In situ/on farm conservation of agrobiodiversity

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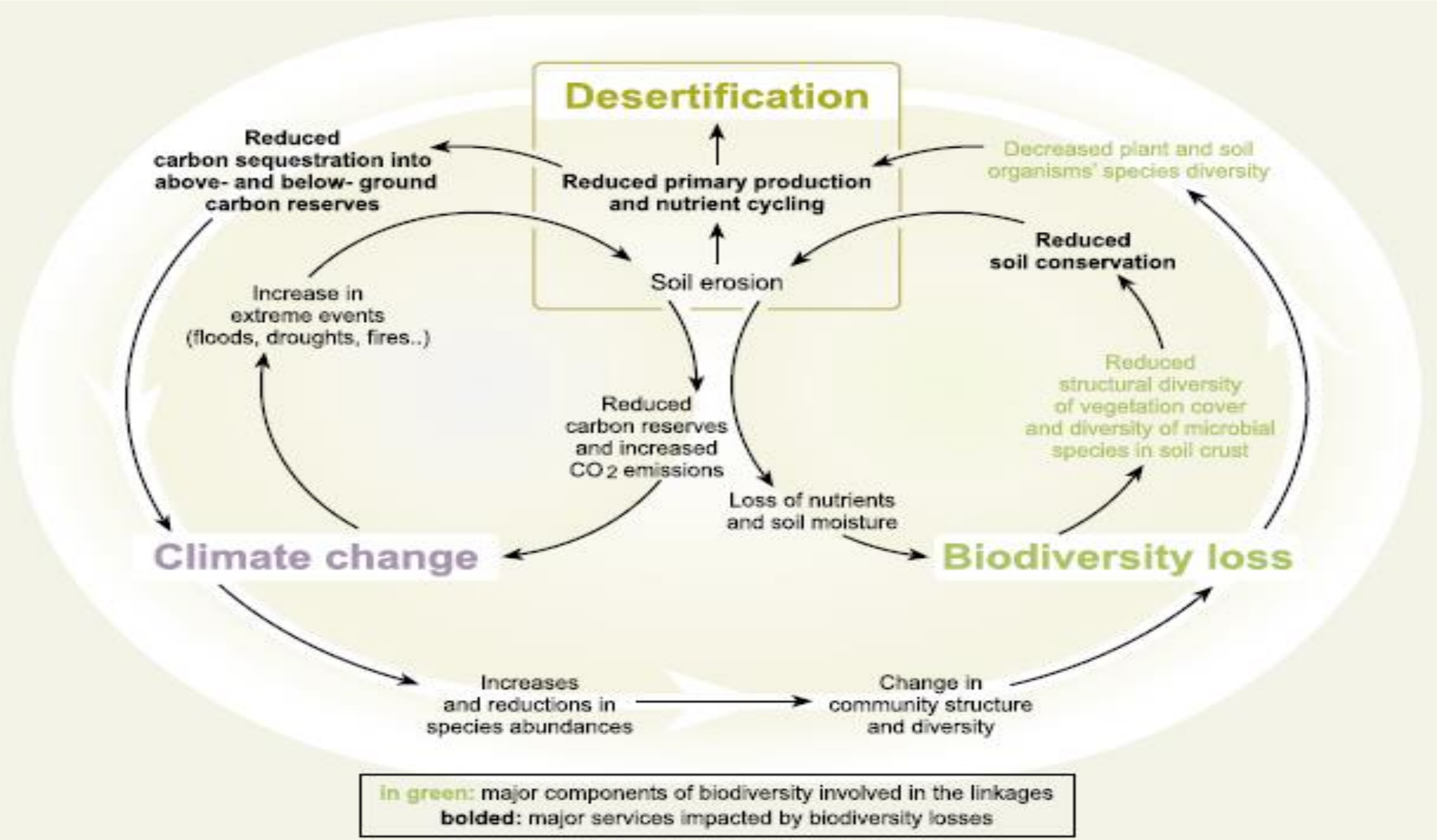
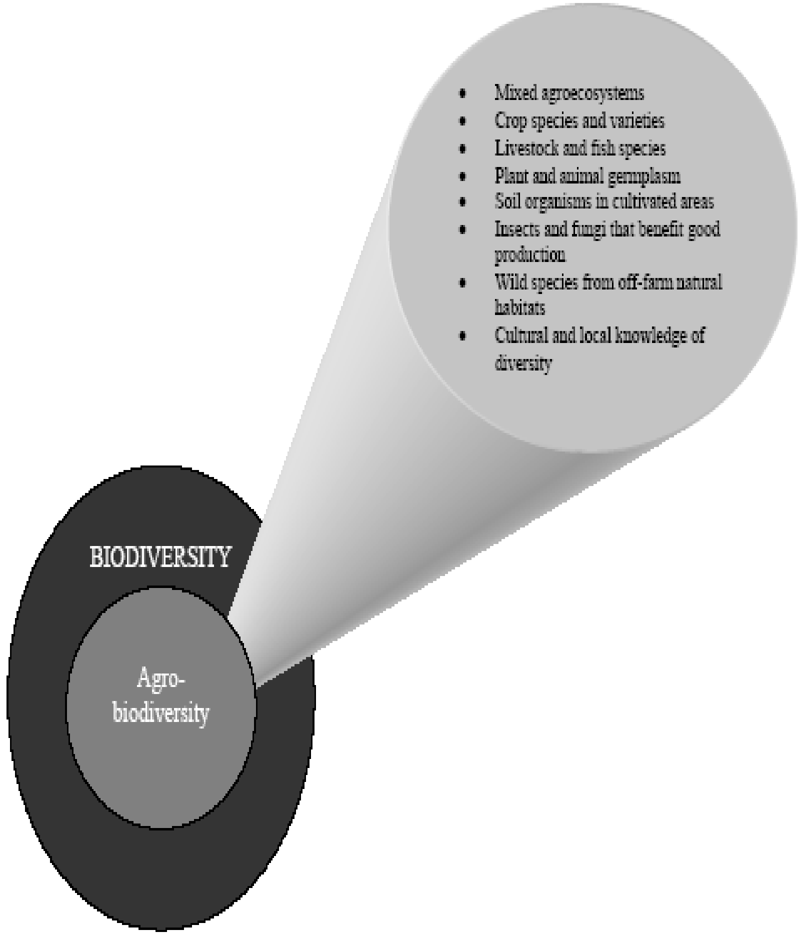


Source: Millennium Ecosystem Assessment

Biological diversity Encompasses the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems, and the ecological complexes they are part; this includes diversity within species, between species, and of the ecosystems (CBD, 1992).

Agricultural biodiversity or agro-biodiversity includes all components of biological diversity relevant to food and agriculture. It encompasses the variety of animals, plants and micro-organisms, at genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-system, its structure, and processes for, and in support of, food production and security (CBD-document SBSTTA-5-10e). It occupies a unique place within the biological diversity and is essential to satisfy basic human needs for food and livelihood security including building materials, fuels, clothing, medicines and means of transport, and by sustaining multifunctional agro-ecosystems.

Figure 2.1: CONCEPTUAL VIEW OF AGROBIODIVERSITY
Source: L.A. Thrupp, World Resources Institute



Distinctive features of agrobiodiversity

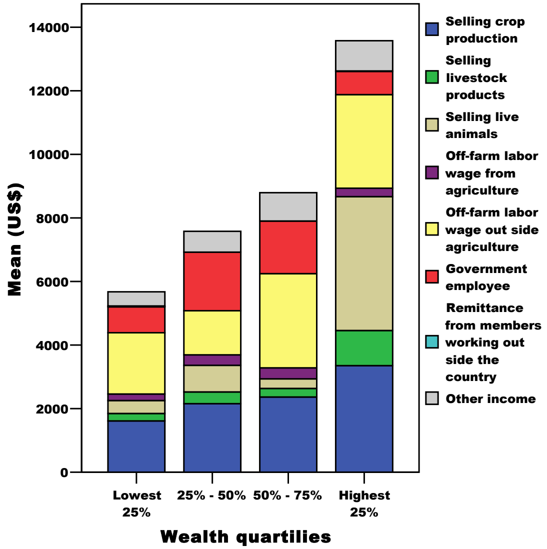
- Essential to satisfy basic human needs for food and livelihood security
- Managed by farmers; indigenous knowledge and culture are part of the management
- A great interdependence between countries for GRFA
- For crops and domestic animals, diversity within species is at least as important as diversity between species
- Its conservation in production systems is inherently linked to sustainable use
- Much biodiversity is now conserved *ex-situ* in genebanks or breeders' materials
- The interaction between environment, genetic resources and management practices often contributes to maintaining agrobiodiversity

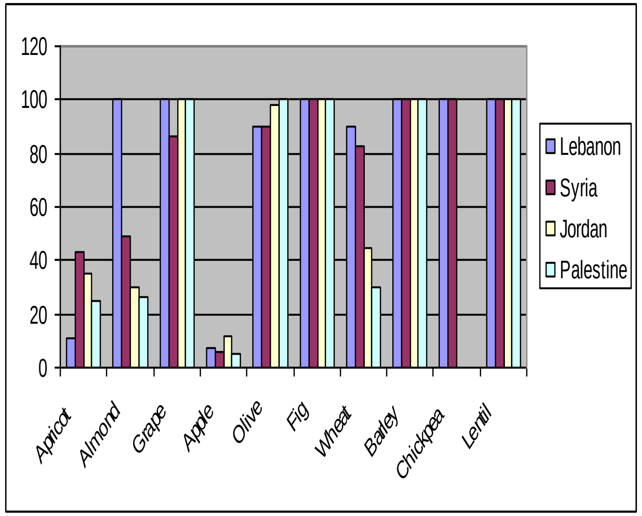
GENERAL BENEFITS OF AGROBIODIVERSITY (UNDP, 1983)

- Key to increasing food production, eradicating poverty and protecting the environment;
- Increase productivity, food security and economic returns;
- Reduce pressure of agriculture on fragile areas, forests and endangered species;
- More stable and sustainable farming systems;
- Contribute to integrated pest management;
- Conserve soil and increase its fertility and health;
- Diversification of products and income opportunities;
- Reduce and spread risks to individuals and nations;
- Help in maximizing the sustainable use of resources and environment;
- Reduce dependency on external inputs;
- Improve human nutrition and health care;
- Conserve ecosystem structure and stability of species.
- Drylands provide critical habitats for wildlife and are indispensable for many migrating species;

IMPORTANCE OF DRYLAND AGROBIODIVERSITY

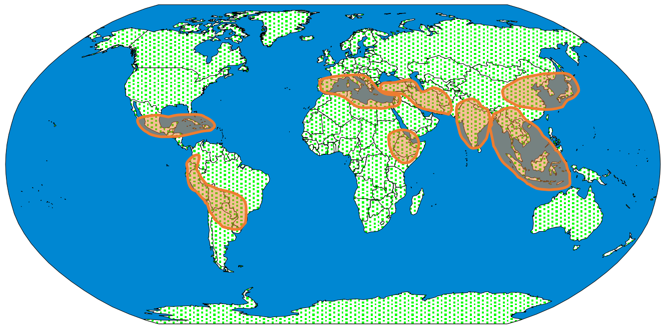
- Agrobiodiversity continues to support the livelihoods of rural poor in drylands and mountainous areas;
- Landraces and local breeds are still prevailing in the traditional farming systems;
- Source of material for rehabilitation of degraded eco- and farming systems;
- Several other social and environmental benefits/services.





N. I. Vavilov presented theory of “Geographic Centers of Cultivated Plants” (Vavilov, 1928).

- There are centers of large variation of cultivated plants;
- Those centers are also the centers of origin; and
- The centers of origin are characterized by a large number of dominant genes and the presence of closely related species (ancestors species).
- These centers of origin included also the centers of domestication



Center of Origin

Center of domestication

Center of domestication

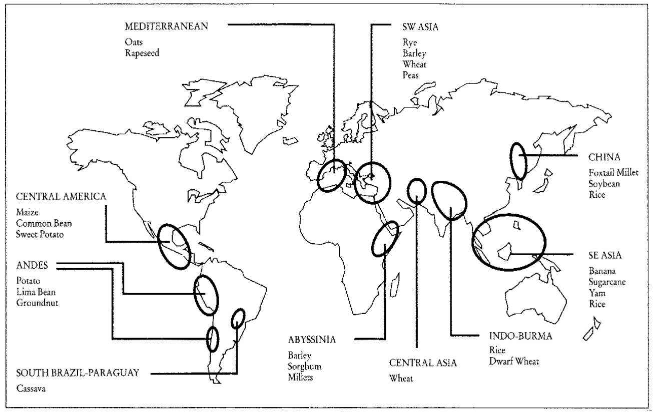
Center of diversity

Primary centers of diversity

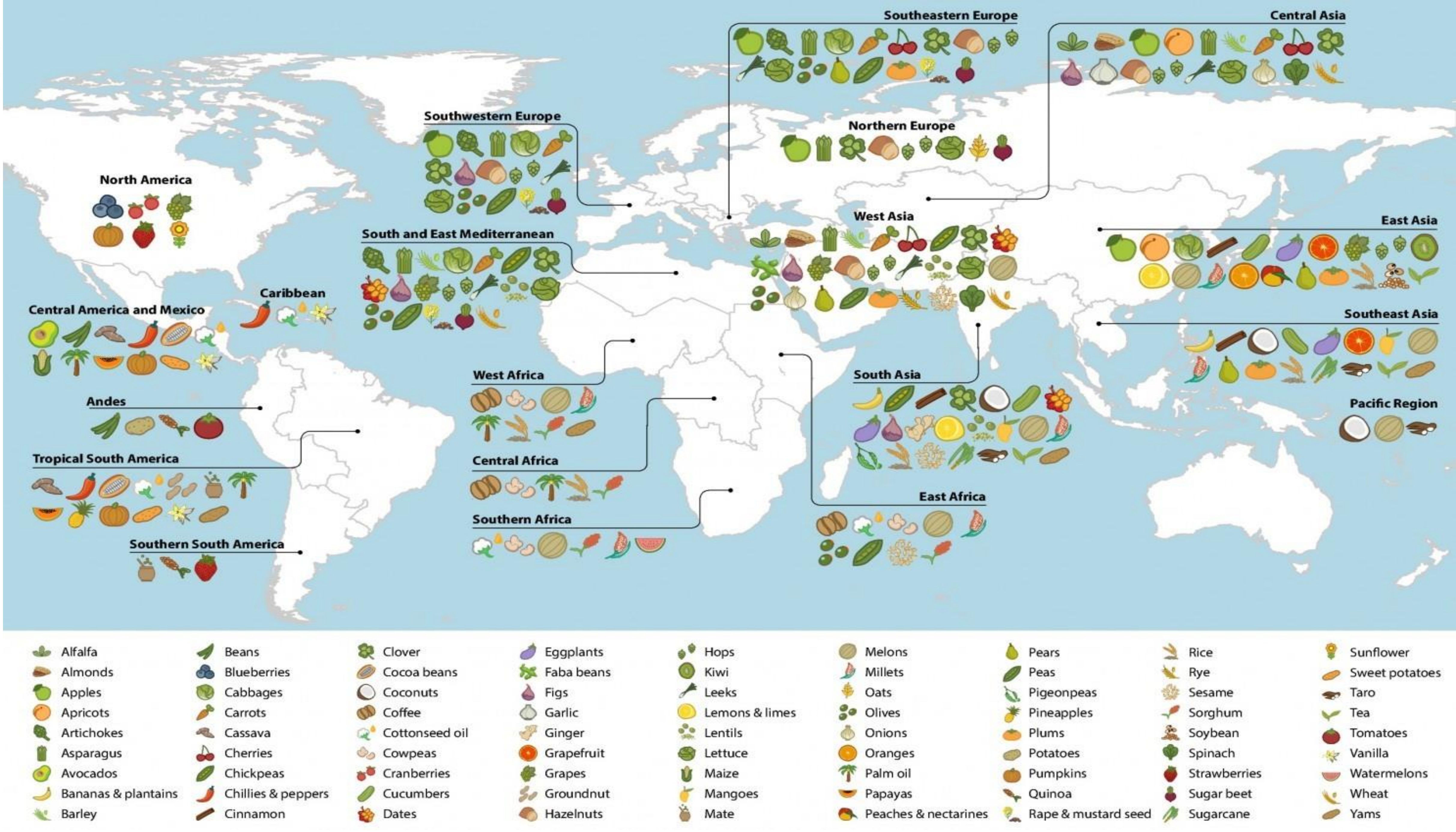
Secondary enters of diversity

Harlan (1975 a, b) classification of cultivated plants based on their geographic patterns of variation

1. **Three factors are liable for the gene center (genetic, evolutionary and ecological).**
2. **The gene centers of today have to be seen as a result of the present climate and environment, which means that a gene center has to be understood as unstable system.**
3. **A possible glacial pre–gene–center may be assumed on the point of intersection of the present centers which would be the Arabian Peninsula. A displacement took place from the central pre-gene–center to the present, surrounding centers.**
4. **In fact distinction should also be extended to the centers of diversity which could also be different from the centers of origin and domestication**



1. **Endemic cultivated plants have a small, defined bounded geographic area; the center of their domestication and variation coincide**
2. **Semi-endemic plants appear in a somewhat larger area; the center of variation shows indefinite bounders, or have intersections**
3. **The mono-centric cultivated plants have a large area of spreading, but also a clearly distinguishable center of origin, which also can be a center of variation**
4. **Oligo-centric cultivated plants are spread over a large area; there can be two, but also several centers of variation**
5. **Non-centric cultivated plants are spread oven a large sized area without a clearly distinguished center of origin or variation**



Southeastern Europe
Central Asia
Southwestern Europe
Northern Europe
North America
West Asia
South and East Mediterranean
East Asia
Caribbean
Central America and Mexico
Southeast Asia
West Africa
South Asia
Andes
Pacific Region
Tropical South America
Central Africa
East Africa
Southern Africa
Southern South America
Alfalfa
Almonds
Apples
Apricots
Artichokes
Asparagus
Avocados
Bananas & plantains
Barley
Beans
Blueberries
Cabbages
Carrots
Cassava
Cherries
Chickpeas
Chillies & peppers
Cinnamon
Clover
Cocoa beans
Coconuts
Coffee
Cottonseed oil
Cowpeas
Cranberries
Cucumbers
Dates
Eggplants
Faba beans
Figs
Garlic
Ginger
Grapefruit
Grapes
Groundnut
Hazelnuts
Hops
Kiwi
Leeks
Lemons & limes
Lentils
Lettuce
Maize
Mangoes
Mate
Melons
Millets
Oats
Olives
Onions
Oranges
Palm oil
Papayas
Peaches & nectarines
Pears
Peas
Pigeonpeas
Pineapples
Plums
Potatoes
Pumpkins
Quinoa
Rape & mustard seed
Rice
Rye
Sesame
Sorghum
Soybean
Spinach
Strawberries
Sugar beet
Sugarcane
Sunflower
Sweet potatoes
Taro
Tea
Tomatoes
Vanilla
Watermelons
Wheat
Yams

Fundamental and underlying causes

- Demographic pressure;
- Poverty;
- Economic growth;
- Trade distortion, marketing opportunities and globalization;
- Inappropriate policies and legislation including non enforcement and non empowerment of local communities;
- Limited public awareness;
- Limited research and extension efforts.

Major causes of biodiversity loss

- Destruction and fragmentation of natural habitats and eco-systems (roads, dams, airports, agricultural expansion,…);
- Over-exploitation including uprooting and overgrazing;
- Introduction of exotic species as weeds, pests, diseases or hybridize with native species;
- Human socio-economic changes, disintegration of local organizations, cultural and religious believes;
- Changes in agricultural practices and land use including introduction of newly released varieties, use of herbicides, changes in grazing regimes, burning,..
- Human disasters including soil and water pollution and contamination;
- Natural calamities: floods, land degradation, climate change

- Climatic change, land degradation and desertification are expected to induce drastic effects on agrobiodiversity in the dry areas;
- The loss of the dryland agrobiodiversity and land degradation will have adverse economic, social and political consequences directly on the living of local communities which will be expanded to national and international levels;
- The assessment of the status and trends of local agrobiodiversity and of the major threats are highly important for designing conservation and management strategies. Eco-geographic/botanic surveys and GIS/RS are used frequently in assessing local agrobiodiversity and changes in land uses, but local knowledge could also help significantly.

Ex-situ and *in-situ* conservation (CBD definitions)

- *Ex-situ* conservation means the conservation of components of biodiversity outside their natural habitats;
- *In-situ* conservation means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in case of domesticates and cultivated species, in the surroundings where they have developed their distinctive properties;
- *In situ* conservation on farm refers to the continuous cultivation and management of a diverse set of populations by farmers in the agroecosystems where a crop has evolved (Bellon et al 1997). It includes cultivated species, forages and agroforestry species and their wild relatives
- *Circa situ* used for trees when trees are removed to managed agroforest areas or on farm-based conservation areas identical to their natural habitats.

In-situ/on-farm conservation (more definitions)

"*In situ* conservation of agricultural biodiversity is the maintenance of the diversity present in and among populations of the many species used directly in agriculture, or used as sources of genes, in the habitats where such diversity arose and continues to grow." (Brown 1999);

"*In situ* conservation specifically refers to the maintenance of variable populations in their natural or farming environment, within the community of which they form a part, allowing the natural processes of evolution to take place." (Qualset, et al. 1997);

"*In situ* conservation refers to the maintenance of genetic resources in natural settings. For crop resources, this means the continued cultivation of crop genetic resources in the farming systems where they have evolved, primarily in Vavilov Centres of crop origin and diversity." (Brush 1991);

"On-farm conservation is the sustainable management of genetic diversity of locally developed crop varieties (landraces), with associated wild and weedy species or forms, by farmers within traditional agricultural, horticultural or agri-silvicultural systems." (Maxted, et. al.);

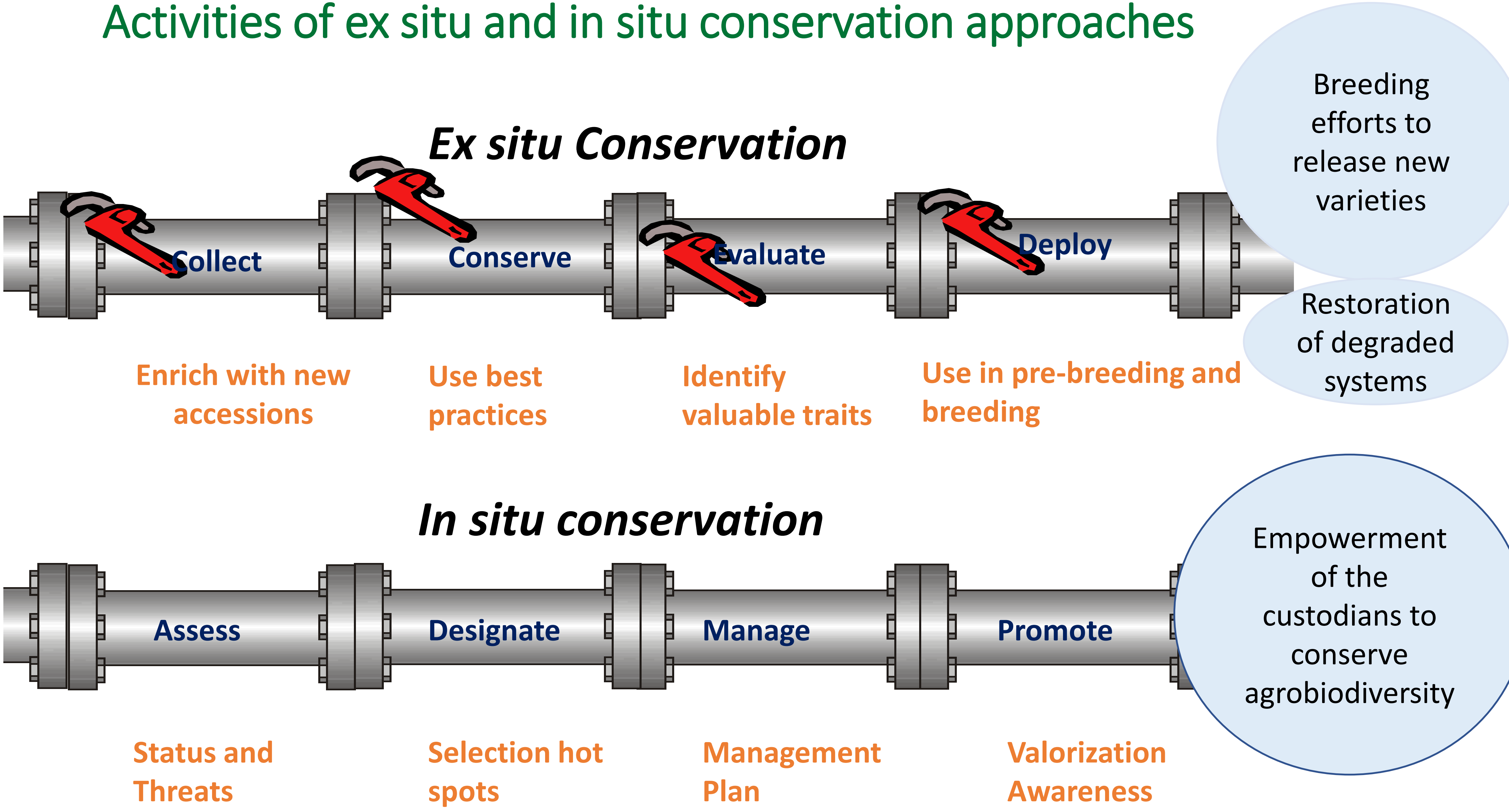
On-farm conservation: The continuous cultivation and management by farmers of a diverse set of populations of a crop in the environment where this crop has evolved (Bellon 1995);

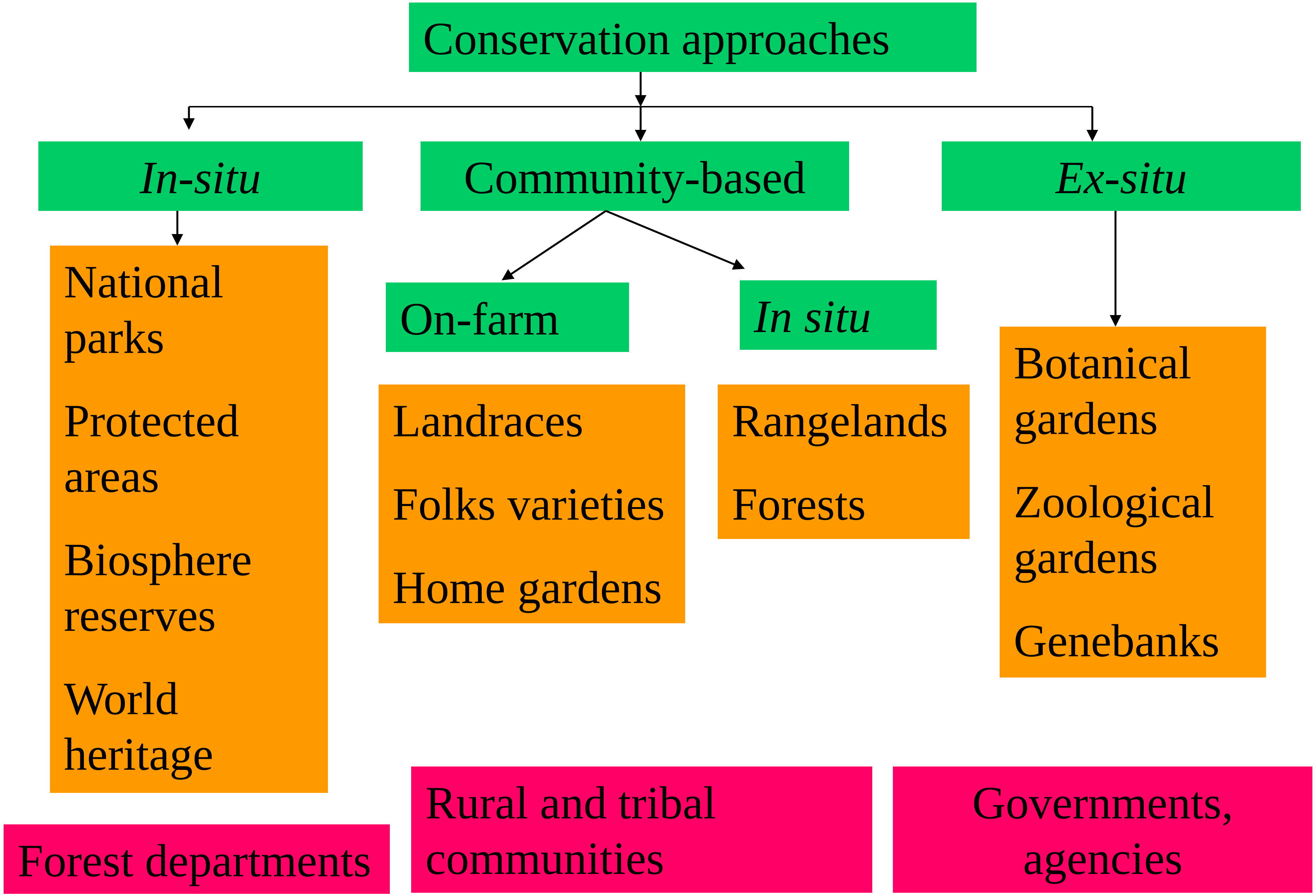
On-farm conservation involves the maintenance of traditional crop varieties (generally known as "landraces") or cropping systems by farmers within traditional agricultural systems (Oldfield & Alcorn, 1987; Altieri & Merrick, 1987; Brush, 1991).

On-farm conservation concerns entire agro-ecosystems, including useful species (such as cultivated crops, forages and agro-forestry species), as well as their wild and weedy relatives constituting the groups of species in the primary, secondary and tertiary gene pools.

- To conserve the processes of evolution and adaptation of crops to their environments;
- To conserve diversity at different levels -- ecosystem, species, within species;
- To integrate farmers into a national plant genetic resources system;
- To conserve ecosystem services critical to the functioning of the earth's life-support system;
- To improve the livelihood of resource poor farmers through economic and social development;

Activities of ex situ and in situ conservation approaches




Conservation approaches
In-situ
Community-based
Ex-situ
National parks
Protected areas
Biosphere reserves
World heritage
On-farm
In situ
Landraces
Folks varieties
Home gardens
Rangelands
Forests
Botanical gardens
Zoological gardens
Genebanks
Forest departments
Rural and tribal communities
Governments, agencies

Differences between natural ecosystems and agro-ecosystems

Item	Natural ecosystems	Agro-ecosystems
Type of system	+/- closed	Open
Nutrient cycling	Closed	Open
Carbon cycling	Closed	Open
Water cycling	Closed	Open
Between species diversity	High	Low
Within species diversity	High	Low
Human management	Low	High
Individual species density	Low	High
Ease of economic valuation	Hard	Easy
Genetic improvement	Low	High

Values and characteristics of different management actions

	Rehabilitation	Reclamation	Restoration
Environmental values	LOW	AVERAGE	HIGH
Economic values	HIGH	AVERAGE	LOW
Costs of establishment	Low	AVERAGE	High
Costs of maintenance	HIGH	AVERAGE	LOW
Species richness	LOW	AVERAGE	HIGH
Degree of stability	LOW	AVERAGE	HIGH

Managing habitats and species

- Many species require interventions;
- Preventing climax conditions;
- Management : some species will benefit, some will be affected and some indifferent;
- Patches in fragmented environments;
- Need to recognize specific requirements of a given species.

Protected areas

- Article 8(d) aims to: *Promote the protection of ecostystems, natural habitats and the maintenance of viable populations of species in natural surroundings*
- *CBD: a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives*
- *IUCN: areas of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*

Protected areas: a central element of any national strategy to conserve biological diversity

Protected areas are a vital contribution to:

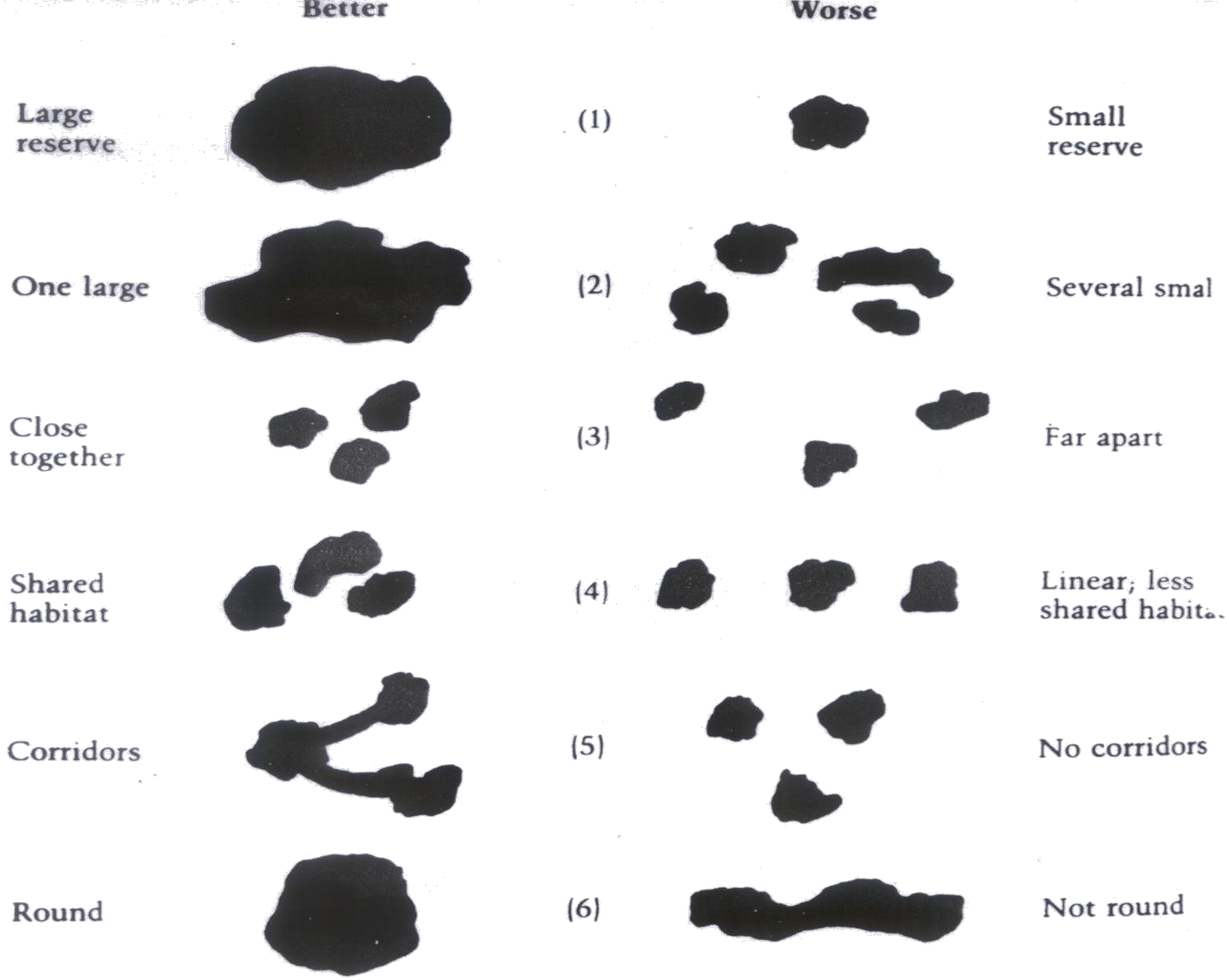
- The conservation of the world's natural and cultural resources.
- The protection of natural habitats and associated flora and fauna,
- The maintenance of environmental stability of surrounding regions.
- Can provide opportunities for rural development and rational use of marginal lands, generating income and creating jobs, for research and monitoring, for conservation education, and for recreation and tourism.

Reserve design and management

- Current consensus is based on Man and biosphere program (UNESCO) with core area (stable habitat) is surrounded by a buffer zone (protection zone, benefits local communities) of and when possible extended to transition zone. The core area should have at least 1000 to 5000 breeding individuals;
- Conservation plan will require: conservation objectives, reasons for sitting a reserve, conservation strategy; taxon description; site evaluation and description; evaluation and monitoring of taxon in the reserve; selection of management techniques;
- There are more than 12 types of protected areas (national park, nature reserve, natural monuments, traditional life, protected landscape, range reserve). Biosphere reserves (UNESCO) must be representative of ecosystem complexes, must have core (>3%, legally protected), buffer (>10%, legally protected) and transition zone.

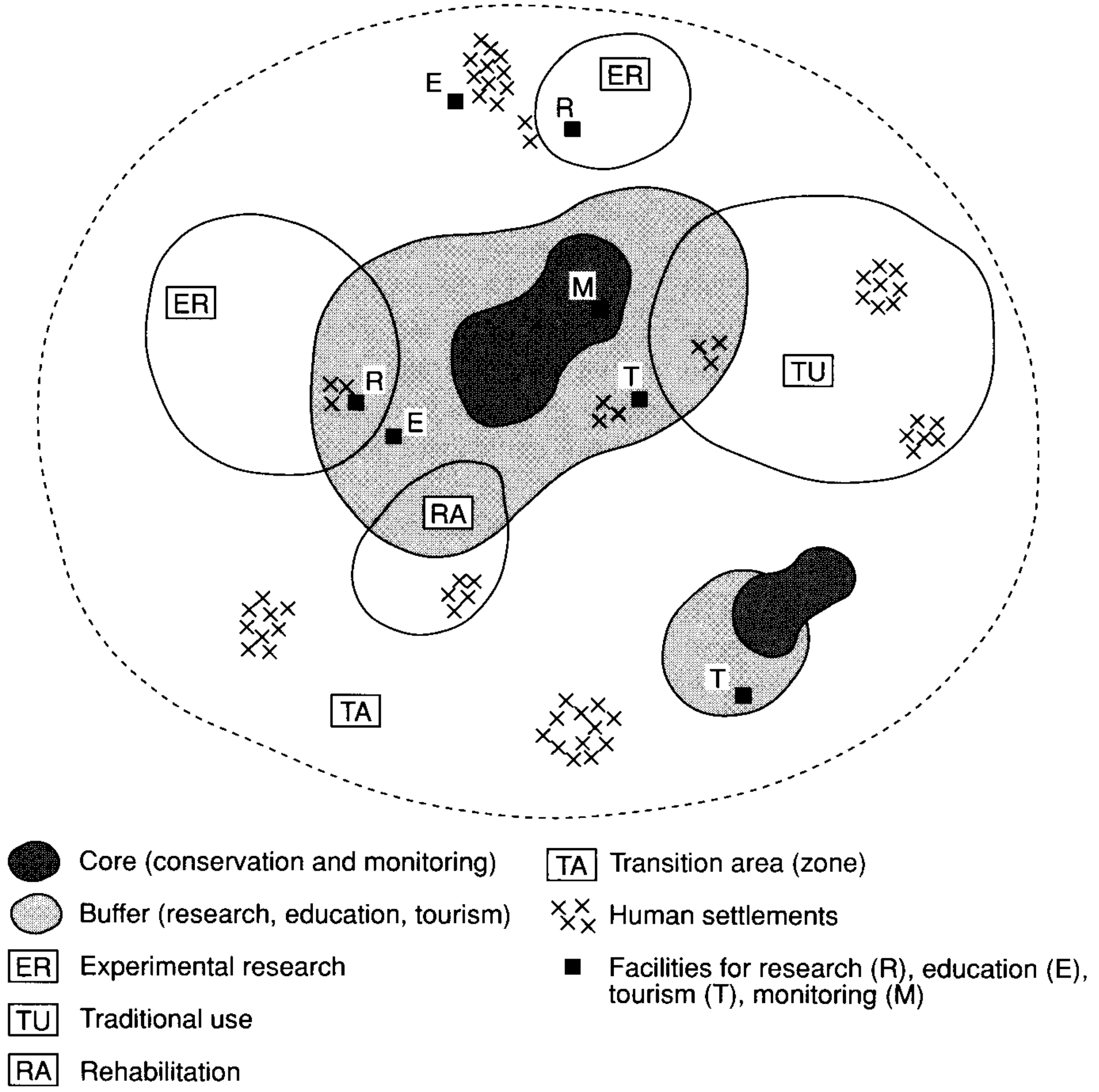
Each biosphere reserve must contain three elements:

- **Core Areas:** These areas are securely protected sites for conserving biological diversity, monitoring minimally disturbed ecosystems, and undertaking non-destructive research and other low-impact uses (such as education).
- **Buffer Zones:** These areas must be clearly identified, and usually surround or adjoin the Core Areas. Buffer Zones may be used for cooperative activities compatible with sound ecological practices, including environmental education, recreation, ecotourism and applied and basic research.
- **Transition, or Cooperation, Zones:** These areas may contain towns, farms, fisheries, and other human activities and are the areas where local communities, management agencies, scientists, non-governmental organizations, cultural groups, economic interests, and other stakeholders work together to manage and sustainably develop the area's resources.

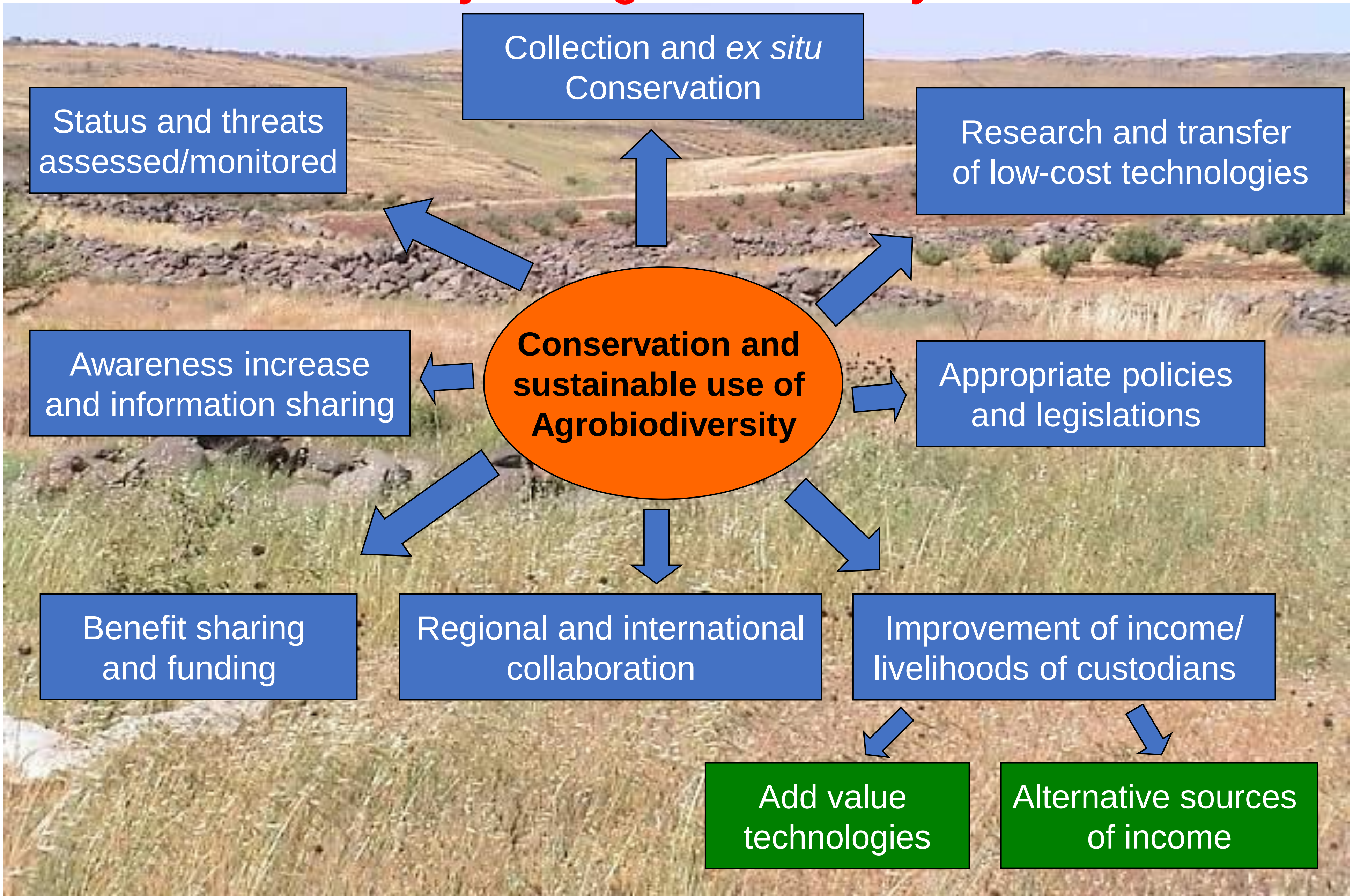


Better
Worse
Large reserve
(1)
Small reserve
One large
(2)
Several smal
Close together
(3)
Far apart
Shared habitat
(4)
Linear; less shared habit..
Corridors
(5)
No corridors
Round
(6)
Not round

Reserve Design (Cox, 1993)



Strategy for promoting *in situ*/on-farm management of dryland agrobiodiversity



Impact of agricultural development on biodiversity

- **Agricultural intensification broadly linked to declines in biodiversity in agro-ecosystems, but was responsible for significant production gains (reduction in landscape diversity, monoculture with uniform varieties, disturbing technological packages, pesticide use);**
- **Under harsh environments, the potential of improved varieties will not be expressed;**
- **There are many low-cost technologies that can enhance productivity of landraces;**
- **There are genetic manipulation techniques that can reconcile between productivity increase and conservation of most of genetic base.**

Technological options for landraces (researchable areas)

- *Landraces genetic improvement*
  1. **Population improvement**
  2. **Multiline and extraction of pure lines**
  3. **Mutation breeding**
  4. **Participatory plant breeding**
- *Seed and seedlings/plantlets quality improvement*
- *Informal/formal seed production and supply*
- *Reduction of losses during storage*

Technological options for landraces

- *Low –cost technological packages*
  1. **Water use efficiency and water harvesting**
  2. **Fertilizers and herbicides**
  3. **Integrated pest management**
  4. **Crop rotations and succession**
  5. **Biological agriculture**

Technological options for wild species and natural habitats

- Water harvesting and combating land degradation;
- Reseeding and replanting with native species;
- Use of appropriate disturbance measures;
- Management and regulation of use;
- Adoption of appropriate alternatives to take pressure on native species (domestication/ cultivation of wild species of HMAP, alternative feed sources, etc.);

Actions for the conservation of agrobiodiversity in rangelands

Improvement
Through reseeding, water and soil conservation,

Introduction of alternative feed sources (shrub plantation, feed blocks, forages,…)

Management of grazing including animal movements

Conservation of rangeland
Native species

Management of livestock (culling,
health, nutrition,..

Add-value to local dairy products

Alternative sources of income

Add-value technologies

- Food processing
- Packaging and labeling
- Processing of wild fruits
- Creation of nurseries

- Formation of Coops’ & NGOs
- Organization of fairs & shops
- Linking to market and private sector

- Cultivation of medicinal plants
- Honey & mushroom production
- Dairy production
- Eco-tourism

Alternative sources of income




Policy options

- Development of national agrobiodiversity conservation strategy;
- Land use suitability maps;
- Use of native species for rehabilitation of degraded systems (reforestation, etc.);
- Farmers rights and local knowledge issues;
- Awareness increase including introduction of biodiversity in education systems;
- Contribution to regional and global actions/fora (networking) on conservation and sustainable use of agrobiodiversity;

Framework for determining priority actions for community-based conservation

	Technological	Add-value	Alternative sources of income	Institutiona l	Policy
International					
Regional					
National					
Community					
Farm/habitat					
Species/crop					

Format for management plans, Hirons et al. (1995) modified by Maxted et al. (1997)

- ***Preamble***: conservation objectives, reasons for siting of reserve, place of reserve in overall conservation strategy for target taxon.
- ***Taxon description***: **taxonomy** (classification, delimitation, description, iconography, identification aids), wider distribution, habitat preferences, phenology, breeding system, genotypic and phenotypic variation, biotic interactions (e.g. pollinators, dispersal agents, herbivores, pests, pathogens, symbionts), local name(s) and uses, other uses, present conservation activities (*ex situ* and *in situ*), threat of genetic erosion.
- ***Site evaluation***: evaluation of populations of the target taxon, reserve sustainability, factors influencing management (legal, constraints of tenure and access), externalities (e.g. climate change, political considerations), obligations to local people (e.g. allowing sustainable harvesting) and anthropomorphic influences.
- ***Site description***: location (latitude, longitude, altitude), map coverage, photographs (including aerial), physical description (geology, geomorphology, climate, hydrology, soils), human population (both within reserve and around it), land use and land tenure (and history of both), vegetation and flora, fauna, cultural significance, public interest (including educational and recreational potential), bibliography and register of scientific research.

Format for management plans, Hirons et al. (1995) modified by Maxted et al. (1997)

- ***Status of target taxon in the reserve***: distribution, abundance, demography, and genetic structure and diversity of the target taxon within the site, autecology within the reserve, interaction with associated fauna and flora, specific threats to population(s).
- ***Site objectives and policy***: site objectives, control of human intervention, allowable sustainable harvesting by local people and general genetic resource exploitation.
- ***Prescription*****:** details (timing, frequency, duration etc) of management interventions that will need to be carried out, schedule of ecological and genetic monitoring, population mapping, staffing requirements and budget, project register.
- ***Monitoring and continue diagnosis***

Examples of actions for community-based conservation

	Technological	Economic	Institutional	Policy
International	Expertise Genetic resources Technologies	Access to markets Funding Tourism	Reserves Training	Expertise Benefit sharing
Regional	Expertise Genetic resources Technologies		Regional networks	Access legislation
National	Research Monitoring Ex-situ conservation Seed production	Marketing Funding Incentives Subsidies Fairs	Committees Education	Land use Access legislation Benefit sharing Certification

Examples of actions for community-based conservation

	Technological	Economic	Institutional	Policy
Community	Local knowledge Participatory research activities Technology transfer	In-kind contribution Businesses Seed production Nurseries Fairs	Cooperatives Traditional systems NGOs Co-management	
Farm/habitat	System diversification Low-cost technologies	Local processing Income generation	Private business	
Species	Crop Management Seed production	Processing	NGOs	

General principles

- **Ensure that development projects focus on conservation;**
- **Seek consensus on conservation agenda among key groups;**
- **Address external factors;**
- **Sustainability of resources;**
- **Plan, monitor, learn and adapt;**
- **Build on what exists;**
- **Clarify the roles in management and control;**
- **Work in strategic partnership and act as facilitator;**
- **Generate benefits for local communities**

Key elements of community-based conservation

- **Regulation to restrict access and use (avoid antagonism and antipathy);**
- **Development of eco-agriculture and sustainable agriculture, biological agriculture, organic farming,…;**
- **Increasing the value of the natural resources;**
- **Alternatives to damaging exploitation;**
- **Include conservation within rural development actions;**
- **Alternative sources of income and add value technologies;**
- **Benefit sharing to local communities;**
- **Possibility for incentives.**

Methods of conservation of plant genetic resources

In situ

- Dynamic conservation benefiting from natural and farmers selection;
- Larger genetic base conserved;
- Conservation of related local knowledge;
- Suitable for recalcitrant species;
- Success depends on the involvement/commitments of various stakeholders and requires a holistic approach and strengthening of scientific basis;
- Benefits and costs for/by farmers;.

Ex situ

- Static conservation for long periods in genebanks;
- Diversity only sampled;
- Good evaluation and readily available for use in crops improvement programs;
- Source of seeds under disasters for restoration and rehabilitation;
- Benefits to breeders and costs by genebanks;
- Requires skilled staff and can be affected by regeneration and genetic drift and shift.

These should be regarded as complementary methods

Complementary action between these strategies is necessary

Type	Advantage	Disadvantage
Ex situ	• Greater diversity of the targeted taxon can be conserved as seed • Easy access for evaluations of resistance to pests and diseases • Easy access for improvement and use • Little maintenance for germplasm conserved over the long term	• Freezes evolutionary developments with regard to environmental changes • Genetic diversity is potentially lost with each regeneration cycle
In situ	• Dynamic conservation with regard to environmental changes • Permits species–pathogen interactions and coevolution • Applicable to many recalcitrant species • Requires active supervision over the long term • Less genetic diversity can be conserved in a single site	• Germplasm is not readily available for use • Vulnerable to disasters, natural and/or man-made • Poorly known methodologies or management regimes