GREEN UPSKILLS!

4 COMPETENCES FOR BEGINNING A GREEN TRANSITION

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GREEN UPSKILLS!:
A MANUAL FOR BASIC GREEN COMPETENCES

4 competences for beginning a green transition

Skills for a greener future. Adult literacy for sustainable development in work space- Green Upskills! no. 2022-2-RO01-KA210-ADU-000102215

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Introduction - Green Upskills!

In a rapidly changing world, the need for sustainable practices and eco-conscious approaches has become more evident than ever before. The Green Upskills! project is a bold and ambitious endeavor aimed at promoting reskilling and upskilling to usher in a greener and more sustainable economy. By providing educators, trainers, facilitators, and adult workers with the knowledge and tools they need, we aspire to equip individuals and communities with the expertise required to embrace a green society actively.

The challenges of transitioning to a greener economy

As industries and economies evolve, so do the demands placed upon the workforce. The ever-growing emphasis on environmental responsibility and sustainable development calls for a workforce that possesses green skills and is capable of creating a positive impact on their workplace and the broader community. Businesses and enterprises are increasingly expected to implement greener production processes and use fewer natural resources, leading to a shift in the skill sets needed in the labor market.

However, navigating this transition is not without its challenges. Many educators, trainers, and facilitators might lack adequate knowledge and skills related to sustainable development and the green economy. Similarly, adult workers on the labor market may find it difficult to acquire the necessary green skills to adapt and thrive in this changing landscape.

The objectives of the project Green Upskills! - *Skills for a greener future. Adult literacy for sustainable development in work space*

The Green Upskills! project sets forth several specific objectives that aim to address these challenges and facilitate a successful transition towards a greener economy. Over a span of 18 months, our primary goals are:

- Empowering educators and facilitators: We seek to equip 12 adult educators, trainers, and community facilitators from two communities involved in the project with comprehensive knowledge and skills related to sustainable development within a green society. This will enable them to design educational programs that cater to the evolving needs of workers and enterprises in the labor market, fostering a seamless green economic transition.

- Developing green skills for adult workers: We aspire to cultivate green and sustainable development skills within the community, benefiting 45 adults actively engaged in the labor market (15 from each organization). These skills will encompass areas such as design thinking, creativity, adaptability, resilience, and empathy, all vital attributes in embracing a circular economy and contributing to a greener future.

- Strengthening training capacities: We aim to enhance the capacity of participating organizations to offer training services specifically geared towards reskilling and upskilling workers within companies. The focus will be on eco-friendly practices, the green economy, and preparing individuals with "skills for the future."

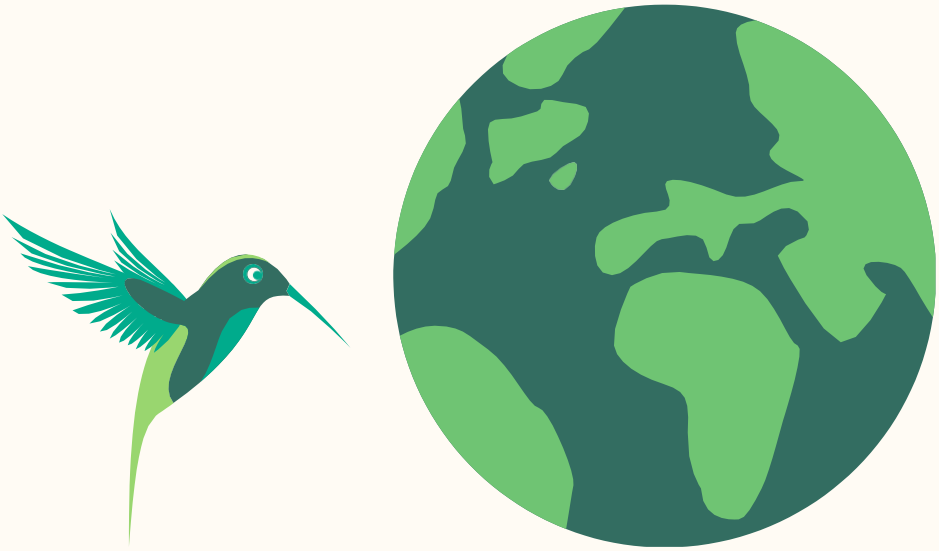
The objectives of the Green Upskills! methodology are to provide a structured and effective framework for achieving the goals of the project. This methodology serves as a guide for educators, trainers, facilitators, and specialists in adult education, enabling them to design and deliver successful training programs that promote green skills and sustainable practices. The key objectives of the methodology include:

• Using the potential of digital tools to design learning processes that promote competencies and education for sustainable development.

• Providing methods for educators to enhance clasic resource-based curricula to develop green skills and eco-firendly attitudes learning and habits development.

• Extending the green competencies of educators in education so they can inspire learners to create behavioral changes in ecological habits and educate them in the best possible way.

• Supporting practitioners to develop sustainability skills in their learners.



Part 1: Methodology

What Is the Green Transition?

The green transition refers to the shift towards a more environmentally sustainable and resource-efficient economy (Jouvet & Jouvet, 2013). This transition depends on progress in several key areas, including improving energy efficiency, transitioning to renewable energy sources, incorporating the value of natural capital into economic decision-making, and revising financial systems to better support green growth. The concept of "green growth" has evolved from simply focusing on the growth of the "eco-industry" to encompassing the transformation of the entire economy and social practices towards more sustainable practices and products that minimize environmental impact and promote ecological preservation (Jänicke, 2012). To successfully navigate this transition, adults must equip themselves with a comprehensive set of green competences - the knowledge, skills, and attitudes necessary to live, work, and make decisions in a more environmentally conscious manner.

The green transition is expected to trigger significant shifts in the labour market, though the overall impact on aggregate employment may be limited. The transition will generate new jobs in renewable energy, energy efficiency, and other green sectors (Renner et al., 2008). This trend is already evident, with a notable increase in transitions from "dirty" to "green" jobs (Curtis et al., 2023).

Jobs in carbon-intensive industries (fossil fuels, traditional manufacturing) are declining, leading to a decrease in demand for skills specific to those sectors. The green transition will require workers to acquire new skills, leading to a potential skills mismatch (Lawrence, 2024). Demand for green skills is already rising, with workers possessing such skills commanding a wage premium (Labour markets in the green economy, 2023).

Targeted training and education programs will be crucial to equipping adults with the competences needed to thrive in the new green economy. Traditional education and training systems often lag behind in providing the specific skills needed for the rapidly evolving green economy. It is therefore essential that adults take the initiative to develop a comprehensive set of green competences, which will empower them to fully participate in and contribute to the successful transition towards a more sustainable future.

Green jobs

Green job skills are increasingly recognized as essential competencies required to thrive in a rapidly evolving labor market that prioritizes sustainability and environmental stewardship. These skills encompass a broad range of technical abilities, knowledge, values, and attitudes necessary for individuals to contribute effectively to sustainable development, economic growth, and social equity. The concept of green skills is not merely confined to environmental science but extends across various sectors, including manufacturing, agriculture, and service delivery, where the overarching goal is to enhance environmental quality and promote sustainability (Strachan et al., 2022; Otieno & Ochieng, 2018).

To delineate the specific skills associated with green jobs, it is crucial to understand the distinction between green and non-green occupations. Green jobs are characterized by their direct or indirect contributions to preserving or restoring the environment, which includes roles in renewable energy, waste management, pollution reduction, and energy efficiency (Otieno & Ochieng, 2018; Valero, 2024). In contrast, non-green jobs may not prioritize environmental considerations, leading to a growing demand for workers who possess the requisite green skills to transition into these emerging roles. This transition is often facilitated by educational institutions and training programs that aim to equip individuals with the necessary

competencies to meet the evolving demands of the green economy (Napathorn, 2021; "Preparing the Workforce for the Low-Carbon Economy: A Closer Look at Green Jobs and Green Skills", 2023).

Acquiring green job skills can be approached through various educational and training pathways. For instance, vocational education programs are increasingly incorporating green competencies into their curricula, emphasizing project-based and problem-based learning strategies that foster critical thinking and innovative problem-solving (Saputri & Ediyono, 2022). Additionally, firms are adopting high-commitment human resource practices that include on-the-job training, mentoring, and coaching to develop the green skills of their workforce (Napathorn, 2021). This approach not only enhances the functional flexibility of employees but also aligns their skills with the strategic goals of the organization in pursuing environmental sustainability.

Moreover, the role of higher education institutions cannot be overstated in preparing graduates for green jobs. Universities are tasked with integrating employability skills into their programs, ensuring that students are equipped with both the technical and soft skills required by employers in the environmental sector (Stewart, 2020). This includes fostering foundational skills such as communication, teamwork, and analytical thinking, which are increasingly recognized as vital for success in green occupations (Kwauk & Casey, 2022; Vona et al., 2018). By providing work-integrated learning experiences, educational institutions can enhance the readiness of graduates to enter the workforce and contribute to sustainability initiatives.

In addition to formal education and training, the importance of lifelong learning and continuous professional development in acquiring green skills cannot be overlooked. As the green economy evolves, workers must remain adaptable and open to acquiring new competencies that align with emerging technologies and practices (Chen et al., 2020; Popp et al., 2022). This may involve participating in workshops, certification programs, and industry conferences that focus on the latest advancements in sustainable practices and technologies. Furthermore, organizations can facilitate this process by creating a culture of learning and development that encourages employees to pursue ongoing education in green skills (Ajadi et al., 2022).

The demand for green skills is also influenced by broader economic and policy frameworks that promote environmental sustainability. Government initiatives, such as green fiscal policies and recovery plans, are designed to stimulate job creation in green sectors while simultaneously addressing skill shortages in the labor market (Popp et al., 2020; Vaquero et al., 2021). These policies often include funding for training programs and incentives for businesses to invest in the development of their workforce's green competencies. As such, individuals seeking to acquire green job skills should remain informed about relevant policy developments and funding opportunities that can support their training and education efforts.

In the context of a just transition to a low-carbon economy, it is essential to recognize the potential barriers that may hinder individuals from acquiring green skills. These barriers can include geographic limitations, access to quality education and training resources, and systemic inequalities within the labor market (Lim, 2023). Addressing these challenges requires a concerted effort from policymakers, educational institutions, and industry stakeholders to create inclusive pathways for skill development that empower all individuals to participate in the green economy.

Furthermore, the integration of green skills into existing job roles can enhance the employability of workers transitioning from traditional sectors, such as fossil fuels, to renewable energy industries. Research indicates that many skills are transferable between these sectors, suggesting that targeted training programs can effectively bridge the gap for displaced workers (Vanatta et al., 2022). By leveraging existing competencies

and providing tailored training, organizations can facilitate smoother transitions for workers seeking to enter green job markets.

We should bare in mind that acquisition of green job skills is a multifaceted process that involves formal education, on-the-job training, continuous professional development, and supportive policy frameworks. As the demand for green jobs continues to rise, it is imperative for individuals, educational institutions, and organizations to collaborate in fostering a skilled workforce capable of driving sustainable development and addressing the pressing environmental challenges of our time. By prioritizing the development of green skills, we can ensure a resilient and equitable transition to a sustainable economy that benefits all stakeholders.

Green education: a confusing concept?

Education for Sustainable Development (ESD), green education, climate education, environmental literacy, ecological literacy, and ecoliteracy are interconnected concepts that play crucial roles in fostering a sustainable future. Each term, while overlapping in some respects, emphasizes different aspects of education and awareness regarding environmental issues. Over time, individuals may have encountered a variety of related concepts concerning education on ecological topics. However, a clearer distinction would provide better clarification. Understanding these distinctions and connections is vital for developing effective educational strategies that address the pressing challenges of sustainability.

ESD is a comprehensive approach that integrates the principles of sustainable development into all aspects of education. It aims to empower individuals with the knowledge, skills, and values necessary to contribute to sustainable development. This concept has gained prominence through initiatives like the United Nations' Decade of Education for Sustainable Development (2005-2014), which highlighted the importance of education in achieving sustainability goals (Tiwary, 2023; Fischer et al., 2015). ESD encompasses various educational practices, including formal, non-formal, and informal education, and emphasizes critical thinking, problem-solving, and participatory learning (Elkhalek, 2021; Laurie et al., 2016).

Green education focuses specifically on environmental issues and practices that promote ecological sustainability. It often includes teaching about renewable energy, conservation, and sustainable practices in daily life. Green education aims to instill a sense of responsibility towards the environment and encourage individuals to adopt sustainable behaviors (O'Flaherty & Liddy, 2017). While ESD encompasses a broader range of topics, green education is more narrowly focused on environmental stewardship and ecological practices.

Climate education is another critical component that specifically addresses the challenges posed by climate change. It aims to inform individuals about the science of climate change, its impacts, and the necessary actions to mitigate its effects. Climate education is essential for fostering awareness and understanding of climate-related issues, which are increasingly relevant in today's world (Fischer et al., 2015). This type of education often intersects with ESD and green education, as it promotes sustainable practices that can help combat climate change.

Environmental literacy refers to the knowledge and skills necessary to understand environmental issues and make informed decisions regarding them. It encompasses an understanding of ecological systems, human-environment interactions, and the social, political, and economic factors that influence environmental issues (Paryanti et al., 2021; Kim et al., 2017). Environmental literacy is a foundational aspect of both ESD and green education, as it equips individuals with the necessary knowledge to engage with sustainability challenges effectively.

Ecological literacy, or ecoliteracy, emphasizes the understanding of ecological principles and systems. It involves recognizing the interconnectedness of living organisms and their environments and understanding the impact of human actions on these systems (Desfandi et al., 2017; Bello et al., 2023). Ecoliteracy goes beyond mere knowledge; it also includes the ability to take action and participate in decision-making processes related to environmental issues. This concept is key for fostering a sense of agency and responsibility among individuals, enabling them to contribute to sustainable communities (Desfandi et al., 2017).

The links between these concepts are evident in their shared goal of promoting sustainability and **environmental stewardship**. ESD serves as an overarching framework that incorporates elements of green education, climate education, environmental literacy, and ecoliteracy. Each of these concepts contributes to a holistic understanding of sustainability and empowers individuals to take action in their communities and beyond (Drăghici, 2019). For instance, a well-rounded ESD program might include components of climate education to address specific environmental challenges while also fostering ecoliteracy to encourage active participation in sustainability efforts.

The significance of these educational approaches cannot be overstated. As global challenges such as climate change, biodiversity loss, and resource depletion become increasingly urgent, the need for an informed and engaged citizenry is paramount. Education plays a critical role in equipping individuals with the knowledge and skills necessary to navigate these complex issues and contribute to sustainable solutions (Tiwary, 2023; Elkhalek, 2021). By fostering a culture of sustainability through ESD, green education, and related concepts, we can cultivate a generation of individuals who are not only aware of environmental issues but are also motivated to take action.

Moreover, the integration of these educational approaches into curricula and educational practices can lead to transformative learning experiences. For example, incorporating experiential learning opportunities, such as community service projects focused on environmental conservation, can enhance students' understanding of sustainability while also fostering a sense of responsibility and agency (Safitri, 2024). Such approaches can help bridge the gap between theoretical knowledge and practical application, ultimately leading to more effective engagement with sustainability challenges.

While education for sustainable development, green education, climate education, environmental literacy, ecological literacy, and ecoliteracy each emphasize different aspects of sustainability education, they are all interconnected and contribute to a comprehensive understanding of environmental issues. ESD serves as the main concept, providing a framework that encompasses the others and emphasizes the importance of equipping individuals with the knowledge, skills, and values necessary to contribute to a sustainable future. As the world faces increasingly complex environmental challenges, the relevance and importance of these educational approaches will only continue to grow.

A simple analogy can help illustrate these concepts: imagine a house. Green education focuses on making the house more environmentally friendly, like installing solar panels or using energy-efficient appliances. Climate education explains why the house is getting hotter—due to climate change—and explores ways to cool it down (mitigation) or cope with the heat (adaptation). Ecoliteracy helps you understand how the house is connected to the larger ecosystem, such as energy sources, waste disposal, or water cycles.

Aspect	Green Education	Climate Education	Ecoliteracy
Focus	Practical actions and solutions to environmental problems.	Understanding climate change, its causes, impacts, and solutions.	Understanding ecological principles and the interconnectedness of living systems.
Scope	Individual and community-level actions, such as reducing waste, conserving energy, and adopting sustainable practices.	Mitigation (reducing emissions) and adaptation (adjusting to climate impacts).	Broader, conceptual focus on systems thinking, ecological principles, and human-nature interdependence.
Examples	School recycling programs, community gardens, workshops on building green infrastructure.	Lessons on the greenhouse effect, climate change simulations, renewable energy projects.	Studying ecosystems, biodiversity, and the ecological footprint of human activities.
Analogy (House)	Making the house more environmentally friendly (e.g., installing solar panels, using energy-efficient appliances).	Explaining why the house is getting hotter (climate change) and how to mitigate or adapt.	Understanding how the house is connected to the larger ecosystem (e.g., energy sources, waste, water cycles).

Key green competences for adults - GreenComp

Green competences should be integrated into a new paradigm shift in education and learning process. Education and training represent a catalyst for what is now called the greening process. The greening concept signifies a fundamental shift towards integrating sustainability principles into all facets of our lives. It represents a move away from traditional, often environmentally damaging practices towards more responsible and sustainable alternatives (Tibbitts et al., 2024).

In the context of ESD, greening usually refers to integrating sustainable practices and environmental awareness into various aspects of the learning process. By integrating sustainability into the curriculum and teaching practices, institutions and trainers can help learners develop the necessary skills and knowledge to become environmentally responsible citizens and professionals. Developing key green competences should be a priority for all adults in order to facilitate the green transition and shift towards more sustainable practices.

According to the *GreenComp - The European sustainability competence framework,* 12 green competences for sustainability are organized in 4 areas (Bianchi et al., 2022):

1. **Embodying sustainability values,** including the competences

• valuing sustainability
• supporting fairness
• promoting nature

2. **Embracing complexity in sustainability,** including the competences

• systems thinking
• critical thinking
• problem framing

3. **Envisioning sustainable futures,** including the competences

• futures literacy
• adaptability
• exploratory thinking

4. **Acting for sustainability,** including the competences

- political agency
- collective action
- individual initiative

Why are green competence so important?

The green transition requires a fundamental shift in the way individuals, communities, and society as a whole approach environmental challenges and sustainable development. Developing green competences is crucial for several reasons: it empowers people to make informed decisions and take meaningful action to address environmental issues, it fosters a sense of individual and collective responsibility for the planet, it helps to reshape social norms and cultural values towards more sustainable practices, and it equips the workforce with the skills needed to drive the transition to a green economy (Cebrián & Pubill, 2015) (Redman & Wiek, 2021) (Khadri, 2022) (Corres et al., 2020).

Empowers informed decision-making and action on environmental issues: Green competences provide individuals with the knowledge, skills, and critical thinking abilities to understand complex environmental problems, analyze potential solutions, and take appropriate actions to mitigate or adapt to environmental challenges. Developing green competences instills a deep sense of personal and community-level ownership over environmental issues, motivating individuals to adopt sustainable behaviors and collaborate with others to address shared ecological concerns.

Fosters sustainability mindsets and cultural transformation: The acquisition of green competences contributes to a cultural shift away from unsustainable lifestyles and toward a more ecologically conscious worldview. As green competences become more widespread, social norms and individual behaviors will increasingly prioritize environmental stewardship, leading to a transformation of societal values, consumption patterns, and economic systems.

Equips the workforce for the green economy: The transition to a green economy requires a workforce with the right mix of skills and knowledge to drive sustainable innovation, implement green technologies, and manage environmental impacts across various industries. Developing green competences in the adult population ensures that workers possess the necessary abilities to thrive in green jobs, contribute to the development of green products and services, and facilitate the broader shift toward a more sustainable economic model.

By cultivating green competences, individuals develop a stronger emotional and intellectual connection to the natural world, recognizing the intrinsic value of ecosystem services and the importance of environmental protection.

Why should (not only) adults benefit from sustainable education and gain green competences?

The need for developing green competences among the adult population is driven by several important factors:

Firstly, the urgency of addressing global environmental challenges, such as climate change, biodiversity loss, and resource depletion, requires widespread public engagement and action. Adults, as decision-makers, consumers, and community members, have a critical role to play in driving the transition towards a more sustainable future. (Fadjarajani & As'ari, 2021) (Hadjichambis et al., 2020) (Cebrián et al., 2020) (Hofmann & Strietska-Ilina, 2014)

Secondly, the success of the green transition will largely depend on the ability of the general public to understand environmental issues, adopt sustainable lifestyles, and actively participate in the shaping of policies and solutions.

Thirdly, developing green competences can empower adults to make informed choices, contribute to local and global environmental initiatives, and inspire the next generation to become active stewards of the environment and play a role in shaping those behaviors. One study found that children's eco-friendly actions are directly influenced by their parents' actions, emphasizing the power of role modeling. Additionally, "subjective norms," or the expectations children perceive from their parents, also significantly impact their environmental behaviors. This means children are more likely to adopt pro-environmental practices if they believe it aligns with their parents' expectations. Interestingly, the study revealed that children are more susceptible to these social influences than adults, further emphasizing the significant impact adults, especially parents, have on shaping the next generation's environmental consciousness (Ando et al., 2015). Therefore, sustainable education for adults is implicitly crucial as it drives pro-environmental behaviors in adults, which then influences children's actions and ultimately contributes to a more sustainable future.

Furthermore, the acquisition of green competences can provide numerous personal and societal benefits, such as improved physical and mental health, enhanced community resilience, and the creation of green job opportunities.

Why greening curriculums is necessary?

Climate change presents an unprecedented challenge, affecting all aspects of sustainable development, including health, food security, economic growth, and biodiversity. Addressing it requires behavioral changes, sustainable practices, and urgent global cooperation. Education plays a key role in this transition, but many national education systems have yet to fully integrate climate change into curricula. A 2021 UNESCO report found nearly half of 100 national curriculums lacked any mention of climate change, and most youth and teachers feel underprepared to address its effects.

Education for Sustainable Development (ESD) and Climate Change Education (CCE) are crucial for achieving Sustainable Development Goals (SDGs). SDG 4.7 focuses on equipping learners with the knowledge and skills to promote sustainable development, while SDG 13 highlights the need for education in climate action. Young people are increasingly calling for a more holistic approach to climate education, aiming to empower individuals as agents of change.

Youth activism further underscores the need for enhanced climate education. Reports like UNESCO's Youth Demands for Quality Climate Change Education and declarations from global youth forums call for inclusive, interdisciplinary education that empowers young people to address climate change. These demands also emphasize the need for governments and corporations to take greater responsibility and highlight the unequal burden on marginalized communities. Cross-sector collaboration and inclusive education are seen as vital to achieving sustainability and addressing the climate crisis equitably.

A response to these demands ***Green Upskills! Manual*** integrates all principles from the UNESCO's "*Greening curriculum guidance: teaching and learning for climate action" (https://doi.org/10.54675/AOOZ1758).* This Guidance aims to support countries, schools or individual practitioners in reassessing their ongoing practices to adopt a more action-oriented, holistic, scientifically accurate, justice-driven and lifelong learning approach to climate change. In developing this methodology we will use the UNESCO's guidance as a framework of educational principles in green education:

Green education has one clearly defined ultimate goal, to have individuals with pro-climate mitigation behaviors. In order to take action essential knowledge, skills, values and attitudes are necessary to be developed. Given the fact that humanity is living a climate crisis, all individuals should benefit from Education for Sustainable Development (ESD).

"[Greening curriculum guidance] offers a flexible framework to support curriculum revision, allowing for context-specific tailoring while achieving educational goals. It is designed to be complemented by other resources that translates the learning outcomes of this guidance for textbook development, transformative pedagogy, and assessment techniques."

What is education for sustainable development?

According to UNESCO: *"Education for sustainable development (ESD) gives learners of all ages the knowledge, skills, values and agency to address interconnected global challenges including climate change, loss of biodiversity, unsustainable use of resources, and inequality. It empowers learners of all ages to make informed decisions and take individual and collective action to change society and care for the planet. ESD is a lifelong learning process and an integral part of quality education. It enhances the cognitive, socio-emotional and behavioural dimensions of learning and encompasses learning content and outcomes, pedagogy and the learning environment itself."*

Through green and climate education we can mobilize educational institutions and stakeholders to address climate change, by empowering people with the knowledge, skills, values and attitudes needed to act as agents of change. A review by Monroe et al. (2019) of 49 articles found that most programs aimed to improve knowledge, but knowledge does not automatically lead to action. To foster pro-environmental behavior, it is essential to cultivate learners' efficacy and green life skills—such as empathy, reasoning, decision-making, and communication (Bouman et al., 2020; Karpudewan & Roth, 2018).

Table 1: Traditional teaching versus transformational ESD learning

Traditional ESD teaching	**Transformational ESD learning**
Passing on content knowledge	Fostering understanding and analysis of the roots of the climate crisis
Teaching attitudes and values	Encouraging values clarification and critical reflection based on lived experience
Seeing people only as the source of the climate	Seeing people as facilitators of change
One-way transmission of information	Dialogue and negotiation on the implications of the information for action
Behaving as an expert – formal & authoritarian	Acting as a partner – informal & egalitarian
Changing personal behaviour	More focus on structural and institutional changes

Source: Adapted from Tilbury, 2011, p.25, in Greening curriculum guidance (UNESCO)

Implementing Green Competences

Developing green competences at the individual and societal level requires a multifaceted approach that includes the following strategies:

Integrating sustainability education into formal learning systems: Institutions of higher education, vocational training programs, and adult education curricula should prioritize the incorporation of sustainability-focused

courses, project-based learning, and hands-on experiences that enable the development of green competences.(Redman & Wiek, 2021)

Promoting workplace training and continuous learning: Employers should invest in green skills development for their workforce, offering training programs, job-specific sustainability education, and opportunities for employees to engage in environmentally-focused initiatives within the organization.(Hofmann & Strietska-Ilina, 2014)

Facilitating access to information and resources: Governments, educational institutions, and civil society organizations should make environmental education materials, green skill-building resources, and information on sustainable living widely available and accessible to the general public.(Ibimilua & Amuno, 2014)

Fostering green competences through non-formal and informal learning opportunities: Community organizations, environmental advocacy groups, and other civil society actors can play a vital role in providing adults with access to workshops, seminars, and experiential learning activities that nurture green competences.(Oyasu, 2019)

Incentivizing the adoption of green competences in the workplace: Employers should invest in professional development programs that equip their workforce with the necessary green competences to support the implementation of sustainable practices, the adoption of green technologies, and the transition to a more environmentally responsible business model.(Martínez-Fernández et al., 2010)(Hofmann & Strietska-Ilina, 2014)

Empowering individuals to take personal action: Governments, media outlets, and community leaders should launch public awareness campaigns and provide resources that enable adults to take ownership of their environmental impact and become active participants in the green transition through the application of their green competences.(Moloney et al., 2009) (Cherian & Jacob, 2012)

Promoting public awareness and community engagement: Governments, media outlets, and community leaders should spearhead public awareness campaigns and community-based initiatives that inspire adults to develop green competences and empower them to take action on environmental issues within their spheres of influence. (Harvie & Jaques, n.d)

The cultivation of green competences is a crucial component of the broader green transition, as it empowers individuals, strengthens communities, and transforms societal norms and economic systems. Ultimately, the development of green competences among the adult population is a critical component of the broader transition towards a more sustainable future.

Factors influencing sustainable consumption behavior: building the foundation for green education

When it comes to education, the ultimate focus should be in behavior change in the way that individuals consume, live, and work (Wagner, 2012). The goal should be to foster an ecological mindset that permeates all aspects of daily life, rather than solely acquiring technical skills. This involves cultivating a deeper understanding of environmental issues, critical thinking skills to navigate complex challenges, and a commitment to adopting sustainable practices. Here are deeper **3 factors** influencing sustainable consumption behavior of a responsible consumer (Saari et al., 2021):

1. Environmental knowledge

This goes beyond basic awareness of environmental issues. It encompasses:

Understanding of scientific concepts: knowing how ecosystems function, the impact of human activities, and the consequences of environmental degradation.

Knowledge of sustainable practices: being aware of specific actions that individuals can take to reduce their environmental footprint, such as reducing energy consumption, conserving water, and properly disposing of waste.

Critical evaluation of information: being able to discern credible sources of information and identify greenwashing tactics used by companies.

Providing factual, science-based information about environmental issues is crucial to fostering sustainable consumption.

2. Environmental risk perception

This refers to an individual's subjective judgment about the likelihood and severity of environmental risks. It is influenced by:

Personal experiences: Directly experiencing the effects of environmental problems, such as extreme weather events or pollution, can heighten risk perception.

Media exposure: The way environmental issues are portrayed in the media can shape public perception of risk.

Trust in information sources: People are more likely to perceive risks as serious if the information comes from trusted sources, such as scientists or environmental organizations.

Emphasis on the importance of communicating environmental risks effectively, using clear and relatable language, to motivate behavioral change is needed.

3. Environmental concern

This represents an individual's emotional connection to the environment and their sense of responsibility for its well-being. It is characterized by:

Values and beliefs: Individuals with strong pro-environmental values are more likely to be concerned about environmental issues and act accordingly.

Altruism and empathy: Concern for future generations and a sense of interconnectedness with nature can drive pro-environmental behavior.

Personal norms: Feeling a sense of moral obligation to protect the environment can influence individual actions.

Around these 3 factors, a comprehensive green education curriculum can be designed to equip adults with the knowledge, skills, and attitudes necessary to lead a sustainable lifestyle and support the green transition.

Factors

The factors represent the foundational elements that shape a person's readiness and motivation to engage in environmental issues.

Factor	Description
1. Environmental Knowledge	Understanding of scientific concepts, sustainable practices, and the ability to critically evaluate environmental information.
2. Environmental Risk Perception	Perception of environmental risks based on personal experiences, media exposure, and trust in information sources.
3. Environmental Concern	Emotional connection to the environment, driven by values, empathy, and personal norms around environmental protection.

Five main approaches to green education

Building on the GreenComp framework and other relevant literature, we have identified five key approaches to guide the development and cultivation of green competences among adults:

1. Systems thinking: Understanding the interconnectedness of environmental, social, and economic systems, and how individual actions can have far-reaching implications. This involves recognizing that environmental issues do not exist in isolation, but are interconnected with social, economic, and political factors. By adopting a systems-thinking approach, individuals can better understand the complex relationships and feedback loops that influence environmental outcomes.

2. Ecological literacy: Possessing a deep understanding of the natural world, including the functioning of ecosystems, the importance of biodiversity, and the impact of human activities on the environment. This knowledge allows individuals to appreciate the intricate workings of the natural world, recognize the value of ecological services, and make informed decisions that minimize their environmental impact and understanding the intricate relationship with the climate.

3. Sustainability mindset: Adopting an ethical, future-oriented perspective that prioritizes environmental protection, resource conservation, and the well-being of present and future generations. This mindset involves considering the long-term consequences of our actions and making choices that promote the sustainable use of resources, reduce waste, and ensure a healthy planet for generations to come.

4. Collective responsibility: Recognizing the shared responsibility for addressing environmental challenges and the need for collaborative action at the individual, community, and global levels. Environmental issues transcend individual boundaries, and addressing them requires coordinated efforts and a sense of collective stewardship among citizens, communities, and nations.

5. Empowerment and agency: Developing the confidence, knowledge, and skills to take meaningful action in support of environmental sustainability and to influence positive change. This empowerment enables individuals to take proactive steps, advocate for environmental policies, and inspire others to join the collective effort towards a more sustainable future.(Bianchi et al., 2022) (Tibbitts et al., 2024)

By taking into account these 5 approaches, adults can develop a **holistic set of green competences** that enable them to make informed decisions, engage in sustainable practices, and contribute to the broader transition towards a green economy and a more environmentally sustainable society (Redman & Wiek, 2021).

Approach	Connection to Factors
1. Systems Thinking	Derived from **environmental knowledge**, this approach helps understand the interconnectedness of ecological, social, and economic systems.
2. Ecological Literacy	Rooted in **knowledge** and **concern**, this deep understanding allows learners to grasp how ecosystems work and how human actions impact nature.
3. Sustainability Mindset	A forward-thinking perspective shaped by **concern** for future generations, promoting ethical, long-term sustainability.
4. Collective Responsibility	Arising from **concern** and **risk perception**, it emphasizes shared responsibility and the need for community-level and global collaboration.
5. Empowerment and Agency	Based on **knowledge** and **risk perception**, this approach gives individuals the tools and confidence to take action and drive change.

Basic green skills and competences and the focus of this toolkit

The development of green competences for adults should focus on equipping them with a range of essential skills and knowledge to effectively manage the green transition.

Based on the reviewed literature, we have identified the following core green competences that every adult person should strive to develop (Cabral & Dhar, 2020)(Fadjarajani & As'ari, 2021)(Hofmann & Strietska-Ilina, 2014):

1. Environmental awareness and analysis:

Developing a deep understanding of environmental issues, such as climate change, biodiversity loss, pollution, and resource depletion, and the ability to critically analyze the root causes and interconnected nature of these challenges.

2. Sustainable lifestyle choices:

Adopting eco-friendly habits and practices in daily life, such as reducing energy and water consumption, minimizing waste, making sustainable transportation choices, and consuming responsibly.

3. Nature connection:

Cultivating a strong connection with the natural world, understanding the functioning of ecosystems, and recognizing the importance of biodiversity and ecosystem services for human well-being.

4. Critical green skills:

Developing the ability to identify and implement practical solutions to environmental problems, through the application of critical thinking, creativity, and a solutions-oriented mindset.

5. Civic engagement and advocacy:

Actively participating in community-based environmental initiatives, engaging in policy discussions, and advocating for sustainable policies and practices at the local, national, and global levels.

6. Environmental management and green skills

Acquiring practical skills and competences to manage green projects, implement eco-friendly technologies, and engage in green entrepreneurship and businesses.

Green skills emerge from the application of the approaches and represent the tangible, actionable abilities individuals develop.

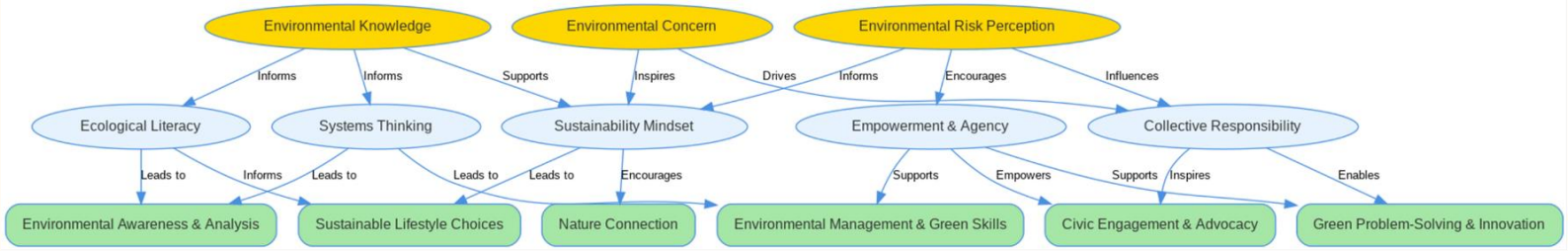
Skill	Linked Approach(es)
1. Environmental Awareness and Analysis	Grows from **systems thinking** and **ecological literacy**, helping individuals understand environmental problems and their causes.
2. Sustainable Lifestyle Choices	Encouraged by **sustainability mindset** and **ecological literacy**, guiding personal choices toward eco-friendly habits and resource conservation.
3. Nature Connection	Developed through **ecological literacy**, fostering a strong bond with nature and an understanding of ecosystems and biodiversity.
4. Critical green skills	Rooted in **systems thinking** and **empowerment**, helping individuals fight misinformation and critically analyze date
5. Civic Engagement and Advocacy	Enabled by **collective responsibility** and **empowerment**, motivating individuals to participate in environmental advocacy and community action.
6. Environmental Management and Green Skills	Supported by **empowerment**, providing practical skills for managing eco-friendly projects, technologies, and entrepreneurship.

By developing these core green competences, adults can become active agents of change, empowered to make informed decisions, adopt sustainable lifestyles, and contribute to the broader transition towards a more environmentally sustainable society. The development of green competences should be facilitated through a combination of formal and informal educational opportunities, including school-based programs, community workshops, online resources, and hands-on experiential learning

This manual sits at the intersection between green education and climate education, focusing on developing the essential green competences that every adult person should strive to acquire in order to effectively manage the green transition and contribute to a more sustainable future and way of living.

This *manual* however has its own limits: it doesn't provide a comprehensive approach to up-skill the workforce with specific technical knowledge and skills needed for various green jobs. Its focus is on empowering the general adult population with general green competences rather than specialized training for green professionals. It rather tries to build a foundation of environmental awareness, sustainable lifestyles and civic engagement that can support the general public for the green transition. In short, this manual serves as an instrument for green competence development for the average adult citizen in order for him/her to immediately act for the environment and the climate.

This diagram visually demonstrates how factors lead to approaches, which in turn produce actionable skills:



This conceptual map reflects the **cascading influence** of **factors** (knowledge, risk perception, and concern) on **approaches** (thinking and behavior) and how these approaches lead to the development of **specific competencies** necessary for sustainability. The connections illustrate a **logical progression**, where understanding, perception, and concern shape how people approach environmental issues, which in turn informs the skills they develop to address these challenges. This structure is designed to show that no element exists in isolation — they are all part of an interconnected framework for fostering environmental sustainability.

Here is an explanation of the **logic** and **rationale** behind the connections between the **factors (A)**, **approaches (B)**, and **green skills (C)** in the conceptual map. I'll break it down by each category, showing how and why they interconnect based on the relationships described in the original content you provided.

1. Factors (a) → approaches (b)

The factors represent fundamental elements that shape how individuals perceive and act upon environmental issues. These factors inform the development of the approaches, which are strategic ways to address environmental sustainability.

- **Environmental knowledge → systems thinking and ecological literacy**:
    - **Why?**: environmental knowledge is the foundational understanding of how ecosystems work, human impacts, and scientific concepts. It naturally leads to **systems thinking**, where individuals recognize how environmental, social, and economic systems are interconnected. **Ecological literacy** is also deeply rooted in this knowledge since understanding the complexities of ecosystems is crucial to making informed decisions.
- **Environmental knowledge → sustainability mindset**:
    - **Why?**: a well-rounded understanding of environmental issues encourages individuals to adopt a **sustainability mindset**, which is future-oriented and focuses on the long-term impacts of human actions on the planet. This mindset requires a broad knowledge base about environmental degradation, resource depletion, and sustainable practices.
- **Environmental risk perception → sustainability mindset**:
    - **Why?**: if individuals perceive environmental risks (like climate change or pollution) as serious, they are more likely to develop a **sustainability mindset** that prioritizes long-term environmental protection and responsibility toward future generations. Risk perception motivates a shift in values and thinking.
- **Environmental risk perception → collective responsibility**:

- **Why?**: recognizing the severity of environmental risks encourages people to see these issues as collective challenges that require coordinated efforts at all levels (individual, community, global). Hence, risk perception fuels a sense of **collective responsibility**.

- **Environmental risk perception → empowerment and agency**:
  - **Why?**: when individuals perceive high environmental risks, they are more likely to feel motivated to take action. This is where the sense of **empowerment and agency** comes in — the belief that they have the power to make a difference by taking concrete steps, advocating for policies, or engaging in environmental activism.

- **Environmental concern → sustainability mindset**:
  - **Why?**: concern for the environment often stems from emotional or moral connections, such as empathy for future generations or a sense of duty to protect nature. These values help individuals develop a **sustainability mindset** that emphasizes ethical, future-oriented behavior.

- **Environmental concern → collective responsibility**:
  - **Why?**: those who are emotionally connected to environmental well-being are more likely to feel a **sense of responsibility** to protect it. This concern pushes people toward actions that involve working together to address global environmental issues.

2. Approaches (b) → green skills (c)

Once the approaches are established, they guide individuals toward developing specific green skills. These skills are practical competencies and attitudes that arise from the strategic approaches taken to tackle environmental challenges.

- **Systems thinking → environmental awareness and analysis**:
  - **Why?**: systems thinking involves understanding the interconnectedness of various systems. It directly leads to **environmental awareness and analysis**, where individuals can critically assess complex environmental issues and understand their root causes. The ability to analyze environmental problems requires thinking in systems.

- **Ecological literacy → environmental awareness and analysis**:
  - **Why?**: **ecological literacy** equips individuals with a deep understanding of how ecosystems function and the impacts of human activities. This knowledge is essential for developing the competence of **environmental awareness and analysis**, where individuals need to understand issues like climate change, biodiversity loss, and resource depletion.

- **Sustainability mindset → sustainable lifestyle choices**:
  - **Why?**: a **sustainability mindset** inherently leads individuals to adopt **sustainable lifestyle choices**, as it emphasizes ethical, resource-conserving, and environmentally responsible behavior. This mindset encourages individuals to reduce their energy and water consumption, minimize waste, and make eco-friendly daily decisions.

- **Ecological literacy → sustainable lifestyle choices**:

    - **Why?**: understanding the science behind ecosystems (ecological literacy) informs how individuals can reduce their environmental footprint. This knowledge helps people make **sustainable lifestyle choices** by understanding the specific actions that minimize harm to the environment.

- **Sustainability mindset → nature connection**:
    - **Why?**: a strong **sustainability mindset** is often tied to a deep emotional and ethical connection with nature. Individuals who prioritize environmental protection are more likely to foster a **connection with nature**, recognizing the intrinsic value of biodiversity and ecosystems.

- **Collective responsibility → green problem-solving and innovation**:
    - **Why?**: tackling environmental challenges requires teamwork and shared efforts, which is the essence of **collective responsibility**. This approach encourages **green problem-solving and innovation**, where individuals work together to develop creative solutions to environmental issues through collaboration and innovation.

- **Empowerment and agency → green problem-solving and innovation**:
    - **Why?**: when individuals feel empowered, they believe they can drive change. This sense of agency motivates them to engage in **problem-solving and innovation** by applying critical thinking and creativity to address environmental problems. Feeling capable of making a difference is key to innovation.

- **Collective responsibility → civic engagement and advocacy**:
    - **Why?**: feeling responsible for the collective good naturally leads to **civic engagement and advocacy**. Individuals who recognize the need for coordinated action are more likely to engage in community-based initiatives, advocate for sustainable policies, and participate in environmental decision-making.

- **Empowerment and agency → civic engagement and advocacy**:
    - **Why?**: when individuals feel empowered to act, they are more likely to engage in **advocacy and civic action**. Empowerment gives them the confidence to influence policies and inspire others to join in collective environmental efforts.

- **Systems thinking → environmental management and green skills**:
    - **Why?**: **systems thinking** helps individuals understand how to manage environmental projects effectively, as they can see the broader context and the interdependencies involved. This approach leads to the acquisition of **green skills** that are crucial for managing sustainability initiatives and implementing eco-friendly technologies.

- **Empowerment and agency → environmental management and green skills**:
    - **Why?**: a sense of **empowerment** motivates individuals to acquire practical **green skills** that allow them to take meaningful action, manage environmental projects, and even engage in green entrepreneurship. Empowered individuals seek out the skills they need to make an impact.

Drawing on the reviewed literature, this manual is proposing 6 key components of green competences listed above in this section. But it only covers the first 4, given the limited purpose of the manual which was explained above.

A. Environmental awareness and analysis

B. Sustainable lifestyle choices

C. Nature connection

D. Critical green skills

E. Civic engagement and advocacy

F. Environmental management and green skills

How to teach green education

What factors influence people to change their behavior in response to climate change?
Below brief overview of the factors influencing behavioral change related to climate change:

Social Norms:

Research suggests that people are more likely to engage in pro-environmental behavior if they believe it is a widely accepted social norm (Schneider & Linden, 2023).

Highlighting the prevalence of climate-friendly actions within a community can motivate individuals to conform and adopt similar behaviors.

Effective Communication:

Traditional information-based campaigns often fail to resonate with audiences (O'Neill & Hulme, 2009).

Framing climate change in a way that connects with people's values, emotions, and personal experiences can be more effective in inspiring action.

For example, emphasizing the local impacts of climate change or highlighting stories of individuals making a difference can be more impactful than presenting abstract scientific data.

Behavioral Interventions:

A study involving 63 countries explored various behavioral interventions to mitigate climate change .

The study found that financial incentives and social pressure were more effective than education or feedback alone in changing behavior (Addressing climate change with behavioral science: A global intervention tournament in 63 countries, 2024). This suggests that combining information with tangible rewards or social influence can be a powerful motivator.

Psychological distance

People are more likely to act if they perceive climate change as a present and personally relevant threat rather than a distant issue. Strategies that make climate change feel immediate and local can help bridge this psychological distance and spur action.

Self-Efficacy

Individuals are more likely to take action if they believe their actions can make a difference.

Values and Beliefs

Personal values and beliefs about the environment, responsibility, and social justice play a significant role in shaping climate-related behaviors.

It's important to note that these factors are not definitive and are interconnected and influence each other. Effective strategies for promoting climate action often involve a combination of these elements, tailored to specific contexts and audiences.

How education can contribute to these factors towards climate action?

There's growing recognition of the crucial role education plays in tackling climate change. Many researchers emphasize the role of education in promoting climate literacy, building personal efficacy, and inspiring climate action.

Increased awareness and knowledge: (The untapped potential of education in the battle against climate change, 2023) suggests that education can increase awareness of climate change as a threat and provide knowledge about effective solutions. This understanding can motivate individuals to make informed choices and support pro-environmental policies.

Shifting values and attitudes: Education can foster pro-environmental values and attitudes, leading to greater concern for the environment and a sense of responsibility towards future generations (Green Light for Comprehensive Climate Change Education, 2023).

Developing skills and agency: Emphasis on the need for education to equip individuals with the skills and knowledge to take meaningful action. This includes critical thinking, problem-solving, and understanding the interconnectedness of social, economic, and environmental issues (Kwauk & Casey, 2021).

Empowering active citizenship: Education can empower individuals to become active citizens who engage in climate advocacy, support sustainable policies, and hold decision-makers accountable (Reimers, 2020).

It's important to note that simply providing information about climate change is not enough. Effective climate education should be engaging, solutions-oriented, and empower individuals to take action. Green Education is not for knowledge sake, it is considered to be a practical and actionable form of education (Damoah, 2023).

Foundational principles of adult learning and sustainability education

Teaching green education, education for sustainable development (ESD), or climate education within the framework of adult education pedagogy necessitates a multifaceted approach that aligns with the principles of adult learning. Adult education must be transformative, participatory, and relevant to learners' lives, particularly in addressing the pressing issues of sustainability and climate change. In developing a curriculum for green competencies one must take into account a synergy between principles of adult learning and the *5 main approaches to green education* previously discussed.

One of the foundational principles of adult education is the recognition of learners' experiences as valuable resources in the learning process. This principle is particularly relevant in the context of ESD, where learners are encouraged to draw upon their personal and professional experiences to engage critically with sustainability issues. Ahrens (2024) emphasizes the need for educators to integrate sustainability into adult education, highlighting the importance of empowering educators to facilitate discussions that bridge the gap between maintaining the status quo and fostering transformative change in sustainability practices. This aligns with the findings of Charatsari et al. (2022), who assert that adult education can promote environmental and social sustainability by motivating learners to take action based on their experiences and values.

Moreover, the pedagogical approach to ESD should incorporate emotional and experiential learning methods. Walsh et al. (2020) argue that transformative education must go beyond cognitive learning to include emotional engagement and real-world applications, fostering sustained behavioral change. Pouratashi (2021) echoes this, noting that both formal and informal education play crucial roles in developing sustainable skills among learners, thereby enhancing their ability to contribute to sustainable development. By creating learning environments that prioritize experiential learning, educators can help adult learners connect theoretical knowledge with practical applications in sustainability.

Another critical aspect of teaching ESD to adults is the incorporation of collaborative and participatory learning strategies. Adefila et al. (2021) highlight the importance of collaborative online learning in addressing complex sustainability challenges, suggesting that such approaches can enhance learners' engagement and problem-solving skills. This participatory approach is essential for fostering a sense of community and shared responsibility among learners, which is vital for effective climate education. Similarly, Urbančič et al. (2019) emphasize the role of open educational resources in promoting collaboration and knowledge sharing, further supporting the development of competencies necessary for sustainable development.

Furthermore, the integration of sustainability education into adult learning must also address the emotional and psychological dimensions of climate change. O'Flaherty and Liddy (2017) discuss the impact of educational interventions on learners' perceptions and attitudes towards sustainability, emphasizing the need for education to address feelings of apathy and anxiety related to climate change. This highlights the importance of creating a supportive learning environment where adult learners can express their concerns and develop resilience in the face of environmental challenges.

Teaching green education, ESD, or climate education through the lens of adult education pedagogy requires a comprehensive approach that values learners' experiences, fosters emotional engagement, promotes collaborative learning, and addresses the psychological aspects of sustainability.

Based on the sources from UNESCO's *Greening curriculum guidance* in relation the principles of adult education, educators can effectively equip adult learners with the knowledge, skills, and values necessary to navigate and contribute to a sustainable future. The following pedagogical principles can be applied:

Learner-centeredness

Focuses on learners' autonomy and active participation. Educators facilitate learning by starting with participants' existing knowledge and experiences. In short-term activities, learners could be given the opportunity to suggest topics or shape discussions. Inquiry-based learning allows participants to develop their own conclusions through exploration and questioning.

Adult learners are often motivated by immediate, real-world applications. Connect climate change to their lived experiences, professions, and communities. For example, tailor content for professionals in urban planning, healthcare, or business, highlighting the specific impacts and solutions relevant to their fields.

Active/experiential learning

Hands-on activities, such as role plays, simulations, storytelling, and debates, help bridge the gap between knowledge and action. This approach promotes engagement and helps participants understand different perspectives and future scenarios. In youth training, experiential learning could involve field trips, practical exercises, or games to stimulate action-based learning.

Adults bring a wealth of experience to the table. Utilize their existing knowledge and skills through case studies, simulations, field trips, and peer-to-peer learning. Encourage them to share their own experiences and insights.

Self-direction and autonomy

Respect adult learners' autonomy by offering choices in learning pathways, topics, and pacing. Encourage self-directed learning projects that align with their interests and goals.

Critical pedagogy

Encourages learners to critically assess the current situation, societal norms, and political decisions regarding climate change. This can be a way to challenge systems and advocate for change. Trainers can use discussions, reflection activities, or project-based work to help participants question existing systems and propose solutions.

Transformative learning

Linked with critical pedagogy, this approach emphasizes personal transformation. It encourages participants to reflect deeply on their own values, behaviors, and lifestyles, which can influence change in their community and society. Short-term programs can incorporate reflection activities to foster this transformation, such as journaling or group reflections.

Problem-based learning

Organizes learning around solving real-world problems. In short-term training, participants can work on specific environmental or sustainability issues, learning through the process of tackling these challenges. Examples include creating action plans or organizing community initiatives.

Project-Based learning

Facilitate collaborative projects that empower learners to apply their knowledge and skills to create tangible solutions. This could include designing community gardens, developing renewable energy solutions, or implementing sustainable business practices.

Collaborative learning

Involves learners working together to achieve a common goal. Trainers can create environments where participants co-design solutions and share experiences. In short projects, engaging community members or peers fosters deeper collaboration.

Community engagement

Connect learning to real-world action by partnering with local organizations, businesses, and government agencies working on climate change issues. Encourage learners to participate in advocacy, volunteering, and citizen science initiatives.

Use of media and new technologies

Visual and interactive technologies like documentaries, social media, and extended reality (xr) tools can enhance learning. Trainers can leverage these to make learning more engaging and relevant. Participants can analyze media critically, understanding how social media and visual content influence their perceptions of climate change.

Critical reflection

Encourage learners to critically examine their own values, beliefs, and behaviors related to climate change. Facilitate discussions about personal responsibility, social justice, and the ethical implications of climate change.

Values clarification

Help learners explore their own values and how they align with sustainability principles. Encourage them to articulate their personal motivations for taking action and identify potential barriers.

Visioning and future planning

Engage learners in envisioning a sustainable future and developing action plans for contributing to that vision. This could involve setting personal goals, advocating for policy changes, or supporting community-based solutions.

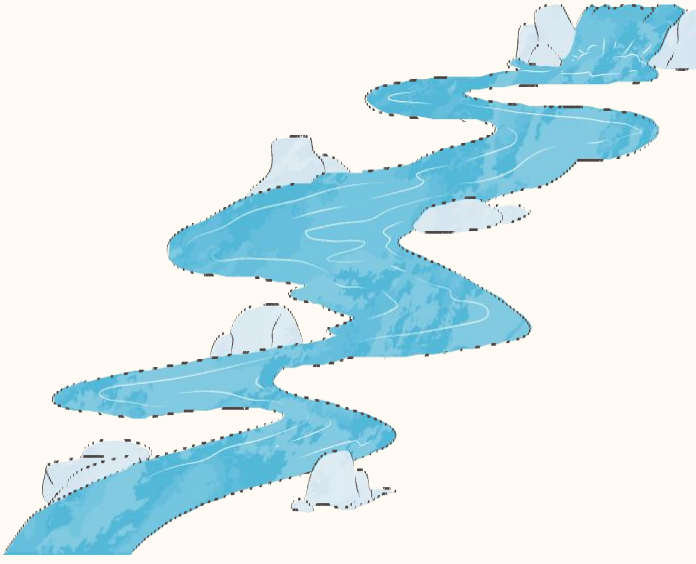
Adult education is most effective when it is voluntary, participatory, and relevant to learners' lives. By incorporating these principles into green, climate, and ESD initiatives, we can empower adults to become informed, engaged, and active participants in creating a more sustainable future.

The assessment of learners' progress should adopt a comprehensive and holistic approach

In certain traditional educational settings, the focus of sustainability-related learning may be primarily on the acquisition and comprehension of knowledge and associated theoretical concepts. However, the anticipated learning outcomes should encompass a broader range of domains, including the cognitive, social, emotional, and behavioral aspects, necessitating a more comprehensive approach to assessment .

According to UNESCO's *Greening curriculum guidance* areas of learner development that might be assessed are:

- Understanding of content, remembering basic factual material
- Skills in asking critical questions, analysing problems, and designing new solutions to problems.
- Clarifying one's own values and understanding the perspectives or points of view of others.



- Motivation or interest to live sustainably and address climate change, both through individual behaviour and through collective action for system change

- Envisioning more positive and sustainable futures

- Application and action.

When assessing learners, we should consider the diverse goals and teaching methods used. And any assessment tools should be designed to ensure fair and equitable implementation, given the broader aim of providing quality education.

By adopting a multidimensional assessment approach that captures the cognitive, affective, and conative (action-oriented) dimensions, we can better evaluate the holistic development of adult learners in education for sustainability.

Part 2: Curriculum

MODULE 1 Key competence: Environmental awareness and analysis			
Developing a deep understanding of environmental issues, such as climate change, biodiversity loss, pollution, and resource depletion, and the ability to critically analyze the root causes and interconnected nature of these challenges.			
Topics	Cognitive	Social and emotional	Behavioral
Climate change, greenhouse gases GHGs and carbon footprint	Learners should be able to: analyze types of extreme events that and assess how they might be affected by global warming explain the basics of the greenhouse effect use the concept of Global Warming potential to compare the effects of GHGs identify major types and sources of pollution in the region. understand the role of Sustainable Development Goals (SDGs)	Learners should be able to: feel concern over the impact of projected climate change on their own and future generations in different regions. appreciate the importance of trees, forests, and mangroves in removing CO2from the air, while also understanding heir various benefits to humans and their role as habitats. reflect on their own commitment to environmental values and on how they and their families can be motivated to reduce greenhouse gas emissions by calculating their own carbon footprint.	Learners should be able to: counter misinformation on climate change in online spaces. raise awareness of the 'greenhouse effect' of CO2 and some other gases, with family and coworkers take personal actions or advocate to preserve or extend tree cover/forest/ mangroves, and/or to reduce use of fossil fuels, e.g. in personal or commercial transportation. critically evaluate information online by checking sources, identifying bias, and verifying facts with credible websites before sharing them. align the behavior in a future orientated way with SDGs

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			align the behavior in a future orientated way with SDGs
MODULE 2. Key competence: Sustainable lifestyle choices			
Adopting eco-friendly habits and practices in daily life, such as reducing energy and water consumption, minimizing waste, making sustainable transportation choices, and consuming responsibly.			
Topics	Cognitive	Social and emotional	Behavioral
Renewable energy use	Learners should be able to: exemplify the main sources of renewable energy (solar, wind, hydro, and bioenergy). demonstrate how using or not using renewable energy would help nature and humanity.	Learners should be able to: embrace the significance of using renewable energy in daily life as an effective alternative to fossil fuels. discuss about the value of renewable energy practices and actively listen to what others think. appreciate cheap, reliable and affordable energy available from renewable sources of energy. express support for renewable domestic energy supply	Learners should be able to: adjust their personal energy use so as to adopt a sustainable lifestyle. disseminate information to others about the use of renewable energy, for example by posting on social media. apply principles to choose the most appropriate renewable energy strategy in any given situation and context, including their own.
Responsible consumption	calculate or estimate the environmental impact (e.g., carbon footprint, water usage) of products and services, helping them recognize how choices affect the planet.	build the emotional resilience to resist social and media pressures to buy unnecessary items, fostering a sense of independence from consumer trends.	practice buying only what they need, choosing sustainable or secondhand options, and avoiding single-use products whenever possible.

	evaluate their motivations for consumption, distinguishing between necessary purchases and impulsive or non-essential ones, and prioritizing long-term value.	learn to make purchasing decisions that align with their personal values (e.g., sustainability, equity), building a sense of identity and ethical responsibility in consumption.	implement waste reduction techniques such as reusing items, composting organic waste, and opting for recyclable or biodegradable materials in their purchases.
Sustainable living spaces	explain and provide examples of what is a sustainable living space. list and compare the advantages of sustainably constructed living spaces for health and happiness. evaluate their own living space concerning its impacts on their physical, emotional, and social comfort.	appreciate the existing, sustainable qualities of their living spaces and the comforts these provide. reflect critically on high-carbon environments and their impact on ecology, society, and economy.	make use of sustainable living spaces for their physical, mental and social well-being. make use of sustainable designs and materials that are eco-friendly, recyclable, and biodegradable (as applicable). advocate with family and friends for energy-efficient lighting and rainwater harvesting systems.
Sustainable mobility	assess the environmental impacts of different forms of transportation used by individuals and communities. differentiate between sustainable and unsustainable vehicles and analyse their respective advantages and disadvantages. investigate the sources that are used for transportation and travel	acknowledge that alternative modes of transportation are needed for the sake of the planet and people recognize the importance of reducing carbon emissions produced by transportation.	adopt sustainable mobility (as applicable). develop a habit of choosing or asking for transportation that is more sustainable. investigate the sources that are used for transportation and travel in different parts of the

	in different parts of the world and in their own (local) context and propose sustainable solutions.		world and in their own (local) context and propose sustainable solutions.
Sustainable diets	identify and illustrate the benefits of following sustainable diets describe how individual habits of eating influence the climate and exhaust the planet's life support systems.	embrace the need of the planet for sustainable diets for ecological balance and conservation.	adjust their dietary habits to promote a sustainable lifestyle. encourage others to engage in everyday practices for eating sustainably.
Sustainable waste practices	evaluate their habits of waste generation, waste reduction and waste management and their impacts on the environment, economy and society.	embrace the positive impacts of sustainable waste practices on the environment, society and the economy	adopt sustainable waste practices in daily life promote sustainable waste practices
MODULE 3: Connect with nature			
Topics	Cognitive	Social and emotional	Behavioral
Reconnect with nature	explain how humans are a part of nature and do not exist apart from it. explain what engagement with nature refers to in terms of human health and happiness. illustrate the benefits of connecting with nature for concentration, learning, and creativity.	appreciate the health, social and economic benefits of (indoor) planting and farming. feel committed to promoting health and well-being for themselves, their family, and others through (indoor) planting and farming. express, in a group, the importance of incorporating alternatives for the	explore growing plants and vegetables at home, in the classroom or in the community. campaign for expanding natural reserves and overcoming threats to local business, industry, and livelihoods.

		natural connection of communities for whom access to nature is obstructed or nearby nature is inhospitable.	
MODULE 4 Climate change and critical thinking			
Topics	Cognitive	Social and emotional	Behavioral
Climate change denial	Learners should be able to: identify and evaluate various arguments about climate change, distinguishing between scientifically valid claims and misinformation. explain how human activities contribute to current climate change and why natural processes alone cannot account for the rapid warming observed today. assess the reliability of different sources of climate-related information by applying critical thinking principles such as checking for bias and evaluating logical consistency.	Learners should be able to: reflect on the emotional impact of misinformation and how it contributes to public confusion and delayed action on climate change. develop empathy towards communities disproportionately affected by climate change, recognizing the social and environmental injustices they face. appreciate the importance of evidence-based decision-making in shaping climate solutions and fostering collaboration across diverse communities.	Learners should be able to: advocate for integrated, cross-sectoral approaches to climate solutions, emphasizing the need to consider both ecological and social dimensions. develop and promote systemic solutions that address root causes of climate change, such as transitioning to renewable energy or creating sustainable food systems. support policy changes that incorporate systemic thinking, ensuring that actions to mitigate climate change account for economic, social, and environmental impacts.

MODULE 1. Environmental awareness and analysis

1.1. Sustainable Development Goals (SDGs)

The SDGs are 17 global objectives set by the United Nations to create a better, more sustainable world by 2030. They cover social, environmental, and economic dimensions, each relevant to promoting long-term sustainability. Below is a breakdown of each goal and its implications for environmental education.

1. No Poverty

Eradicating poverty reduces environmental degradation by providing resources for sustainable livelihoods. Incorporate community-based activities that demonstrate the links between economic stability and environmental stewardship.

2. Zero Hunger

Achieving zero hunger requires sustainable agriculture, which protects biodiversity and reduces pollution. Activities can focus on urban gardening, permaculture, and food security projects.

3. Good Health and Well-being

Promoting health involves reducing pollution, improving sanitation, and creating access to green spaces. Encourage practices that link wellness with nature, like outdoor exercises and clean-air initiatives.

4. Quality Education

Quality education empowers people with the knowledge to make sustainable choices. Incorporate eco-literacy and critical thinking about environmental impacts into the curriculum.

5. Gender Equality

Promote gender equality in environmental leadership, recognizing that diverse perspectives strengthen sustainability efforts. Create awareness activities emphasizing the role of women in conservation and eco-innovation.

6. Clean Water and Sanitation

Access to clean water and sanitation is essential for health and ecosystems. Activities can include water conservation practices, rainwater harvesting workshops, and waterway clean-up projects.

7. Affordable and Clean Energy

Transitioning to clean energy reduces greenhouse gas emissions and mitigates climate change. Practical projects can involve creating solar energy models or understanding the impact of energy conservation.

8. Decent Work and Economic Growth

Green jobs in renewable energy, agriculture, and conservation support both economies and ecosystems. Introduce career pathways in sustainable fields and teach skills for green entrepreneurship.

9. Industry, Innovation, and Infrastructure

Sustainable infrastructure and innovation foster responsible production and resource use. Activities could include designing eco-friendly buildings or exploring technology's role in sustainability.

10. Reduced Inequality

Inequality often amplifies environmental challenges for marginalized communities. Discuss environmental justice and incorporate social inclusion in projects that support sustainable development.

11. Sustainable Cities and Communities

Urban sustainability includes efficient resource management and green spaces. Engage youth in designing eco-friendly cities and consider sustainable transportation solutions.

12. Responsible Consumption and Production

Reducing waste and consumption is essential for sustainable development. Integrate lessons on recycling, composting, and mindful consumer choices.

13. Climate Action

Climate action involves reducing carbon footprints and building resilience to climate impacts. Projects could focus on local climate initiatives or the role of youth in advocacy.

14. Life Below Water

Conserving oceans and marine life is vital for biodiversity and climate stability. Activities may include coastal clean-ups, marine ecosystem education, and pollution awareness.

15. Life on Land

Land ecosystems support all terrestrial life, requiring protection from deforestation and pollution. Projects could involve reforestation, habitat preservation, or biodiversity monitoring.

16. Peace, Justice, and Strong Institutions

Environmental sustainability depends on strong governance and community cooperation. Develop activities around environmental rights, laws, and community decision-making.

17. Partnerships for the Goals

Achieving the SDGs requires collaboration across sectors. Facilitate partnerships with local environmental groups, and engage students in community-based sustainability projects.

For more information about SDGs and their history see more:

https://sdgs.un.org/goals#history

To see the implementation progress of SDGs see this report for 2024:

https://unstats.un.org/sdgs/files/report/2024/SG-SDG-Progress-Report-2024-advanced-unedited-version.pdf

1.2. Your carbon footprint

Understanding and reducing your carbon footprint

The concept of carbon footprint has emerged as a critical metric for understanding the environmental impacts of human activities at both global and individual levels. At the global level, the carbon footprint encompasses the total greenhouse gas emissions produced directly and indirectly by human activities, expressed in terms of carbon dioxide equivalents (CO2e). This measurement includes not only carbon dioxide but also other greenhouse gases such as methane and nitrous oxide, which contribute to climate change. The cumulative carbon footprint is particularly significant as it reflects the long-term impacts of emissions over a specified period, such as 2025 to 2050, and incorporates short-lived climate forcers that can have immediate but transient effects on global warming (Morfeldt et al., 2023). Global average per capita footprints range from 1 tone CO2e per year in African countries to around 30 tCO2e/y in the United States (Hoekstra & Wiedmann, 2014). Household consumption accounts for 72% of global emissions, with food (20%), housing (19%), and mobility (17%) being major contributors, while water footprint studies reveal similar patterns of resource consumption across nations.

The global carbon footprint is influenced by various factors, including industrialization, energy consumption, and agricultural practices. For instance, the transition from fossil fuel-based energy systems to renewable energy sources is essential for reducing the carbon footprint on a national and global scale. Studies have shown that the carbon footprint associated with energy production is projected to decrease significantly in the coming decades as countries adopt more sustainable practices and technologies (Ottelin et al., 2015). Furthermore, the interconnectedness of global trade means that the carbon footprint of a nation can be affected by the production and consumption patterns of other countries, highlighting the need for international cooperation in addressing climate change (Wang & Li, 2012).

On an individual level, the carbon footprint refers to the total amount of greenhouse gases emitted by a person through their daily activities, including transportation, energy use, and dietary choices. Individual carbon footprints can vary widely based on lifestyle choices, with transportation and food consumption being the largest contributors. For example, a study indicated that dietary changes, such as reducing meat consumption and minimizing food waste, can significantly lower an individual's carbon footprint (Heller & Keoleian, 2014). Household consumption accounts for 72% of global emissions, with food (20%), housing

(19%), and mobility (17%) being major contributors. While water footprint studies reveal similar patterns of resource consumption across nations, the carbon footprint of scientific activities, such as conference travel, is relatively small but still significant at the individual level. Despite arguments against individual mitigation efforts, there are compelling reasons for individuals to reduce their carbon footprint, as collective action may be most effective in addressing climate change. These findings underscore the importance of considering both national and individual responsibilities in mitigating global carbon emissions. Moreover, the proliferation of online carbon footprint calculators has enabled individuals to assess their emissions and identify areas for improvement, fostering a greater awareness of personal environmental impacts (Sukor, 2014).

Furthermore, the significance of individual carbon footprints extends beyond personal awareness; they play a crucial role in broader environmental sustainability efforts. By understanding their carbon footprints, individuals can make informed decisions that contribute to collective efforts to mitigate climate change. This is particularly relevant in the context of urban areas, where the carbon footprints of residents can be influenced by factors such as housing, transportation infrastructure, and local energy sources (Connolly et al., 2012). Efforts to promote sustainable practices at the individual level can lead to substantial reductions in overall greenhouse gas emissions, thereby supporting global climate goals.

In a nutshell, the carbon footprint serves as a vital indicator of the environmental impact of human activities, both at the global and individual levels. Understanding the complexities of carbon emissions and their sources is essential for developing effective strategies to combat climate change. As individuals become more aware of their carbon footprints and the factors that influence them, they can take actionable steps toward reducing their environmental impact, contributing to a more sustainable future.

Think of it like a footprint in the sand, but instead of sand, it's our atmosphere, and instead of a foot, it's the impact of our actions. Here are some key points about carbon footprints:

Scope: Carbon footprints can be calculated for individuals, businesses, events, products, and even entire countries.

Units: Typically measured in tonnes of carbon dioxide equivalent (CO2e). Other greenhouse gases are converted to their CO2e based on their global warming potential.

Factors: Numerous factors contribute to a carbon footprint, including energy consumption, transportation, food production, waste generation, and deforestation.

Importance: Understanding carbon footprints is crucial for identifying areas where emissions can be reduced to mitigate climate change.

There are numerous ways individuals can reduce their carbon footprint. The toolkit suggests focusing on household actions, such as using readily available technology to reduce energy consumption. This can be achieved with low or no cost and without significant lifestyle changes. Additionally, adopting sustainable habits can play a crucial role, including:

Transportation: Utilizing public transportation, cycling, or walking as eco-friendly alternatives to driving can significantly lower one's carbon footprint. These modes of transportation not only reduce emissions but also promote physical activity and improve overall health and well-being. Additionally, carpooling and ridesharing with colleagues or friends can further minimize the environmental impact of personal transportation.

Energy Consumption: Reducing energy consumption by using energy-efficient appliances and LED light bulbs can result in substantial savings and emissions reductions. This can be further enhanced by adopting

simple energy-saving habits, such as turning off lights and electronics when not in use, and properly insulating one's home to minimize heating and cooling needs.

Food Choices: Minimizing meat consumption and prioritizing locally sourced, seasonal produce can help lower the environmental impact of one's dietary choices. Opting for a plant-based or flexitarian diet, as well as supporting local farmers and reducing food waste, can significantly reduce the carbon footprint associated with food production and transportation.

Waste Management: Practicing conscious shopping habits to reduce waste and making full use of recycling systems can divert resources from landfills and incineration. This includes reducing the use of single-use plastics, composting organic waste, and properly sorting and disposing of recyclable materials to ensure they are reprocessed effectively.

Reducing carbon footprint can be classified in lower-impact and high-impact actions (Wynes & Nicholas, 2017):

High impact actions: to reduce one's carbon footprint include shifting toward a plant-based diet, avoiding air travel, and living car-free.

Lower-impact actions: such as improving home energy efficiency, adjusting household appliances, and recycling, are also important and can be more easily implemented by the general public.

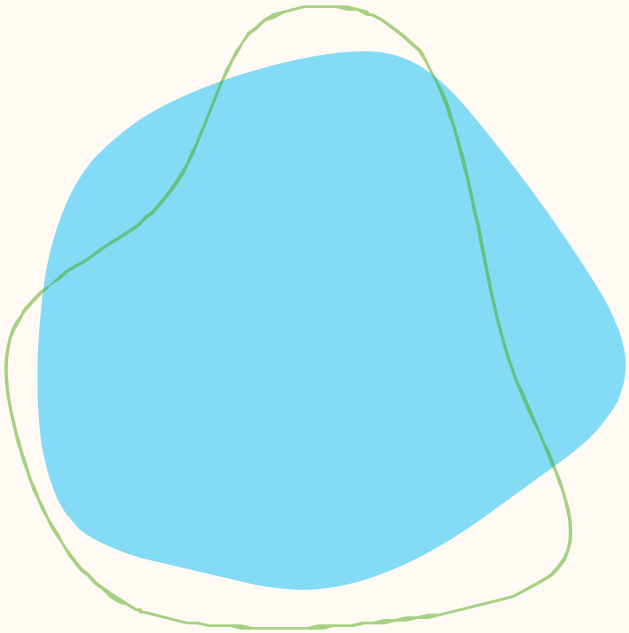
However, the toolkit emphasizes that even smaller, everyday changes can collectively contribute to significant emissions reductions. Remember, even small changes in these areas can make a meaningful difference in reducing one's carbon footprint and contributing to a more sustainable future.

Find out your carbon footprint with a carbon footprint calculator

Whether you want to take a deep dive or start with a quick check-in, online carbon footprint calculators can provide valuable insights into your environmental impact.

There are many online calculator, by we recommend The Consumer Footprint Calculator is tool designed for European Citizens that allows individuals to estimate their environmental impact based on their consumption habits.

It considers 5 areas of consumption: food choices, transportation methods, appliance usage, household goods, housing. These five aspects are The calculator then links these consumption patterns to their associated environmental impacts, providing insights into an individual's ecological footprint.



Food: This category assesses the environmental impacts associated with your dietary choices. It considers factors like:

Types of food consumed: Meat, dairy, fruits, vegetables, processed foods, etc.

Origin of food: Local vs. imported, farming practices used.

Amount of food wasted: Food waste contributes significantly to environmental problems.

Mobility: This category analyzes the environmental impact of your transportation habits. Factors considered include:

Mode of transport: Car, public transportation, cycling, walking, air travel.

Fuel efficiency of vehicles: For car usage, the calculator considers fuel type and consumption.

Distance traveled: Longer distances generally translate to a larger footprint.

Appliances: This category evaluates the environmental impact of the appliances in your home. It considers:

Types of appliances: Refrigerator, washing machine, dryer, dishwasher, television, computer, etc.

Energy efficiency of appliances: Appliances with higher energy efficiency ratings have a lower impact.

Frequency of use: How often you use each appliance influences your overall footprint.

Household goods: This category assesses the environmental impact of the various goods you purchase for your household. This includes:

Furniture: Materials used, manufacturing processes, and lifespan of furniture.

Electronics: Similar to appliances, energy consumption and lifespan are considered.

Clothing and textiles: Production processes, materials used, and disposal practices all contribute to the environmental impact.

Housing: This category considers the environmental impact of your dwelling. Factors taken into account include:

Type of housing: Apartment, detached house, etc.

Energy consumption: Heating, cooling, and electricity usage.

Water consumption: Indoor and outdoor water use.

Construction materials: The environmental impact of materials used in building the house.

By analyzing these five areas, the Consumer Footprint Calculator provides a comprehensive picture of your overall environmental impact based on your consumption habits.

The Consumer Footprint Calculator goes beyond just calculating a numerical footprint. It also connects the results to broader sustainability frameworks:

Planetary boundaries: It assesses the impact of consumption choices against the Earth's capacity to sustain them, as defined by the Planetary Boundaries framework. This helps users understand if their lifestyle is within safe operating limits for humanity.

Sustainable development goals: The calculator also links individual consumption patterns to the United Nations' Sustainable Development Goals, particularly SDG 12 on responsible consumption and production. This highlights how personal choices can contribute to or hinder global sustainability efforts.

By using carbon footprint calculators, individuals can gain a deeper understanding of their environmental impact and identify areas where they can make changes to reduce their footprint.

How does The Consumer Footprint calculator works?

Here's a breakdown of how a user would typically interact with the Consumer Footprint Calculator:

1. Access: The user would access either the web-based version (more user-friendly) or the Excel-based version (more detailed) of the calculator. **Available here: https://knowsdgs.jrc.ec.europa.eu/cfc**

2. Input information: The user would be presented with a questionnaire covering the five consumption areas: Food, Mobility, Appliances, Household Goods, and Housing. For each area, the user would input specific details about their consumption habits. For example, for "Food," they might specify how much meat they eat, their consumption of local produce, or their food waste habits.

3. Calculate footprint: Once the user has input all the relevant information, the calculator would process the data and provide an estimate of the user's overall carbon footprint, as well as breakdowns for each consumption category.

4. Interpret results: The users can then explore the environmental impacts of their own lifestyle through five results sections:

— Assessment against planetary boundaries (Figure 9)

— Results by area of consumption (Figure 10)

— Comparison with average EU citizen (Figure 11)

— Product contribution to overall impacts (Figure 12)

— Assessment against Sustainable Development Goals (Figure 14)

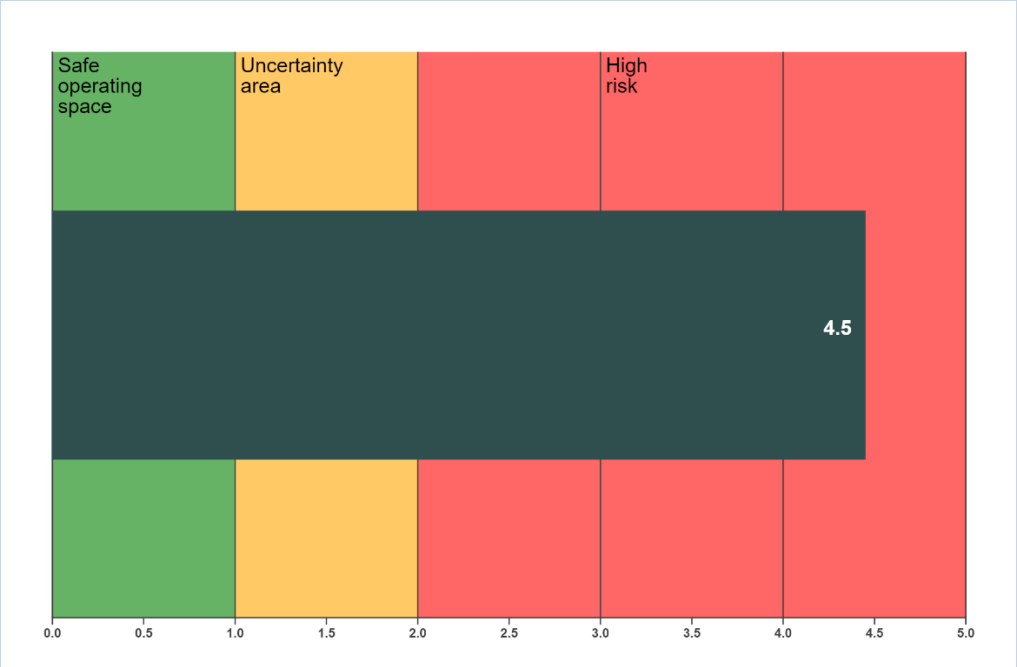
Let's take the results step by step:

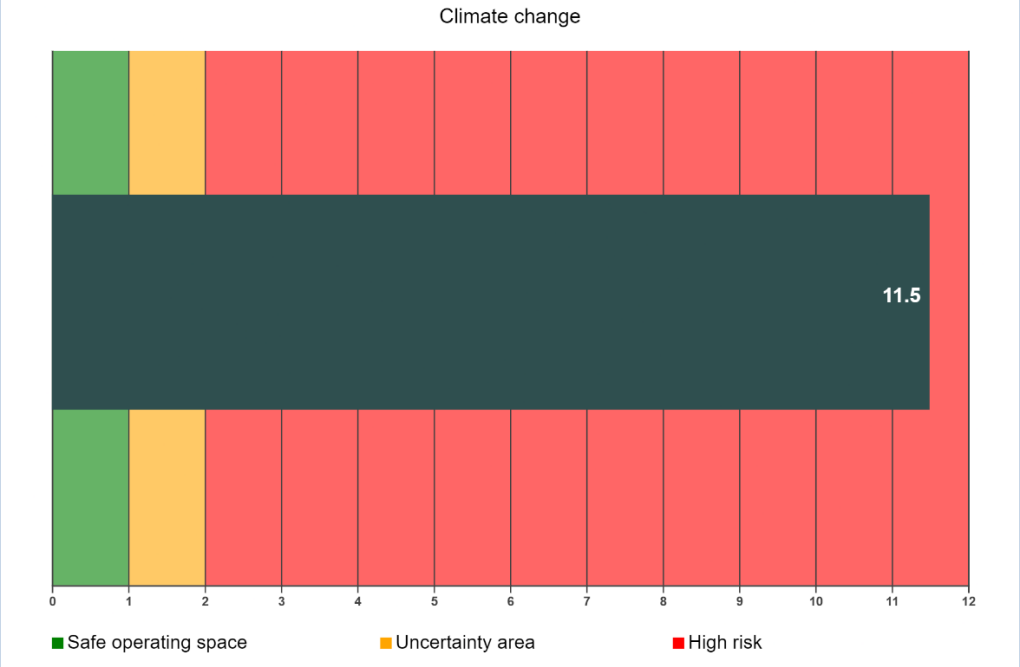
a) Assessment against planetary boundaries: It uses the idea of "planetary boundaries" to show whether our actions are safe for the Earth. This concept, created by scientists in 2009, sets limits to how much humans can use the planet's resources without causing serious harm.

Think of it like a budget: the Earth can only handle so much pollution, resource use, or habitat destruction before it starts breaking down. If we stay within the "budget," everything is fine. But if we go over, we risk damaging the planet's systems, like weather patterns, oceans, and forests, which are vital for life. The calculator breaks this "budget" into shares for each person on Earth, so you can see how your impact compares. It measures your actions and shows whether:

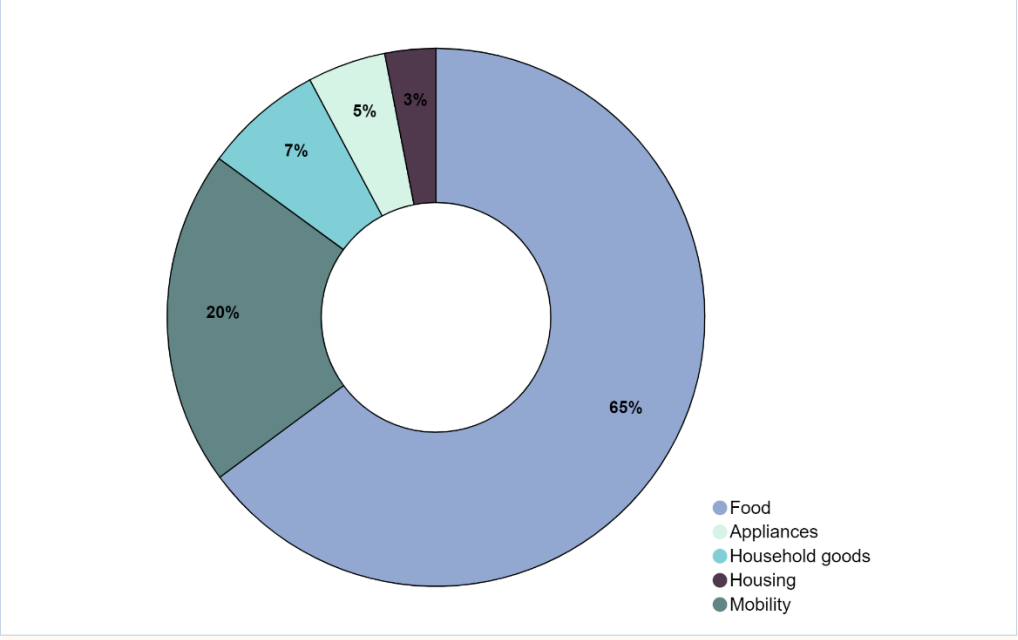
- You are within the safe zone (impact less than 1),
- You are in an uncertain area (impact between 1 and 2), or
- You are in a high-risk zone (impact greater than 2), meaning you're using more than your share and could harm the environment.

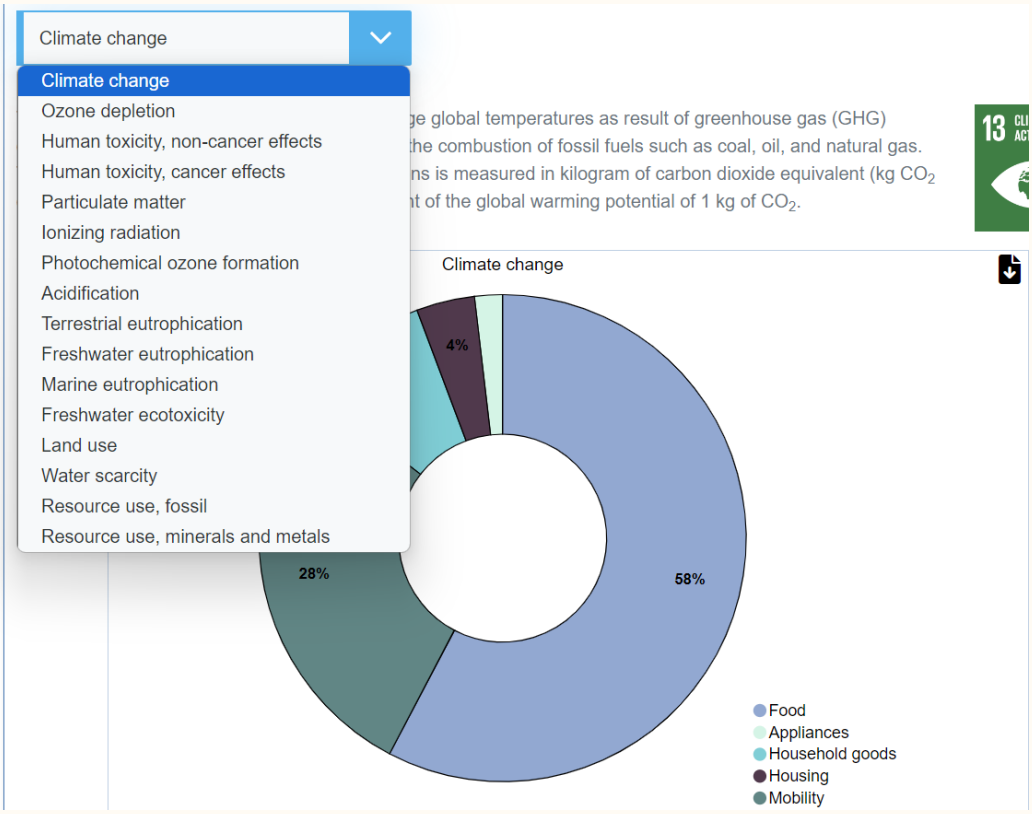
This tool helps you see where you stand, either for individual environmental issues (like carbon emissions) or as an overall score.



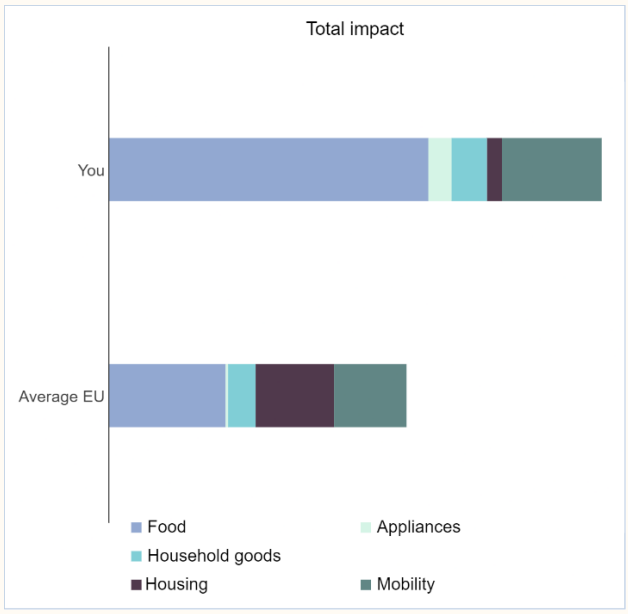


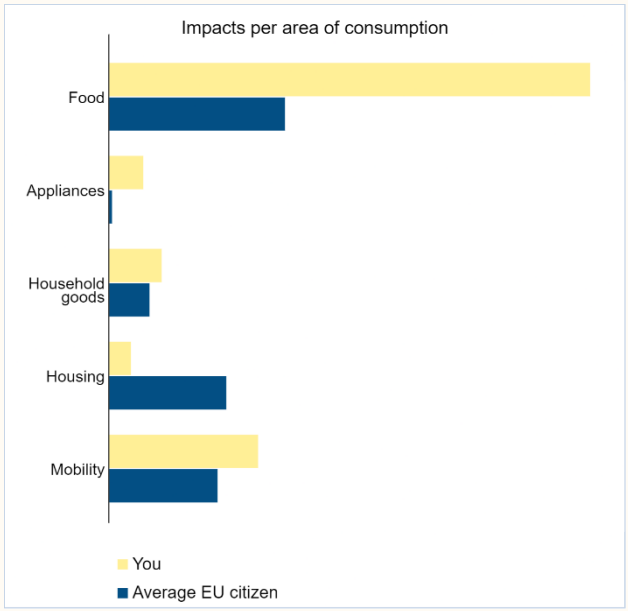
b) Results by area of consumption: This section breaks down your footprint by the five areas studied: Food, Mobility, Appliances, Household Goods, and Housing. You can see which areas contribute the most to your total impact. This allows you to identify which parts of your lifestyle have the biggest environmental costs, so you can target those for improvement.



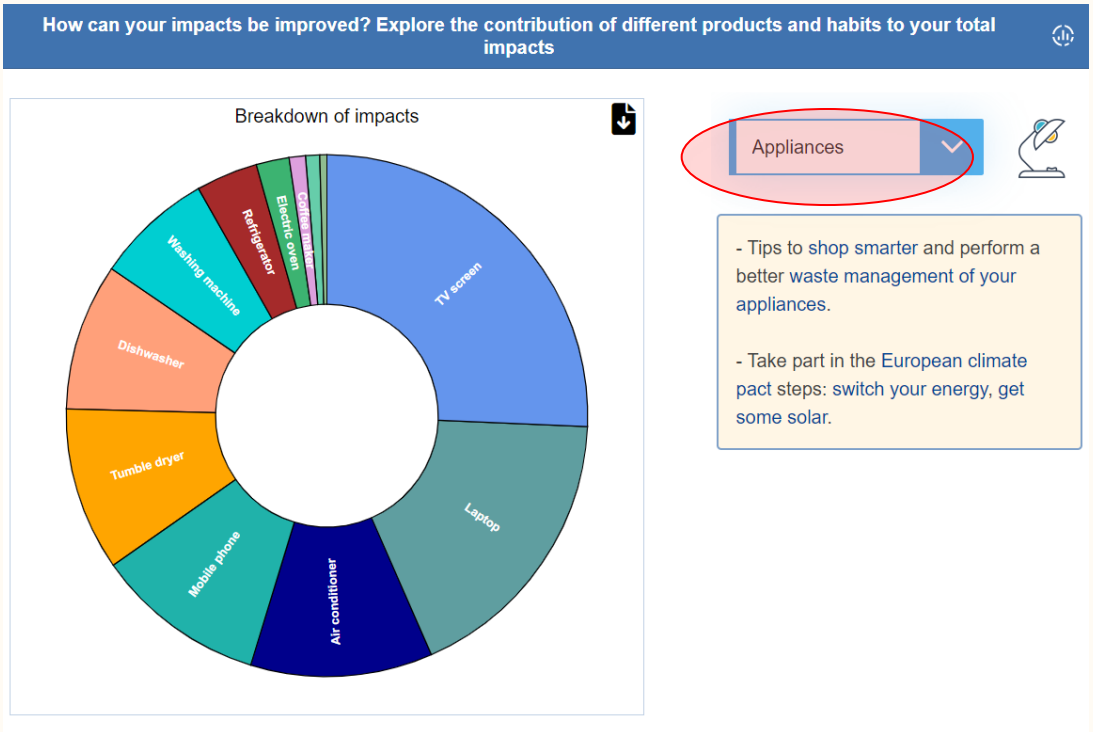


c) Comparison with average EU citizen: To put your results in context, the calculator compares your footprint to the average footprint of citizens in the European Union. This helps you see whether your environmental impact is above or below the norm. If your footprint is higher, you know you have more room for improvement compared to others.

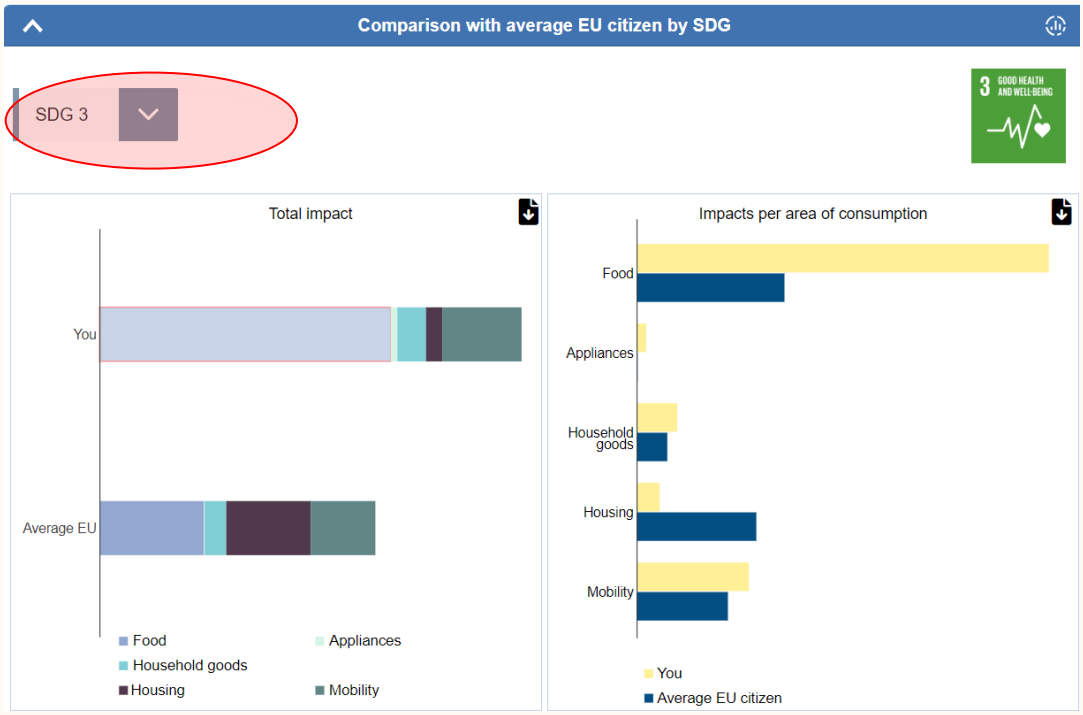


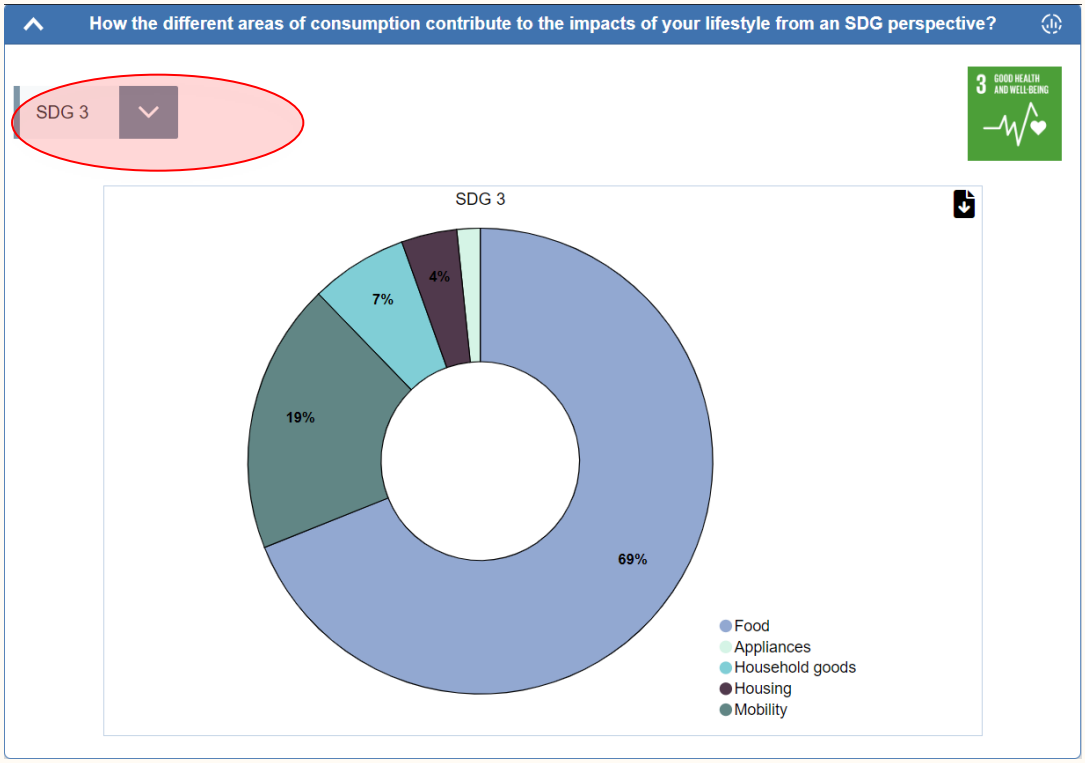


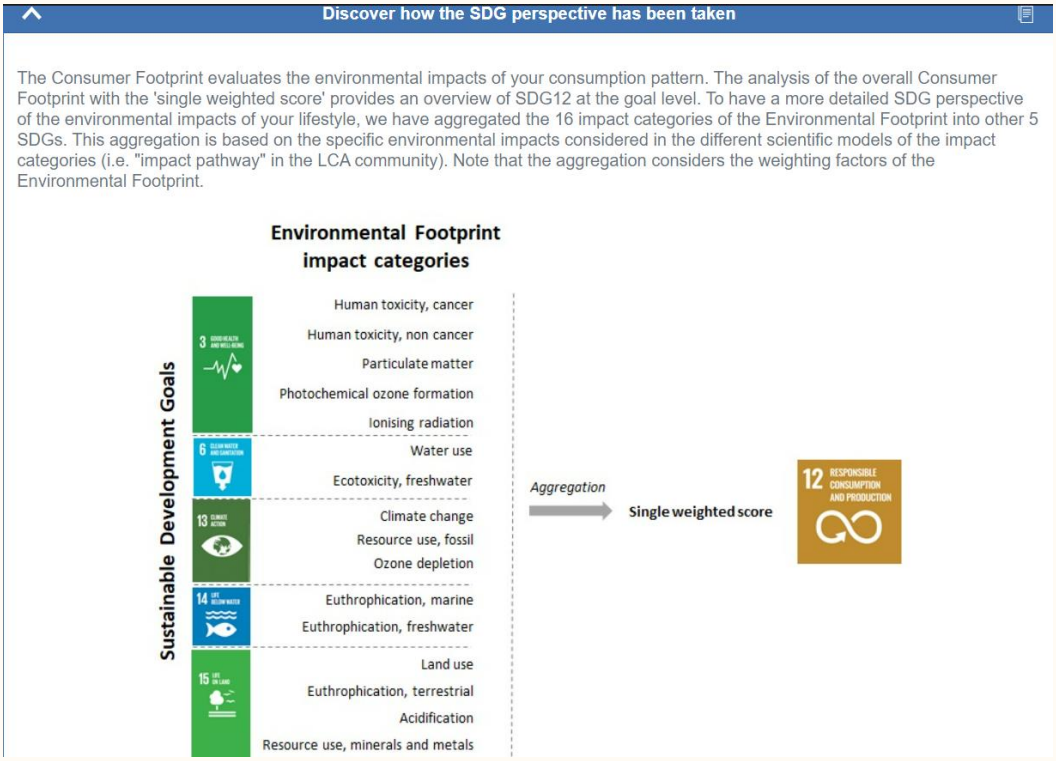
d) Product contribution to overall impacts: One of the main benefits of the Consumer Footprint Calculator is that it gives very detailed results about you consumption patterns and behavior. It lets you see how much different products you use contribute to your overall environmental impact. This helps you figure out which types of products are causing the most harm to the environment. With this information, you can make more informed choices about what to change in your lifestyle to reduce your impact. The calculator also provides links to helpful resources, like climate action tips from the EU and the United Nations, to guide you in making more sustainable choices.



e) Assessment against Sustainable Development Goals: Finally, the calculator relates your consumption patterns to the United Nations Sustainable Development Goals. This demonstrates how your personal choices connect to the global sustainability agenda. For example, if your footprint is unsustainable, the calculator can show you which SDGs are most affected, such as SDG 12 on responsible consumption and production, SDG 13 on climate action, or SDG 15 on life on land. This allows you to understand your role as an individual in contributing to or hindering the achievement of these important global goals.







For businesses and companies you can use the following carbon calculator: https://portal.skoot.eco/business-calculator

The benefit of using a carbon footprint calculator like this is that it helps individuals become more eco-literate - developing the knowledge, skills, and awareness to understand their environmental impact and take actions to reduce it. This is a crucial part of empowering people to participate in the green transition, as individual behavior change is a key driver of broader sustainability efforts. Digital carbon calculators are just one tool in a larger toolkit of green competences that can equip people to live more sustainably.

1.3. Understanding climate change

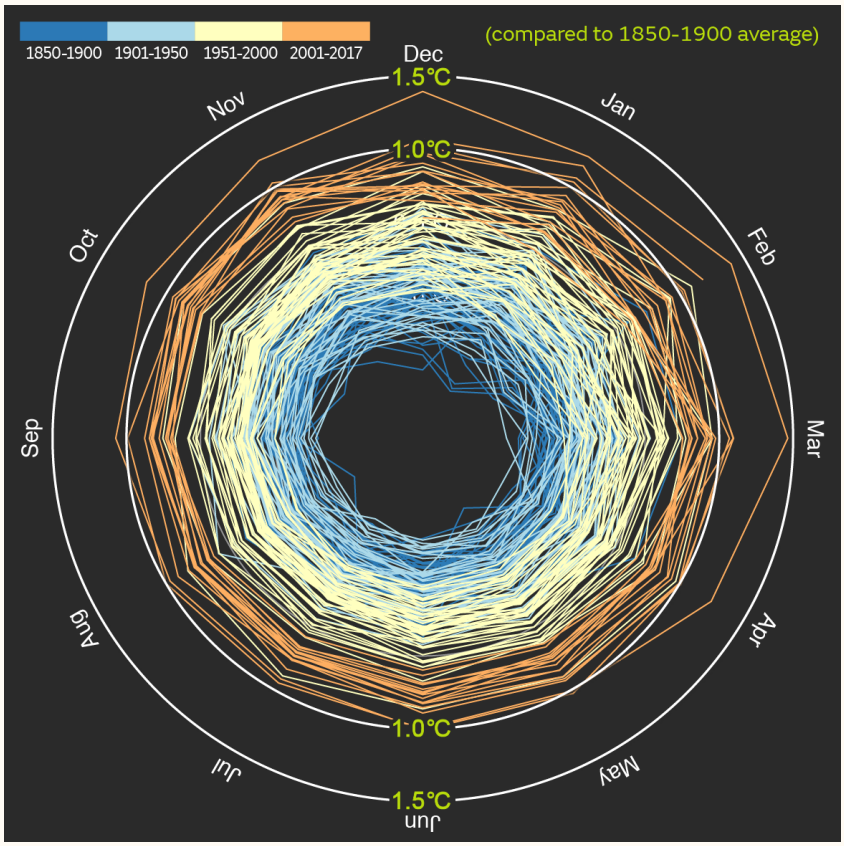
Understanding the science and causes of climate change is another core aspect of the essential green competence of environmental awareness and analysis. Learners should have a basic grasp of:

What is climate change?
Climate change describes a broad, persistent alteration in the Earth's typical weather conditions and mean temperatures over an extended period. This phenomenon is driven by the human-induced release of carbon dioxide and other greenhouse gases into the atmosphere since the mid-19th century, causing global warming and resulting in long-term transformations to the climate system. But what evidence do we have to support this claim?

Are humans to blame? Unfortunately the evidence is quite clear: anthropogenic or human generated greenhouse gas emissions are the primary cause of climate change (Awanthi & Navaratne, 2018) (Lettice et al., 2017). Climate scientists overwhelmingly agree this is the case.

For 11,000 years before the Industrial Revolution, the average global temperature remained relatively stable at around 14°C. However, this changed in the mid-1800s when the Industrial Revolution began. During this period, humans started burning fossil fuels like coal, oil, and gas to generate energy. This process releases greenhouse gases such as carbon dioxide, methane, and nitrous oxide into the atmosphere. Over

time, large quantities of these gases have accumulated, forming a "blanket" that traps heat and causes the Earth to warm.



This graph shows the average global temperature for each month, from 1850 to 2017. The temperature increases as you move away from the centre of the circle. https://www.metoffice.gov.uk/weather/climate-change/what-is-climate-change

The atmospheric concentration of carbon dioxide has risen by 40% over the course of the 20th and 21st centuries, reaching levels exceeding 400 parts per million (ppm) as of 2019, which is higher than at any point in at least 2 million years. Greenhouse gases such as carbon dioxide trap heat in the atmosphere, forming an insulating "blanket" that causes the Earth's surface to warm. This greenhouse effect was first observed in the 1980s, leading to the establishment of the Intergovernmental Panel on Climate Change in 1988 to provide policymakers with scientific information on climate change. Robust evidence has demonstrated that the elevated levels of greenhouse gases in the atmosphere, primarily from human-generated sources, are the primary driver of rising global temperatures. While natural factors such as volcanic activity and solar fluctuations may play a minor role, the IPCC has concluded that human activities are unequivocally the cause of climate change. The impacts of climate change are manifested not only in rising temperatures and carbon dioxide levels, but also in a wide range of other environmental indicators, which can be further explored on the global climate dashboard.

Available scientific indicators of climate change can be found here: https://climate.metoffice.cloud/dashboard.html

For a visual representation on how the climate system works, check out this video https://www.youtube.com/watch?v=lrPS2HiYVp8&t=1s

The role of greenhouse gas emissions

Greenhouse gasses come from both human and natural sources. Gasses like carbon dioxide, methane, and nitrous oxide naturally occur in the atmosphere. Others, such as chlorofluorocarbons (CFCs), are only produced by human activity.

When greenhouse gasses such as carbon dioxide accumulate in the atmosphere, they act like a blanket around the earth. Sunlight passes straight through this blanket and reaches the planet's surface. The earth then absorbs this sunlight and emits longer-wave infrared radiation back out to space. As the infrared radiation leaves the atmosphere, it encounters the greenhouse gas blanket. Most of it goes straight through, but some is absorbed and reflected back down to earth. This trapping of infrared radiation causes the surface to heat – a process known as the 'greenhouse effect'.

It is crucial to understand that the greenhouse effect is essential for sustaining life on earth. Without a blanket of greenhouse gasses trapping heat, the temperature would be bitterly cold, and human survival would be impossible. However, by adding extra greenhouse gasses into the atmosphere, humans have intensified the greenhouse effect. The gas blanket has become thicker and is absorbing more infrared radiation than before. In other words, the greenhouse effect is stronger and is causing the planet to heat up, instead of maintaining a stable temperature.

What are the sources of greenhouse gasses?

Fossil fuel combustion for electricity and heat generation accounts for approximately one-quarter of anthropogenic (or human generated) greenhouse gas emissions. Another quarter is attributed to agriculture, forestry, and other land use practices. Deforestation and livestock farming contribute significantly to this, as forests are effective carbon sinks, and livestock production leads to methane emissions and increased land use. Additionally, transportation, industry, and other sources such as aviation and cement manufacturing also generate substantial greenhouse gas emissions. Overall, the primary sources of human-made greenhouse gas emissions are fossil fuel use, land-use changes, and industrial processes.

Burning fossil fuels – Fossil fuels such as oil, gas, and coal contain carbon dioxide that has been 'locked away' in the ground for thousands of years. When we take these out of the land and burn them, we release the stored carbon dioxide into the air.

Deforestation – Forests remove and store carbon dioxide from the atmosphere. Cutting them down means that carbon dioxide builds up quicker since there are no trees to absorb it. Not only that, trees release the carbon they stored when we burn them.

Agriculture – Planting crops and rearing animals releases many different types of greenhouse gases into the air. For example, animals produce methane, which is 30 times more powerful than carbon dioxide as a greenhouse gas. The nitrous oxide used for fertilizers is ten times worse and is nearly 300 times more potent than carbon dioxide!

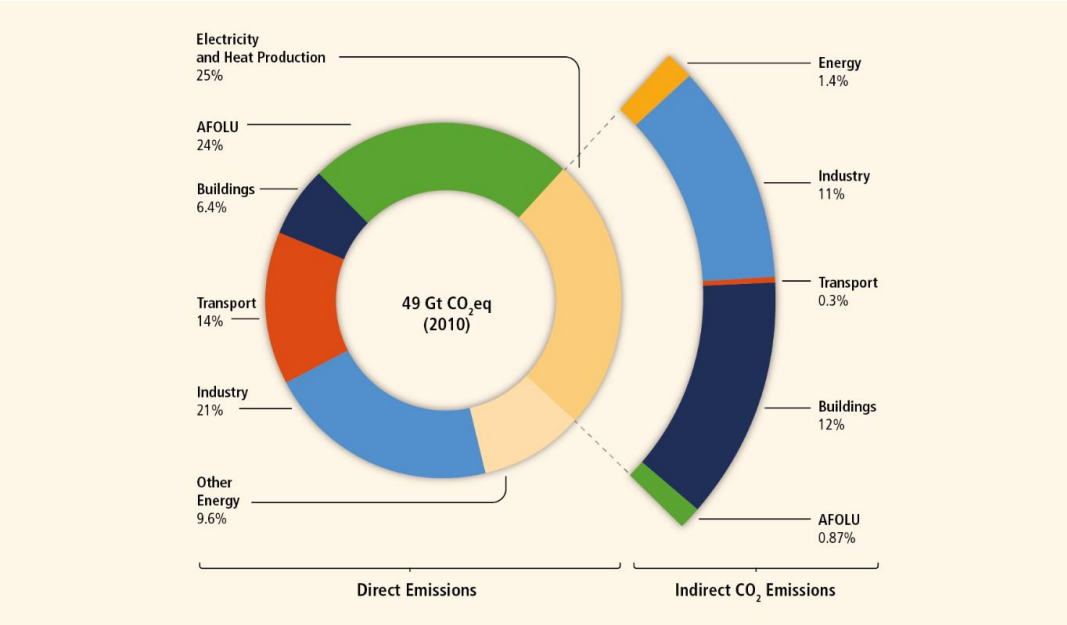
Cement – Producing cement is another contributor to climate change, causing 2% of our entire carbon dioxide emissions.

Greenhouse gasses can persist in our atmosphere for tens or hundreds of years. The gasses that are already present in our atmosphere are effectively locked in and will continue to contribute to increasing global temperatures, even if we were to stop all emissions today.

Despite halting all emissions, we cannot avoid some degree of further warming. The amount of additional warming we will experience, beyond what has already been caused, depends on the changes we make

moving forward. Our current and future actions will determine how much more the planet's temperature rises, underscoring the urgency of transitioning to a more sustainable, low-emission future.

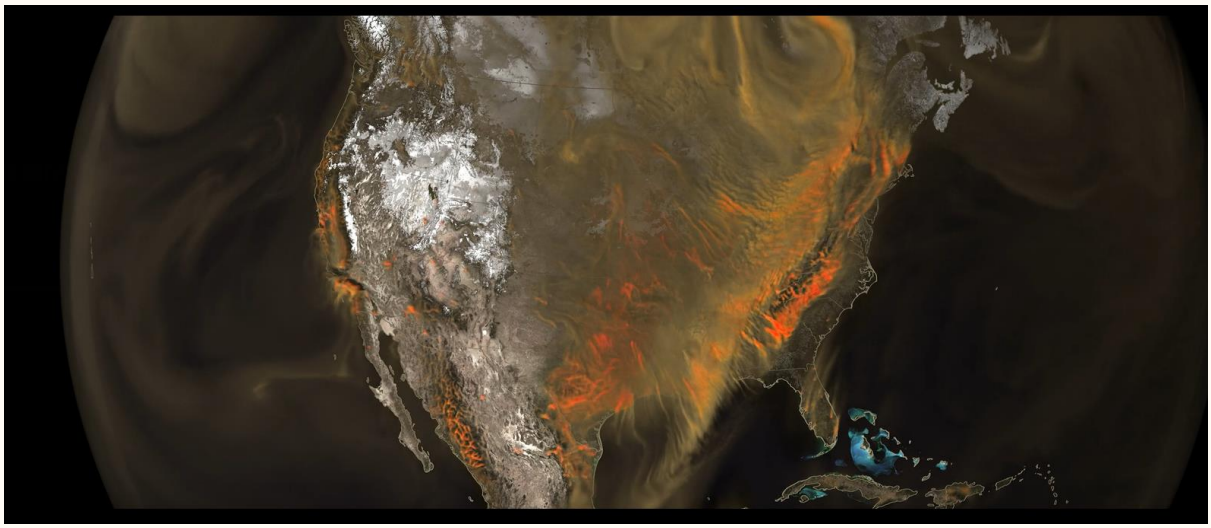
Greenhouse Gas Emissions by Economic Sectors



This chart shows the human-made greenhouse gas emissions, taken from the IPCC AR5 report. AFOLU stands for Agriculture, Forestry, and Other Land Use.

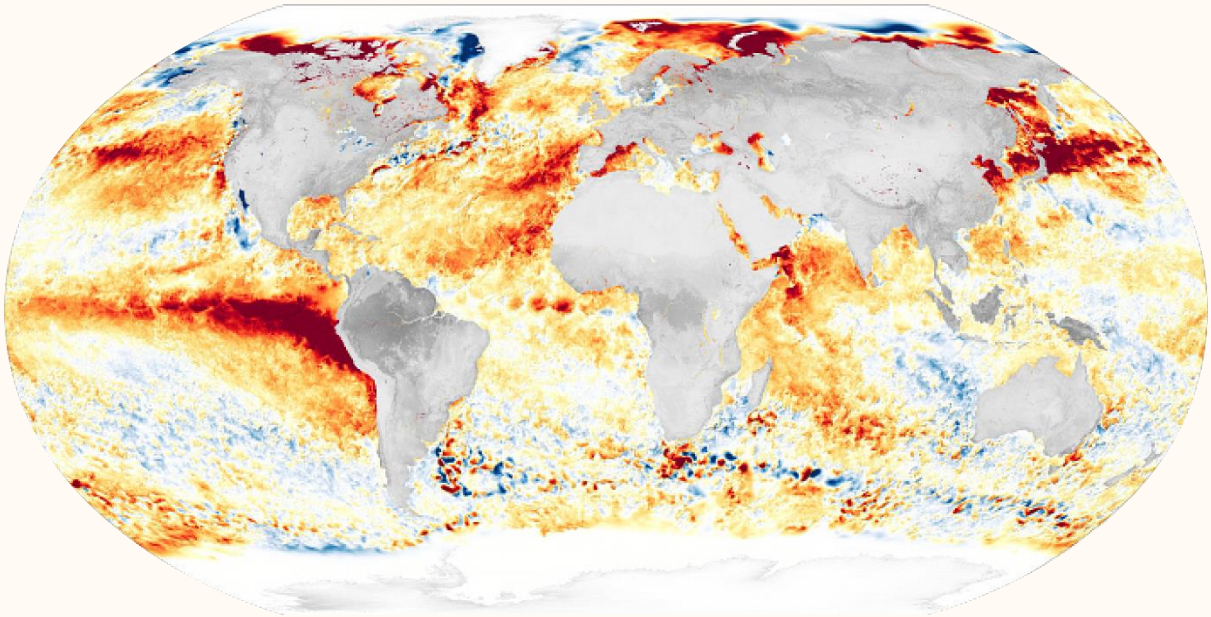
DIGITAL INSTRUMENT: Watch Carbon Dioxide Move Through Earth's Atmosphere (NASA)

https://science.nasa.gov/earth/watch-carbon-dioxide-move-through-earths-atmosphere/



Global CO2 ppm for January-March of 2020 Eastern United States

Rising greenhouse gas concentrations not only warm the air, but the ocean, too. Research shows that around 90 percent of the excess heat from global warming is being absorbed by the ocean. Ocean heat has steadily risen since measurements began in 1955, breaking records in 2023. All this added heat has led to more frequent and intense marine heat waves



Credit: NASA 2024 https://science.nasa.gov/earth/explore/the-ocean-and-climate-change/

The image visualizes sea surface temperature anomalies in August 2023. Warm colors (red, orange) show where the ocean was warmer than normal. Cool colors (blues) show where temperatures were cooler. The red swath in the Eastern Pacific was due to an El Niño event. El Niño is a climate phenomenon in the tropical Pacific that results in warmer than normal sea surface temperatures leading to weather impacts across the planet.

DIGITAL INSTRUMENT: Watch the Amazon deforestation in the last decades

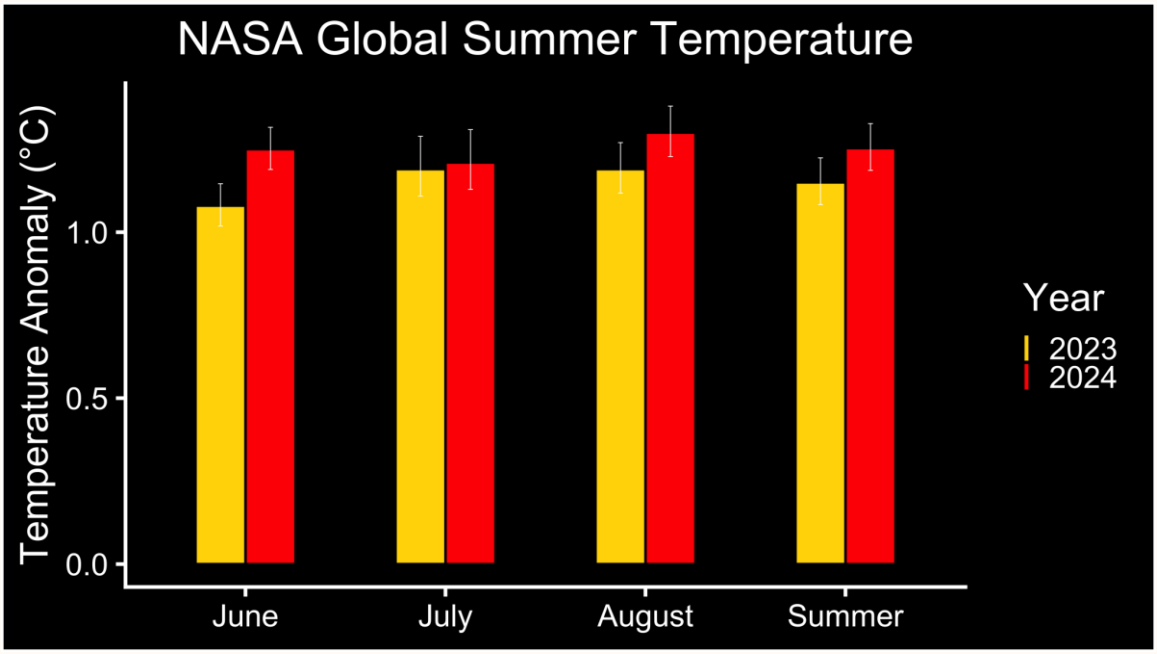
https://science.nasa.gov/resource/amazon-deforestation-video/

The impact of climate change

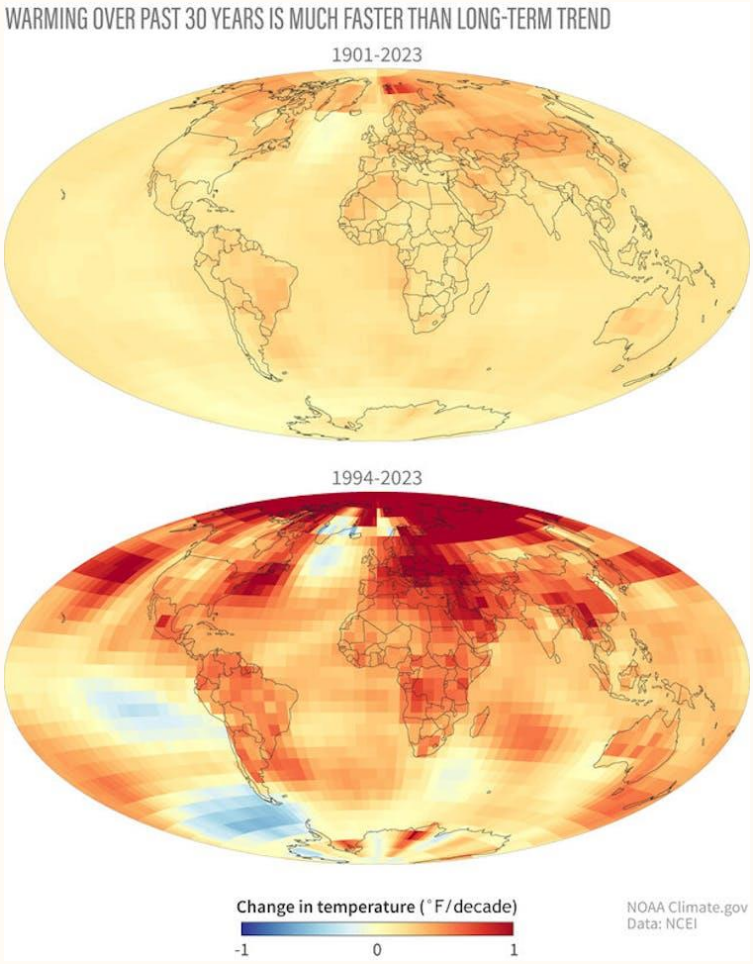
The impacts of climate change are already being observed worldwide, with rising temperatures, changing precipitation patterns, increased frequency and intensity of extreme weather events, sea level rise, and impacts on ecosystems and human health.

Some of the key impacts include:

Higher temperatures - Heat-trapping gases emitted by power plants, automobiles, deforestation and other sources are warming up the planet. In fact, the five hottest years on record have all occurred since 1997 and the 10 hottest since 1990. High temperatures are to blame for an increase in heat-related deaths and illness, rising seas, increased storm intensity, and many of the other dangerous consequences of climate change. During the 20th century, the Earth's average temperature rose one degree Fahrenheit to its highest level in the past four centuries – believed to be the fastest rise in a thousand years. Scientists project that if emissions of heat-trapping carbon emissions aren't reduced, average surface temperatures could increase by 3 to 10 degrees Fahrenheit by the end of the century. Don't be fooled by average temperatures: a one degree increase may be found in one place, a 12-degree increase in another, while at the same time other locations may become much colder. According to NASA, 2024 was the hottest year so far.



This bar graph shows GISTEMP summer global temperature anomalies for 2023 (shown in yellow) and 2024 (shown in red). June through August is considered meteorological summer in the Northern Hemisphere. The white lines indicate the range of estimated temperatures. The warmer-than-usual summers continue a long-term trend of warming, driven primarily by human-caused greenhouse gas emissions. NASA/Peter Jacobs



Sea level rise - as the Earth heats up, sea levels rise because warmer water takes up more room than colder water, a process known as thermal expansion. Melting glaciers compound the problem by dumping even more fresh water into the oceans. Rising seas threaten to inundate low-lying areas and islands, threaten dense coastal populations, erode shorelines, damage property and destroy ecosystems such as mangroves and wetlands that protect coasts against storms. Sea levels have risen between four and eight inches in the past 100 years. Current projections suggest that sea levels could continue to rise 4 - 36 inches over the next 100 years. A 36-inch increase in sea levels would swamp every city on the East Coast of the United States, from Miami to Boston. Worldwide, approximately 100 million people live within three feet of sea level. Sea level rise associated with climate change could displace tens of millions of people in low-lying areas – especially in developing countries. Inhabitants of some small island countries that rest barely above the existing sea level are already abandoning their islands and becoming some of the world's first climate change refugees.

DIGITAL INSTRUMENT: How much is 5,000 gigatonnes of ice?

https://science.nasa.gov/resource/how-much-is-5000-gigatonnes-of-ice/

This is the amount of ice lost from the polar ice caps that NASA's original GRACE mission observed from 2002 to 2017. During the 15-year lifetime of the original GRACE mission (2002-2017), 5,641 gigatonnes of ice of were lost in Greenland and Antarctica. Ninety-nine percent of the world's freshwater ice is located in these ice sheets. This is enough to cover Texas in a sheet of ice 7.92 meters high.

Ecosystem and biodiversity loss - climate change and the impacts of climate change affect ecosystems in a variety of ways. For instance, warming could force species to migrate to higher latitudes or higher elevations where temperatures are more conducive to their survival. In the same way, as sea level rises, saltwater intrusion into freshwater systems, may force some key species to relocate or die, removing predators or prey that were critical in the existing food chain. The impact of climate change on a particular species can ripple through a food web and affect a wide range of other organisms. Declines in the duration and extent of sea ice in the Arctic leads to declines in the abundance of ice algae, which thrive in nutrient-rich pockets in the ice. These algae are eaten by zooplankton, which are in turn eaten by Arctic cod, an important food source for many marine mammals, including seals. Seals are eaten by polar bears. Declines in ice algae can contribute to declines in polar bear populations. As habitats change, the availability of food, water and shelter will change, forcing species to either adapt or migrate. The rapid nature of climate change is likely

to exceed the ability of many species to migrate or adjust. Experts predict that one-fourth of Earth's species will be headed for extinction by 2050 if the warming trend continues at its current rate.

Agriculture - The toll that climate change will take on agriculture is nearly incalculable. As a result, our food security will be at risk. All over the world, farmers are already struggling to keep up with shifting weather and increasingly unpredictable water supplies. Farmers also must contend with unexpected attacks from weeds, diseases and pests, which all affect crop yield. Overall, climate change could impact agriculture in many ways. Some of these effects are biophysical, some are ecological, and some are economic, including:

- A shift in climate and agricultural zones towards the poles;
- Changes in production patterns due to higher temperatures;
- A boost in agricultural productivity due to increased carbon dioxide in the atmosphere;
- Changing precipitation patterns;
- Increased vulnerability of the landless and the poor.

Water resources - There are four main factors worsening water scarcity according to the Intergovernmental Panel on Climate Change (IPCC):

- Population growth - In the last century, world population has tripled. It is expected to rise from the present 6.5 billion to 8.9 billion by 2050. Water use has been growing at more than twice the rate of population increase in the last century, and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water.
- Increased urbanization will focus on the demand for water among a more concentrated population. Asian cities alone are expected to grow by 1 billion people in the next 20 years.
- High level of consumption- As the world becomes more developed, the amount of domestic water used by each person is expected to rise significantly.
- Resources of freshwater will disappear as climate change increases.

Extreme weather events - Scientific research indicates that climate change will cause hurricanes and tropical storms to become more intense — lasting longer, unleashing stronger winds, and causing more damage to coastal ecosystems and communities. Scientists point to higher ocean temperatures as the main culprit, since hurricanes and tropical storms get their energy from warm water. As sea surface temperatures rise, developing storms will contain more energy. At the same time, other factors such as rising sea levels, disappearing wetlands, and increased coastal development threaten to intensify the damage caused by hurricanes and tropical storms.

Droughts and forest fires - Climate change is intensifying the circulation of water on and above the surface of the Earth — likely causing drought and floods to be more frequent, severe and widespread. Higher temperatures increase the amount of moisture that evaporates from land and water, leading to drought in many areas. Lands affected by drought are more vulnerable to flooding once rain return. As temperatures rise globally, droughts will become more frequent and more severe, with potentially devastating consequences for agriculture, water supply and human health. This phenomenon has already been observed in some parts of Asia and Africa, where droughts have become longer and more intense. Hot temperatures and dry conditions also increase the likelihood of forest fires. In the conifer forests of the western United States, earlier snowmelts, longer summers and an increase in spring and summer temperatures have

increased fire frequency by 400 percent and have increased the amount of land burned by 650 percent since 1970.

Human health: The impacts of climate change on health will depend on many factors, including the effectiveness of a community's public health and safety systems to address or prepare for the risk and the behavior, age, gender, and economic status of individuals affected. Impacts will likely vary by region, the sensitivity of populations, the extent and length of exposure to climate change impacts, and society's ability to adapt to:

More heat related illnesses and deaths: Abrupt change of temperatures leading to heat waves or cold spells are becoming widespread, causing indirectly fatal illnesses, such as heat stress or hypothermia, as well as increasing death rates from heart and respiratory diseases. Statistics on mortality and hospital admissions show that death rates increase during extremely hot days, particularly among very old and very young people living in cities. Excessive heat is more likely to impact populations in northern latitudes where people are less prepared to cope with excessive temperatures. Young children, older adults, people with medical conditions, and the poor are more vulnerable. The 2003 European heat wave — involving temperatures that were 18°F (10°C) above the 30-year average, with no relief at night — killed 21,000 to 35,000 people in five countries. 2,300 people who died in the United States last summer in 2023 mention the effects of excessive heat, the highest number in 45 years of records, according to an Associated Press analysis of Centers for Disease Control and Prevention data.

DIGITAL INSTRUMENT: Climate Time Machine: Climate change in recent history.

This series of visualizations shows how some of Earth's key climate indicators are changing over time: Sea Ice, Sea level, Carbon Dioxide, Global Temperature, Ice Sheets, Ocean Warming.

https://climate.nasa.gov/interactives/climate-time-machine/?intent=021

MODULE 2. Sustainable lifestyle choices

2.1. Renewable energy use

Renewable energy use refers to utilizing the energy derived from natural sources that could be replenished at a higher rate than they are consumed and that does not put the source in danger of depletion or disappearance. Renewable energy includes solar, wind, hydro, geothermal, ocean and bioenergy, and these are effective alternatives to fossil fuels. Considering its reliability, stability and affordability, renewable energy has its own merits and harms to nature, humanity and economy.

What is net zero carbon emissions? Net zero means balancing the amount of greenhouse gases we release with the amount we remove from the air. This can be done by cutting emissions through using renewable energy, being more energy-efficient, and changing our consumption habits. It also involves using things like carbon capture, planting trees, and direct air capture to actively remove greenhouse gases. The goal is to get to a point where we're emitting no more greenhouse gases than we're taking out of the atmosphere, resulting in a neutral or even negative carbon footprint.

Renewable energy like solar, wind, and hydropower is key to making our energy systems more eco-friendly and sustainable. These clean energy sources have seen a big boost in recent years, thanks to government support and big drops in the costs of solar panels and wind turbines.

Increasing the use of renewable energy sources like solar, wind, and hydropower in electricity, heating, and transportation is crucial for limiting global temperature rise to 1.5°C. In a scenario where we achieve net zero emissions by 2050, renewable energy helps almost completely eliminate carbon emissions from electricity production. At the same time, renewable fuels for transport and renewable heating options lead to major emissions cuts in transportation, buildings, and industry.

The electricity sector is the shining star for renewables, with big growth in solar and wind power in recent years, building on the already important role of hydropower. But electricity is only about 20% of global energy use, so we really need to find more ways to use renewable energy for transportation and heating too to make the energy transition work. IEA (2021), Net Zero by 2050, IEA, Paris https://www.iea.org/reports/net-zero-by-2050.

Why is solar PV important?

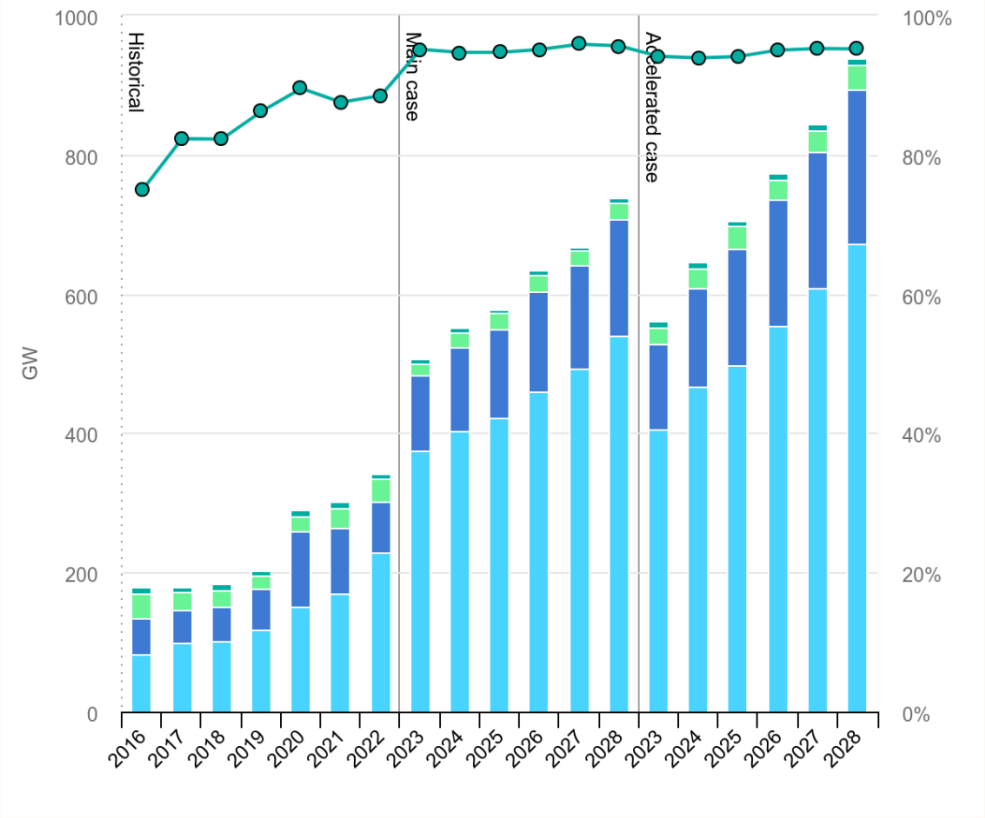
Solar photovoltaics (PV) is a very modular technology that can be manufactured in large plants, which creates economies of scale, but can also be deployed in very small quantities at a time. This allows for a wide range of applications, from small residential roof-top systems up to utility-scale power generation installations.

> PV cells harness the photovoltaic effect to convert light into electrical energy. Multiple PV cells are combined in PV panels that are manufactured as PV modules for sale and installation. Installation can include a device called a tracker to tilt the PV module and increase the solar incidence during the course of the day. Most solar energy is generated using PV. As of 2023, crystalline polysilicon is the dominant technology for PV modules, with more than 95% market share. Within this category, a shift to more efficient monocrystalline wafers accelerated in the early 2020s, with the technology capturing almost all crystalline PV production. As of 2023, commercial monocrystalline PV has an efficiency of around 15-23%.

Solar PV has seen dramatic cost reductions in the past decade and is now the cheapest source of new electricity generation in many parts of the world. This makes it very attractive particularly for rural electrification and developing countries.

Solar PV also has the advantage of being a very scalable and distributed technology. This means that small rooftop systems can meet a household's electricity needs, or solar farms can feed into a national grid. The exceptional growth in PV deployment in recent years will need to continue and scale up to follow the Net Zero Emissions by 2050 Scenario, requiring continued policy ambition.

Solar power had a record-breaking year in 2022, with generation rising by 270 terawatt-hours to nearly 1,300 terawatt-hours. This was the biggest growth of any renewable energy source, even surpassing wind power for the first time. This growth rate lines up with what's needed to reach net-zero emissions by 2050. And with solar power becoming more economically attractive, and major support from countries like China, the US, Europe, and India, the outlook for continued solar expansion in the coming years is bright. In fact, the progress on solar has been so impressive that its status has been upgraded from "needs more effort" to "on track" in 2023 (*IEA (2024), Renewable electricity capacity additions by technology and segment, 2016-2028, IEA, Paris* https://www.iea.org/data-and-statistics/charts/renewable-electricity-capacity-additions-by-technology-and-segment-2016-2028.



To keep solar growing at a pace that aligns with net-zero goals, we'll need annual capacity additions to be nearly three times higher than 2022 levels by 2030. Achieving that will take sustained policy support and efforts from both the public and private sectors, especially when it comes to integrating solar into the grid and addressing policy, regulatory, and financing challenges *(IEA (2023), Tracking Clean Energy Progress 2023, IEA, Paris https://www.iea.org/reports/tracking-clean-energy-progress-2023.*

The European Union is accelerating solar PV deployment in response to the energy crisis, with 38 GW added in 2022, a 50% increase compared to 2021. New policies and targets proposed in the *REPowerEU Plan* and The Green Deal Industrial Plan are expected to be important drivers of solar PV investment in the coming years.

Why is hydroelectricity important?

Hydropower is currently the biggest renewable energy source, generating more electricity than all the other renewable technologies put together. It's expected to stay the top renewable electricity producer through the 2030s. After that, it'll keep playing a crucial part in cleaning up the power system and making it more flexible.

Hydropower: An energy source that converts the potential and kinetic energy of water into electricity. In energy statistics, the electricity output is taken as a primary energy source. Includes large hydropower, small hydropower and micro hydropower (including run-of-river), but excludes ocean energy. In energy statistics, hydropower does not include pumped-storage hydropower.

Even as hydropower gets surpassed by wind and solar in the future, it'll still be crucial as a reliable, on-demand power source to support the variability of renewable energy. Pumped storage systems could also be a big player in smoothing out the ups and downs of solar and wind power generation.

Despite the lack of major policy changes, hydropower is expected to grow at a slower pace globally in the coming decade. This deceleration is largely due to decreased hydropower project development in China, Latin America, and Europe. That said, increased hydropower expansion in the Asia-Pacific, Africa, and the Middle East helps offset some of these slowdowns. Climate change-fueled erratic rainfall patterns are also disrupting hydroelectric power generation in various regions around the world.

Hydropower had a solid year in 2022, with generation rising by nearly 70 terawatt-hours to reach around 4,300 terawatt-hours. It's still the biggest renewable electricity source, outpacing all the other renewables combined. This increase came from boosting capacity in 2021-2022, but the utilization rate stayed below past levels due to persistent droughts in major hydropower countries like Canada, China, Turkey, and the US, as well as in western Europe. Looking ahead, the Net Zero by 2050 plan expects hydropower to keep chugging along at close to a 4% annual growth rate through 2030, providing around 5,500 terawatt-hours per year. But the recent growth rate has been less than a third of what's needed, so we'll have to ramp up efforts - like streamlining permits and making sure projects are sustainable. Hydropower plants are a reliable backbone for future clean energy systems, so we should give them the support they deserve *[IEA (2023), Tracking Clean Energy Progress 2023, IEA, Paris https://www.iea.org/reports/tracking-clean-energy-progress-2023, Licence: CC BY 4.0]*.

While hydropower is still the top renewable electricity source, its current growth rate isn't enough to meet the goals of the Net Zero Emissions scenario. To reach around 5,500 terawatt-hours of annual hydropower generation by 2030, we'd need almost 4% annual growth - a tough target given the challenges of climate change disrupting water availability and an aging hydropower infrastructure. On the capacity side, we'd need to add nearly 50 GW of new hydropower plants per year through 2030, which is about double the recent average. Significantly greater global effort, especially in developing and emerging markets, will be necessary to achieve this level of hydropower expansion.

Why is wind power important?

Onshore wind power has become a well-established and widely-used technology around the world. Over the past few years, onshore wind turbines have gotten bigger and more efficient, allowing them to generate more electricity even in areas with lower wind speeds. And offshore wind is expected to really take off in the coming years as wind farms out at sea can harness the stronger winds found over the open water.

Wind power is already producing around 6% of the world's electricity, and it's the fastest-growing renewable electricity source. Since 2010, wind power capacity has more than doubled, reaching nearly 850 GW globally in 2022. The leading countries for wind power today are China, the United States, Germany, India, and Spain.

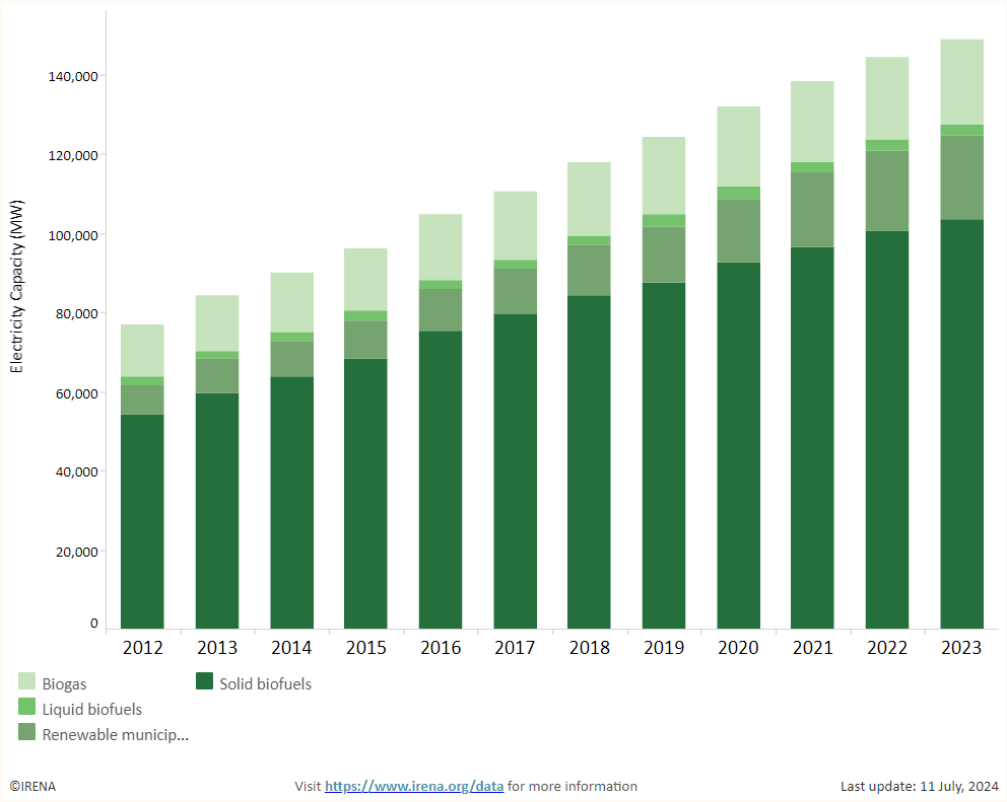
Looking to the future, wind power is poised for a rapid expansion as countries and companies strive to reach net-zero emissions goals. Onshore wind is projected to nearly double by 2030, while offshore wind capacity could increase 15-fold. Achieving these ambitious goals for wind power growth will require overcoming various challenges, including grid integration, social acceptance, and supply chain constraints. Overall, wind is a crucial technology for decarbonizing the power sector and realizing a sustainable energy future (*IEA (2023), Tracking Clean Energy Progress 2023, IEA, Paris https://www.iea.org/reports/tracking-clean-energy-progress-2023, Licence: CC BY 4.0).*

The European Union is accelerating wind deployment in response to the energy crisis, with 13 GW added in 2022. New policies and targets proposed in the *REPowerEU Plan* and *The Green Deal Industrial Plan* are expected to be important drivers of wind power investment.

Why is bioenergy important?

Bioenergy is generated from organic matter, referred to as biomass, which absorbs carbon through the photosynthetic process of plants. When this biomass is utilized for energy production, the stored carbon is released back into the atmosphere during combustion. However, as additional biomass is generated, an equivalent amount of carbon is reabsorbed, rendering modern bioenergy as a near-zero-emission fuel source. Bioenergy is currently the largest contributor to renewable energy globally, accounting for 55% of renewable energy and over 6% of the overall global energy supply (*IEA (2024), Renewable Energy Progress Tracker, IEA, Paris https://www.iea.org/data-and-statistics/data-tools/renewable-energy-progress-tracker).*

> Bioenergy use falls into two main categories: "traditional" and "modern". Traditional use refers to the combustion of biomass in such forms as wood, animal waste and traditional charcoal. Modern bioenergy technologies include liquid biofuels produced from bagasse and other plants; bio-refineries; biogas produced through anaerobic digestion of residues; wood pellet heating systems; and other technologies. *https://www.irena.org/Energy-Transition/Technology/Bioenergy-and-biofuels*



Bioenergy is a crucial renewable energy source, contributing significantly more to overall energy demand than wind and solar combined, even excluding traditional biomass use. While heating is the biggest use of bioenergy, it can play a vital role in decarbonizing hard-to-electrify industries like aviation and shipping, even as space heating becomes more electrified.

Bioenergy is a crucial part of cutting emissions during the energy transition, since it's a low-emission fuel that can be used in all sorts of contexts - from powering and heating homes and businesses with solid bioenergy and biogases, to fueling cars, ships, and planes with liquid biofuels. Plus, it can often tap into existing infrastructure like natural gas pipelines and oil distribution networks, making it a flexible and convenient option.

Brazil is the leader in liquid biofuels and has the largest fleet of flexible-fuel vehicles, which can run on bioethanol – an alcohol mostly made by the fermentation of carbohydrates in sugar or starch crops, such as corn, sugarcane or sweet sorghum. In March 2023 the **European Union** reached a provisional agreement between the Council and Parliament on the update to the Renewable Energy Directive (RED III). The agreement includes strengthening sustainability criteria around the use of biomass for energy by applying the "cascading" principle while incorporating national priorities. The European Union also set a target in 2022 to achieve 35 bcm annual production of biomethane by 2030 (compared to 3.5 bcm today) and launched the Biomethane Industrial Partnership in September 2022 to help support this goal.

Why are behavioral changes important?
But technology alone won't cut it - we can't reach net zero emissions by 2050 without people on board and taking action. This includes one-time moves like buying an electric car or insulating a house, which aren't counted as behavior changes but still involve low-carbon tech and people's involvement. But we also need ongoing adjustments to our daily lives to cut down on wasteful or excessive energy use. This is especially important in wealthier parts of the world where energy-hungry lifestyles are common. Behavior changes like cycling or walking instead of driving, turning down the heat, and taking local vacations can make a difference. Plus, if manufacturers use materials more efficiently and encourage recycling, that can reduce industrial energy use too.

People have shown they can and do change their behaviors, from what they eat to their smoking habits to how they use plastics. We've even seen rapid, widespread changes in people's behaviors during the COVID-19 pandemic. So it's unrealistic to assume people's lifestyles and consumption patterns won't shift as we work towards net zero emissions by 2050. The potential for individuals to make sustainable choices and drive changes to our energy system shouldn't be overlooked.

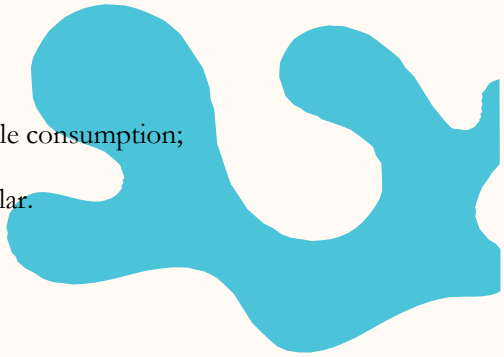
2.2. Responsible consumption

Our planet has provided us with an abundance of natural resources.But we have not utilized them responsibly and currently consume far beyond what our planet can provide. We must learn how to use and produce in sustainable ways that will reverse the harm that we have inflicted on the planet.

Responsible consumption is a way of consumption that takes into account the foundations of sustainable development. That is to say, this is a way of consuming that is beneficial considering 3 different cornerstones, by no specific order. First, it benefits the economy, especially the local economy, as it allows goods and services to be traded, benefiting the agents involved in these trades. Secondly, it has a positive impact on society, as the products or services purchased are linked to a workforce that has fair wages and working conditions and they're also positively good for the buyers (in matters such as health). Finally, a responsible consumer also acknowledges the impacts associated with products' different stages (from its production, transportation, and disposal) and tries to buy the ones with a lower impact.

Sometimes we also use the term "sustainable consumption" when we talk about responsible consumption. However, the definition of responsible consumption is wider than the definition of sustainable consumption. Sustainable consumption applies more specifically to the concept of sustainability, that is to say, the environmental dimension of purchasing goods and services. The Ministry of Sustainable Development defines sustainable consumption in three dimensions:

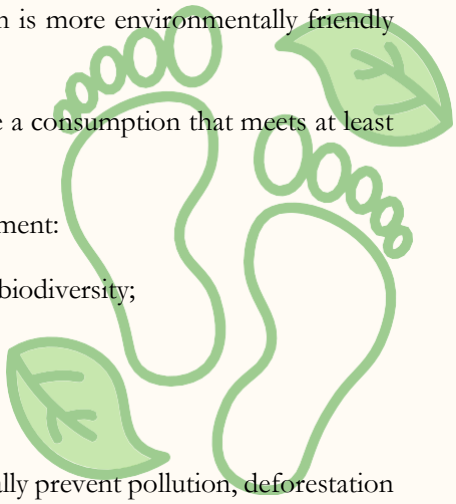
- Buying better – buying greener products;
- Consuming better – wasting less and having a more sustainable consumption;
- Throwing away better – take into account recycling in particular.



By its turn, responsible consumption has a larger meaning. It implies the concept of consumer responsibility which can affect many areas from the ecological impact of consumption to its social, economic and health impact. To better distinguish both:

- Sustainable consumption means to consume in a way that allows us to preserve our resources and the environment as much as possible.

Responsible consumption means instead to have a consumption which is more environmentally friendly but also considers the social and economic impacts of consumption.



If a definition of responsible consumption was to be given, it would be a consumption that meets at least one or more of the following criteria:

Consumption of green products that have a low impact on the environment:

- Products from certified sectors respecting the environment or biodiversity;
- Commodities with a low carbon footprint;
- Organic products;
- Goods that preserve the quality of soil, water and air and generally prevent pollution, deforestation and the depletion of natural resources.

Consumption of products according to their respect for social norms and their impact on societies:

- Goods made in good working conditions, without forced child labor and that respect working hours and international conventions;
- Products manufactured in compliance with ethical standards (especially corruption);
- Goods made in cooperation with local communities, respecting their lifestyles and business profit (such as fair trade).

Consumption of "healthier" products, respecting health standards:

- Products without phthalates, bisphenol, and other toxic and dangerous products;
- Commodities without pesticides or other chemical inputs;
- Goods manufactured in accordance with hygiene standards;
- Food products with healthy nutritional composition.

Consumption of products with a positive economic impact:

- Locally made products;
- Productions that encourage the economic autonomy of their producers (as opposed to reliance on commercial or industrial systems such as supermarkets);
- Goods that create more jobs as well as economic and social integration for workers;
- Products that promote employees' work-life quality.

The consumption of products manufactured under conditions respecting certain ethical or moral principles:

- Respect for animal welfare;
- Respect for fairness and individual freedoms;

Any other principle contributing to the development of the general interest.

Tips for sustainable consumption

Buy less

- Every product, even a glas of water, includes an invisible "ecological bag", made with nature, energy and work consumption

Buy light

- Choose products with a small package!

Buy smart

- Durable goods are too often changed and replaced before time. We could for example, change our car after 15 years instead of 7!

Buy easy

- Avoid product working with batteries and electricity if it is not necessary. Simplicity and soberness are a sign of beauty!

Buy close

- Buying local products reduces environmental damages due to transportation and make econoy stronger.

Buy healthy

- Buy fresh and local products, produced by biological methods, with no preservatives or colorants.

Buy fair

- Buy product coming from solidal markets and equitable marketing associations. To us, it means paying
- a little more, to the small producers it means to double their income.

Buy carefully

- Avoid sinthetic products or materials produced by big industrial enterprises. Too often, the legislation is created according to economic lobbies, hiding environmental and healthy problems.

Buy honestly

- Avoid products that are too much advertised. Remember that you pay for advertising as well.

What are the obstacles against responsible consumption?

One of the main obstacles against responsible consumption is the mindset of consumers that has been shaped by many years of capitalism and consumerism (Reisch et al., 2013).

Many people still associate success and social status with the accumulation of goods and the exposure of a luxurious lifestyle. The rise of a throwaway culture and planned obsolescence has also created an expectation of cheap, easily replaceable products that do not last. A shift in this mindset is crucial for transitioning to more responsible consumption patterns. It is no wonder then that one barrier against responsible consumption has to do with value systems or cultural norms.

Other studies found that there is a gap between consumers' stated intentions to buy sustainable products and their actual purchasing behavior. This "attitude-behavior gap" has been attributed to factors like price, quality, availability, and convenience of sustainable products compared to conventional alternatives. Lubowiecki-Vikuk et al. (2021) highlights a discrepancy between a consumer's environmental awareness and their actual purchasing decisions. While many individuals express concern for the environment, this doesn't always translate into buying eco-friendly products. This is referred to as the "green purchasing inconsistency" or the "green attitude-behaviour gap". Essentially, the study suggests that there's a disconnect between what consumers say they care about and how they act when making purchasing decisions. This could be due to various factors, such as:

Price sensitivity: Sustainable products are often perceived as more expensive, potentially deterring some consumers.

Lack of information: Consumers may not have access to clear and reliable information about the environmental impact of different products, often have difficulty understanding complex product certifications and labels, making it hard to differentiate between truly sustainable products and greenwashing.

Habit and convenience: Existing habits and the convenience of conventional products can outweigh environmental concerns during purchasing decisions. We often buy things on autopilot, sticking to familiar brands and routines. Even if someone is environmentally conscious, the sheer ease of grabbing the usual product can win out.

Skepticism about environmental claims: Some consumers may be doubtful about the legitimacy of companies' environmental claims or "greenwashing" practices.

Structural factors like insufficient recycling infrastructure, underdeveloped green markets, and policy disincentives can also hinder responsible consumption.

Alongside the guidelines provided by national governments and NGOs, in recent years, scholars and researchers documented the growing level of environmental concern of consumers, who show a more favourable attitude towards sustainable products and are more aware of their role and responsibilities (Camilleri et al., 2023). Companies are trying to achieve these goals in multiple ways, such as production processes that are less harmful for the environment, investments in innovative technologies, the achievement of quality standards and certifications, investments in image and brand equity,and the development of new sustainable products designed to conquer new markets and satisfy the growing demand for green goods (Camilleri et al., 2023).

2.3. Sustainable living spaces

Sustainable living spaces refer to environments designed to minimize ecological impact while promoting the well-being of their inhabitants. This concept encompasses various aspects, including energy efficiency, resource conservation, and the integration of nature into living and working environments. The

transformation of non-sustainable houses and living spaces into sustainable ones involves a multifaceted approach that includes architectural design, community engagement, and the adoption of sustainable practices.

To begin with, the architectural design of living spaces plays a crucial role in sustainability. Sustainable architecture emphasizes the use of eco-friendly materials, energy-efficient systems, and designs that harmonize with the natural environment. For example, the incorporation of green roofs, solar panels, and rainwater harvesting systems can significantly reduce a building's carbon footprint and resource consumption (Stāmure et al., 2015). Additionally, the orientation of buildings to maximize natural light and ventilation can enhance energy efficiency and improve indoor air quality (Jiang, 2019).

Moreover, the concept of "Production-Living-Ecological" (PLE) spaces highlights the importance of integrating various functions within urban environments to promote sustainability (Fu et al., 2021). This approach encourages the development of mixed-use spaces that combine residential, commercial, and ecological functions, thereby reducing the need for transportation and fostering community interactions. By creating environments where people can live, work, and enjoy nature in close proximity, urban planners can enhance the livability of cities and promote sustainable lifestyles (Xu, 2021).

Individuals can also contribute to the transformation of their living spaces by adopting sustainable practices in their daily lives. For instance, reducing waste through recycling and composting, conserving water, and using energy-efficient appliances are practical steps that can lead to significant environmental benefits (Roy, 2024). Furthermore, engaging in community initiatives, such as local gardening projects or neighborhood clean-up events, can foster a sense of community and promote collective responsibility for the environment (Jaufar, 2021).

The integration of green spaces within urban environments is another critical aspect of sustainable living. Urban green spaces not only provide recreational opportunities but also contribute to biodiversity, improve air quality, and enhance mental well-being (Selanon, 2023). Designing public parks, community gardens, and green corridors can create a more sustainable urban ecosystem and improve the quality of life for residents. Research has shown that access to green spaces is particularly beneficial for marginalized communities, as it promotes social equity and inclusion (Selanon, 2023).

In addition to individual actions, community engagement and education are vital for promoting sustainable living practices. Living Labs, for example, serve as collaborative spaces where individuals can experiment with sustainable solutions and share knowledge (Zavratnik et al., 2019). These participatory environments encourage innovation and empower communities to take ownership of their sustainability initiatives. By fostering a culture of sustainability, communities can collectively address environmental challenges and promote long-term ecological health (Zavratnik et al., 2019).

Furthermore, the concept of co-living and co-working spaces has gained traction as a sustainable alternative to traditional housing models. These shared living arrangements not only reduce resource consumption but also foster social connections among residents (Roy, 2024). By sharing resources and spaces, individuals can lead more sustainable lifestyles while cultivating a sense of community and belonging (Roy, 2024).

The role of technology in promoting sustainable living cannot be overlooked. Smart home technologies, such as energy management systems and smart thermostats, can optimize energy use and reduce waste (Fu et al., 2021). Additionally, advancements in building materials and construction techniques, such as the use of recycled materials and modular construction, can further enhance the sustainability of living spaces (Stāmure et al., 2015).

In conclusion, transforming non-sustainable houses and living spaces into sustainable ones requires a comprehensive approach that integrates architectural design, community engagement, individual actions, and technological innovations. By adopting sustainable practices and fostering a culture of sustainability, individuals and communities can significantly reduce their ecological impact and enhance their quality of life. The recommendations for individuals include embracing energy-efficient technologies, participating in community initiatives, and advocating for sustainable urban planning practices. Ultimately, the shift towards sustainable living spaces is not only beneficial for the environment but also essential for the well-being of current and future generations.

Transforming a non-sustainable living space into a sustainable one can be achieved through a variety of affordable strategies and practices. This transformation not only addresses environmental concerns but also enhances the quality of life for residents. Below are several actionable tips, tools, and examples supported by relevant literature.

1. **Energy Efficiency Improvements**

One of the most immediate steps individuals can take is to enhance energy efficiency in their homes. This can be achieved through simple measures such as sealing leaks, adding insulation, and using energy-efficient appliances. According to , sustainable urban spaces can significantly benefit from improved energy management practices, which are both cost-effective and environmentally friendly (Kaya & Erbaş, 2023). Additionally, utilizing LED lighting and energy-efficient heating systems can reduce energy consumption and lower utility bills, aligning with findings from that emphasize the role of learning in facilitating transitions toward sustainability (Charatsari et al., 2022).

2. **Water Conservation Techniques**

Implementing water-saving practices is another crucial aspect of creating a sustainable living space. Simple measures such as installing low-flow faucets and showerheads, fixing leaks, and using rain barrels for irrigation can drastically reduce water usage. The importance of such practices is highlighted in the work of , which discusses the role of education in promoting sustainable practices, including water conservation (Moyer & Sinclair, 2020). Furthermore, urban greening strategies, as discussed by , can contribute to water management by enhancing local climates and reducing runoff (Hamza, 2024).

3. **Sustainable Transportation Options**

Encouraging the use of sustainable transportation methods, such as biking, walking, or using public transport, can significantly reduce the carbon footprint of a household. The transformation of urban spaces to support these modes of transport is essential, as noted by , who emphasizes the need for cities to create environments conducive to sustainable mobility (Cimbaljević, 2023). For instance, communities can advocate for bike lanes and pedestrian-friendly infrastructure, which not only promote sustainability but also improve public health.

4. **Waste Reduction and Recycling**

Implementing a robust recycling program and reducing waste through composting can significantly contribute to sustainability. The literature suggests that community engagement in waste management practices is vital for successful implementation (Yassein, 2023). For example, educational initiatives that inform residents about the benefits of recycling and composting can lead to higher participation rates, as highlighted by the findings of on transformative social learning (Wals, 2010).5. **Community Engagement and Education**

Creating spaces for community engagement and education about sustainability is crucial. This can be achieved through workshops, community gardens, and local sustainability initiatives. The role of collective identity in fostering sustainable practices is underscored by , who argue that community-based approaches can significantly enhance sustainability transformations (Ulug et al., 2021). Moreover, educational programs that focus on sustainability can empower individuals to make informed choices, as discussed by (Köhler et al., 2019).

6. **Utilizing Local Resources**

Supporting local economies by sourcing food and materials locally can reduce the carbon footprint associated with transportation. This practice not only promotes sustainability but also strengthens community ties. The concept of local sourcing is supported by the narratives of sustainability presented by , which highlight the importance of local networks in fostering sustainable practices (Vicdan & Hong, 2017).

7. **Incorporating Green Spaces**

Integrating green spaces into urban environments can enhance biodiversity, improve air quality, and provide recreational opportunities. The transformation of urban areas to include parks and community gardens is a practical example of sustainable urban design, as discussed by , who explores the governance of productive landscapes (Tomprou, 2023). Such spaces can serve as community hubs, promoting social interaction and environmental stewardship.

Transforming non sustainable living spaces into sustainable ones is not only feasible but can also be affordable with the right strategies. By focusing on energy efficiency, water conservation, sustainable transportation, waste reduction, community engagement, local resource utilization, and green spaces, individuals can make significant strides towards sustainability. The integration of these practices, supported by academic literature, highlights the multifaceted approach needed to foster sustainable living environments.

2.4. Alternative transportation options

To promote sustainable mobility effectively, individuals can engage in various initiatives that align with the principles of accessibility, equity, and environmental sustainability. Sustainable mobility encompasses a range of transportation modes, including walking, cycling, public transit, and the use of low-carbon vehicles. The following guidelines outline actionable steps individuals can take to contribute to sustainable mobility.

1. Embrace Active Transportation:

Individuals can prioritize walking and cycling as primary modes of transport for short distances. Active transportation not only reduces carbon emissions but also promotes health and well-being. Research indicates that increasing access to cycling infrastructure significantly enhances equity in transportation, particularly in mid-sized cities where such facilities are often underdeveloped (Winters et al., 2018). Furthermore, integrating active transportation into daily routines can alleviate congestion and improve urban air quality (Gallo & Marinelli, 2020).

2. Advocate for Public Transit Improvements:

Engagement with local government and community organizations to advocate for improved public transit services is crucial. This includes pushing for more frequent services, better coverage in underserved areas, and affordable fare structures. Studies have shown that equitable access to public transport can significantly enhance social equity, particularly for disadvantaged groups (Adorno et al., 2016; Li et al., 2019). Individuals

can participate in public forums or community meetings to voice their needs and support policies that prioritize public transit development (Zinia et al., 2023).

3. Support Carpooling and Ridesharing:

Carpooling and ridesharing can reduce the number of vehicles on the road, thereby decreasing emissions and traffic congestion. Individuals can utilize platforms that facilitate carpooling arrangements or engage in community initiatives that promote shared rides (Cheng et al., 2016). Research indicates that such collaborative transportation efforts can enhance social connections and reduce transportation costs for participants (Young & Farber, 2019).

4. Promote Electric and Alternative-Fuel Vehicles:

Individuals can consider transitioning to electric or alternative-fuel vehicles, which contribute to lower emissions compared to traditional gasoline-powered cars. Supporting policies that incentivize the use of electric vehicles, such as tax rebates or the installation of charging stations, can further facilitate this transition (Venter et al., 2017). Additionally, awareness campaigns about the benefits of these vehicles can encourage broader community adoption (Gallo & Marinelli, 2020).

5. Engage in Local Transportation Planning:

Active participation in local transportation planning processes can ensure that community needs are met and that equity considerations are integrated into transportation policies. Individuals can collaborate with local authorities to advocate for inclusive planning that addresses the mobility needs of all demographics, particularly marginalized groups (Almashhour, 2023; Boisjoly, 2017). This can involve participating in surveys, focus groups, or public consultations aimed at assessing transportation needs and preferences (DeAlba-Martínez et al., 2020).

6. Educate and Raise Awareness:

Education plays a vital role in promoting sustainable mobility. Individuals can organize or participate in workshops and seminars that inform others about the benefits of sustainable transportation options and the importance of equity in mobility (Gallo & Marinelli, 2020; Guimarães et al., 2020). By raising awareness about the environmental and social impacts of transportation choices, individuals can inspire collective action towards more sustainable practices.

7. Utilize Technology and Data:

Leveraging technology can enhance the efficiency of transportation systems. Individuals can use mobile applications that provide real-time information on public transit schedules, traffic conditions, and available carpooling options. Furthermore, engaging with data collection initiatives can help identify gaps in transportation services and inform policy decisions aimed at improving accessibility (Peungnumsai et al., 2020; Allen & Farber, 2020).

In conclusion, individuals have a significant role to play in advancing sustainable mobility through active participation, advocacy, and education. By embracing these guidelines, individuals can contribute to a more equitable, accessible, and environmentally friendly transportation system.

2.5. Sustainable diets

In addition to transportation, another key aspect of sustainable living is adopting a sustainable diet. Sustainable diets are those that have low environmental impact, contribute to food and nutrition security, and promote healthy lifestyles [Green et al. 2015] (Qiu et al., 2024).

The book *"Sustainable Diets: How Ecological Nutrition Can Transform Consumption and the Food System"* (2017) by Pamela Mason and Tim Lang provides an in-depth exploration of the concept of sustainable diets. This unit will examine the findings of the authors to further investigate the notion of sustainable dietary practices.

Sustainability itself is a term that has taken on various meanings since its popularization in the 1980s. For many, it refers solely to environmental sustainability, but the authors argue that it must also include social, economic, and cultural factors. When applied to diets, this complexity grows, because food is both a physiological necessity and a social construct influenced by culture, income, and availability.

The core challenge: aligning sustainability and diet

Sustainable diets pose both practical and theoretical problems. The term "diet" doesn't just refer to one meal, but rather the cumulative pattern of eating over time. A sustainable diet should ensure individual health, minimize environmental impact, and consider cultural appropriateness, accessibility, and economic fairness. But what makes a diet sustainable in one context might not be applicable in another. This is particularly evident when comparing wealthy nations to low-income countries, where the issues of overconsumption and malnutrition can coexist. Diets in wealthier nations have evolved into "feast-day" diets, meaning that many people consume rich, calorie-dense foods on a daily basis, rather than reserving such foods for special occasions. This pattern is neither sustainable for human health nor for the environment, as it demands excessive resources and contributes to public health crises like obesity and non-communicable diseases (NCDs) such as diabetes and cardiovascular disease.

Conceptualizing a sustainable diet

Sustainable diets are more than just a combination of health and environmental considerations. They must also factor in socio-cultural values, economic feasibility, and governance structures. Sustainable food systems, therefore, must strike a balance between:

- Environmental impact (such as reducing greenhouse gas emissions, water use, and biodiversity loss)
- Public health (ensuring that diets promote long-term well-being and prevent NCDs)
- Economic fairness (making sure food is affordable and equitable)
- Cultural appropriateness (considering the social and cultural significance of food choices)
- Governance (who makes decisions about food production and consumption, and how policies are implemented).

The authors argue that the typical approach to sustainability, which concentrates on the intersecting concerns of the environment, society, and economy, is overly simplistic when it comes to food systems. Instead, they suggest a more nuanced, six-part framework:

1. Health (nutrition and food safety)
2. Environment (including climate change, biodiversity, and resource use)
3. Social values (such as cultural significance and social norms around food)

4 Food quality (authenticity, taste, and overall quality)

5 Economic issues (affordability, labor, and pricing)

6 Governance (decision-making processes and policies)

This wider framework is necessary because sustainable diets have to balance various, sometimes conflicting, priorities. This chapter doesn't go into the six parts in depth, instead it uses them as a guideline of principles in order to plan a sustainable diet, which is in accordance to our holistic approach to sustainable education.

1 **Health**: Sustainable diets should promote long-term health by providing essential nutrients while reducing the risk of non-communicable diseases. Individuals are encouraged to consume more plant-based foods, such as fruits, vegetables, legumes, and whole grains, while reducing intake of processed foods high in fat, sugar, and salt.

2 **Environment**: Individuals should consider the environmental footprint of their food choices. This includes reducing the consumption of resource-intensive foods, such as meat and dairy, and favoring foods that have a lower carbon footprint, such as locally sourced, organic produce, and plant-based options.

3 **Social values**: Sustainable diets should respect cultural and social norms. This means integrating food choices that are not only healthy and environmentally friendly but also culturally appropriate and enjoyable, acknowledging the role of food in social identity and pleasure.

4 **Food quality**: Choosing high-quality food, which is fresh, minimally processed, and locally produced, is emphasized. Authenticity and the integrity of food production methods play an important role in sustainable diets.

5 **Economic issues**: A sustainable diet should also be affordable. While individuals are encouraged to seek out ethically produced food, this should not come at the expense of economic accessibility. The authors recommend supporting fair trade products and ensuring that food choices contribute to the broader economy by supporting local producers.

6 **Governance**: Individuals are encouraged to make food choices that align with broader sustainability policies and guidelines. This means being aware of food labeling, understanding the origins of food, and supporting policy efforts that promote sustainable agricultural practices.

Several key challenges in promoting sustainable diets

Consumer behavior and choice: The modern food system, particularly in wealthy nations, has been shaped by a consumerist ethic that prioritizes choice and abundance. Many consumers are unaware of the environmental and health impacts of their food choices, and the idea of limiting personal choice for the sake of sustainability is met with resistance. The authors question whether the principle of "consumer choice" should remain as central as it is, given the stakes for public health and the environment.

Conflicting perspectives among stakeholders: Achieving a coherent message about sustainable diets is difficult because of the diverse and sometimes conflicting perspectives of various stakeholders—nutritionists, environmentalists, economists, policy makers, and food industry players. These groups often have different priorities, leading to fragmented policy efforts and a lack of clear direction.

Policy inertia: While there have been some governmental efforts to promote sustainable diets (such as in Germany, Sweden, and France), these initiatives often lose momentum due to political and economic pressures. For example, the Eurozone fiscal crisis in the early 2010s diverted attention away from

sustainable food policies, as governments focused on economic recovery instead. Moreover, the authors note that even when progress is made, it is often reversed or watered down due to pushback from industries that profit from the status quo.

The environmental impact of our current food behavior

Our food choices have a huge impact on the environment and its resources. The production of our food is the single biggest contributor to issues like water use, soil degradation, loss of biodiversity, and greenhouse gas emissions. Studies show that North America and Europe are consuming biological resources as if they had five and three planets, respectively, to support their consumption. Every stage of the food system, from growing to processing, transporting, storing, preparing, and disposing of food, contributes to greenhouse gas emissions. Around 20-30% of all human-caused greenhouse gases are linked to the food system, with agriculture being the biggest culprit. This includes methane from livestock and rice farming, nitrous oxide from fertilized soils, and carbon dioxide from fossil fuel use in farming. The dramatic rise in global greenhouse gas emissions since pre-industrial times is tied to climate change and rising global temperatures. Food production also requires massive amounts of essential resources like energy, water, and land. The global food system uses 30% of the world's energy, with the average American diet requiring the equivalent of 2,000 liters of oil per year. Agriculture accounts for 92% of the world's freshwater use and takes up 38% of the Earth's ice-free land. Yet despite all these resources being poured into food production, a staggering 30-50% of all food produced globally ends up being wasted. This food waste has severe consequences for the climate, water, land, and biodiversity. In the US alone, a quarter of all freshwater and 300 million barrels of oil are used to produce and distribute food that ultimately goes to waste, which has contributed to a tripling of greenhouse gas emissions over the past century. [Fanzo, J., Davis, C. (2021) *Sustainable Diets: Aligning Food Systems and the Environment.*

Some key elements of a sustainable diet include:

- Eating more plant-based foods like fruits, vegetables, legumes, and whole grains, which have a lower carbon footprint than animal-based products.
- Reducing consumption of meat, especially red meat, which is resource-intensive and has higher greenhouse gas emissions. (Agarwal & Alam, 2018)
- Choosing locally sourced and seasonal produce to minimize the carbon footprint associated with food transportation.
- Reducing food waste by planning meals, storing food properly, and composting inedible food scraps.
- Supporting sustainable agriculture practices that minimize the use of pesticides, conserve natural resources, and promote biodiversity.
- Educating oneself and others about the environmental and health impacts of different food choices (Reisch et al., 2013).

By adopting these sustainable dietary practices, individuals can significantly reduce their carbon footprint and contribute to a more environmentally-friendly food system. Research has shown that adopting a more plant-based, low-meat diet can significantly reduce an individual's carbon footprint. Additionally, reducing food waste is crucial, as an estimated one-third of all food produced globally is wasted. (Hopwood et al., 2022) (Whalen et al., 2013) (Agarwal & Alam, 2018)

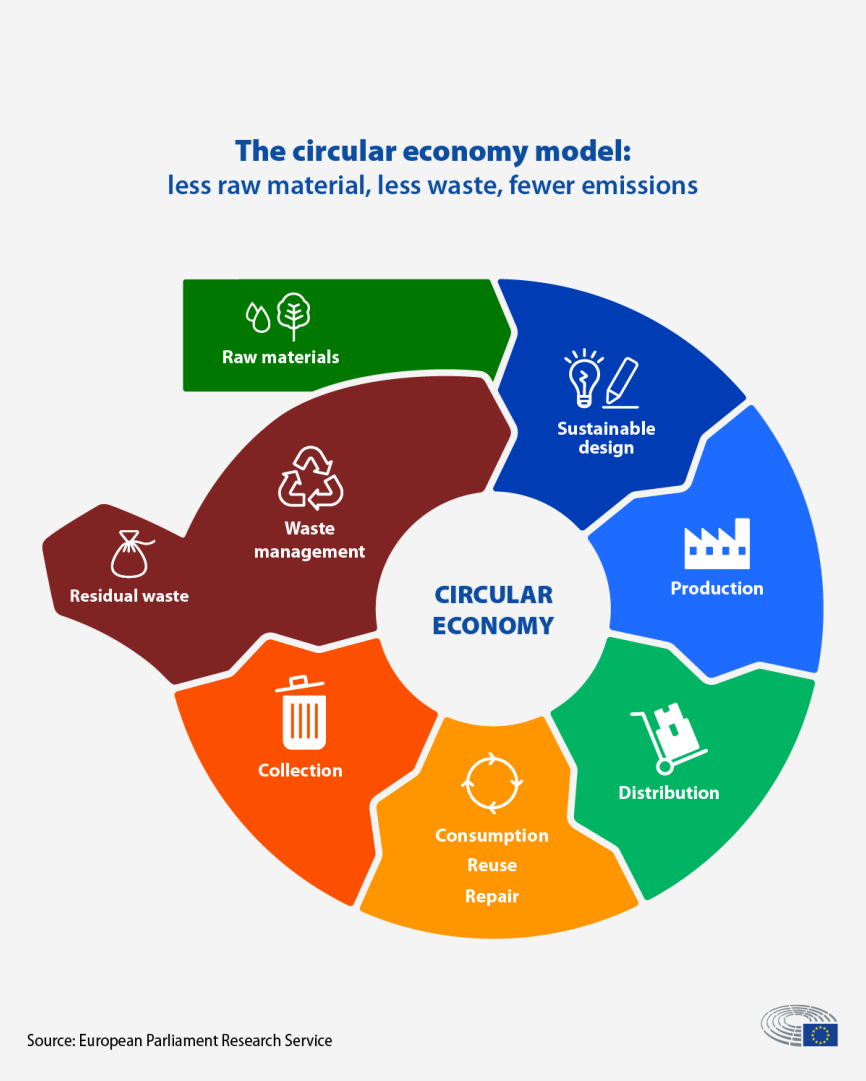
2.6. Sustainable waste practices

The foundation of sustainable waste practices lies in the principles of the circular economy. By moving away from the traditional linear model of consumption, which often results in excessive waste, we open the door to more responsible resource use and innovative approaches to handling materials. Circular economy shifts our focus toward maintaining the value of products and resources within the system for as long as possible. This mindset not only reduces waste but also creates a framework within which sustainable waste practices can flourish. The relationship between these two concepts is essential for fostering a more resilient and environmentally conscious future.

What is the circular economy?

The circular economy is a model of production and consumption focused on extending the lifespan of products through practices such as sharing, leasing, reusing, repairing, refurbishing, and recycling materials. By keeping products and their materials in use as long as possible, this approach seeks to minimize waste. When a product reaches the end of its useful life, its components are recycled back into the economy, adding repeated value.

This is a shift from the linear economic model, which follows a take-make-consume-dispose approach and relies on large volumes of inexpensive materials and energy. The linear model also involves planned obsolescence, where products are intentionally designed with limited lifespans to drive repeat purchases. In response, the European Parliament has advocated for measures to address this practice.



Why do we need to switch to a circular economy?

To protect the environment

Reusing and recycling products would slow down the use of natural resources, reduce landscape and habitat disruption and help to limit biodiversity loss. Another benefit from the circular economy is a reduction in total annual greenhouse gas emissions. According to the European Environment Agency, industrial processes and product use are responsible for 9.10% of greenhouse gas emissions in the EU, while the management of waste accounts for 3.32%. Creating more efficient and sustainable products from the start would help to reduce energy and resource consumption, as it is estimated that more than 80% of a product's environmental impact is determined during the design phase. A shift to more reliable products that can be reused, upgraded and repaired would reduce the amount of waste. Packaging is a growing issue and, on average, the average European generates nearly 180 kilos of packaging waste per year. The aim is to tackle excessive packaging and improve its design to promote reuse and recycling.

Reduce raw material dependence

The world's population is growing and with it the demand for raw materials. However, the supply of crucial raw materials is limited. Finite supplies also means some EU countries are dependent on other countries for their raw materials. According to Eurostat, the EU imports about half of the raw materials it consumes. The total value of trade (import plus exports) of raw materials between the EU and the rest of the world has almost tripled since 2002, with exports growing faster than imports. Regardless, the EU still imports more than it exports. In 2021, this resulted in a trade deficit of €35.5 billion. Recycling raw materials mitigates the risks associated with supply, such as price volatility, availability and import dependency. This

especially applies to critical raw materials, needed for the production of technologies that are crucial for achieving climate goals, such as batteries and electric engines.

Create jobs and save consumers money

Moving towards a more circular economy could increase competitiveness, stimulate innovation, boost economic growth and create jobs (700,000 jobs in the EU alone by 2030). Redesigning materials and products for circular use would also boost innovation across different sectors of the economy. Consumers will be provided with more durable and innovative products that will increase the quality of life and save them money in the long term.

What is the EU doing to become a circular economy?

To support the shift to a circular economy, the European Commission introduced the circular economy action plan in March 2020, which aims to encourage sustainable product design, waste reduction, and empower consumers, such as through a "right to repair." The plan focuses on resource-intensive sectors, including electronics, ICT, plastics, textiles, and construction. In February 2021, the Parliament approved a resolution supporting the action plan, calling for a fully circular, carbon-neutral, environmentally sustainable, and toxic-free economy by 2050. It also proposed stricter recycling rules and binding targets for material use and consumption by 2030.

In March 2022, the Commission launched its first set of measures to speed up this transition, including promoting sustainable products, empowering consumers, revising construction product regulations, and developing a sustainable textiles strategy. In November 2022, the Commission proposed new EU-wide rules on packaging, aiming to reduce packaging waste, improve design, and create clear labeling for reuse and recycling. The proposed rules also seek to foster bio-based, biodegradable, and compostable plastics.

Principles of Zero Waste

In her work Zero Waste Home, the author and activist Bea Johnson outlines five key principles that have become the foundational tenets for the zero waste movement globally. These principles provide a framework for individuals to reduce their environmental impact through conscious consumption and waste management practices.

- Refuse what you don't need. The principle of refusing unnecessary items aims to prevent the influx of unwanted materials into one's household. This applies to various types of promotional products, junk mail, and single-use plastic items that are commonly offered or distributed, which contribute to excess waste.
- Reduce what you do use. This equals less waste overall.
- Reuse whatever you can. Can you extend the life of something by fixing, passing down, or repairing it? Can you buy or sell second-hand items? Reusing also means replacing disposable products with reusable ones that can be washed instead of thrown away.
- Recycle what you can't refuse or reduce. While recycling can save some resources, not all items can be recycled indefinitely. Eventually, they'll end up in landfills. Zero-waste advocates focus on avoiding these non-recyclable items.
- Rot what's left over. Composting organic materials such as food waste, paper, and biodegradable items like wooden or bamboo toothbrushes reintroduces nutrients and organic matter back into the soil.

Getting started with a zero-waste lifestyle means taking a close look at your daily habits and figuring out where you can cut back on waste. Here are some tips for beginners:

- Bring less stuff into your home. The fewer things you buy, the less waste you'll have to deal with. This applies to food, clothes, toys, and all other purchases.

- Shop at bulk food stores using reusable containers. If you have a zero-waste store nearby, you can find all sorts of unpackaged items. If not, look for the biggest bulk section at your regular grocery store and bring your own bags and jars.
- Say no to unnecessary freebies and promos. Those cheap trinkets often end up in the trash quickly, so it's okay to politely decline them.
- Carry reusable containers for takeout meals. Pack your own containers to fill up at work or at home, and then just wash and reuse them.
- Rethink some of your go-to products. See if you can swap out some of your regular items for zero-waste alternatives, like cleaning supplies and personal care items.
- Use up what you already have before making changes. Don't feel like you have to replace everything all at once - just make swaps when it makes sense.

Some key sustainable waste practices include:

- Reducing food waste through better planning, storage, and composting of inedible food scraps.
- Minimizing packaging waste and opting for recyclable or biodegradable materials.
- Recycling as much as possible, including paper, plastics, metals, and electronics.
- Properly disposing of hazardous waste, such as batteries, paints, and electronics, to prevent environmental contamination.
- Supporting local initiatives and policies that promote waste reduction, recycling, and the circular economy.

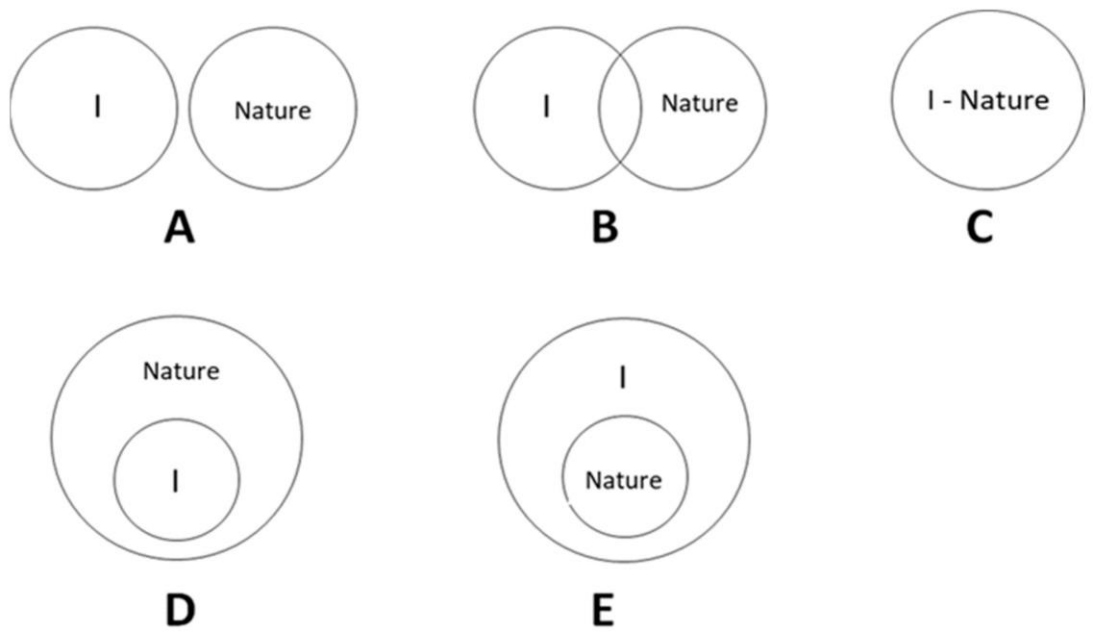
While adopting a zero-waste lifestyle may seem challenging at first, taking it step-by-step and focusing on easy, practical changes can go a long way.

Module 3. Reconnect with nature

Embracing a more environmentally sustainable way of life also requires a deeper connection with the natural world. This means cultivating an appreciation for the delicate balance of ecosystems, understanding our place within nature, and recognizing the intrinsic value of the natural world beyond its utility to humans.

The research shows that adults benefit from connecting with nature in several meaningful ways. By actively engaging with nature, adults can experience improvements in their mental health and well-being. These benefits are not just short-term; with repeated exposure, many of the positive effects are sustained over time. Importantly, studies have found that both active and passive contact with nature—whether through direct interaction or even viewing nature images—can lead to increased feelings of connectedness. This connection also correlates with increased pro-environmental behaviors, a greater sense of happiness, and even improvements in mindfulness practices. Connecting with nature helps people become more aware of their surroundings, improves emotional well-being, and provides a sense of calm and relaxation. The sustained benefits make nature-connectedness practices highly useful for both individual mental health and environmental conservation efforts (Sheffield et al., 2022).

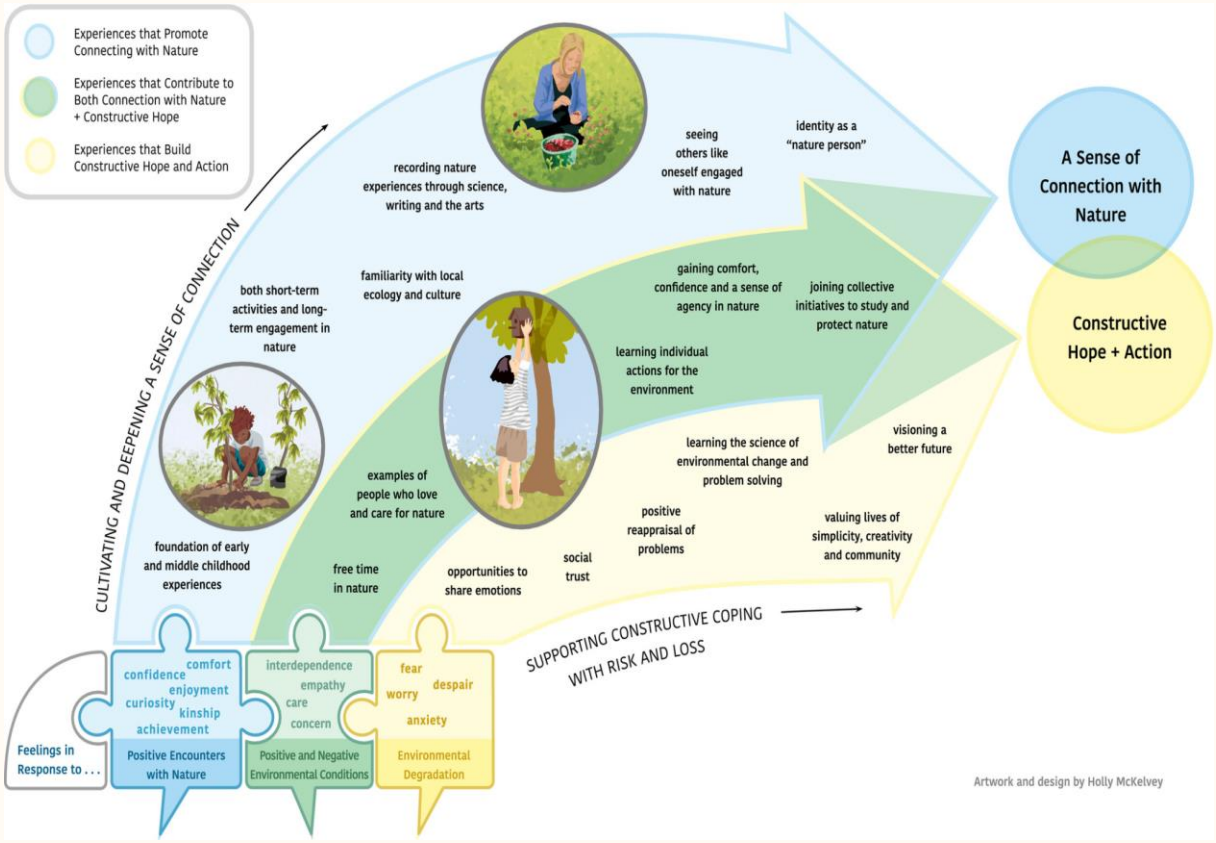
Active engagement involves sensory awareness, mindfulness, and appreciating nature's beauty. For example, participants took part in activities such as mindfulness walks, guided forest tours, forest bathing, or noting "three good things in nature" each day. Other activities involved sensory exploration, meditation in nature, and paying attention to how natural elements made them feel. Some studies used repeated exposure to nature, like daily outdoor activities or using a smartphone app to track positive interactions with green spaces. Passive engagement included walking in nature without specific instructions, viewing images of nature, and participating in virtual reality experiences of nature (Dean et al., 2018) (Pretty, 2004) (Bourrier et al., 2018) (Bratman et al., 2019). Childhood activities such as picking flowers, spending time outdoors alone or with family, were shown to be strong predictors of adult nature connectedness. In contrast, more structured forms of outdoor learning were less influential. These experiences help individuals maintain a feeling of being part of the natural world throughout their lives. However, despite the strong influence of childhood nature experiences on feelings of connection to nature, they do not necessarily translate into more frequent adult nature activities. This discrepancy may be attributed to the modern urban lifestyle, which limits opportunities for adults to engage with nature, even if they have the desire to do so. Some research suggests that rapid urbanization and the rise of technology, particularly in younger generations, have contributed to a decline in nature-related activities and, consequently, to lower levels of nature connectedness. This lack of connection may result in fewer pro-environmental behaviors in the future, as younger people become less aware of the natural world and its importance. (Barrable et al., 2024).



Adjustment of Schultz's *Inclusion of Nature in Self scale*. Instead of representing only degrees of overlap between a person (I) and nature, this adaptation represents three ways of understanding connectedness with nature. The images on the scale represent humans and nature as separate (A), separate yet intertwined (B), or indistinguishable (C), humans as part of nature (D), and nature as part of humans (E). *Brambilla E, Petersen E, Stendal K, Sundling V, MacIntyre TE, Calogiuri G. Effects of immersive virtual nature on nature connectedness: A systematic review protocol. DIGITAL HEALTH. 2022;8. doi:10.1177/20552076221120324*

When people feel more connected to nature, they're more likely to take actions that protect the environment. The bond they develop with the natural world makes them want to care for and preserve it. Research explains that when adults develop a sense of connectedness with nature, they are more likely to engage in pro-environmental behaviors(Barrable et al., 2024). The cause-effect relationship stems from the psychological and emotional bond formed through nature engagement, which fosters a greater sense of responsibility toward protecting natural environments. As people feel more connected to nature, they are more inclined to adopt behaviors such as reducing waste, conserving energy, or participating in nature conservation efforts. This relationship is well-supported by research showing that nature-connectedness

leads to actions that benefit both human well-being and the planet's health (Sheffield et al., 2022)(Barrable et al., 2024).



Nature connectedness plays a crucial role in promoting sustainability by bridging the gap between personal well-being and environmental responsibility. It suggests that fostering nature connectedness can be a transformational strategy for addressing sustainability challenges like climate change and environmental degradation. By helping people feel closer to nature, interventions can lead to sustained changes in behaviors that support ecological conservation and a reduction in consumerism. Moreover, research calls for broader sustainability interventions that include nature-related education, repeated nature engagement practices, and greater integration of nature into daily life as a way to encourage both human and planetary health

To foster this important relationship, adults can engage in a variety of nature-based activities, such as:

• Taking regular walks in natural areas

• Gardening or caring for houseplants

• Observing wildlife and natural phenomena

• Practicing mindfulness exercises outdoors

Reconnect with nature: growing your own food and urban gardening

Connecting with nature through food production can be a powerful way for adults to develop a deeper appreciation and sense of responsibility for the environment (Winter et al., 2019)(Yang et al., 2018). Growing your own food, whether in a backyard garden, community plot, or even a small indoor or balcony setup, helps people understand the sources of their sustenance and the natural cycles that support life. Tending to plants and witnessing their growth can instill a sense of wonder, patience, and care for living

systems. Additionally, urban gardening and community agriculture projects bring people together, fostering social connections and a shared stewardship of green spaces.

Urban gardening has emerged as a critical response to the challenges posed by modern urban living, including food insecurity, environmental degradation, and social isolation. The practice of growing food in urban settings not only provides fresh produce but also contributes to the greening of cities, enhancing biodiversity and improving air quality (Barthel et al., 2013; Thomaier et al., 2014). Urban gardens can take various forms, including community gardens, rooftop gardens, and home gardens, each offering unique benefits to their participants and the surrounding environment (Thomaier et al., 2014).

Research indicates that urban gardening can significantly impact food security, particularly in lower-income households where access to fresh produce may be limited (Church et al., 2015; Mead et al., 2021). By cultivating their own food, individuals can mitigate the effects of food deserts and reduce reliance on industrial food systems, which are often characterized by long supply chains and environmental harm (Barthel et al., 2013; Edmondson et al., 2019). Furthermore, urban gardening fosters a sense of community among participants, promoting social cohesion and collective stewardship of shared green spaces (Park & Shin, 2021; Hoop & Jehlička, 2017).

Mobilizing Community Action

Beyond individual action, it is crucial that communities and institutions work together to promote nature connectedness and sustainable living. Policymakers, educators, and community leaders can implement programs and infrastructure that make it easier for people to engage with nature regularly (Ives et al., 2018) (Winter et al., 2019). This could include:

• Expanding access to urban green spaces, parks, and community gardens.

• Incorporating nature-based learning into school curriculums, such as outdoor classrooms, school gardens, and field trips to local natural areas, to help students develop a deeper connection to the environment.

• Organizing community events and volunteering opportunities focused on environmental stewardship, like beach cleanups, tree planting, and habitat restoration projects, to bring people together and foster a shared sense of responsibility for the local ecosystem.

• Incentivizing businesses to adopt sustainable practices and support green initiatives, such as providing tax credits or public recognition for companies that implement eco-friendly policies, invest in renewable energy, or sponsor community environmental programs.

By creating the conditions for people to regularly interact with and appreciate the natural world, we can cultivate a broader cultural shift toward environmental responsibility and sustainable living

Reconnecting with nature

Engaging in urban gardening allows individuals to reconnect with nature in profound ways. The act of nurturing plants and witnessing their growth can evoke a sense of wonder and appreciation for the natural world (Svendsen et al., 2016; Dobson et al., 2020). This connection is particularly important in an era where urbanization has led to a disconnection from natural ecosystems. Studies have shown that spending time in green spaces can improve mental health, reduce stress, and enhance overall well-being (Svendsen et al., 2016; Dobson et al., 2020; Stubberfield et al., 2022).

Moreover, urban gardening encourages individuals to adopt sustainable practices, such as composting, water conservation, and organic gardening techniques. These practices not only benefit the environment but also empower individuals to take an active role in their food production (Kersten et al., 2022; Galhena et al., 2013). By understanding the ecological processes involved in gardening, individuals can develop a

greater sense of responsibility for their local environment and contribute to the broader goals of sustainability and conservation (McMillen et al., 2020).

Stewardship and community engagement

Stewardship is a fundamental principle underlying the practice of urban gardening. It involves the responsible management of resources and the commitment to protecting the environment for future generations (McMillen et al., 2020; Farges, 2014). Urban gardeners often take on the role of stewards, caring for their plots and the surrounding community spaces. This stewardship extends beyond individual gardens, as participants often engage in collective efforts to maintain and improve shared green areas

Community engagement is a vital component of successful urban gardening initiatives. Collaborative projects, such as community gardens, foster relationships among participants and promote a sense of belonging (Park & Shin, 2021; Hoop & Jehlička, 2017). These gardens serve as spaces for education, where individuals can learn about sustainable practices, nutrition, and the importance of biodiversity. Furthermore, community gardens can act as catalysts for social change, addressing issues such as food insecurity and environmental justice.

Benefits of growing your own food

Growing one's own food offers numerous benefits, both personal and communal. Individuals who engage in home gardening often report increased physical activity, improved dietary habits, and enhanced mental well-being The physical demands of gardening can help combat sedentary lifestyles, which are prevalent in modern society. Additionally, homegrown produce is typically fresher and more nutritious than store-bought alternatives, contributing to better health outcomes

The act of growing food also fosters a sense of accomplishment and self-sufficiency. Individuals who cultivate their own gardens often express pride in their ability to produce food, which can enhance their confidence and overall life satisfaction This empowerment is particularly significant in urban settings, where individuals may feel disconnected from food sources and the agricultural processes that sustain them (Kersten et al., 2022; Dobson et al., 2020).

Educational Initiatives and Support

Educational initiatives play a crucial role in promoting urban gardening and green competences. Programs that provide training and resources for aspiring gardeners can empower individuals to develop the skills necessary for successful food production.Workshops, community events, and online resources can facilitate knowledge sharing and foster a sense of community among participants.

Furthermore, schools and educational institutions can integrate gardening into their curricula, providing students with hands-on experiences that connect them to food systems and environmental stewardship. By cultivating a culture of gardening and sustainability among young people, we can foster a new generation of environmentally conscious citizens who value their relationship with nature (Kersten et al., 2022; Dobson et al., 2020; Galhena et al., 2013).

Module 4. Climate change and critical thinking

Climate change is a complex and multidimensional challenge that affects all aspects of human life and the environment. Understanding and addressing climate change requires the application of critical thinking skills, which involve questioning assumptions, analyzing evidence, and evaluating various solutions. The ability to assess climate change-related information critically helps individuals make well-informed decisions and take responsible actions in their personal lives and within their communities.

Critical thinking in the context of climate change begins with understanding the scientific basis of climate change. The Earth's climate system is governed by physical laws, and our understanding of how the climate is changing relies on interdisciplinary research from fields such as atmospheric science, biology, and Earth science. Scientific observations provide compelling evidence that human activities, particularly the emission of greenhouse gases from the burning of fossil fuels, are the primary drivers of recent climate change.

People who are climate-literate are equipped to critically evaluate the evidence surrounding climate change. They can distinguish between credible scientific information and misinformation or misconceptions. This skill is vital as climate change is often politicized, and misinformation can spread through various channels, including social media. Climate literacy helps individuals recognize that natural causes alone cannot explain the current rapid changes in global temperature and weather patterns. It also emphasizes the importance of evidence-based decision-making in tackling the climate crisis.

It's about arguments

Much of the public discussion about climate science consists of polarized assertions: climate change is happening or it isn't; carbon dioxide causes global warming or it doesn't; humans are responsible or they aren't. Even though scientists put forth their best efforts to communicate their findings, the complexity of climate science and deliberate obfuscation campaigns create confusion. People who lack the expertise to evaluate scientific claims often substitute their judgment about the science itself with opinions about the character of those presenting the information. This highlights the need for a more structured and systematic approach to critically analyzing climate claims.

A key part of climate literacy involves the ability to assess evidence and the strength of claims. This is especially important when dealing with climate change denial or misinformation. One method to evaluate contrarian climate claims, as outlined by researchers like Dave Kinkead and John Cook, is through six simple steps. These steps provide a framework for understanding and critiquing the logical structure of an argument without needing specialized knowledge of climate science.

1. **Identify the claim**: The first step is to clearly identify the claim being made. For instance, one common argument is that climate change is occurring due to natural processes.
2. **Construct the supporting argument**: Every argument is built on premises that support the conclusion. In the case of the claim that climate change is natural, the premises might be:
    - The climate has changed in the past through natural processes.
    - The climate is currently changing.
    - Therefore, the climate is currently changing through natural processes.
3. **Determine the intended strength of the claim**: Many arguments against human-caused climate change are presented as definitive, meaning the conclusion must necessarily follow from the premises. This is where deductive reasoning comes into play.
4. **Check the logical structure**: The argument's conclusion does not necessarily follow from the premises. Just because climate has changed naturally in the past does not mean the current changes

are also natural. This is a flaw in reasoning that often appears in climate change denial arguments (Climate-Literacy-Guide-…).

5. **Check for ambiguity**: The term "climate change" can have different meanings, and these differences must be accounted for. For example, current climate change is happening at a much faster rate than historical climate changes caused by natural processes. Clarifying these distinctions exposes flaws in the argument.

6. **Check premises for truth or plausibility**: Even if the logic is sound, the truth of the premises must be examined. For instance, the assumption that past causes of climate change must explain present changes is demonstrably false. This method of analysis reveals that many contrarian claims about climate change fail under scrutiny.

This structured approach to evaluating climate claims enables individuals to critically assess arguments without needing a deep understanding of the underlying science. By focusing on the logical consistency and plausibility of claims, people can defend against misinformation and better engage with the realities of climate change.

The role of science and misinformation. Critical thinking becomes even more vital when we consider the role that misinformation and deliberate campaigns of climate denial have played in shaping public discourse. Research has shown that misinformation can spread quickly, muddying public understanding of climate science. This has prompted efforts to "inoculate" individuals against misinformation by preemptively exposing them to false arguments and explaining why those arguments fail. This process of inoculation helps build resilience against adopting beliefs based on flawed reasoning, reinforcing the need for critical thinking in public discussions about climate change.

Systemic thinking and climate change

In addition to critical thinking, systemic thinking is essential for understanding the full scope of climate change. While critical thinking helps individuals dissect individual claims, systemic thinking allows them to see the broader picture and understand the interconnectedness of various factors. Climate change impacts ecosystems, human health, and economies, and these impacts are all interconnected. Addressing climate change requires understanding how these systems interact and how changes in one area can affect others.

For instance, systemic thinking highlights the concept of tipping points—thresholds within the climate system where gradual changes can lead to sudden, irreversible shifts. Understanding these tipping points requires seeing the interconnectedness of different components of the Earth's climate system, from ice sheets to ocean currents.

Systemic thinking also involves considering the social, historical, ethical, and political dimensions of climate change. Climate change does not affect everyone equally; some communities, especially marginalized and low-income populations, are more vulnerable to its impacts. This disparity is due to a combination of factors, including geographic location, economic resources, and social inequality. For example, communities of color and low-income groups are often located in areas more exposed to climate hazards, such as floods or heatwaves. Systemic thinking helps us understand these social injustices and emphasizes the importance of inclusive and equitable climate solutions.

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Part 3. Repository with educational tools

This repository offers an exploration of activities designed to develop cognitive, social, emotional, and behavioral skills linked to responsible consumption. By strengthening these skills, learners will become adept at analyzing product information, understanding environmental impacts, and distinguishing between needs and wants. The activities will also encourage self-reflection, empathy, and value alignment, enabling participants to make choices that resonate with their personal ethics and contribute positively to their communities.

Through collaborative learning, research, and hands-on exercises, learners will gain practical insights into topics such as reducing personal carbon footprints, understanding climate solutions, and debunking misconceptions about sustainability. These activities promote holistic, actionable knowledge that encourages responsible consumption and climate-conscious habits, empowering learners to contribute meaningfully to the global movement for environmental sustainability.

All these activities align with the theoretical framework discussed in Part 2. Reflecting the manual's holistic approach, the activities below are designed to address multiple competencies simultaneously. It is, in fact, part of the trainer's skill to deepen exploration of these topics, while facilitating discussions that encourage the natural development of various competencies. This adaptable approach allows trainers to tailor sessions to the learners' interests and needs, fostering a richer understanding and greater personal engagement with the topics.

Component	Details
Activity Title	Climate Change Jargon
Target Audience	<14
Duration	30 – 60 min
Materials Needed	Jargon Cards Flipchart Paper Stickers
Goal	Help participants understand and communicate key climate change terms effectively.
Green Upskills! Key competence	Competence 1: Environmental Awareness and Analysis
Learning Objectives	1. Identify and define key terms related to climate change. 2. Improve comprehension of climate-related jargon. 3. Develop skills to simplify and explain complex terms.
Handouts:	Dowload climate-change-jargon-busting
Resources for trainer:	Read Module 1 Additional resources: https://www.metoffice.gov.uk/weather/climate-change/what-is-climate-change Handout 1
Adapted from:	https://www.metoffice.gov.uk/

Activity steps

1. **Introduction (5 minutes)**

Begin by asking participants what they already know about climate change. Write "climate change" on the board and explain it as the long-term shift in global weather patterns, intensified by human activities since the mid-1800s.

2. **Brainstorming climate change words (10 minutes)**

Divide participants into small groups (3-4 people per group).

Ask each group to list as many words related to climate change as they can in 3 minutes. They do not need to fully understand the words to include them.

After time is up, have each group share a few words from their list with the class.

3. **Jargon-busting (20 minutes)**

Understanding known words: instruct each group to highlight words they are familiar with and can explain. Ask each group to briefly share and explain one or two words they understand.

Identifying unknown words: ask each group to choose a few words they do not understand. Write these on the board as a list of "jargon" terms.

Jargon-busting cards: distribute the jargon-busting cards that contain simple explanations of common climate change terms (such as "greenhouse gas," "carbon footprint," and "adaptation").

Have participants refer to these cards to find definitions and explanations for their unknown words.

4. **Create a jargon-busting poster (15 minutes)**

Each group selects one climate-related term from their list and creates a poster that explains it in simple, accessible language.

Encourage them to use visuals, analogies, or examples to make the concept easy to understand.

If time allows, each group presents their poster to the others.

5. **Wrap-up and reflection (10 minutes)**

Conclude with a group reflection on the importance of clear communication in climate science.

Ask each participant to choose one term they learned and explain it in their own words.

Reflection questions

1. **Which climate change terms were the most challenging to understand, and why?**
2. **How did using the jargon-busting cards help clarify these terms?**
3. **Why do you think clear communication about climate change is essential?**
4. **How might you use your new understanding of these terms to explain climate change concepts to others?**

Component	Details
Activity Title	Carbon Footprint Calculator
Target Audience	<14
Duration	
Materials Needed	Projector/screen for displaying the calculator Paper and pens SDG posters or visuals
Goal	To help participants understand their carbon footprint and identify practical lifestyle changes to reduce it.
Green Upskills! Key competence	Main: Competence 2. Sustainable Lifestyle Choices Secondary: Competence 1: Environmental Awareness and Analysis
Learning Objectives	1. Understand how to calculate their carbon footprint using an online tool. 2. Analyze how different lifestyle choices contribute to their carbon footprint. 3. Identify at least two actionable lifestyle changes that can reduce their carbon footprint.
Handouts:	-
Resources for trainer:	SDG cards: https://go-goals.org/ Consumer Footprint Calculator: https://knowsdgs.jrc.ec.europa.eu/cfc

Activity steps:

Briefly introduce the concept of carbon footprint and the importance of measuring it to promote sustainable choices. 10 min

1. Calculator Overview

Present The Consumer Footprint Calculator and explain its purpose. Highlight the five areas of consumption (Food, Mobility, Appliances, Household Goods, Housing) and how these impact individual carbon footprints.10 min

2. Using the Calculator (Individual Activity)

Ask participants to access the online calculator. Guide them in entering details about their lifestyle in each of the five areas to obtain their carbon footprint results. 10 min

3. Interpreting Results

Instruct participants to review their results, including areas of consumption with the highest environmental impact, comparison with the average EU citizen, and assessment against planetary boundaries. 10 min

4. Identifying Changes (Small Group Activity)

Divide participants into small groups. Ask them to discuss their results and identify two to three specific lifestyle changes they could make to reduce their carbon footprint, focusing on high-impact areas identified in Step 3. 15 min

5. Linking to SDGs

Facilitate a group discussion on how their consumption habits affect the Sustainable Development Goals (e.g., SDG 12, SDG 13). Encourage them to share ideas for changes that align with these goals and reduce their environmental impact. 10 min

6. Action Plan (Individual Activity)

Have each participant create a simple action plan outlining one to two immediate and realistic steps they will take based on their findings to lower their carbon footprint. 10 min

Wrap-Up and Reflection

Summarize the steps for calculating and interpreting carbon footprints. Invite participants to share what they found most surprising and how they plan to apply these insights in their daily lives. - 10 min

1. Which area of your lifestyle had the highest carbon impact, and why?

2. What was the most surprising result from the carbon footprint calculation?

3. How did comparing your carbon footprint to the average EU citizen's footprint affect your understanding of your environmental impact?

4. What specific actions do you plan to take to reduce your carbon footprint, and how will they contribute to a more sustainable lifestyle?

5. How does using a carbon footprint calculator contribute to your eco-literacy and your understanding of global sustainability goals?

Component	Details
Activity Title	Food Choices and Climate Impact
Target Audience	<16
Duration	60 minutes
Materials Needed	Projector/screen for displaying Copies of key excerpts from the article, projector, pens, paper, optional recipe cards or food-related visuals.
Goal	Help participants understand the impact of their food choices on climate change and identify strategies for making more sustainable dietary choices.
Green Upskills! Key competence	Main: Competence 2. Sustainable Lifestyle Choices Secondary: Competence 1: Environmental Awareness and Analysis
Learning Objectives	1. Understand which food groups contribute most to climate change. 2. Identify simple dietary changes that can reduce their carbon footprint. 3. Develop practical approaches to reduce food waste.
Problem solving	If your target group English level is lor, you might have to translate the content from the NY Times article.
Handouts:	Create cards for each category from the article Your Questions About Food and Climate Change, Answered https://www.nytimes.com/interactive/2022/dining/climate-change-food-eating-habits.html
Resources for trainer:	Your Questions About Food and Climate Change, Answered https://www.nytimes.com/interactive/2022/dining/climate-change-food-eating-habits.html

Activity steps

1. **Introduction and discussion (10 minutes)**

   Begin by asking participants what they know about the relationship between food and climate change.

   Briefly introduce key statistics: meat and dairy contribute around 14.5% of global greenhouse gas emissions, which is comparable to all transportation emissions combined**.**

2. **Exploring climate impact by food group (20 minutes)**

   Group activity: divide participants into small groups and assign each group a food category (e.g., red meat, poultry, dairy, seafood, plant-based foods).

   Instructions: have each group use the article excerpt to explore the climate impact of their assigned food group, considering greenhouse gas emissions, land use, and water consumption.

   Report back: each group shares a summary of their findings with the class, highlighting the biggest environmental impacts and any surprising details (e.g., the impact of cheese vs. Chicken).

3. **Strategies for reducing carbon footprint (15 minutes)**

Presentation: present the article's recommendations for reducing food-related climate impact, including:

- Reducing red meat and dairy consumption.
- Replacing beef with lower-impact proteins like chicken or plant-based foods.
- Incorporating more plant-based protein sources (e.g., beans, tofu, nuts).
- Choosing low-carbon seafood options like wild sardines and mollusks.

Discussion: facilitate a short discussion on which of these strategies feel realistic or achievable for participants and how they might apply these in their own diets.

4. **Reducing food waste (10 minutes)**

   Presentation and discussion: explain that food waste contributes significantly to climate impact, with around 20% of food in the u.s. going to waste. Review practical ways to reduce food waste, including meal planning, storing food properly, and being mindful of expiration dates.

   Reflection: ask participants to share one habit they could change to reduce food waste in their homes.

5. **Creating a personal climate-friendly action plan (10 minutes)**

   Individual reflection: have each participant create a brief action plan by identifying two specific, achievable changes they can make in their diet to reduce their climate impact.

   Examples:

   - Replace beef meals with chicken or plant-based meals twice a week.
   - Buy only what's needed for each week to minimize food waste.

   Sharing: invite participants to share their action plans if they're comfortable doing so.

Reflection questions

1. Which food group was most surprising in terms of its climate impact? Why?
2. What challenges do you think people might face in shifting to a lower-impact diet?
3. How does reducing food waste contribute to a more sustainable lifestyle?
4. What's one new food or recipe you would consider trying to reduce your carbon footprint?

Component	Details
Activity Title	The stabilization game "Wedges"
Target Audience	<18
Duration	2-3 standard class periods (40-50 minutes)
Materials Needed	1 copy of the instructions and the Wedge table for each pupil (print on one side only to allow use of the game board pieces!) 1 wedge worksheet and 1 game board with multi-colored wedge pieces for each group, plus scissors for cutting out the game pieces and glue or tape to secure the pieces to the board Color pens Scissors Optional - transparencies, posters or other materials for group presentations
Goal	To convey the scale of the effort needed to deal with the carbon and climate situation and the need to develop a portfolio of options. By the end of the exercise, learners should understand the scale of human carbon emissions and feel comfortable comparing the effectiveness, benefits and drawbacks of a variety of carbon reduction strategies.
Green Upskills! Key competence	Main: Competence 1: Environmental Awareness and Analysis Secondary: Competence 2. Sustainable Lifestyle Choices Competence 4: Critical green skills
Learning Objectives	1.Will learn about currently available technologies that can substantially reduce carbon emissions 2. Develop critical reasoning skills as they create their own portfolio of emission reduction strategies, and verbally communicate the rationale for their selections. 3. Working in teams, learners will develop the skills to negotiate a solution that is both physically plausible and politically acceptable and defend their solution in front of a larger group.
Handouts:	Handout 2 Teachers guide
Adapted from	http://cmi.princeton.edu
Resources for trainer:	The stabilization triangle https://www.youtube.com/watch?v=FaFE8F-k4R4

Activity Steps

Lesson procedure/methodology

I. Introduction (40 minutes)

a. **Motivation.** Review the urgency of the carbon and climate issue and the potential ways it may affect students' futures.

b. Introduce the concepts. Present the ideas of the Stabilization Triangle and its eight "wedges."

c. Present the technologies. Briefly describe the 15 wedge strategies identified by CMI, then ask students to familiarize themselves with the strategies as homework. Participants are free to critique any of the wedge strategies identified by CMI, and teams should feel free to use strategies not on our list.

d. Form teams. Teams of 3 to 6 players are best, and it is particularly helpful if each student be an "expert" in a few of the technologies to promote good discussions. You may want to identify a recorder and a reporter in each group.

e. Explain the rules.

II. The game (40 minutes)

a. Completing the stabilizing triangle. Teammates should work together to build a team stabilizing triangle using 8 color-coded wedges labeled with specific strategies. Many strategies can be used multiple times.

b. Feather worksheet. Each team should complete a **feather stabilization worksheet**, to ensure that players have not violated the constraints of the game, to calculate costs, and to predict the judges' scores for their solution. NOTE: Costs are indicative only - they are not intended to be used to produce a numerical score that wins or loses the game!

c. Triangle Review. Each team should review the strengths and weaknesses of their strategies in preparation for reporting and defending their solutions to the class.

III. Reporting (depending on the number of groups, this may require additional class time)

a. Representatives from each team will defend their solutions to the class in a 5-minute report. The presentation may be a simple verbal discussion by the group or a reporter assigned by the group. If additional time is available, presentations may include visual aids such as a poster, PowerPoint presentation, etc.

b. Students should address not only the technical viability of their solutions, but also the economic, social, environmental, and political implications of large-scale implementation of their chosen strategies.

IV. Judging

The assessment ensures that economic and political impacts are taken into account and emphasizes the need for consensus among a broad coalition of stakeholders. For a class, judges can be recruited from local government, colleges, businesses, and non-profit organizations, or a teacher/facilitator can quiz each team on the viability of their strategies.

V. Closure/evaluation of student learning

In addition to addressing game play and lessons learned, discussion questions are provided below that provide an opportunity to develop and assess students' understanding of the wedge concept and its applications.

1) Given the physical challenges and risks, how many wedges do you think each wedge strategy can realistically produce?

2) In choosing mitigation strategies, it is important to avoid double counting - eliminating the same emissions with two different strategies. For example, there are 6 strategies to reduce emissions from electricity, but we estimate that 50 years from now carbon emissions from the electricity sector will be reduced by only 5 wedges.

Can you think of reasons, other than the adoption of alternative or nuclear energy, why emissions from the electricity sector would be lower or higher than we predicted? Examples: increased use of carbon-intensive coal at the expense of natural gas (higher), slower population growth (lower), substitution of electricity with fuel, such as through plug-in electric cars (higher).

3) Industrialized and developing countries currently each contribute about half of the world's emissions, although poorer countries have about 85% of the world's population. (The US alone emits a quarter of the world's CO2 emissions .) If we agree to freeze global emissions at current levels, it means that if **emissions in one part of the world are increasing due to economic/industrial development, then emissions must be reduced elsewhere**. Should richer countries reduce their emissions in 50 years time, so that extra carbon emissions can be made available to developing countries? If so, by how much?

4) Nuclear power already provides half of the emission reductions - what do you think the future should be for these plants?

5) Emissions from cars are a popular target for reducing greenhouse gases. What percentage of greenhouse gases do you think come from passenger vehicles worldwide? (answer: about 18%)

Component	Details
Activity Title	Arguments against misinformation
Target Audience	<18
Duration	2 hours
Materials Needed	- Whiteboard and markers - Printed handouts with common climate denialist claims - Examples of valid and invalid arguments - Access to research articles or credible sources about climate change
Goal	To equip participants with the critical thinking skills necessary to evaluate arguments and combat misinformation about climate change.
Green Upskills! Key competence	Competence 4: Critical green skills
Learning Objectives	1. Understand the structure of arguments (premises and conclusions). 2. Distinguish between deductive and inductive arguments. 3. Identify common fallacies and flaws in climate denialist claims. 4. Apply critical thinking skills to assess the validity of arguments related to climate change.
Resources for trainer:	"Deconstructing climate misinformation to identify reasoning errors" John Cook et al 2018 Environ. Res. Lett. 13 024018 open here: https://iopscience.iop.org/article/10.1088/1748-9326/aaa49f#erlaaa49fs2 (see Flowchart for evaluating contrarian claims.) Optional: The five climate disbeliefs: a crash course in climate misinformation, open here: https://www.youtube.com/watch?v=JuUz2AwoSko How to use critical thinking to spot false climate claims: https://theconversation.com/how-to-use-critical-thinking-to-spot-false-climate-claims-91314

Activity Steps

1. **Introduction to Argument Structure (20 minutes)**

Theory: Explain the concept of an argument as a connected series of statements used to establish a proposition. Discuss premises (claims that support the argument) and conclusions (what the argument is trying to prove).

Definition:

Premise: A statement that provides support for the conclusion (e.g., "All swans are white").

Conclusion: The statement that follows from the premises (e.g., "All swans are birds").

Example: Present a simple argument.

Premises: P1: "All humans are mortal." P2: "Socrates is a human."

Conclusion: "Socrates is mortal."

2. **Identifying Argument Types (20 minutes)**

Theory: Discuss the differences between deductive and inductive reasoning. Deductive arguments aim for certainty if premises are true, while inductive arguments deal with probabilities.

Definitions:

Deductive Argument: If the premises are true, the conclusion must also be true (e.g., a mathematical proof).

Inductive Argument: The premises support the conclusion but do not guarantee it (e.g., "It has rained every day in July for ten years, so it might rain this July").

Activity: Provide participants with examples and ask them to classify them as deductive or inductive.

Example 1:

Argument: P1: "All greenhouse gases trap heat in the atmosphere." P2: "Carbon dioxide is a greenhouse gas."

Conclusion: "Carbon dioxide traps heat in the atmosphere."

Classification: Deductive – if both premises are true, the conclusion must also be true.

Example 2:

Argument: P1: "In recent decades, average global temperatures have risen significantly." P2: "Many climate scientists attribute this rise to human activities."

Conclusion: "Human activities are likely causing global warming."

Classification: Inductive – the conclusion is likely but not certain, as it's based on evidence and scientific consensus.

Example 3:

Argument: P1: "Most of the hottest years on record have occurred since the year 2000." P2: "Carbon dioxide levels have also risen during this period."

Conclusion: "Rising carbon dioxide levels are causing warmer temperatures."

Classification: Inductive – the correlation suggests a probable causation but does not guarantee it.

3. **Analyzing Denialist Claims (30 minutes)**

Theory: Introduce common climate denialist claims and explain how to break them down into arguments.

Examples: Present claims such as:

"The climate has changed naturally before, so current climate change is natural."

"There is no scientific consensus on climate change."

Activity: In small groups, participants choose a claim, identify its premises and conclusion, and determine if the argument is deductive or inductive.

These examples involve common climate-related claims. Participants should identify the premises and conclusions and determine whether the argument is deductive or inductive.

Claim 1: "If climate change were real, we would see consistent global warming. But there are still cold winters, so global warming must not be happening."

Premises:

- P1: "Climate change would cause consistent warming across all seasons."
- P2: "We are still experiencing cold winters."

Conclusion: "Global warming is not happening."

Type: Inductive – the argument is based on an observation (cold winters) but incorrectly generalizes it to dismiss global warming as a whole.

Claim 2: "Scientists have been wrong about climate predictions before, so we shouldn't trust their claims about future warming."

Premises:

- P1: "Scientists have made incorrect predictions about climate in the past."

Conclusion: "Current scientific claims about climate change are likely wrong."

Type: Inductive – the argument suggests that past inaccuracies indicate future errors but does not account for improved data or models.

Claim 3: "The Earth's climate has always changed naturally, so the current climate change must be natural as well."

Premises:

- P1: "Earth's climate has naturally fluctuated in the past."

Conclusion: "Current climate change is a natural phenomenon."

Type: Inductive – this is a generalization based on past occurrences, overlooking evidence of human impact on climate.

Claim 4: "CO_2 levels were much higher in the past before humans existed, so high CO_2 levels today can't be dangerous."

Premises:

- P1: "Earth had higher CO_2 levels before human existence."
- P2: "High CO_2 levels in the past were not harmful to the environment."

Conclusion: "High CO_2 levels today are not harmful."

Type: Inductive – the argument implies that past conditions determine current safety levels, ignoring modern environmental and species adaptation factors.

Claim 5: "If climate change were human-caused, then we would see direct evidence of it affecting human activities in dramatic ways. But we don't see that happening, so human-caused climate change is not real."

Premises:

- P1: "If human-caused climate change were real, it would cause immediate and dramatic disruptions."
- P2: "We are not experiencing dramatic disruptions in our daily lives."

Conclusion: "Human-caused climate change is not real."

Type: Deductive – this is structured to suggest certainty but is flawed by a narrow interpretation of "evidence."

Claim 6: "Scientists are only pushing the climate change agenda for funding, so we should question their motives and not believe in climate change."

Premises:

- P1: "Scientists benefit from funding by supporting climate change claims."

Conclusion: "Climate change is not real, and scientists are promoting it for personal gain."

Type: Inductive – the argument bases its conclusion on presumed motives rather than scientific evidence, making it speculative.

More common examples here:

"The UK's carbon footprint is tiny compared to China's, so it doesn't make sense for us to take action, at least until they do."

"People are developing new, green technology right now, we just need to wait for it"

"People respond best to voluntary policies, and we shouldn't try to force people to do anything"

4. **Evaluating Argument Validity (30 minutes)**

Theory: Explain how to check if an argument is valid by ensuring that the conclusion logically follows from the premises.

Example of Valid vs. Invalid:

Valid: P1: "All birds lay eggs." P2: "A penguin is a bird." C: "A penguin lays eggs."

Invalid: P1: "A previous change in climate was not due to human activity." P2: "The climate is currently changing." C: "The current change in climate is not due to human activity."

Activity: Provide participants with a mixed set of arguments and ask them to evaluate their validity.

Example 1 (Valid):

Premises: P1: "Burning fossil fuels releases carbon dioxide." P2: "Carbon dioxide traps heat in the atmosphere."

Conclusion: "Burning fossil fuels contributes to global warming."

Validity: Valid – the conclusion logically follows from the premises.

Example 2 (Invalid):

Premises: P1: "Climate models have limitations." P2: "Climate change predictions are based on models."

Conclusion: "Climate change predictions are inaccurate."

Validity: Invalid – limitations in models do not imply that all predictions are inaccurate.

Example 3 (Valid):

Premises: P1: "The majority of climate scientists agree that human activities are causing global warming."

Conclusion: "There is a scientific consensus on human-caused global warming."

Validity: Valid – the conclusion is logically supported by the premise.

5. **Identifying Fallacies and Ambiguities (20 minutes)**

Theory: Discuss common fallacies in climate denial arguments (e.g., non sequitur, equivocation).

Definitions:

Non Sequitur: An argument where the conclusion does not logically follow from the premises.

Equivocation: Using ambiguous language to mislead or confuse (e.g., "Nothing is better than eternal happiness; a ham sandwich is better than nothing, so a ham sandwich is better than eternal happiness").

Activity: Give examples of flawed arguments and ask participants to identify the fallacies.

Example 1 (False Cause Fallacy):

> **Claim**: "Earth's temperature has always fluctuated, so current warming is just another natural cycle."
>
> **Fallacy**: False Cause – assumes that because temperature fluctuations happened naturally in the past, current warming must also be natural without considering human influence.

Example 2 (Appeal to Ignorance):

> **Claim**: "There is no absolute proof that climate change is caused by humans, so it must not be true."
>
> **Fallacy**: Appeal to Ignorance – assumes that a lack of absolute proof disproves human-caused climate change, disregarding substantial evidence.

Example 3 (Strawman):

> **Claim**: "Environmentalists believe we should stop all industrial activity to combat climate change."
>
> **Fallacy**: Strawman – misrepresents the stance of environmentalists, exaggerating it to an extreme view that is easier to refute.

Bonus:

"Taking action on climate change will generate huge social costs. The most vulnerable people in our society will suffer the most from increased taxation"

6. **Checking for Truth or Plausibility (20 minutes)**

Theory: Explain the importance of ensuring that premises are true or plausible for the argument to hold.

Example:

Analyze the premise, "If there is no empirical evidence for something, then it is not happening." Discuss its implausibility.

Activity: Participants evaluate a set of premises from denialist arguments and discuss their truthfulness or plausibility.

Example 1:

> **Premise**: "Human activities only contribute a tiny fraction of all carbon dioxide emissions, so they can't be responsible for climate change."
>
> **Evaluation**: Misleading – while natural sources emit CO_2, human activities significantly increase atmospheric CO_2, which accumulates and amplifies the greenhouse effect.

Example 2:

> **Premise**: "Volcanoes release more CO_2 than human activities."

Evaluation: False – scientific data shows that annual human CO_2 emissions far exceed volcanic emissions.

Example 3:

Premise: "Climate change is a hoax because winters are still cold."

Evaluation: Implausible – climate change refers to long-term temperature trends, not short-term weather variations; colder winters do not invalidate global warming.

7. **Wrap-Up and Discussion (20 minutes)**
    - **Summary**: Recap the steps taken to evaluate climate change arguments. Highlight the importance of critical thinking in combating misinformation.
    - **Discussion**: Engage participants in a discussion about their experiences with misinformation and how they plan to apply these skills in their daily lives.

Comprehension questions:

1. **What were the main steps we took to evaluate the arguments we analyzed?**
2. **Which types of arguments (inductive or deductive) did you find more challenging to evaluate, and why?**
3. **How did analyzing these arguments change your perspective on the methods used in climate denialist claims?**

Reflection questions:

1. **Can you share an experience where you encountered misinformation about climate change or another topic? How did you handle it?**

   Allows participants to connect personally and consider real-world applications of the critical thinking skills they've practiced.

2. **What are some indicators that an argument or claim might be misleading or poorly constructed?**

   Reinforces key concepts learned, like recognizing unsupported premises, generalizations, and logical fallacies.

3. **How can you apply what you've learned today in discussions with friends, family, or online?**

   Encourages practical thinking on using these skills to address misinformation constructively in daily interactions.

4. **In what ways could you share these skills with others to improve critical thinking and awareness of misinformation?**

   Inspires participants to think about spreading critical thinking techniques, fostering a community of informed individuals.

5. **How do you think practicing critical thinking might help in understanding other complex or controversial topics?**

   Emphasizes that these skills are versatile and beneficial for a wide range of topics, not just climate change.

6. **What strategies will you use to ensure that you're consuming reliable and accurate information in the future?**

   Prompts participants to think about personal habits and tools they can use to verify information and protect against misinformation.

Component	Details
Activity	Exploring climate solutions through "The climate game"
Objective	Engage participants in exploring strategies for addressing climate change by making informed decisions through the "Climate Game" by Financial Times.
Materials Needed	Projector for demonstration
Learning Goals	1. Develop an understanding of climate policy choices and their consequences. 2. Identify and analyze potential paths toward reducing global emissions. 3. Reflect on the challenges and complexities involved in achieving global climate targets.
Green Upskills! Key competence	Competence 1: Environmental awareness and analysis Competence 2: Sustainable lifestyle choices
Materials Needed	Access to the Climate Game on Financial Times (https://ig.ft.com/climate-game/), internet access, paper and pens for reflections, projector or screen for group play (optional).
Trainer Resources	The Climate Game cheat sheet: how to get to net zero by 2050 https://www.ft.com/content/ff6c1eba-4111-44cf-b37d-01b477a3761d
Duration	60-75 minutes
Bonus follow up activity	Quiz: How Does Your Diet Contribute to Climate Change? https://www.nytimes.com/interactive/2019/04/30/climate/your-diet-quiz-global-warming.html

Activity Stepts

1. **Introduction (10 minutes)**

Begin with a short discussion on global climate goals and why strategic, large-scale action is required to prevent catastrophic climate impacts. Explain that participants will act as decision-makers in "The Climate Game," working toward these goals by balancing environmental, social, and economic factors. See Module 2 from the Manual.

2. **Exploration in Pairs (20 minutes)**

Have participants form pairs and play "The Climate Game." They should discuss each decision they make in the game, considering trade-offs and potential outcomes.

Encourage them to focus on areas such as renewable energy investment, economic policies, public transportation, and industrial reforms.

After finishing the game, they should note their "world temperature" result and reflect on their strategies.

3. **Group Reflection and Discussion (15 minutes)**

Bring the group back together and ask pairs to share their experiences.

Guiding questions:

What was the final global temperature increase in your game, and how close was it to the target of 1.5°C?

Which decisions were the most difficult to make, and why?

How did the consequences of each decision affect your approach?

4. **Real-World Connections and Implications (10 minutes)**

Discuss how the game illustrates real-world climate decision-making and its challenges.

Ask participants to reflect on how individual lifestyle choices align with broader policy decisions they encountered in the game.

5. **Wrap-Up (5-10 minutes)**

Summarize key insights, emphasizing the importance of strategic decision-making in achieving climate targets.

Discuss how participants can apply lessons from the game to advocate for sustainable practices and support policy changes in their communities.

Follow-Up Assignment: Ask participants to write a short reflection on how they would prioritize climate action in their own lives and communities, using insights from the game to guide their choices.

HANDOUT 1

Climate change jargon busting

1 If your group is new to the concept of climate change, you can start by asking them what they know about it. Explain that climate change is the long-term shift in average weather patterns across the world. Since the mid-1800s, humans have contributed to the release of carbon dioxide and other greenhouse gases into the air. This causes global temperatures to rise, resulting in long-term changes to the climate.

2 Write down the phrase climate change on the board or screen, and tell the group they are going to look at words connected to climate change

3 Split the group into teams of three or four, and ask each to write down as many words as possible connected to climate change in a time limit (e.g. 3 minutes). They don't have to be words they know the meaning of, although if they do, then they can share that with others later, but they should write down any that they think are connected to climate change

25 minutes

Groupwork

Jargon-busting cards

4 Then, ask the teams to highlight or circle words they think they understand the meaning of and could explain. Ask each team to share a couple of those words and explain what they mean, then ask them to share a couple of words they don't know the meaning of. This serves as an opportunity to share knowledge about the meaning of these words and highlight that some words are hard to understand

5 Explain that words by a profession or group that are difficult to understand are often called **jargon**. Explain that jargon-busting means giving simple, plain English explanations of jargon

6 Hand out the **jargon-busting** climate change cards (on page 3 to 7) and see if young people can highlight or circle any more words in their list. Words included on the cards are: greenhouse gas, climate, global warming, net zero, 1.5 degrees, greenhouse effect, CO_2 emissions, COP, fossil fuels, sea level rise, extreme weather, carbon footprint, carbon neutral, carbon offsetting, air pollution, biodiversity, deforestation, mitigation, adaptation

7 Ask each group to choose a word they want to **jargon-bust** and ask them to create a picture or poster to help another group understand the word better. If you have time, ask groups to present their jargon word to the rest of the groups

Optional extension

To extend this activity if you're in a school, ask the group to undertake a survey across the school featuring selected climate change words, to find out which words other classes are familiar with. To do this, they could list all the words and ask other young people in the school to circle the words they don't know or don't understand. If you're not in a school, you could get young people to do the same with their family or friends.

Ask your group to pick a word that other young people in the school, or in their family or group of friends, didn't understand and create a poster or display to explain what this word means. This could be displayed in the hall or corridor, or in their home, as the 'word of the week'.

Jargon-busting cards

Greenhouse effect

The greenhouse effect is the warming of planet Earth. It is caused by gases in the atmosphere capturing energy from the sun. These gases are called **greenhouse gases**. Without the greenhouse effect, Earth would be too cold for life to exist. But human activities such as burning coal, deforestation (chopping down lots of trees), driving cars or flying planes are increasing the greenhouse effect which causes the Earth to warm up more than it should.

Greenhouse gases

Greenhouse gases are gases in the air that capture energy from the Sun and warm the Earth's surface and air above it. The main ones are carbon dioxide, methane, nitrous oxide, and water vapor. Without these gases, Earth would be too cold for life and for humans to exist. But human activities such as burning coal, **deforestation** (chopping down lots of trees), driving cars or flying planes are increasing the amount of greenhouse gases in our atmosphere which is causing the Earth to warm up more than it should.

Climate change

Climate change refers to a global change in the planet's weather and average temperatures over a long period of time. Scientists have observed that the surface of the Earth is warming, and many of the warmest years on record have happened in the past 20 years. This warming has led to other changes in our weather patterns – such as more severe weather events around the world.

Climate

Climate is the average measurements of temperature, wind, snow, humidity and rain in the course of a long period of time in a particular location. Climate is like the weather, but over many years. To help you remember, someone once said "Climate is what you expect, weather is what you get".

Jargon-busting cards

CO_2 emissions

CO_2 stands for carbon dioxide, which is a **greenhouse gas**. Carbon dioxide is necessary for life on Earth. However, human activities such as burning coal, deforestation (chopping down lots of trees), driving cars or flying planes are increasing the amount of greenhouse gases in our atmosphere, which causes the Earth to warm up more than it should. CO_2 emissions usually refers to the CO_2 emitted because of human activities.

Net zero

Net zero refers to a state in which the **greenhouse gases** going into the atmosphere are balanced by removal out of the atmosphere. To achieve this, we need to lower the emissions we are sending into the atmosphere, from activities such as industry, transport, intensive agriculture, as well as removing greenhouse gases already in the atmosphere. Think about a bath with the taps turned on, to ensure the amount of water stays the same in the bath, you could either turn the tap off, or drain the water down the plug hole - or a combination of the two.

Carbon footprint

The term carbon footprint refers to how much carbon dioxide and methane is released into the air because of human activities. Companies, places, schools and individuals can have carbon footprints, made up from how much electricity they use, goods they produce or what they dispose of.

The Paris Agreement

The Paris Agreement is an agreement between more than 190 countries, planning to reduce greenhouse gases and limit global warming. It also looked at ways countries could change to deal with problems caused by **climate change**, and asked countries to spend money to make sure this would happen. It was signed in Paris in 2015.

Jargon-busting cards

1.5 degrees (1.5ºC)

Scientists agree that the rise in average global temperature, compared to the average global temperature recorded before we started emitting lots of greenhouse gases (often called pre-industrial temperature), must be kept below 1.5°C by the end of the century to avoid the worst impacts. If we don't manage to keep the temperature rise below 1.5°C, it means that sea levels could rise significantly, extreme weather events would be more frequent, and biodiversity could decline.

Fossil fuels

All the machines we use on a daily basis (such as cars, computers or TVs) require energy to make them work. Most of that energy comes from burning fossil fuels, which include oil, coal, and gas.

The issue with fossil fuels is that the planet's supply is limited, so it means that once we've used up all the resources, they will be no more resources. In addition, using fossil fuels harms the environment, because when we burn them, they release harmful gases which increase **global warming**.

Mitigation

Mitigation refers to human actions that seek to reduce **greenhouse gas** emissions and limit global warming. Mitigation measures may be carried out at different levels: international, national and local.

You may also make changes on a personal level in your consumption habits, for example by using public or alternative transport to get around, such as bicycles.

Jargon-busting cards

Extreme weather

Extreme weather is when a weather is significantly different from the usual weather. Types of extreme weathers include flooding, drought, storms, cold spells and heat waves. **Climate change** is expected to increase the intensity, frequency, and impacts of extreme weather events.

COP

COP, which stands for Conference of the Parties, it is a conference run by the United Nations, an international organisation aiming at maintaining peace and security. Every year, leaders from many countries meet in a different place to discuss what needs to be put in place to tackle **climate change**.

Carbon offsetting

Carbon offsetting is the action of compensating for greenhouse gas **emissions** arising from human activity, by giving money to organisations which help the environment by reducing carbon emissions or concentrations in the atmosphere – for instance by planting trees.

Air pollution

Air pollution is contamination of the indoor or outdoor environment. It can come from heating, transport, industry or forest fires. Outdoor and indoor air pollution can cause respiratory issues and other diseases and can affect animals and plants.

Sea level rise

Sea level rise is an increase in the level of the world's oceans and seas due to the effects of **global warming**. When it gets warmer, water expands so it takes up more space, which causes sea level to rise. Sea level is also rising because glaciers and ice caps are melting and adding more water to the oceans.

Global warming

Global warming is the term used to describe the rising of the average temperature on Earth. The current **climate change** comes from global warming caused by human activity, such as burning coal, using oil, driving cars, or producing goods.

Jargon-busting cards

Biodiversity

Biodiversity covers the variety of living species on Earth, such as plants, animals and bacteria. Many species are being threatened with extinction due to **climate change** and human activities, putting biodiversity at risk.

Adaptation

Adaptation is the process of adjusting our lifestyle to the changes brought by **global warming** and **climate change**. For example, some coastal towns are building sea walls, which are walls to protect the coast, to protect themselves against **sea level rise**.

Deforestation

Deforestation means chopping down lots of trees in forest across the world to make space for agriculture, new constructions or mining activities and use the trees for fuel and constructions. Deforestation can negatively impact people, animals and plants because it destroys the environment they live in.

Climate activism

Climate activism is when people come together to put pressure on leaders to take action to tackle **climate change**. The Swedish activist Greta Thunberg is one of the most famous young activists, known for challenging world leaders to take immediate action for climate change.

High Meadows Environmental Institute | Carbon Mitigation Initiative

PRINCETON UNIVERSITY

Author: Roberta Hotinski

Stabilization Wedges: A Concept & Game

The **Carbon Mitigation Initiative** is a joint project of Princeton University, BP, and Ford Motor Company to find solutions to the greenhouse gas problem. To emphasize the need for early action, Co-Directors Robert Socolow and Stephen Pacala created the concept of stabilization wedges: 25-billion-ton "wedges" that need to be cut out of predicted future carbon emissions in the next 50 years to avoid a doubling of atmospheric carbon dioxide over pre-industrial levels.

The following pages contain:

- An introduction to the carbon and climate problem and the stabilization wedge concept (pp. 1-3)
- Descriptions of currently available mitigation tools that have the capacity to reduce future emissions by at least one wedge (pp. 4-8)
- Materials and instructions for carrying out the "Stabilization Wedges Game," an activity that drives home the scale of the carbon mitigation challenge and the tradeoffs involved in planning climate policy (pp. 9-16)

For more information about CMI, contact

Carbon Mitigation Initiative
Princeton Environmental Institute
Princeton University
Princeton, NJ 08544
USA

http://cmi.princeton.edu

You can download a free up-to-date copy of this guide and view additional resources at our wedge website:

http://cmi.princeton.edu/wedges/

We hope to revise these materials with your input! If you have questions/feedback, please contact Kristina Corvin at kcorvin@princeton.edu

The Carbon and Climate Problem

Evidence continues to accumulate that carbon dioxide, or CO_2, from fossil fuel burning is causing dangerous interference in the climate. . Nine of the ten warmest years on record have occurred since 2001 and the ten warmest years have occurred since 1998. Tropical glaciers with ice thousands and tens of thousands years old are disappearing, offering graphic rebuttal to claims that the recent warming is part of a natural cycle. Models predict that, without action to curb the growth of greenhouse gases in the atmosphere, we risk triggering catastrophe -- cessation of the dominant pattern of ocean circulation, loss of the West Antarctic ice sheet, or a several-fold increase in category-five hurricanes.

CO_2 and some other gases in the atmosphere change the climate by letting sunlight pass through the atmosphere and warm the planet, but hindering the escape of heat to outer space (a phenomenon popularly known as "the greenhouse effect"). By burning fossil fuels, which are composed mainly of hydrogen and carbon, we add CO_2 to the atmosphere.

The Earth's atmosphere currently contains about **800 billion tons** of carbon as CO_2, and combustion of fossil fuels currently adds about **8 billion tons of carbon** every year. If we think of the atmosphere as a bathtub, these carbon emissions are like water coming out of the tap to fill the tub (**Figure 1**). The ocean and land biosphere act as two drains for this bathtub – carbon can be taken out of the atmosphere by being dissolved in the surface ocean or being taken up by growing forests. However, these two "drains" only take out about half the carbon we emit to the atmosphere every year. The remainder accumulates in the atmosphere (currently at a rate of roughly 4 billion tons per year), so the level of carbon in the tub is rising.

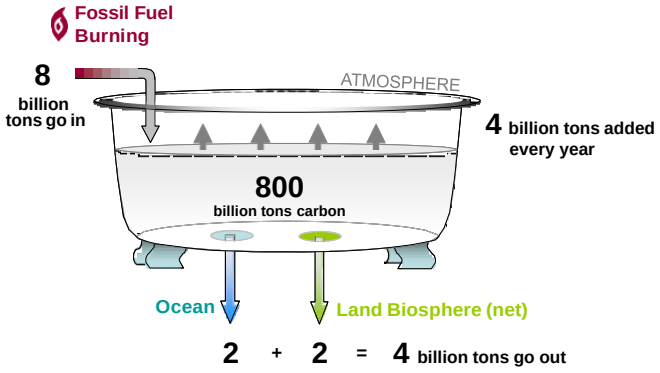


Figure 1. The atmosphere as a bathtub, with current annual inputs and outputs of carbon. The level in the tub is rising by about 4 billion tons per year.

The fossil fuel tap was "opened" with the Industrial Revolution. In pre-industrial times, the atmosphere contained only about 600 billion tons of carbon, 200 billion tons less than today (Figure 2). As an illustration of the importance of CO_2 to the Earth's climate, ice core records show that past atmospheric carbon changes of a similar magnitude have meant the difference between Ice Ages and the familiar warmer conditions of the past 10,000 years.

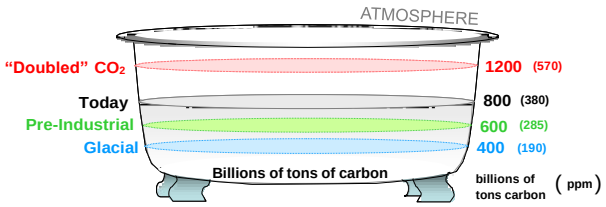


Figure 2. Past, present, and potential future levels of carbon in the atmosphere in two units. 2.1 billions of tons of carbon = 1 part per million (ppm).

Observations indicate that the carbon already added to the atmosphere has raised the global average temperature by around 1º Fahrenheit since the 19th century, and almost every year the fossil fuel tap is opened wider. An average of many forecasts predicts that we'll be adding **16 billion tons** of carbon per year to the "bathtub" in 50 years, twice today's rate, unless action is taken to control carbon emissions. If we follow this path, the amount of carbon in the atmosphere will reach 1200 billion tons -- **double its pre-industrial value** – well before the end of this century, **and will continue to increase** into the future. As a result, the Earth's temperature is expected to rise at a rate unprecedented in the last 10,000 years. **How can we get off this path?**

An Introduction to Stabilization Wedges

The "stabilization wedges" concept is a simple tool for conveying the emissions cuts that can be made to avoid dramatic climate change.

We consider two futures - **allowing emissions to double versus keeping emissions at current levels** for the next 50 years (Figure 3). The emissions-doubling path (black dotted line) falls in the middle of the field of most estimates of future carbon emissions. The climb approximately extends the climb for the past 50 years, during which the world's economy grew much faster than its carbon emissions. Emissions could be higher or lower in 50 years, but this path is a reasonable reference scenario.

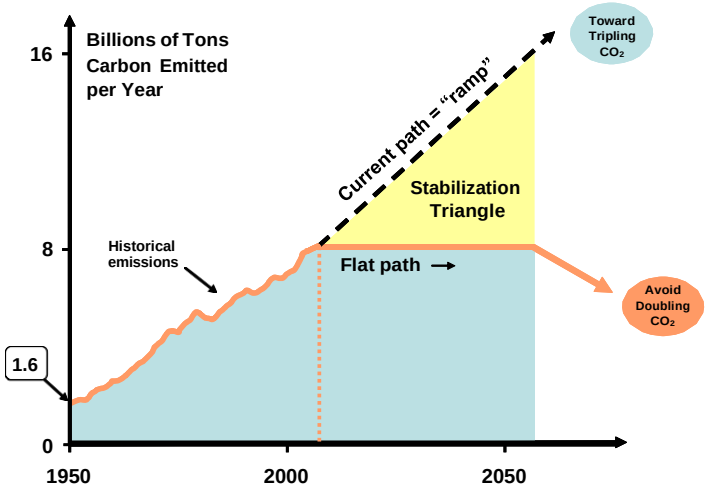


Figure 3. Two possible emissions scenarios define the "stabilization triangle."

The emissions-doubling path is predicted to lead to significant global warming by the end of this century. This warming is expected be accompanied by decreased crop yields, increased threats to human health, and more frequent extreme weather events. The planet could also face rising sea-level from melting of the West Antarctic Ice Sheet and Greenland glaciers and destabilization of the ocean's thermohaline circulation that helps redistribute the planet's heat and warm Western Europe.

In contrast, we can prevent a doubling of CO_2 if we can keep emissions flat for the next 50 years, then work to reduce emissions in the second half of the century (Figure 3, orange line). This path is predicted to keep atmospheric carbon under 1200 billion tons (which corresponds to about 570 parts per million (ppm)), allowing us to skirt the worst predicted consequences of climate change.

Keeping emissions flat will require cutting projected carbon output by about 8 billion tons per year by 2060, keeping a total of ~200 billion tons of carbon from entering the atmosphere (see yellow triangle in Figure 3). This carbon savings is what we call the **"stabilization triangle."**

The conventional wisdom has been that only revolutionary new technologies like nuclear fusion could enable such large emissions cuts. There is no reason, however, why one tool should have to solve the whole problem. CMI set out to quantify the impact that could be made by **a portfolio of existing technologies** deployed on a massive scale.

To make the problem more tractable, we divided the stabilization triangle into **eight "wedges."** (Figure 4) A wedge represents a carbon-cutting strategy that has the potential to grow from zero today to avoiding 1 billion tons of carbon emissions per year by 2060, or one-eighth of the stabilization triangle. The wedges can represent ways of either making energy with no or reduced carbon emissions (like nuclear or wind-produced electricity), or storing carbon dioxide to prevent it from building up as rapidly in the atmosphere (either through underground storage or biostorage).

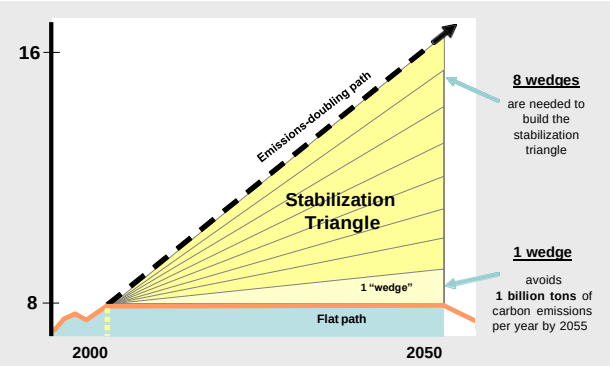


Figure 4. The eight "wedges" of the stabilization triangle.

Keeping emissions flat will require the world's societies to "fill in" the eight wedges of the stabilization triangle. In CMI's analysis, **at least 15 strategies are available now** that, with scaling up, could each take care of at least one wedge of emissions reduction. No one strategy can take care of the whole triangle -- new strategies will be needed to address both fuel and electricity needs, and some wedge strategies compete with others to replace emissions from the same source -- but there is already a more than adequate portfolio of tools available to control carbon emissions for the next 50 years.

Wedge Strategies Currently Available

The following pages contain descriptions of 15 strategies already available that could be scaled up over the next 50 years to reduce global carbon emissions by 1 billion tons per year, or **one wedge.** They are grouped into four major color-coded categories:

Efficiency & Conservation

- Increased transport efficiency
- Reducing miles traveled
- Increased building efficiency
- Increased efficiency of electricity production

Fossil-Fuel-Based Strategies

- Fuel switching (coal to gas)
- Fossil-based electricity with carbon capture & storage (CCS)
- Coal synfuels with CCS
- Fossil-based hydrogen fuel with CCS

Nuclear Energy

- Nuclear electricity

Renewables and Biostorage

- Wind-generated electricity
- Solar electricity
- Wind-generated hydrogen fuel
- Biofuels
- Forest storage
- Soil storage

Each strategy can be applied to one or more sectors, indicated by the following symbols:

= Electricity Production, =Heating and Direct Fuel Use, =Transportation, = Biostorage

Increased Efficiency & Conservation

1. Transport Efficiency

A typical 30 miles per gallon (30 mpg) car driving 10,000 miles per year emits a ton of carbon into the air annually. Today there are about about 600 million cars in the world, and it's predicted that there will be about 2 billion passenger vehicles on the road in 50 years. **A wedge of emissions savings would be achieved if the fuel efficiency of all the cars projected for 2060 were doubled from 30 mpg to 60 mpg**. Efficiency improvements could come from using hybrid and diesel engine technologies, as well as making vehicles out of strong but lighter materials.

Cutting carbon emissions from trucks and planes by making these engines more efficient can also help with this wedge. Aviation is the fastest growing component of transportation.

2. Transport Conservation

A wedge would be achieved if the number of miles traveled by the world's cars were cut in half. Such a reduction in driving could be achieved if urban planning leads to more use of mass transit and if electronic communication becomes a good substitute for face-to-face meetings.

3. Building Efficiency

Today carbon emissions arise about equally from providing electricity, transportation, and heat for industry and buildings. The largest potential savings in the buildings sector are in space heating and cooling, water heating, lighting, and electric appliances.

It's been projected that the buildings sector as a whole has the technological and economic potential to cut emissions in half. **Cutting emissions by 25% in all new and existing residential and commercial buildings would achieve a wedge worth of emissions reduction.** Carbon savings from space and water heating will come from both end-use efficiency strategies, like wall and roof insulation, and renewable energy strategies, like solar water heating and passive solar design.

4. Efficiency in Electricity Production

Today's coal-burning power plants produce about one-fourth of the world's carbon emissions, so increases in efficiency at these plants offer an important opportunity to reduce emissions**. Producing the world's current coal-based electricity with doubled efficiency would save a wedge worth of carbon emissions.**

More efficient conversion results at the plant level from better turbines, from using high-temperature fuel cells, and from combining fuel cells and turbines. At the system level, more efficient conversion results from more even distribution of electricity demand, from cogeneration (the co-production of electricity and useful heat), and from polygeneration (the co-production of chemicals and electricity).

Due to large contributions by hydropower and nuclear energy, the electricity sector already gets about 35% of its energy from non-carbon sources. Wedges can only come from the remaining 65%.

Suggested Link:
IPCC Working Group III Report "Mitigation of Climate Change", Chapters 4, 5 & 6
http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm

Carbon Capture & Storage (CCS)

If the CO_2 emissions from fossil fuels can be captured and stored, rather than vented to the atmosphere, then the world could continue to use coal, oil, and natural gas to meet energy demands without harmful climate consequences. The most economical way to pursue this is to capture CO_2 at large electricity or fuels plants, then store it underground. This strategy, called carbon capture and storage, or **CCS**, is already being tested in pilot projects around the world.

5. CCS Electricity

Today's coal-burning power plants produce about one fourth of the world's carbon emissions and are large point-sources of CO_2 to the atmosphere. **A wedge would be achieved by applying CCS to 800 large (1 billion watt) baseload coal power plants or 1600 large baseload natural gas power plants in 50 years. As with all CCS strategies, to provide low-carbon energy the captured CO_2 would need to be stored for centuries.**

There are currently 3 pilot storage projects in the world, which each store about 1 million tons of carbon underground per year. Storing a wedge worth of emissions will require 3500 times the capacity of one of these projects.

6. CCS Hydrogen

Hydrogen is a desirable fuel for a low-carbon society because when it's burned the only emission product is water vapor. Because fossil fuels are composed mainly of carbon and hydrogen they are potential sources of hydrogen, but to have a climate benefit the excess carbon must be captured and stored.

Pure hydrogen is now produced mainly in two industries: ammonia fertilizer production and petroleum refining. Today these hydrogen production plants generate about 100 million tons of capturable carbon. Now this CO_2 is vented, but only small changes would be needed to implement carbon capture. **The scale of hydrogen production today is only ten times smaller than the scale of a wedge of carbon capture.**

Distributing CCS hydrogen, however, requires building infrastructure to connect large hydrogen-producing plants with smaller-scale users.

7. CCS Synfuels

In 50 years a significant fraction of the fuels used in vehicles and buildings may not come from conventional oil, but from coal. When coal is heated and combined with steam and air or oxygen, carbon monoxide and hydrogen are released and can be processed to make a liquid fuel called a "synfuel."

Coal-based synfuels result in nearly twice the carbon emissions of petroleum-derived fuels, since large amounts of excess carbon are released during the conversion of coal into liquid fuel. The world's largest synfuels facility, located in South Africa, is the largest point source of atmospheric CO_2 emissions in the world. **A wedge is an activity that, over 50 years, can capture the CO_2 emissions from 180 such coal-to-synfuels facilities.**

Suggested link:
IPCC Special Report on Carbon dioxide Capture and Storage, SPM
http://www.ipcc.ch/pdf/specialreports/srccs/srccs_summaryforpolicymakers.pdf

Fuel Switching

8. Fuel-Switching for Electricity

Because of the lower carbon content of natural gas and higher efficiencies of natural gas plants, producing electricity with natural gas results in only about half the emissions of coal. **A wedge would require 1400 large (1 billion watt) natural gas plants displacing similar coal-electric plants.**

This wedge would require generating approximately four times the Year 2000 global production of electricity from natural gas. In 2060, 1 billion tons of carbon per year would be emitted from natural gas power plants instead of 2 billion tons per year from coal-based power plants.

Materials flows equivalent to one billion tons of carbon per year are huge: a wedge of flowing natural gas is equivalent to 50 large liquefied natural gas (LNG) tankers docking and discharging every day. Current LNG shipments world-wide are about one-tenth as large.

Nuclear Energy

9. Nuclear Electricity

Nuclear fission currently provides about 17% of the world's electricity, and produces no CO_2. **Adding new nuclear electric plants to triple the world's current nuclear capacity would cut emissions by one wedge if coal plants were displaced.**

In the 1960s, when nuclear power's promise as a substitute for coal was most highly regarded, a global installed nuclear capacity of about 2000 billion watts was projected for the year 2000. The world now has about one-sixth of that envisioned capacity. If the remainder were to be built over the next 50 years to displace coal-based electricity, roughly two wedges could be achieved.

In contrast, phasing out the worlds' current capacity of nuclear power would require adding an additional half wedge of emissions cuts to keep emissions at today's levels.

Nuclear fission power generates plutonium, a fuel for nuclear weapons. These new reactors would add several thousand tons of plutonium to the world's current stock of reactor plutonium (roughly 1000 tons).

IPCC Working Group III Report "Mitigation of Climate Change", Chapter 4 - Energy Supply
http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter4.pdf

Renewable Energy & Biostorage

10. Wind Electricity

Wind currently produces less than 1% of total global electricity, but wind electricity is growing at a rate of about 30% per year. **To gain a wedge of emissions savings from wind displacing coal-based electricity, current wind capacity would need to be scaled up by a factor of 10.**

This increase in capacity would require deployment of about 1 million large windmills. Based on current turbine spacing on wind farms, a wedge of wind power would require a combined area roughly the size of Germany. However, land from which wind is harvested can be used for many other purposes, notably for crops or pasture.

11. Solar Electricity

Photovoltaic (PV) cells convert sunlight to electricity, providing a source of CO_2-free and renewable energy. The land demand for solar is less than with other renewables, but **installing a wedge worth of PV would still require arrays with an area of two million hectares, or 20,000 km^2.** The arrays could be located on either dedicated land or on multiple-use surfaces such as the roofs and walls of buildings. The combined area of the arrays would cover an area the size of the U.S. state of New Jersey, or about 12 times the size of the London metropolitan area.

Since PV currently provides less than a tenth of one percent of global electricity, achieving a wedge of emissions reduction would require increasing the deployment of PV by a factor of 100 in 50 years, or installing PV at about 2.5 times the 2009 rate for 50 years.

A current drawback for PV electricity is its price, which is declining but is still 2-5 times higher than fossil-fuel-based electricity. Also, PV can not be collected at night and, like wind, is an intermittent energy source.

12. Wind Hydrogen

Hydrogen is a desirable fuel for a low-carbon society because when it's burned the only emission product is water vapor. To produce hydrogen with wind energy, electricity generated by wind turbines is used in electrolysis, a process that liberates hydrogen from water. **Wind hydrogen displacing vehicle fuel is only about half as efficient at reducing carbon emissions as wind electricity displacing coal electricity, and 2 million (rather than 1 million) windmills would be needed for one wedge of emissions reduction.** That increase would require scaling up current wind capacity by about 20 times, requiring a land area roughly the size of France.

Unlike hydrogen produced from fossil fuels with CCS, wind hydrogen could be produced at small scales where it is needed. Wind hydrogen thus would require less investment in infrastructure for fuel distribution to homes and vehicles.

Renewables & Biostorage (cont'd)

13. Biofuels

Because plants take up carbon dioxide from the atmosphere, combustion of biofuels made from plants like corn and sugar cane simply returns "borrowed" carbon to the atmosphere. Thus burning biofuels for transportation and heating will not raise the atmosphere's net CO_2 concentration.

The land constraints for biofuels, however, are more severe than for wind and solar electricity. Using current practices, just one wedge worth of carbon-neutral biofuels would require 1/6th of the world's cropland and an area roughly the size of India. Bioengineering to increase the efficiency of plant photosynthesis and use of crop residues could reduce that land demand, but large-scale production of plant-based biofuels will always be a land-intensive proposition.

Ethanol programs in the U.S. and Brazil currently produce about 20 billion gallons of biofuel per year from corn and sugarcane. **One wedge of biofuels savings would require increasing today's global ethanol production by about 12 times, and making it sustainable.**

14. Forest Storage

Land plants and soils contain large amounts of carbon. Today, there is a net *removal* of carbon from the atmosphere by these "natural sinks," in spite of deliberate deforestation by people that *adds* between 1 and 2 billion tons of carbon to the atmosphere. Evidently, the carbon in forests is increasing elsewhere on the planet.

Land plant biomass can be increased by both reducing deforestation and planting new forests. **Halting global deforestation in 50 years would provide one wedge of emissions savings.** To achieve a wedge through forest planting alone, new forests would have to be established over an area the size of the contiguous United States.

15. Soil Storage

Conversion of natural vegetation to cropland reduces soil carbon content by one-half to one-third. However, soil carbon loss can be reversed by agricultural practices that build up the carbon in soils, such as reducing the period of bare fallow, planting cover crops, and reducing aeration of the soil (such as by no till, ridge till, or chisel plow planting). **A wedge of emissions savings could be achieved by applying carbon management strategies to all of the world's existing agricultural soils.**

Suggested links:
U.S. DOE, Energy Efficiency & Renewable Energy
http://www.eere.energy.gov/

IPCC Working Group III Report "Mitigation of Climate Change", Chapters 8 & 9
http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm

The Stabilization Wedges Game — Lesson Plan

Goals
The core purpose of this game is to convey the scale of effort needed to address the carbon and climate situation and the necessity of developing a portfolio of options. By the end of the exercise, students should understand the magnitude of human-sourced carbon emissions and feel comfortable comparing the effectiveness, benefits, and drawbacks of a variety of carbon-cutting strategies. The students should appreciate that **there is no easy or "right" solution to the carbon and climate problem.**

Objectives
Students will learn about the technologies currently available that can substantially cut carbon emissions, develop critical reasoning skills as they create their own portfolio of strategies to cut emissions, and verbally communicate the rationale for their selections. Working in teams, students will develop the skills to negotiate a solution that is both physically plausible and politically acceptable, and defend their solution to a larger group.

National Science Content Standards

- Systems, Order and Organization
- Science as Inquiry
- Science in Personal and Social Perspectives
  Natural and Human Induced Hazards
  Environmental Quality

Materials (see **Student Game Materials** at end of packet)
- 1 copy of Instructions and Wedge Table **per student (print single-sided to allow use of gameboard pieces!)**
- 1 Wedge Worksheet and 1 Gameboard with multi-colored wedge pieces **per group**, plus scissors for cutting out game pieces and glue sticks or tape to secure pieces to gameboard
- Optional - overhead transparencies, posters, or other materials for group presentations

Time Required
We suggest using 2-3 standard (40-50 minute) class periods to prepare for and play the Stabilization Wedges game. In the first period, the Stabilization Triangle and the concept of wedges are discussed and the technologies introduced. Students can further research the technologies as homework. In the second period, students play the game and present their results. Depending on the number of groups in the class, an additional period may be needed for the presentation of results. Assessment and application questions are included and may be assigned as homework after the game has been played, or discussed as a group as part of an additional class period/assignment.

Lesson Procedure/Methodology

I. **<u>Introduction</u> (40 minutes)**

a. Motivation. Review the urgency of the carbon and climate problem and potential ways it may impact the students' futures.

b. Present the Concepts. Introduce the ideas of the Stabilization Triangle and its eight "wedges".

c. Introduce the Technologies. Briefly describe the 15 wedge strategies identified by CMI, then have students familiarize themselves with the strategies as homework. Participants are free to critique any of the wedge strategies that CMI has identified, and teams should feel free to use strategies not on our list.

d. Form Teams. Teams of 3 to 6 players are best, and it is particularly helpful to have each student be an appointed "expert" in a few of the technologies to promote good discussions. You may want to identify a recorder and reporter in each group.

e. Explain the Rules. See instructions in **Student Game Materials** at back of packet

II. **Playing the Game (40 minutes)**

a. Filling in the Stabilization Triangle. Teammates should work together to build a team stabilization triangle using 8 color-coded wedges labeled with specific strategies. Many strategies can be used more than once.

b. Wedge Worksheet. Each team should fill in one **stabilization wedge worksheet** to make sure players haven't violated the constraints of the game, to tally costs, and to predict judges' ratings of their solution. NOTE: Costs are for guidance only – they are not meant to be used to produce a numerical score that wins or loses the game!

c. Reviewing the Triangle. Each team should review the strengths and weaknesses of its strategies in preparation for reporting and defending its solutions to the class.

III. **Reports (depending on the number of groups this may require an additional class period)**

a. Representatives from each team will defend their solutions to the class in a 5-minute report. The presentation can be a simple verbal discussion by the group or a reporter designated by the group. If additional time is available, the presentations could include visual aids, such as a poster, PowerPoint presentation, etc.

b. Students should address not only the technical viability of their wedges, but also the economic, social, environmental and political implications of implementing their chosen strategies on a massive scale.

IV. **Judging**

In CMI workshops, the teams' triangles have been judged by experts from various global stakeholder groups, such as an environmental advocacy organization, the auto industry, a developing country, or the U.S. Judging ensures that economic and political impacts are considered and emphasizes the need for consensus among a broad coalition of stakeholders. For a classroom, judges can be recruited from local government, colleges, businesses, and non-profit organizations, or a teacher/facilitator can probe each team about the viability of its strategies.

V. **Closure/Assessment of Student Learning**

In addition to addressing the game and lessons learned, discussion questions are provided below that give opportunity to develop and assess the students' understanding of the wedges concept and its applications.

1) Given physical challenges and risks, how many wedges do you think each wedge strategy can each realistically provide?

2) In choosing wedge strategies, it's important to avoid double counting – removing the same emissions with two different strategies. For example, there are 6 strategies for cutting emissions from electricity, but we project only 5 wedges worth of carbon produced from the electric sector 50 years from now. Can you think of reasons, other than the adoption of alternative or nuclear energy, that emissions from electricity would be lower or higher than we predict? Examples: increased use of carbon-intensive coal versus natural gas (higher), slower population growth (lower), substitution of electricity for fuel, as via plug-in electric cars (higher).

3) Industrialized countries and developing countries now each contribute about half the world's emissions, although the poorer countries have about 85% of the world's population. (The U.S. alone emits one fourth of the world's CO_2.) If we agree to freeze global emissions at current levels, that means if **emissions in one region of the world go up as a result of economic/industrial development, then emissions must be cut elsewhere**. Should the richer countries reduce their emissions 50 years from now so that extra carbon emissions can be available to developing countries? If so, by how much?

4) Nuclear energy is already providing one-half wedge of emissions savings – what do you think the future of these plants should be?

5) Automobile emissions are a popular target for greenhouse gas cuts. What percent of greenhouse gases do you think come from the world's passenger vehicles? (answer: about 18%)

Resources & Feedback

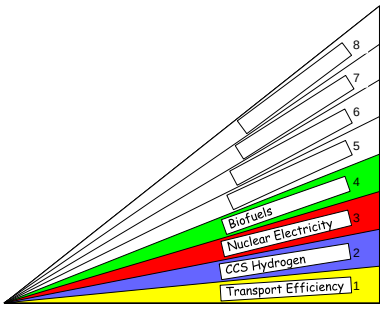
More stabilization wedge resources, including background articles and slides, are available at **http://cmi.princeton.edu/wedges**

Student Game Instructions & Materials

The goal of this game is to **construct a stabilization triangle using eight wedge strategies**, with only a few constraints to guide you. From the 15 potential strategies, choose 8 wedges that your team considers the best global solutions. Keep costs and impacts in mind.

1) Find the Wedge Gameboard in the back of this packet and cut apart the red, green, yellow, and blue wedge pieces supplied (if not already done for you).

2) Read the information on each of the 15 strategies in the **Wedge Table** below. Costs ($, $$, $$$) are indicated on a relative basis, and are intended only to provide guidance, not a numerical score. Feel free to argue against any information presented and include alternative wedge strategies if you can support them.



3) Each team should **choose one wedge strategy at a time** to fill the 8 spots on the wedge gameboard (see illustration of gameboard with 4 wedges filled in at left – this is only an example!).

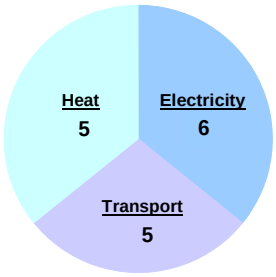
4) The four colors of the wedge pieces indicate the major category (fossil fuel-based (blue), efficiency and conservation (yellow), nuclear (red), and renewables and biostorage (green)). Choose a red, yellow, blue, or green wedge for your strategy, then **label the wedge to indicate the specific strategy** (examples shown in illustration at left).

5) Most strategies may be used more than once, but not all cuts can come from one energy sector.

Of the 16 billion tons of carbon emitted in the 2060 baseline scenario, we assume electricity production accounts for 6 wedges, transportation fuels accounts for 5 wedges, and direct fuel use for heat and other purposes accounts for 5 wedges (see pie chart right).

Because biostorage takes carbon from all sources out of the atmosphere, biostorage wedges do not count toward an energy sector.

Carbon Emissions by Sector



Need 8 wedges – not all wedges can come from one energy sector!

6) Cost and impacts must be considered. Each wedge should be viewed in terms of both technical and political viability.

7) For each of the 8 strategies chosen, each team should **fill out one line in the Wedge Worksheet**. After all 8 wedges have been chosen, tally total cuts from each energy sector (Electricity, Transport, and Heat) and costs. Use the scoring table to predict how different interest groups would rate your wedge on a scale from 1 to 5.

8) Each team should **give a 5-minute oral report** on the reasoning behind its triangle. The report should justify your choice of wedges to the judge(s) and to the other teams. **Note: There is no "right" answer** – the team that makes the best case wins, not necessarily the team with the cheapest or least challenging solution

Stabilization Wedges — 15 Ways to Cut Carbon

= Electricity Production, =Heating and Direct Fuel Use, =Transportation, = Biostorage

Strategy	Sector	Description	1 wedge could come from…	Cost	Challenges
1. Efficiency — Transport		Increase automobile fuel efficiency (2 billion cars projected in 2050)	**… doubling the efficiency of all world's cars from 30 to 60 mpg**	**$**	Car size & power
2. Conservation - Transport		Reduce miles traveled by passenger and/or freight vehicles	**… cutting miles traveled by all passenger vehicles in half**	**$**	Increased public transport, urban design
3. Efficiency - Buildings		Increase insulation, furnace and lighting efficiency	**… using best available technology in all new and existing buildings**	**$**	House size, consumer demand for appliances
4. Efficiency — Electricity		Increase efficiency of power generation	**… raising plant efficiency from 40% to 60%**	**$**	Increased plant costs
5. CCS Electricity		90% of CO_2 from fossil fuel power plants captured, then stored underground (800 large coal plants or 1600 natural gas plants)	**… injecting a volume of CO_2 every year equal to the volume of oil extracted**	**$$**	Possibility of CO_2 leakage
6. CCS Hydrogen		Hydrogen fuel from fossil sources with CCS displaces hydrocarbon fuels	**… producing hydrogen at 10 times the current rate**	**$$$**	New infrastructure needed, hydrogen safety issues
7. CCS Synfuels		Capture and store CO_2 emitted during synfuels production from coal	**… using CCS at 180 large synfuels plants**	**$$**	Emissions still only break even with gasoline
8. Fuel Switching — Electricity		Replacing coal-burning electric plants with natural gas plants (1400 1 GW coal plants)	**… using an amount of natural gas equal to that used for all purposes today**	**$**	Natural gas availability
9. Nuclear Electricity		Displace coal-burning electric plants with nuclear plants (Add double current capacity)	**… ~3 times the effort France put into expanding nuclear power in the 1980's, sustained for 50 years**	**$$**	Weapons proliferation, nuclear waste, local opposition
10. Wind Electricity		Wind displaces coal-based electricity (10 x current capacity)	**… using area equal to ~3% of U.S. land area for wind farms**	**$$**	Not In My Back Yard (NIMBY)
11. Solar Electricity		Solar PV displaces coal-based electricity (100 x current capacity)	**.. using the equivalent of a 100 x 200 km PV array**	**$$$**	PV cell materials
12. Wind Hydrogen		Produce hydrogen with wind electricity	**… powering half the world's cars predicted for 2050 with hydrogen**	**$$$**	NIMBY, Hydrogen infrastructure, safety
13. Biofuels		Biomass fuels from plantations replace petroleum fuels	**… scaling up world ethanol production by a factor of 12**	**$$**	Biodiversity, competing land use
14. Forest Storage		Carbon stored in new forests	**… halting deforestation in 50 years**	**$**	Biodiversity, competing land use
15. Soil Storage		Farming techniques increase carbon retention or storage in soils	**… practicing carbon management on all the world's agricultural soils**	**$**	Reversed if land is deep-plowed later

For more information, visit our website at http://cmi.princeton.edu/wedges.

Wedge Worksheet

1. Record your strategies to reduce total fossil fuel emissions by 8 wedges by 2060.
(1 "wedge" = 1 billion tons carbon per year)

- You may use a strategy more than once
- Use only whole numbers of wedges
- You may use a maximum of
  - 6 electricity wedges (E)
  - 5 transportation wedges(T)
  - 5 heat or direct fuel use wedges (H)

	Strategy	Sector (E,T,H or B)	Cost ($)	Challenges
1				
2				
3				
4				
5				
6				
7				
8				
	TOTALS	E =___ (6 max) T =___ (5 max) H = (5 max) B = ___	_____	

2. Guess the score each stakeholder group would give your team's triangle on a scale of 1 to 5 (5 = best).

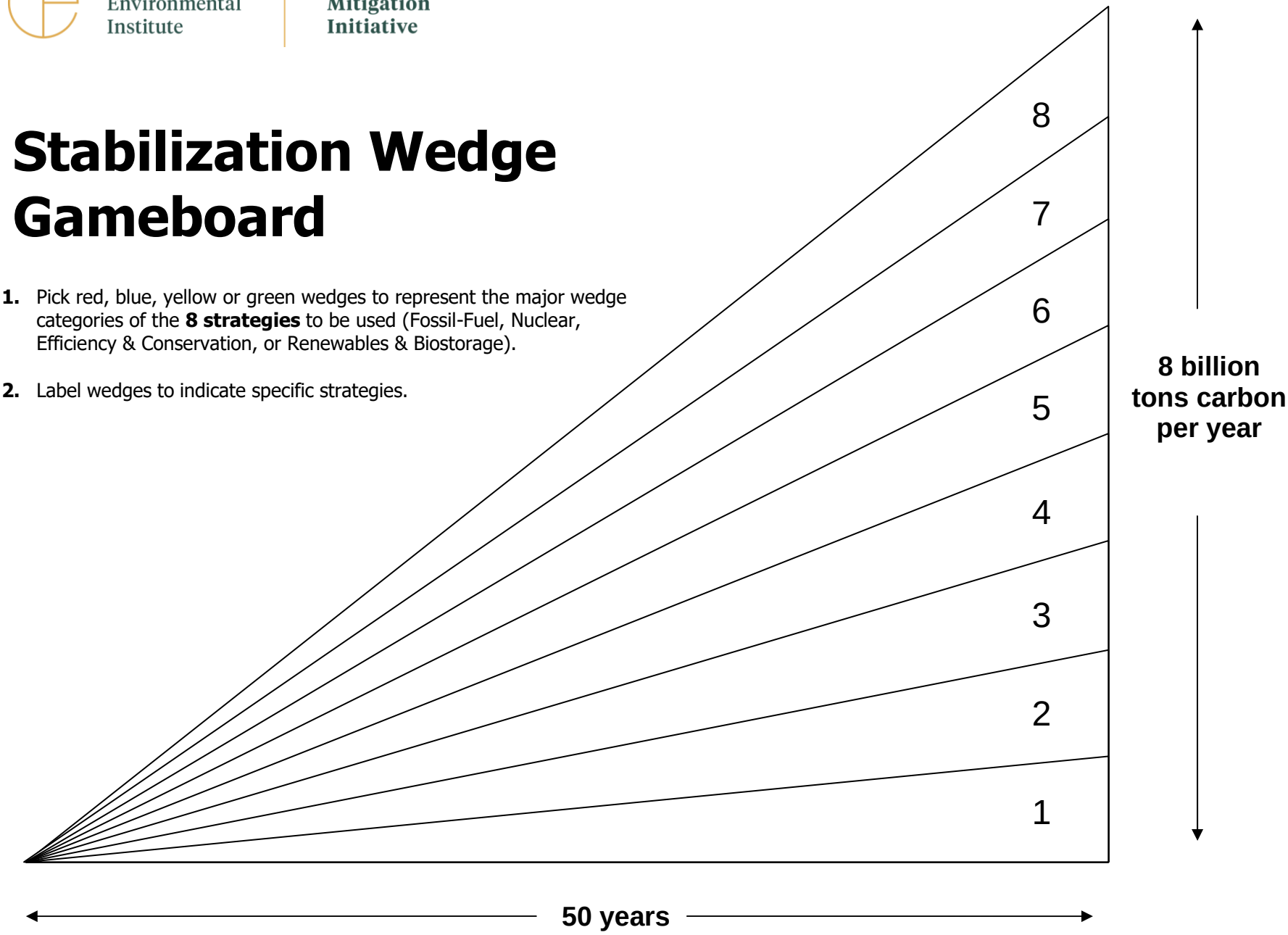
Judge:	Taxpayers/ Consumers	Energy Companies	Environmental Groups	Manufacturers	Industrialized country governments	Developing country governments
Score:						

High Meadows Environmental Institute | Carbon Mitigation Initiative

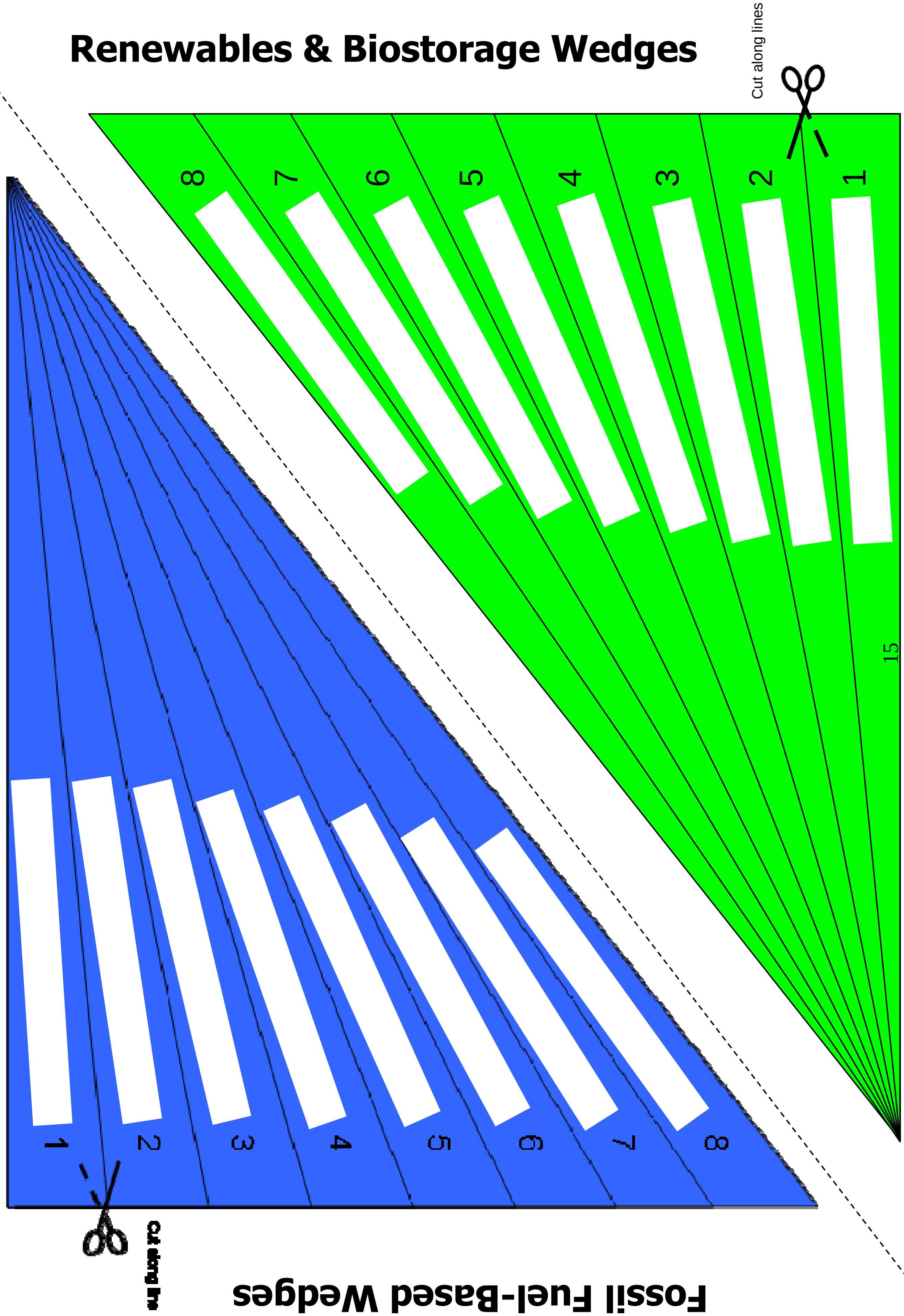
Stabilization Wedge Gameboard

1. Pick red, blue, yellow or green wedges to represent the major wedge categories of the **8 strategies** to be used (Fossil-Fuel, Nuclear, Efficiency & Conservation, or Renewables & Biostorage).

2. Label wedges to indicate specific strategies.

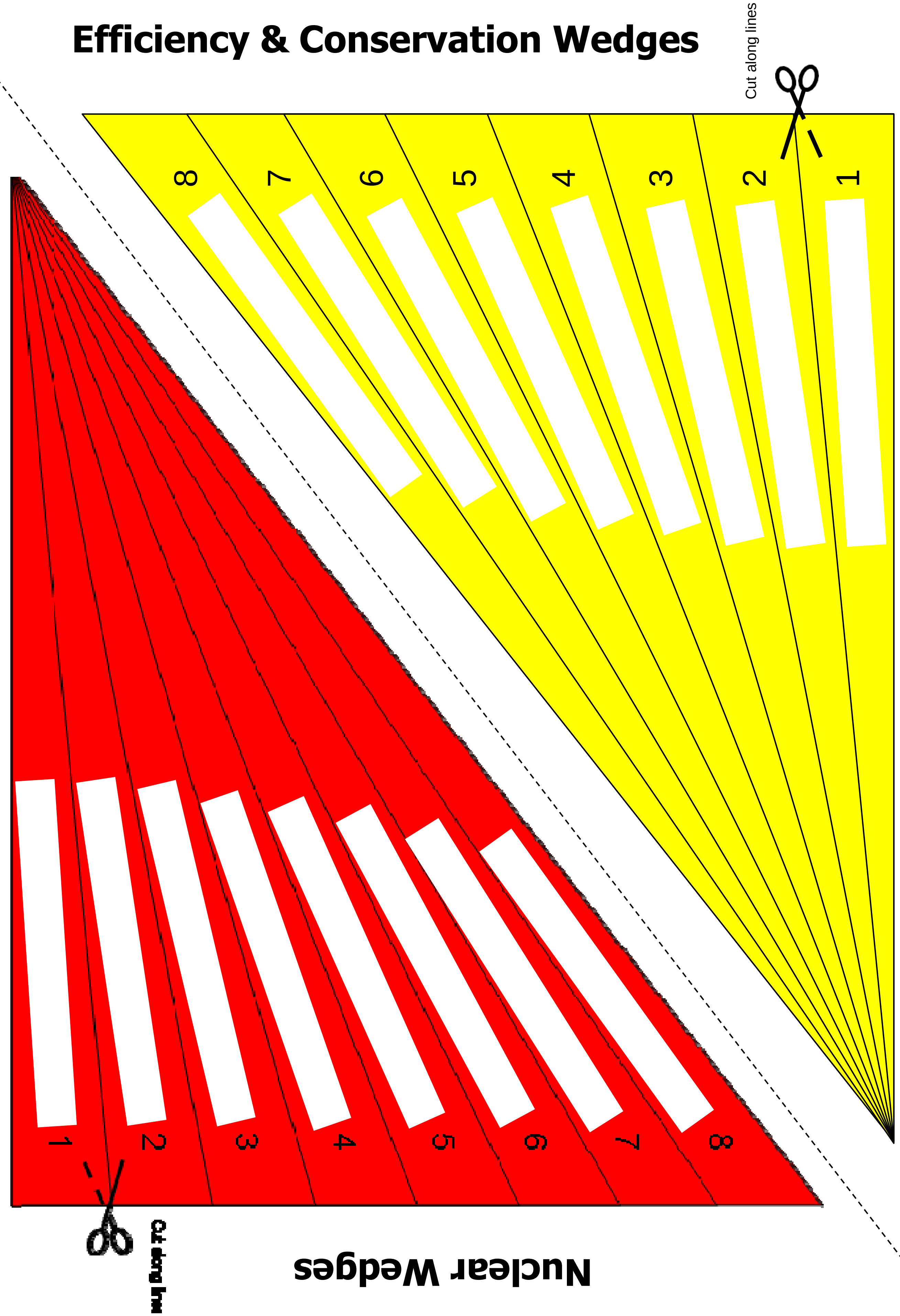


Renewables & Biostorage Wedges



Fossil Fuel-Based Wedges

Efficiency & Conservation Wedges



Nuclear Wedges