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AI-driven, human centered

Module 1: Foundations of generative AI in sustainable design

1.4 Basic of Sustainable Design

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Co-funded by the European Union

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1.4.1: Basic of Sustainable Design

Today’s focus

- ❑What is **sustainable design**?
- ❑What is its **purpose**?
- ❑What are the **key areas** of sustainable design?

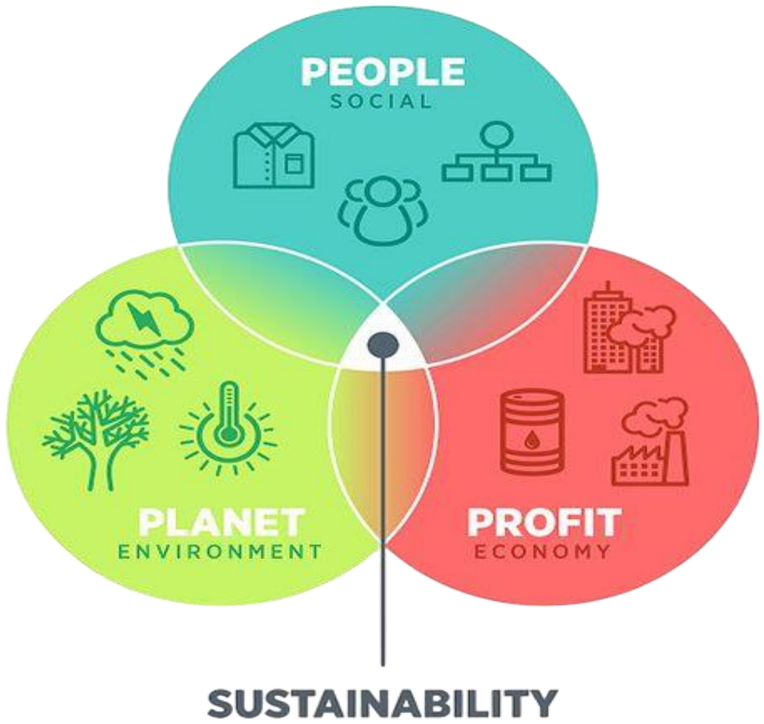
1.4.1: What is Sustainable Design?

Understanding Sustainable Design

Sustainable design is an approach to creating products, systems, environments, or services that:

- minimize negative impacts on the **environment**, **society**, and the **economy.**

- while meeting the needs of **current and future generations.**

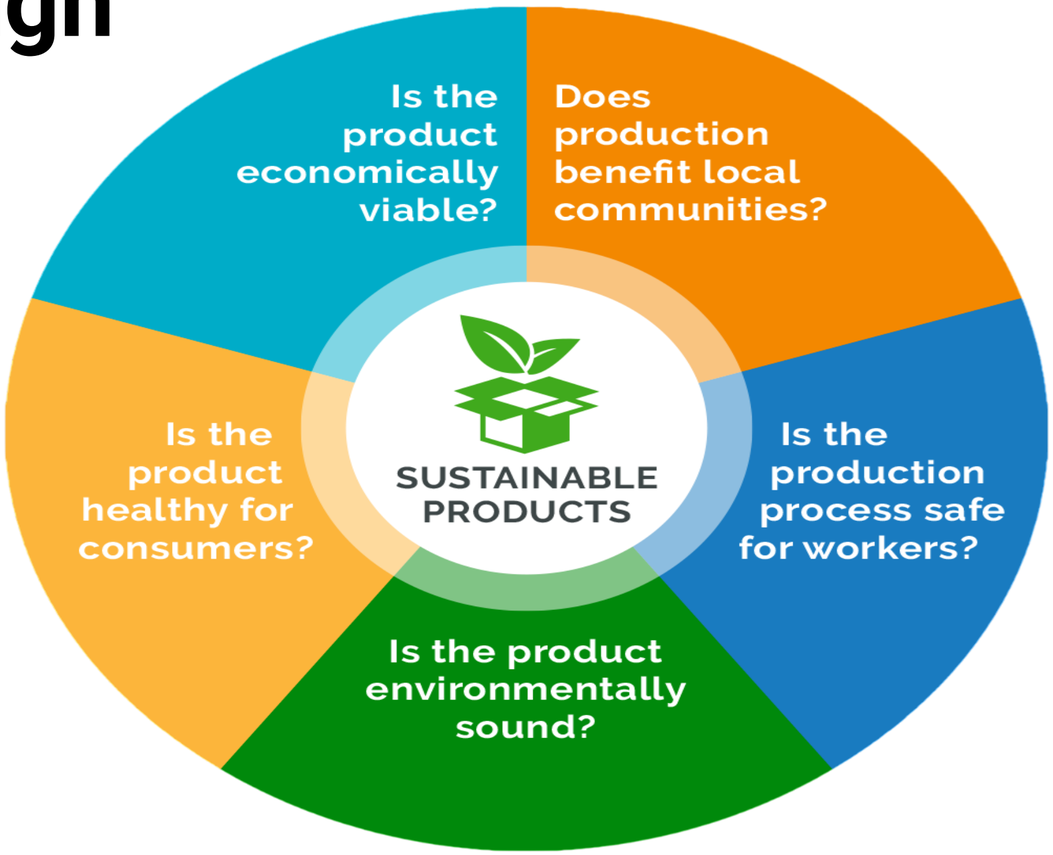


1.4.1: What is Sustainable Design?

Understanding Sustainable Design

- It considers the **entire lifecycle** of a product from **material sourcing** and **production**, to **use**, **maintenance**, and **recycling/disposal.**

- The goal: **designing with long-term balance**, not just looks or function.



1.4.1: What is Sustainable Design?

Human-Centered & Ethical Responsibility in Sustainable Design

👤 Human-Centered Design:

- This approach prioritizes the user experience at every stage of the design process, ensuring that solutions are not only practical but also safe, comfortable, and intuitive to use.

- By integrating principles of ergonomics, it promotes physical comfort, reducing strain and fatigue, and making products and environments easier and more natural to interact with.

1.4.1: What is Sustainable Design?

Human-Centered & Ethical Responsibility in Sustainable Design

👤 Human-Centered Design:

- Beyond the physical aspect, human-centered design also addresses emotional well-being by fostering mental health and encouraging social connection.

- It aims to create experiences that resonate positively with users, supporting their overall quality of life and promoting a sense of inclusion and belonging.

1.4.1: What is Sustainable Design?

Human-Centered & Ethical Responsibility in Sustainable Design

⚖️ Ethical Responsibility:

- The company is committed to ensuring fair and safe practices throughout the entire supply chain, placing respect for human rights and the well-being of all workers at the core of its values.

- This involves promoting dignified, safe, and healthy working conditions free from discrimination and exploitation.

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1.4.1: What is Sustainable Design? 2 slide.

Human-Centered & Ethical Responsibility in Sustainable Design

⚖️ Ethical Responsibility:

- Furthermore, the company implements strict criteria for ethical sourcing, carefully selecting suppliers who meet high standards of social and environmental sustainability.

- Through continuous monitoring and transparent collaboration, the company ensures that every stage of production contributes to sustainable and responsible development, minimizing environmental impact and supporting the welfare of local communities.

1.4.1: What is Sustainable Design?

Enviromental sustainable design

Environmental sustainable design aims to **minimize the negative impact on the planet** by preserving resources, reducing pollution, and promoting eco-friendly practices across the product lifecycle.

🔑 Key Principles:

- **Resource Efficiency**: Minimize use of materials, water, and energy.
- **Eco-Friendly Materials**: Use renewable, biodegradable, or recycled resources.
- **Energy Reduction**: Design for low energy use (e.g., passive heating/cooling).
- **Waste Reduction**: Apply circular design (reuse, repair, repurpose).
- **Biodiversity Protection**: Avoid harm to ecosystems and wildlife.

1.4.1: What is Sustainable Design?

Social Sustainable Design

Sustainable design isn’t just about the planet or profit — it’s also about **people**.
The **social dimension** ensures design choices improve lives, support communities, and foster equity. Designing for **inclusion**, **accessibility**, and **fairness**.

🔑 Key Principles:

- **Equity & Inclusion**: Products and spaces usable by all, regardless of background, age, or ability.
- **Community Impact**: Designs that benefit local communities, from shared spaces to supply chain ethics.
- **Cultural Sensitivity**: Respecting and integrating cultural values in design decisions.

1.4.1: What is Sustainable Design?

Economic sustainable design

Economic sustainable design ensures that solutions are not only eco- and people-friendly, but also **financially viable** over time. It focuses on balancing **cost efficiency**, **resource optimization**, and **long-term value**.

🔑 Key Principles:

- **Cost-Effective Solutions**: Use affordable materials/processes to cut production costs.
- **Value for Users**: Durable, high-quality products that reduce replacement/repair needs.
- **Long-Term Growth**: Flexible designs that evolve with minimal cost.
- **Circular Economy**: Promote reuse, repair, and recycling in business models.

1.4.2: How sustainability designs our world?

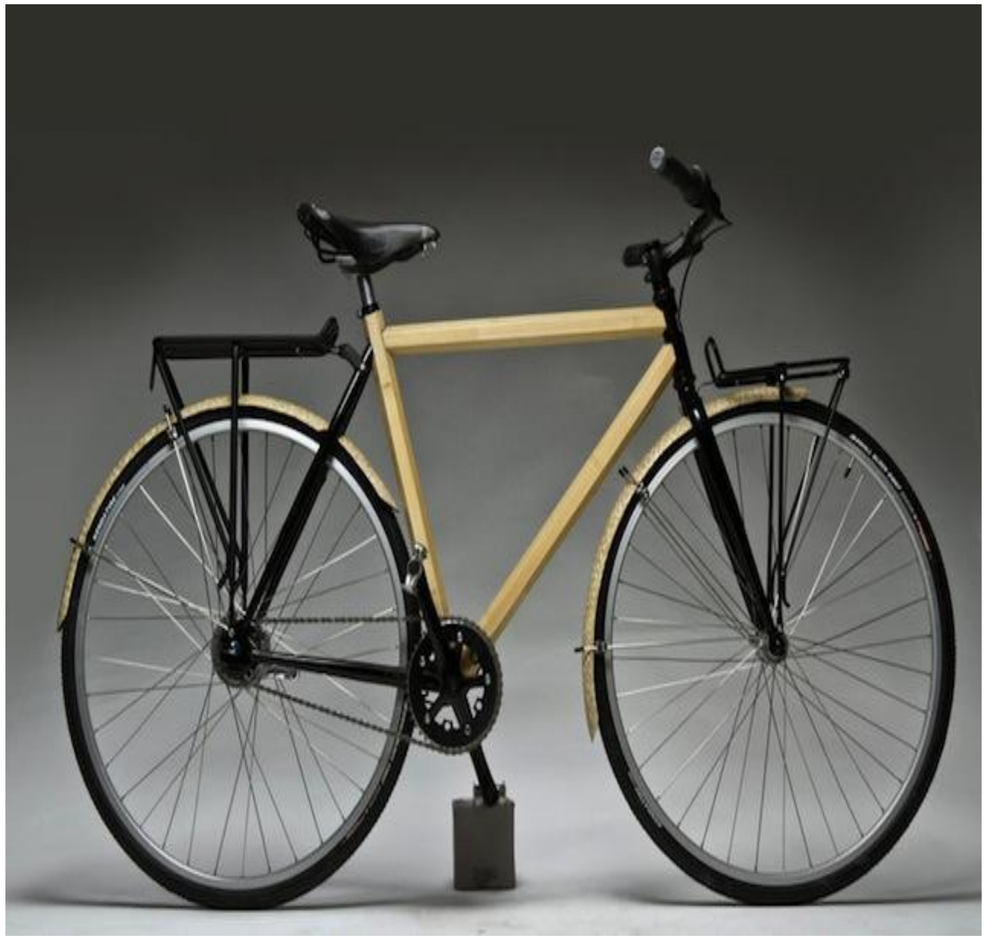
- Sustainable design plays a crucial role in shaping how products, services, and environments affect the world around us.
- It helps industries reduce waste and resource use, making production more efficient and responsible.
- It supports communities by promoting equity, accessibility, and improved quality of life.
- Sustainable design encourages us to think critically about the long-term impact of our choices and to develop solutions that are both innovative and respectful of people and the planet.

1.4.2: Real-world examples

Semester Bicycle

URL: https://www.wired.com/2013/08/semester-bike-bamboo-local-production/?

- The **Semester Bicycle** is a sustainable, hand-built bike created to provide jobs and training in Greensboro, Alabama, a struggling community in the U.S. South.
- Design professor **Lance Rake**, inspired by a bamboo craft program in India, partnered with local organizer **Pam Dorr** to create a product that supports local employment.
- The project combines sustainable design with **social** impact by training young workers in bike production.

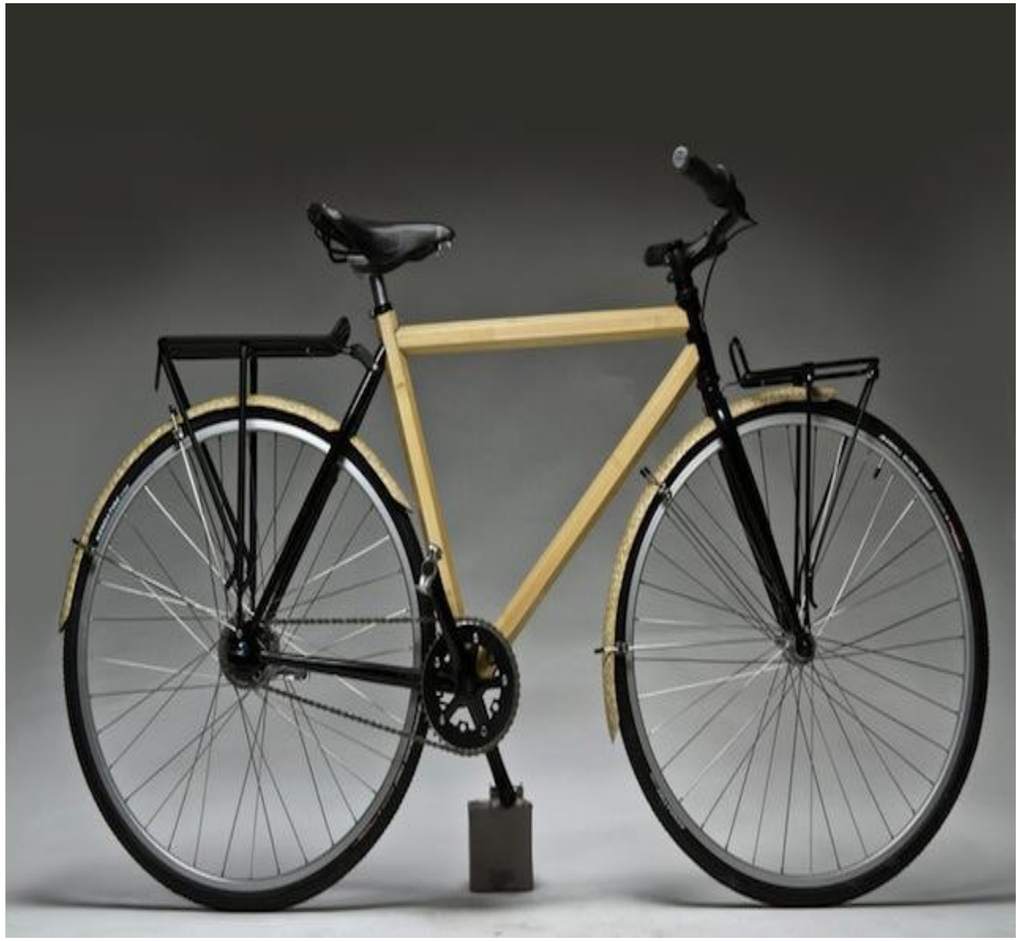


1.4.2: Real-world examples

Semester Bicycle: A model of sustainable design

Environmental Sustainability

- Uses **bamboo**, a fast-growing, renewable resource.
- Reduces carbon footprint through **local, manual production.**
- Minimizes use of **industrial machinery and synthetic materials.**
- Encourages **long product life** through durable, repairable design.

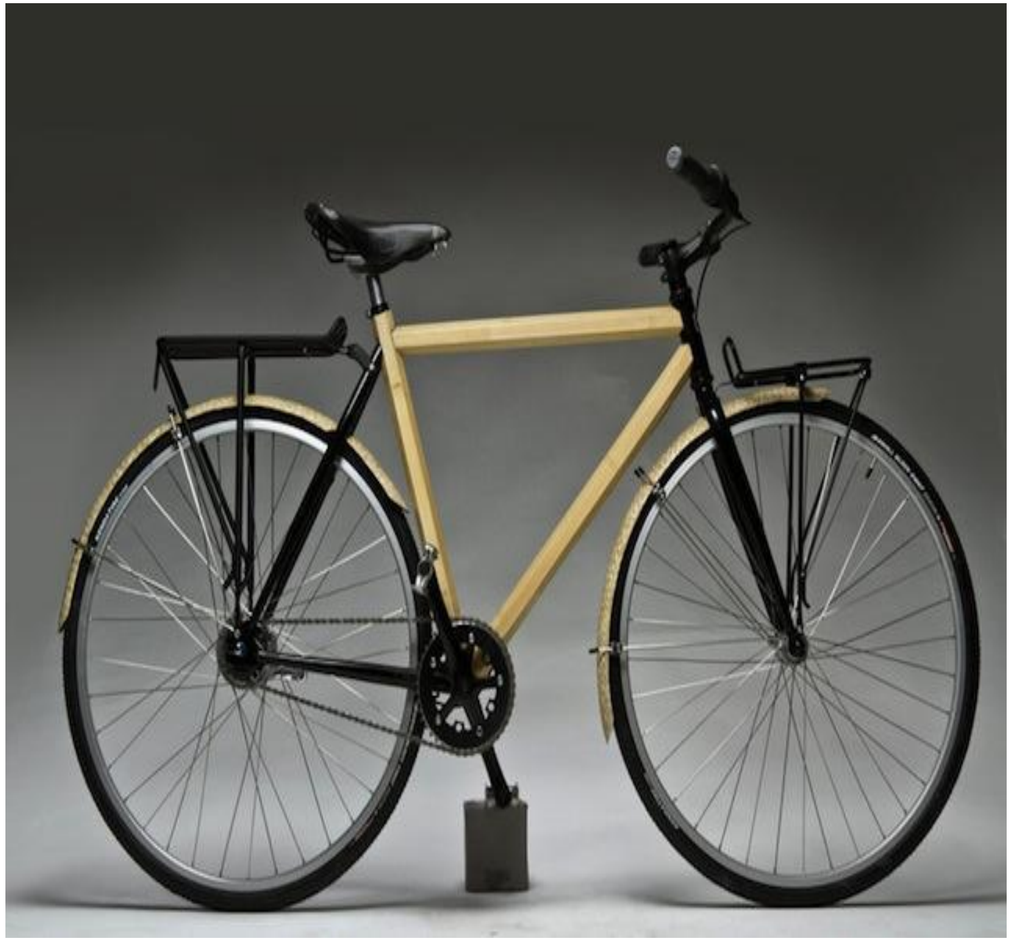


1.4.2: Real-world examples

Semester Bicycle: A model of sustainable design

Social Sustainability

- Provides **job training** and **skills development** for local youth.
- Builds **community empowerment** through active participation.
- Strengthens **local identity** with a product tied to place and people.
- Fosters **inclusive economic opportunity** in an underserved region.

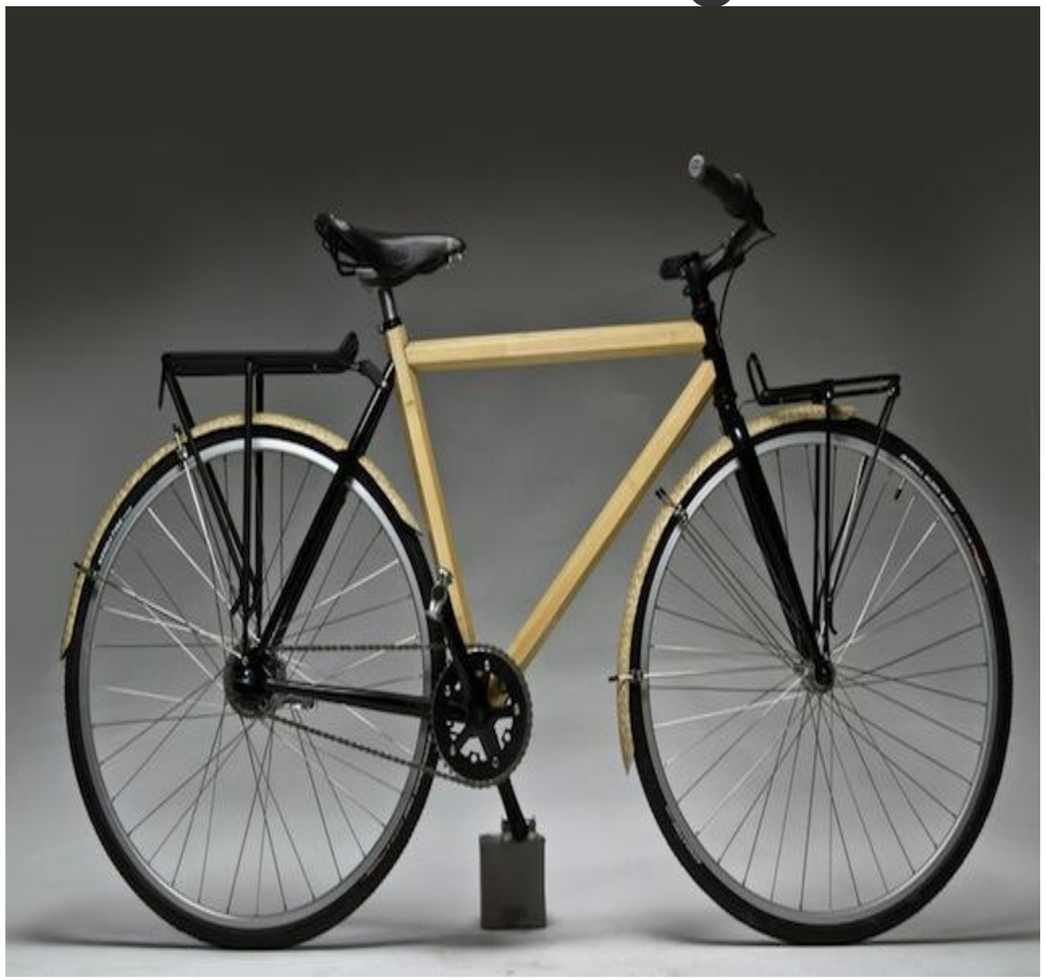


1.4.2: Real-world examples

Semester Bicycle: A model of sustainable design

Economic Sustainability

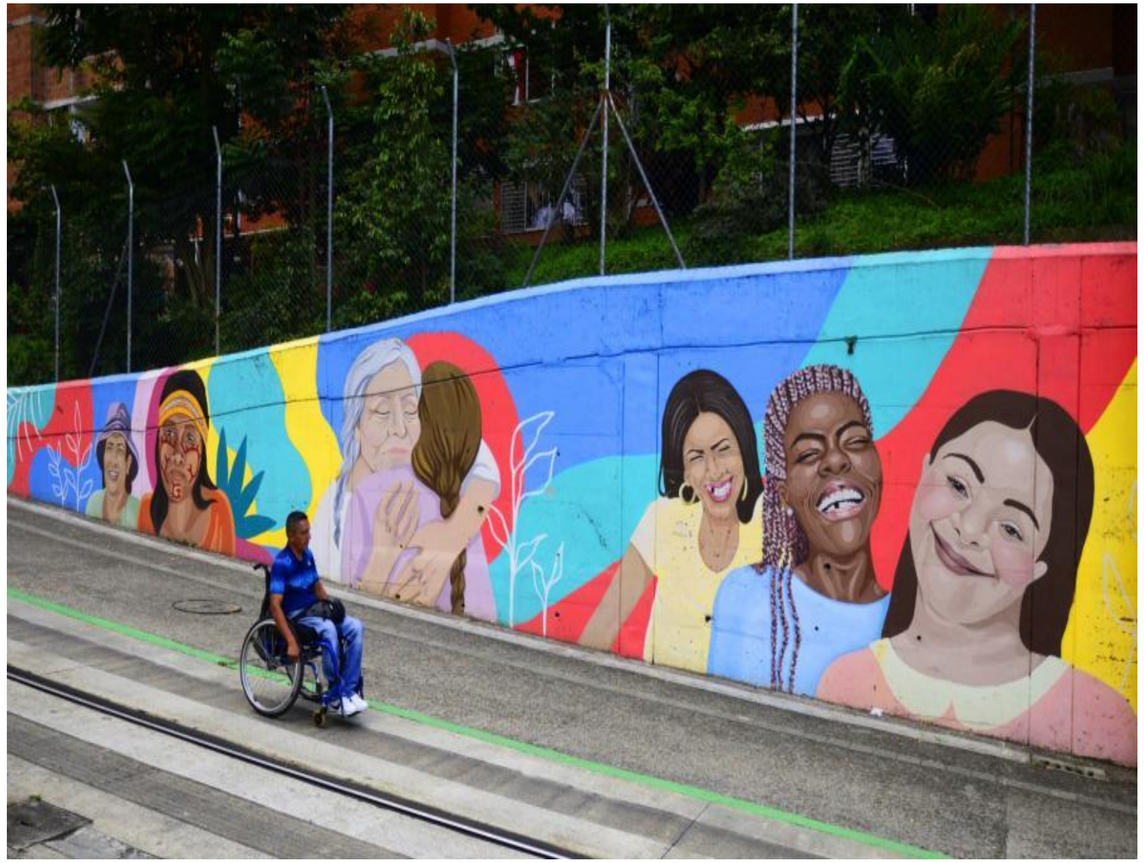
- Creates a **marketable, handcrafted product** with unique appeal.
- Encourages **local entrepreneurship and ownership.**
- Supports **long-term economic resilience** in rural Alabama.
- Promotes a **scalable, small-scale production model** that can be replicated.



1.4.2: Real-world examples

Medellìn

- In Medellín, Colombia, a series of **urban and social design interventions**—like the Metrocable system and library parks—transformed one of the most dangerous cities into a more inclusive, connected, and safe environment.
- The city invested in **accessible public infrastructure** to integrate marginalized communities living in the hills.
- This approach shows how thoughtful design can drive both **social equity** and **urban regeneration**.

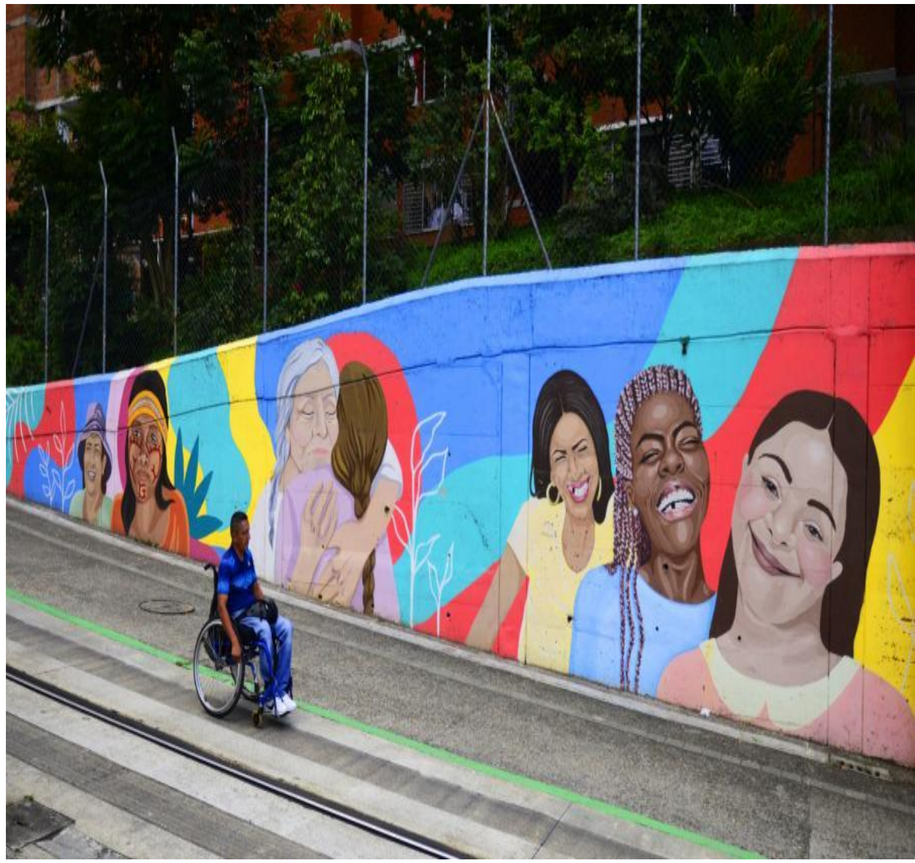


1.4.2: Real-world examples

Medellìn: A model of sustainable design

Environmental Sustainability

- **Reduced car usage** and emissions through public transit systems like the Metrocable.
- **Integration of green spaces** (e.g., library parks) to improve air quality and urban biodiversity.
- **Focus on pedestrian-friendly urban design** to lower environmental footprint.
- **Promoted reuse of existing urban areas** rather than expanding into natural zones.

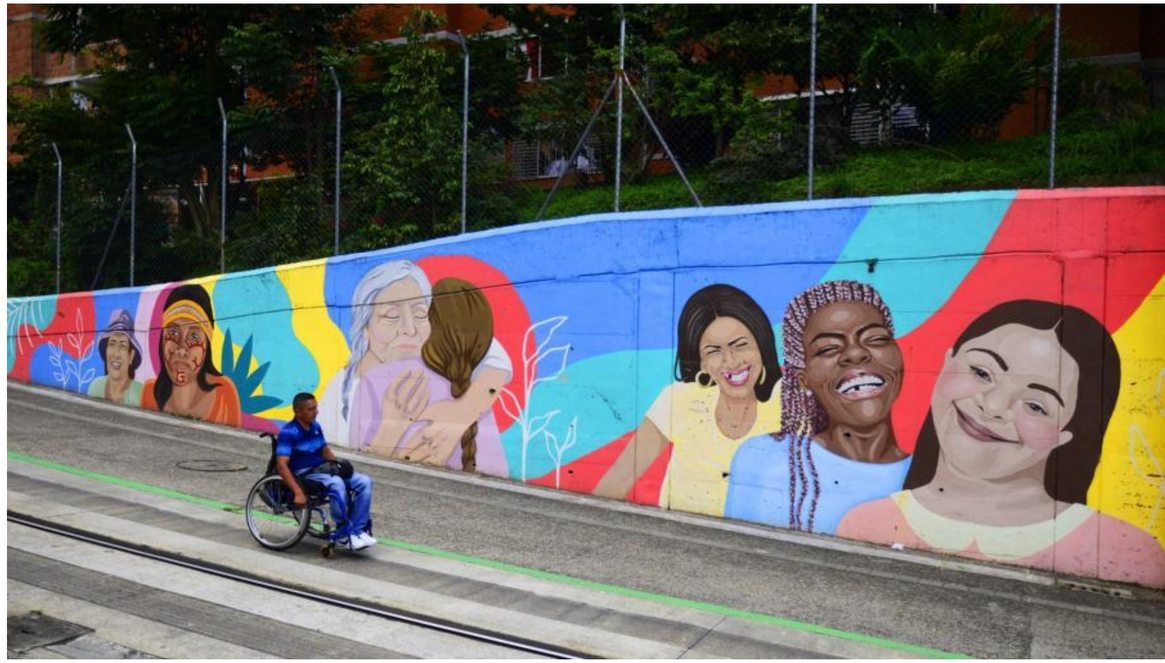


1.4.2: Real-world examples

Medellìn: a model of sustainable design

Social Sustainability

- **Improved mobility and access to services** for marginalized hilltop communities.
- **Fostered inclusion and reduced crime** by connecting people to education and opportunity.
- **Encouraged civic pride** and community participation **through public spaces.**
- **Enhanced safety** through better lighting, design, and social cohesion.

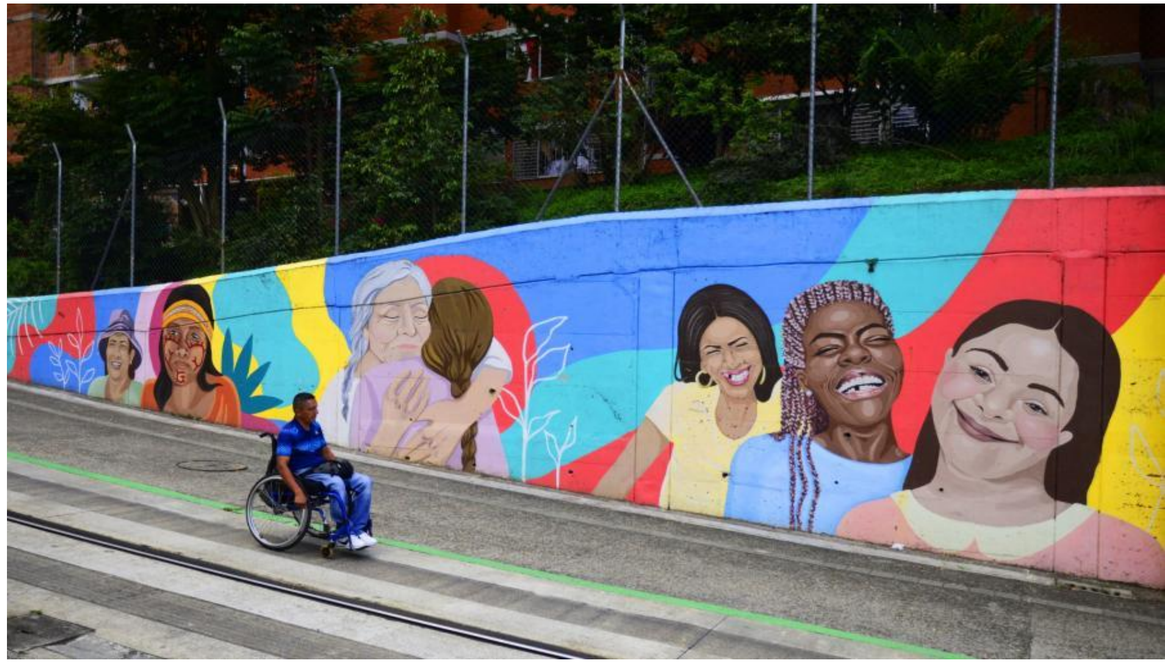


1.4.2: Real-world examples

Medellìn: A model of sustainable design

Economic Sustainability

- **Boosted local employment** via construction and maintenance of transit and public infrastructure.
- **Attracted tourism and investment** by reshaping the city’s global image.
- **Enabled better access** to jobs and education for underserved populations.
- **Supported long-term economic growth** by linking isolated neighborhoods to the urban economy.



1.4.3: Integrating sustainability at every stage of design

“Design and artificial intelligence (AI) may seem like two distant fields, with the former focusing on the designer’s creativity and sensitivity, and the latter on the rigorous calculation of the machine.
Therefore, these two fields are often perceived as opposite: either human or machine, while the possibility of a human and machine collaboration is overlooked.”

{Fabio Antonio Figoli, Francesca Mattioli, Lucia Rampino - Artificial intelligence in the design process}

1.4.3: Integrating sustainability at every stage of design

AI technologies support sustainability across all dimensions of design. They help reduce material waste and optimize energy use (**environmental**), cut production costs and improve efficiency (**economic**), and promote accessibility and inclusivity through data-driven insights (**social**).

By **integrating AI tools** at each design stage— we ensure that **sustainable choices are embedded** into both the product and its impact on people and systems.

1.4.3: Integrating sustainability at every stage of design

Example: Designing a Sustainable Car Using AI at Every Stage

STAGE 1: Concept Development

- AI analyzes environmental data, user behavior, and market trends to create sustainable vehicle concepts that balance ecological goals, economic feasibility, and social needs. It helps ensure low emissions and resource efficiency while considering cost and production viability.

- Additionally, AI integrates important social factors such as safety and accessibility from the very beginning. This comprehensive approach supports the development of vehicles that are both innovative and responsible, meeting today’s challenges with sustainable solutions.

1.4.3: Integrating sustainability at every stage of design

Example: Designing a Sustainable Car Using AI at Every Stage

STAGE 2: System - level design

- AI breaks down the vehicle into optimized subsystems, aiming to reduce material usage and lower energy consumption without compromising performance.
- Through advanced simulations, it enhances overall resource efficiency and supports inclusive design by considering diverse user needs. AI also anticipates manufacturing costs and potential supply chain issues early in the process.
- This system-wide perspective helps create vehicles that are both efficient and adaptable. The result is a smarter, more sustainable design from the inside out.

1.4.3: Integrating sustainability at every stage of design

Example: Designing a Sustainable Car Using AI at Every Stage

STAGE 3: Detail design

- AI defines key elements like materials, shapes, and tolerances to ensure the final product is durable, cost-effective, and environmentally compliant. It helps identify materials that are ethically sourced and sustainable, reducing environmental impact.
- By promoting local sourcing, AI also strengthens economic resilience and supports local communities.
- This phase ensures that every design choice aligns with both performance goals and ethical standards. The result is a well-balanced product that’s built to last and built responsibly.

1.4.3: Integrating sustainability at every stage of design

Example: Designing a Sustainable Car Using AI at Every Stage

STAGE 4: Testing and Refinement

- AI runs thousands of virtual simulations to evaluate performance, safety, energy efficiency, and usability across diverse real-world scenarios.
- This includes testing for accessibility in different social and environmental contexts. Virtual testing significantly reduces the need for physical prototypes, cutting down on material waste and accelerating development timelines.
- As a result, products reach the market faster and with greater confidence in their reliability. This process boosts both economic efficiency and design inclusivity.

1.4.3: Integrating sustainability at every stage of design

Example: Designing a Sustainable Car Using AI at Every Stage

STAGE 5: Production Ramp-up

- AI monitors initial manufacturing data to streamline production, minimize defects, and enhance worker safety and training programs. It helps identify opportunities for material reuse and recycling, promoting circular economy principles.
- Real-time insights enable quick adjustments to improve efficiency and reduce waste. AI also integrates feedback from early users and stakeholders to refine product quality and increase social acceptance.
- This phase ensures a smooth, responsible, and adaptive transition into full-scale production.

1.4.3: Integrating sustainability at every stage of design

Concept development

- Use **AI** to **analyze** material impacts, energy consumption, and social factors early on.
- **AI-driven lifecycle assessments** guide **sustainable choices** from the start.
- **Data exploration helps** identify environmental, economic, and social **risks**.
- **AI supports** concept development by **generating** innovative, sustainability-focused **design alternatives** and evaluating their feasibility from the outset.

1.4.3: Integrating sustainability at every stage of design

System level design

- Apply **generative AI** to define product architecture and break down systems into **efficient, sustainable components.**
- Simulate energy use and material efficiency digitally to **optimize subsystems** and **reduce waste.**
- Support **ergonomic and accessible design through AI-driven modeling,** while guiding early decisions on assembly and production planning.

1.4.3: Integrating sustainability at every stage of design

Detail Design

- Use **generative AI t**o specify geometries, materials, and tolerances with **a focus on sustainability and performance.**
- **Optimize** material selection and production processes to **lower environmental impact** and **reduce costs.**
- Leverage AI to ensure robust, manufacturable designs and to streamline tooling and supply chain planning.

1.4.3: Integrating sustainability at every stage of design

Testing and refinement

- Use **AI-powered simulations** to assess environmental, social, and economic impacts **before production**.
- **Virtually test** alpha and beta prototypes for durability, energy efficiency, and user satisfaction using real-world scenarios.
- Leverage AI insights to guide rapid, resource-efficient design iterations and **reduce the need for physical prototyping**.

1.4.3: Integrating sustainability at every stage of design

Production ramp-up

- **AI analyzes real-world product performance** and production data to measure sustainability outcomes and identify process issues.
- Support **continuous improvement** by integrating **AI-driven insights** from **user feedback** and lifecycle assessments.
- Enable circular **economy strategies** by detecting opportunities for **reuse, recycling**, and **design refinements** before full-scale launch.

Thank you!

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