



# Sustainability and Agriculture and Food Technology

**Smart-Edu4.0**  
**Erasmus+ project**



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# Sustainability - Agriculture and Food Technology

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“Sustainability” and “Agriculture and Food Technology” are two areas that are increasingly interconnected.

Agriculture and food technology involve the use of technology to improve the efficiency and sustainability of agriculture and food production.

Sustainability, on the other hand, is the ability to maintain or improve the well-being of the planet and its inhabitants for the long term.



Source: <https://www.savills.co.uk/services/investment/agricultural-investment.aspx>



# Sustainability - Agriculture and Food Technology

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The presentation should cover a range of topics related to “Sustainability” and “Agriculture and Food Technology”.

Topics included in the presentation are:

1. Sustainable Agriculture Practices
2. Precision Agriculture
3. Sustainable Food Processing
4. Sustainable Packaging
5. Food Waste Reduction
6. Sustainable Supply Chain
7. Plant-Based Alternatives
8. Underutilized Ingredients



# Sustainable Agriculture Practices

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Discussing sustainable agriculture practices such as crop rotation, cover cropping, intercropping, conservation tillage, and integrated pest management that can improve soil health, reduce water usage, and minimize environmental impacts.

## Agroforestry

Crops are intentionally intermingled with trees and shrubs.

There are three types of agroforestry currently being practiced:

- Forest farming where crops grow beneath the canopy of an existing forest.
- Alley cropping where crops are planted between rows of trees and shrubs.
- Silvopasture where livestock forage among trees and enjoy the shade and protection they provide.

Benefits: biodiversity, helps to filter runoff, and reduces stress on soil and livestock.



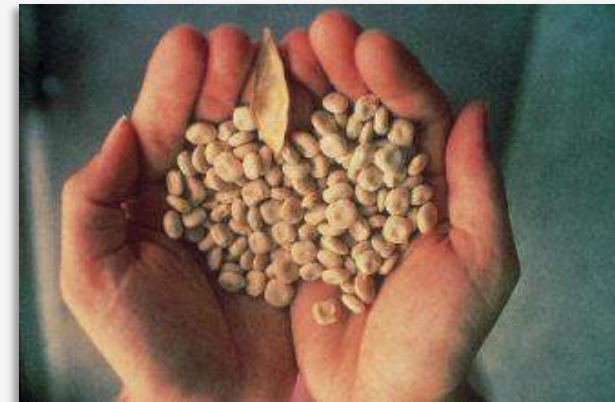
Source: <https://www.edengreen.com/blog-collection/sustainable-farming-practices>  
<https://www.state.gov/dipnote-u-s-department-of-state-official-blog/science-speaks-agroforestry/>



# Sustainable Agriculture Practices

## Cover Crops

In agriculture, cover crops are planted to slow soil erosion and enhance water availability. They can also help deal with pests or plant diseases while promoting biodiversity.



Some common cover crops include:

- Legumes such as red clover, vetch, peas, and beans
- Cereals like rye, wheat, barley, and oats
- Broadleaf plants like buckwheat, mustards, and forage radishes

Source: <https://www.edengreen.com/blog-collection/sustainable-farming-practices>  
<https://www.sare.org/resources/cover-crops/>



# Sustainable Agriculture Practices

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## Crop Rotation

One of the most well-known ways to improve soil health, crop rotation, means that farmers use fields to grow different crops each season instead of the same one over and over.

When the same crop is grown in a field year after year, eventually the nutrients that crop needs become depleted. Crop rotations can be simple, with just a few plants rotated over and over. Or, they can be more complex.



Source: <https://www.edengreen.com/blog-collection/sustainable-farming-practices>  
<https://rodaleinstitute.org/why-organic/organic-farming-practices/crop-rotations/>



# Sustainable Agriculture Practices

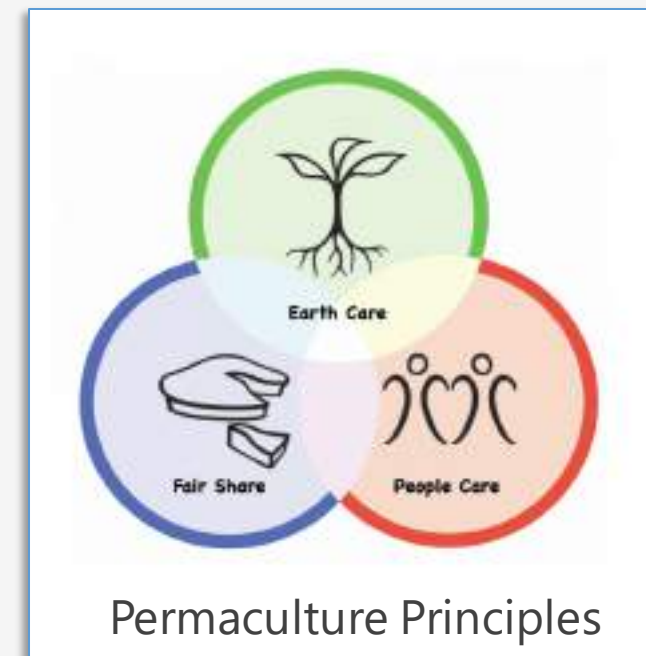
## Permaculture

Permaculture is a holistic approach to the food supply, wherein farmers intentionally design their operations to balance ecosystems in a way that reflects those seen in nature.

Permaculture seeks to balance the needs of humans, animals, plants, and the environment, all into one seamless system.



Permaculture originally came from "permanent agriculture", but was later adjusted to mean "permanent culture", incorporating social aspects.



Source: <https://www.edengreen.com/blog-collection/sustainable-farming-practices>  
<https://permacultureapprentice.com/permaculture-property-design-features/>

# Sustainable Agriculture Practices

## Hydroponic Vertical Greenhouses

Hydroponic vertical greenhouses solve many of the challenges of traditional agriculture by removing soil from the equation altogether. Hydroponics is the practice of growing plants in water rather than soil. Vertical farms stack crops vertically in trays or towers rather than planting them low along the ground.

When you combine these two practices, then enclose the system in a greenhouse with CEA (controlled environment agriculture) systems.

Advantages:

- recycle water through their systems over and over, using 98% less water than traditional farms and wasting none.
- use 90% less light energy than other vertical farming systems.



Source: <https://www.edengreen.com/blog-collection/sustainable-farming-practices>  
<https://ponicslife.com/what-is-hydroponics-everything-you-need-to-know/>



# Sustainable Agriculture Practices

## Vertical Farming

Vertical farming is an innovative method of agriculture that involves growing crops in vertically stacked layers using advanced technologies such as hydroponics, aeroponics, and aquaponics. Vertical farming has several potential benefits for the agriculture and food technology industries. Here are some of them:

1. Increased Crop Yields
2. Reduced Water Usage
3. Reduced Pesticide Use
4. Controlled Environment
5. Fresher, Healthier Produce



Overall, vertical farming has the potential to revolutionize the way we produce food, particularly in urban areas where space is limited and environmental challenges are increasing.

Source: <https://www.mccormick.it/as/precision-farming/>  
<https://www.agritecture.com/blog/2021/5/3/the-most-innovative-vertical-farming-companies-of-the-decade>



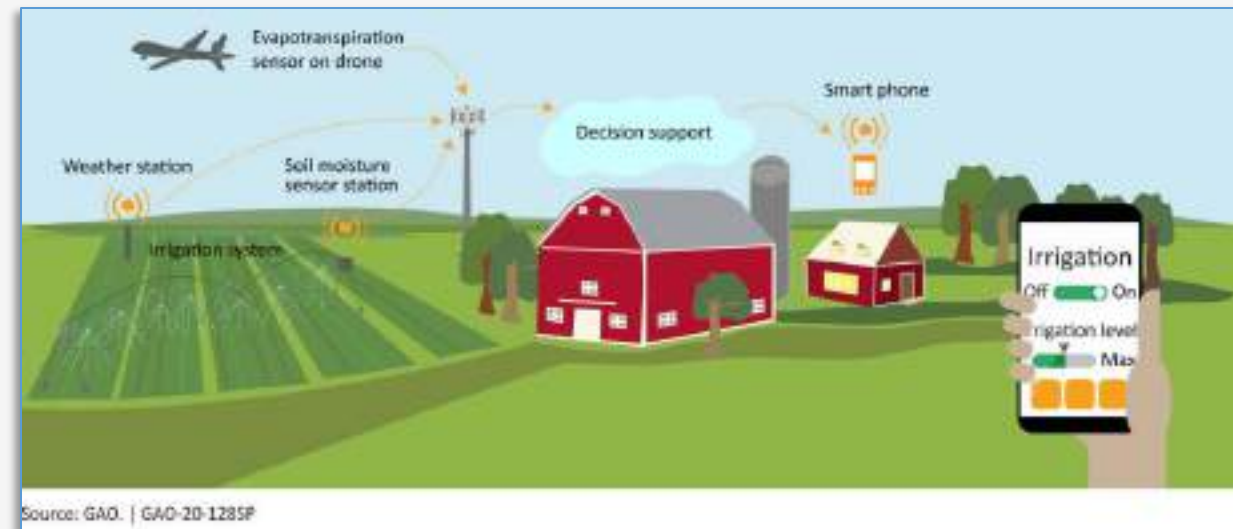
# Precision Agriculture

Highlighting the role of technology in sustainable agriculture, such as precision agriculture techniques like drones, sensors, and satellite imagery that can improve crop yield, reduce waste, and optimize resource utilization.

## Precision Agriculture

can be defined as “the application of modern information technologies to provide, process and analyze multisource data of high spatial and temporal resolution for decision making and operations in the management of crop production”

It is referred to as “precision” because thanks to the state-of-the-art tools used, it is possible to perform the right intervention, in the right place, at the right time.



A possible configuration of a smartphone-integrated precision agriculture system

Source: <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/precision-agriculture>  
<https://www.mccormick.it/as/precision-farming/>  
<https://www.sciencedirect.com/science/article/pii/S2211912416300190>  
[https://en.wikipedia.org/wiki/Precision\\_agriculture](https://en.wikipedia.org/wiki/Precision_agriculture)

# Precision Agriculture

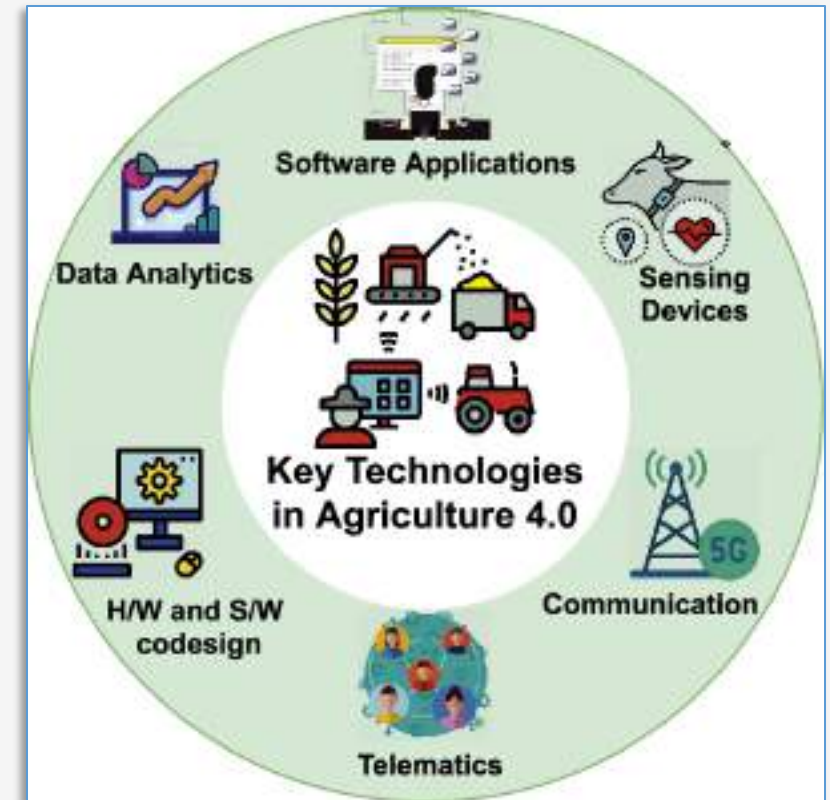
Nowadays there is increasing talk about **Agriculture 4.0**, which is the evolution of the precision farming concept: this term refers to all the tools and strategies that use cutting-edge technologies in an interconnected manner starting with the use of data to improve and optimize production

## The advantages of precision farming

Producing more with fewer resources whilst maintaining superior quality standards: this is the ultimate goal of precision farming.

This type of approach generates a two-fold advantage:

- for farming enterprises, which can optimize efforts and resources, reduce consumption and waste, and boost land productivity.
- for the environment, a reduction in waste of fertilizers and herbicides, emissions and soil compaction thanks to a more rational use of resources



Source: <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/precision-agriculture>  
<https://www.mccormick.it/as/precision-farming/>

[https://www.researchgate.net/publication/352164961\\_A\\_survey\\_on\\_the\\_role\\_of\\_Internet\\_of\\_Things\\_for\\_adopting\\_and\\_promoting\\_Agriculture\\_40/figures?lo=1](https://www.researchgate.net/publication/352164961_A_survey_on_the_role_of_Internet_of_Things_for_adopting_and_promoting_Agriculture_40/figures?lo=1)

# Precision Agriculture

## Precision farming tools and technologies

There are many tools available to precision farming, yet none of them can replace the professional experience of those working in the farming sector, as all of them provide valuable support to boost performance and results.

## Data collection tools

Monitoring the health status of crops requires a huge effort, especially when they extend over very large areas.

## Satellite crop monitoring

Among the most significant data is the health of the plants, which is measured with parameters such as the

- Normalized Difference Vegetation Index (NDVI), which helps to identify plants that are photosynthetically active and therefore healthy.
- Normalized Difference Moisture Index (NDMI), which identifies the water stress of the plants by reading the moisture rate.



Source: <https://www.mccormick.it/as/precision-farming/>

# Precision Agriculture

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## Internet of Things: sensors and drones

Alternative solutions, which does not involve the use of satellites, are **agricultural drones and environmental sensors installed in the fields**, capable of recording climatic data and information on soil water requirements.

Satellites and drones, are particularly useful for large areas of land,

Sensors can also be used in enclosed spaces such as greenhouses and nurseries.

Thanks to all this data collected by satellites, drones, and sensors, it is possible to **generate interactive maps that photograph the health state of the field.**

The advantage of **crop monitoring systems** is that they allow farmers to accomplish constant control over even very large areas or even fields that are very far apart from each other, by setting a series of automated interventions (**put in place targeted actions**).



Source: <https://www.mccormick.it/as/precision-farming/>  
<https://ruralmarketing.in/stories/sensor-based-drone-usage-in-agriculture-is-the-need-of-the-hour-js-moa/>

# Precision Agriculture

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## Field intervention tools

Collecting data is the initial key pillar for precision farming. The next step consists in the effective on-field interventions.

**Variable rate: differentiated spreading of fertilizer and plant protection products**

Precision farming technologies also include equipment capable of dosing fertilizers and plant protection products in a differentiated manner on the field, according to the requirements of the crops.

Variable rate technology is based on **2 different modes** to obtain this information:

- **sensors** that record data in real time
- **prescriptive maps** based on the previously collected data using imagery systems



Source: <https://www.mccormick.it/as/precision-farming/>

<https://www.mckinsey.com/industries/agriculture/our-insights/agricultures-connected-future-how-technology-can-lead-new-growth>

# Precision Agriculture

## Precision steering and automated driving systems for tractors and agricultural machinery

The satellite steering and driving systems for tractors are some of the most renowned technologies in precision farming. These systems can improve work efficiency and boost productivity, reducing production costs, whilst saving time and fuel.

Types of precision guidance and steering systems:

- the guidance bar systems
- precision steering
- semi-automated driving



The advantages of these instruments?

Faster and more accurate processing, reduced waste, and less stress for the operator who can pay more attention to other aspects of the job, such as controlling the equipment.

Source: <https://www.mccormick.it/as/precision-farming/>  
<http://www.gap.gov.tr/en/project-on-precision-farming-and-promotion-of-sustainable-practices-page-54.html>  
<https://www.aliexpress.com/item/1005004626628894.html>

# Precision Agriculture

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## Remote management and diagnostics of the tractor fleet

Fleet Management tools allow users to conveniently monitor a large amount of information from their office PC monitor such as travel, consumption, daily and monthly work.

- real-time check-up on the health of the tractor
- remote maintenance and diagnostics functions

## Future prospects of precision farming

Robots applied to agriculture, capable of managing crops more and more accurately with the possibility of collecting data on the state of health of the soil, automated seeding and harvesting, thanks to sensors.



Source: <https://www.mccormick.it/as/precision-farming/>  
<https://howtorobot.com/expert-insight/agricultural-robots>





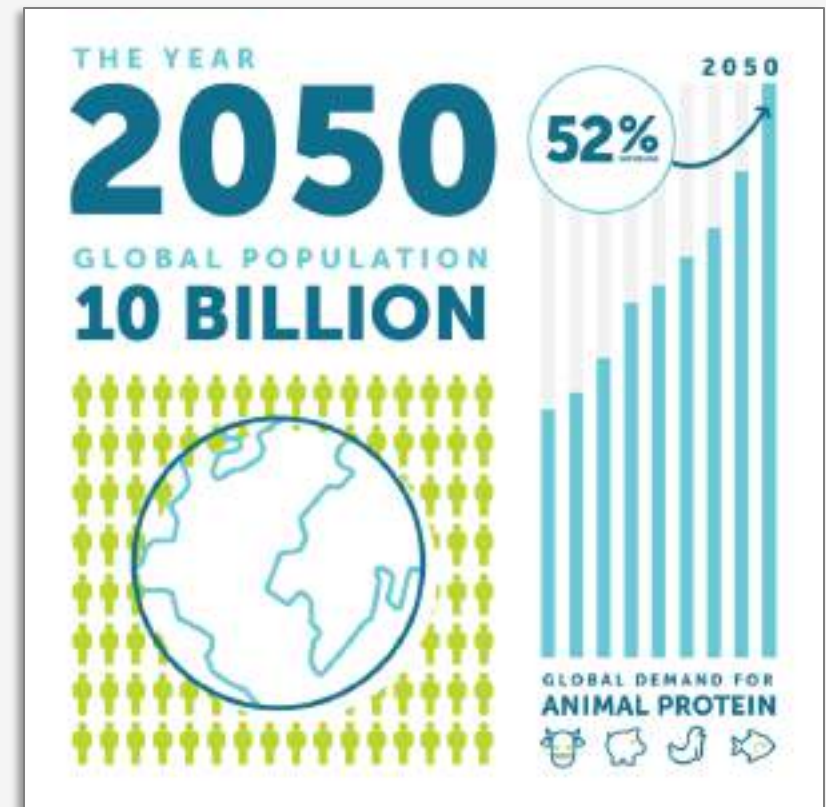
# Sustainable Food Processing

Examining how sustainable food processing practices, such as energy-efficient technologies, use of renewable energy sources, and waste reduction techniques, can help reduce environmental impacts and enhance the sustainability of the food industry.

Global population about 10 billion by 2050 → food production will need to increase by at least 70%.

Challenge: finding innovative ways to minimize food production's environmental impact and support the planet's capacity to continue producing food far into the future.

Encouraging sustainable food processing and manufacturing is one of the primary objectives of the EU's new Farm to Fork strategy, a hallmark initiative of the new European Green Deal.



Source: [https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#\\_ftn1](https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#_ftn1)  
<https://www.fao.org/news/story/en/item/35571/icode/>  
[https://twitter.com/gsa\\_seafood/status/1116684915909828608?lang=zh-Hant](https://twitter.com/gsa_seafood/status/1116684915909828608?lang=zh-Hant)



# Sustainable Food Processing

Here are four ways food processors and manufacturers can reduce their environmental footprint.

## 1. Use eco-friendly packaging

Food packaging is a major source of waste and pollution.

Over 78 million metric tons of plastic packaging is produced each year, only 14% of which is recycled.

- Most of the plastic is made using non-renewable sources.
- Opting for wood- and paper-based alternatives.

Desirable:

- paper and wood used to make the packaging come from sustainably managed forests.
- Innovative alternative packaging from biodegradable materials.
- Metal food packaging: sustainably sourced aluminum



Source: [https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#\\_ftn1](https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#_ftn1)  
<https://www.nationalgeographic.com/environment/future-of-food/food-packaging-plastics-recycle-solutions/>  
[https://www.e3s-conferences.org/articles/e3sconf/pdf/2019/56/e3sconf\\_ic-amme2018\\_01033.pdf](https://www.e3s-conferences.org/articles/e3sconf/pdf/2019/56/e3sconf_ic-amme2018_01033.pdf)  
<https://www.accelerantmanufacturing.com/blog/why-should-you-use-eco-friendly-cannabis-pre-roll-packaging>



# Sustainable Food Processing

## 2. Reduce food waste

According to the Food and Agriculture Organization of the United Nations (FAO), nearly a third of food produced for human consumption gets wasted each year.

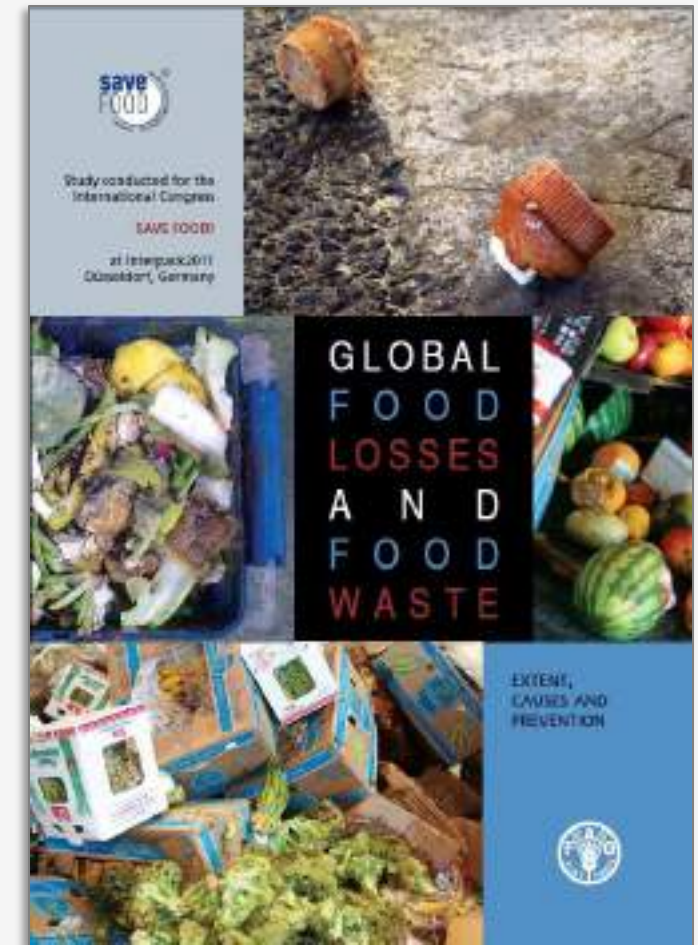
This amounts to 1.3 billion tons of food waste annually.

Also, loss of the resources used to produce it (i.e., water, soil nutrients, transportation energy, labor).

Almost half of all food waste stems from processing and manufacturing.

One of the main causes of food waste during processing and manufacturing is inefficiency.

The EU has committed to halving food waste by 2030



Source: [https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#\\_ftn1](https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#_ftn1)  
<https://www.fao.org/3/i2697e/i2697e.pdf>  
<https://www.bcg.com/publications/2018/tackling-1.6-billion-ton-food-loss-and-waste-crisis.aspx>  
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.360.951&rep=rep1&type=pdf>



# Sustainable Food Processing

## 3. Improve energy & water efficiency

Food processing and manufacturing are both energy- and water-intensive.

Processing and manufacturing are responsible for 23% of the food industry's overall energy expenditure in the US.

Water is used extensively in food processing, both as an ingredient, and in various industrial processes (e.g. cleaning, sanitizing, cooling, cooking).

Reducing energy and water consumption can be challenging in the food processing and manufacturing sector:

- deployment of smart meters
- implementation of energy efficiency and sustainable water management systems



Source: [https://certificationbureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#\\_ftn1](https://certificationbureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#_ftn1)

University of Michigan, Center for Sustainable Systems (<http://www.umich.edu/~css>)

<https://www.facilitiesnet.com/energyefficiency/article/Water-and-Energy-Efficiency-Technology-Allows-FM-To-Do-More-With-Less--16838>

# Sustainable Food Processing

## 4. Use sustainable ingredients

There are several agricultural commodities whose production raises environmental and social sustainability concerns. The farming of “dirty” palm oil, cocoa and coffee, has been linked to deforestation, habitat destruction and child & forced labor.

Fish products are another area of concern – nearly 90% of the world’s fisheries are either fully exploited, overexploited or depleted.

Overfishing and destructive fishing methods are threatening fish populations around the world.

Food processors and manufacturers can take a stand against these and other harmful agricultural practices.



Source: [https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#\\_ftn1](https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#_ftn1)  
<https://unctad.org/en/pages/newsdetails.aspx?OriginalVersionID=1812>  
<https://theinsidescop.eliorgroup.com/en/what-exactly-sustainable-ingredient>  
<https://earth.org/how-does-cocoa-farming-cause-deforestation/>

# Sustainable Packaging

Sustainable packaging in agriculture and food technology refers to the use of packaging materials and methods that minimize the environmental impact of the packaging while maintaining product safety and quality.

Here are some key points on sustainable packaging in agriculture and food technology:

- 1.Reduce, Reuse, Recycle
- 2.Biodegradable and Compostable Materials
- 3.Innovative Packaging Materials
- 4.Carbon Footprint Reduction
- 5.Extended Shelf Life
- 6.Consumer Education

By adopting sustainable packaging practices, we can reduce waste, conserve resources, and improve the sustainability of our food system.



Source: [https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#\\_ftn1](https://certification.bureauveritas.com/magazine/4-ways-make-food-processing-more-sustainable#_ftn1)  
<https://www.newfoodmagazine.com/article/90810/food-packaging-types-importance-trends/>

# Food Waste Reduction

Discussing strategies for reducing food waste and the environmental and economic benefits of doing so, including the use of composting, anaerobic digestion, and food recovery programs.

Reducing food waste is an important issue both from an environmental and economic perspective.

According to the United Nations Food and Agriculture Organization, around one-third of all food produced for human consumption is lost or wasted (approximately 1.3 billion tons per year).

This represents a significant loss of resources and has negative impacts on the environment, including greenhouse gas emissions, water consumption, and land use.



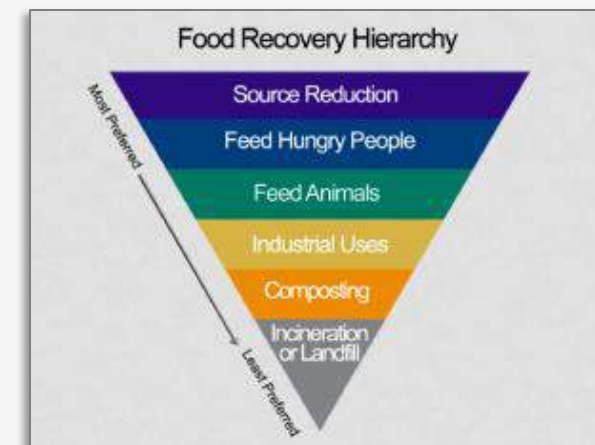
Source: <https://www.sbs.com.au/food/article/2016/06/03/10-ways-reduce-food-waste-and-save-money>



# Food Waste Reduction

There are several **strategies** that can be employed to reduce food waste, including:

- 1.Reduce food waste at the source: better inventory management, improved food storage practices, more accurate portion control.
- 2.Donate excess food to food banks and shelters: excess food is distributed to those who need it, rather than being wasted.
- 3.Composting: process of breaking down organic material, such as food waste, into nutrient-rich soil.
- 4.Anaerobic digestion: process that breaks down organic material in the absence of oxygen, producing biogas that can be used for energy.
- 5.Food recovery programs: focus on recovering excess or unsold food from retailers, restaurants, and other food service providers and distributing it to those in need.



Source: <https://www.cabrini.edu/about/media-hub/news/2021/food-recovery-program-are-you-eating-that>

<https://www.bamco.com/waste/>



# Food Waste Reduction

By implementing these strategies, there are several environmental and economic benefits that can be realized.

**Environmental benefits** of reducing food waste:

- 1.Reducing greenhouse gas emissions:
- 2.Conserving natural resources:
- 3.Reducing landfill waste:

**Economic benefits** of reducing food waste:

- 1.Cost savings:
- 2.New revenue streams:
- 3.Community building:



Source: <https://lomi.com/blogs/news/the-benefits-of-reducing-food-waste>



# Sustainable Supply Chain

Highlighting the importance of sustainable supply chains in the food industry, including responsible sourcing of raw materials, reducing carbon footprint, and minimizing waste and emissions throughout the supply chain.

A sustainable supply chain in the food industry refers to the responsible sourcing of raw materials, reducing carbon footprint, and minimizing waste and emissions throughout the entire supply chain.

Importance of sustainable supply chains in the food industry:

- 1.Meeting consumer demand: by providing products that are ethically and sustainably produced.
- 2.Reducing environmental impact: help to minimize the environment impact.
- 3.Ensuring the future of food production: help to ensure the long-term viability of food production.



Source: <https://www.legalzoom.com/articles/creating-a-sustainable-supply-chain-management-plan>

# Sustainable Supply Chain

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To achieve a sustainable food supply chain, there are several strategies that can be employed. These include:

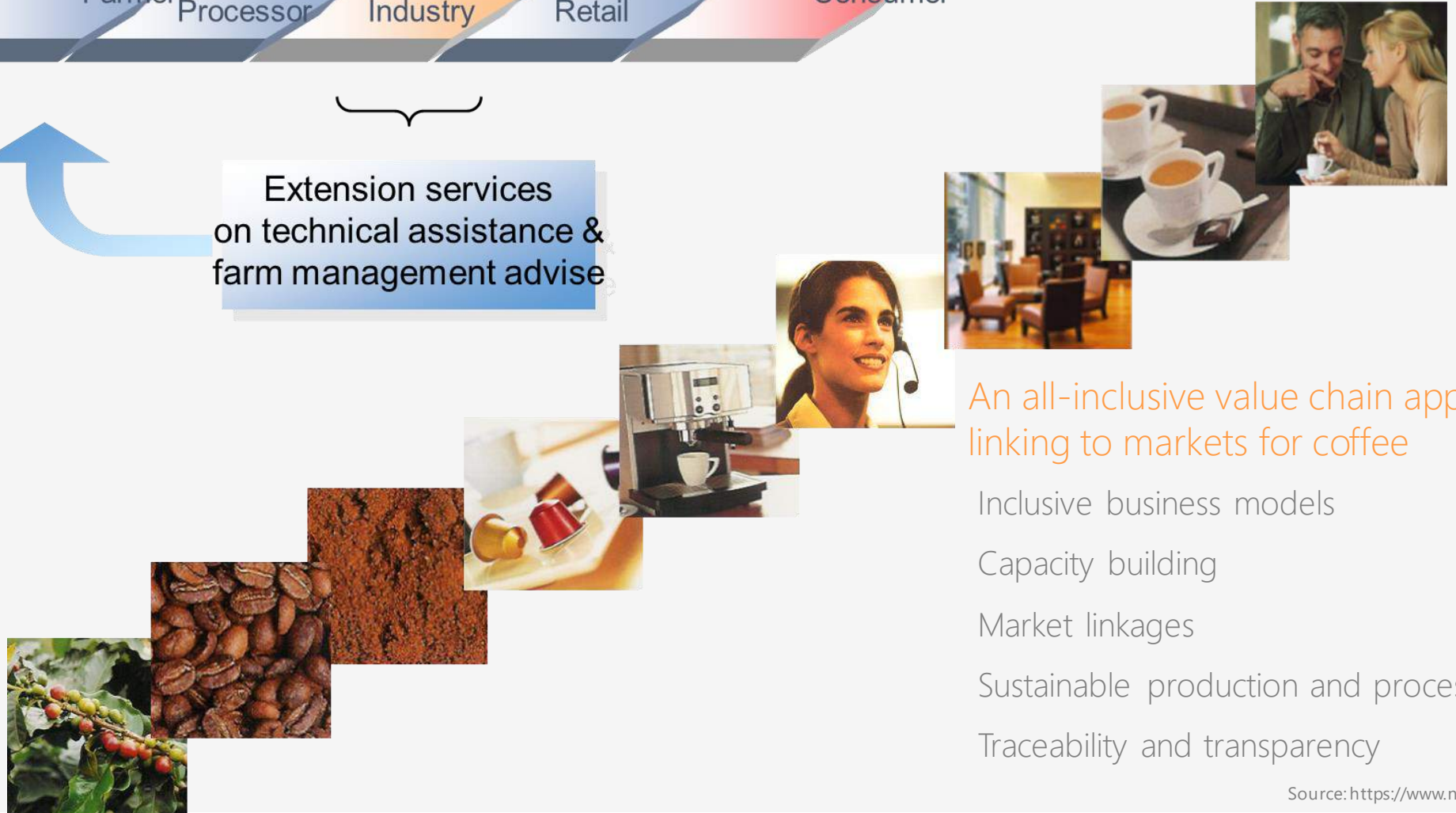
1. Responsible sourcing: sourcing raw materials from suppliers who use sustainable and ethical practices.
2. Reducing waste and emissions: optimizing transport and logistics, reducing packaging waste, and implementing efficient waste management practices.
3. Promoting energy efficiency: reducing the energy consumption of food processing and storage facilities, using renewable energy sources, and optimizing energy use in transport and logistics.
4. Collaboration and transparency: Collaboration between stakeholders in the food supply chain. Transparency is also important to ensure that all stakeholders are aware of the sustainability practices being employed throughout the supply chain.



Source: <https://www.kinaxis.com/en/blog/sustainable-supply-chain-why-progress-perfection>



# Example of a sustainable chain approach linking to markets



An all-inclusive value chain approach linking to markets for coffee

Inclusive business models

Capacity building

Market linkages

Sustainable production and processing

Traceability and transparency

Source: <https://www.nestle.com/>

# Plant-based alternatives

Plant-based alternatives refer to products that are made from plant-based ingredients as a substitute for animal-based products. Here are some key points on plant-based alternatives in agriculture and food technology:

1. Health Benefits: lower in saturated fats and higher in fiber and nutrients.
2. Environmental Benefits: less land, water, and other resources to produce.
3. Ethical Concerns: can be a more ethical choice for consumers
4. Innovation: developed using innovative techniques
5. Market Growth: plant-based alternative market is growing rapidly.
6. Nutritional Concerns: can be lower in certain nutrients such as protein, iron, and vitamin B12.



Source: <https://kellswholemeal.ie/are-plant-based-alternatives-healthier-than-meat/>

# Underutilized Ingredients

Underutilized ingredients refer to food items that are often overlooked or discarded, despite being nutritious and flavorful. These ingredients can include plant-based foods such as fruits, vegetables, and grains, as well as animal-based foods such as offal and bone broth.



Key points on underutilized ingredients.

- Nutritional Value: including vitamins, minerals, and antioxidants.
- Economic Value: source of income for farmers and producers.
- Sustainability: can be a more sustainable choice.
- Culinary Potential: new and exciting flavors and textures to food products.
- Cultural Significance: representing traditional foods and flavors.

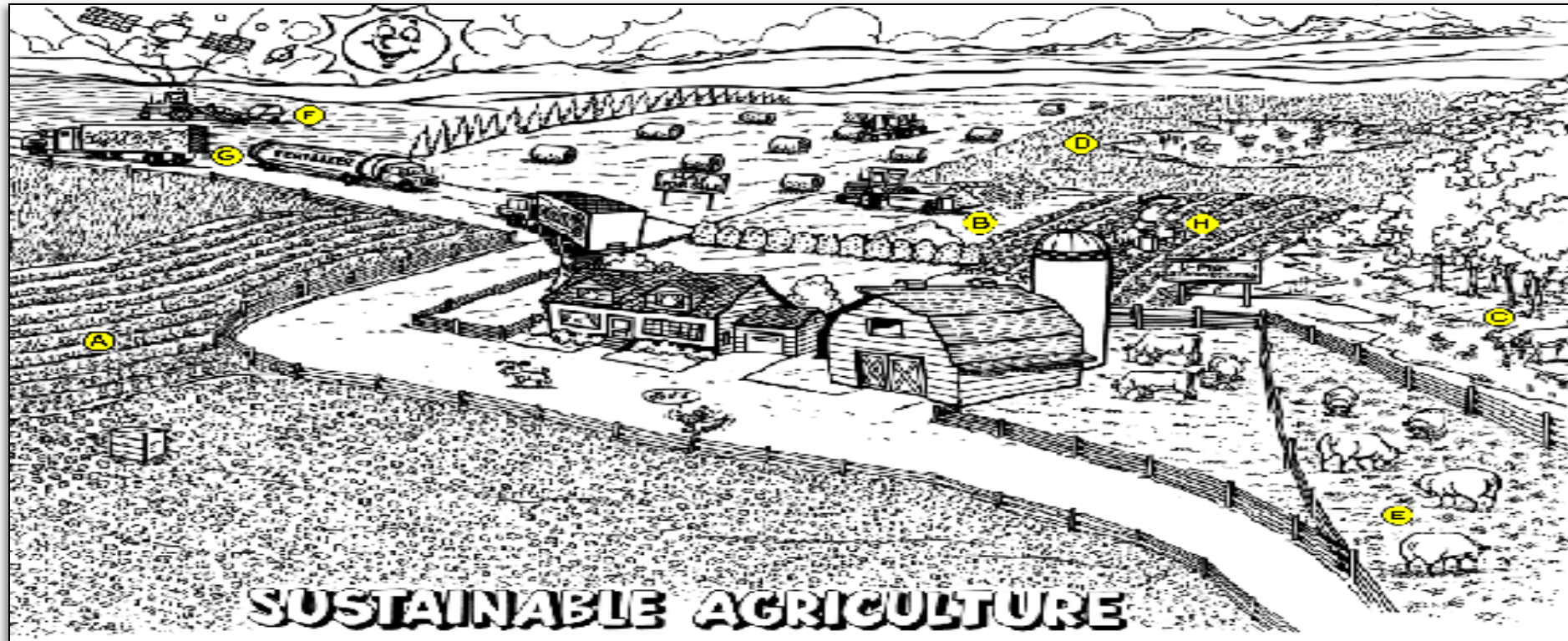


Source: <https://www.globalseafood.org/advocate/underutilized-marine-organisms-as-potential-aquaculture-feed-ingredients/>

# Conclusions

Sustainability is critical for agriculture and food technology

Sustainability is critical for agriculture and food technology to ensure a healthy and resilient food system for the future.



A. Crop rotation keeps the soil healthy. B. Mixed farms allows the uses of livestock manure. C. Conserving natural areas protects our environment. D. Small changes in practices can help, rather than harm, the environment. E. Grass-fed livestock control weeds without chemicals or mowing. F. Science can determine the right amount of fertilizers and pesticides. G. Farming removes nutrients and fertilizers or manures replace them. H. Farming multiple crops allows farmers to reduce their financial risks by having multiple products to sell.

Source: <https://slideplayer.com/slide/5116206/>

# Conclusions

## Need for the development of Sustainable Agriculture

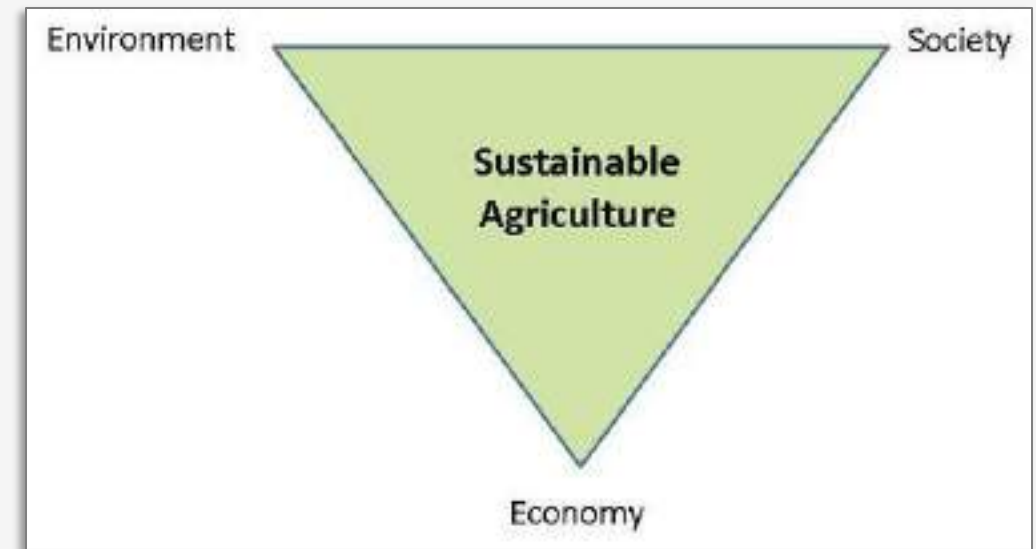
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The Food Industry relies on the **increasing supply of safe agricultural raw materials in quality and quantity**

However, respecting the **limits of natural resources and weakening of rural societies** threatens agricultural production

**Consumers' confidence** depends on the quality & safety of the food supply chain

→ Need for the development of **Sustainable Agriculture**



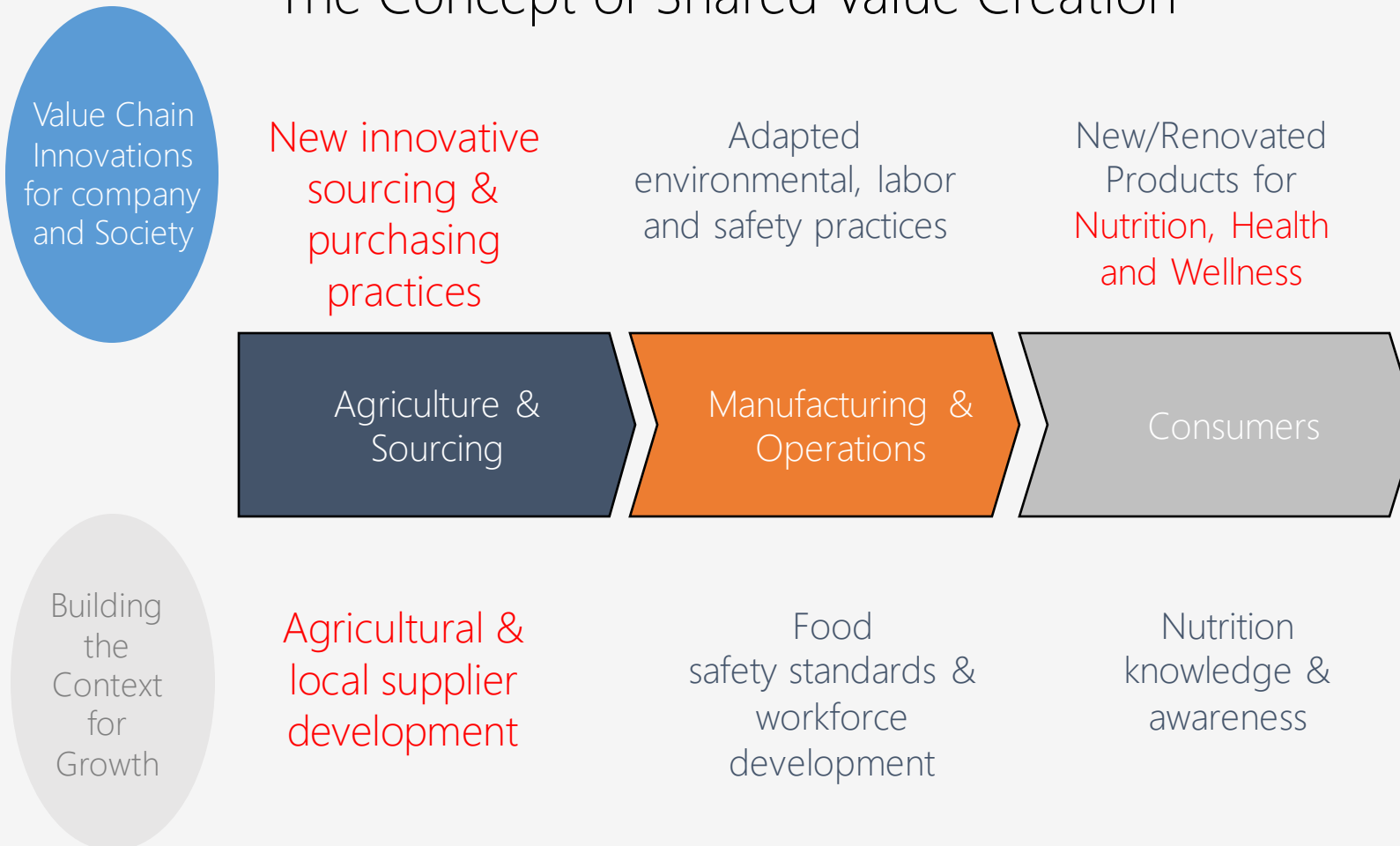




# Conclusions

The food technology sector has a significant role to play in supporting sustainable agriculture.

## The Concept of Shared Value Creation



Source: <https://www.nestle.com/>



# Conclusions SDGs related to ...

The adoption of sustainable agriculture and food technology practices is essential for achieving the United Nations Sustainable Development Goals (SDGs) related to food security, poverty reduction, climate action, and environmental protection.



Source: <https://www.mdpi.com/2071-1050/10/3/815/>



# Conclusions Sustainability is also a business case



Sustainable sourcing practices are widely accepted by leading Business Research Institutions as being the way forward to successful business

# Conclusions

The big challenge today is breaking the link between economic growth and negative environmental impact. There are clear limits to the earth's natural resources capacity.



Overall, the integration of sustainable agriculture and food technology practices can promote a more equitable, efficient, and resilient food system that provides safe, nutritious, and affordable food while protecting the planet and supporting rural livelihoods.

Source: <https://www.nal.usda.gov/fams-and-agricultural-production-systems/sustainable-agriculture>  
<https://pubs.acs.org/doi/10.1021/acsnano.1c03948>

Any questions?

Thank you 😊



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