



The Beneficial Roles of Agroforestry – *Reducing Fertiliser, Mitigating Climate Change, and Improving Soil Health*

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A large, mature tree with a thick trunk and dense green foliage stands in the foreground, partially obscuring the view of a lush green field. In the field, several cows of various breeds (black and white, brown and white) are grazing. The background is filled with more trees under a clear blue sky. A small orange horizontal bar is located in the top left corner.

What Does
Agroforestry
really mean?

Agroforestry Definitions

Silvo-pastoral agroforestry: grazing of farm livestock among and under trees.

Silvo-arable agroforestry: where crops are grown beneath trees often in rows which are large enough for a tractor to tend to the crops without damaging the trees. Includes alley cropping (planting single rows of trees and growing crops in the alleyways in between), and forest farming (the cultivation of shade-tolerant crops under the protection of a managed forest).



Let's look at Agroforestry
from an **ecological**
perspective
before we consider its role
as a farming practice...

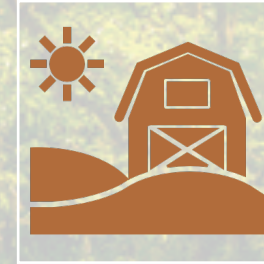
Agroforestry can be considered as a symbiotic relationship between farming and the land




Tree roots reach deep into the ground, extracting nutrients from deep within the soil, while adding to the soil biomass, and increasing the carbon content of the soil;



Trees help to cycle nutrients; and tree roots bind the soil together, preventing it from being eroded by the wind or the rain;



Trees provide shelter for farm livestock, extending the grazing season, while the dung from animals sheltering under trees provides nutrients and organic matter.



Ecological relationships include not only predator-prey, but three other very important relationships:

- **Symbiosis** – a symbiotic relationship is one in which both organisms benefit, most frequently to the extent that one cannot exist without the other; another name for it is mutualism;
- **Commensalism** – a relationship in which one organism benefits and the other is neither helped nor harmed; and,
- **Parasitism** – a relationship in which one species (the parasite) benefits and the other species (the host) is harmed.

Using these ecological definitions, consider how we are using land, soil and other species at the present time !

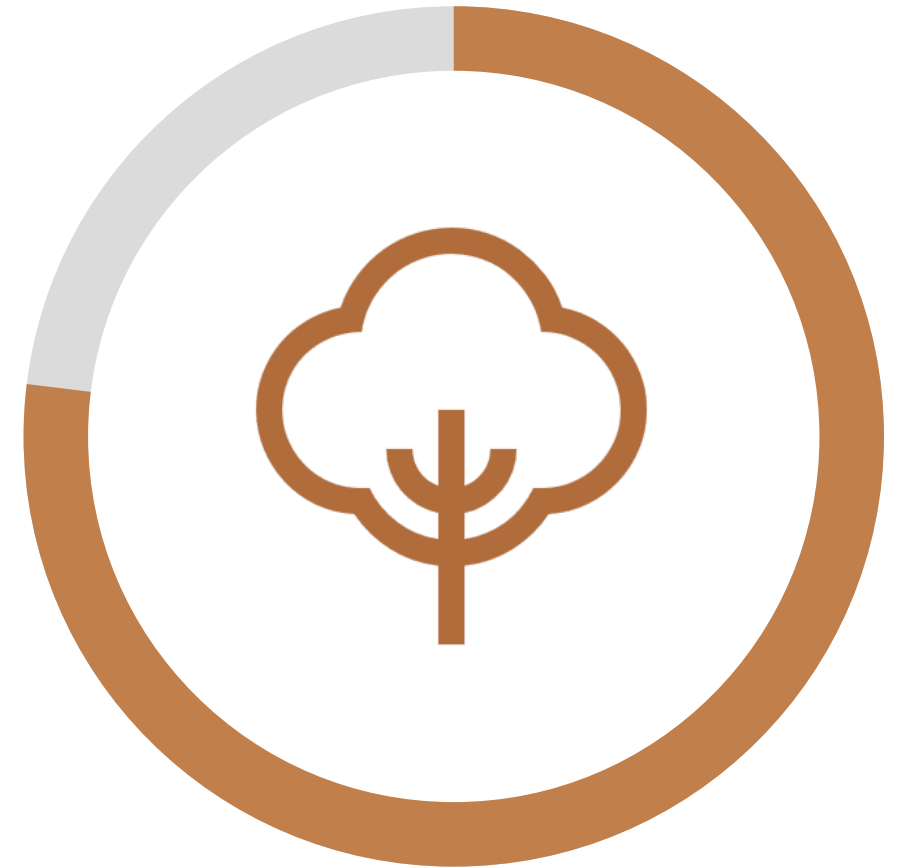
The evidence is becoming more clear that our relationship with the natural environment is immensely destructive:

- **Massive reduction in biodiversity** – including many species of birds and insects becoming rare, and their survival threatened;
- **Soil damage** – erosion and loss of soil organic matter, loss of topsoil;
- **Water pollution** – run-off of surface-water contaminated with silt, nutrients (from excessive application of fertilisers and animal slurry) and agro-chemicals; and pollution of groundwater; and,
- **Climate change** – as a consequence of greenhouse gas emissions from use of fossil fuels and huge numbers of ruminants on farms.



Farming and the Natural Environment

- Approximately **70 billion** farm animals are reared for food in the world each year, including 1.5 billion cattle, 1.2 billion sheep, and 967 million pigs;
- The combined weight of cattle, chickens, and pigs exceeds the total weight of **all wild animals and humans** !
- **Half** of the world's **habitable** land is used for agriculture;
- If we combine pastures used for grazing with land used to grow crops for animal feed, livestock accounts for **77% of global farming land**;
- Of the 28,000 species considered to be threatened with extinction on the IUCN Red List, **agriculture is listed as a threat for 24,000 of them.**

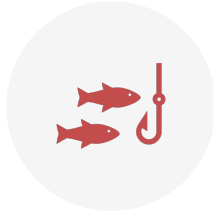




Does farming contribute to climate change ?

- While fossil fuel burning is the largest contributor to climate change, accounting for over 75% of global greenhouse gas emissions, **agriculture is the second largest contributor.**
- Livestock production—primarily cows—produce **14.5%** of global greenhouse gas emissions;
- About **a third** of human-caused methane emissions come from livestock, mostly from beef and dairy cattle; and,
- More than 40% of livestock’s climate footprint is made up of methane emissions, mostly from beef and dairy cattle.
- Methane emissions can be reduced by specific diets, but are there other ways of achieving the needed reduction ?

Agriculture is not the only human activities that causes damage to biodiversity, water quality, soil and climate. For example:



draining of wetlands
for port development



discharge of partially
treated waste into our
rivers



plastic waste in the
world's oceans



transport and power
generation are
massive emitters of
greenhouse gases



buildings are
responsible for 36% of
EU's emissions

Let's consider what agroforestry might be able to achieve in addressing some or all of these problems

Biodiversity loss

Soil damage

Water pollution

Climate change

While at the same time helping the farmer in several ways, and perhaps helping his/her livestock as well. ...

Ecosystem Services Provided by Agroforestry

Ecosystem services	Spatial Scale		
	Farm/Local	Landscape / Regional	Global
Net Primary Production			
Pest Control			
Pollination/Seed Dispersal			
Soil Enrichment			
Soil Stabilization / Erosion Control			
Clean Water			
Flood Mitigation			
Clean Air			
Waste reduction			
Carbon Sequestration			
Biodiversity conservation			
Aesthetics/Cultural			

Adapted from
“Agroforestry for ecosystem services and environmental benefits: an overview”;
 Shibu Jose;
 Agroforest Syst. (2009) 76: 1-10.

General Benefits



The integration of trees, agricultural crops, and/or animals into an agroforestry system has the potential to enhance soil fertility, reduce erosion, improve water quality, enhance biodiversity, increase aesthetics, and sequester carbon.



As shown on the previous slide, services and benefits provided by agroforestry practices occur over a range of spatial and temporal scales.

Net Primary Production

The integration of trees, agricultural crops, and/or animals into an agroforestry system has the potential to increase primary production;

Primary production, the transformation of solar energy into biomass, becomes many layered;

Diverse systems are more productive than monocultures;

Solar energy is more efficiently utilised.

Trees also have a longer growing season than most agronomic crops, which increases nutrient use and use efficiency in an agroforestry system by capturing nutrients before and after the cropping season.

Tree roots reach down below those of cereals or vegetables which means that the farmer can get more crops from the same hectare.

Pest Control

Pests thrive in a monoculture, and the mixture of species present in agroforestry can reduce pest infestations; Trees provide shelter for predators which can attack pests and reduce their numbers.

Pollination / Seed Dispersal

For crops requiring insect pollination, such as oilseed rape and field beans, agroforestry and windbreaks provide shelter for pollinator activity, particularly where shelter trees are integrated into existing hedges.

Agroforestry trees and shelter belts provide food and habitat for pollinating insects, and are used a 'highways' for the movement of bees, hoverflies and other pollinators.





Soil Enrichment

- The role of agroforestry in **enhancing and maintaining long-term soil productivity and sustainability** has been well documented.
- Use of trees which **can biologically fix nitrogen**, e.g., alder, is common in many agroforestry systems.
- Non-nitrogen-fixing trees can **also enhance soil physical, chemical and biological properties** by adding significant amount of above and belowground organic matter and releasing and recycling nutrients in agroforestry systems.
- Studies show **improved soil stability, increased levels of soil carbon, soil nitrogen, and soil enzyme activity** in soils under agroforestry compared to standard field crops.
- Organic matter added from leaf litter and root debris can **promote better soil structure**; while the decomposition of organic matter – such as fallen leaves, small branches, – is essential to reintroduce **important nutrients and trace elements** such as potassium, calcium, and magnesium in the soil and to allow other plants to absorb these nutrients.
- Tree roots **can access nutrients at deeper soil levels** and can be more efficient at extracting nutrients than other plants.
- Agroforestry can be utilised to produce **biochar**.

Soil Stabilization / Erosion Control

- A recent study in Britain has shown that soil degradation could have an annual cost of **£1.2 billion with about half related to the loss of soil organic matter, 40% to compaction, and 12% to soil erosion.**
- Developments in agriculture over the last 50 years, such as increase in field size and use of heavier machinery, and loss of hedgerows have increased the risk of **soil erosion.**
- Climate change and predicted increase in frequency of severe weather events, **is likely to magnify the impact of erosion**
- Erosion can reduce **the long-term fertility** of the soil by removing **nutrient rich topsoil** and **organic matter**, and can affect **water infiltration and increase runoff.**
- Erosion can lead to **loss of seeds, fertilisers and pesticides and incur costs** associated with repeat operations.
- On vulnerable soils, especially sandy soils, **wind erosion can cause loss of topsoil, seeds, fertiliser and agrochemicals, and cause damage to ditches and watercourses.**
- Soils under agroforestry **are much less likely** to be affected by erosion, loss of topsoil and compaction by heavy machinery.



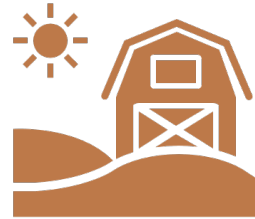
Clean Water

Agroforestry helps to **maintain good water quality**, for the following reasons:

- Trees can help **reduce soil and water movement**, by increasing water infiltration rates and slowing the flow of transported sediments
- .
- By **trapping pollutants** bound to soil particles, trees can act as **nutrient sinks**, and can help reduce water pollution.
- Targeted tree planting in agroforestry has been identified **as a way to mitigate diffuse pollution from agriculture and to deliver the quality standards** required by the Water Framework Directive.
- Agroforestry practices are a **proven strategy to provide clean water**.
- In conventional agricultural systems, **less than half of the applied N and phosphorous fertilizer** is taken up by crops; consequently, excess fertilizer is **washed off agricultural fields via surface runoff, or leached into groundwater, thereby contaminating water sources and decreasing water quality**.



Trees also reduce nutrient movement into groundwater by taking up the excess nutrients.



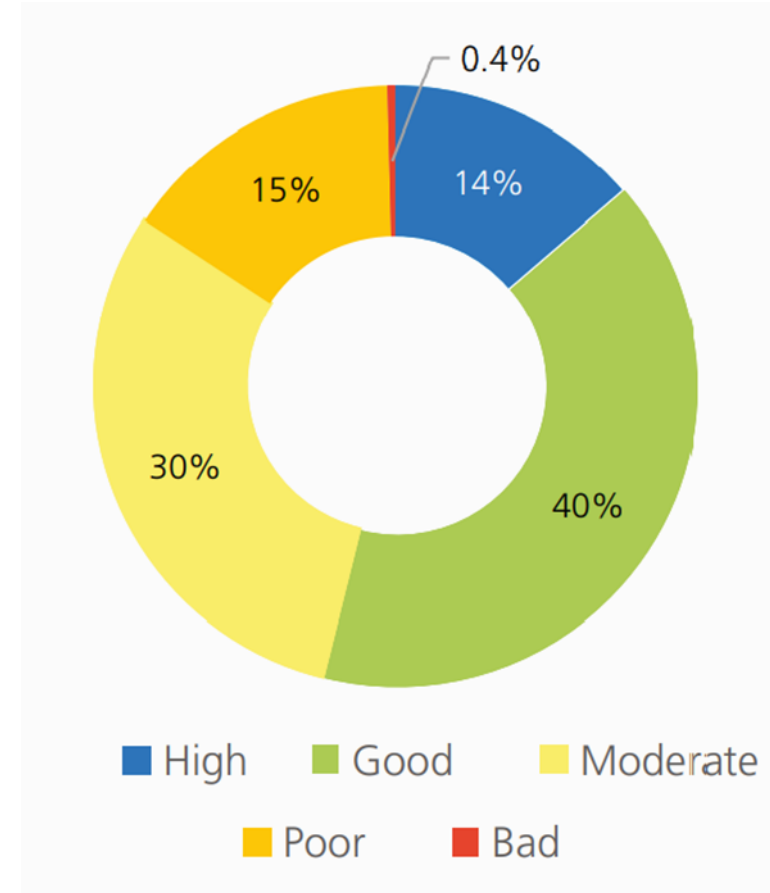
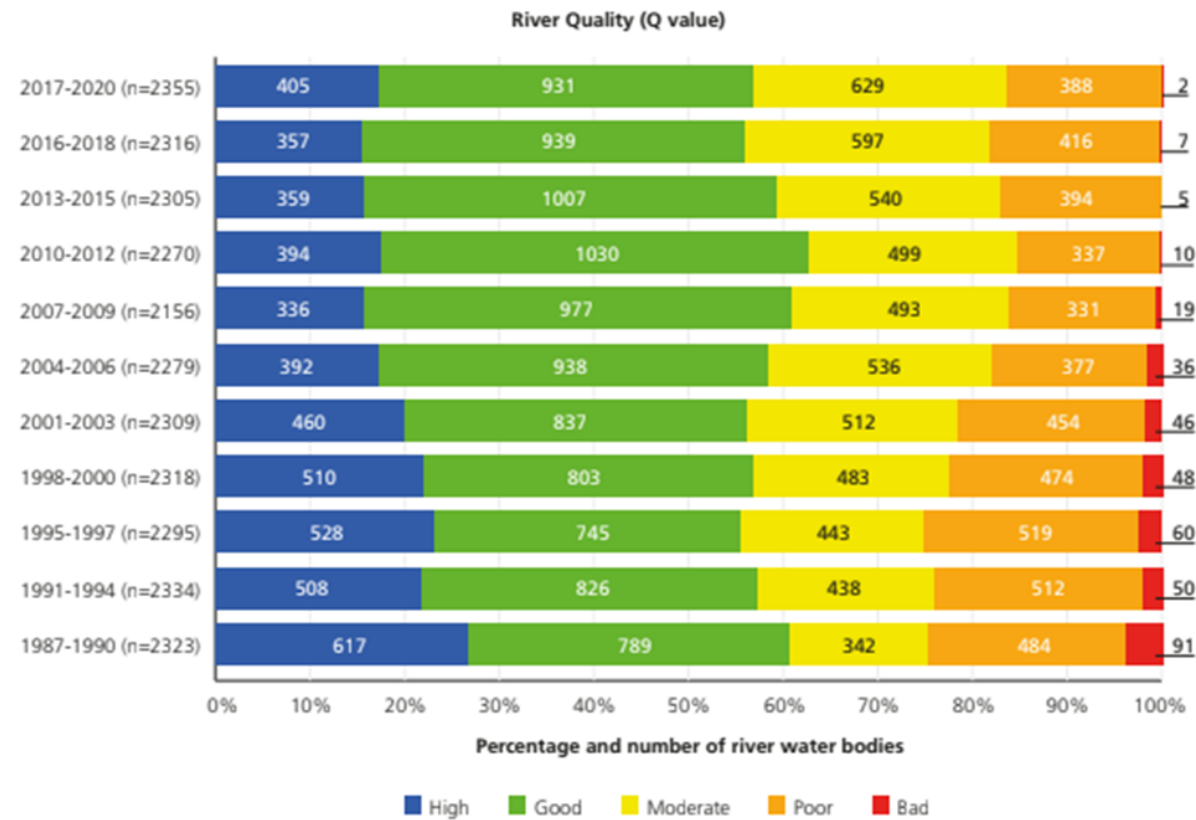
Several studies have shown that agroforestry reduces nonpoint source pollution, compared standard field crop agriculture.



Trees with deep rooting systems in agroforestry can also improve groundwater quality, whereby excess nutrients which have been leached below the rooting zone of agricultural crops are taken up by tree roots; these nutrients are then recycled back into the system through root turnover and litterfall, increasing the nutrient use efficiency of the overall system.

Trends in Water Pollution in Ireland

Of the 1,836 (out of 2355) river water bodies assessed in 2019 and 2020, 345 improved in quality and 230 declined, resulting in a net improvement in quality in 115 river water bodies.



Could be sustainable, depending on the type of pollutant. But heavy metals, POPs and plastics bio-accumulate:
unsustainable.

According to the Environmental Protection Agency (EPA):

*“If the current level of progress continues, **Ireland will fail** to meet the EU and national goal of restoring all waters to good, or better, status by 2027.”*

*“The scale of the declines in our estuaries and coastal waters is alarming. In recent years the EPA highlighted that nutrient levels in our rivers and groundwaters are **too high** and that trends were going in the wrong direction. We are now seeing the impact of these emissions on our estuaries and coastal waters. Areas such as Cork Harbour, Wexford Harbour and the Slaney, Suir and Nore estuaries have lost their good water quality status. This directly impacts the marine biodiversity and ecological value in these areas”.*

Air Quality, Clean Air and Shelter

Agroforestry practices including silvo-arable agroforestry, windbreaks and shelterbelts can:

- ✓ reduce wind chills,
- ✓ reduce wind velocity,
- ✓ protect crops from strong winds,
- ✓ farm livestock can shelter under trees; improving their quality of life,
- ✓ reduce wind erosion and the amount of particulate matter in the air,
- ✓ remove atmospheric carbon dioxide and produce oxygen,
- ✓ reduce noise pollution; and,
- ✓ mitigate odour from concentrated livestock operations (e.g., pig farming).

Carbon sequestration and climate mitigation



A large number of studies in recent years has demonstrated the **carbon sequestration and climate mitigation potential of agroforestry** systems around the world.



The incorporation of trees in agroforestry systems **increases the amount of carbon sequestered** compared with a monoculture field of crop plants or pasture.



In addition to the significant amount of carbon stored in above-ground biomass, agroforestry systems can also **store carbon belowground**.



Carbon sequestered in agroforestry systems could be sold in **carbon credit markets**, where these markets exist.



The largest amount and most permanent form of carbon may be sequestered by **increasing the rotation** age of trees and by manufacturing durable products from them after harvesting; for example in the construction of all-timber houses which will last for several generations.



Wood fuel, as a renewable energy source, **displaces fossil fuels and reduces the carbon footprint of the farm**, as well as **securing part of the farm's energy** needs at a time when energy prices are increasing.



More about the carbon sequestration and climate mitigation benefits of agroforestry....

- We have significant areas of partly abandoned croplands and former arable fields, in some of which the soil has been degraded (visible on the edges of many towns in Ireland), and it is suggested that agroforestry has **enormous potential to improve these lands and to sequester additional quantities of carbon.**
- On marginal or less productive lands, the productivity of even a short rotation alley cropping system has the potential to lead to a **higher energy efficiency and net energy production per hectare** than under conventional management, mainly as a consequence of a lower energy demand, associated with fundamental savings in fertiliser input, and the higher energy available from the trees,
- Even a short rotation alley cropping system of agroforestry offers a **significant potential to reduce fossil energy use and reduce greenhouse emissions**, and may therefore improve **the environmental sustainability of agriculture** on marginal lands.

Biodiversity Conservation

Ecosystems and species important in **sustaining human life and the health of our planet** are disappearing at an alarming rate.

Agroforestry can play five major roles in conserving biodiversity:

- i) agroforestry provides **habitats for species** that can tolerate a certain level of disturbance;
- ii) agroforestry helps to **preserve the DNA** of sensitive species;
- iii) agroforestry helps **reduce the rates of conversion of natural habitat to farmland by providing a more productive, sustainable alternative to traditional agricultural systems** that generally involve clearing areas of natural habitats;
- iv) agroforestry provides **connectivity by creating corridors** between habitat remnants which may support the integrity of these remnants and the conservation of area-sensitive floral and faunal species; and,
- v) agroforestry helps **conserve biological diversity** by providing other ecosystem services such as erosion control and water recharge, thereby preventing **degradation and loss of surrounding habitat**.

Biodiversity Conservation and the Role of Agroforestry

- Agroforestry systems that include timber, fruit, and native forest species also contribute **to biodiversity conservation** by providing **habitat** for avian, mammalian, and other species, enhancing landscape connectivity, and reducing edge effects between forest and agricultural land.
- Agroforestry systems can also support a **richness of birds** that are as abundant, species-rich, and diverse as found in forests; but research has shown that the species composition was highly modified with fewer forest-dependent species, more non-forest species and different dominant species.
- Native woodland creation **helps wildlife**, particularly where it buffers and extends ancient woodlands.
- Newly-created woodland develops a rapid increase in the **abundance of insects**, thereby attracting birds; while the abundance of insects also attracts foraging bats; up to nine species of bats have been found to use even very early-stage woodland.
- Agroforestry practices also provide **improved wildlife habitat by increasing structural and compositional plant diversity on the landscape**.
- The literature on the role of agroforestry in conserving biodiversity is **growing rapidly**.





Aesthetics and Cultural Values

- In Ireland we had a tradition of **caring for the environment**, and we lost it; now we must recover that tradition before the loss becomes irretrievable.
- In those categories of agroforestry with high-value trees, the enhancement of biodiversity and wildlife habitats were the **dominant positive attributes**, while a high cultural value was also considered as an **extremely important attribute**.
- Most of the high nature and cultural value agroforestry systems are wood pastures which are also widely recognised in Europe for their **high ecological value**.
- Look at any website which promotes mental or spiritual healing, and you will find that spending time in a forest (“forest bathing”) is considered to be an **immensely beneficial activity**.

Summary

Agroforestry is such a varied practice, from farm to farm, country to country, continent to continent.

What is clear is that agroforestry is **multi beneficial**, for crops, soil, farm livestock, biodiversity, water and air quality, carbon sequestration and climate change mitigation, and for the cultural benefits of a forested landscape with trees and farm animals or crops.



Is this the agricultural landscape we prefer?

Or this?



Thanks for listening!



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27th May 2023 Opportunities in Agroforestry – Information Seminar, Tracton Arts and
Community Centre