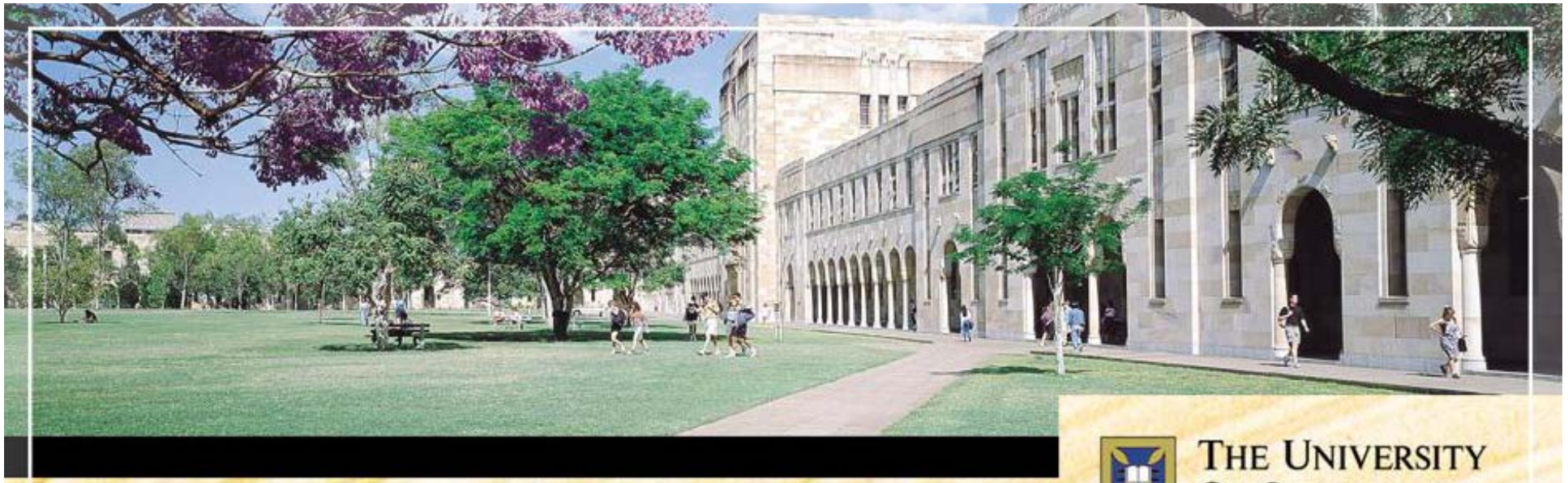

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Soil Resources and Sustainable Crop Production

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President, International Union of Soil Science

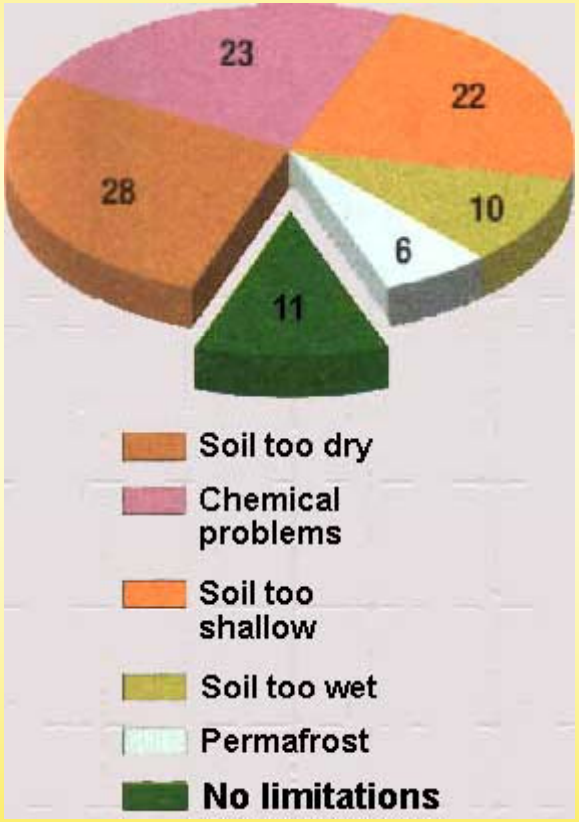
Soil Resources – A Global View

- How much is there?
- How good is it?
- What can it be used for
- Is it in the right places?
- How can we nurture and protect it?
- What are the key issues and prospects for the future?

Soil - the basis of life

- Soils are essential to crop production and support plant, animal and human life on earth.
- In addition to food, the soil/plant system produces fibre for clothing, bedding etc. and wood for fuel and building materials.
- For crop production to be sustainable, soils must be retained *in situ* and be maintained in a healthy and fertile condition to supply nutrients and water.
- Over exploitation of soils can cause major problems and loss of soil and or fertility.

Soil limitations on agriculture

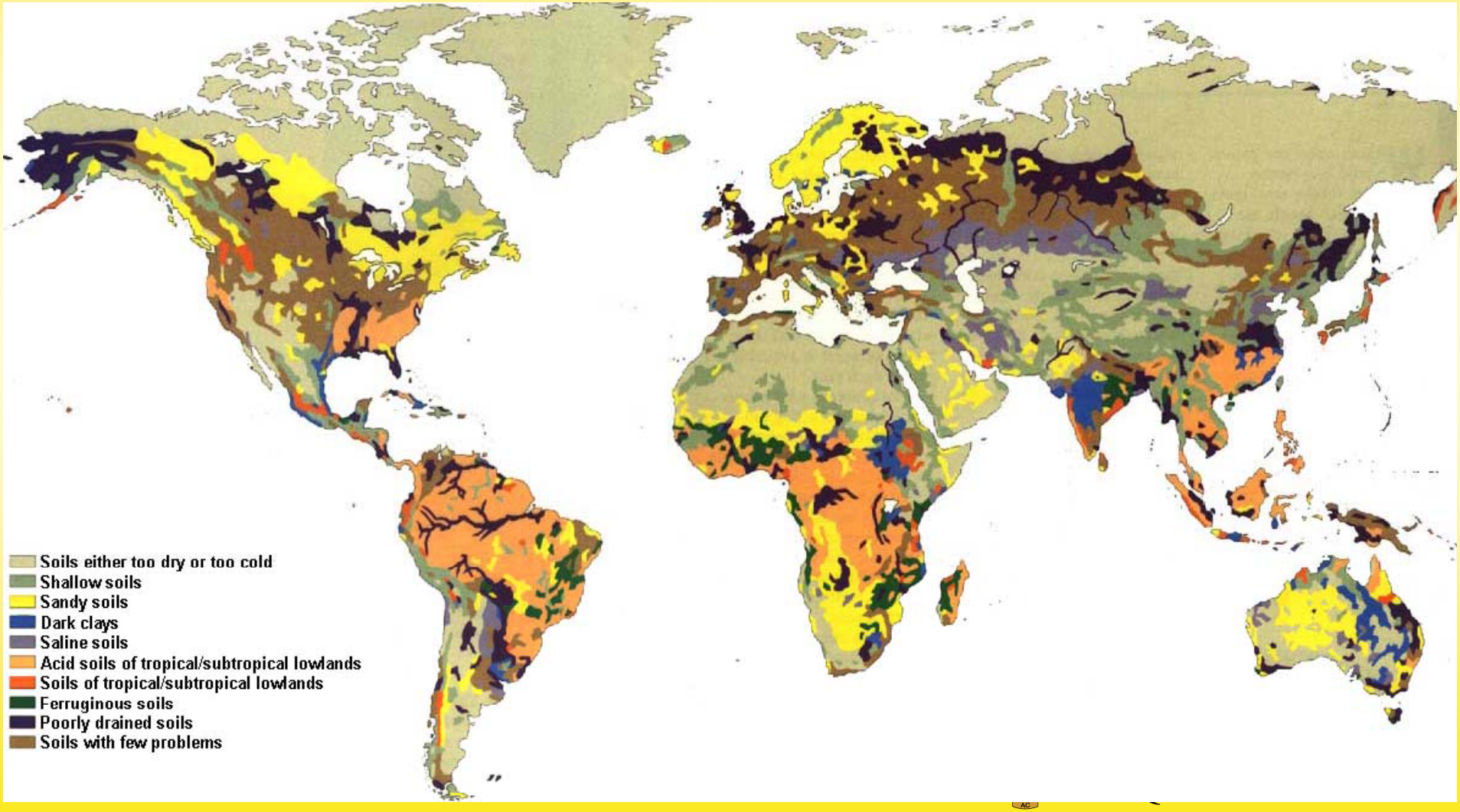


- Most soils have some limitations on their capacity or flexibility to grow crops
- Only ~10% of our soil resources are considered to have no or minimal limitations
- Other soils can still be productive but will grow a limited range of crops in a restricted area or season or may need remedial treatment

Alleviation of Soil Limitations

- Some soil limitations cannot be alleviated eg. too cold, too hot, too shallow.
- Other limitations can be alleviated in whole or in part eg.
  - irrigation in dry areas, drainage of wet soils:
  - addition of nutrients to increase fertility or lime to correct acidity;
  - modification of cultivation and management system;
  - recycling of crop residues and animal manure.
- These remedies greatly increase the range of soils available for crop and pasture production.

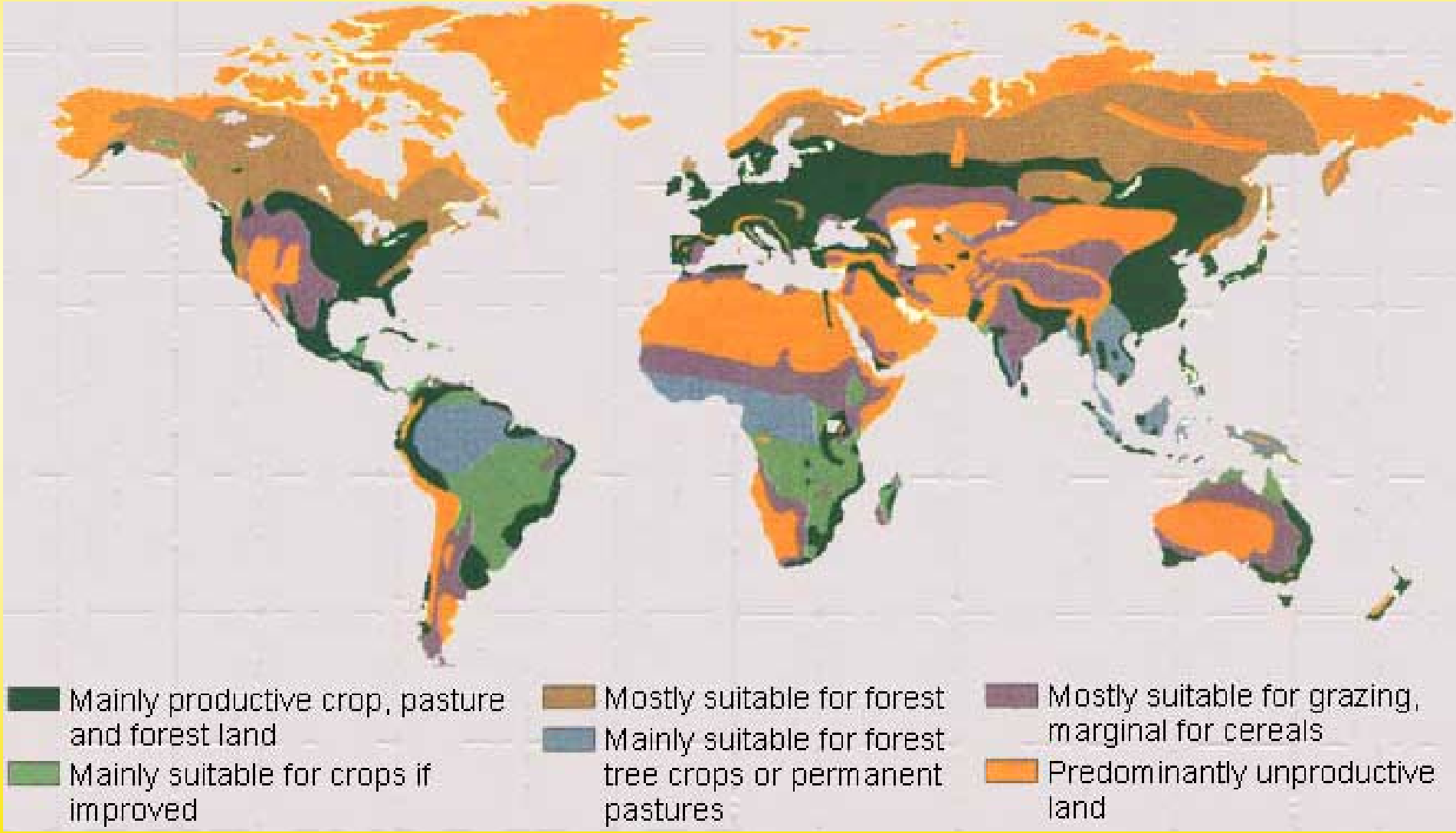
Global Soil Resources



What can we grow and where?

- Given the soil resources available, we need to use them as effectively as possible.
- Over time production systems have been developed that operate effectively on different soils in different environments
- The current production systems used are not perfect and can still be improved by better management, use of fertilisers etc.
- Categorisation of soil and the environment into different production systems is referred to as land productivity or capability assessment.

Land Productivity and Capability



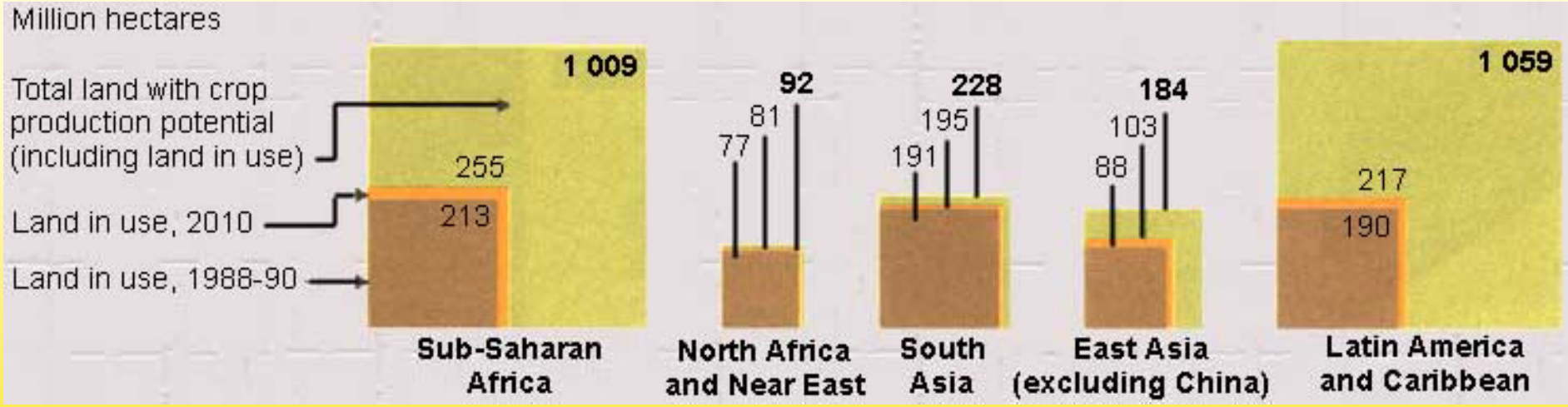
Areas under different land use

Total global land area ~149 million km^2

Land Use	~Area %
Arable	11
Permanent Crops	4
Pastures	24
Forests	31
Urban	1.5
Other	29

Land areas with cropping capability – Where can we expand production?

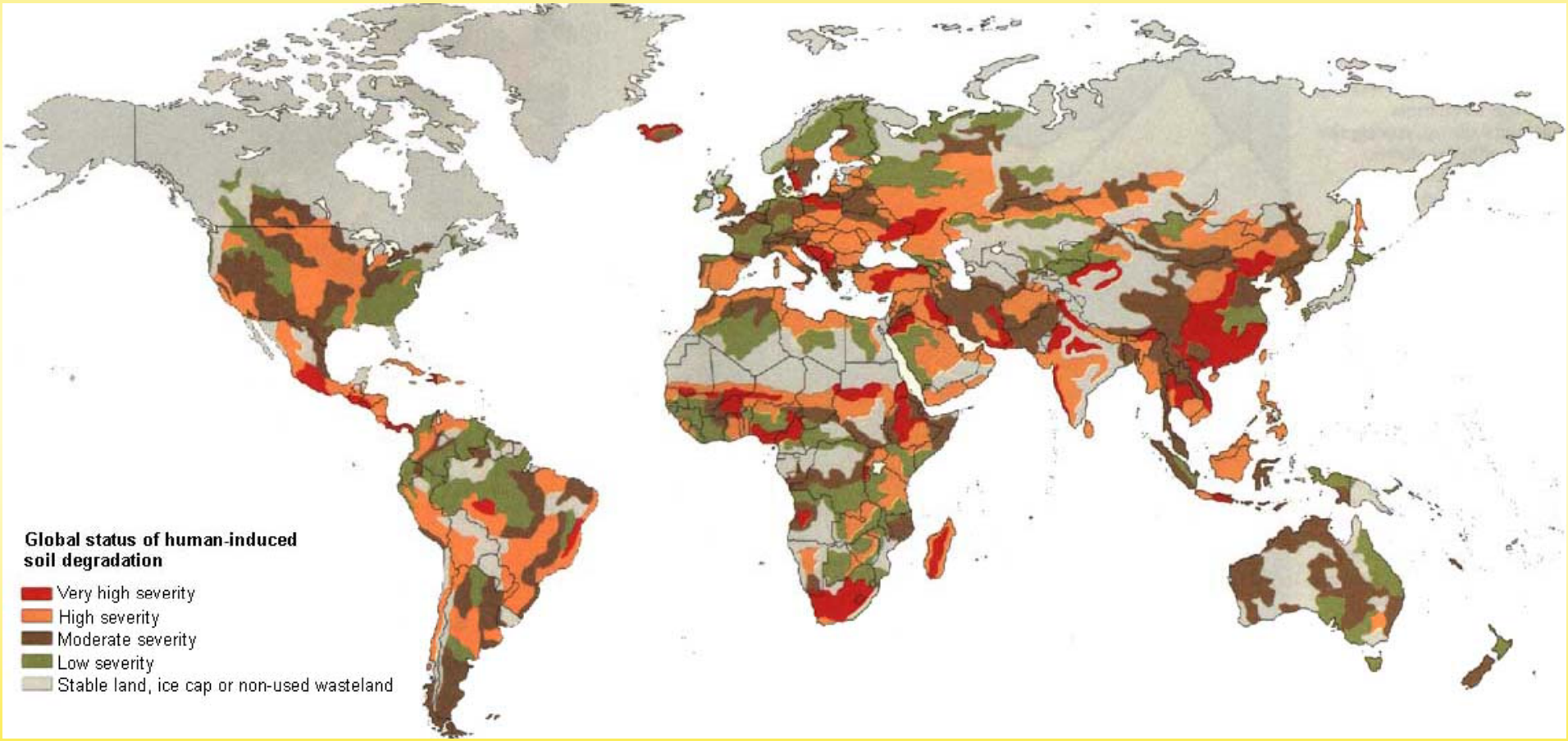
- There is potential to increase the area for crop production in Africa, Latin America and parts of East Asia but very little opportunity elsewhere



Soil Degradation and its Causes

- In addition to the limitations on soil capability there is the added problem of soil erosion and degradation of soil.
- Erosion is a natural phenomenon and is part of the geological weathering cycle. However, the process can be accelerated by misuse and mismanagement resulting in major losses of soil.
- As much as 2,000 million hectares of arable and pasture land is affected by erosion and 5-7 million hectares is lost each year.

Areas of Human-induced soil degradation



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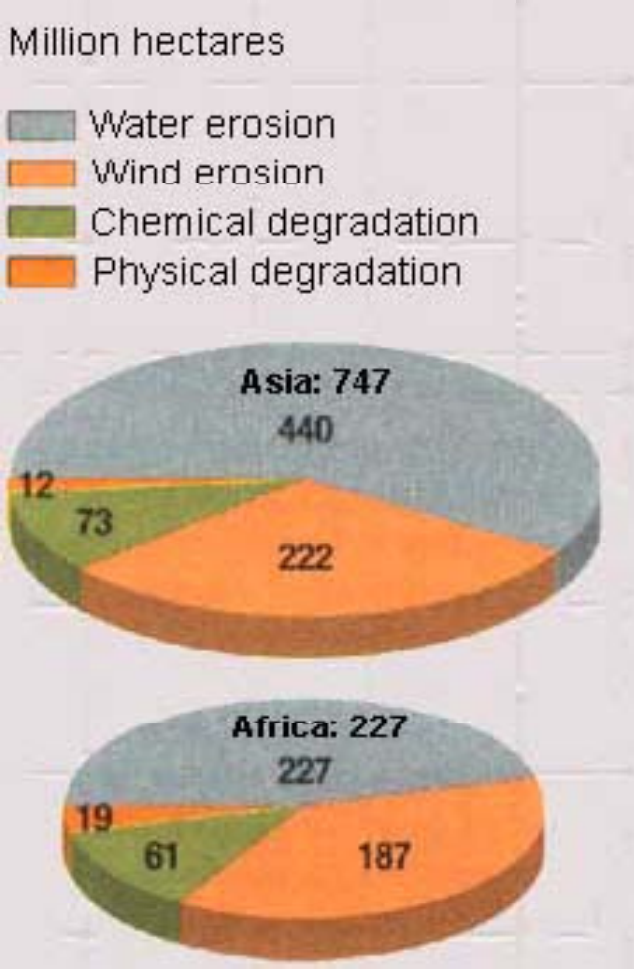
Major causes of soil degradation

- The main causes of erosion are overgrazing and deforestation (especially on sloping land)
- Excessive cultivation, overstocking with animals and other forms of mismanagement lead to physical degradation of soil
- The pressure on land for food production is the root cause of these

Agents of Soil Degradation

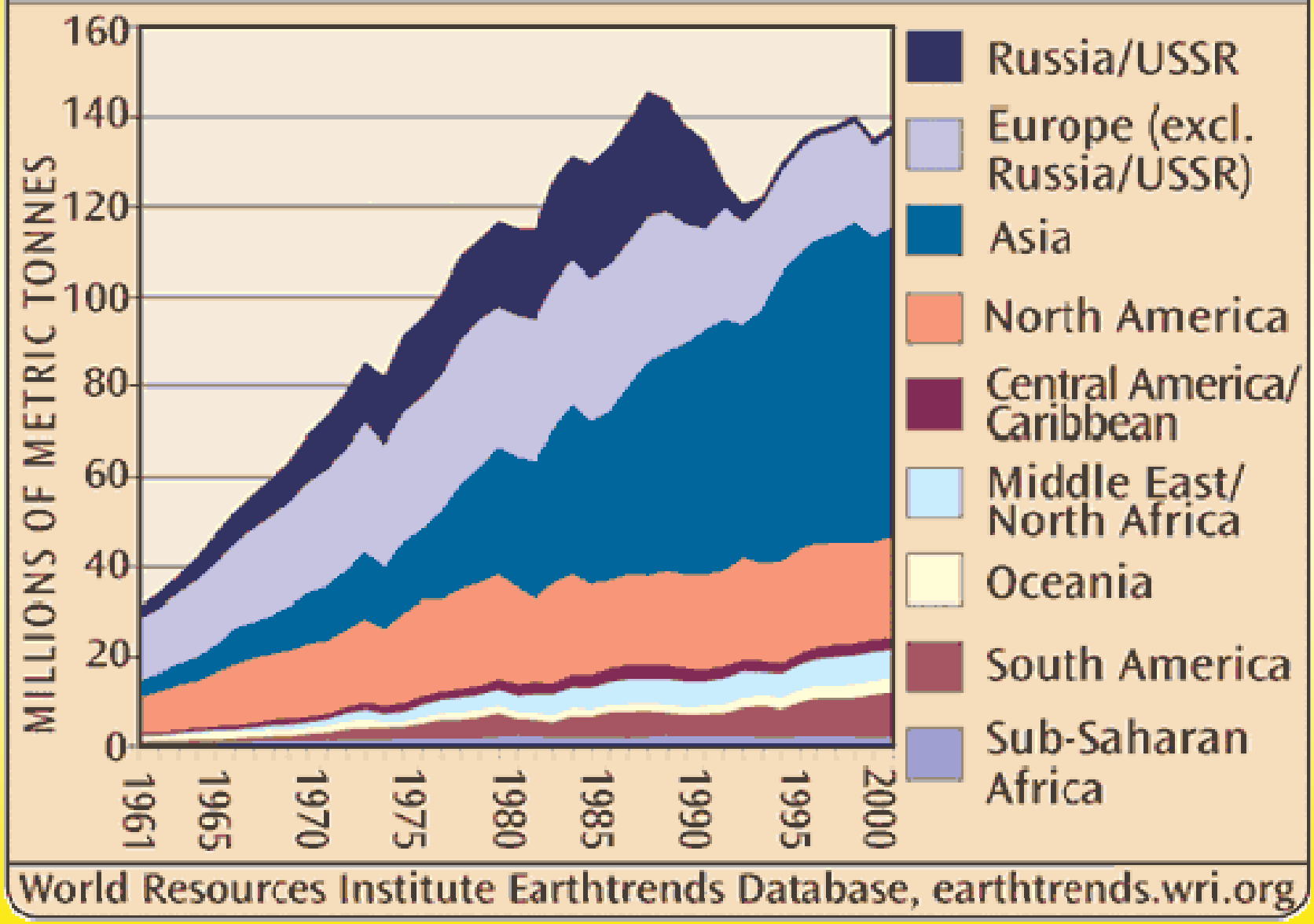


- Principal agents of degradation are; erosion by water and wind and physical degradation by mismanagement
- Erosion can be reduced by using a range of practices to maintain, soil organic matter, vegetation cover and manage watersheds & flows
- Physical degradation can be reduced by improved cultivation and animal husbandry practices

Use of Fertilizers

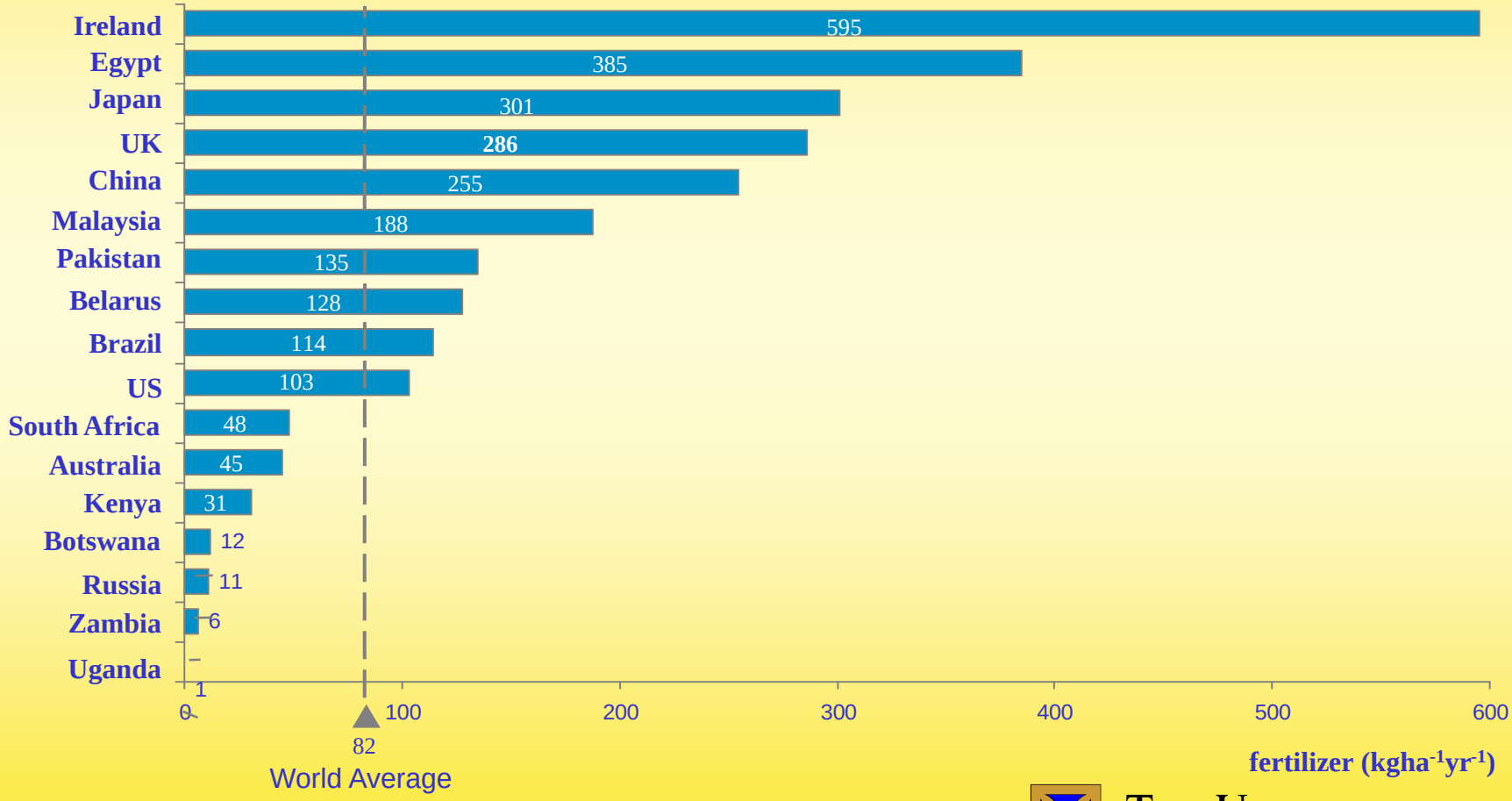
- The productivity of many soils can be greatly increased substantially through the use of fertilizers
- Fertilizer use has increase dramatically over the last hundred years
- Fertiliser use together with mechanisation, have been the main reason for increased productivity of soils and agriculture

WORLD FERTILIZER CONSUMPTION 1960-2001



World Resources Institute Earthtrends Database, earthtrends.wri.org

Annual average fertiliser use on arable and permanent cropland



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Use of Fertilizers on Croplands

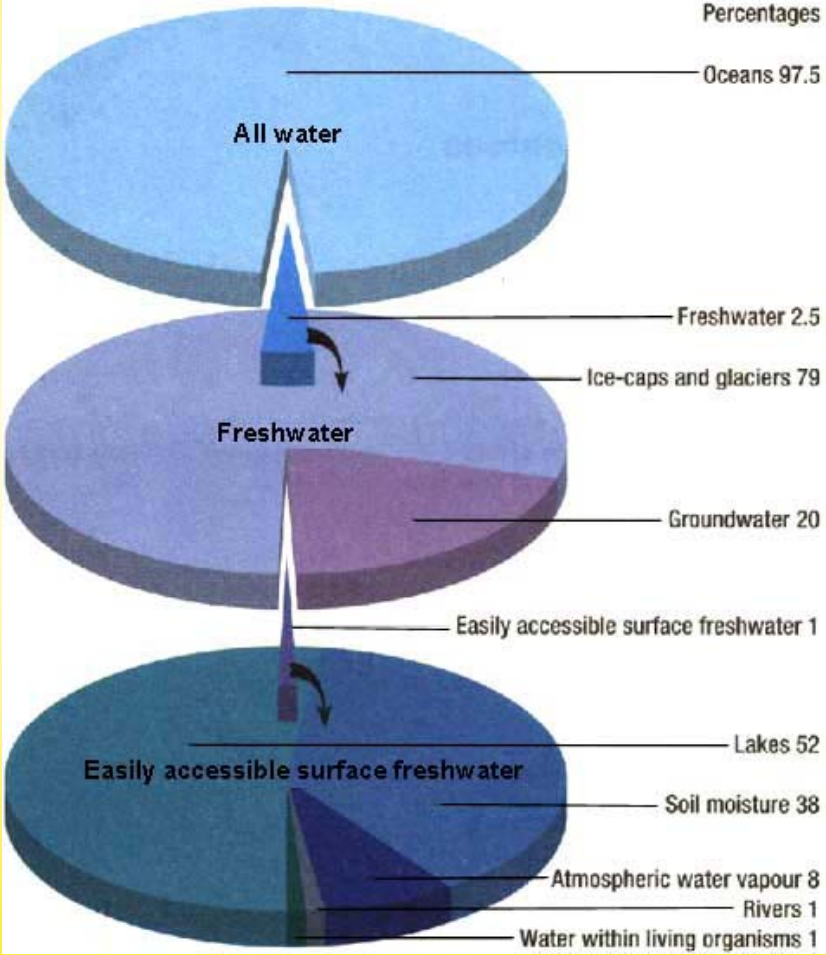
Worth noting:

- The large decline of use in the former USSSR countries
- Large increase in fertiliser use in Asian countries
- China uses twice as much per hectare as the USA
- The amounts of fertiliser used vary greatly from country to country – from excessive to miniscule

Fertiliser Reserves

- In terms of sustainability of crop production the supply of the major nutrients as fertiliser is not a problem for the foreseeable future
- There are sufficient known reserves of phosphate to last 500-700 yr and of potassium to for 1000 yr
- Supply of nitrogen fertiliser is dependent on an energy supply to convert atmospheric nitrogen to ammonia. In the future energy from nuclear, hot rocks or renewable sources will probably be used to produce N-fertiliser

Distribution and Availability of Earth's Water Resources



- 1.4 billion km^3 of water on Earth, 97.5% as saltwater
- ~2.5% freshwater mainly as ice and groundwater
- Only 0.01% of total water is readily available for human use
- Desalination to supply coastal cities is an option to increase availability

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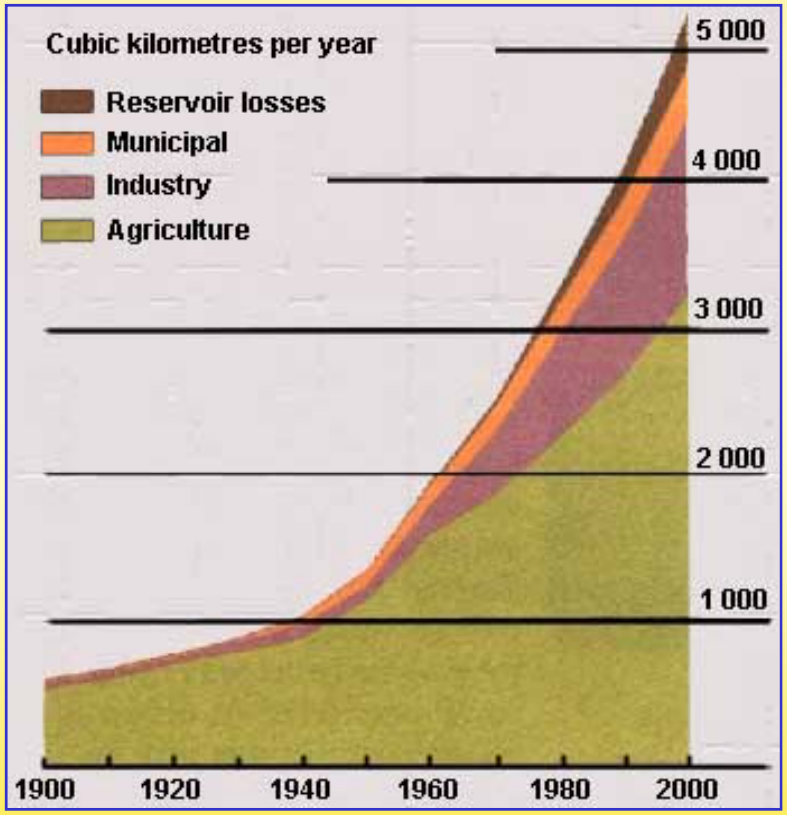
Annual use of available water



- Water use has increased rapidly and it is becoming scarce in many countries
- Agriculture is the major consumer of fresh water
- Competition for this water from industry and cities will grow as shortages become more common
- This represent a threat to crop production

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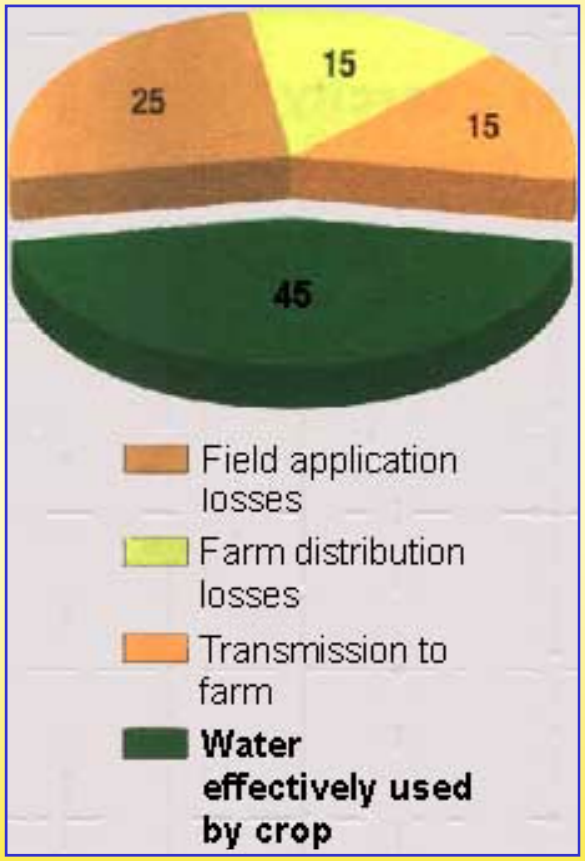
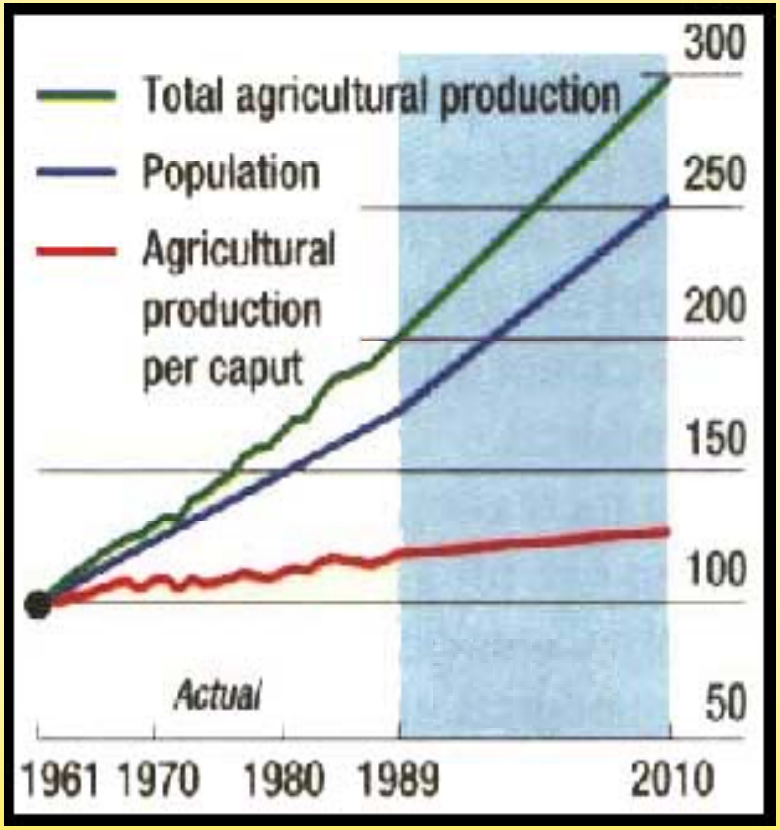
Irrigation losses



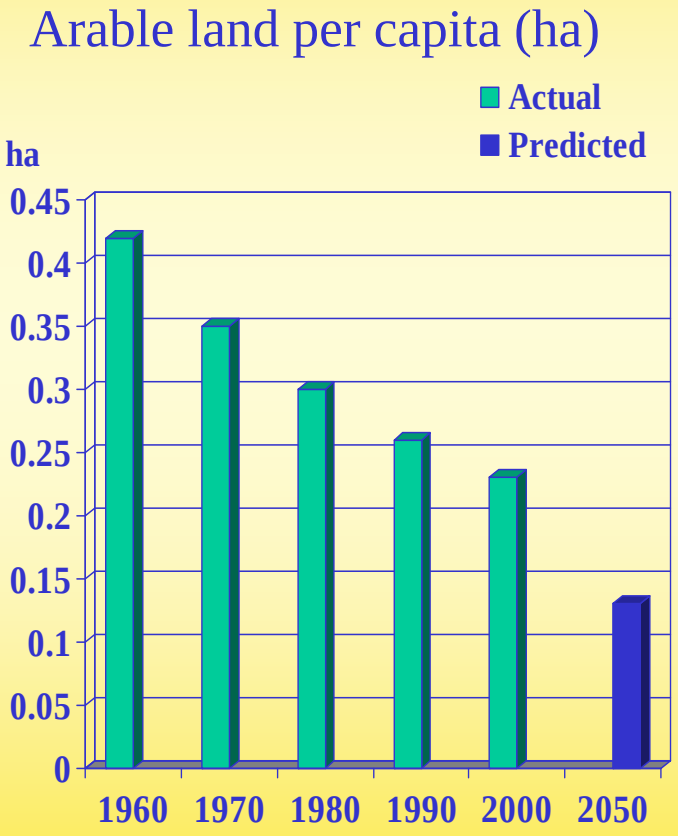
- Irrigated land is highly productive, 2.5 times that of rain fed production
- Large water losses occur in irrigated system so that less than half the water is used by crops
- Reduction of losses will help to increase efficiency and sustainability of these systems

Growth in agricultural production and global population



- Despite the declining area of land per capita, agricultural production has so far kept pace with population growth through increasing productivity per hectare
- There are physical and biological limits to increasing productivity as the area per capita declines

Growing pressure on land resources



- Declining area of land per capita as population grows and the area of arable land remains constant
- By 2025 this area will be close to the limit of land required to feed a person using existing technology and cropping systems

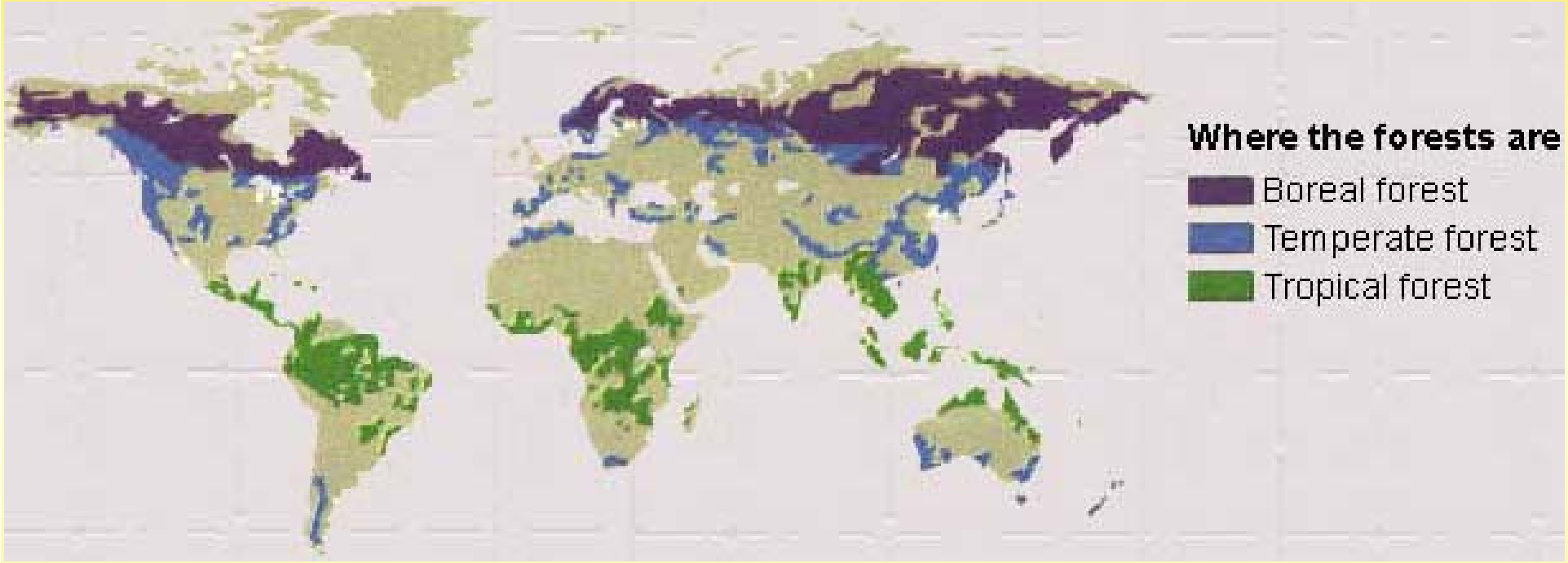
Pressure on Land for Cropping

- The increasing demand for food, fuel and fibre is placing mounting pressure on land resources
- This results in a number of practices:
  - Clearing of forests for crop production particularly in areas of rapidly increasing population
  - Moving cropping activities to poorer quality, more marginal land
  - Clearing of vegetation from sloping lands

Pressure on Land for Cropping

- The impact of recent clearing on forests has be very severe, particularly in tropical rainforest (more than 60% cleared compared to ~10% of deciduous forests)
- This has major global environmental consequences in terms of increased carbon emission and decreased sequestration

Forested Areas



The areas most affected by clearing are developing countries with high population growth and less stringent regulation and control processes to prevent or limit clearing activities

New challenges

- In addition to feeding a growing population, new challenges are emerging:
  - Impact of climate change on crop production
  - Competition for land to produce biofuels
  - Use of more land to produce animal protein
  - Incorporation of carbon sequestration into our agronomic and animal husbandry practices
- Each of these challenges will add new dimensions to the decisions made about land use and will require major changes in crop production systems

New challenges – Climate change

- Temperature increases, changes in rainfall patterns
- Increase in severity and frequency of extreme events; droughts, floods, cyclones etc
- Cropping and animal production systems will gravitate to new locations on different soils
- Systems will need to be modified to adapt to new environments

New challenges - Biofuels

Competition with food for land to produce biofuels;

- First generation biofuels using food crops (starch and edible oils) grown on high quality land will not last due to ethical and economic reasons
- Second generation biofuels based on cellulose ‘waste’ and non-edible oils grown on marginal land may well have a future
- Note the competition for plant residues (soil health, biofuel and biochar production & animal feed)

New challenges – Carbon Sequestration

- Soil represents the largest C reservoir in the terrestrial part of the C-cycle and can be implemented immediately with the right management systems and the help of farmers
- Biochar provides an opportunity to store much larger amounts of C in soil for very long periods of time but soil organic matter levels must also be maintained

An interesting Possibility

- If the procedures outlined could increase the soil carbon levels by *10 percent on their current values* and if all of that carbon came from the atmosphere
- Then the concentration of CO_2 in the atmosphere would fall to **270 ppm - *which is the same as its pre-industrial level!***

Other Issues

- The price of food should allow all farmers to invest money to maintain and improve their key natural resource base – the soil
- Soil resources can cope with incresing population for some time but not indefinitely
- At what stage will we be brave enough to discuss population control,
- Now? Soon? Never?

Thank you for your attention

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