THE NEED FOR SUSTAINABLE FOOD PRODUCTION SYSTEMS

Boris BOINCEAN,

Doctor habilitate of agricultural sciences, research professor

HEAD OF THE DEPARTMENT OF SUSTAINABLE FARMING SYSTEMS, RESEARCH INSTITUTE OF FIELD CROPS “SELECTIA”

Chief of the Chair of Natural Sciences and Agroecology at the Alecu Russo Balti State University

Agriculture in all over the world is facing many challenges at the moment and in the future:

•Limited natural resources, including nonrenewable sources of energy with regularly increased prices on them;

•Worsening of economic conditions for farmers activities because of unfair increased prices for industrial inputs and agricultural products;

•Providing food security at the local, regional and global levels in the conditions of higher density of population;

•Loss of biodiversity and genetic diversity both in the soil and on the surface of the soil;

•Soil degradation and the danger of ground waters and food pollution on the whole food chain in the condition of globalization of economy;

•Increased negative consequences of global warming;

•Rural community desintegration.

- The role of soils very often is neglected or underestimated
- 95% of our food comes from the soil
- It takes 1000 years to built a 3 cm of upper soil layer, which can be easily destroyed during one hour as a result of torrential rain or wind erosion
- The ecological role of soils is poorly understood but critical to primary productivity, water and nutrient cycles, and carbon storage

Soil is the vital skin of Planet Earth.

Soil connects, responds to, and shapes the land, the atmosphere and its climates, surface water and groundwater, and ecosystems.

We take soil for granted – treat it as an apparently limitless resource to be husbandred or exploited for production, often without regard to soil quality.

Soil quality is responsible for providing good ecosystem services (productive, hydrological and ecological functions).

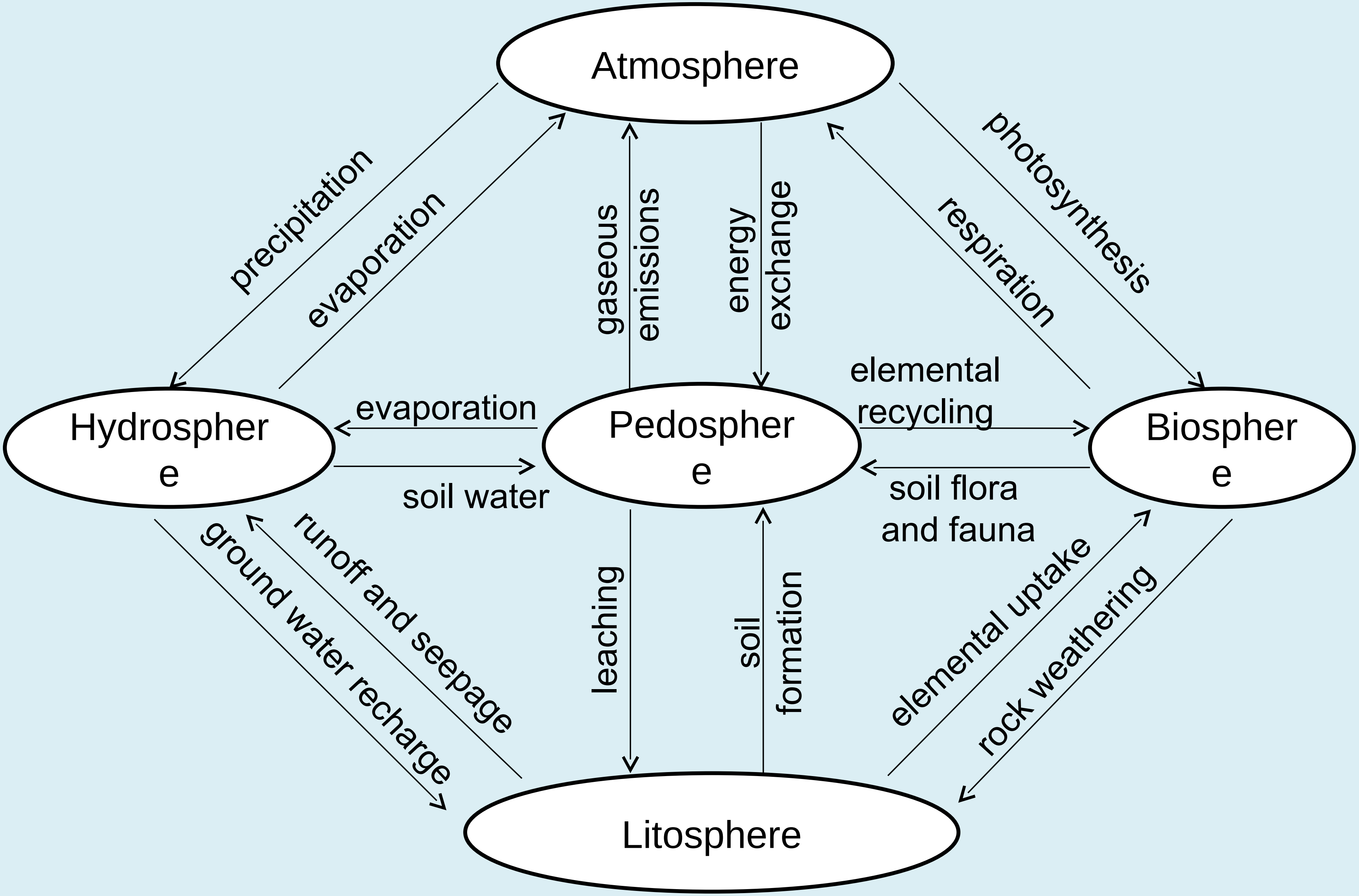

Fig.1. Main interaction between the pedosphere (soil), biosphere (plants, animals), litosphere (rocks), hydrosphere (water) and atmosphere (air)

- The explosion of human population and the industrial model of agricultural intensification have increased soil degradation and the loss of ecological and social services that soil provide
- The most pressing global issues today and for the foreseeable future are:
  - How to achieve sustainable agricultural development?
  - How to make farming resilient to global warming?

- Conventional agriculture isn’t sustainable from economic, energetic, ecologic and social points of view. It means agriculture is in crisis.

- Conventional agriculture is built around two related goals: the maximization of production and the maximization of profit. The concept of “green revolution” doesn’t suit anymore the requirements for sustainable development of agriculture or business as usual is not sustainable.

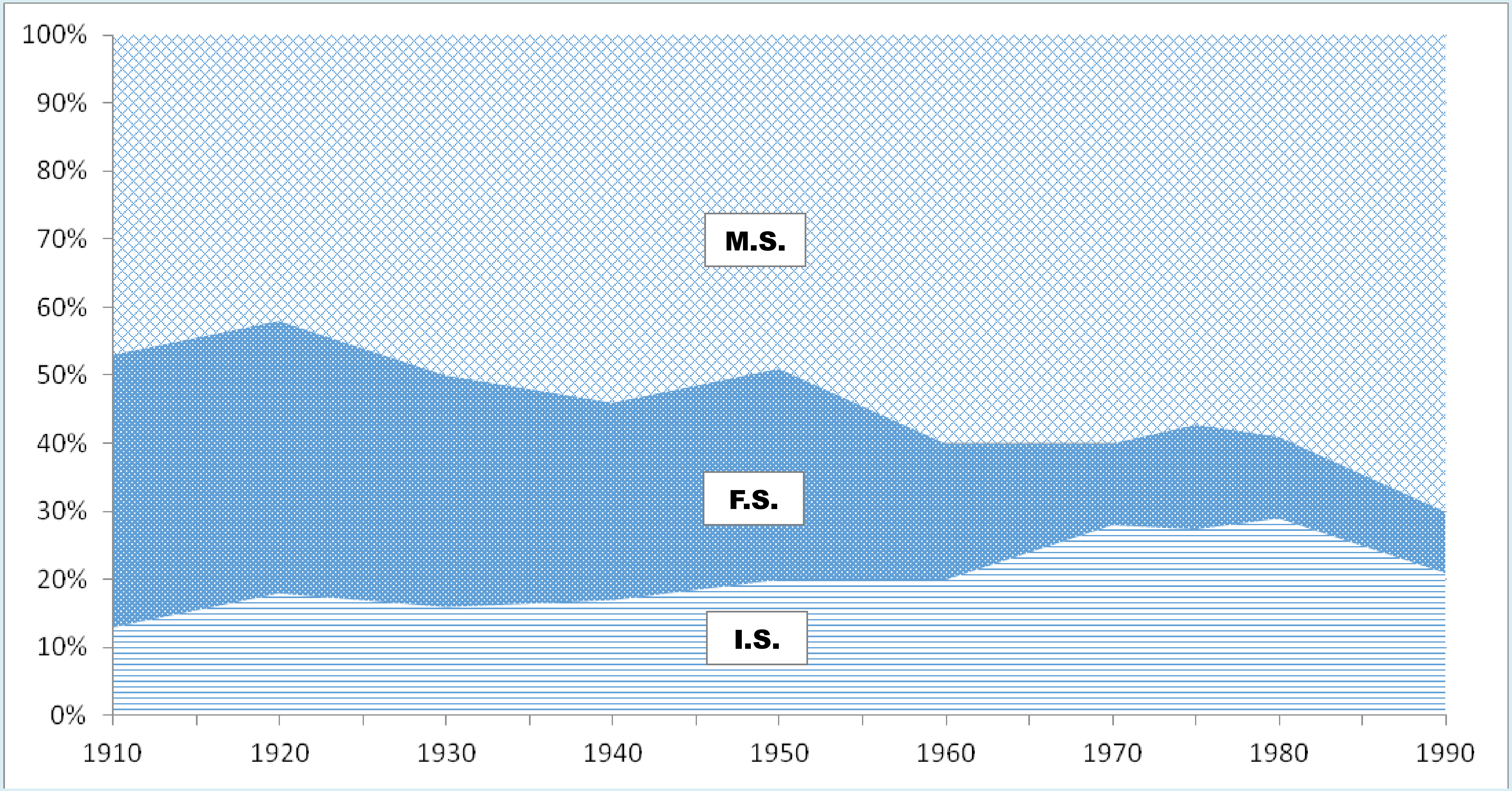

Fig. 2. Distribution of profit between the three sectors of agroindustrial complex (according prof. S. Smith, 1991)

I.S. – input sector

F.S. – farming sector

M.S. – marketing sector (processing, packaging, transportation, marketing)

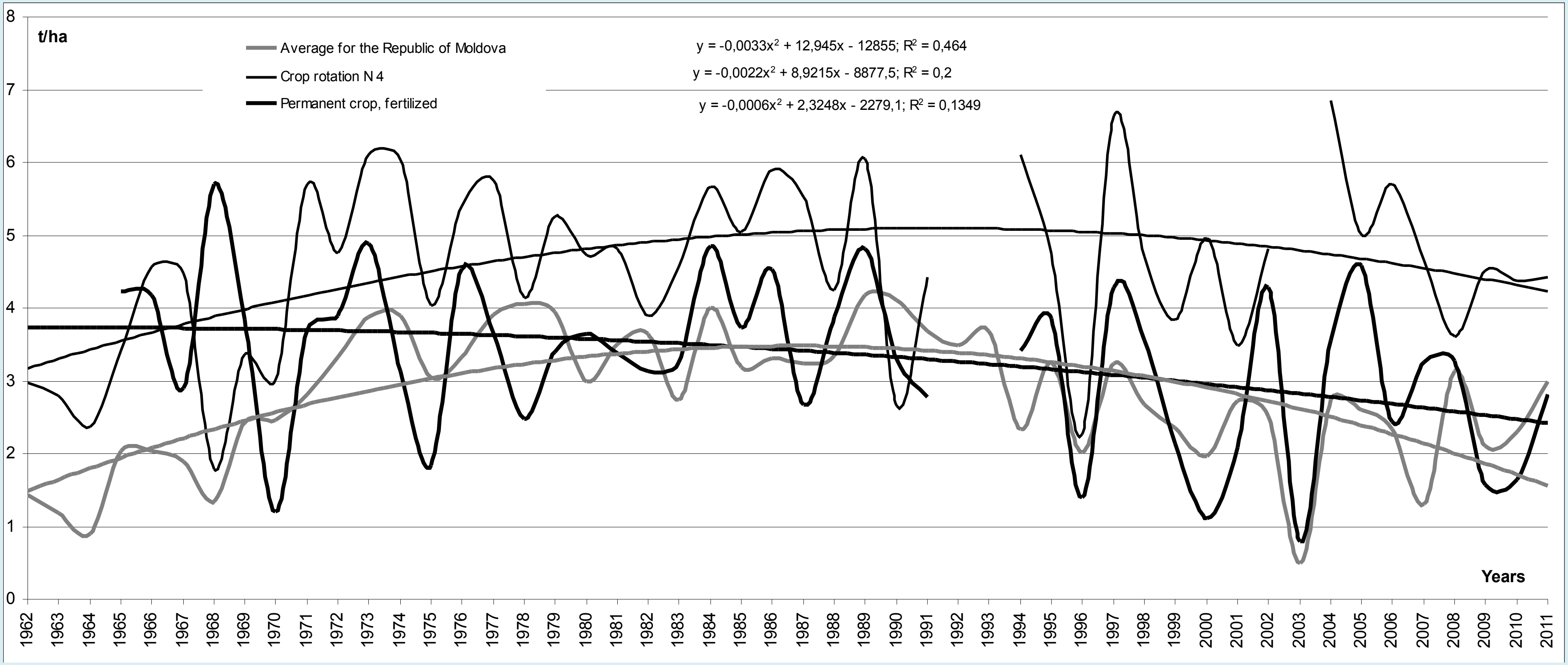

Fig.3. Yields of winter wheat in the long-term field experiment of the RIFC "Selectia" (crop rotation and permanent crop) and in average for the Republic of Moldova, 1962-2011, Mg/ha

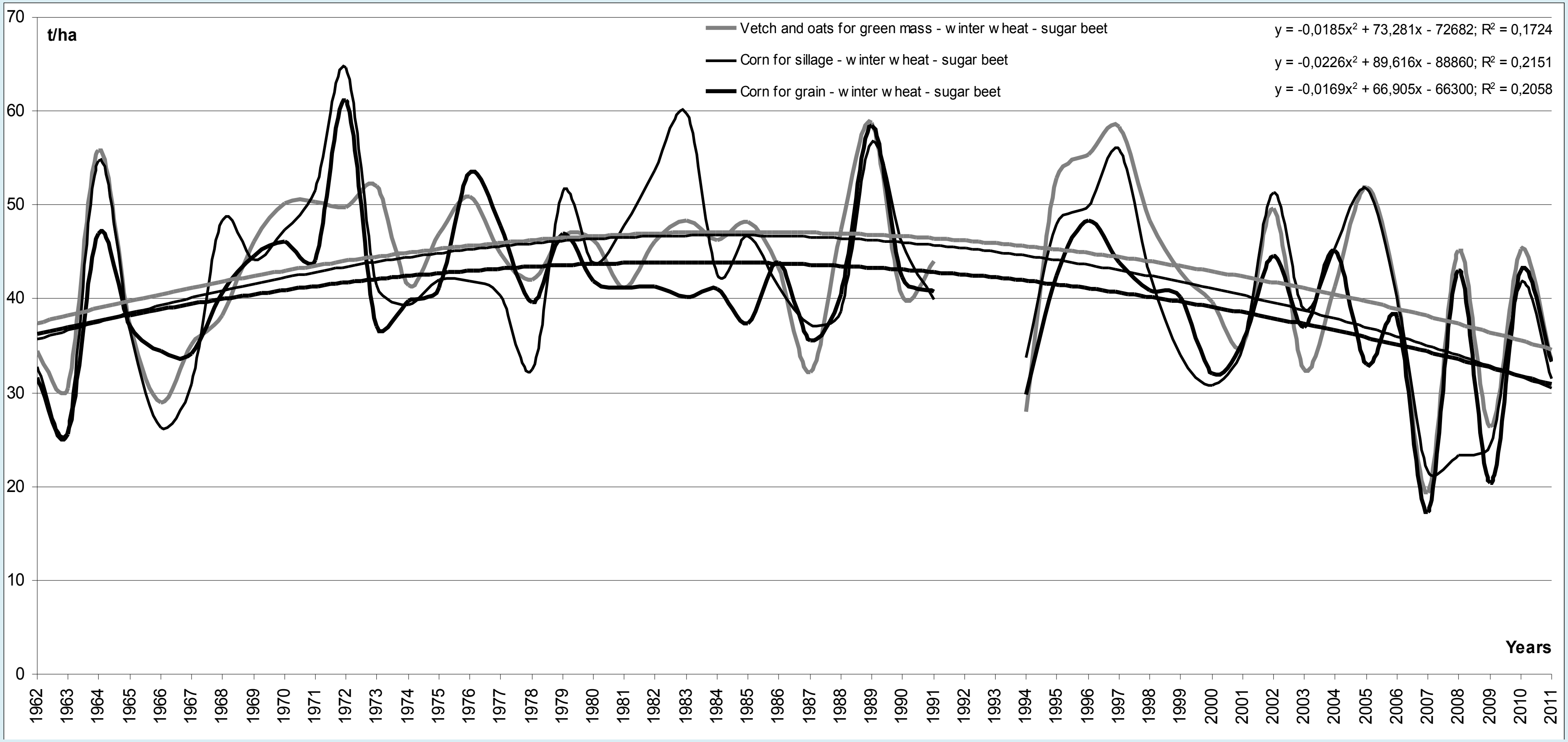

Fig.4. Yields of sugar beets in different links of crop rotations in the long-term field experiments of the RIFC "Selectia" , t/ha

- Food production is threated like an industrial process, where plants assume the role of miniature factories: their output is maximized by industrial inputs and soil is simply the medium in which their roots are anchored.

- Six basic practices are used without taking in consideration their long-term consequences on the environment and health of people:
    - intensive tillage, mainly moldboard plow
    - monoculture
    - irrigation
    - application of inorganic fertilizers
    - chemical pest, disease and weed control
    - genetic manipulation of crop plants

- **Intensive tillage** leaves the soil free of any cover for extended periods. Heavy machinery, regular and frequent passes over the field degrade soil quality (loss of soil organic matter, compaction, soil erosion etc.)

- **Monoculture** – growing only one crop in the field, often on a very extensive scale. It is closely connected with intensive use of industrial inputs

Table 1. The yield of winter wheat after different predecessors in crop rotation and in permanent mono-cropping, average for 1994-2011, in the long-term field experiments of Selectia Research Institute of Filed Crops, Republic of Moldova, t/ha and %

Crop rotation, permanent crop	Predece-ssors	Fertilization		± from fertilization	Yield reduction relatively to mixture of vetch and oats for green mass	
		unfertilized	fertilized		unfertilized	fertilized
Crop rotation	Mixture of vetch and oats for green mass	4,20	4,54	+0,34/8,1%	-	-
	Corn for silage	3,30	4,01	+0,71/21,5%	-0,90/21,4%	-0,53/11,7%
	Corn for grain	2,75	3,59	+1,02/39,7%	-1,63/38,8%	-0,95/20,9%
Permanent crop	Winter wheat	1,95	2,84	+0,89/45,6%	-2,25/53,6%	-1,70/37,4%

- **Application of synthetic fertilizers**, which are produced by industrial factories using fossil fuels and mined mineral deposits. They are supplying plants nutrients needs for the short term, but ignore long-term soil fertility.

  - Leaching of fertilizers in groundwater used for drinking makes significant health hazard

  - Volatilization of CO_2, NO, N_2O in the atmosphere is increasing the global warming effect

Table 2. The share of soil fertility in yield formation (%) in crop rotation and permanent crop for winter wheat, average for 1994-2011

Crop rotation, permanent crop	Predecessors	Fertilized plots	Unfertilized plots
Crop rotation	Mixture of vetch and oats for green mass	91,9	100
	Corn for silage	78,5	100
	Corn for grain	60,3	100
Permanent crop	Winter wheat	54,4	100

- **Irrigation**:
  - Only 16 % of the world's agricultural land is irrigated, but this land produces 40% of the world's food. Unfortunately groundwater is often pumped faster than it is renewed by rainfall. It means we are borrowing water from the future generations
  - Irrigation has a negative impact on the environment: higher rates of soil organic matter mineralization, higher rates of soil erosion, soil compaction etc.

• **Chemical pest, disease and weed control**

- After the World War II, chemical pesticides were widely used as the new, scientific weapon in humankind's war against plant pests, pathogens and weeds.
- Pesticides can reduce pest populations in the short term, but because they also kill pests natural predators, pest populations can often quickly rebound and reach even greater numbers than before. So, farmers have to use more chemicals, which is named "pesticide treadmill".
- Populations continually exposed to pesticides are subjected to intense natural selection for pesticide resistance. As a result, the pesticides use have increased dramatically, but the crop losses remained fairly constant or even increased.
- Pesticides have a negative influence on the environment and health of people.

- **<u>Manipulation of plant genoms</u>**

  - Hybrids are more productive than varieties, but they need higher rates of mineral fertilizers and a better protection against pest and disease damage
  - Hybrid plants cannot produce seeds with the same genome as their parents, what makes farmers dependent on commercial seed producers
  - GMO began recently to be used on large scale in agriculture. GMO cultivars don’t produce higher yields, but they are making farmers completely dependent from industrial inputs, especially from pesticides.

Why conventional agriculture is not sustainable?

- **<u>Soil degradation</u>** (soil erosion, compaction, contamination by pesticides, loss of soil fertility, deterioration of soil structure etc.)

  - Water and wind erosion are the most widespread forms of soil degradation (annual losses of soils consists 5-30 t/ha, but the annual rates of creation consists only 1 t/ha). The productivity of erodated soils is maintained artificially by adding synthetic fertilizers which cannot rebuild soil fertility and restore soil health

  - In order to be sustainable agriculture must reverse the process of soil degradation

- **Waste and overuse of water**

  - Agriculture accounts for approximately 2/3 of global water use and is a leading cause of regional water shortage. Agricultural practices should be oriented toward conservation of water rather than maximization of production

- **<u>Pollution of the Environment</u>**

- Agricultural pollutants include pesticides (insecticides, fungicides, herbicides etc.), fertilizers, salts etc. They can contaminate agricultural products, drinking water and aquatic ecosystems. Pesticides applied in large quantities on a regular basis (often from aircraft) are killing beneficial insects and wildlife directly and poisoning farm workers
- Mineral fertilizers (nitrates) are leaching in groundwater contaminating the drinking water; in aquatic and marine ecosystems they are causing eutrophication and the death of many types of organisms

Conventional agricultural practices are leading to declines in biodiversity, destroying the balance of natural ecosystems, compromising the natural resource on which humans and agriculture depend

- **Dependence on External Inputs**
  - Conventional agriculture has achieved its high yields mainly by increasing agricultural inputs, but in the last decades yields in all countries, in which Green Revolution practices have been adopted, began to decline.
  - Agriculture cannot be sustained as long as the dependence from inputs remains, because:
    - natural resources from which many of the inputs are derived are nonrenewable and their supplies finite;
    - dependence on external inputs leaves farmers, regions and whole countries vulnerable to supply shortages, market fluctuations, and price increases.

- **<u>Loss of Genetic Diversity</u>**

  - During the last decades the genetic base of most major crops has become increasingly uniform.

  For example, only 6 hybrids of corn account for more than 70% of the world's corn crop, which makes crop more vulnerable to attack of pests and pathogens; to changes in climate and other environmental factors.

- **<u>Loss of local control over agricultural production</u>**

- Large scale monoculture systems with high levels of mechanization and external inputs have drastically reduced the number of farms and farmers everywhere.
    - In USA since 1920 the numbers of farms have decreased from more than 6,5 mln to less than 2 mln, and the population that lives and works on farms has dropped below 2%. In developing countries rural people continue to abandon the land to move to urban and industrial areas
    - Large scale commodity–oriented farming is encouraging not only exodus from rural areas, but they also reduce the control of rural communities on food growing. Experience – based management skill is replaced by purchased inputs requiring more capital, energy, and use of non-renewable resources
    - The share of the consumer dollar in the farmer profit is now less than 9%

- **Global inequity**

  - Despite increases in productivity and yields hunger persists all over the globe
  - Those with more land and resources have had better access to the new technologies
  - As long as conventional agriculture is based on First – World technology and external inputs accessible to so few, the practice of agriculture will perpetuate inequity, and inequity will remain a barrier to sustainability

- **<u>Agroecology as a basis for sustainable agriculture</u>**
  - Agroecology is the application of ecological concepts and principles to the design and management of sustainable agroecosystems

    The agroecological approach to agriculture builds on the resource-conserving aspects of local and small-scale agriculture
  - Agroecology supposes a holistic (systemic) approach to agricultural intensification instead of a reductionistic (simplistic) approach
  - Agroecology is based on using natural ecosystems as models for agroecosystems

Structural and functional differences between natural ecosystems and agroecosystems (Odum, 1969 and Gliessman, 2000

Indicators	Natural ecosystems	Agroecosystems
Net productivity	Medium	High
Trophic interaction	Complex	Simple, linear
Species diversity	High	Low
Genetic diversity	High	Low
Nutrient and energy cycles	Closed	Open
Stability (resilience)	High	Low
Human control	Independent	Dependent
Temporal permanence	Long	Short
Habitat heterogeneity (ecological infrastructure)	Complex	Simple

Agriculture: a catalyst for transitioning to a Green Economy

- SUSTAINABLE SYSTEMS for agricultural production(organic, biodynamic, Fairtrade, Global GAP) present viable alternatives to existing, unsustainable farming practices.

Such systems offer opportunities for competitive economic returns, the supply of essential and life supporting ecosystem services, the creation of decent jobs and livelihoods, increased resilience to climate change, and enhanced food security

Soil quality (soil health) is crucial in the transition to a more sustainable agriculture

- Changes in the soil structure due to compaction by heavy farm equipment supress root development, thus reducing the quantity of soil nutrients and water that can be accessed by crops
- A decline in soil organic matter following intensive tillage can reduce the water-holding capacity of a soil, making the crop more susceptible to water deficits and drought during the growing season
- A soil with good physical, chemical and biological, properties is able to produce higher crop yields, can generate more income than a poor – quality soil

Physical, chemical and biological soil indicators for assessing soil quality (John Doran, 1996):

A. Physical:

- Texture
- Topsoil depth
- Water infiltration rate
- Bulk density
- Water – holding capacity

B. Chemical:

- Soil organic matter
- Total nitrogen
- pH
- Electrical conductivity
- Extractable nutrients (N, P, K)

C. Biological:

- Microbial biomass carbon
- Microbial biomass nitrogen
- Potentially mineralizable nitrogen
- Soil respiration
- Earthworms

Soil organic matter content can be used as a universal indicator of soil quality. The search for chemical and physical fractions of the soil organic matter pool that could be relevant indicators of soil quality is ongoing.

A good quality soil can provide besides a relevant crop production a better ecosystem services:

- filtering and purifying water before it is released to waterways
- inorganic and organic pollutants can be absorbed and some can be degraded
- buffer for climate changes by promoting the growth of plants that sequester CO_2 from the atmosphere and contributing to the humification and physical protection of carbon from plants and other organic residues
- healthy soil provides health for the whole chain: crops – animals – people
- changing the habits to eat will stimulate transition to a more sustainable agriculture.

Participatory workshop (discussions in groups):

1. How does the holistic approach of agroecology allow for the integration of the three most important components of sustainability: ecological soundness, economic viability and social equity?
2. Why has it been so difficult for humans to see that much of the environmental degradation caused by conventional agriculture is a consequence of the lack of an ecological approach to agriculture?
3. How food consumption can promote the new paradigm of sustainable development of agriculture?

Mahatma Gandhi listed 7 sins of humanity:

1. Wealth without work
2. Pleasure without conscience
3. Knowledge without character
4. Commerce without morality
5. Politics without principle
6. Religion without sacrifice
7. Science without humanity

The last one “Science without humanity” is especially relevant to the tragedy that 1.020 million people or 15% of the world total population still remains food insecure.

“Poor soils make poor people, poor people make soils worse, and desperate humanity does not care about sustainability and stewardship.

If Gandhi were alive today he would add three more sins into this list of 7:

8. Technology without wisdom
9. Education without relevance
10. Humanity without conscience

To treat the world community as one family, we must build bridges across nations. Working together to address global issues is an effective strategy to build such bridges.

Thanks for your attention !