GLOBAL SOIL RESOURCES: PROBLEMS OF QUALITY, FERTILITY AND SAFETY

Emer. Prof. Dr. ir. Oswald Van Cleemput
Ghent University
Belgium
Oswald.Vancleemput@Ugent.be

INTRODUCTION

and

PROBLEM SETTING

Growing demand for food

World population:

2006: 1351 million developed countries
5218 million developping countries
6569 million

2050: 1439 million developped countries
7671 million developping countries
9111 million

Food consumption per day

2006: 18 trillion kcal
2050: 28 trillion kcal

Source FAO 2012

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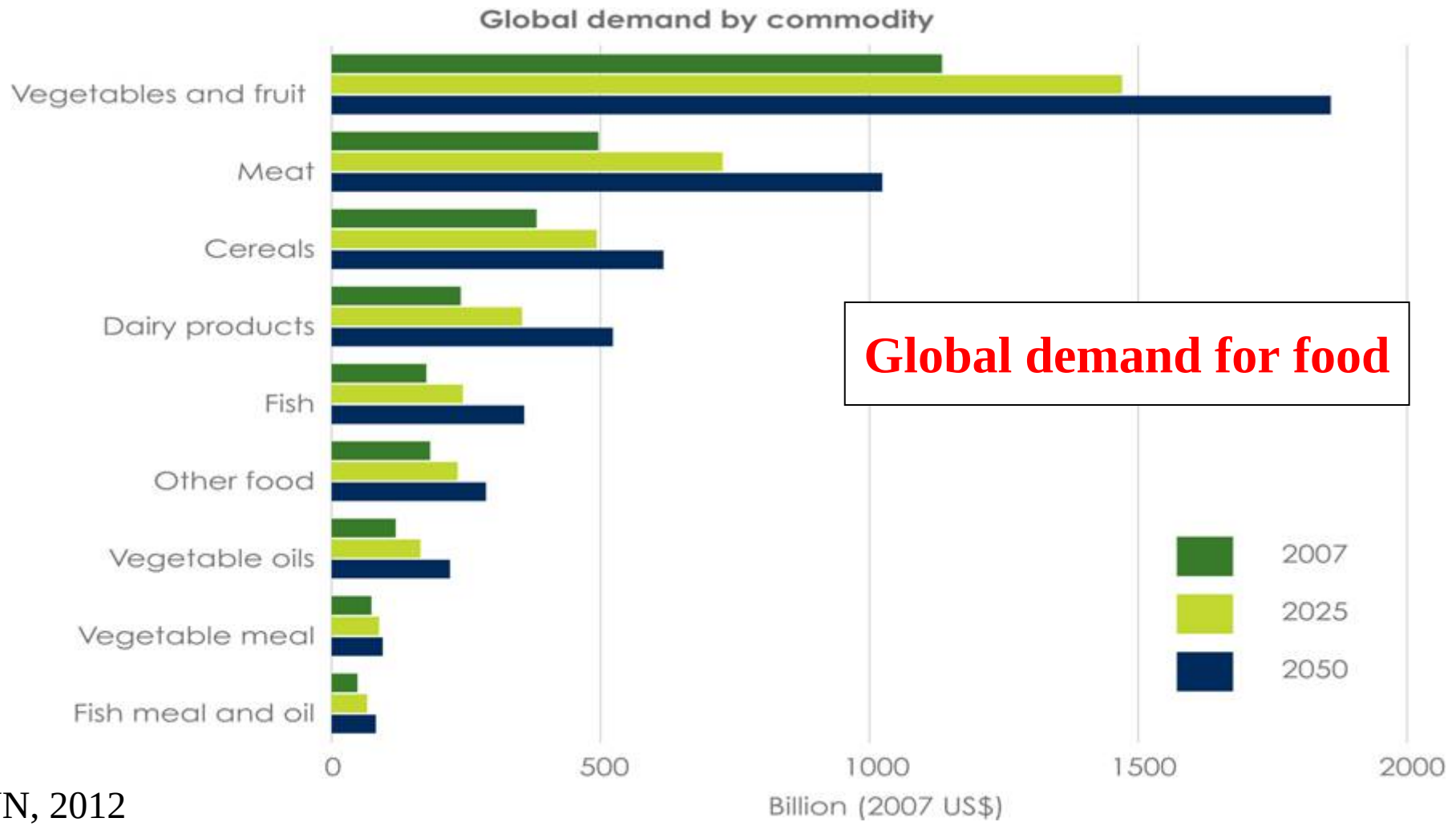


Global demand for food

UN, 2012

Soils ->> Food

Terrestrial earth's surface

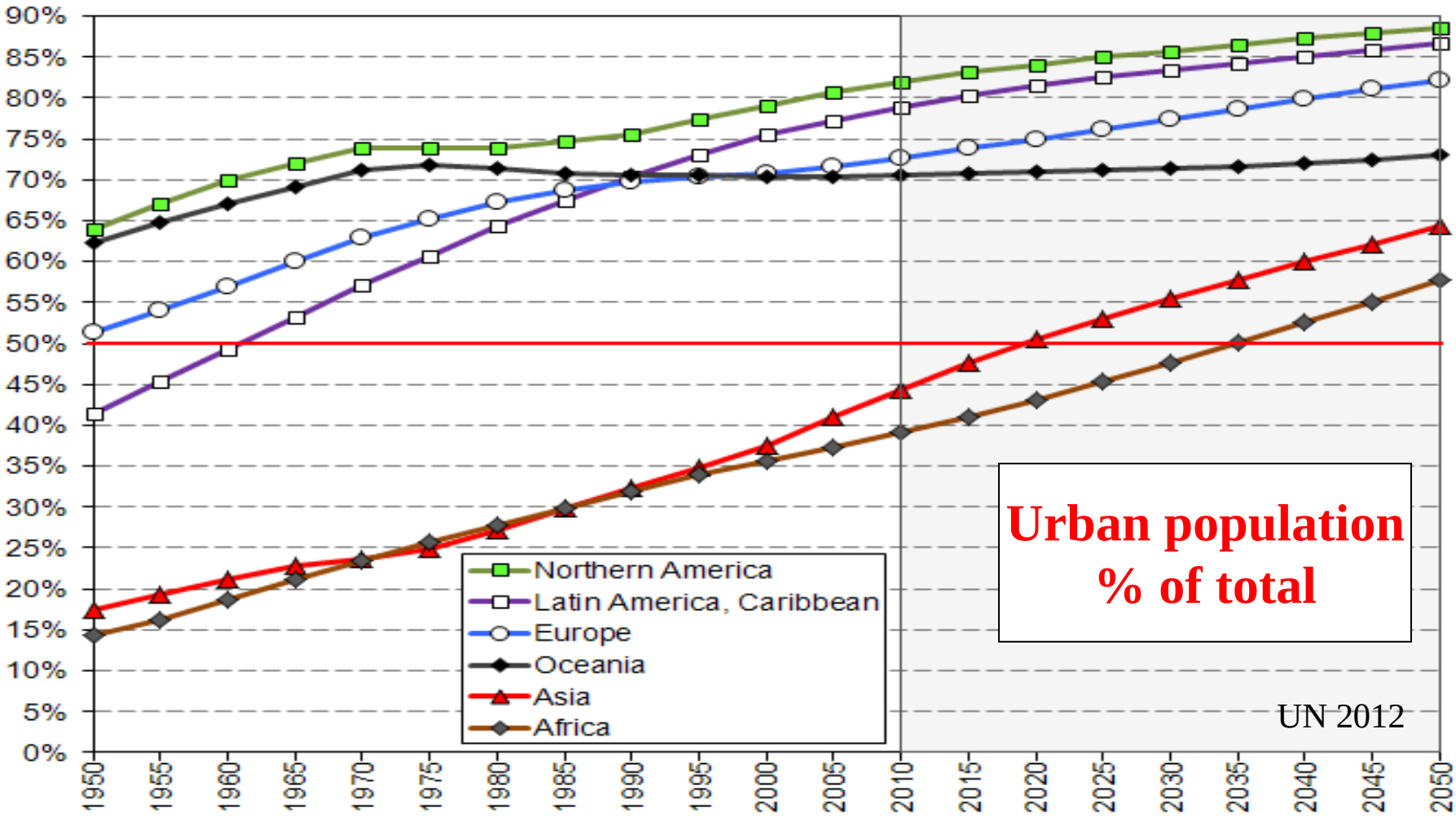
- **25%** is intensively managed (agriculture, managed natural and plantation forests, managed nature preserves)
- **70%** is under some form of human intervention

Observations

Some negative trends for available land

Crop production area shrinked as a result of:

- Urbanization, erosion, global warming
- Forcast for avarage use of arable land: from 0.23 ha to 0.14 ha in 2050
- Consequence: cultivation of marginal land
- In addition, the demands for alternative crops increases: biofuels, 'health' foods


90%
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2050
Northern America
Latin America, Caribbean
Europe
Oceania
Asia
Africa
Urban population
% of total
UN 2012

However,

Some positive points

- More land was converted to cropland in the last 50 yrs than in 150 years between 1700-1850
- Fresh water withdrawals doubled
- Flows of biologically available N doubled, flows of P tripled

---------- ***consequences :***

- CO_2 increased by 32% since 1750, 60% of this since 1959 (excessive ploughing)
- Inorganic and organic pollution
- Significant losses of wildlife habitat and global biodiversity

Overall result:

More food ...nevertheless:

- 800 million people are undernourished or malnourished (2010)
- 2.2 billion people live with a minimum of caloric intake
- There is a strong climatic-geographical correlation with undernourishment: too cold, too wet, too dry, too hot for a high level of agricultural production
- Poverty and unstable markets and governments makes it difficult to benefit from technology development

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PROBLEM TACKLING

- Problems linked to:

1. Soil Quality
2. Soil Fertility
3. Soil Safety
4. Future developments
5. Conclusion

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1. Soil Quality

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Soil Quality ??

Historically: linked to agricultural productivity

- Relative to a standard ? Or a degree of excellence ?
- Linked to a number of functions: sustaining biological activity, diversity, productivity, regulating and partitioning water and solute flow, filtering, buffering, degrading, immobilizing and detoxifying organic and inorganic materials, storing and cycling nutrients, providing support for socio-economic structures and protection for agro-ecological treasures associated with human activities.

Soil Quality

The soil condition – soil quality – is of global concern.

- Soils are fundamental to the well-being and productivity of agricyltural and natural ecosystems.
- Soils suitable for cultivation are about 25% of the total land area of the globe and only about 3% has a high agricultural production capacity.
- Focus goes more and more to sustainability of human uses of soil (soil resources are finite, fragile and slowly renewable).

Soil Quality Context

Soil quality in agricultural context is different from soil quality in a natural ecosystem.

Agricultural context: soil quality may be managed to optimize production without adverse environmental effects.

Natural ecosystems: soil quality may be observed, as a baseline or set of values against which future changes in the system may be observed.

Soil Quality Measurement

Minimum data set for soil quality analyses:

- Physical characteristics (Aggregation, bulk density, infiltration, WHC, …)
- Chemical Characteristics (OM, pH, EC, Fertility …)
- Biological characteristics (Mineralization, respiration, …)
- Productivity characteristics (Yield)

Threats to Soil Resources and Quality

Global availability of soil resources decreased because of:

- Rapid increase of the world population
  - Conversion to industrial land uses
  - Urbanization
  - Development of infrastructures
- Soil degradation (1945 Mha)
- Land degradation (3506 Mha)
- Desertification (1137 Mha)(land surface doubled in 25 yrs)
- Vulnerability to desertification (4324 Mha)

R. Lal, 2011

Threats to Soil Resources and Quality

Global availability of soil resources decreased because of:

- Environmental pollution
- Salinization
- Deforestation
- Excessive ploughing -> CO_2 emission
- Excessive reliance on fossil fuel energy

Threats to Soil Resources and Quality

Global availability of soil resources decreased because of:

- Water and wind erosion
- Overgrazing
- Drought and forest fires
  - Fires: surface area of India and Pakistan every year
  - Frequency: land irretrievably lost

Overall threats are linked to soil, water, nutrients and energy

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Threats to Soil Resources and Quality






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2. Soil Fertility

THE GREEN REVOLUTION

Advances in production agriculture

- production increase of 3-6 times (the last century)
- saved millions of people from hunger and starvation

Not not for all regions ???????

- Application of science and technology alone cannot solve all problems...social, cultural, political reasons.
- Scientific know-how has not been used for practical problemes (lack of simple, practical language, not at village level, no contribution of the farmer).
- Institutions and infrastructure are too weak to provide input to enhance productivity.

What about Sub-Saharan Africa, South Asia and other regions ??

Characteristics

- resource-poor farmers
- small-size holdings (0.5-2 ha)
- extractive farming practices
- low crop yield
- negative nutrient budget
- soil degradation by physical, chemical and biological processes

Vicious cycle: soil degradation – low yield – more degradation – lower yield

What is needed ???

Task: growing more food, fibre and livestock on less water and declining total land area

Food production will have to double in volume with minimum environmental impact: intensive farming with fewer emissions, fewer natural resources and fewer chemical agents

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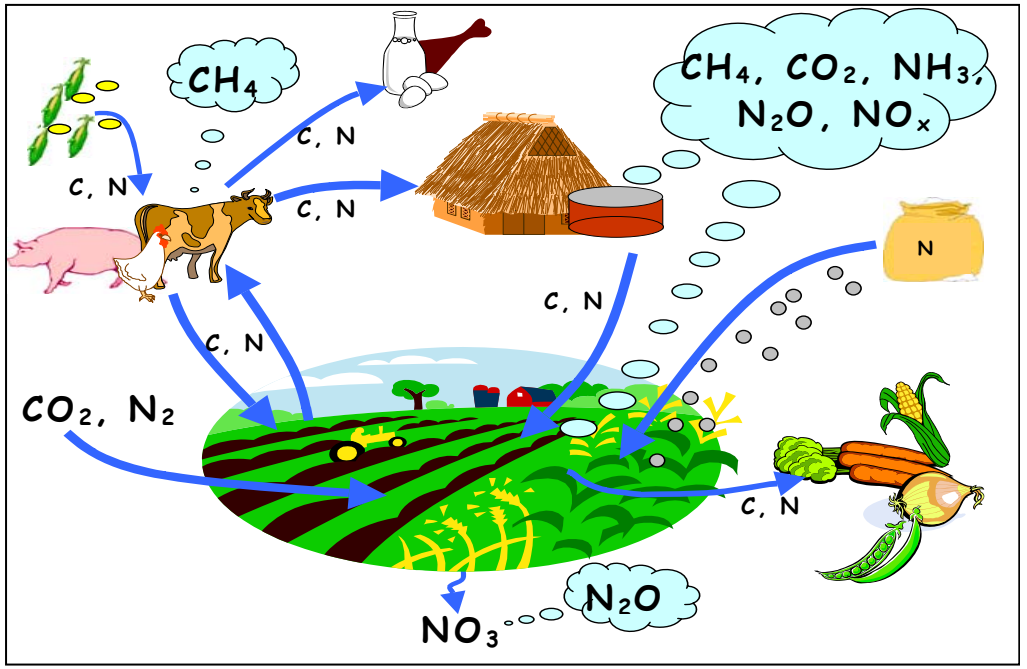
Food production against environmental pollution



Overall solutions

Through which management practices?

- Improving soil fertility (recycling nutrients, BNF, chemical fertilizers as supplement, positive nutrient balance, quality and quantity of OM)
- Conserving water in root zone (mulching, plastic film, avoid weed competition)
- Managing soil erosion (water and wind) (NT, contour farming, appropriate engineering techniques)
- Minimizing soil crusting and compaction (reducing traffic, grazing pressure, enhance bioturbation)
- Recycling water (farm ponds)

But,

Agriculture, grazing and forestry are invasive activities, highly disruptive to natural ecosystems

The regenerative capacity of soils under natural conditions is less and slower than needed by the modern society

When soils are stressed beyond there limits of resilience, they cannot return to their former productive status without massive external inputs

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3. Soil Safety

Soil – Soil water – Soil pollution – Environmental pollution – Food toxicity

Some sources influencing soil safety:

- Agricultural activities (fertilization, herbicides, pesticides …)
- Industrial activities (storage of waste, mining, burning of fuels, …)
- Traffic
- Volcanoes
- Fire
- …..

Soils can emit or ab(d)sorb

- **Gaseous compounds**
- **Bioavailability**

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Pollution < --- > Safety

- Organic pollution:
  bio-availability -> mineralization
- Inorganic pollution:
  difficult, expensive, time-consuming, secondary waste
- Gaseous emissions (greenhouse gases, ozone depletion, climate change):
  fertilization and water use efficiency

Challenges to make soils more safe..., to avoid remediation

Aspects in <u>nutrient delivery</u> to crops:

- A form that resists leaching and fixation
- Increasing soil capacity to retain added nutrients
  e.g. nutrients on hydrotalcite and bentonite (expensive; on areas of known risks)

Challenges to make soils more safe..., to avoid remediation

Aspects on <u>productivity of water:</u>

- through improving nutrient supplying and water holding capacity
- nutrient and water conservation methods
- access to stored soil water through addressing soil physical constraints
- reuse of waste products from industry and megacities as soil conditioners

Challenges,... but how ?

***Modern technologies* that are scale neutral**

(large scale commercial agriculturists versus small scale resource-poor farmers)

1. **Nanotechnology**
2. **Biotechnology**
3. **Information technology**

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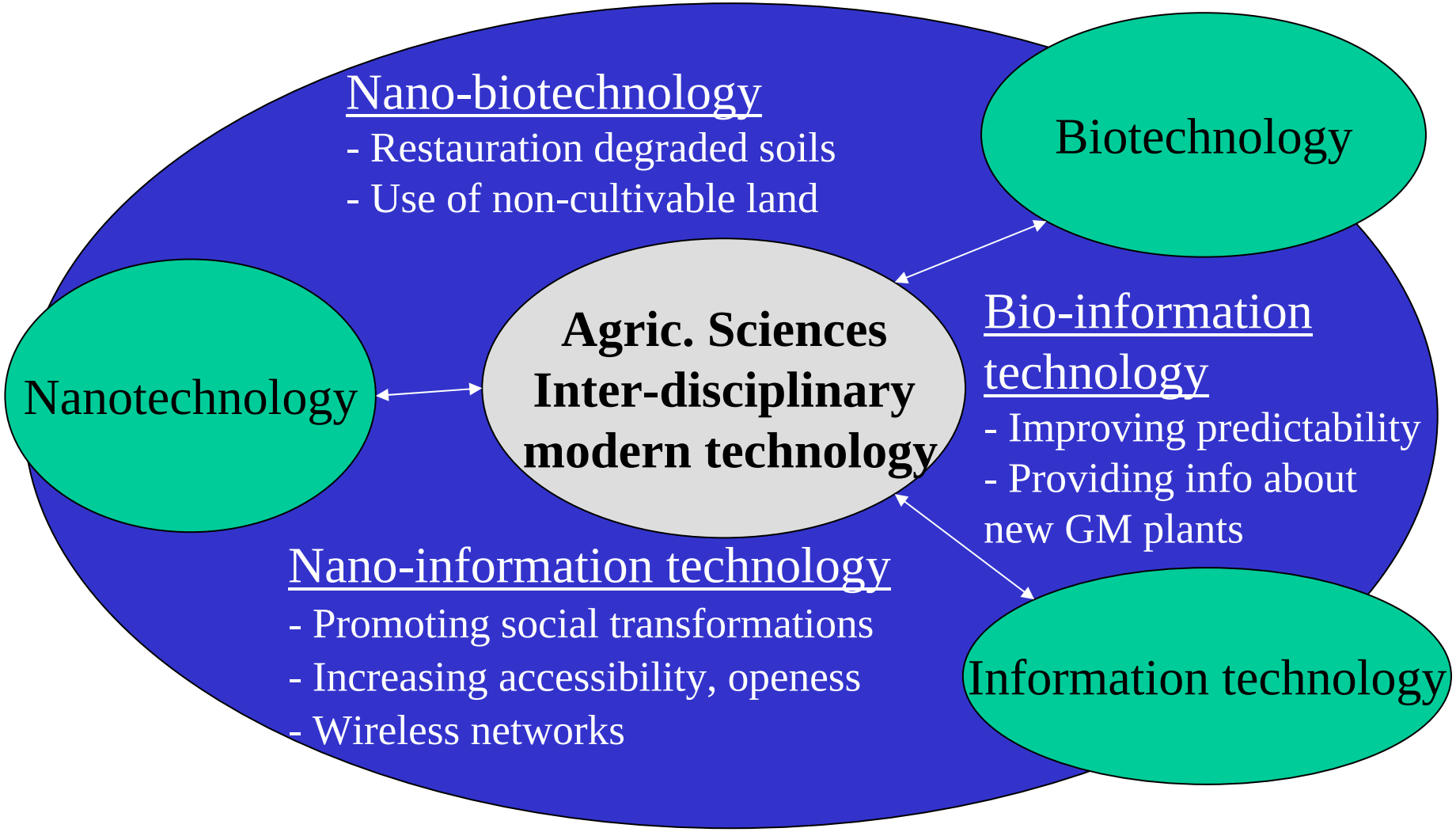

4. Future developments

Research priorities:

- maximizing productivity (agronomic and biomass) per unit of input of water, chemicals and energy
- Minimizing environmental pollution (water pollution, soil contamination)
- Moderating climate through soil and terrestrial C sequestration
- Using soil as medium for waste disposal

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Therefore, interactions <u>with</u> other disciplines

soils and human health
soils as repository of germoplasm
soils as foundation for engineering and civil structures
soils as source for industrial raw material

Interaction of disciplines

- Basic sciences:

Hydrology, climatology, geology, ecology, biology, chemistry, physics, mathematics

- Applied Sciences:

Economics, political sciences, social sciences

- Communication skills:

Interaction with other scientists, policy makers, funding organizations, industry stakeholders, teachers, public at large

5. Conclusion

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Agriculture is a basic activity linking entire social systems in a web of production, distribution and consumption

Soil science should not be seen within a strictly agricultural context (crop production)

Of importance are:

- - poverty reduction
- - environmental conservation + below-ground and above-ground biodiversity
- - equitable food distribution

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115 yr

Congratulations

15 yr

Global Confederation of Higher Education Associations for Agricultural and Life Sciences

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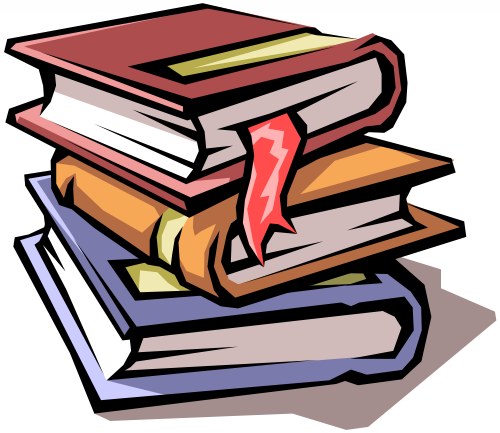

THANK YOU