SCRIPT Agrobiodiversity and ecosystem services main concepts

**SLIDE 1**

Welcome to the today lecture. I am Prof. Francesco Romagnoli from the Institute of Energy Systems and Environment at the Riga Technical University. I am happy to share with you the contents of the lecture on “Agrobiodiversity and ecosystem services main concepts”.

**SLIDE 2**

This lecture is organized into three main parts: Agrobiodiversity main concepts, Connecting Global Priorities within agrobiodiversity and examples of agrobiodiversity assessment and preservation strategies

**SLIDE 3**

I am now going to focus on the main aspects and concepts of Agrobiodiversity.

**SLIDE 4**

Four main parts will be dedicated to this section:

* An introduction about biodiversity
* Overview about agrobiodiversity
* Management of agrobiodiversity
* Holistic concepts of Agrobiodiversity and assessment methods

**SLIDE 5**

Let’s now start with an overview about biodiversity.

**SLIDE 6**

According to the definition from the Convention on Biological Diversity, Article 2 Biodiversity means “*Variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*”.

Biodiversity (also called Ecological or biological diversity) refers to diversity in plants and animal and is a major point of discussion encompassing the future of biology and agricultural activities,

Basically it can be represented as

* **the richness and beauty of all life on Earth**, such as ants to whales, genes to ecosystems. Its quality, diversity and functioning is the world’s natural capital and it builds the basis of our economic and social well-being and that of all future generations.
* **the diversity of all life on earth** which varies over time and place. For example, fewer birds live in Scandinavia in winter than in summer and a different number of organisms can be found in the tundra and the savannah. Biodiversity is not limited to national parks: it is everywhere.
* **Integral to sustainable development** by providing vital goods and services, such as food, timber, carbon sequestration and flood regulation.

**SLIDE 7**

Diversity can be considered in different forms and scales in terms of :

* diversity between species
* Diversity within species
* Diversity of ecosystems

**SLIDE 8**

Biodiversity can also be identified as other types of dimensions, namely ecological, genetic and organismal.

* **Ecological diversity** includes a larger scale in terms of Bioregions, landscapes, Ecosystems, Habitat, Niches, populations
* **Genetic diversity** includes population, individuals, chromosomes, genes, and nucleotides
* **When we refer to organismal diversity, we talk about** kingdoms, phyla, families, genera, species, subspecies, population, individuals.

As you can see population is an overarching key aspect.

**SLIDE 9**

Let‘s now tal about Some data and general trends

* In the United States, biodiversity has declined by 31% since the 15th century.
* 71% of fish species have become extinct in Europe/Central Asia
* 87% of wetlands have been lost since the beginning of the modern era
* More than 25,000 species are on the list of threatened or endangered animal and plant species around the globe

Eight out of 18 ***ecosystem services defined by Millennium Ecosystem Assessment (MEA)*** have substantially decreased since 1960.

But what are **Ecosystem services (which we will in-depth see in the continuation of this presentation)?**

Ecosystem service means benefits people receive from ecosystems. These include:

* provisioning services (like food, water);
* regulating services and service (regulation of floods, drought,...);
* supporting services (soil formation)
* cultural services (recreational);
* and other non-material benefits (health and well being)

The most impacted ecosystem services amongst others are: pollination, drinking water purification, and protection against erosion and flooding

But some ecosystem services have been intensified, like producing agricultural goods, animal husbandry, and harvesting timber from forests.

**SLIDE 10**

Looking on other figures towards about the overall status of biodiversity worldwide, we found that

* the actual estimated total number of species on Earth is about 6.5 million species
* 86% of all species on land and 91% of those in the seas have yet to be discovered, described and catalogued
* The actual species extinction rate is in the range of 50 – 300 species per day, with a total species number in 130.000 years equals to 0

With the current extinction rate, only a marginal number of species and their role in providing ecosystem services can be described and discovered.

It should be highlighted that this loss is anthropologically caused and has little to do with natural variations.

**SLIDE 11**

The factors more affecting the current level of biodiversity are related to immediate or underlined causes. About immediate cause the more relevant factors can be summirezed in terms of:

* Destruction and degradation of ecosystems, in terms of expansions of agriculture, forest and aquaculture and thus land use change as well as involving habitat losses and ist fragmentation
* Overexploitation of natural resources including overuse of soild, overfishing and deplitation of water resrouces together with too high exploitation of wild living organisms
* Contamination, icluding pollutions of soil water and atmoshpere
* Climate change in terms of number and range of species will decline greatly as temperatures continue to rise

Biodiversity is a non-detachable part of the concept of sustainability. Biodiversity is essential for agricultura producution, as agricultura should be for biodiversity conservation

As well, new species introductions could represent drivers on biodiversity loss how will see better in the next slide…

**SLIDE 12**

Invasive alien species are non-native species causing damage to the environment and potentially causing species extinction, modifying ecosystem processes and acting as disease vectors. In addition, the problems caused by alien invasive species have potentially large economic consequences.

In the slide, we could see 3 different types of invasive spesies in EU from North Korea, China and Himalayan countries.

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**SLIDE 14**

Understanding the drivers behind the trends in biodiversity losses is essential to address the causes of its loss and, at the same time, to seize opportunities for biodiversity in supporting schemes.

The main factors affecting the current level of biodiversity consided as underlying causes can summirezed in terms of:

* Human social organization
* Growth of human population
* Patterns of natural resource consumption
* Global trades
* Economic systems and policies that fail to value the environment
* Inequity in ownership, management and flows of benefits

**SLIDE 15**

Agriculture is the largest contributor to biodiversity loss. The current biodiversity situation in Europe reflects the impact of the development and expansion of farming in the past few centuries. Biodiversity is also affected by land-use change, habitat fragmentation and destruction, climate change, and invasive alien species.

The result has been increased use of chemicals and machinery, and more open and homogeneous landscapes. As it possible to see from the picture on the right, losses of diversity increase the risk of declining yields due, for example, to loss of disease resistance or environmental tolerance, or to decreasing vitality, fertility or fitness caused by inbreeding (the production of offspring from the mating or breeding of individuals or organisms that are closely related genetically). Losing genetic diversity means irretrievably losing future breeding options. This may also reduce the capacity of ecosystem to adapt to unforeseeable disease risks or to environmental variations like climate change. Thus Intensive livestock farming is claimed to have an undesirable effect on biodiversity

In the pictures are reported 3 different scenarios for the loss of number of species beyond the 21st century: the EU, the German and the one of the Convention on Biological Diversity. Two of them are more optimistic but the one of on Biological Diversity is still adverse. This is why the cconvention on Biological Diversity (CBD) post-2020 global biodiversity framework encourages countries to take action for safeguarding agrobiodiversity by making better use of the vast number of species and varieties available for human consumption.

**SLIDE 16**

A new study published today in the journal *Nature* gives a global view of this damage since the 1500s. It shows that by 2005, worldwide land use change had caused a drop of 14 per cent in the average number of species found in local ecosystems. Most of this loss came in the last 100 years.

The study is the first global analysis of human impacts on local biodiversity. Scientists submitted data from more than 70 countries and considered around 27000 species. The team's figure of a 14 per cent drop in species in local ecosystems is a global average. So local biodiversity in some areas is still quite intact, but others - including Western Europe - have had losses of 20-30 per cent.

This is important because 20 per cent is widely considered the tipping point beyond which an [ecosystems](https://phys.org/tags/ecosystems/)' ability to provide the natural services like flood protection or control of pest outbreaks are compromised.

'For example as biodiversity declines, outbreaks of crop pests become more likely,' said Andy Purvis, the study's lead scientist and Museum biodiversity expert. 'We can spray crops and spend money to reduce that risk but that is basically compensating for something that biodiversity used to provide before'. ([https://phys.org/news/2015-04-major-biodiversity-losses-reversed.html#jCp](https://phys.org/news/2015-04-major-biodiversity-losses-reversed.html))

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The International Union for Conservation of Nature (IUCN) redlist provides information about range, population size, habitat and ecology, use and/or trade, threats and necessary conservation actions

Established in 1964, IUCN Red List of Threatened Species has evolved to become the world´s most comprehensive information source on animal, fungi, and plant species' global conservation status.

To date, IUCN assessed 98,500 species for the IUCN Red List, detecting 27 00 species with extinction risk rapresent more that the 27% of the assessed species

This trend is because less space and resource means smaller number of individual in total and potential diversification, which is an irreversible change!

**SLIDE 18**

Why biodiversity is important? This is mostly due to its intrinsic (also called inherent value) and extrinsic (also called utilitarian or instrument value.

**Intrinsic value** is in general The value of something independent of its value to anyone or anything else. It is a value independent of any benefit to humans.

Intrinsic value of biological diversity is initially ambiguous to which objects or characteristics of biological diversity have to being valued. For example if we are talking about all aspects of biological diversity in terms of species or ecosystems we can argue that intrinsic value of one species is often in conflict with the intrinsic value of other species.

**Extrinsic in general** defined all values that derive from something external to the thing valued.

Extrinsic value for biodiveristy differs on the basis of external factors. Some species have trivial or negative extrinsic values. Moreover extrinsic value varies across human cultures and societies and with such factors as socioeconomic conditions, individual experiences, and educational backgrounds.

This way the extrinsic value is affected by several stakeholders or actors having a direct effect on biodiversity resource exploitation of use like: local communities, land planner, different lobbies, governmental and non-governmental agency.

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Talking about **direct use values, we see in this slide an overall summary. Food and medicine rapresents one of those**

**About** food production today, most people rely on aournd 20 types of plants, and only 3 to 4 are stable crops, and diversity is critical for developing new strains and breeds.

**Regarding medicine a**bout 80% of the people in developing countries use plants as a primary source of medicine. 57% of the 150 most-prescribed drugs have their origins in biodiversity

**Indirect Use Values** can be defined as both eco- and other types of services and regulating global processes, such as:

* atmosphere and climate
* Soil and water conservation
* Nutrient cycling
* Pollination and seed dispersal
* Control of agricultural pests
* Genetic library
* Inspiration and information
* Cultural, spiritual, and aesthetic
* Community Resilience planning
* Strategic

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Let’s not more concretely move to the concept of agrobiodiversity…

**SLIDE 21**

**We have seen as Biodiversity is essential to**:

* ensure the production of food, fibre, fuel, fodder;
* maintain other ecosystem services;
* allow adaptation to changing conditions - including climate change
* sustain rural peoples' livelihoods .

**Certainly, Biodiversity and agriculture are strongly interdependent for several in terms of different perspective.**

* Origin of all species of crops and domesticated livestock and the variety within them. it is also the foundation of ecosystem services essential to sustain agriculture and human well-being.
* Today's crop and livestock biodiversity are the result of many thousands years of human intervention.
* Biodiversity and agriculture are strongly interrelated because while biodiversity is critical for agriculture, agriculture can also contribute to the conservation and sustainable use of biodiversity.
* Sustainable agriculture both promotes and is enhanced by biodiversity.
* Ecosystem services essential to sustain agriculture and human well-being

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**Agrobiodiversity is an important part of biodiversity**

It is a vital sub-set of biodiversity. Many people's food and livelihood security depend on the sustained management of various biological resources that are important for food and agriculture.

Agrobiodiversity (as you can see in Figure) can be broadly defined as all domesticated biodiversity (namelly crops and livestock) within agricultural systems, plus non-domesticated biodiversity that interplay in various ways with the health and functioning of agricultural systems. The former role is declining primarily in response to farm intensification, which has eroded natural capital in many agroecosystems. Biodiversity and agrobiodiversity are underpinned by sustaining natural capital and agroecosystems. The various elements that comprise agrobiodiveristy are outlined

**Agricultural biodiversity, also known as agrobiodiversity thus** includes:

* Harvested crop varieties, livestock breeds, fish species
* non domesticated (wild) resources within field, forest, rangeland including tree products, wild animals hunted for food and in aquatic ecosystems (e.g. wild fish);
* Non-harvested species in production ecosystems that support food provision, including soil micro-biota, pollinators and other insects such as bees, butterflies, earthworms, greenflies; and
* Non-harvested species in the wider environment that support food production ecosystems (agricultural, pastoral, forest and aquatic ecosystems).

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The term ‘agrobiodiversity’ was coined in the 1980s. According to UNCED (1992), it has evolved only in recent years in the wake of the general biodiversity discourse. Agrobiodiversity is the sub-set of general biodiversity directly developed and managed by humans. Analogous to the term biodiversity, agrobiodiversity encompasses different levels. It refers to the biodiversity of agroecosystems along with species of crops and farm animals, and the genetic variance within populations, varieties and races. Soil organisms, insects, fungi, and wild species from off-farm natural habitats as well as cultural and local knowledge on biodiversity form the basis of the exploitation of biodiversity.

Four principal components of agrobiodiversity exist:

1. genetic resources for food and agriculture;
2. biodiversity that supports ecosystem services of agriculture;
3. abiotic factors, e.g., climate; and
4. socioeconomic and cultural dimensions.

**SLIDE 24**

Providing a general definition agrobiodiversity can be defined as *“…The variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agroecosystem”.*

* Agricultural biodiversity includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems. It defined as “the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agroecosystem.
* It can be considered an essential part of agrobiodiversity as it is the human activity of agriculture which conserves this biodiversity.
* Agrobiodiversity is the outcome of the interactions among genetic resources, the environment and the management systems and practices used by farmers and herders. It has developed over millennia, as a result of both natural selection and human interventions.

**SLIDE 25**

Agrobiodiversity is complex and this relied on the some definition given to agrobiodveristy

Agrobiodiversity includes all crops and livestock, their wild relatives, and all interacting and supporting species such as pollinators and symbiotic agents related to pests, parasites, predators, and competitors. In the current definition, agrobiodiversity refers to a comprehensive concept emphasizing crops and livestock.

The Food and Agriculture Organization (FAO) explains agrobiodiversity as the variety and variability of animals, plants and micro-organisms that are crucial for food and agriculture, and which originate from the interaction between the environment, genetic resources and the management systems and those practices used by people. In particular, it contains two categories:

1. the wild relatives of domesticated species (for example, wild relatives of crop species or species that are genetically usable breeding materials);
2. or breeding individuals of plants and domesticated animals (which in the case of crops, is referred as landraces). This FAO definition seems to be comprehensive and acceptable in many scientific communities.

Agricultural expansion and intensification led to biodiversity loss in agroecosystems (Tscharntke et al., 2012) and reduction in the types and levels of ecosystem services that people benefit from (Barral et al., 2015). Farmland biodiversity is a ground for provision of ecosystem services needed to sustain agriculture per se and the environment as a whole.

**SLIDE 26**

Understanding the complexity of the values and processes underlying the management of local genetic resources and related traditions is a fundamental step for both private and public stakeholders to take for agrobiodiversity resource conservation and sustainable valorization

* Agricultural biodiversity is the result of natural selection processes (for example adapting to changing weather patterns or particular land characteristics) that have been intertwined with the careful selection and inventive developments of farmers, forest dwellers, hunter-gatherers, herders and shers over millennia (e.g. selecting for taste, ease of processing or harvesting).
* Sustainable managing agricultural biodiversity provides resources and processes embedded in farming systems, which allow these systems to meet current food and nutrition needs, while having minimal negative impact on the environment and generating multiple ecosystem services.
* Agrobiodiversity is the result of the interaction between the environment, genetic resources and management systems and practices used by culturally diverse peoples, and therefore land and water resources are used for production in different ways.
* Thus, agrobiodiversity encompasses the variety and variability of animals, plants and micro-organisms that are necessary for sustaining key functions of the agro-ecosystem, including its structure and processes for, and in support of, food production and food security.
* Local knowledge and culture can therefore be considered as integral parts of agrobiodiversity, because it is the human activity of agriculture that shapes and conserves this biodiversity

**SLIDE 27**

Following the definitions above, it is essential to any understanding of agrobiodiversity to know

1. how farmers practices and circumstances affect different aspects of biological diversity ranging from genetic to the whole landscape; and
2. how biological diversity affects rural elements of society from individual livelihoods to households, communities and the wider economy.
3. Overlying this two-way interaction are different scales of operation, both spatially and temporally, and different degrees of modification of natural biological diversity.

The figures shows the conceptualization of the elements of agrodiversity according to Brookfield and their relationship with each other. Each element contains components that contribute to the main characteristics that would typify that particular element and the start of the construction of a potential agrodiversity database.

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Locally varied food production systems could be under threat, including local knowledge and the culture and skills of women and men farmers. With this decline, agrobiodiversity is disappearing; the scale of the loss is extensive. With the disappearance of harvested species, varieties and breeds, a wide range of unharvested species also disappear.

Figures and trends shows that more than 90 percent of crop varieties have disappeared from farmers' fields; half of the breeds of many domestic animals have been lost. In fisheries, all the world's 17 main fishing grounds are now being fished at or above their sustainable limits, with many fish populations effectively becoming extinct. Loss of forest cover, coastal wetlands, other “wild” uncultivated areas, and the destruction of the aquatic environment exacerbate the genetic erosion of agrobiodiversity.

More in specific:

* Since the 1900s, some 75-percent of plant genetic diversity has been lost as farmers worldwide have left their multiple local varieties and landraces for genetically uniform, high-yielding varieties.
* 30-percent of livestock breeds are at risk of extinction; six breeds are lost each month.
* Today, 75-percent of the world's food is generated from only 12 plants and five animal species.
* Of the 4-percent of the 250-000 to 300-000 known edible plant species, only 150 to 200 are used by humans. Only three-rice, maize and wheat - contribute nearly 60-percent of calories and proteins obtained by humans from plants.
* Animals provide some 30-percent of human requirements for food and agriculture and 12-percent of the world's population live almost entirely on products from ruminants.

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Why it is important agrobiodiversity? In agricultural systems biodiversity is important for:

1. for the production of food, fibre, fuel, fodder...(**goods**)
2. to conserve the ecological foundations to sustain life (**life support function**)
3. to allow **adaptation** to change situations (like climate change, natural disaster, etc. …)
4. and to sustain **rural peoples’ livelihoods** (sustainable agriculture – food security, income, employment,...)
5. Biodiversity loss in the agricultural landscape affects not just the production of food, fuel, and fiber but also a range of ecological services supporting clean water supplies, habitats species and human health

**There is a specific role played by agrobiodiversity**: it has been developed through human intervention over generations and it requires human management to sustain it

**SLIDE 30**

Experience and research have shown that the role of agrobiodiversity can be defined in terms of:

* Increase productivity, food security, and economic returns,
* Reduce the pressure of agriculture on fragile areas, forests and endangered species,
* Make farming systems more stable, robust, and sustainable,
* Contribute to sound pest and disease management,
* Conserve soil and increase natural soil fertility and health,
* Contribute to sustainable intensification
* Diversify products and income opportunities
* Reduce or spread risks to individuals and nations
* Help maximize effective use of resources and the environment,
* Reduce dependency on external inputs
* Improve human nutrition and provide sources of medicines and vitamins, and,
* Conserve ecosystem structure and stability of species diversity.

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What is nowadays required is a fundamentally different model of agriculture based on diversifying farms and farming landscapes.

There is a general consensus that business as usual is not working, and it is time for a paradigm shift. The 2030 Agenda and its Sustainable Development Goals provide such a framework, which focuses on achieving multiple benefits at the same time – for example:

* including nutrition goals in farming systems;
* increasing yields without increasing the levels of inorganic and synthetic chemicals in the system;
* shaping landscapes which create positive synergies between wild and cultivated lands;
* improving environmental integrity while reducing poverty and gender inequality.

The Sustainable Development Goals are indivisible and not hierarchical. However, none of the social and economic goals can be achieved if there is an inadequate natural physical resource base to sustain human life.

In this representation of the Sustainable Development Goals, the economy serves society, and both depend on the integrity of the biosphere. In this vision, all the Sustainable Development Goals are directly or indirectly connected to a sustainable product value chain still preserving agrobiodiverisity.

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Thus as presented in the picture agricultural biodiversity contributes to multiple sustainability dimensions and SDGs. Measuring agrobiodiversity enables researchers, policy makers, and farmers to work toward a more sustainable food system. Numerous validated methodologies and indicators have been developed for assessing agricultural biodiversity; however, quantifying biodiversity remains problematic as no single indicator is universally applicable (Morris et al., 2014). Indices include the Simpson's diversity (Simpson, 1949), Shannon's diversity (Spellerberg and Fedor, 2003), and more recently, Dietary Species Richness (Lachat et al., 2018)—each holding strengths and limitations.

Beyond conventional measures of agricultural production, metrics should include additional indicators that measure agrobiodiversity for nutritional quality, nutritional diversity, food systems, and dietary diversity (Hunter et al., 2016). As a potential solution, Biodiversity International has recently developed the Agrobiodiversity Index (ABD Index) as a method of measuring agrobiodiversity in a consistent, long-term manner to be applied across all pillars of sustainable food systems. The ABD Index assesses diversity in production, food markets, consumption, conservation, and seed systems. We will see a bit more of this index in the third part of this video lecture.

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How we can describe the components of agrobiodiversity? These can be differentiated in terms of:

1. Habitat diversity – land use varies with soil and terrain. Hedges, borders, three in the land scape and farm type
2. Inter-species diversity – different species of plan, animal and microbial
3. Intra-species diversity – very important for agrobiodiversity including genetic resources and unique traits like resistance to drought, cold, disease and other aspects like rooting, taste and storage
4. Harvested species and associated species: species used for food (e.g. rice, maize), pollinators, beneficial or harmful predators, soil organisms.
5. Socio economic and cultural diversity include: traditional and local knowledge of agrobiodiversity, cultural factors ….in terms of type of farmer and farm, regulations, common property, resources an ownerships, tourism connect agricultural land scale
6. And understanding the implication of agrobiodiversity in ecosystem systems within specific functions and processes and services provided

**SLIDE 34**

As said Agricultural biodiversity is defined as “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”

As it possible to see there are several key components and dynamics affecting agrobiodiversity.

Agrobiodiversity can be identified at levels:

1. **ecosystem levels** (in terms of landscapes, bioregions, landscapes, biomes, habitats and **populations**),
2. **species or organismal levels** (in terms of kingdome, phyla, families, genera, species, subspecies and populations),
3. **genetic diversity** (individuals, genes) thus the variation which a species can have

As it is possible to see from the picture the variety of crops, animals has certain values providing specific product on one side and on the other regulating ecosystems and ecosystem services

Agricultural biodiversity is a critical component of a sustainable food system. Without agricultural biodiversity, a food system cannot be sustainable.

What we need is to be able to produce a wide variety of nutritious foods while having minimal impact on the environment – a sustainable food system.

The loss of agricultural biodiversity in our global food production systems is an issue of increasing concern, recognized by the Rio Convention on Biological Diversity and the Sustainable Development Goals of the United Nations.

When we lose agricultural biodiversity, we also lose the options to make our diets healthier and our food systems more resilient and sustainable.

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It is interesting to have a look on the concept of Functional AgroBiodiversity. By definition, how how can be seen from the conceptual diagram reported in the slide, functional AgroBiodiversity provides regulating, provisioning and cultural ecosystem services that are essential for human well-being. Positive synergies often exist among regulating, provisioning and cultural services and biodiversity conservation.

The green area in the diagram highlights the core focus of Ecosystems services. The red area highlights positive spin-off of Functional AgroBiodiversity to the local context (for example water quality or recreation), global environment (e.g. [climate change](https://en.wikipedia.org/wiki/Climate_change)) and society as a whole. The graph is adapted from the [Millennium Ecosystem Assessment](https://en.wikipedia.org/wiki/Millennium_Ecosystem_Assessment) . Supporting services are not included here as they are not directly used by the people.

The concept of functional agrobiodiversity is increasingly being used as a framework in scientific research, policymaking and on-farm implementation.

Trying to provode a defmotopm Functional agrobiodiversity (FAB) refers to ‘those elements of biodiversity on the scale of agricultural fields or landscapes, which provide ecosystem services that support sustainable agricultural production and can also deliver benefits to the regional and global environment and the public at large’.

Important relationships between agriculture and FAB which could be taken into account by agro-environmental measures

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As also described in the previous conceptual scheme FAB supports agricultural production guarantying:

1. Direct contributions to the crop yield by **pollination**, mainly by insects, but also mammals and birds, some pollinating insects have below-ground larval stages. Wild agrobiodiversity also plays an important supplementary role. A significant portion of fruit production is dependent on pollination by insects.
2. biological **pest control** by parasitism and predation, often made by insects which may have below-ground larval stages or use soil animals as alternative prey; natural enemies of plague insects can help to keep them below the damage threshold, so that the use of crop protection products is limited or not necessary; disease can be controled by fungi and bacteria, indirectly also by soil animals such as earthworms;
3. **nutrient regulation of soils and crops** e.g. by nitrogen-fixing bacteria, efficient uptake of nutrients via mycorrhiza; a provisional service is g**enetic diversity** as a prerequisite for the ability to adapt. It is vitally important to maintain genetic diversity, in order for agricultural crops and livestock to be able to adapt – naturally or with human intervention – to future needs and challenges.
4. Soil organisms ensure the maintenance and development of good soil structure, with positive effects on water regulation, erosion, leaching, etc. the **favourable soil structure is made** by fungi, bacteria, earthworms and other soil animals; moreover aeration and creation of soil pores by burrowing soil animals allows easy soil penetration and growth of plant roots. Moreover **natural and semi-natural vegetation in the agricultural landscape** can help in erosion control, relieve heat stress in cattle, etc. It also provides a habitat for other useful organisms, such as natural enemies of plague species, and it determines the appearance of the landscape.
5. **decomposition and mobilisation and immobilisation** of nutrients by microorganisms decomposing organic matter and mineralizing nutrients, processes which are mediated by soil animals (e.g. via bioturbation, litter fragmentation and translocation of plant remains);
6. **regulate soil water-drainage and moisture holding capacity** . Double sided arrows indicate mutual dependency of services; these may result in synergies or trade-offs.

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The status of agrobiodiversity varies importantly at EU level.

Looking at the study of Overmarset in 2014 it is possible to see how agrobiodiversity, here defined as the total number of species, presents a wide range.

The study of Overmarset in 2014 based on Sum of the species occurrence maps for the 132 species included in the analysis per 50 km grid cell revealed that the state of the overall biodiversity in agriculture is better in the southern and eastern parts compared to the western and northern part of the European Union (EU). They adopted a species-oriented methodology enabling spatially explicit indicator for biodiversity quantification on agricultural lands. The provided map demonstrates great variety in the state of the biodiversity of agricultural areas in the EU.

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Because agricultural biodiversity has co-evolved with farming and breeding systems, so it is already deeply integrated within these systems. Therefore, increasing what we know about agricultural biodiversity, its components, and their interactions can help countries leverage their existing resources and knowledge for integrated nutrition and environmental outcomes.

Agricultural biodiversity is, however, under threat. Despite the many benefits it provides, agricultural biodiversity is being lost as:

* Farming production systems have shifted to more intensive production practices which rely on fewer varieties, genes or species
* Traditional agricultural practices and knowledge are displaced (by intensive, external input-based management practices) and undervalued
* Climate change and land-use changes accelerate land degradation
* Value chains are under pressure to provide standard products year round in any country and any season.

Conservation approaches have been developed to stem agrobiodiversity loss and strengthen seed systems to ensure that agrobiodiversity **preservation, availability and accessibility** when and where it is needed.

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There are many reasons for this decline in agrobiodiversity. The decline has accelerated throughout the 20th century and increased demands from a growing population and greater competition for natural resources. The principal underlying causes include:

* **The rapid expansion of industrial and Green Revolution agriculture.** This includes intensive livestock production, industrial fisheries and aquaculture. Some production systems use genetically modified varieties and breeds. Moreover, relatively few crop varieties are cultivated in monocultures and a limited number of domestic animal breeds, or fish, are reared or few aquatic species cultivated.
* **Globalization of the food system and marketing.** The extension of industrial patenting, and other intellectual property systems, to living organisms has led to the widespread cultivation and rearing of fewer varieties and breeds. This results in a more uniform, less diverse, but more competitive global market. As a consequence there have been:
* changes in farmers' and consumers' perceptions, preferences and living conditions;
* marginalization of small-scale, diverse food production systems that conserve farmers' varieties of crops and breeds of domestic animals;
* reduced integration of livestock in arable production, which reduces the diversity of uses for which livestock are needed; and,
* **Reduced** use of “nurture” fisheries techniques that conserve and develop aquatic biodiversity.
* The main cause of loss of variability from crop populations (also called genetic erosion of crops)is **the replacement of local varieties by improved or exotic varieties and species.** Frequently, genetic erosion occurs as old varieties in farmers' fields are replaced by newer. Genes and gene complexes, found in the many farmers' varieties, are not contained in the modern. Often, the number of varieties is reduced when commercial varieties are introduced into traditional farming systems.

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The main global threats to which agrobiodiversity is exposed are:

* **Climatic Change** including global warming, which have an effect on the provision on service for example like food production in terms of food provision security availability, access absorption
* **Population Growth and Overpopulation**, which depends on the way resources are used and distributed amongst the population
* **Cultural change**, in an **urban – industrialization** era culture Farmers' attitudes and desires are influenced by their society's culture, moreover **Cultural changes** could have an effect on field appliances and bring introduction of new crops

Other threats are represented by:

* **Environmental pollution** and use of pesticides which indirectly bring to acidification problems
* **Deforestation** decreasing the size of the arable land and thus diversity. Clearing the Earth's forests on a large scale worldwide and resulting in many land damages. One of the causes of deforestation is to clear land for pasture or crops
* **Natural disaster** to which fiels crops or livestock are exposed to
* **Overgrazing** - Overgrazing can be defined as the practice of grazing too many livestock for too long a period on land unable to recover its vegetation, or of grazing ruminants on land not suitable for grazing as a result of certain physical parameters such as its slope. Overgrazing exceeds the carrying capacity of a pasture thus not giving the possibility to provide an ecosystem service with loss of biodiversity
* **Overharvesting** “that refers to the harvesting of a renewable resource like plants, fish stocks, forests, grazing pastures, and game animals. Sustained overharvesting is one of the primary threats to biodiversity bring leading to resource destruction, including extinction at the population level and even extinction of whole species.
* **Desertification**. Desertification is **caused by reduction of biodiversity and causes further reduction of biodiversity**. Reduction of biodiversity reduces carbon sinks hence increasing climate change. Thus, it is the loss of biodiversity that initiates the vicious circle of desertification-global warming-further loss of biodiversity
* **Eutrophication** is process by which a water body becomes enriched in dissolved nutrients (such as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen. The **eutrophication** in an aquatic ecosystem causes significant changes in **biodiversity**. Eutrophication leads to **changes in the availability of light and certain nutrients to an ecosystem**. This causes shifts in the species composition so that only the more tolerant species survive and new competitive species invade and out-compete original inhabitants.

Thus non-living factors that affect agrobiodiversity are thus climatic and chemicals

**SLIDE 41**

In this slide we are to explain a bit more about land degradation.

Landscapes around the world are undergoing simplification due to changing patterns of land use. Changing land-use practices can result in a reduction of agrobiodiversity —crop, livestock and aquatic diversity and the biodiversity associated with ecosystem functions, such as pollination and soil productivity. Land-use changes that take insufficient account of their consequences for agrobiodiversity may lead to the loss of landscapes’ capacity to support sustainable production and rural livelihoods

Although land use activities have positive effects on biodiversity of a region in many cases, land use might also lead to decreasing species abundance (Henzen, 2008). The interrelationship between land use and biodiversity is vital to harmonize the links between people and surrounding environment (Haines-Young, 2009).

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The biodiversity concept along with the overall richness of species, present in a particular area, covers the diversity of genotypes, functional groups, communities, habitats and ecosystems. Consequently, there is a complex relationship between biodiversity and land use (Zeller et al., 2017). These dual relationships are often bilateral and thus identification and justification of cause and effect relationships are difficult. In some places, land use plans or land management activities may be crucial for sustaining specific patterns of biodiversity such as urban forest and urban agriculture (Haines-Young, 2009).

To attain a systemic and systematic conservation plan, assessments of lands impact are required.

**SLIDE 42**

An effect of land degradation is presented in this Picture due to an overand intnsive use of land

This figure shows the trade-offs among ecocsystem services and biodiersity with land use intensification, using food production as an example. In this specific example as food production increases, there is a decreas in other ecosystem services and biodiverstiy (illustrated by reduced bars) as compared to the undegraded state. In extreme cases, land has been degraded to the point of abandonment (right panel), thus providing less of all ecosystems services. This pattern generally applies to all ecosystems and land-use types. Source: Adapted from Van der Esch et al. (2017)

**SLIDE 43**

The Convention on Biological Diversity was inspired by the world community's growing commitment to sustainable development. It **represents** the **conservation of biological**

**diversity**, **the sustainable use of its components**, and **sharing of benefits** arising from the use of genetic resources.

According to The Convention on Biological Diversity , **agrobiodiversity is comprised of four dimensions**

1. **PLANT**
2. **ANIMAL**
3. **MICROBIAL, and**
4. **and FUNGI**

**SLIDE 44**

Looking such dimensions with particular attention for the food and agriculture plant genetic resources, includes crops, wild plants harvested and managed for food, trees on farms, pasture and rangeland species.

**With referring to The International Treaty on Plant Genetic Resources for Food and Agriculture- 2001 there are specific aims**

The Treaty facilitates access to the genetic materials of the 64 crops in the Multilateral System for research, breeding and training for food and agriculture.

The Treaty aims at:

1. recognizing the enormous contribution of farmers to the diversity of crops that feed the world;

2. establishing a global system to provide farmers, plant breeders and scientists with access to plant genetic materials;

3. ensuring that recipients share benefits they derive from the use of these genetic materials with the countries where they have been originated.

**SLIDE 45**

Animal genetic resources (AnGR) is used to include all animal species, breeds and strains that are of economic, scientific and cultural interest to humankind in terms of food and agricultural production for the present or the future..

Another equivalent term increasingly used is farm animal genetic resources.

More than **40 species of animals** that have been domesticated (or semi-domesticated) during the past 10 to 12 thousand years which contribute **directly** (through animal products used for food and fibre) and **indirectly** (through functions and products such as draft power, manure, transport, store of wealth etc.)

In the picture …

**SLIDE 46**

Microorganisms include all living organisms other than plants and animals and are mostly microscopic cellular organisms that include bacteria, mycoplasmas, protozoa, fungi and some algae.

As we said soil microrganisms ensure the maintenance and development of good soil structure, with positive effects on water regulation, erosion, leaching, etc. In addition, a healthy soil ecosystem ensures the release of nutrients and better disease resistance, which are essential to good crop development. Moreover they have a function of **nutrient regulation of soils and crops** e.g. by nitrogen-fixing bacteria, efficient uptake of nutrients.

There are some key issue regarding such genetic resource like:

* Lack of information of microorganism diversity, combined to
* Lack of research programs related to their role in ecosystem functions.
* Moreover it is difficult to detect early changes in ecosystems without proper techniques. One example is drinking water testing for microbial contamination.

**SLIDE 47**

Fungi are among the most important organisms in the world, not only because of their vital roles in ecosystem functions but also because of their influence on humans and human-related activities.

Fungi are essential to such crucial activities as decomposition, nutrient cycling, and nutrient transport and are indispensable for achieving sustainable development.

**SLIDE 48**

FAO proposes 5 main the benefits provided by agrobiodiversity:

1. Offering a diverse nutritious food necessary to provide source of food and nutrition to human, livestock and cultivated plants,
2. Support plants and animal adapting to climate changes
3. Increase resilience of producers
4. Preserve human health and ecosystems
5. Improve soil fertility and water quality

Moreover should be also considered as benefits:

* The medical and health value
* The genetic resource provided for plant and animal
* The overall taxonomy knowledge
* And of course the overall socio-economic to support livelihood

We will further an emphasis on ecosystems services in the next slides.

**SLIDE 49**

We already saw how the scheme of Functional Agricultural biodiversity (FAB) described the benefits towards agrobiodiveristy preservation. Here we can will say something more about **agricultural practices based on biodiversity**

**Using agricultural practices based on biodiversity – genetic, varieties, species, soil and landscapes – can increase yields, and reduce waste and dependencies on external inputs.**

• Soil erosion can be reduced by using agricultural biodiversity practices, such as hedgerows, cover crops, agroforestry or intercropping. In Indonesia, intercropping coffee trees with vegetables in hilly areas led to a 64% reduction in soil erosion, and no decrease in coffee yield.

• Pest and diseases can be controlled by selecting plants that increase the number of pest predators, or by using pest or disease resistant varieties.

• Greater diversity in landscapes – with patches of trees, wild vegetation, oral strips – leads to more diverse pollinators. Organic elds worldwide have been found to host about 70% more bees and 50% more kinds of bees than conventional elds.

• Crop diversity, increased vegetation diversity and certain agroecological practices enhance wild biodiversity conservation.

• Soil quality. Cropping systems with high agricultural biodiversity from crop rotations, displayed increased soil carbon by 28%–112% and nitrogen by 18%–58% compared with those with low agricultural biodiversity.

• Yield. with patches of trees, wild vegetation, oral strips corn and soybean systems by adding crop rotations while reducing tillage increased yield by 7% and 22% respectively.

• Diversity among and within species increases resilience to environmental fluctuations because they respond differently to change or create beneficial synergies.

**SLIDE 50**

Let’s now to have a closer look about the link among agricultural biodiversity and ecosystem services.

Ecosystem services as defined as “those benefits people obtain from ecosystems. These include services such as food, water, timber and fibre (provisioning); services that affect climate, floods, disease, wastes and water quality (regulating); services that provide recreational, aesthetic and spiritual benefits (cultural). The human species, while buffered against environmental changes by culture and technology, is fundamentally dependent on the flow of ecosystem services.”

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* Ecosystems have potential to supply a range of services that are of fundamental importance to human well-being, health, livelihoods, and survival (Costanza et al., 1997; Millennium Ecosystem Assessment (MEA), 2005; TEEB Synthesis, 2010).
* Different ways of defining ecosystem service have been developed so far – they can be described as the benefits that people obtain from ecosystems (MEA, 2005) or as the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010).
* More recent publications define the ecosystem services (ES) as contributions of ecosystem structure and function (in combination with other inputs) to human well-being (Burkhard et al., 2012; Burkhard B. & Maes J. Eds., 2017).

**SLIDE 52**

As it can be seen also in the figure the components of agrobiodiversity that support ecosystem services upon which agriculture is based include a diverse range of organisms that contribute to nutrient cycling, pest and disease regulation, pollination, pollution and sediment regulation, maintenance of the hydrological cycle, erosion control, carbon sequestration and climate regulation.

The economic assessment of services provided by agrobiodiversity at the landscape level is affected by the combination of different types of agricultural and non-agricultural ecosystems.

In specific there are 4 main categories describing the ecosystem services: provision services, regulating services, supporting services, and cultural services.

**SLIDE 53**

Mostly based on the Millennium Ecosystem Assessment (MEA) ecosystem services there are 4 types of categories that can be defined as:

1. **provisioning services** (i.e., products obtained from ecosystems such as food, forage, feed, fiber, and fuel), A good that humans can use directly. Examples of provisions include lumber, food crops, medicinal plants, natural rubber, and furs.
2. **regulating services** (e.g., climate regulation), Natural ecosystems help to regulate environmental conditions. Natural ecosystems, such as tropical rainforests and oceans, remove carbon from the atmosphere. Ecosystems also are important in regulating nutrient and hydrologic cycles.

**Resilience** depends greatly on species diversity. For example, several different species may perform similar functions in an ecosystem, but differ in their susceptibility to disturbance. If a pollutant kills one plant species that contains nitrogen-fixing bacteria, but not all plant species that contain nitrogen-fixing bacteria, the ecosystem can still continue to fix nitrogen

1. **Supporting services**. i.e. feedback services, that are necessary for proper delivery of the other three types of services, such as nutrient cycling. Focusing on relations between ecosystem services and agriculture. Natural ecosystems provide numerous **support services** such as pollination of food crops. Ecosystems also provide natural pest control services because they provide habitat for predators that prey on agricultural pests.
2. **cultural services** (i.e., non-material benefits such as aesthetic and recreational enjoyment), The awe-inspiring beauty of nature has instrumental value because it provides an aesthetic benefit for which people are willing to pay. Similarly, scientific funding agencies may award grants to scientists for research that explores biodiversity with no promise of any economic gain.

With referring to the picture Le Roux et al. ([2008](https://link.springer.com/article/10.1007/s13593-015-0306-1)) categorized services into “input services” (to farming systems) and “output services” (from). Input services include Millennium Ecosystem Assessment ’s “supporting services” (e.g., soil fertility, microclimate regulation) and “regulating services” (e.g., pollination, natural pest control) (Figs. [2](https://link.springer.com/article/10.1007/s13593-015-0306-1), [3](https://link.springer.com/article/10.1007/s13593-015-0306-1), and [4](https://link.springer.com/article/10.1007/s13593-015-0306-1)). “Input services” enable farming systems to depend less on marketed inputs, e.g., mineral fertilizers, pesticides, and irrigation water. “Output services” include what we call hereafter “agricultural services” that are marketed with their quantitative and qualitative properties (e.g., cash crops, milk, meat), and “environmental services” that are nonmarketed, e.g., cultural value.

**SLIDE 54**

In the last part of this presentation we are going to see some holistic view on the concepts of agrobiodiversity and an introduction to specific assessment methods

**SLIDE 55**

Agriculture and food systems are prominent drivers of changes in global Earth and socioeconomic systems in the “Anthropocene,” a time of intense human interactions with the planet.

* Biodiversity of agriculture and food systems has undergirded the long-term development and spread of agriculture beginning 4,000–7,000 years ago
* Changes of the modern, industrial period beginning around 1800 (Foley et al., 2013) have subsequently transformed the biodiversity of agriculture and food systems
* The human-environment interactions of this biodiversity—referred to as agrobiodiversity—are increasingly recognized as central in planetary-scale changes involving the environmental and social dimensions of sustainability
* agrobiodiversity as a complex, human-interdependent resource system
* The human-environment interactions of the biodiversity of agriculture and food systems have been integral and are subject to expanding planetary transformations.

This dynamics are summarized in the figures. Farmers' selection and management practices, and their use of genetic resources, have played an important role in agrobiodiversity conservation. Local knowledge, and related gender differences, can be seen as key factors in shaping and influencing plant and animal diversity. Farmers' selection and management practices, and their use of genetic resources, have played an important role in agrobiodiversity conservation.

The key points to note about this definition are:

1. First, and most importantly, the biological diversity of agri-food systems includes vital coupling to the human system, most directly the people who are growers and their skills, knowledge, and other factors. Agrobiodiversity exists squarely at the intersection of human and natural systems.
2. Second, it encompasses both our cultivated species of plants and animals, which are crops and livestock chosen and evolved for production, as well as their still living wild relatives and the biodiversity of the ecosystems associated with this production (both the agroecosystem itself and the surrounding uncultivated ecosystem).

Agrobiodiversity production in the natural system must be sufficient to offer positive feedbacks into the human system in order to offer the incentive for continued production.

The points just described in the definition of agrobiodiversity are illustrated in figure, which depicts agrobiodiversity as a Coupled Human-Natural System (CNHS).

Source: Factors in human systems and natural systems commonly associated with active use of agrobiodiversity *Credit: Karl Zimmerer;* https://www.e-education.psu.edu/geog3/node/1060

**SLIDE 56**

Under the Convention on Biological Diversity, **mainstreaming biodiversity** is defined as: “the integration of the conservation and sustainable use of biodiversity in cross-sectoral plans such as poverty reduction, sustainable development, climate change adaptation/mitigation, trade and international cooperation, as well as in sector-specific plans such as agriculture, fisheries, forestry, mining, energy, tourism, transport and others.”

In practice, mainstreaming means that specific components of biodiversity (e.g. genetic, varietal, species, landscape) are integrated into other sectors for the generation of mutual benefits.

Examples are: linking tourism to biodiversity for conservation and economic returns; or using diversity in agriculture to increase productivity and resilience while at the same time conserving biodiversity.

*Source:* [*www.bioversityinternational.org*](http://www.bioversityinternational.org/)*, Mainstreaming in sustainable food systems agrobiodiversity [1]*

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According to the table this integration may be into the plans, policies and practices of natural resource sectors, such as agriculture or forestry, or other economic and social sectors, such as poverty alleviation or climate adaptation. Methods can comprise changes in policies, plans or laws, public–private partnerships or communication campaigns

Mainstreaming agricultural biodiversity in food systems contributes to their sustainability and enables policymakers to make progress toward their commitments to the Sustainable Development Goals

and the Aichi Biodiversity Targets. Governments make a difference through the food and agricultural policies they adopt. Corporations make a difference through the business models they select. Given the right policy environment, together with appropriate management actions and information, from the same starting point, different results are possible. Policies and actions matter.

**SLIDE 58**

In figure 1 is summarized the the Expanded Definition of Agrobiodiversity by multiple types and scales of agrobiodiversity as a complex, human-interdependent resource system as well agrobiodiversity—including associated sociocultural practices

Agrobiodiversity exerts influence on, and is affected by, the factors of environmental and biotic resources (e.g., soil, water, pollinators) together with sociocultural and linguistic practices, development and technologies, and multi-scale institutions and social relations. But agrobiodiversity—including associated sociocultural practices

The knowledge concept and definition of biodiversity can be Expanded Definition of Agrobiodiversity comprised of four themes: (1) ecology and evolution; (2) governance; (3) food, nutrition, and health; and (4) global environmental and socioeconomic changes

**SLIDE 59**

Agrobiodiversity Knowledge concept comprised of four themes: (1) ecology and evolution; (2) governance; (3) food, nutrition, and health; and (4) global environmental and socioeconomic changes.

The framework highlights the distinct themes and networks (Fig. 2) whose overlap enables cross-theme integration

**Governance of agrobiodiversity** refers to policy and legal research as well as wide-ranging biocultural approaches.

**Biocultural approaches**, defined the biological and cultural dimensions of human-environment systems. Thy can focus on the long-term co-evolution of agrobiodiversity and incorporated new scientific advances

**Market- and livelihood-based approaches** include the support of economic value chain approaches involving indigenous and smallholder producers, retailing and wholesale outlets for agrobiodiversity across urban and rural spaces

Please look on the further reading of Karl S. Zimmerer et. al., 2019 The biodiversity of food and agriculture (Agrobiodiversity) in the anthropocene: Research advances and conceptual framework, Anthropocene

**SLIDE 60**

Thank you for your attention. Now it will follow the second part of the lecture of today lead by Dr. Maksims Feofilovs.