Agricultural University of Tirana
Faculty of Agriculture
and Environment

University of Prishtina
Faculty of Agriculture
and Veterinary Sciences

Agricultural University of Plovdiv
Department of Agrochemistry
and Soil Sciences

Corvinus University of Budapest
Department of Ecological
and Sustainable Production

University of Sarajevo
Faculty of Agriculture
and Food Sciences

Research Institute of
Organic Agriculture
Switzerland

Joint Bachelor Course on Organic Agriculture 2014

Lecture 4: Organic Agriculture and Environment

- Prof. Dr. Esma Velagic-Habul (Faculty of Agriculture and Food Sciences Sarajevo)
- Prof. Dr. Syle Sylanaj (University of Prishtina)

SNF/SCOPES

Content

- Environment and human population
- Intensive conventional farming and environment:
  effects on soils, water, atmosphere, biodiversity
- Opportunities and challenges of organic agriculture
  preserving natural resources

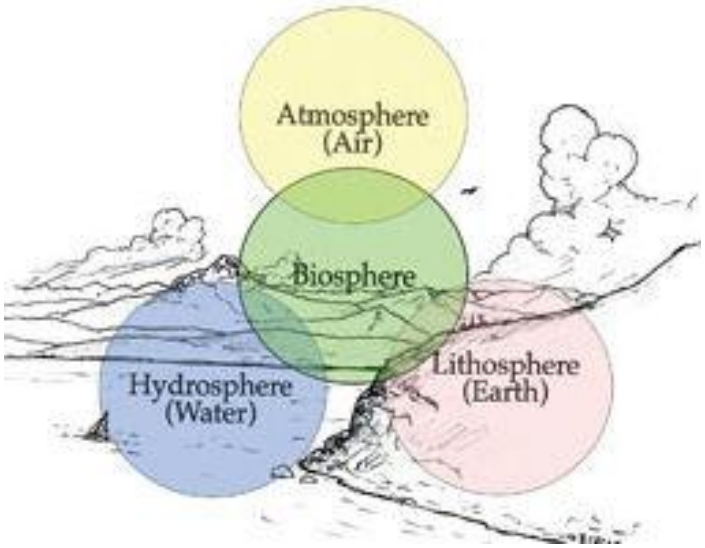
1. Environment and human population

Environment and human population – Natural cycling

- Natural cycling (cycling of substances): a pathway by which a chemical species moves through both biotic (biosphere) and abiotic compartments of earth (lithosphere, atmosphere and hydrosphere).

- Four main natural cycles

- There is no izolated system on the earth – everything is connected

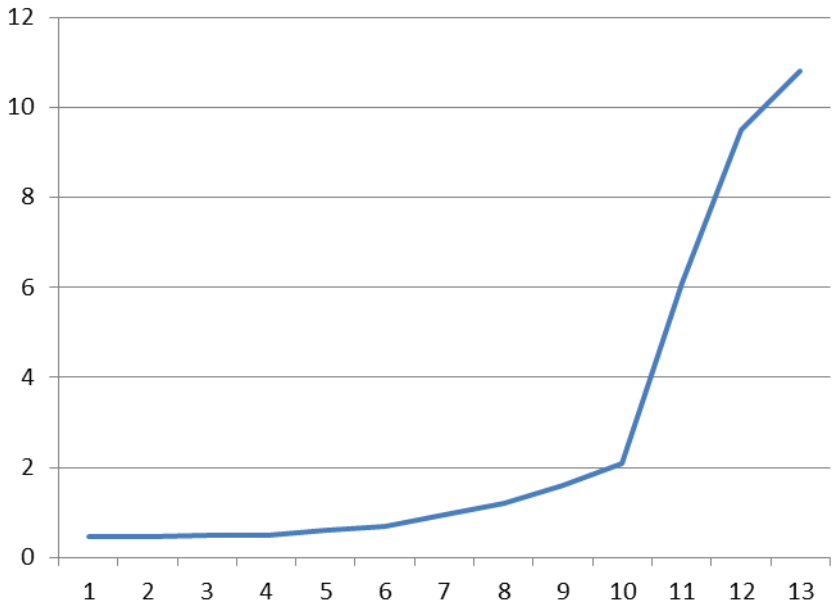


www.flatheardwatershed.org

Habul et al., 2014, 4

Environment and human population

World human population (billions)



- Increase of world human population in period 1500 – 2100 year (World human watch, 20.11.2013)
- Enormous pressure on natural resources

- x-axis: period

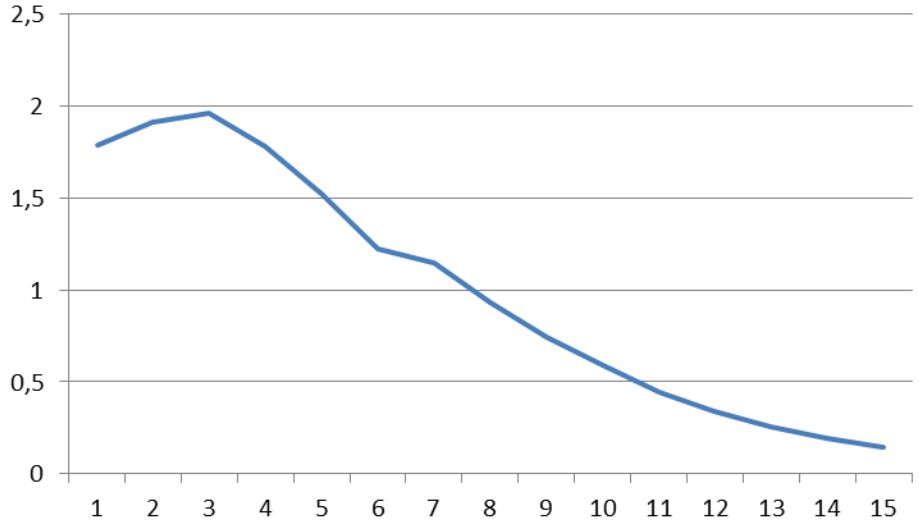
01: 1500-1550
02: 1550-1600
03: 1600-1650
04: 1650-1700
05: 1700-1750
06: 1750-1800
07: 1800-1850
08: 1850-1900
09: 1900-1950
10: 1950-2000
11: 2000-2050
etc.

Habul et al. 2014, 5

Environemt and human population: Growth rate

- period 1950 – 2090
- annual growth rate is currently declining –
- < 1% by 2020 (<0,5% up to 2050)

Percent rate (PR)(World human watch, 20.11.2013)



$$PR(\%) = \frac{\frac{(present - past\ value)}{past\ value} \cdot 100\%}{period\,(in\ our\ case\ 10\ years)}$$

- x-axis: period

01: 1950 – 1960
02: 1960 – 1970
03: 1970 – 1980
04: 1980 – 1990
05: 1990 – 2000
06: 2000 – 2010
07: 2010 – 2020
08: 2020 – 2030
09: 2030 – 2040
10: 2040 – 2050
11: 2050 – 2060
12: 2060 – 2070; etc.

Habul et al. 2014, 6

Environment and human population: environment degradation

Human impact on environment

- Land and soil (scarcity and contamination)
- Water (scarcity and contamination)
- Athmosphere (contamination)
- Ecosystem (contamination and decrease of biodiversity)

Environmental degradations result mainly from increasing trends in

- overpopulation,
- economic development,
- non-sustainable agriculture

Habul et al. 2014, 7

Environment and human population: land

- 0.5 ha/capita
  - minimum area considered essential for production of diverse, healthy nutritious diet of plant and animal products
- Currently
  - 13 billion ha total world land area
  - crops 11%; pasture 27%; forest 32%; urban lands 9%; 21% of unsuitable (e.g. infertile soil)
  - globally 0,23 ha/capita available (USA 0,40 ha; China 0,08 ha)
  - avilable resource is not adequatly used: grain production (FAO, 2000): USA 1481 kg/capita ; China 785 kg/capita
- Reasons for degradation and scarcity of land resources
  - climate change, agriculture, resources exploitation (mining)

Environment and human population: land

Soil degradation

- Erosion
  - Wearing away of topsoil by natural physical forces of water, wind or forces associated with farm activities (tillage)
  - ca 10 million of ha/a of cropland worldwide are abandoned due to erosion and diminished production caused by erosion
  - topsoil renewal is extremly slow: about 500 years for 2,5 cm
- Salinization
  - ca 10 million ha/a worldwide (mainly caused by irrigation and /or improper drainage methods)
  - ca 1,3% of total cropland/a
- Urbanization and waste disposal (in progress)
  - Land sealing (constructed infrastructure)
  - Accumulated contaminated sites
- Need for new land (replace of yearly losses) comes from the world's forest area (losses of biodiversity and CO_2 sinks)

environmanagementbitkolkata.blogspot.com

Environment and human population: water

- Water resources (in total, around 1 386 000 000 km^3)
  - surface water: 122 210 km^3 (0,3% of total fresh water)
  - atmosphere : 13 000 km^3
  - groundwater: 10 530 000 km^3

  (serc.carlton.edu)
- Scarcity of fresh water
  - Local availability and pollution are main problems
  - Access to clean drinking water
- Water scarcity affects almost every continent and more then 40% of total human population (FAO)
- 2030: 47% of world population will be living in areas of high water stress (FAO)

Habul et al. 2014, 11

Environment and human population: water

Agriculture - the largest user of fresh water (www.ifad.org):

- Irrigation : 70%
- Industry: 22%
- Domestic use: 8%

Water footprints (Mekonnen and Hoekstra, 2010):

- For 1 kg of cereals: 1644l of water
- For 1 kg carcass from beef cattle: on average 13246 l of water
  - Most of it is attributed to water use for feed production

Environment and human population: water

- Water quality degradation (Pollution): directly or indirectly discharge of pollutants (physical, chemical, microbiological) into the water body, without adequate treatment to remove harmful substances or organisms

- Agriculture is the major cause of degradation of surface and groundwater resources through erosion and chemical runoff (phosphorus, nitrogen, metals, pathogens, sediment, pesticides, salt, Biological Oxygen Demand BOD, trace elements (e.g. selenium).

Habul et al. 2014, 13


erosion
www.asce.org


Discharge of heavy metals -cadmium
www.bechorganicfarm.org

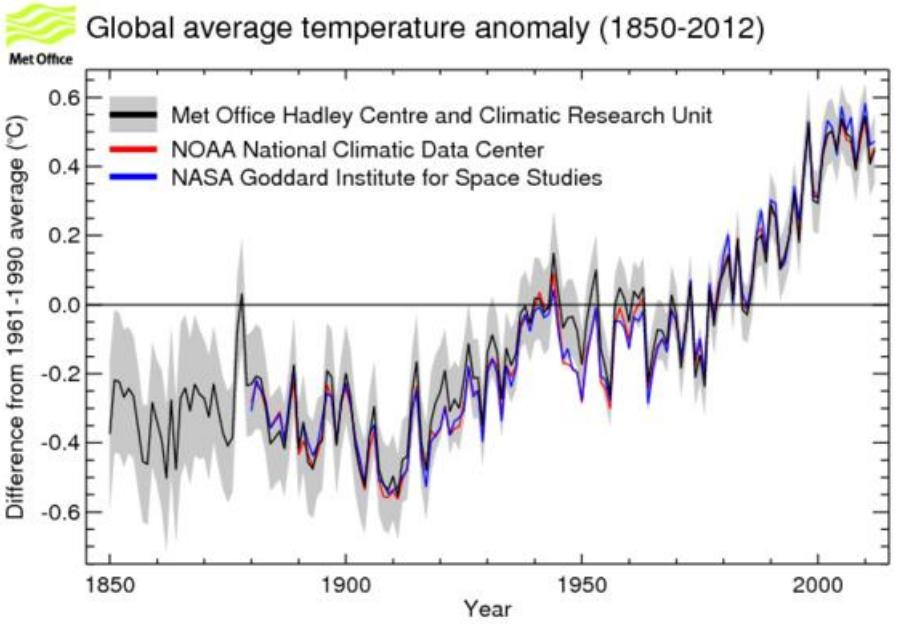

Pollution by fertilizers
Alchemistviolet.blogspot.com


Livestock access to watersource
www.omafra.gov.on.ca

Environment and human population: atmosphere

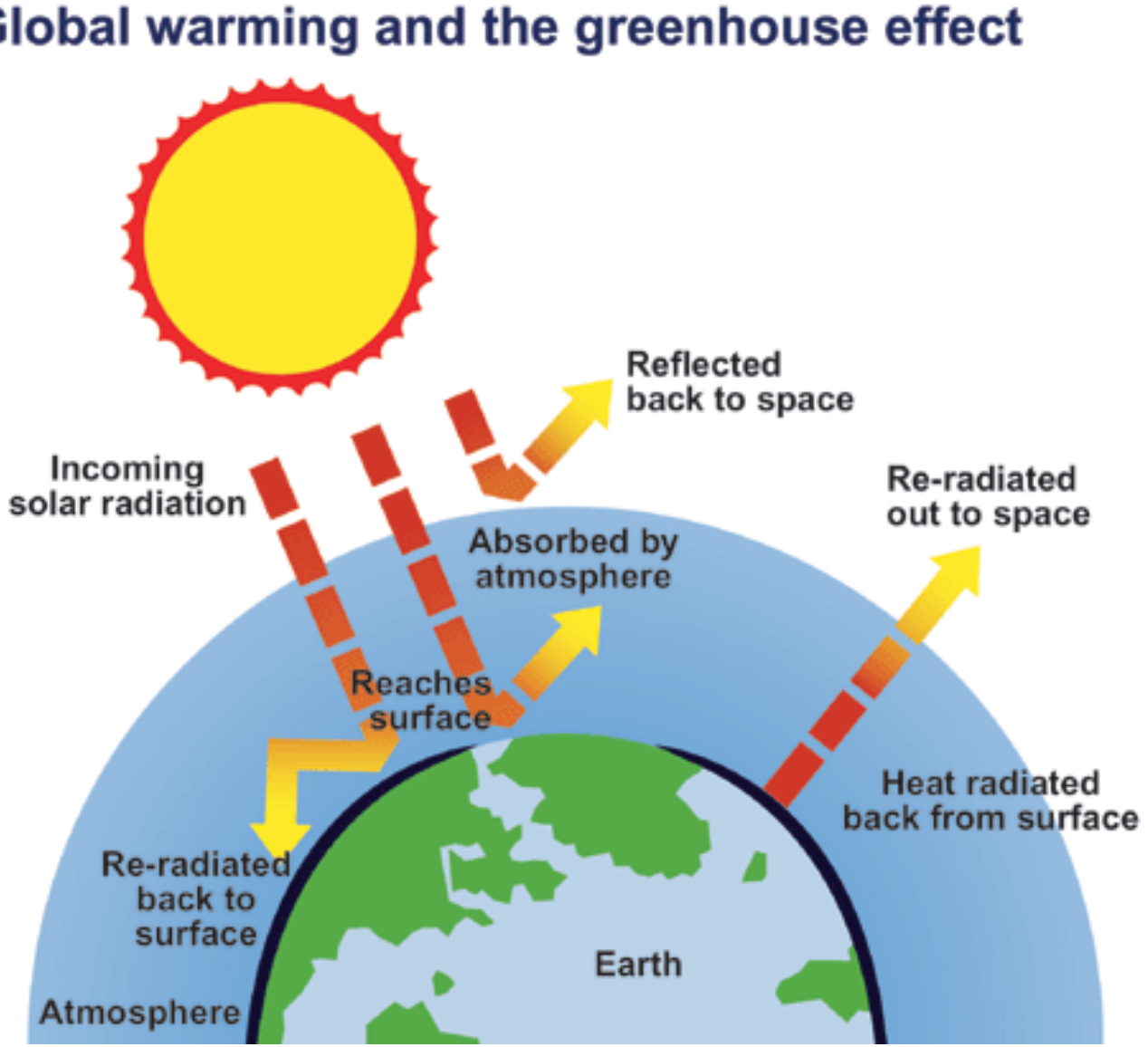
- Atmosphere
  - Layer of gases surrounding the planet retained by earth's gravity (max. 100 km).
- Global warming
  - Warming caused by human technology since the 19th century
  - A gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of CO_2, CFCs and other pollutants (Oxford dictionary).

Abnormal variations to the expected climate within the earth's atmosphere and subsequent effects on other parts of the earth



Source http://www.metoffice.gov.uk/climate-guide/science/temp-records

Environment and human population: atmosphere



http://www.co2crc.com.au/

Habul et al. 2014, 16

Environment and human population: atmosphere

- Agriculture contribution: mainly from enteric fermentation in domestic livestock, livestock manure management, rice cultivation, soil management, field burning of residues

- CH_4 and N_2O are the primary GHGs emited by agricultural activities (around 40% and 90% respectively to total amount)

- soil organic matter is a carbon pool and its distruction leads to sequestration of atmospheric CO_2 (strong focus on increase/ maintainance of soil organic matter in organic agriculture)

Habul et al. 2014, 17

Global warming (climate changes)

- Global-warming potential (GWP)
  - Relative measure of how much heat is traped by any gas in comparison to similar amount of CO_2 (commonly calculated over a specific time interval : 20, 100 or 500 years).
    - e.g. 20 year GWP of methane is 86
- Projections of future climate change suggest further global warming, sea level rise, and an increase in the frequency and severity of some extreme weather events and weather – related disaster.
- Effects include loss of biodiversity, stress to existing food-production systems and increased spread of infectious diseases (such malaria)

Habul et al. 2014, 18

Draught and desertification

www.redorbit.com

www.unccd.int

Flood

Thawing of polar ice

Globalwarmningbyakshay.blogspot.com

Environment and human population: biodiversity

Biodiversity

- Variety of life at all levels of organization (from genetic diversity within a species to diversity within entire regions or ecosystems)

Agrobiodiversity

- The variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries (FAO, 2000).
- Agrobiodiversity is the result of natural selection processes and the careful selection and inventive developments of farmers, herders and fishers over millennia (FAO, 2000).

Ecosystem services

- multitude of ways from ecosystems that humankind benefits

Habul et al. 2014, 21

Environment and human population: biodiversity

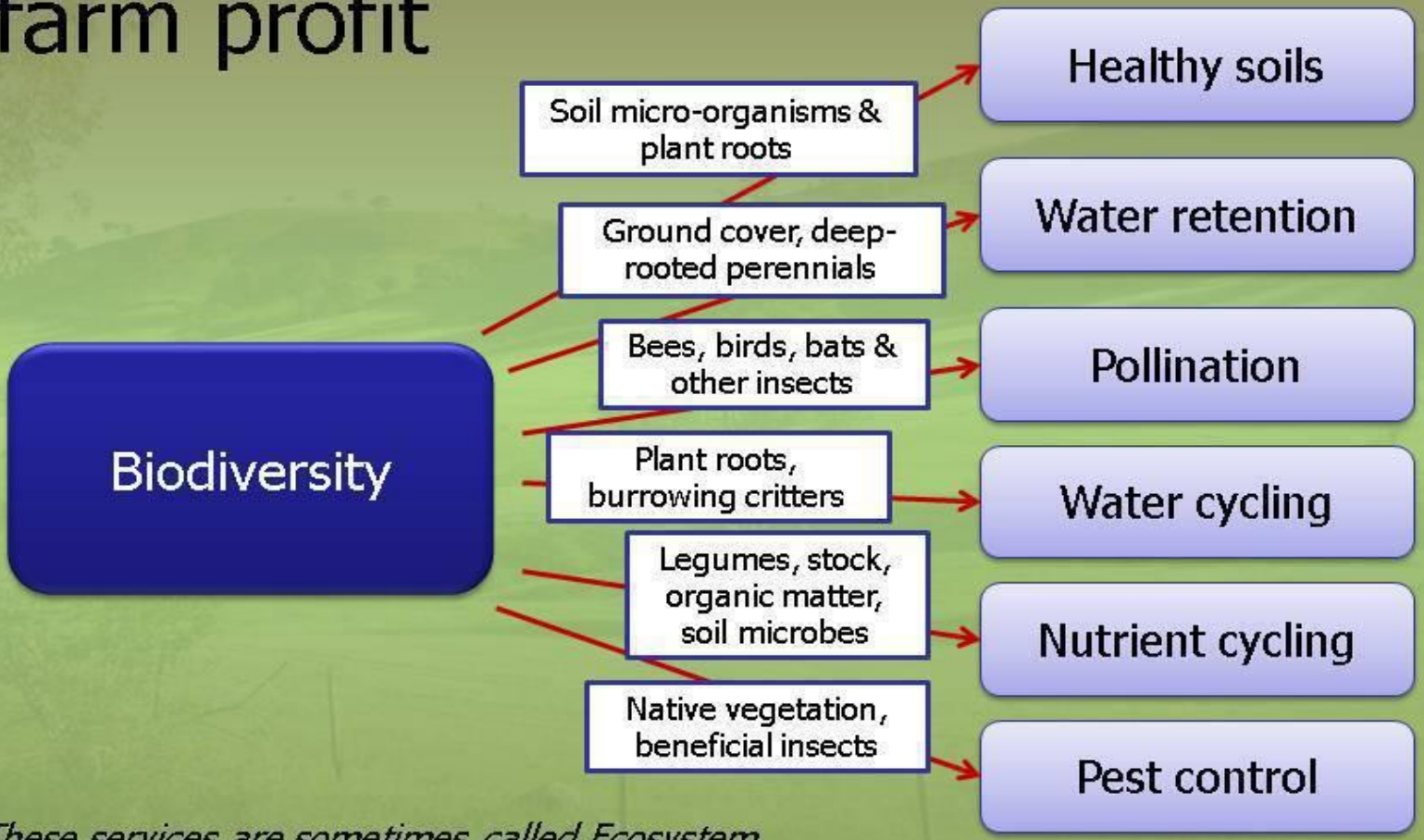
Why is it important?

- Beneficial Environmental Services
  - E.g. maintenance of the basic planetary life support system, important for food security

- Irish Potato Femine (1840) – catastrophe mainly caused by monoculture production

- The loss of genetic diversity in plant crops and animal breeds is dangerous because it makes our food supply more vulnerable to outbreaks of pests and diseases

How biodiversity supports farm profit



Integrating Production & Biodiversity

✓ *These services are sometimes called Ecosystem Services*

www.agbiodiversity.com

Name of Module Here

Habul et al. 2014,23

2. Intensive conventional agriculture and environment

Habul et al. 2014, 24

Sources of negative environmental impacts through intensive conventional agriculture

- Overuse of agrochemicals in plant and animal production and protection
- Heavy machinery (inappropriate mechanisation)
- Genetic modification in plant breeding (GMO, nanotechnology → affecting animals through feeding)

Habul et al. 2014, 25

Conventional agriculture and biodiversity

- Contributions to loss of biodiversity by
  - loss as the result of monoculture raising
  - loss as the result of genetic modification and loss of particular recombinants of genes (or gene complexes) – such as those manifested in locally adapted landraces or domesticated animals or plants that have become adapted to the natural environment from which they originated.
  - loss as the result of disturbance of natural balance caused by agricultural practice (eutrophication, salinization, desertification, global warming, etc)
- main problem related to agro-ecosystem management is the general tendency towards genetic and ecological uniformity imposed by the development of modern agriculture.

Habul et al. 2014, 26

Intensive conventional agriculture: degradation of land

- 20% of world's pastures and rangelands (70% of rangelands in dry areas) have been degredated mostly through:
  - overgrazing
  - compaction of soil
  - erosion created by livestock keeping

- Cleaning of land for feed crop production and expansion of pasture (deforestation)

Habul et al. 2014, 27

Conventional plant production: agrochemicals

Production, distribution and application of agrochemicals

1. Fast – dissolving mineral (industrial) fertilizers
2. Synthetic pesticides in agriculture
3. Storage of agrochemicals and disposal of old stock
4. Complex technologies with unknown effects (nanotechnology)

Conventional plant production: fertilizers

- Water fast-dissolving mineral fertilizers (plant nutrients)
  - easily available, strong and fast incorporation in plant tissues

- Main problems
  - production based on explotation of non-renewable sources and energy (oil and fuels)
  - application causes groundwater and surface water contamination (eutrophication)
  - application increases concentration of greenhouse gases (N_2O)
  - mineral fertilizers are responsible for the declining soil fertility and vitality of cultivated crops

Habul et al. 2014, 29

Conventional plant production: fertilizers

Explotation of non-renewable resources and energy for mineral fertilizer production

- highly energy demanding production (fossil fuels)
- causing airpollution, acidification of soils, deforestration, stress on biodiversity, etc.
- E.g. a typical ammonia plant (produces 1000 t ammonia/d requires 6000 t of water steam and high T (400^{o}C) (energy)

- Production, distribution(transport, marketing, retail), application, storage and disposal of agrochemicals contribute to
  - Large scale long-term contamination with toxic chemicals of ecosystem and living beings
  - Toxic agrochemicals demand special treatments during storage and disposal (legally defined as special dangerous waste)

Conventional plant production: synthetic pesticides

- Disease and pests cause the most damage to the crop
- Conventional agriculture is yield-orientated (kg per ha)
  - strong pesticide input to maintain increase production quantity
- Environmental degradation through synthetic pesticides
  - poison pesticides contaminate the soil, water and air
  - application of synthetic pesticides causes disease resistance developing in plants, weeds, plant-eating-insects, fungi and bacteria

Habul et al. 2014, 31

Conventional plant production: storage of agrochemicals and disposal of old stock

- Agrochemicals are often very toxic, ask for special treatment during storage
- In legislatives they have the status: special, dangerous waste
- Potential to pollute soils, water, air and endanger human and animal health

Habul et al. 2014, 32

Conventional plant production: unknown effects

- Dimension and impacts of agrochemicals and synthesized fertilizers are not entirely detectable
  - interaction, amplification and acceleration of negative aspects vary due to occurring condition and concurring agro-ecological, ecosystem, biodiversity and anthropocentric elements
  - Consequences therefore not recordable and manageable in total

- The facts: Investigation of water quality around the world, has shown that there is no part of ocean that is not contaminated (disregarding how remote) with pesticides.

- Soils contamination (input of radionuklides with fertilizers)

Conventional animal husbandry

1. Degradation of land, mostly through overgrazing,
2. Compaction and erosion created by livestock keeping
3. Large-scale animal husbandry (especially poultry and pigs) - “intensive farming”
4. Use of industrial feed components
5. Controlled reproduction. Single-sided breeding for the sake of high productivity
6. Animal welfare

Habul et al. 2014, 34

Large-scale animal husbandry (especially poultry/pigs)

- Locally concentrated , strong pressure on natural resources

Water:

- domesticated animals consume 1/10 of fresh water of global human water use
- strong cause of water pollution and waste production along production cycle (veterinary pharmaceutical residues, bedding materials, manure, slaughter waste, etc)
- Microbiological contamination of soil, water and air

Air:

- Gas emissions contribute to global warming (CO_2, CH_4, NH_3, H_2S, volatile organic compounds, dust)

Habul et al. 2014, 35

Large-scale animal husbandry (2)

- Microbiological contamination of soil, water and air:
  - Weakness in the biosecurity of production sites
- Stress on biodiversity
  - concentrated on a very small number of breeds (“high yielding breeds”), which resulted in erosion of genetic diversity

Habul et al. 2014, 36

Large scale production of eggs and meat

Habul et al. 2014, 37

Application of industrial feed components

This includes usage of:

- growth stimulators,
- preventive use of medication,
- syntethic flavour enhancers and preservatives,
- preventive use of medication (antibiotics, retardants)
- hormone treatment

Resulting in:

- Pollution of soil, water and food

Habul et al. 2014, 38

Controlled reproduction & Animal welfare

Controlled reproduction with focus on high productivity

- artificial insemination is associated with risk to disseminate genetic defects and to spread infections
- single-sided breeding (quantitative productivity)
- stress on biodiversity

Animal welfare

- Poor animal welfare has a negative impact on animal production and reproduction
- Poor animal welfare can result in loss of market access
- Legislation requires livestock owners to care for the welfare of their animals

Habul et al. 2014, 39

3. Opportunities and Challenges of Organic Agriculture in preserving natural resources

Opportunities and Challenges of Organic Agriculture

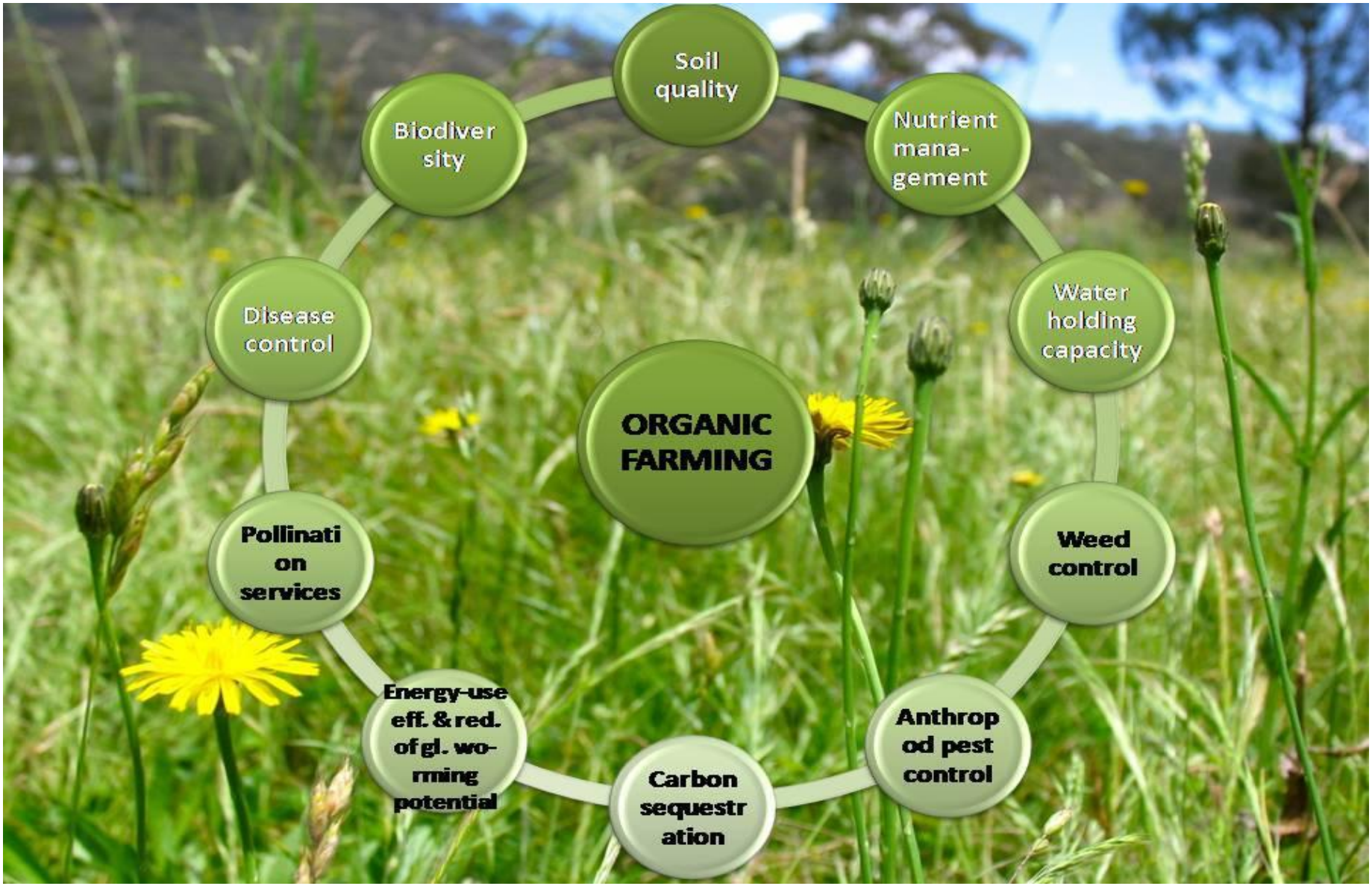
- Organic production is an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards and production method in line with the preference of certain consumers for products produced using natural substances and processes (EC. No. 834/2007)

- OA primarily relies on renewable resources within locally organised agricultural systems

- OA has a very strong emphasis on maintaining and improving soil fertility

Habul et al. 2014, 41

Opportunities and Challenges of Organic Agriculture



SNF/SCOPES

Kremen, Miles, 2012

Habul et al. 2014, 42

Benefits of Organic Agriculture

- high food quality
- high biodiversity
- plant protection by natural predators
- preservation of natural resources

Habul et al. 2014, 43

Opportunities and Challenges of Organic Agriculture: plant nutrition

- Use of agrochemicals such as fast-dissolving mineral fertilizers for plant production is strongly controlled or even prohibited
  - natural fertilzers are applied (mineralisation on field as an intergrated part of embedded natural agro-ecosystem)
  - mineral fertilizers only as slow dissolving compounds
    - nutrients are made available to the plant by the action of soil micro-organisms
  - pesticide and fertilizer application according to weather and growing stage
  - One goal is nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, as well as effective recycling of organic materials including crop residues and livestock manures

Habul et al. 2014, 44

Opportunities and Challenges of Organic Agriculture: weed control & mechanisation

- Weed, disease and pest control rely primarily on
  - crop rotations
  - natural predators
  - diversity
  - organic manuring
  - use of resistant varieties
  - limited (preferably minimal) thermal, biological and chemical intervention
- Careful mechanical intervention No use of heavy machinery impacting soil's physics
  - Avoidance of heavy machinery impacting soil´s physics, e.g. causing compression and structure modification (importance for ventilation and air-water exchange)
  - Use of less pressure on the wheels

Habul et al. 2014, 45

defenceforumindia.com

robotreviews.com

Invention of new machinery, addopted to requirement of organic production

Habul et al. 2014. 46

Organic agriculture: animal husbandry (1)

- Livestock production is fundamental to the organization of agricultural production on organic farms (organic matter, soil improvement)
- Manure is an important source of plant nutrients
- Organic livestock farming should respect high animal welfare standards and pay full regard to animal´s evolutionary adaptation, behavioural needs with respect to nutrition, housing, health, breeding and rearing
- e.g. animal welfare: avoidance of any suffering, including mutilation
- e.g. nutrition:
  - Livestock shall be fed with organic feed.
  - Growth promoter and synthetic amino acids are forbidden

Habul et al. 2014, 47

Organic agriculture: animal husbandry (2)

- e.g. breeding/ natural behavior: use of natural reproduction methods (cloning and embryo transfer are prohibited, natural mating should be used, but artificial insemination is allowed)
- e.g. rearing: Organic livestock should be born and raised on organic holding
- Persons who keep animal should possess the necessary basic knowledge and skills with regard to health and welfare needs of animals.

Habul et al. 2014, 48

agriculture.insights2.org

Organic farms:

poultry

sheep

cattle

Organic agriculture and biodiversity

- Holistic farming is basic concept of sustainable agriculture
- Organic farming relays on biodiversity of ecosystem to maintain soil fertility and to keep pests under control naturally
- It gives attention to the impact of the farming system on the wider environment and the conservation of wildlife and natural habitats
- OA encourages the use of side adapted breeds
- GMOs are incompatible with the concept of OA

Habul et al. 2014, 50

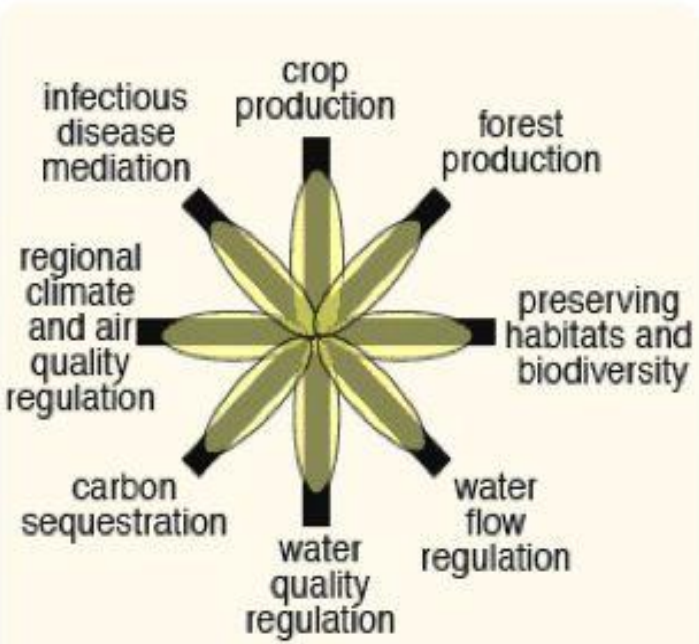
Organic agriculture and biodiversity

- Organic agriculture plays an important role in meeting Aichi Biodiversity Targets (Strategic Plan for biodiversity 2010-2020)
  - Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society
  - Reduce the direct pressures on biodiversity and promote sustainable use
  - To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity
  - Enhance the benefits to all from biodiversity and ecosystem services
  - Enhance implementation through participatory planning, knowledge management and capacity building
- Aichi Biodiversity Target 7: By 2020 areas under agriculture, aquaculture and forestry are managed sustainably ensuring conservation of biodiversity

Habul et al. 2014, 51

Organic agriculture and biodiversity

- Some of the services that could be provided from organic agriculture in restoring ecosystems



cropland with restored ecosystem services

www.triplepundit.com

Summary

1. Environment and human population

- Natural cycling
- World human population
- Environmental degradation
- Land and soil
- Water
- Atmosphere
- Biodiversity

Summary

2. Intensive conventional agriculture and environment

- Sources of negative environmental imapcts through intensive conventional agriculture
- Conventional agriculture and biodiversity
- Conventional plant production
  - agrochemicals
  - fertilizers
  - synthetic pesticides
  - storage of agrochemicals and disposal of old stocks
  - unknown effects
- Conventional animal husbandry
  - Large-scale animal husbandry
  - Application of industrial feed components
  - Controlled reproduction and animal welfare

Summary

3. Opportunities and Challenges of Organic Agriculture in preserving natural resources

- plant nutrition
- weed control and mechanisation
- animal husbandry
- biodiversity

Literature

- Council Regulation (EC) No.834/2007. Official Journal of EU.
- FAOSTAT, Database: data.fao.org
- FAO (2011): The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk. Food and Agriculture Organization of the United Nations, Rome and Earthscan, London.
- Helberg, N., Muller, A (2012): Organic Agriculture for Sustainable Livelihoods. Routledge
- Kremen, C., A.,Miles (2012): Ecosystem services in biologically diversified versus conventional farming system: benefits, externalities and trade offf. Ecology and Society 17(4):40.
- www.ipcc.ch/report/ar5/wg1/
- Mekonnen, M.M. and Hoekstra, A.Y. (2010) The green, blue and grey water footprint of farm animals and animal products, Value of Water Research Report Series No.48, UNESCO-IHE.
- http://www.metoffice.gov.uk/climate-guide/science/temp-records (accessed: 13.05.14)
- Šarapatka, B., J.Urban et al.(2009): Organic agriculture. IAEI, Prague.
- Trefil,J.,R.M.Hazen (2012): The Sciences – An Integrated approach. John Wiley & Sons.6th edition.
- Velagić-Habul, E. (2009): Okoliš i prehrambena industrija (Environment and Food technology)- lecture/class notes. FAUS.
- www.worldmeters.info (world.human.watch)

Acknowledgement

This lesson was prepared within the project „Advancing training and teaching of organic agriculture in South-East Europe (Albania, Bosnia and Herzegovina, Kosovo, Bulgaria and Hungary)“ , funded by the Swiss National Science Foundation (SNFS) within the SCOPES program 2009-2012 (project No. IZ74Z0_137328).