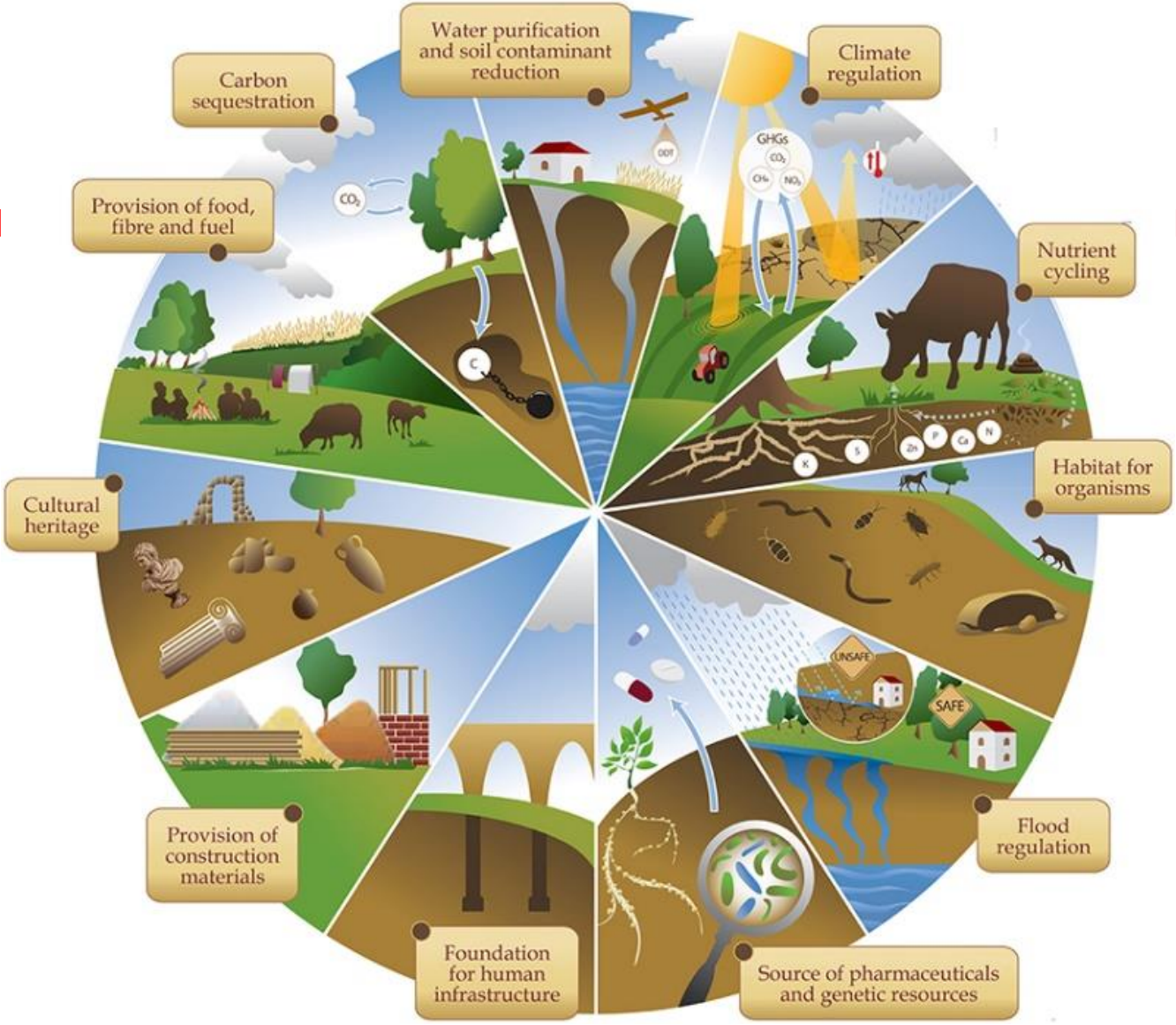
Sustainable Development Goals (UN)

Please visit this site and read about each goal:

https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Ecosystem Services Valuation

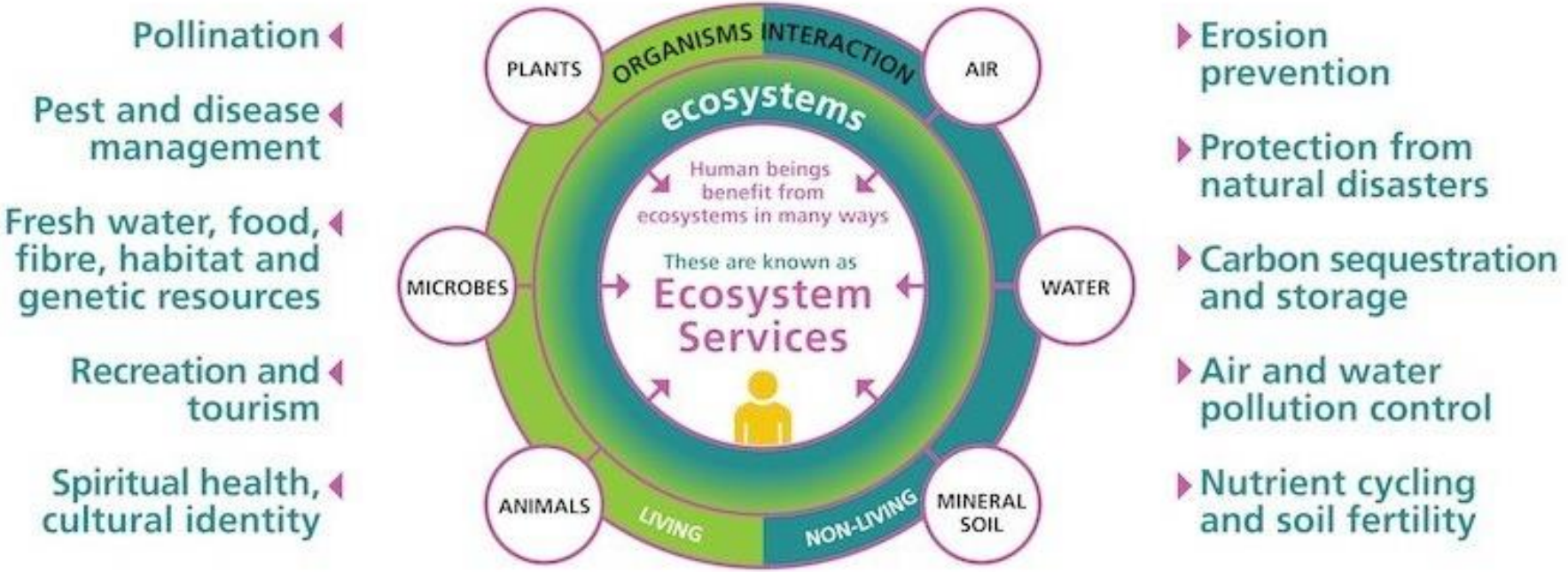


Based on Maggie Winslow, Ph.D. Fall 2013 presentation and
Millennium Ecosystem Assessment: www.milleniumassessment.org

Ecosystem services

Walter Westman, Nature, 1977. Nature services.
Ehrlich & Ehrlich, 1981. How much are Nature´s services worth?

Ecosystems are communities formed by the interaction of the living (plants, animals, microorganisms) and not living factors (air, water, mineral soil). Human beings are part of the ecosystems and benefit from them.

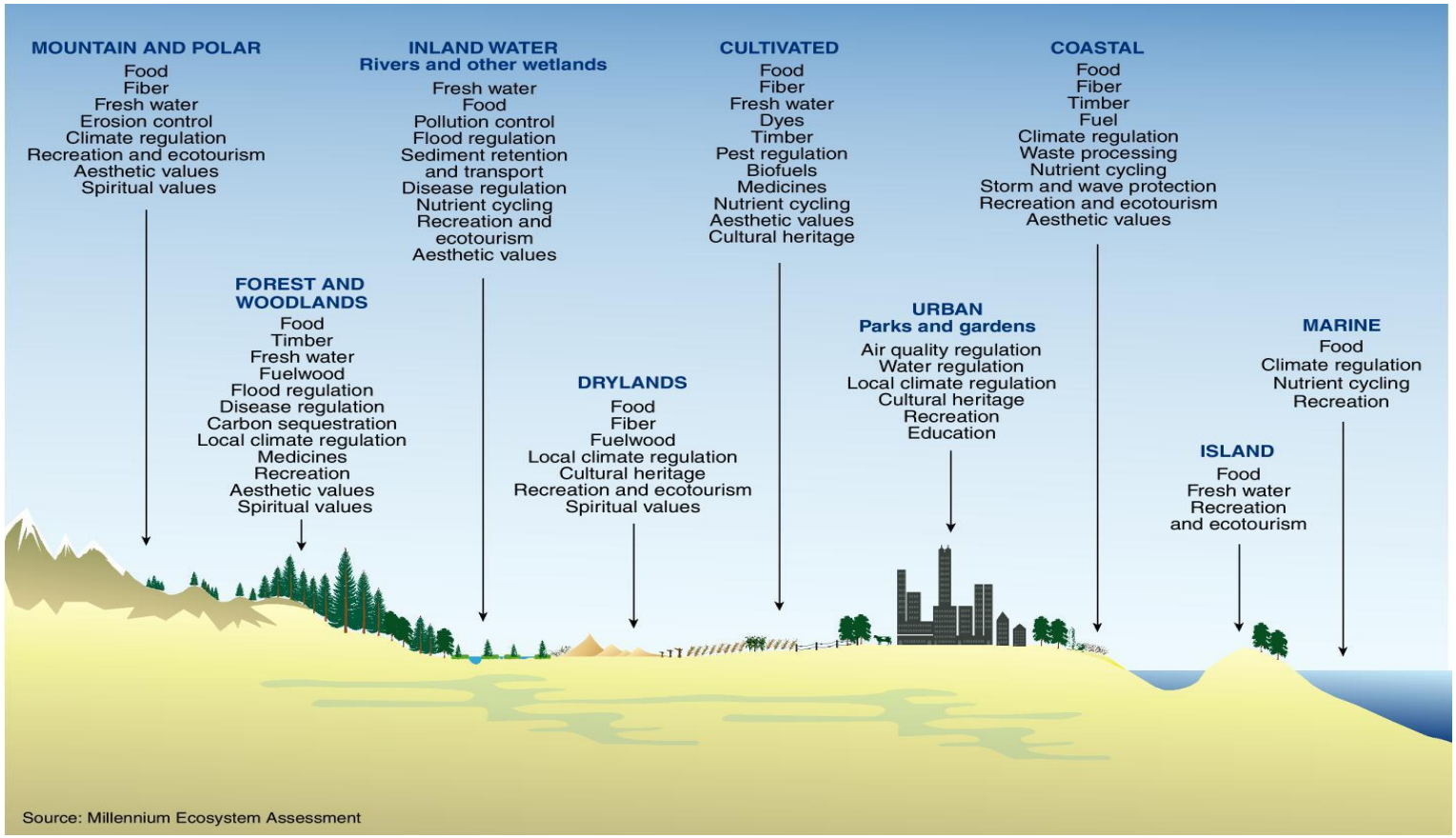


https://wle.cgiar.org/content/what-are-ecosystem-services

Ecosystem Services

All human beings depend on nature and the ecosystem services that provide the conditions for a healthy, adequate and safe life.

Ecosystem services are "The benefits that humans receive from the natural functioning of healthy ecosystems" (Jeffers et al., 2015),



https://www.unpei.org/sites/default/files/PDF/ecosystems-economicanalysis/MEA-A-Toolkit.pdf

Ecosystems services

PROVISIONING SERVICES

Products obtained from ecosystems

- Energy
- Seafood
- Biomedial
- Transportation
- National defense

REGULATING SERVICES

Benefits obtained from the regulation of ecosystem processes

- Flood prevention
- Climate regulation
- Erosion control
- Control of pests and pathogens

CULTURAL SERVICES

Nonmaterial benefits obtained from ecosystems

- Educational
- Recreational
- Heritage
- Spiritual

SUPPORTING SERVICES

Services necessary for the production of all other ecosystem services

- Biological diversity maintenance
- Nutrient recycling
- Primary productivity

source: *Final Recommendations of the Interagency Ocean Policy Taskforce, 2010*

Natural resources and processes from which humanity benefits directly or indirectly and which are vital for the survival of humanity, and yet we waste or overuse them.

https://roa.midatlanticocean.org/ocean-ecosystem-and-resources/characterizing-the-mid-atlantic-ocean-ecosystem/ecosystem-services/

Ecosystems services and ecosystem functions

Ecosystem service	Ecosystem functions	Examples
Gas regulation	Regulation of atmospheric chemical composition	CO_2/O_2 balance, O_3 for UVB protection, and SO_x levels
Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels	Green-house gas regulation, DMS production affecting cloud formation
Disturbance regulation	Capacitance, damping, and integrity of ecosystem response to environmental fluctuations	Storm protection, flood control, drought recovery, and other aspects of habitat response to environmental variability mainly controlled by vegetation structure
Water regulation	Regulation of hydrological flows	Provisioning of water for agricultural (e.g., irrigation) or industrial (e.g., milling) processes or transportation
Water supply	Storage and retention of water	Provisioning of water by watersheds, reservoirs, and aquifers
Erosion control and sediment retention	Retention of soil within an ecosystem	Prevention of loss of soil by wind, runoff, or other removal processes, storage of silt in lakes and wetlands
Soil formation	Soil formation processes	Weathering of rock and the accumulation of organic material
Nutrient cycling	Storage, internal cycling, processing, and acquisition of nutrients	Nitrogen fixation, N, P, and other elemental or nutrient cycles
Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds	Waste treatment, pollution control, detoxification
Pollination	Movement of floral gametes	Provisioning of pollinators for the reproduction of plant populations
Biological control	Trophic-dynamic regulations of populations	Keystone predator control of prey species, reduction of herbivory by top predators
Refugia	Habitat for resident and transient populations	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or over wintering grounds
Food production	That portion of gross primary production extractable as food	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming, or fishing
Raw materials	That portion of gross primary production extractable as raw materials	The production of lumber, fuel, or fodder
Genetic resources	Sources of unique biological materials and products	Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants)
Recreation	Providing opportunities for recreational activities	Eco-tourism, sport fishing, and other outdoor recreational activities
Cultural	Providing opportunities for non-commercial uses	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems

See next slide...

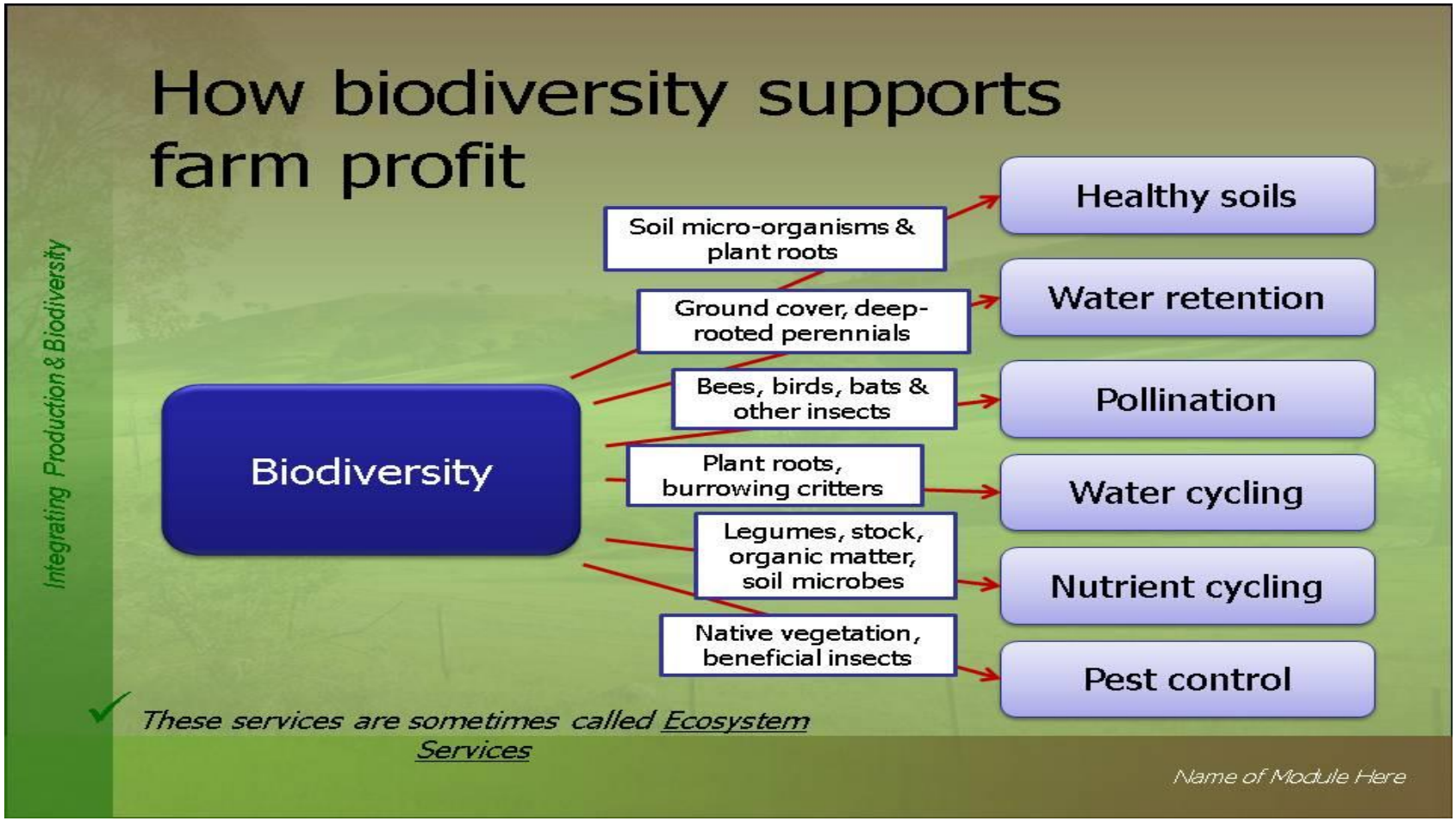
From: Constanza et al. 2017

Ecosystems services and ecosystem functions

Ecosystem Service	Ecosystem functions	Examples
Water regulation	Regulation of hydrological flows	Provisioning of water for agriculture (e.g. irrigation) industrial (milling), processes or transportation
Erosion control and sediment retention	Retention of soil within the ecosystem	Prevention of loss of soil by wind, runoff, or other removal processes, storate of silt in lakes and wetlands

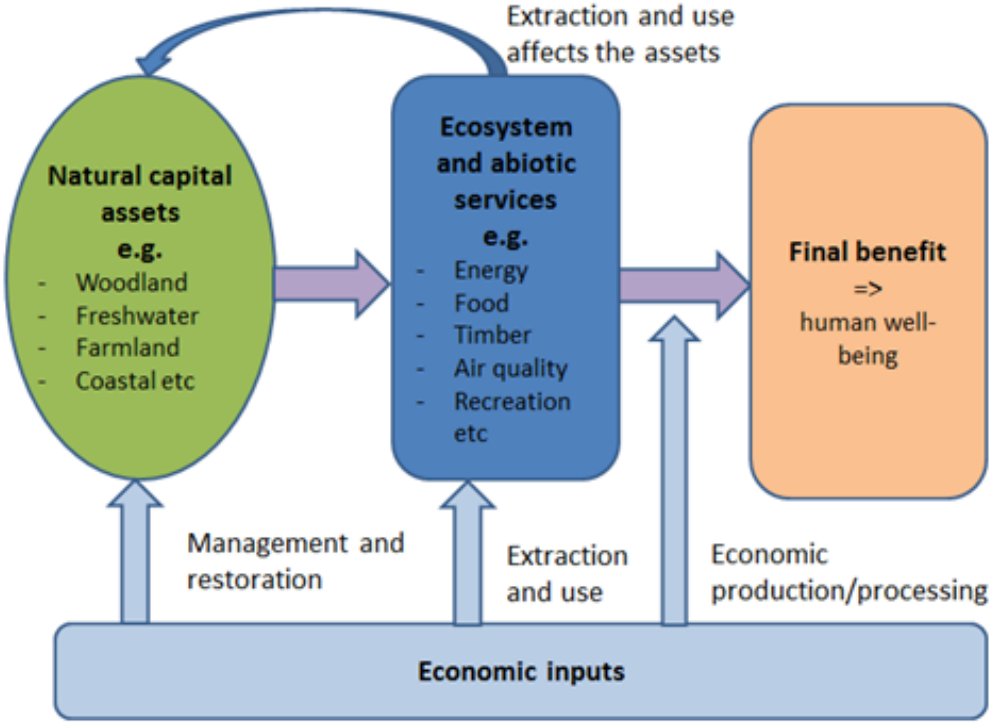
From: Constanza et al. 2017

Example:
Ecosystem services that impact on agricultura production



http://agbiodiversity.com/AgBiodviersityProject/Howbiodiversitysupportsfarmprofits/tabid/133/Default.aspx

Ecosystem services & natural capital



Natural capital: the ecosystems that provide the services.

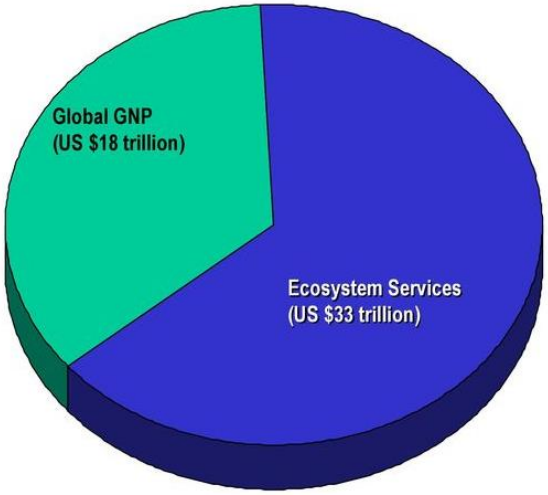
During the second half of the 20th Century, it became more apparent the non-market value of natural amenities.
For some time they were two parallel worlds: the ecosystems and the economy-social aspects.
Now we understand the societal dependence on natural ecosystems: assets, services and final benefits.

https://www.ons.gov.uk/economy/environmentalaccounts/methodologies/principlesofnaturalcapitalaccounting

How much are nature's services worth?

ECOSYSTEM SERVICES	VALUE (trillion $US)
Soil formation	17.1
Recreation	3.0
Nutrient cycling	2.3
Water regulation and supply	2.3
Climate regulation (temperature and precipitation)	1.8
Habitat	1.4
Flood and storm protection	1.1
Food and raw materials production	0.8
Genetic resources	0.8
Atmospheric gas balance	0.7
Pollination	0.4
All other services	1.6
Total value of ecosystem services	**33.3**

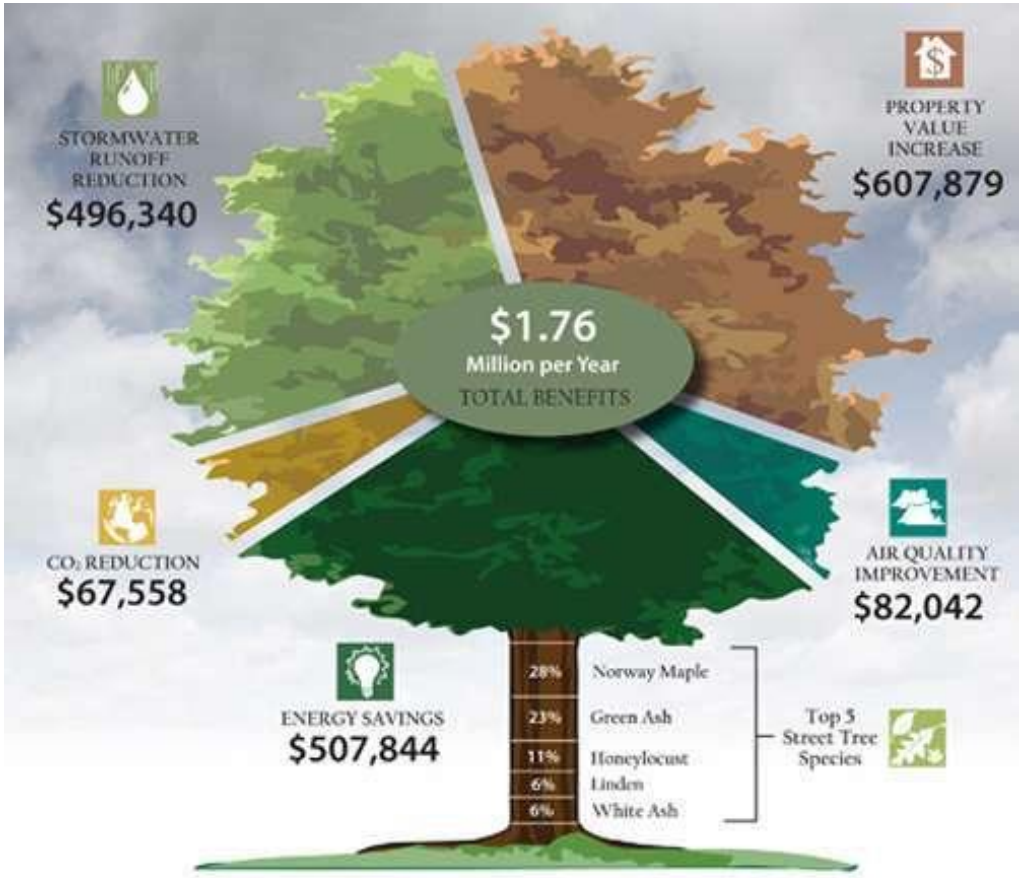
Source: Adapted from R. Costanza *et al.*, "The Value of the World's Ecosystem Services and Natural Capital," *Nature*, Vol. 387 (1997), p. 256, Table 2.



It is very difficult to set numbers, this is just a shy approximation, but human societies put a price tag on everything. However, it is an interesting exercise to have an approximate idea on how much ecosystem services could cost.

https://www.griequity.com/resources/Environment/Valuing%20Ecosystem%20Services.htm

How much are tres really worth?



The idea was to demonstrate that ecosystems services are much more important to human wellbeing than conventional economic thinking.

We probably will never know its real $ value.

Scientists demonstrate the need for more research and highlights the importance of ecosystems services and its impact on human welfare.

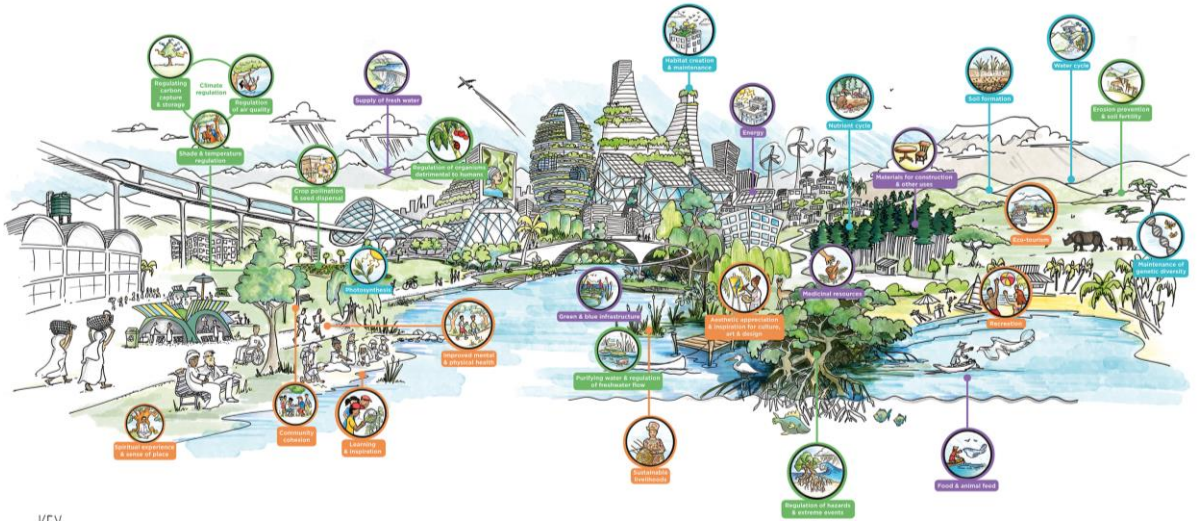
https://www.totallandscapecare.com/landscaping-business/feature-article/how-much-are-trees-really-worth/

Nature's worth…

In 1966, scientist made a meta-analysis of existing literature on the 16 biomes and using a basic value transfer technique, they assumed a constant value/ha for each biome:

The entire biosphere value (obviously, outside of market) is estimated between US$ 16-54 trillion (10^{12}).

If ecosystems services were added to the real cost in terms of the added value to the global economies, the actual price system would be very different nowadays.



https://cbc.iclei.org/value-nature-urban-life/

A typical day on planet earth, humans will:

- add 15 million tons of carbon to the atmosphere
- destroy 115 square miles (297 square kilometers)
- create 72 square miles of desert (186 square kilometers)
- eliminate between 40 – 100 species
- erode 71 million tons of top soil
- add 2,700 tons of CFCs to the stratosphere
- increase the population by 263,000 (360,000 in 2019) every day

David Orr, Ecological Literacy, 1992

Unprecedented change…

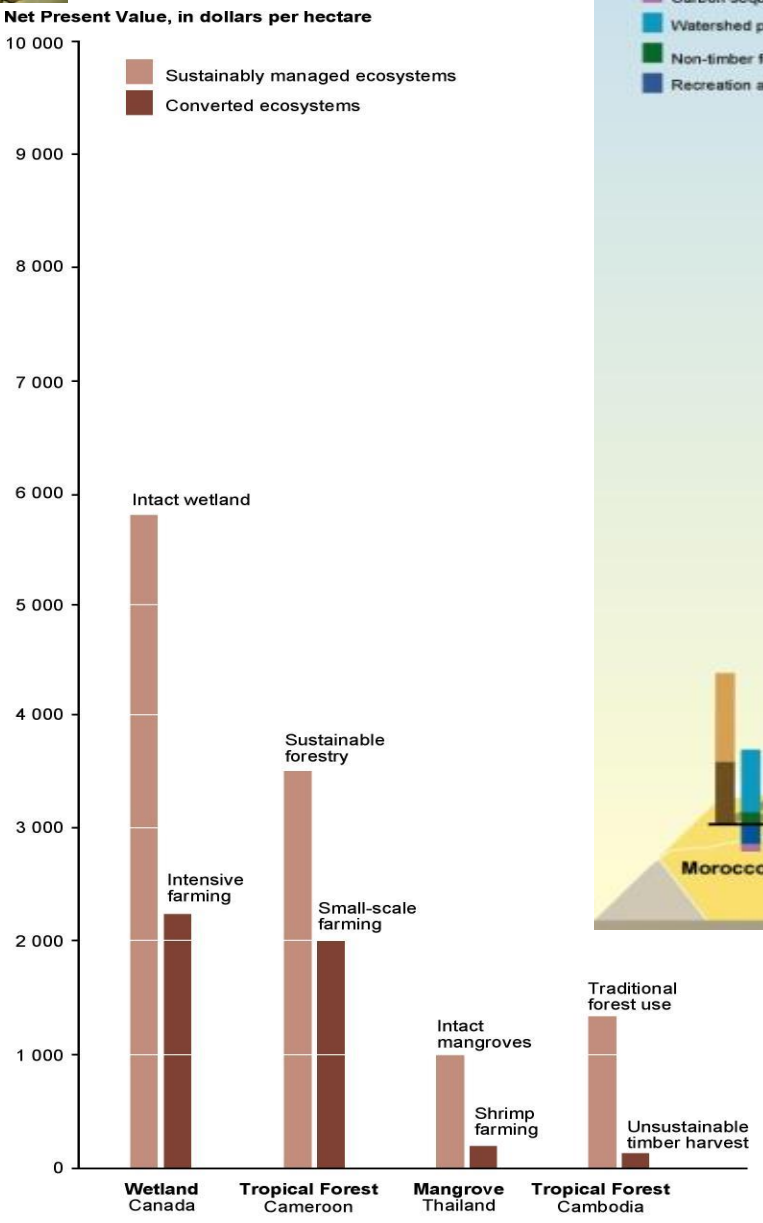
- Human beings are adding dramatic changes to the planet ecosystems to satisfy their own needs (food, energy, minerals, etc.).

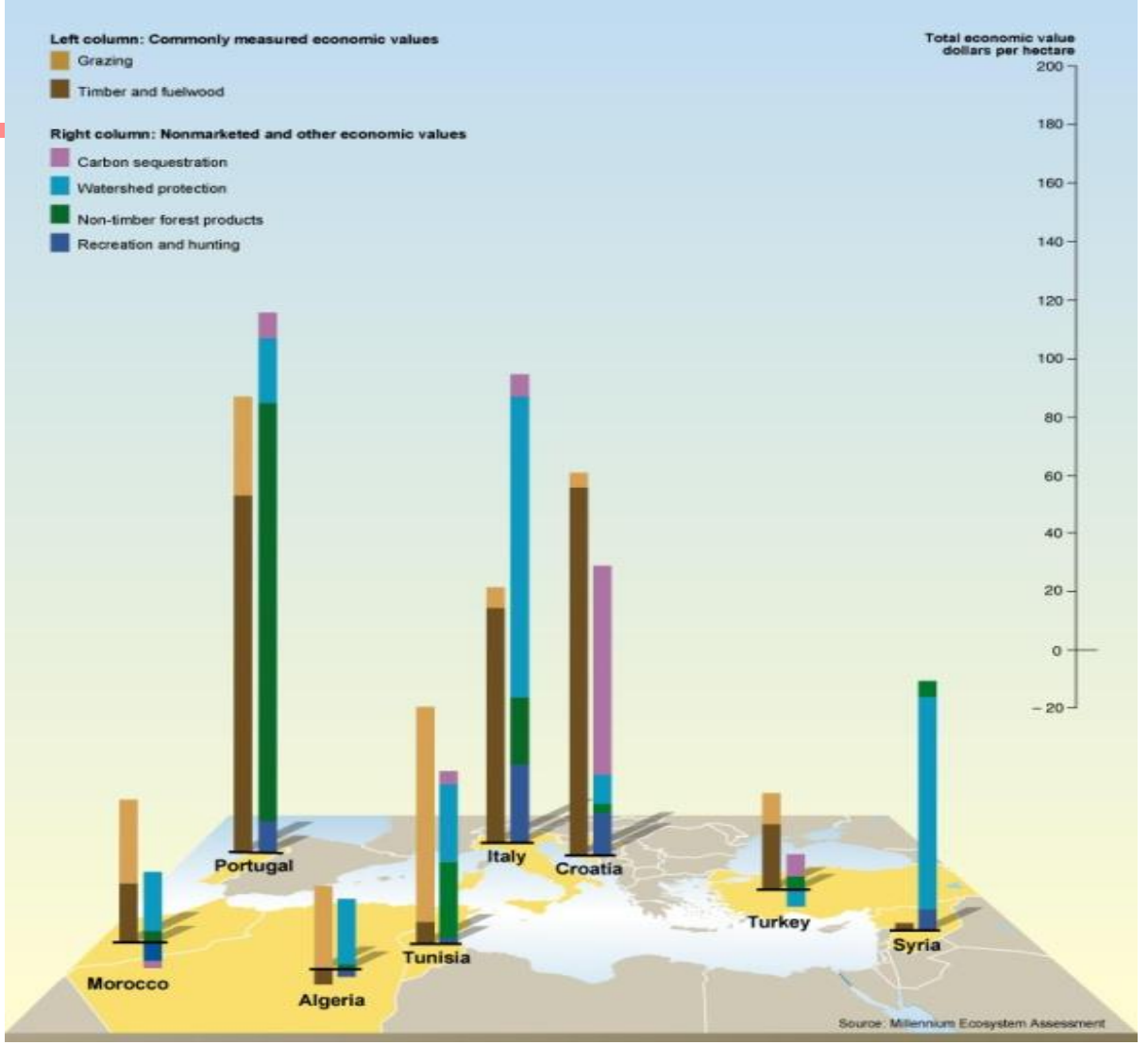
- These changes had improved the life of millions of people. However we have debilitated the nature's capacity to keep providing the required services such as clean water, clean air, disaster protection, medicines, etc.

- The pressure on the ecosystems are a global phenomenon that will worsen in the next few decades unless we change our attitude and the way we take for granted the ecosystem services.

- Politicians and entrepreneurs did not take into account the ecosystems services, nor their value.

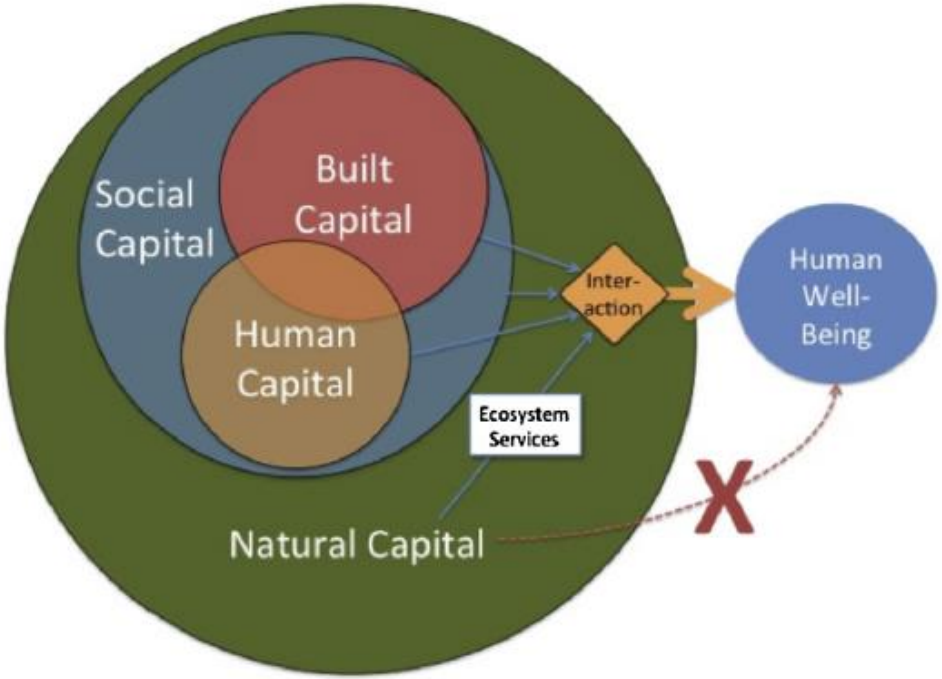
Consequences





The loss of ecosystem services represent a major obstacle to reach the *Millennium Development Goals* needed to reduce poverty, hunger and diseases.

Human wellbeing



Human wellbeing is based on the built capital and the human capital (which is the economy).

They are embedded in a society, that it is embedded in the nature (natural capital) and contribute to the human wellbeing.

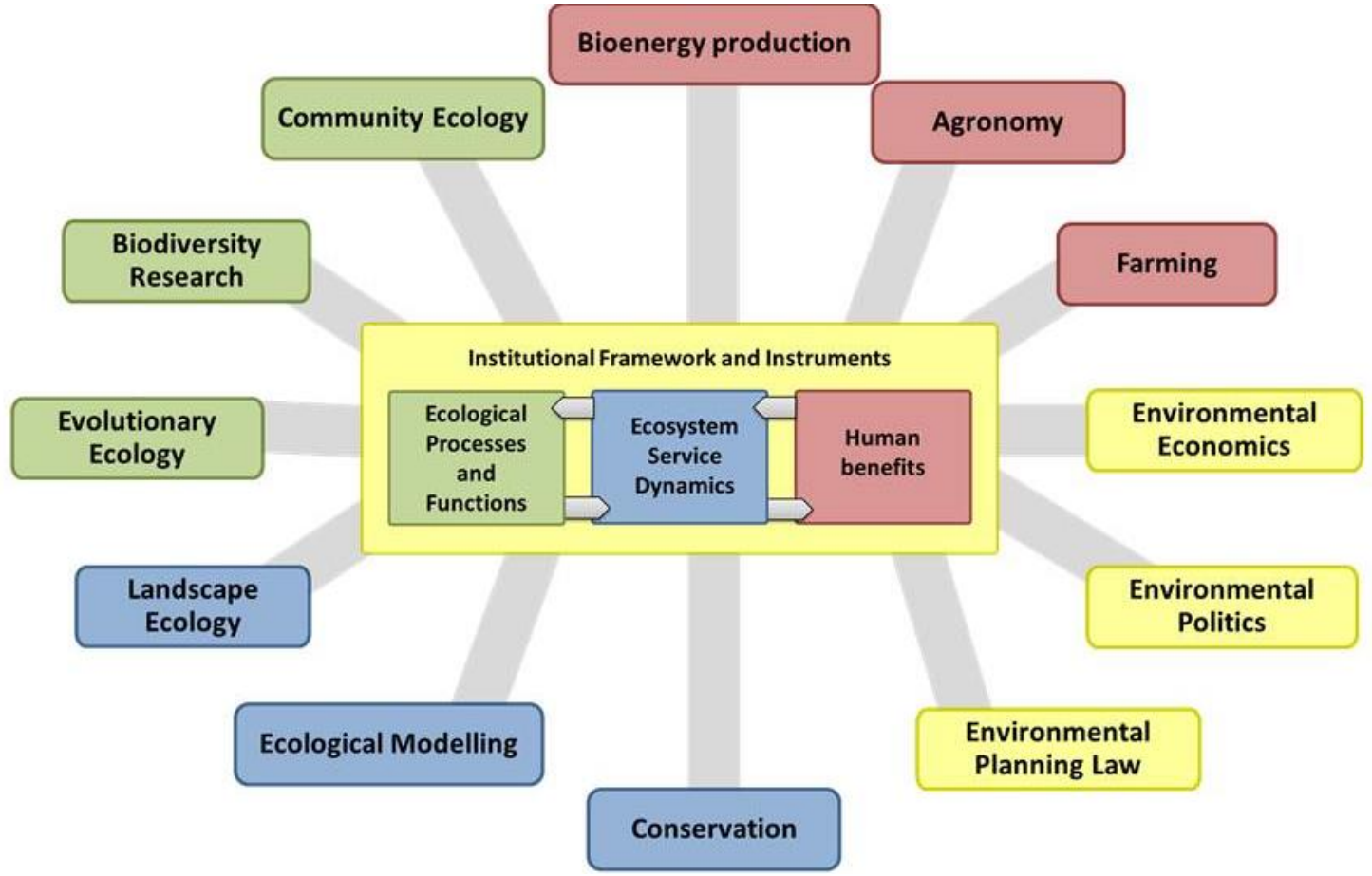
Human wellbeing do not flow directly from the natural capital. It is a result of the interactions of all these capitals.

We must take this transdisciplinary perspective, in order to address and value the ecosystems services.

Linking Ecosystem Services & Human Well-being. Millennium Ecosystem Assessment

https://www.robertcostanza.com/wp-content/uploads/2017/02/2017_J_Costanza-et-al.-20yrs.-EcoServices.pdf

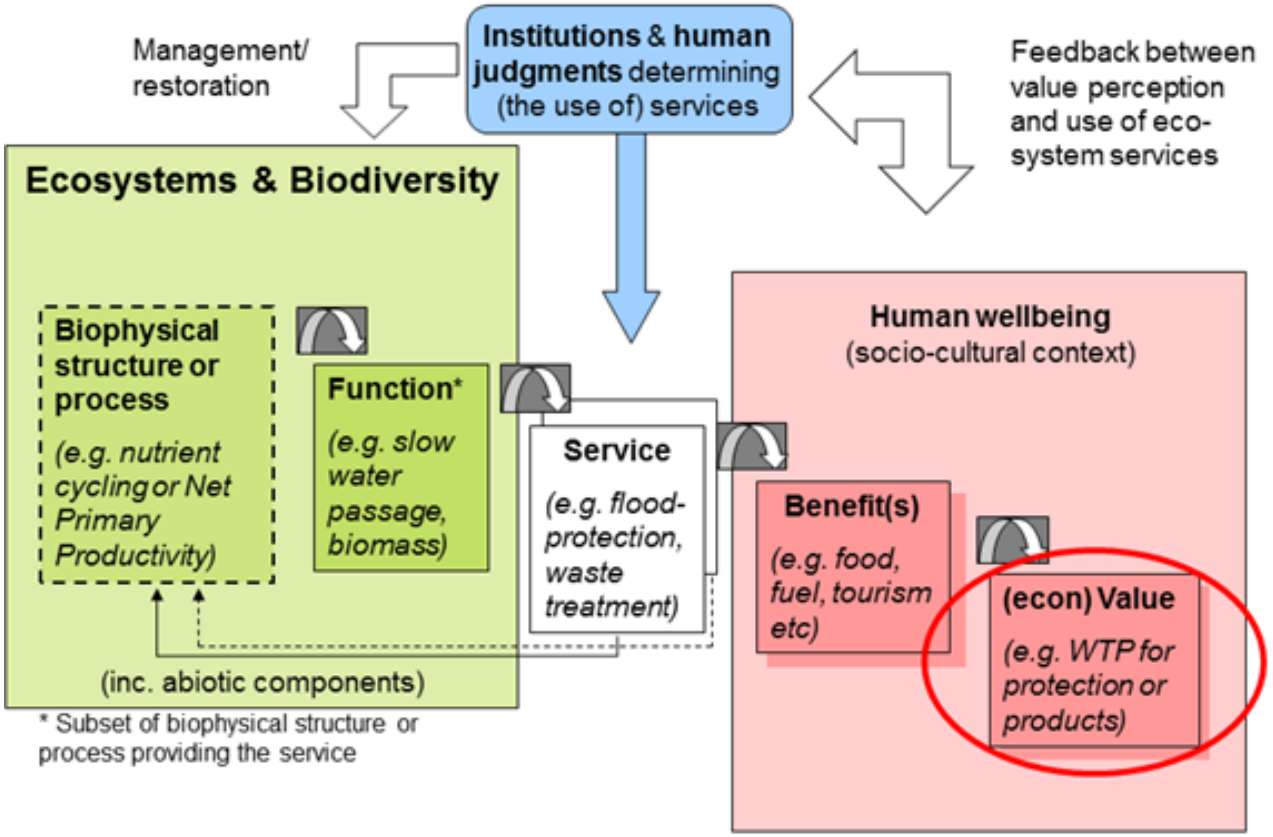
Ecosystems services framework and instruments



The way that we care or not care for some of these aspects, impacts directly on the human wellbeing.

https://www.ufz.de/index.php?en=43685

The cascade of services



Provision of service

Regulation of service

Cultural service

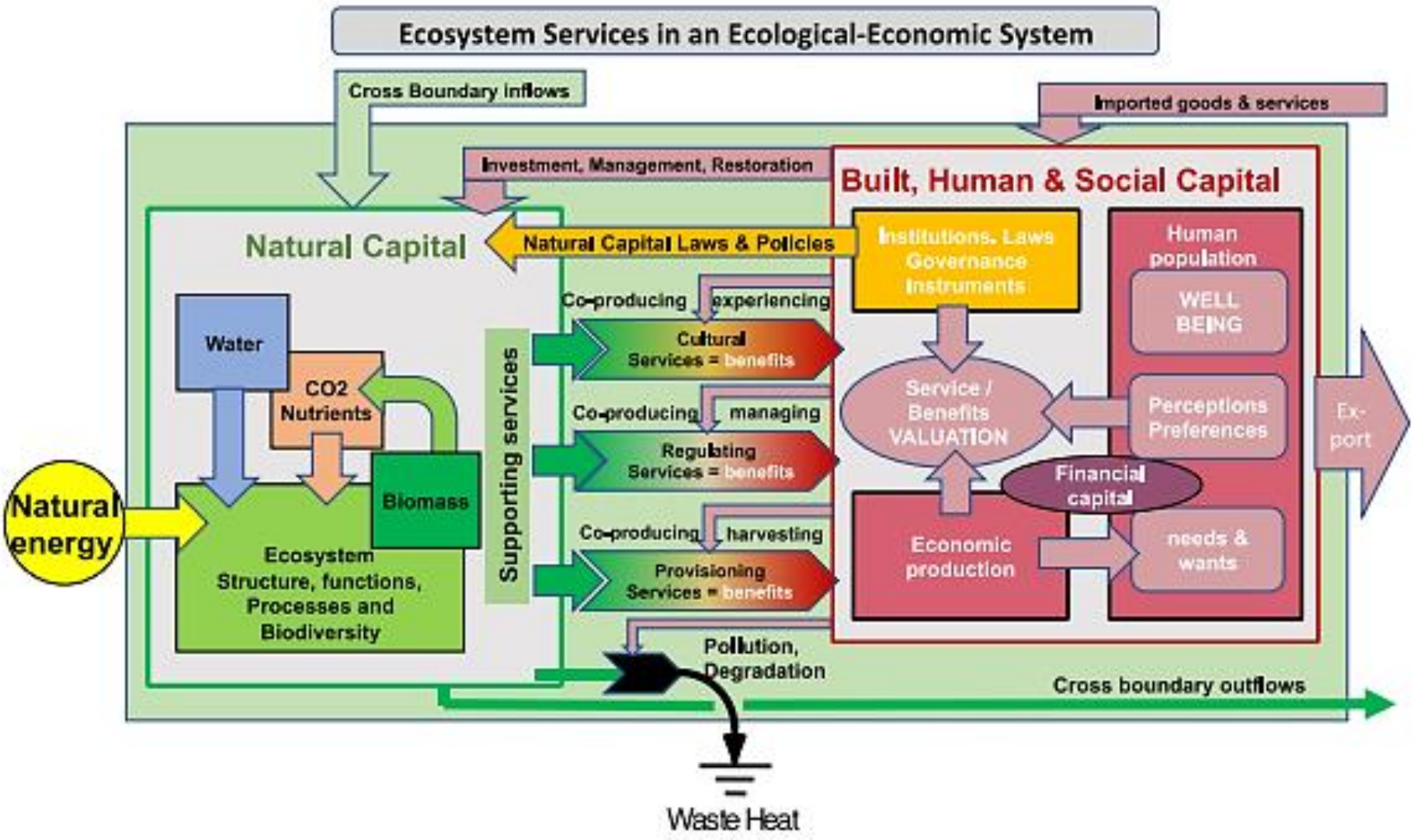
Supporting service

The way that we care or not care for some of these aspects, impacts directly on the human wellbeing.

WTP – willingness to pay

http://www.marine-vectors.eu/Landing_pages/Ecosystem_services

Beyond the cascade, more complex…



From: Constanza et al. 2017

Changes in cost of ecosystem services

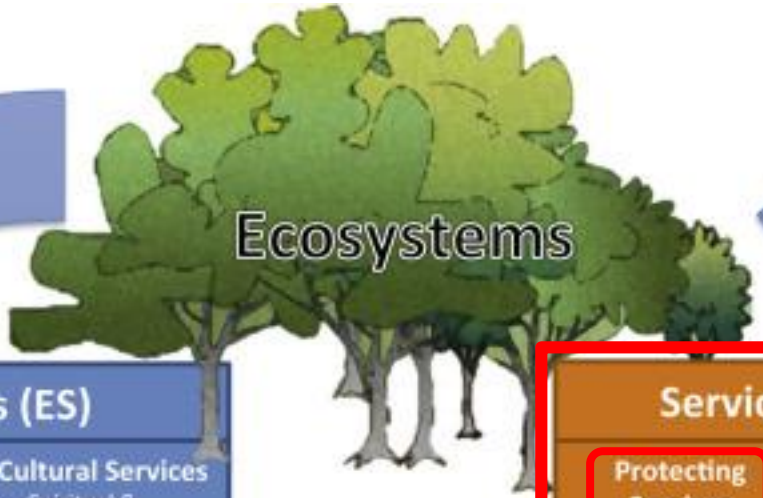
Changes in area, unit values and aggregate global flow values from 1997 to 2011.

							A. *Original* Assuming 1997 area and 1997 unit values	***B.*** *Change unit values only* Assuming 1997 area and 2011 unit values	***C.*** *Change area only* Assuming 2011 area and 1997 unit values	***D.*** *Change both unit values and area* Assuming 2011 area and 2011 unit values	***E.*** *Column C - Column A*	***F.*** *Column D - Column B*
Biome	**Area (e6 ha)**		**Change**	**Unit values 2007$/ha/yr**		**Change**	**Aggregate Global Flow Value e12 2007$/yr**				**2011-1997 Change in Value e12 2007$/yr**	
	1997	**2011**	**2011-1997**	**1997**	**2011**	**2011-1997**	**1997**	**2011**	**2011**	**2011**	**1997 unit values**	**2011 unit values**
Marine	**36,302**	**36,302**	0	796	1,368	572	**28.9**	**60.5**	**29.5**	**49.7**	0.6	(10.9)
Open Ocean	**33,200**	**33,200**	0	348	660	312	11.6	21.9	11.6	21.9	-	-
Coastal	**3,102**	**3,102**	0	5,592	8,944	3,352	17.3	38.6	18.0	27.7	0.6	(10.9)
Estuaries	180	**180**	0	31,509	28,916	-2,593	5.7	5.2	5.7	5.2	-	-
Seagrass/Algae Beds	200	**234**	34	26,226	28,916	2,690	5.2	5.8	6.1	6.8	0.9	1.0
Coral Reefs	62	**28**	-34	8,384	352,249	343,865	0.5	21.7	0.2	9.9	(0.3)	(11.9)
Shelf	2,660	**2,660**	0	2,222	2,222	0	5.9	5.9	5.9	5.9	-	-
Terrestrial	**15,323**	**15,323**	0	1,109	4,901	3,792	**17.0**	**84.5**	**12.1**	**75.1**	(4.9)	(9.4)
Forest	**4,855**	**4,261**	-594	1,338	3,800	2,462	6.5	19.5	4.7	16.2	(1.8)	(3.3)
Tropical	1,900	**1,258**	-642	2,769	5,382	2,613	5.3	10.2	3.5	6.8	(1.8)	(3.5)
Temperate/Boreal	2,955	**3,003**	48	417	3,137	2,720	1.2	9.3	1.3	9.4	0.0	0.2
Grass/Rangelands	**3,898**	**4,418**	520	321	4,166	3,845	1.2	16.2	1.4	18.4	0.2	2.2
Wetlands	**330**	**188**	-142	20,404	140,174	119,770	6.7	36.2	3.4	26.4	(3.3)	(9.9)
Tidal Marsh/Mangroves	165	**128**	-37	13,786	193,843	180,057	2.3	32.0	1.8	24.8	(0.5)	(7.2)
Swamps/Floodplains	165	**60**	-105	27,021	25,681	-1,340	4.5	4.2	1.6	1.5	(2.8)	(2.7)
Lakes/Rivers	**200**	**200**	0	11,727	12,512	785	2.3	2.5	2.3	2.5	-	-
Desert	**1,925**	**2,159**	234	-	-	0	-	-	-	-	-	-
Tundra	**743**	**433**	-310	-	-	0	-	-	-	-	-	-
Ice/Rock	**1,640**	**1,640**	0	-	-	0	-	-	-	-	-	-
Cropland	**1,400**	**1,672**	272	126	5,567	5,441	0.2	7.8	0.2	9.3	0.0	1.5
Urban	**332**	**352**	20	-	6,661	6,661	-	2.2	-	2.3	-	0.1
Total	51,625	51,625	0				45.9	145.0	41.6	124.8	(4.3)	(20.2)

(Green values that increased, red, values that have decreased)

Costanza, et al. 2014.

Ecosystem services and/or services to ecosystems



Ecosystem Services (ES)

Provisioning Services
- Food
- Fresh water
- Fuelwood
- Fiber
- Biochemicals
- Genetic resources

Regulating Services
- Climate regulation
- Disease regulation
- Water regulation
- Water purification
- Pollination

Cultural Services
- Spiritual & religious
- Recreational
- Ecotourism
- Aesthetic
- Inspirational
- Educational
- Sense of place
- Cultural heritage
- S2E

Supporting Services
Ecosystem functions: Nutrient cycling, Evolution, Soil formation, Spatial structure, Primary production

Reciprocity

Services to Ecosystems (S2E)

Protecting Services
- Habitat protection
- Weeding/ culling
- Ritual regulation
- Cultural prohibitions & prescriptions on species and habitats

Enhancing Services
- Cultivation
- Domestication
- Trait selection
- Translocation, range spreading
- Pruning
- Fertilizing
- Nutrient (re)cycling

Restoring Services
- Improving soil / water/air quality
- Habitat/niche (re)construction
- Nutrient release (burning)
- Planting, sowing
- Revitalisation of eco-cultural harvesting

Supporting Services
Enhancing cultural-ecological integrity, symbiotic actions, cultural beliefs, Indigenous worldviews, TEK

https://www.sciencedirect.com/science/article/pii/S0959378015300145

So far, ecosystems services…

- have not only become popular, but they have entered into the economic business equation.
    - Dow Chemical $10 million collaboration with The Nature Conservancy to evaluate cost/benefits of every business decision

- have inconsistent approaches per countries, companies, governments, etc. So it makes it difficult to standardize cost of services.

- generate relevant ecological-social knowledge for stakeholders and policy decision makers.

- accounting and assessment need to be developed to reach and standard social-ecological lens.

- must have a broad range of scales in space, time or governance. These disparities, may impact in different ways to different countries, mainly between rich and poor countries.

The Outcome

Environmentalists can study, not value
Economists can value, not study

- Findings weighted more heavily in creating policy

Class, what would you do….?

Video

Sir Partha Dasgupta:

Measuring wealth "Beyond GDP

https://www.youtube.com/watch?v=8uGPthIEWTE

(4'26")

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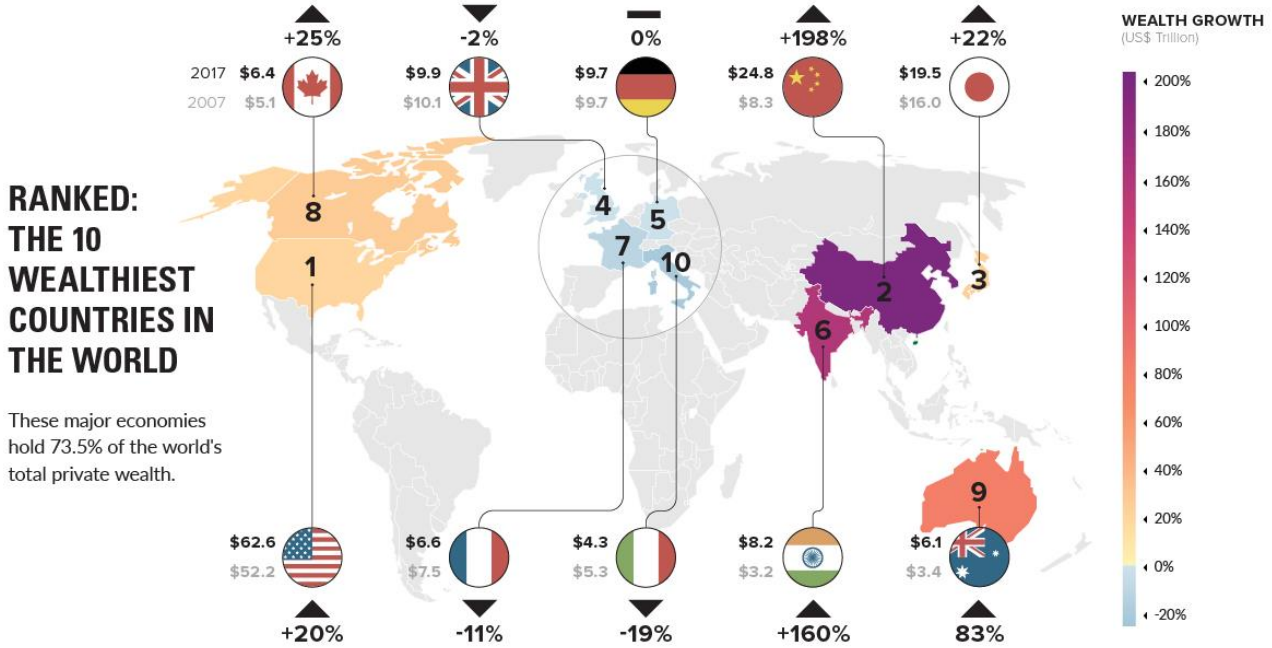
Richness of Nations

The wealth of the Nation by Symour Fogel

Richness of Nations

A central presumption in modern development discourse is the significance of income growth for human betterment. By income, in the context of a country, we mean gross domestic product (GDP), which is the market value of the flow of final goods and services in a given year. GDP is a measure of economic activity..



http://mgiep.unesco.org/article/wealth-well-being-and-the-sustainable-development-goals
https://www.visualcapitalist.com/chart-the-10-wealthiest-countries-in-the-world/

Richness of Nations

The rogue word in GDP is "gross", which signals that GDP does not deduct the depreciation of capital goods that accompany their usage. Just as a household can increase its disposable income by running down its bank balance and selling off its material assets, a country can achieve high growth rates by depleting its productive capital. The problem is that income would not be sustainable under those circumstances. At some point in the future, GDP would simply have to decline.

http://mgiep.unesco.org/article/wealth-well-being-and-the-sustainable-development-goals

The Idea of Wealth

For a household, income growth is a means of improving quality of life. However, because the household cares about its future, income figures are only relevant once the depreciation of assets has been taken into account. Economic betterment for the household requires that it consumes less than its net income. In simpler terms, a household should not live beyond its means. That, in turn, means that the household accumulates wealth.

http://mgiep.unesco.org/article/wealth-well-being-and-the-sustainable-development-goals

The Breadth of Capital Goods

A brief tour of an economy's stock of assets would uncover three categories:

1. Reproducible (or manufactured) capital (roads, buildings, ports, machines, equipment)

2. Human capital

   A. personal character, knowledge, and skills (aptitude, self-awareness, sociability, education, tacit knowledge)

   B. health (body mass index, life expectancy)

3. Natural capital (agricultural land, forests, grasslands, coastal fisheries – more generally, ecosystems; the atmosphere; the oceans; sub-soil resources).

.

Why it is necessary…

1. To modify the accounting systems in order to include the value of the services, ecosystems and human and natural capital.

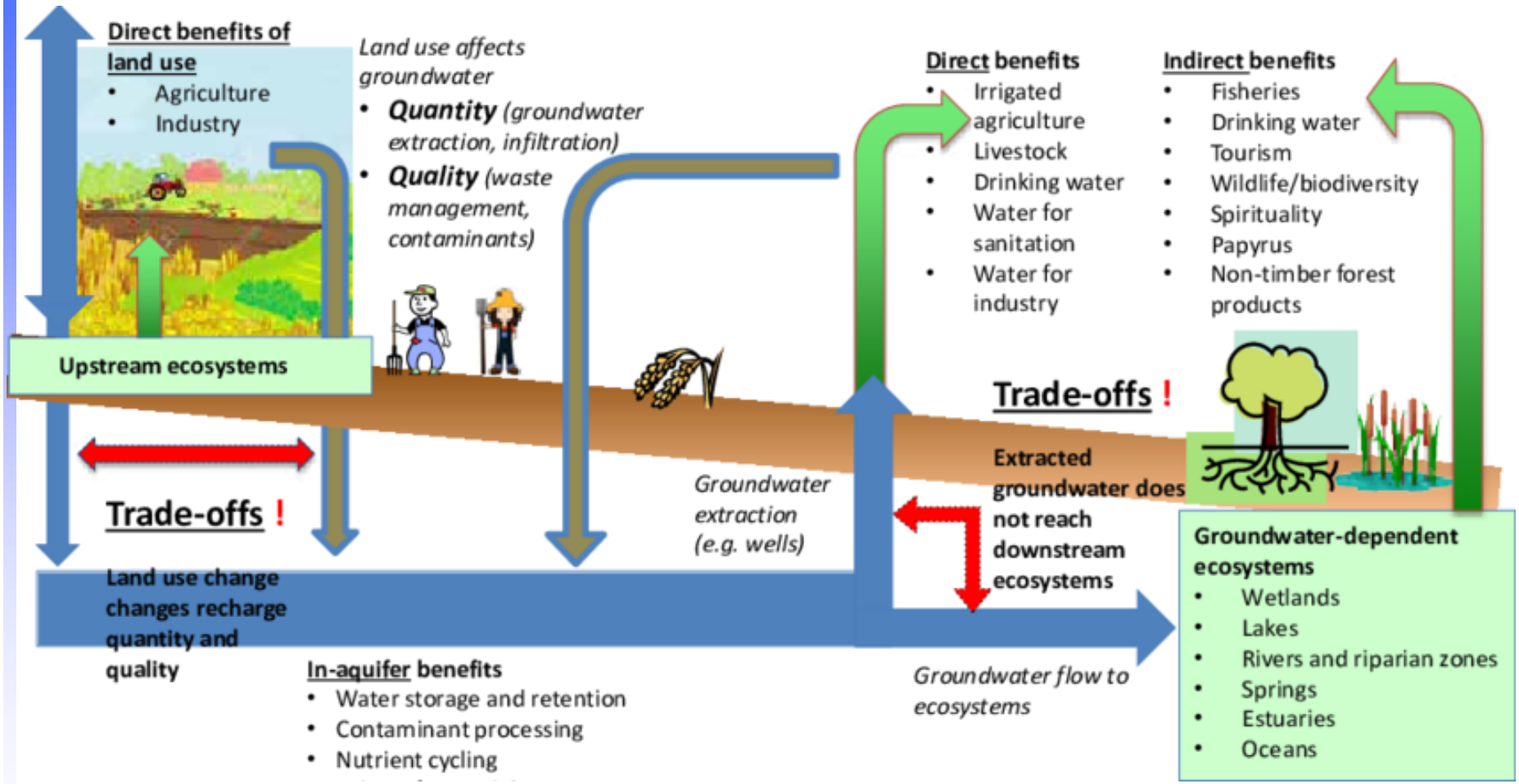
2. To evaluate projects for recovery of lost ecosystems natural and contrast them vs. other projects.

Because the capital services of natural ecosystems will be under much more stress in the future, we can only expect that their value will increase.

Costanza et al. (2014) conclude that the accounting value of ecosystem services expressed in monetary units are quite useful to raise awareness on: the magnitude of the services provided.

In other words, "it helps to build a more comprehensive and balanced picture of the assets that support human wellbeing and human's interdependence between wellbeing and life on the planet."

Why it is necessary…



https://www.researchgate.net/publication/301650568_Groundwater_and_ecosystem_services_a_framework_for_managing_smallholder_groundwater-_dependent_agrarian_socio-ecologies/figures?lo=1

International Space Station

There are sleeping quarters for six astronauts, however, astronauts have been known to just tie their sleeping bag to a bulkhead.

https://www.nasa.gov/mission_pages/station/images/station_post_construction/index.html

International Space Station (ISS)

Dimensions:
171 ft. long, 240 ft. wide, 90 ft. high (109 X 73 m aprox),

Living space: 15,000 ft^3 (424 m^3) .

Weight: 477,000 lbs (202 metric ton).

Altitude: Approximately 220 miles above earth (354 km aprox)

Orbital inclination/path:
51.6 degrees, covering 90% of the world's population.

Speed:
17,500 miles per hour (28,163.5 km per hour), orbiting the Earth 16 times a day.

https://www.nasa.gov/mission_pages/station/main/s114e7221_feature.html

NASA ISS Control Center

Johnson Space Center – Houston
Shuttle Mission Control Room

Johnson Space Center – Houston
ISS Mission Control Room

NASA ISS Control Center

Kennedy Space Flight Center –
Cape Canaveral, Florida
Shuttle Firing Room

Marshall Space Flight Center –
Huntsville, Alabama
Payload Operations
& Integration

NASA ISS Control Center

Korolev, Russia
ISS Mission Control Center

Tsukuba Space Center – Japan
JEM Mission Control Room

International ISS Control Center

St. Hubert, Canada
MSS Control Center

Columbus Control Center -
Oberpfaffenhofen, Germany
Main Control Room

ISS by the numbers

961	Hours of spacewalks
110	Launches
32,033	Cubic feet of pressurized volume
827,794	Pounds on-orbit
23,000	Meals eaten
1,800,000	Lines of software code
90	Kilowatts of power
100,000	People worldwide on the team

150 billion USD, Estimated cost
3 billion USD per year, current cost by NASA
7.5 million USD, per day spending on one occupant in ISS

Estimated cost for all humans today (around 7,687,877,900 humans):
5.7659 e16 or 57,659,000,000,000,000 USD

GDP of the world: 80,738 Trillion/year or 80,738,000,000,000

https://www.quora.com/What-is-the-cost-of-ISS, http://www.worldometers.info/world-population/
https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=1W