DEGREBE

Development of Green Skills for Better Employability

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Module 3 Water pollution, Resilience

Water is the Earth's most abundant chemical compound. It is used everywhere in households, industries, energy production and agriculture. Other than being essential for the survival of mankind it is also essential for sustainable and socio-economic development. Nevertheless, considering the vast number of settings that water is used in it can be inferred that it is susceptible to contamination and in turn pollution. The UN has coined access to sanitary water as a human right and as such water pollution is a topic of utmost importance.

There are approximately 326 million trillion gallons of water. What is noteworthy, however, is that only less than 1 percent of the Earth's water is drinkable. In light of this fact, the proper handling of water is a prerequisite for the sustainability of humanity and the planet. In other words, it is crucial that we take action to eliminate cases of water pollution.

What Is Water Pollution?

Water pollution occurs when substances are discharged into water bodies rendering the water unsafe for human use and impairing aquatic ecosystems. Examples of water bodies include but are not limited to oceans, rivers, streams, lakes, groundwater, reservoirs and aquifers.

Point source pollution vs Nonpoint source pollution

- ***Point source pollution*** *refers to pollution from a single source that can be identified easily, such as a sewage pipe, drain etc. Point source water pollution is a common type of pollution; one example is whenever industrial waste is dumped into rivers or other water bodies.*
- ***Nonpoint source pollution*** *refers to pollution that does not necessarily originate from a single source that can be easily identified. For example, rainfall can mix*

with contaminants and transfer them into water bodies such as lakes. Nonpoint source pollution is the most significant cause of water pollution, as its source cannot be identified and managed easily.

What Are the Causes of Water Pollution?

Water is widely known as a "universal solvent," as it can dissolve more substances than any other liquid. Due to its dissolving capabilities, water is especially susceptible to pollution by toxic substances from farms, towns, and factories readily dissolve into and mix with it.

Groundwater makes up the largest share of freshwater in most countries. According to the UN, out of 89 countries with water quality data, only 52 have information regarding the quality of groundwater. (UN-Water, 2021). This suggests that in almost half the countries, bad-quality groundwater can potentially spread contamination to the population and the environment as it flows into streams, lakes, and oceans.

Most commonly, water gets polluted when contaminants such as fertilisers, pesticides, and waste find their way to it from landfills and septic systems. Decontamination is extremely costly and difficult; polluted aquifers may remain unsafe and unusable for many years.

1. Agriculture as a Polluting Industry

Agriculture ranks as the number one consumer of water globally. That is, on an annual basis, approximately 70 percent of global freshwater withdrawals are used for agricultural purposes and consequently, this sector is the greatest polluter of water. What is special about the agricultural sector is that it is both a cause and a victim of water pollution. In fact, water pollution is triggered by a variety of agricultural practices such as:

a) Livestock breeding

Livestock excretes a significant amount of organic matter. Excess nutrients in organic matter can produce algae in water bodies. The presence of algae in an aquatic ecosystem depletes the level of dissolved oxygen which is a necessity for the ecosystem's species' survival. Improper management of livestock wastes (manure) can cause surface and groundwater pollution. Water pollution from animal production systems can be by direct discharge, runoff, and/or seepage of pollutants to surface or groundwater. Manure constitutes the main source of nitrogen and phosphorus in surface and groundwater. Manure can contain antibiotics and hormones which have affected the reproductive system of fish in some cases. It also can contain pathogens such as Salmonella, E. coli, Cryptosporidium, and faecal coliform. Animal waste has the ability to pass on over 40 diseases to humans! In addition to diseases, animal poo can contain heavy metals like lead which is known to cause kidney issues and nervous system disorders.

b) Pesticides

The term pesticides refers to any chemical that is used to eliminate or regulate pests such as insects, fungi, weeds, bugs and others. The use of pesticides has brought about increased food production and affordability. Thus, they are an important element in keeping crops healthy. Nevertheless, the use of pesticides in agriculture may cause several problems for humans and animals. By being mixed with water and consumed, pesticides can cause:

- Acute and chronic poisoning
- Allergies
- Carcinogenic effects
- Death to animals

c) Fertilisers

Fertilisers are natural or artificial substances that contain nutrients for plants, and are used for improving growth and production. In summary, fertilisers enhance the fertility of soil or even replace chemical elements that are missing. As mentioned above, excessive nutrients from fertilisers in water can produce algae in water bodies.

The agricultural sector is one of the main pillars of the EU economy. It encompasses farmers from multiple countries, equipped with different natural resources. In addition, agriculture is not exclusively about production but also processing, distribution, retail, consumption and waste management. Considering this interconnectedness, unpredictable events have the potential to create a domino effect across the whole agricultural supply chain and at a European level. As such, there are numerous risks for which farmers have to be prepared for; some of the major ones being:

- **Production risks**: These are any factors that may impact the expected quantity and quality of production. For instance, a drought or poor weather conditions.
- **Market risks**: As a result of globalisation and trade liberalisation, markets for agricultural commodities are quite integrated. Nevertheless, this feature of the market can act as a double-edged sword. For instance, at times this high level of integration can be beneficial because it promotes competition and improves product quality and prices. On the other hand, it can be detrimental for farmers because it increases the volatility of prices and can also increase operation/production costs.
- **Human risks**: These are any factors that may impact farmers or the human resources of the agricultural sector. For instance, if employees/employers become ill.
- **Financial risks**: These are any factors that might influence a farmer's cash flow such that it proves inadequate for them to meet financial obligations. For instance, if banks increase their interest rates which increases the cost of borrowing.

It should be obvious that not all risks can be eliminated but rather they can be managed.

Water, climate change and agriculture are highly related. Extreme weather conditions increase water scarcity, unpredictability, pollution, or all three. These repercussions on the entire water cycle pose a number of dangers to farmers' access to clean water:

- Flooding and rising sea levels - they have the potential to contaminate water bodies with seawater or other waste.
- Melting glaciers and ice caps - their meltwater can feed into rivers.

- Droughts and heatwaves - they can bring about wildfires which have the potential to wipe out whole agricultural fields.

Furthermore, agriculture is water-intensive and can further intensify water scarcity. As such, growing water shortages and environmental water demands are putting more pressure on farmers to regulate water use. More importantly, it is crucial not to waste scarce water by allowing it to become polluted. This necessitates the development of resilient agricultural systems.

2. The Role of Resilient Farmers in the Modern Agriculture Sector

In the 21st century, the responsibilities and duties of 'farmers' are not limited to the production and distribution of crops and animal products. The modern agricultural sector is going through a major shift towards the implementation of highly technological means that improve yield overall, as well as render farmers more capable to act as 'socially/environmentally responsible businessmen'.

More specifically, farmers/entrepreneurs in Agriculture (Agri-preneurs) should be in a position to:

- Provide eco-friendly services and products to consumers; they should participate in local/regional recycling schemes and become ambassadors of Green Practices in Agriculture.
- Exploit beneficial means that will enable them to save energy and raw materials; this often requires to be involved in Innovation Projects as well as training in new technologies.
- Assess the capacity of their farm to incorporate new technologies that will allow them to utilise solar, wind and hydro energy.
- Utilise resources and raw materials in a responsible manner; running a successful farm should not come at the cost of limited natural resources or at the cost of the well-being of local/regional communities

Now more than ever, farmers and agripreneurs are required to hone their skills, future-proof their farms and make their business (Socially and Environmentally) ‘sustainable’ while remaining profitable in a highly competitive, challenging and ever-evolving market; in other words, they need to be **‘**resilient**’.**

Resilience in agriculture

Resilience is defined as the ability to recover swiftly from adversities. More importantly, note that being resilient is about recovery which implies that difficulties are likely to occur at some point and it's only a matter of overcoming them. With that being said, being resilient does not imply one does not experience any stressors. Instead, it requires one to embrace a given stressor and work through it.

Throughout history, a range of unpredictable events negatively affected the agricultural sector to the point where it had to take drastic measures in order to adapt. Resilience in the context of agriculture measures the amount of disruption an agricultural system can endure before a crucial "threshold" is passed and the system must undergo a significant transformation. In the past, wars used to be the main stressor that would prompt agricultural resilience. In the present it could be argued that stressors on our agricultural systems are climate change and changes in the way land is used. In fact, it could be argued that the agricultural sector is at a turning point. That is, in order to meet global food demand by 2050 production must increase by more than 70 per cent. Furthermore, while demand for food is on an increasing trajectory, global production is predicted to steadily decline anywhere between two to six per cent with each decade as a direct consequence of climate change (Time, 2022).

Resilience in Agriculture - Soft Skills Development

Which Soft Skills Make Farmers 'Resilient'?

<table>
<tr><td>Critical Thinking</td><td>Identification of potential benefits and opportunities that emerge
Dynamic decision making
Risk Management;
Identifying risks
Implementing actions against risks
Assessing the potential impact of risks
Assessing the effectiveness of risk management actions</td></tr>
<tr><td>Creativity and Innovation</td><td>Thinking outside the box
Putting bold ideas to the test
Exhibiting persistence upon failure</td></tr>
<tr><td>Resource management</td><td>Time; planning ahead, frequent evaluation of the impact/effectiveness of technologies and development actions/initiatives
Raw materials; ethical raw material sourcing, sourcing locally, assessment of the quality of resources
People; staff and management training</td></tr>
<tr><td>Team management</td><td>Maintaining a positive attitude in the face of uncertainty
Cultivation of Innovation-oriented organisation culture
Assessment of the formation and performance of teams, for the purpose of developing future strategies
Implementation of Team Support Systems
Acceptance of failure
Acceptance of new ideas from employees
2Employee skills development (Training)</td></tr>
</table>

Adaptability	**Comprehension of local/national/regional/European laws and regulations** **Cultivation of a common vision among organisation leaders** **Willingness to adopt both innovative and conventional ways of thinking** **Being up to date with technology (training, workshops, becoming members of local/regional professional groups)**

3. Managing Water Pollution in Agriculture

When thinking about the problem of water pollution and the skills required to deal with it in the context of agriculture, one is most likely to first think about technical/hard skills rather than soft skills. Soft skills are competencies that have to do with how one operates and relates to others. Moreover, while having the technical know-how is crucial in crafting a given solution plan, successfully implementing such a plan may often require collaboration with other parties. As such, this necessitates the possession of various soft skills such as communication, teamwork, problem-solving and so on. Nonetheless, in the case of agriculture 'resilience' is arguably among the most needed qualities.

In light of growing water shortages and environmental water demands, there is more pressure on farmers to regulate their use of water. More importantly, it is crucial not to waste scarce water by allowing it to become polluted.

Types of Water Pollution

1. Nutrient pollution

Nutrient pollution refers to the contamination of water as a result of an input of excessive nutrients. The main nutrients that are responsible for this type of pollution include but are not limited to nitrogen and phosphorus.

Two of the most common causes of nutrient pollution are pesticides and fertilisers. Once they are sprayed, they can very well mix with the water and seep into the soil. As such, any local water bodies that are supplied with groundwater are contaminated. Nitrate fertilisers are very soluble in water and are easily washed off fields by rain and then into rivers and reservoirs. Because nitrates are all soluble, they cannot easily be removed from the water. Pesticides used by farmers to kill weeds or insects may be washed or blown into streams and rivers.

When an abundance of the aforementioned nutrients is present within a water body it can lead to eutrophication which is a process that stimulates the growth of algae, a phenomenon known as "Eutrophication". This presents a problem because a) algae depletes the dissolved oxygen from the water (which is needed for the survival of aquatic species) and b) it blocks sunlight from reaching aquatic ecosystems.

Sources of Nutrient Pollution:

- Fertilisers and Pesticides
- Animal manure
- Sewage treatment plant discharge
- Stormwater runoff
- Car emissions
- Emissions of power plants
- Failing septic tanks

Protection against Nutrient Pollution:

- Implementation of risk assessment of the economic, social and environmental risks associated with Nutrient Pollution
- Having the necessary knowledge to:

apply fertilisers at appropriate times and amounts

avoid over-watering so as to prevent sedimentation

- Using environmentally friendly materials such as phosphate-free detergents and soap

2. Sewage and Wastewater Pollution

In modern societies, sewage is a common cause of water contamination. Sewage-polluted water can transfer bacteria and viruses to people and animals that come in contact with it or even worse, by consumption. Sewage-polluted water is usually treated in special treatment plants and disposed of through pipes that lead into the sea. Untreated waste which is discharged into aquatic basins can contaminate the water with pathogens. Unfortunately, even in today's highly technological world, a large proportion of wastewater is discharged untreated directly into the closest drainage channel with total disregard of the consequences. If untreated, sewage flows into rivers where it is decomposed by microorganisms, therefore starving aquatic species of oxygen.

Sources of Sewage and Wastewater Pollution:

- Chemical substances
- Pharmaceutical substances
- Detergents
- Feces
- Urine

Protection against Sewage and Wastewater Pollution:

- Compliance with local water laws and regulations
- Process improvement
  - Not disposing of chemical waste in sinks/toilets
  - Not disposing of cooking oils and fats
  - Not flushing pharmaceutical substances
  - Not dumping trash into freshwater bodies
- Displaying leadership by volunteering in community water clean-ups

3. Pollution by Oil Spills

An oil spill is a type of pollution that occurs when liquid petroleum hydrocarbons are released into the marine environment. In most cases this is a direct consequence of human activities such as drilling in the ocean. In other cases, oil is also naturally released from underneath the seafloor through fractures known as seeps. When oil contaminates the oceans, it can very well flow into lakes, rivers or other drinking water bodies which are naturally connected to the ocean. As a result, water becomes inconsumable. Moreover, when considering the fact that only a litre of oil has the ability to contaminate 1 million litres of water, the impact of oil spills in contributing to water pollution becomes quite apparent.

Protection against Oil Pollution:

- Preventive Maintenance; Oil companies should be proactive by inspecting their equipment and infrastructure so as to prevent the probability of oil spills from happening altogether. In addition, it is a good practice to conduct maintenance work periodically.
- Recycle and reuse plastic products - plastic is a petroleum product
- Participation Oil Pollution awareness campaigns on local/regional/EU levels

4. Radioactive Water Pollution

Radioactive waste is a type of hazardous waste that contains radioactive material. Radioactive water pollution, in particular, emerges as a consequence of improper handling of nuclear materials and debris following an explosion. Additionally, the mining and exploitation of radioactive elements like uranium can introduce radioactive pollution into our water supplies.

Causes of Radioactive Pollution:

- Nuclear power generation
- Rare-earth mining
- Nuclear medicine
- Nuclear research
- Reprocessing of nuclear weapons

Protection against Radioactive Pollution:

- Being proactive by:

  - Disposing of radioactive waste in thick concrete containers so as to prevent its leakage
  - Labelling radioactive materials

- Embracing innovation by using renewable sources of energy rather than nuclear power which also relies on the mining of radioactive uranium

5. Sediment Pollution

'Sediment' refers to particles such as sand, clay and silt that settle at the bottom of a body of water. Sediment can have a number of negative impacts on the quality of water, and subsequently the health of humans and animals. Sediment particles are carried and settle in water by the wind, water and ice. Sediment water pollution can have significant impacts such as:

- It clogs water passages and increases the possibility of flooding
- It causes water cloudiness, making it harder for animals to find food
- It prevents aquatic vegetation from thriving
- It destroys the natural habitat of aquatic species
- It increases the water treatment costs and reduces the quality of drinking water

Protection against Sediment Pollution:

- Training of staff on available means that can be used against sediment pollution such as:

  - Installing storm drain filtration devices
  - Installing perimeter control (i.e silt fences)

- Floating turbidity curtains may be used as a last resort for when sediment has already settled into water bodies

6. Thermal Pollution

One form of pollution which is commonly caused by industrial facilities is thermal pollution. This form of pollution occurs when there is a rapid shift from the natural temperature of a given water body as a result of human influence. Industrial plants draw water from nearby bodies to cool down their machinery and then eject it back but at a higher temperature. This can be problematic for the reason that hot water decreases the water's dissolved oxygen concentration.

Protection from thermal pollution:

- Using artificial lakes to let the heated water naturally lose its temperature with time to then be released into water bodies or recycled for further use.
- In power plants, steam is used to power turbines which generate electricity. This implies that waste heat is produced. As such, reducing energy consumption will reduce levels of thermal pollution.
- Reusing the hot water to heat homes and buildings.

7. Pollution by Inorganic Matter

a) Marine Dumping and Plastic Pollution in the Sea:

Every year a multitude of materials are either dumped or flow into the ocean. Out of all the litter that is present in the aquatic environment, plastic is the leading one. To illustrate, it is estimated that 40 percent of the ocean's surface is covered by plastic materials. Moreover, given the rates at which plastic is currently being dumped into the ocean it is expected that by 2050 there will be more plastic than fish in the sea (World Economic Forum, 2016).

Plastic is a synthetic, organic polymer made from petroleum. Its features deem it ideal for a range of purposes including (but not limited to): packaging, construction, farming and agriculture, electronics and household items. Due to this versatility some 380 million tons of plastic are produced every year globally and of which 14 million eventually flow into the ocean (Statista, 2020).

Certain particularities make the presence of plastic into the ocean problematic. Firstly, depending on the material and its structure, plastic can take anywhere from 20 to 500 years to decompose (Global Recycle, 2022). Moreover, only 9 percent of plastic is recycled. The implications are that the rate at which plastic decomposes is much lower than the rate at which it flows into the ocean and this discrepancy is only increasing year after year. As a result, most plastic found in the ocean may stay there until it decomposes. However, plastic may decompose to smaller micro pieces which are not even visible to the naked eye.

b) Industrial waste:

Water is used by industrial facilities in order to flush waste away from the plant. Examples of industries which cause water pollution include but are not limited to petroleum refineries, iron and steel mills, power plants, and food processing industries. While there are certain regulations in tact to protect water bodies from harmful waste, there is always the possibility that the process of discharging waste is mismanaged, thereby resulting in water pollution.

4. Module Summary

In light of climate change, growing water shortages and environmental water demands there is now more pressure than ever to regulate the use of water such that water pollution is minimised. On that note, agriculture ranks as the number one polluter of water globally. These facts necessitate the development of resilient agricultural systems. In fact, agriculture that is resilient is sturdy and flexible enough to respond to the increasing environmental, economic, social, and institutional problems of the modern world.

Water pollution has many sources (see table below) and therefore dealing with it requires a number of collaborations to happen. While coming up with solutions is mostly about having technical skills, successfully implementing solutions is about being able to work with others synergistically. This calls for farmers to also possess soft skills such as teamwork, communication, adaptability and so on. By developing their soft skills, farmers can improve agricultural resilience to ensure that the system can cope with the challenges of the future.

Source	Contaminant	Impact
Organic matter from Sewage and Wastewater	• **Pesticides, fertilisers, animal manure, human waste, nitrates & phosphates** • **Human waste, Pathogens** • **Detergents** • **Pharmaceuticals**	• **Oxygen depletion, the life of the aquatic ecosystem suffers.** • **Transfer of pathogens (bacteria, viruses) to people and animal**
Oil spills	• **Power plants** • **Petroleum refineries** • **Cargo ships/tankers**	**On aquatic species and birds:** • **Hypothermia** • **Drowning** • **Deformities** • **Blindness** • **Poisoning** **Oil spills destabilise ecosystems to an extreme degree.**
Radioactive matter	• **Nuclear power generation** • **Rare-earth mining** • **Nuclear medicine** • **Nuclear research** • **Reprocessing of nuclear weapons**	• **Makes water unusable for generations** • **Cancer** • **Destabilize ecosystems to an extreme degree** • **Mutations**

Sediment	• **Soil** • **Slit** • **Dust** • **Dirt**	• **Flooding** • **Destabilisation of aquatic ecosystems** • **Starvation of aquatic animals** • **Expensive water treatment cause** • **Lowers the quality of drinking water**
Thermal	**Rapid shift from the natural temperature of a given water body as a result of human influence.**	• **Reduction of dissolved oxygen in the water, starving aquatic species of oxygen** • **Destabilisation of aquatic ecosystems**
Inorganic matter	• **Heavy metals (i.e. mercury, lead)** • **Excess nutrients such as nitrates and phosphates** • **Metal particles** • **Rubber residues** • **Toxins from pesticides and herbicides** • **Pharmaceuticals** • **Microplastics**	• **Oxygen depletion, the life of the aquatic ecosystem suffers.** • **Transfer of pathogens (bacteria, viruses) to people and animal** • **Destabilisation of aquatic ecosystems** • **Lowers the quality of drinking water**

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