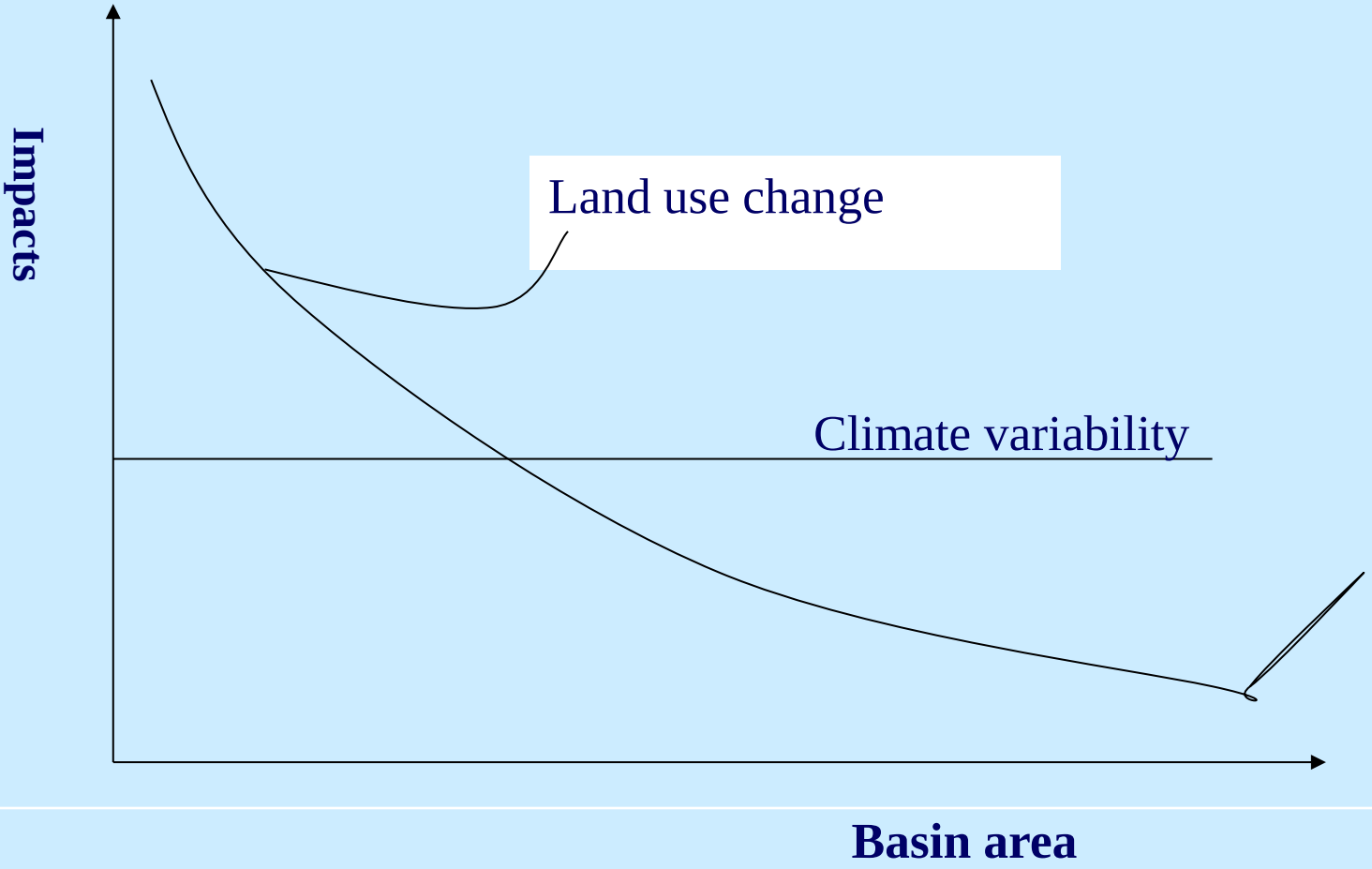
Integrating functions:

6. Attenuation/filtering/damping function
7. Flushing function

Watershed Functions Feedback System



Comparison of Climate and Land Use Change Impacts



Watershed Management Perspective

- *Watershed management is defined as the planned manipulation of one or more of the factors of the environment of a natural or disturbed drainage basin so as to affect a desired change in or maintain a desired condition of the watershed resources (Black, 1996)*

3 main goals: (i) rehabilitation; (ii) protection and conservation; and (iii) enhancement

- Best Management Practices: optimality conditions

Several types of reforestation are now being practiced in the tropics

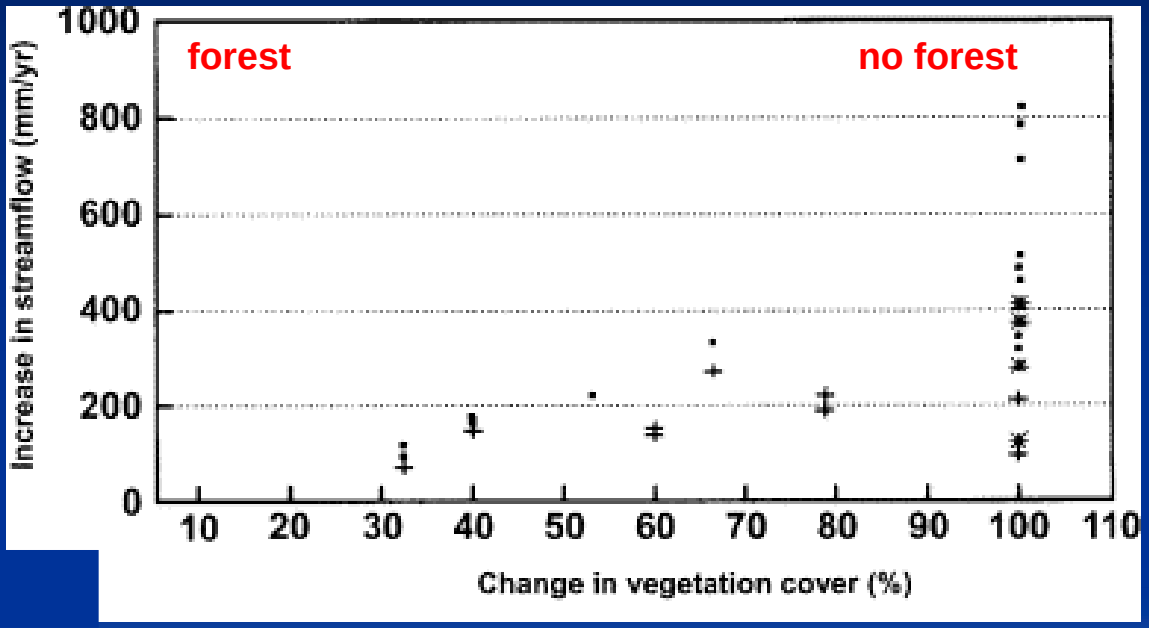
- Large scale (>1000 ha) industrial plantations covering one or more watersheds.
  - Clear felled after short rotations of <10 years (e.g. for pulpwood). OR
  - Clear felled after 20-40 years (e.g. for sawlogs)
- Small scattered farm woodlots or plantations covering <5 ha.
  - These form just one component of the landscape mosaic
- Natural forest regrowth – protected from further disturbances; this varies in age, biodiversity, tree cover.
  - in some cases these might be enriched with commercially valuable species

In the case of plantations, a variety of methods are being used.

	Monocultures	Multi-species plantings
Evergreen	• Eucalyptus • Acacia • Pinus	• Mixtures of timber trees • Agroforestry
Deciduous	• Teak	

Deforestation impact on water yield

apparently very compelling experimental evidence for a negative impact:



Bruijnzeel (2004) *Agric. Ecosyst. Environ*. 104: 185-228.

See also Scott *et al.* (2004) in *Forests, Water and People in the Humid Tropics*, Cambridge University Press

AGENDA FOR ACTION TOWARDS SUSTAINABLE WATERSHEDS: NEEDS OF INTEGRATION

The major threats to the environment

Pollution and overexploitation of natural resources

Degradation of evolutionary developed biogeochemical cycles, energy flow and water circulation

Sustainable Development

Technical Sciences and Management

- an urgent need for reduction of energy, matter consumption and wastes per GNP -

↓

Ecoefficiency & Factor four

Environmental Sciences and Management

ECOHYDROLOGY –integrative science

- restitution of water, energy and nutrients pathways in degraded ecosystems
- enhancement of ecosystem **Carrying Capacity** against human impact

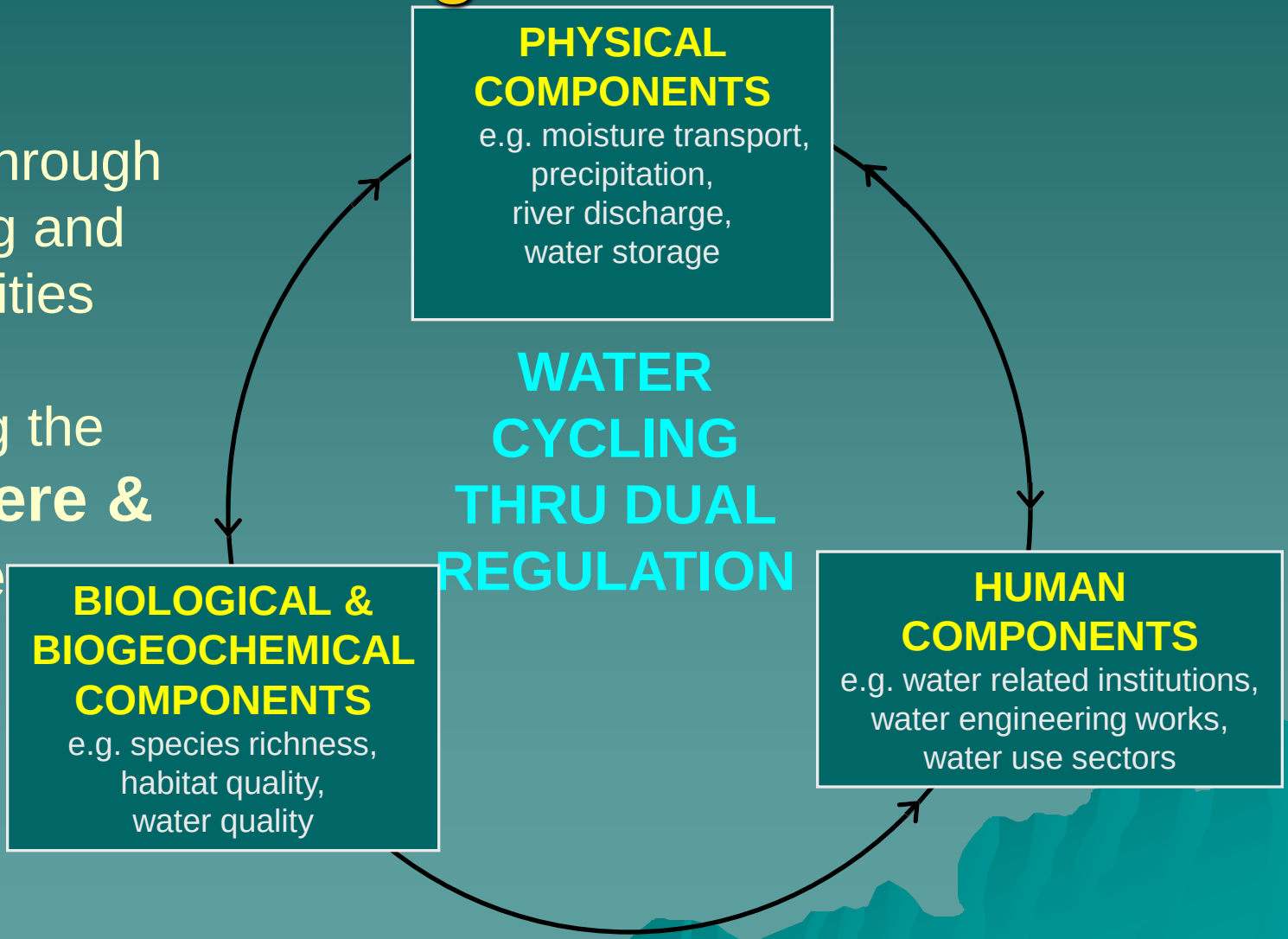
Watershed management: manipulating the hydrosphere & biosphere to guarantee sustainability

FUNCTION MEASURES:

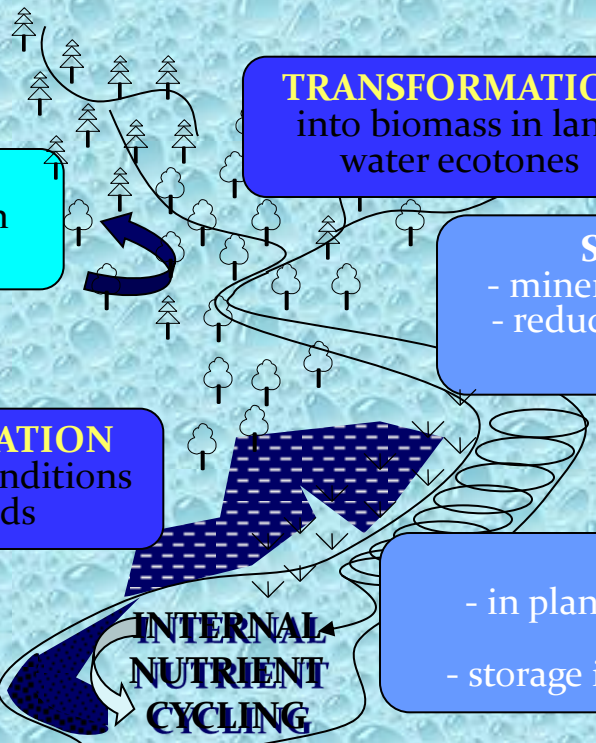
- production
- rehabilitation
- protection
- chemical pathways/flushing
- Habitat/biodiversities
- Attenuation

Integration Needs in Watershed Management

Integration through water cycling and human activities through manipulating the **hydrosphere & biosphere**



INTEGRATED APPROACH TO WATERSHED MANAGEMENT AND RESTORATION



RETENTION
of nutrient and water in the catchment

TRANSFORMATION
into biomass in land water ecotones

SELFPURIFICATION
- mineralization of organic matter
- reduction of spiralling transport rate

DENITRIFICATION
in anaerobic conditions of wetlands

TRAPPING
- in plant biomass (seasonally removed)
- storage in the unavailable pool

SEDIMENTATION
- in the river valley
- in the back waters
- small retention

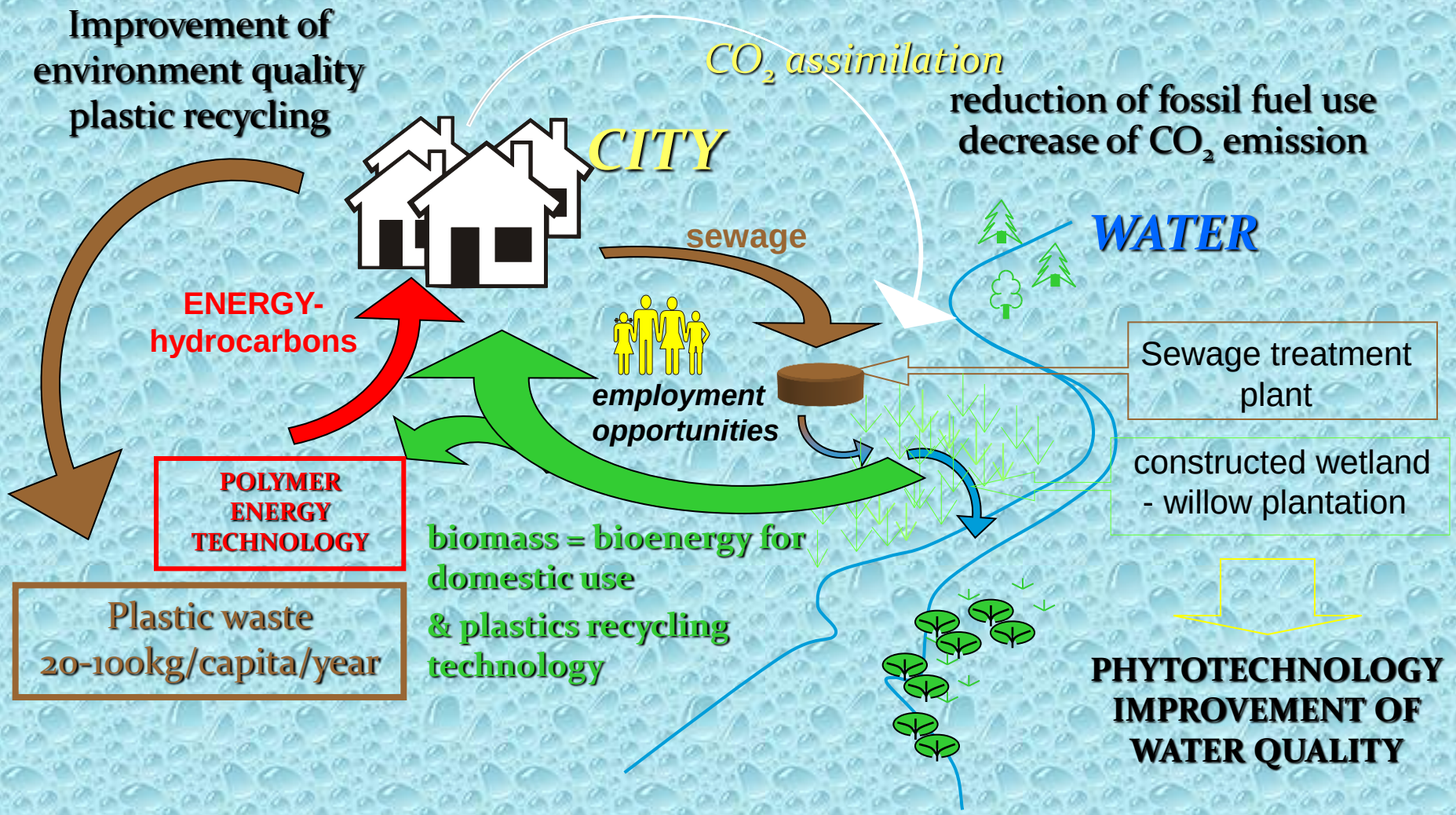
BIOFILTRATION
- reduction of algae biomass

HYDROLOGICAL
control of water quality

International Centre for Ecology Polish Academy of Sciences, Warsaw
Department of Applied Ecology University of Lodz

CONVERSION OF WATER POLLUTANTS INTO BIOMASS AND IT'S USE FOR CONVERSION OF PLASTIC WATSES INTO ENERGY

Example for a Sustainable Development Tool



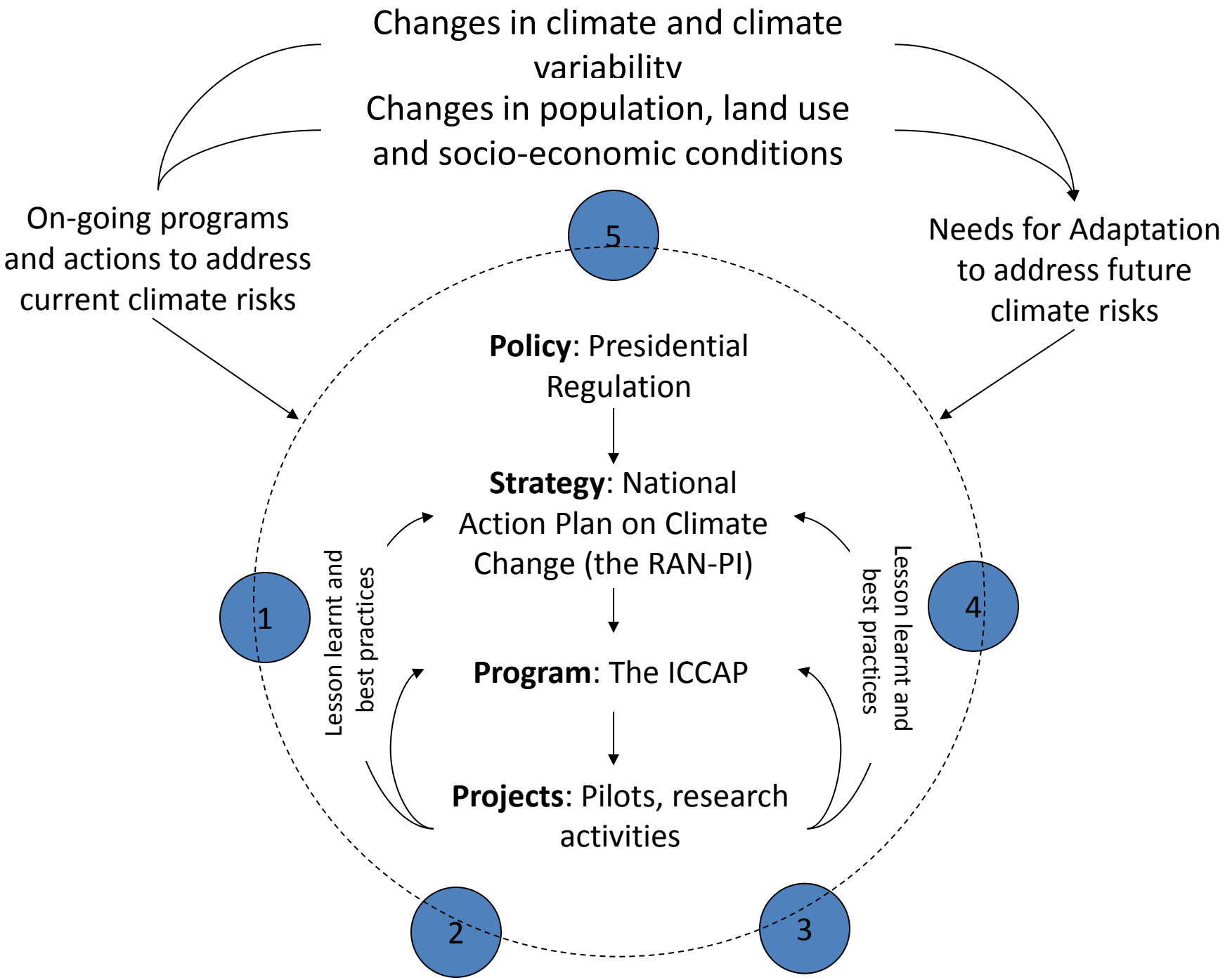
International Centre for Ecology Polish Academy of Sciences, Warsaw
Department of Applied Ecology University of Lodz

MITIGATION AND ADAPTATION OPTIONS

- Mitigation and Adaptation options already being addressed into the National Development Planning response to Climate Change
- Mitigation options: Forest/peatland management and REDD mechanism; Renewable, clean energy and Energy efficiency; CDMs, improved agronomy for rice crops; Waste management
- Adaptation options: water sectors; disaster risk reduction; vulnerability assessment; EWS; etc

Water Sector Adaptation Programs

- **Capacity building**
  - Through knowledge improvement of water managers in using climate information to manage climate risks
- **Technology Transfer**
  - Through construction of effective early warning system using space technology, radar, etc.
- Framework and methods to determine impacts, vulnerability and necessary adaptation efforts
- **Setting up standard and criteria** for structural and infrastructures planning, and spatial planning that proof adaptable to possible climate change


Changes in climate and climate variability
Changes in population, land use and socio-economic conditions
On-going programs and actions to address current climate risks
Needs for Adaptation to address future climate risks
5
Policy: Presidential Regulation
Strategy: National Action Plan on Climate Change (the RAN-PI)
Program: The ICCAP
Projects: Pilots, research activities
Lesson learnt and best practices
Lesson learnt and best practices
1
2
3
4

CONCLUDING REMARKS

- Indonesia even with abundant water resources is vulnerable to water, food, and environmental security
- Land use and land cover changes as triggered by population pressure have caused environmental degradations and intensified water related disasters: floods, droughts, forest fires, landslides, and health diseases
- Necessary institutional framework and W/M methods to determine impacts, vulnerability and necessary adaptation efforts for sustainable watershed management

THANK YOU

TERIMA KASIH