TWIN TRANSFORMATION PROJECT

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INCREASING THE GREEN AND DIGITAL COMPETENCIES OF SME OWNERS AND EMPLOYEES IN THE SHOE MANUFACTURING AND LEATHER SECTOR

TWIN TRANSFORMATION CURRENT SITUATION NATIONAL REPORT OF TÜRKİYE

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PREFACE

This report was prepared to assess the impact of green and digital transformation on SMEs and tradespeople. These national reports will serve as the cornerstone of the joint report. Initially, a desk study was conducted during the preparation of the report. Following this, interviews were conducted with relevant public and private institutions and organizations. The information gathered was presented in a specific format in the report.

1. NATIONAL LEGISLATION ON GREEN AND DIGITAL TRANSFORMATION

In Türkiye, green and digital transformation lies at the core of national policies and strategies shaped in line with the Sustainable Development Goals. In parallel with international developments such as the European Green Deal and the Digital Europe Programme, Türkiye has established a comprehensive legislative framework in the areas of environmental sustainability and digitalisation. This transformation process is supported by key policy documents including the Industry and Technology Strategies, the Climate Change Action Plan, the National Artificial Intelligence Strategy, and the Digital Türkiye Roadmap. These strategies are substantiated by laws and regulations addressing energy efficiency, renewable energy, waste management, carbon footprint calculation, digital skills, and data security. Accordingly, Türkiye's national legislation encompasses regulations that encourage both public institutions and the private sector to align with the green and digital transformation processes.

1.1. Signed International Agreements/Protocols and Their Implementation

Türkiye first demonstrated its commitment to global climate governance by becoming a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 2004. Since then, it has developed policies in alignment with international agreements and protocols aimed at combating climate change and promoting sustainability, thereby reinforcing its environmental commitments. In 2021, Türkiye ratified the Paris Agreement upon recognition of its special circumstances, committing to reduce greenhouse gas emissions and enhance climate resilience. This commitment has been concretized through the Climate Change Action Plan, with energy transition, carbon pricing, and renewable energy investments identified as priority areas.

In addition, Türkiye has integrated the United Nations Sustainable Development Goals (SDGs) into its national development plans, promoting clean energy, circular economy, sustainable agriculture, and transport systems. While Türkiye is not subject to binding emission reduction obligations under the Kyoto Protocol, it has voluntarily implemented emission reduction and energy efficiency policies.

Within the scope of the Stockholm Convention, a National Implementation Plan has been put into effect to eliminate persistent organic pollutants (POPs) and improve waste and chemical management.

On the digital front, Türkiye has pursued policies in line with the EU Digital Agenda, expanding digital infrastructure, enhancing digital literacy, and widely implementing e-government services such as the e-Government Gateway. The Law on the Protection of Personal Data (KVKK) adopts principles aligned with the EU General Data Protection Regulation (GDPR), thereby enhancing digital trust and privacy.

Furthermore, Türkiye actively participates in the World Trade Organization (WTO) framework on e-commerce and follows the OECD's recommendations on digital economy to

ensure a transparent and secure digital marketplace. In cooperation with the International Telecommunication Union (ITU), Türkiye supports global ICT standards and advances investments in 5G and fiber optic infrastructure. All these efforts are supported by national strategy documents and policies targeting green and digital transformation.

1.2. National Legal Regulations (Laws, Regulations, and Guidelines)

To support green and digital transformation, Türkiye has developed an extensive framework of national laws, regulations, and strategic action plans.

In the area of green transformation, the Türkiye Climate Change Strategy (2010–2023) and the Türkiye Green Deal Action Plan (2021) provide the overarching framework. These documents promote a low-carbon, climate-resilient development model, emphasizing sustainable agriculture, energy transition, and green finance. Additionally, the 2021 Economic Reform Package encourages the development of Green Organized Industrial Zones and the adoption of sustainable production technologies (CBDDO, 2023).

This strategic vision is supported by the following key legislative instruments:

- Environment Law (Law No. 2872) and Environmental Impact Assessment (EIA) Regulation: Provide the legal foundation for environmental protection, industrial emissions control, and ecosystem conservation.
- Renewable Energy Law (Law No. 5346) and the Renewable Energy Resources Support Mechanism (YEKDEM): Encourage investments in renewable energy sources such as solar and wind.
- Energy Efficiency Law (Law No. 5627): Aims to ensure more efficient use of energy resources, particularly in the building sector.
- Zero Waste Regulation: Mandates waste segregation, recycling, and reduction practices for municipalities and large institutions.
- Forest Law (Law No. 6831) and the Law on the Protection of Wetlands (Law No. 3578): Serve as legal frameworks for the protection of carbon sinks and biodiversity.

Türkiye introduced its first Climate Law on 9 July 2025, establishing a comprehensive legal basis for climate change mitigation. The law aligns with the 2053 Net Zero Emissions and Green Development targets, addressing emission reductions, climate adaptation, energy efficiency, renewable energy use, and green financing mechanisms. It includes structural regulations such as the establishment of a Climate Council, a national emissions trading system, a carbon market, and a border carbon adjustment mechanism. The law emphasizes principles of just transition, climate justice, and transparency, requiring the preparation of national and local climate action plans and measures in areas such as technology development, updated education programs, early warning systems, and water management. Related obligations are required to be fulfilled by 31 December 2027 (Ministry of Environment, Urbanization and Climate Change, 2025).

In the field of digital transformation, Türkiye's determination is reflected in the Eleventh Development Plan (2019–2023) and the Twelfth Development Plan (2024–2028). These plans identify "Competitive Production through Green and Digital Transformation" as a strategic priority, with a focus on circular economy, carbon pricing, green hydrogen technologies, and clean energy infrastructure (CBDDO, 2023).

The legal infrastructure for digitalisation is based on the following regulations:

- Law on the Regulation of Electronic Commerce (Law No. 6563)

- Personal Data Protection Law (Law No. 6698)
- Electronic Signature Law (Law No. 5070)
- Law on the Regulation of Publications on the Internet and Combating Crimes Committed Through Such Publications (Law No. 5651)

These regulations contribute to ensuring data security, privacy, and trust in digital services. The National Cyber Security Strategy and Action Plan aims to strengthen the resilience of digital infrastructures.

The Digital Türkiye Roadmap outlines Türkiye's vision to become a regional technology leader. In the public sector, digitalisation is regarded as a key tool to achieve the 2053 Net Zero Emission targets. The e-Government Gateway facilitates the transition to paperless, data-driven public services. The transition from e-government to digital government is guided by the Digital Government Strategy, developed in line with OECD recommendations (CBDDO, 2025).

All these legal and strategic frameworks are implemented through the Presidential Annual Programmes, ensuring institutional coherence and policy integration in accordance with Presidential Decree No. 1.

2. NATIONAL-LEVEL IMPLEMENTATIONS, RESPONSIBLE INSTITUTIONS AND ORGANIZATIONS, AND THEIR ROLES IN GREEN AND DIGITAL TRANSFORMATION

2.1. Public Institutions Responsible for Green and Digital Transformation: Authorities and Responsibilities

Türkiye's green and digital transformation is shaped by a coordinated network of public authorities, research institutions, and SME-focused organizations that contribute to policy design, innovation support, and alignment with international sustainability and technology standards. As the country pursues a dual transformation agenda aligned with global goals, effective coordination among national actors becomes increasingly critical. This section outlines the institutional framework driving this transformation and emphasizes support mechanisms and the distinctive responsibilities of key institutions, particularly in assisting SMEs.

The **Ministry of Environment, Urbanization and Climate Change** plays a leading role in Türkiye's green transformation by defining national climate strategies, managing commitments under international frameworks such as the UN Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, and initiating policies in areas such as circular economy, carbon pricing, and sustainable energy.

The **Ministry of Trade** aligns economic policies with the European Green Deal, coordinates the Green Deal Working Group, and takes measures in areas including green finance, carbon adjustment, and sustainable production.

The **Ministry of Industry and Technology** has a key role in promoting both green and digital transformation. While supporting sustainable industrial production, energy efficiency, and Green Organized Industrial Zones, it also fosters digital innovation by enhancing smart manufacturing, digital entrepreneurship, and industrial digital capabilities.

In the digital field, the **Presidency's Digital Transformation Office (CBDDO)** leads the digitalisation of the public sector. Established following the 2018 government reforms, the Office has assumed a strategic coordination role in digital governance, cybersecurity, big data, artificial intelligence, and the protection of critical infrastructure, supporting Türkiye's transition to a fully integrated digital state model.

The **Scientific and Technological Research Council of Türkiye (TÜBİTAK)** strengthens R&D capacity in green and digital domains. It leads research in areas such as artificial intelligence, the Internet of Things (IoT), big data, and cybersecurity, while also supporting green innovation programmes aimed at developing environmentally friendly technologies and processes.

The **Small and Medium Enterprises Development Organization (KOSGEB)** contributes by enhancing SMEs' capacities in green and digital domains. Through projects like the Türkiye Green Industry Project, KOSGEB supports investments in renewable energy, resource efficiency, and digitalisation, thereby facilitating the transition of SMEs to sustainable and competitive production models.

2.2. Professional Organizations and NGOs Representing Artisans and SMEs: Roles and Responsibilities in Green and Digital Transformation

In Türkiye's transition toward a sustainable and digital economy, both governmental bodies and professional organizations and non-governmental organizations (NGOs) play significant roles. Particularly in facilitating the green and digital transformation of small and medium-sized enterprises (SMEs), these intermediary organizations act as bridges between policymakers and local businesses, offering guidance, training, advocacy, and financial support. This support is especially critical for artisans and micro-enterprises facing challenges in accessing resources and institutional networks.

The **Confederation of Turkish Tradesmen and Craftsmen (TESK)** has placed importance on the twin transformation and has undertaken several initiatives and projects in this field. TESK signed a cooperation protocol with the Environment Agency to engage its member artisans and craftsmen in the collection and recycling of plastic packaging waste. Moreover, in partnership with Google, TESK developed digital training materials and delivered education sessions to enhance the digital skills of artisans and promote e-commerce. It also commissioned research to identify new digital competencies to be integrated into vocational training programmes. TESK prioritizes the twin transformation in its ongoing domestic and international projects and programmes, emphasizing this issue in all its activities. A significant portion of in-service training is now delivered online, and many services are provided through digital platforms. Similar efforts are being carried out at the level of organizations affiliated with TESK. For example, the **Turkish Federation of Shoemakers** and its member chambers are actively engaged in twin transformation efforts, contributing to the advancement of their respective sectors.

Another prominent professional organization representing SMEs, the **Union of Chambers and Commodity Exchanges of Türkiye (TOBB)** and its sub-organizations, also conduct a wide range of activities in support of the twin transformation.

Many NGOs in Türkiye are also dedicated to advancing green and digital transformation. This report provides brief information about only a few key ones.

Among the leading actors in this area is the **Industry 4.0 Digital Transformation Association**, which was established to support SMEs. The association offers specialized

training, consultancy, and strategic planning services to help businesses adopt smart technologies and implement high resource-efficiency production methods. It contributes to increasing the resilience and competitiveness of SMEs by promoting the development of sectoral standards, inter-sectoral collaboration, and the creation of Industry 4.0-compliant industrial zones.

In addition to these efforts, the **Türkiye Environmental Agency (TUÇA)**, established in 2020, plays a critical role in advancing the country's green and digital transformation agenda. Operating under the Ministry of Environment, Urbanization and Climate Change, TUÇA implements national strategies in waste management, circular economy, and low-carbon development. It integrates digital tools into environmental governance through initiatives such as the Deposit Management System and promotes sustainability via public awareness campaigns, educational programmes, and cross-sectoral partnerships.

In parallel, the **Informatics Association of Türkiye (TBD)**, one of the country's leading NGOs in information and communication technologies (ICT), continues to contribute significantly to digital transformation. With over 12,000 members from the public sector, private enterprises, and academia, TBD plays an active role in shaping national digital policies, enhancing ICT literacy, and supporting the development of human resources in the technology sector. Through reports, research, and national congresses, the association advocates for a technology-driven, competitive Türkiye and helps align public policies and institutional capacities with the demands of the digital age.

These institutions and organizations not only provide essential tools and support for SMEs to adapt to green and digital transformation but also contribute to establishing the practical and institutional frameworks needed to advance Türkiye's broader transformation agenda.

In the context of the footwear manufacturing sector, two key institutions stand out: the **Türkiye Footwear Industry Research, Development, and Training Foundation (TASEV)** and the **Footwear Suppliers Association (AYSAD)**. Both organizations are engaged in activities and projects related to twin transformation. AYSAD focuses on trade fairs, while TASEV, as an institution accredited by the National Agency, supports its member companies by facilitating internship opportunities in EU countries, encouraging experience exchange, and exploring cooperation possibilities.

3. ECONOMIC AND SOCIAL IMPACTS OF GREEN AND DIGITAL TRANSFORMATION ON CRAFTSPEOPLE AND SMES – CHALLENGES ENCOUNTERED AND NECESSARY MEASURES TO BE TAKEN

SMEs are particularly important in maintaining the vibrancy and continuity of the economy, especially under today's changing and increasingly competitive conditions. SMEs not only contribute to economic development through their own production, but also support large enterprises by supplying inputs for their products. SMEs hold a significant share in both the national and global economy.

As the driving force and backbone of the production economy, SMEs also play a vital role in the implementation of Industry 4.0 (I4.0). Compared to large enterprises, SMEs face distinct challenges and obstacles in transitioning to I4.0. This transition process is often more burdensome for SMEs, so their adaptation to I4.0 must be supported and incentivized.

International studies show that although SMEs are aware of the benefits and advantages of I4.0, they cite the following common reasons for not adopting it (Pessl et al., 2017, p.195):

- High investment costs due to the incompatibility of existing production infrastructure with I4.0;
- Lack of transparency or insufficient understanding of the benefits of I4.0;
- Concerns about organizational adaptability and information technology (IT) security.

Indeed, a study conducted in Germany on the difficulties SMEs face in adopting I4.0 identified the following main issues (bilisim.com, 2018):

- SMEs do not invest in the infrastructure, technology, and software required for I4.0 implementation;
- They struggle to ensure interdepartmental coordination, which complicates the management of I4.0 strategies and projects across the organization;
- SMEs hesitate to undertake radical transformation, largely due to the lack of qualified personnel capable of working in the I4.0 field;

They are generally weak in terms of cybersecurity.

These challenges related to I4.0 are not unique to Turkey—they are a global concern that all countries must address proactively. Therefore, first governments and then businesses must develop appropriate measures, strategies, roadmaps, and tailored models to ensure effective transformation.

In this context, the SWOT analysis prepared by MUSIAD illustrates the strengths, weaknesses, opportunities, and threats facing Turkish enterprises/SMEs in their I4.0 journey. Based on this analysis, weaknesses should be addressed and strengthened, opportunities should be seized, and appropriate precautions should be taken against potential threats.

Analysis of Turkey for the E4.0 (Industry 4.0) Model

Strengths	**Weaknesses**
• Rapidly growing economy	• Qualified workforce
• High market demand	• Academic structure
• Young population	• Lack of a single public authority for the sector
• Technological affinity	• Insufficient domestic market size
• Widespread engineering education	• Weak culture of technology development
• Sectoral diversity	• Labor law
• Easy access to foreign markets	• Bureaucratic approach
• Domestic transportation convenience	• Need for project financing

• Adaptability to multiculturalism	• Lack of a joint action plan
Opportunities	**Threats**
• Incentives • Widespread technopark infrastructure and increasing number of R&D centers • Economic growth potential • Continuation of investment environment	• Bureaucracy's approach to the sector • Employment pressure • Quality of academic education • Foreign manufacturers keeping the market under pressure

3.1. Economic and Social Impacts of Twin Transformation

Twin transformation—the simultaneous implementation of green and digital transformation—creates profound and multifaceted effects on economic and social structures. This transformation process brings about fundamental changes in many areas, from production processes and employment to consumer behavior and public policies.

Economically, twin transformation enhances resource efficiency, thereby increasing the competitiveness of businesses while also laying the groundwork for the emergence of new sectors and employment opportunities.

On the social front, digitalization and environmental awareness are reshaping individuals' lifestyles, educational needs, and workforce skills, highlighting the importance of an inclusive and fair transition process.

In this context, twin transformation is not only a technological or environmental shift but also a comprehensive development approach aimed at increasing societal welfare.

3.1.1 Financial Challenges and Investment Requirements

SMEs operating in traditional sectors such as shoe manufacturing face not only great opportunities in the twin transformation process but also significant challenges and investment requirements. These challenges and needs are summarized in the tables below:

1. Challenges Faced by SMEs in the Twin Transformation Process

Challenge Area	Description
Lack of Capital and Financing	Establishing digital infrastructure and transitioning to sustainable production require high investments; most SMEs lack the necessary budget.

Limited Access to Technology	Access to systems such as 3D printers, automation, and ERP is limited and costly.
Lack of Qualified Human Resources	SMEs struggle to find experts in areas like software development, data analysis, and sustainable production.
Lack of Knowledge and Awareness	There is widespread lack of understanding about what digitalization and sustainability entail.
Difficulty Complying with Regulations	Adapting to and implementing external market standards—especially those of the European Green Deal—is challenging.
Internal Resistance and Cultural Barriers	Traditional business culture can resist change and hinder transformation efforts.

2. Investment Needs

Investment Area	Detailed Needs
Digital Infrastructure	- ERP systems - 3D design software - Automation machinery - E-commerce integration
Training and Human Resources	- Digital skills training - Awareness on sustainability and circular economy - Technical personnel
Sustainable Production Technologies	- Energy-efficient machinery - Access to recyclable materials - Waste management systems
Certification and Documentation	- Carbon footprint measurement - Consultancy and costs for eco-friendly certifications (e.g., ISO 14001, FSC, GOTS)
Consulting and Outsourcing	- Digital transformation consultancy

	- Services for developing green transformation strategies

3. Solution and Support Recommendations

To increase the effectiveness of public support mechanisms, it is essential to expand and tailor the supports provided by institutions such as the Ministry of Industry and Technology, KOSGEB, Development Agencies, TÜBİTAK, the Ministry of Trade, the Ministry of Labour and Social Security (MoLSS), and İŞKUR—especially for small and medium-sized enterprises (SMEs). This approach would enable SMEs to carry out their digital and green transformation processes more effectively and sustainably.

In addition, in the context of strengthening industrial clusters in organized industrial zones, the establishment of shared prototyping centers and digital laboratories is of great importance. These infrastructures will enhance firms' R&D and innovation capacities, thereby boosting their competitiveness.

To accelerate digital transformation, it would be beneficial to expand digital coaching programs similar to the "Digital Innovation Hubs," which have proven successful in Europe. These structures would support businesses in adapting to digital technologies and foster the sharing of knowledge and experience.

Lastly, in order to promote sustainability-oriented investments, financial incentive mechanisms such as tax reductions and interest subsidies for loans need to be implemented. These kinds of supports will encourage businesses to increase their investments in environmental and digital transformation, thereby contributing to the acceleration of sectoral transformation.

3.1.2 Opportunities and Economic Benefits for SMEs

Twin transformation is not merely a pressure for compliance for SMEs but also presents significant opportunities and benefits. Especially for SMEs operating in traditional sectors such as footwear manufacturing, this transformation can create advantages in various areas—from efficiency gains to increased brand value.

The table below provides a detailed explanation of these opportunities and benefits:

1.Opportunities and Benefits of Twin Transformation for SMEs

Opportunity / Benefit Area	Description
Increased Efficiency	Through digitalization, production processes become traceable, errors are reduced, and costs are lowered.
Access to New Markets	Sustainable and eco-friendly products offer a competitive advantage, particularly in the European market.

Customer Satisfaction and Loyalty	Personalized products, fast delivery, and transparent production processes build customer trust.
Stronger Brand Value and Image	Green and digital solutions position SMEs as modern, responsible, and innovative brands.
Regulatory Compliance and Easier Export	Early alignment with regulations such as the European Green Deal reduces the risk of penalties and facilitates exports.
Energy and Raw Material Savings	Eco-friendly production techniques lower energy costs and provide long-term economic benefits.

2. Opportunities Illustrated with Concrete Examples (Specific to the Footwear Sector)

Application	Opportunity Created
3D printing for prototype production	Reduces sample production time and cost, enabling small SMEs to reach the market quickly.
Use of recycled materials	Increases preference both in the domestic market and in Europe by positioning the brand as environmentally friendly.
E-commerce integration	Enables access not only to local but also to global customer bases.
Carbon footprint calculation and certification	Removes technical barriers to export to Europe and provides pricing advantages.

3. Long-Term Strategic Gains

Increased Competitiveness: SMEs that adapt to the transformation become stronger players in both local and global markets.

Resilience to Crises: Through digital systems, SMEs become more resilient to extraordinary situations such as pandemics and energy crises.

Institutionalization and Sustainable Growth: With a transparent, data-driven, and environmentally friendly structure, companies achieve healthier growth.

3.1.3 Changing Consumer Behavior and Market Dynamics

Consumer Behavior Changes and Explanations

Behavior Change	Explanation
Increase in online shopping	E-commerce became permanent after the pandemic. Consumers now discover and order shoes digitally.
Expectation of fast delivery and easy return	With digitalization, consumers expect same-day or quick delivery and seek easy return options.
Tendency for product personalization	Consumers are increasingly interested in custom-made shoes enabled by 3D printing and digital design.
Demand for transparent and eco-friendly production	Especially Gen Z values information about production methods, material sources, and environmental impact.
Sensitivity to social responsibility	Fair labor conditions, vegan shoes, and ethical production influence purchasing decisions.

Behavioral Change	**Description**
Increase in online shopping	E-commerce has become permanent after the pandemic. Consumers now discover and order footwear online.
Expectation of fast delivery and easy returns	With digitalization, consumers expect same-day or rapid delivery and convenient return options.
Trend toward product personalization	Consumers are increasingly interested in custom footwear made possible through 3D printing and digital design.
Demand for transparent and eco-friendly production	Especially among Generation Z, there is a strong focus on how products are made, the source of materials, and their environmental impact.
Sensitivity to social responsibility	Purchasing decisions are influenced by factors such as fair working conditions, vegan shoes, and ethical production.

Changing Market Dynamics

Market Dynamic	Impact
Changing Market Dynamics	Market Dynamic
Rising demand for sustainable products	The market is shifting toward recycled, vegan, or low-carbon footwear.
Rise of new brands and micro-entrepreneurs	Thanks to digital channels, small producers can enter the market more easily, leading to an increase in boutique brands.
Localization of the supply chain	Pressures from the green transition are reducing sourcing from the Far East and promoting regional supply.
Impact of the European Green Deal	Companies exporting to Europe are required to provide sustainability certifications and carbon footprint reports.

3.2. Challenges Faced by SMEs and the Footwear Sector

3.2.1. Barriers to Technology Implementation and Transition to Green Practices

While digital and green transformation is becoming increasingly important in the footwear manufacturing sector, these transformation processes present significant challenges for many SMEs.

Advanced technology investments required for digital transformation—such as automation systems, robotics, artificial intelligence, 3D printers, and IoT applications—are costly, posing a major barrier, especially for small-scale enterprises. Similarly, implementing green transformation—such as using recyclable materials, producing with energy-efficient machines, or transitioning to renewable energy sources—also requires high upfront investments and technical infrastructure.

The financing of these investments is often challenging due to SMEs' limited resources. Moreover, lack of access to support mechanisms further exacerbates these barriers. In addition, infrastructure shortcomings needed for supply chain digitalization, concerns about data security, and the need to restructure operational processes create practical difficulties in implementation.

3.2.2. Resistance to Change and Lack of Knowledge

Resistance to digital and green practices in SMEs is one of the most significant obstacles to transformation. In many enterprises dominated by traditional production mindsets, there is notable resistance to technological innovations and environmentally oriented practices.

This resistance mainly stems from a lack of knowledge. Business owners and employees often lack sufficient information about the benefits of digital tools, the long-term advantages of green practices, and the requirements of legal regulations. The lack of training and awareness slows down the adoption of new technologies, while difficulties in accessing a skilled workforce limit implementation capacity.

All these factors hinder SMEs' adaptation to twin transition and deepen the digital-green gap in the sector.

3.3. Solutions and Adaptation Strategies for SMEs and Artisans

3.3.1. Technological Integration

For SMEs, technological integration in the twin transition entails planning and embedding digitalization (Industry 4.0, automation, artificial intelligence, etc.) and green transformation (energy efficiency, sustainable production, carbon footprint reduction, etc.) processes together into business operations. The following steps should be followed for a healthy integration:

1. **Current State Analysis**
   • Analyze the digital maturity and environmental impact of the enterprise.
   • Conduct SWOT analysis, carbon footprint measurement, and energy efficiency audits.
   • Identify technologies in use, software, and levels of automation.
2. **Strategy Development**
   • Twin transition must be addressed within a strategic framework.
   • Set digitalization and sustainability goals in a complementary way.
3. **Selection of Appropriate Technologies**
   Identify applicable and cost-effective technologies suitable for the SME's sector:
4. **Digital Technologies:**
   • ERP, CRM, MES systems
   • Industrial IoT (IIoT)
   • Cloud computing
   • AI-supported production planning
   • Cybersecurity infrastructures
5. **Green Transformation Technologies:**
   • Energy monitoring systems
   • Waste and water recycling systems
   • Renewable energy (solar panels, biogas)
   • Carbon footprint tracking software
6. **Integration Process**
   • Integrate selected technologies into existing production processes, which may include:
   • Process digitalization
   • Data collection via sensors
   • Energy optimization in production lines
   • Use of decision support systems
7. **Training and Workforce Transformation**
   • Provide training for staff to adapt to new technologies.
   • Aim to create a "green-collar" workforce (technicians and engineers proficient in environmental technologies).
8. **Monitoring and Continuous Improvement**
   • Continuously monitor installed systems (IoT, SCADA, energy management

software).
• Optimize energy, raw materials, time, and costs using real-time data.
• Track KPIs (Key Performance Indicators) such as carbon emissions, waste levels, and digital efficiency.

9. **Utilization of Financial Incentives and Supports**
   • Leverage grants and loans from KOSGEB, TÜBİTAK, development agencies, and ministries for technological transformation.
   • Manage funding through a project-based approach for twin transition.

10. **Example: Integration Scenario**
    A footwear manufacturing SME integrates energy monitoring sensors into its production line and digitalizes its production planning (ERP-MES integration). As a result, it both tracks carbon emissions and optimizes cost and waste management by reducing production waste.

3.3.2. Sustainable Business Model Adaptations

For SMEs, adopting sustainable business models in the context of twin transition means addressing both digitalization and environmental sustainability holistically to enhance efficiency, competitiveness, and environmental performance.

Below are examples of applicable sustainable business models for SMEs:

1. **Circular Economy-Based Business Models**

Objective: Transform waste into resources to reduce costs and minimize environmental impact.
Practices:
• Reusing production waste (e.g., turning textile scraps into yarn)
• Using recycled packaging
• Offering services instead of products (e.g., "product-as-a-service" or rental models)
• Wastewater treatment and reuse systems

2. **Green Supply Chain Management**

Objective: Ensure sustainability starting from suppliers.
Practices:
• Considering carbon footprint in supplier selection
• Preferring local and low-emission logistics
• Digital tracking of the supply process (e.g., using blockchain and ERP systems)

3. **Data-Driven Decision Making and Energy Management**

Objective: Optimize energy and resource use through digital technologies.
Practices:
• Monitoring energy consumption in production via IoT sensors
• Using Energy Management Software (EMS)
• Preventing waste through real-time production planning

4. **Design and Production Based on Product Life Cycle**

Objective: Ensure products are long-lasting, repairable, and recyclable.
Practices:
• Modular product design
• Choosing environmentally friendly materials
• Simulating environmental impact using digital twins

5. **Sharing and Platform Economy Models**

Objective: Use resources more efficiently and reduce costs through capacity sharing.

Practices:

• Shared use of machinery
• Providing services via digital platforms (e.g., Software as a Service – SaaS)
• Renting idle capacity to other businesses

6. **Sustainable Finance and Reporting**

Objective: Integrate sustainable practices into financial models and reporting.

Practices:

• ESG (Environmental, Social, Governance) reporting
• Carbon accounting
• Incentive systems based on sustainability performance
• Use of green finance tools (e.g., green loans, sustainable investment funds)

7. **Employee and Customer-Oriented Transformation**

Objective: Embed sustainability into corporate culture.

Practices:

• Environmental and digital awareness training for employees
• Offering sustainable products and services to customers
• Developing environmentally friendly innovations based on customer feedback

3.3.3. Sustainable Business Model for the Footwear Manufacturing Sector (Twin Transition-Based)

A twin transition-focused sustainable business model specifically designed for SMEs in the footwear sector can be structured under the following components. This model ensures the integration of both digital and green transformation.

1. **Digitalization Steps (Digital Twin – Industry 4.0)**

Objective: Automate production processes and increase efficiency and traceability.

Practices:

• Use CAD/CAM digital cutting and design software to reduce waste
• Digitalize production with MES (Manufacturing Execution System)
• Track materials and products with RFID or barcode systems
• Use automatic quality control systems (AI-based error detection)
• Implement mass customization systems for customer-specific orders

2. **Green Transformation Steps**

Objective: Reduce energy and raw material consumption and minimize environmental impact.

Practices:

• Use organic or recycled leather, rubber, and textile materials
• Implement waste separation and recovery systems (e.g., reuse of leather scraps)
• Use energy-efficient machines (e.g., presses with heat recovery systems)
• Power production facilities with renewable sources like solar energy
• Use water-based adhesives to reduce chemical emissions

3. **Circular Economy Model Practices**

Objective: Extend the lifespan of products and materials, closing the resource loop.

Practices:

• “Repair – return – reuse” campaigns for customers

• Modular design (e.g., replaceable soles, laces, linings)
• Reuse leftover materials to produce children's shoes or accessories

4. **Green Supply and Logistics**

Objective: Ensure sustainability across the entire supply chain.

Practices:

• Work with suppliers with low carbon footprints
• Optimize transportation using digital order and shipment management
• Use recyclable or biodegradable packaging in logistics

5. **Energy and Resource Monitoring**

Objective: Monitor and optimize consumption using data-driven methods.

Practices:

• Install IoT-based energy and air monitoring sensors in production lines
• Use real-time energy consumption panels for machine performance tracking
• Apply carbon emission tracking software (digital carbon accounting)

6. **Workforce and Cultural Transformation**

Objective: Integrate sustainability into organizational culture.

Practices:

• Provide training on sustainable materials and digital systems
• Encourage environmentally conscious production (suggestion-reward systems)

7. **Consumer Communication and Marketing**

Objective: Establish sustainability as a brand value.

Practices:

• Display carbon footprint, recycling rate, and water use on product labels
• Add a “sustainable product collection” section in online stores
• Manage product development based on digital customer feedback loops

8. **Support and Financing Resources**

Support and financing resources are of critical importance for SMEs and artisans to successfully carry out the twin transition process (green and digital transformation). In this context, numerous national and regional institutions provide support in various areas.

KOSGEB (Small and Medium Enterprises Development Organization) offers financial support for digital transformation projects, green industry applications, and capacity-building activities for enterprises. TÜBİTAK (Scientific and Technological Research Council of Turkey) contributes to strengthening technological infrastructure by supporting projects focused particularly on material R&D and energy efficiency solutions.

At the regional level, development agencies such as İSTKA (Istanbul Development Agency) and BEBKA (Bursa Eskişehir Bilecik Development Agency) implement dedicated support programs for twin transformation processes in their respective regions.

The Ministry of Trade, on the other hand, supports projects that meet green criteria for exports, particularly to enhance the international competitiveness of companies that have completed their green transformation processes.

These resources provide significant financial and technical advantages for businesses on their twin transformation journey.

For a footwear-sector SME, a sustainable business model should begin with the adoption of digital production technologies and the integration of smart resource management practices.

In this context, digitalizing production processes will not only increase operational efficiency but also optimize resource use, reducing waste.

At the same time, choosing environmentally friendly, green materials and utilizing energy-efficient production systems are essential for minimizing the company's environmental impact. Furthermore, an approach that prioritizes recyclable options and long-lasting product designs will align with the principles of the circular economy and support sustainability by extending product life cycles.

In addition to these elements, a people-oriented sustainability approach that emphasizes employee well-being and development, as well as customer satisfaction, should be integrated into the corporate culture. This holistic approach will not only fulfill the SME's environmental responsibilities but also enhance its competitiveness and contribution to society.

3.4. Support and Incentive Mechanisms to Accelerate the Twin Transition of Artisans and SMEs

3.4.1. Government and EU Support Programs

Various support and incentive mechanisms exist to accelerate the digital and green transformation processes of artisans and small and medium-sized enterprises (SMEs). These mechanisms provide financial and technical assistance through programs funded by both the government and the European Union (EU).

The Ministry of Industry and Trade offers a variety of support programs to enhance the competitiveness of SMEs and facilitate their transition to sustainable production methods. Under these programs, enterprises can invest in digitalization, energy efficiency, renewable energy use, and environmentally friendly production technologies. The Ministry also provides consultancy services and training to help businesses manage their transformation processes more effectively.

KOSGEB also implements numerous support programs for SMEs. These include grants and interest-free loans for digital and green transformation projects, as well as training and consultancy services. KOSGEB's supports present significant opportunities for SMEs to strengthen their technological infrastructure and adopt sustainable production methods.

In addition, Development Agencies offer various grant programs and technical support for SMEs and artisans to promote regional development. These agencies contribute to accelerating digitalization and green transformation processes by supporting projects tailored to local needs.

Furthermore, İŞKUR (Turkish Employment Agency) supports artisans and SMEs under its Active Labour Market Programs and Projects (ALMP). These programs offer vocational training, employment incentives, and consultancy services to help businesses meet their need for qualified labor. These supports make it easier for enterprises to acquire the human resources they need during the transformation process.

In summary, with the help of government and EU-funded support programs, SMEs and artisans can implement digital and green transformation more rapidly and effectively. These programs provide not only financial resources but also opportunities for developing technical knowledge and skills.

3.4.2. Private Sector Collaboration and Industry Partnerships

Private sector collaboration and industry partnerships play a significant role in accelerating the twin transformation (green and digital) processes of artisans and SMEs. These partnerships serve as effective tools to help small-scale enterprises overcome their limited financial and technical capacities, gain access to new technologies, and achieve sustainability goals.

Private sector collaborations generally involve cooperation between SMEs and large-scale companies, technology providers, consultancy firms, or sustainability-focused startups. Within such collaborations, SMEs can be provided with digital infrastructure, their production processes can be optimized, green production techniques can be introduced, or recycling systems can be established. For example, a large footwear brand may support small producers in its supply chain by setting up carbon footprint tracking systems and offering energy efficiency consulting—this is one such collaboration.

Industry partnerships are established through sectoral associations, organized industrial zones (OIZs), technology development centers, and university-industry cooperation platforms. These partnerships aim to conduct joint R&D projects, contribute to the development of sustainable materials, and facilitate access to digital manufacturing technologies. For instance, pilot projects under the EIT (European Institute of Innovation & Technology) – Manufacturing initiative that support SMEs in the footwear industry to adopt 3D printing technologies are examples of such partnerships.

In the context of Turkey, OIZs and TÜBİTAK-supported SME R&D programs offer mechanisms that support such collaborations. Furthermore, chambers of industry and commerce implement matchmaking programs between large companies and small producers to provide mentorship in digital and green transformation processes.

Thanks to these partnerships, SMEs can reduce transformation costs and increase their competitiveness, facilitating easier integration into global markets.

4. IMPACTS OF TWIN TRANSFORMATION ON THE LABOR MARKET (EMPLOYMENT/PROFESSIONAL EDUCATION/NEW SKILLS/NEW PROFESSIONS)

4.1. Changes in Labor Demand and Emerging Professions

Twin transformation not only transforms the labor market quantitatively but also qualitatively; therefore, vocational training, continuous skill development, and lifelong learning policies are among the most critical building blocks of this new era.

4.1.1. The Impact of Automation and Technology-Driven Job Transformations

The twin transformation—comprising green and digital transitions—brings about significant structural changes in the labor market. It alters the nature of labor demand and leads to the emergence of new professions. While transforming some occupations in traditional sectors, this process also creates jobs that require new skill sets, necessitating the workforce to adapt to these emerging needs.

When examining changes in labor demand, there is a notable increase in the need for employees with digital skills. The integration of technologies such as automation, artificial

intelligence, big data, and the Internet of Things (IoT) into production processes highlights professions such as software developers, data analysts, and cybersecurity experts. Simultaneously, the green transformation drives demand for expertise in energy efficiency, carbon management, environmental compliance, and sustainability auditing.

In this context, the following new professions stand out:

- Artificial Intelligence and Machine Learning Specialist
- Digital Transformation Consultant
- Data Science and Analytics Expert
- Energy Manager
- Sustainability Specialist / Environmental Engineering Consultant
- Green Building Designer
- Recycling Systems Manager
- Cybersecurity Analyst
- E-commerce and Digital Marketing Specialist

Moreover, technicians and operators in the manufacturing sector are now expected to possess versatile skills, including the ability to work with digital machinery, master automation systems, and account for environmental impacts.

4.1.2. New Professions Emerging from Green and Digital Technologies

The industrial revolution and the growth-focused economic mindset that came with mass production continued to disregard environmental damage, leading to escalating ecological problems. These issues disrupt the planet's ecological balance, alter environmental conditions, and threaten the continuation of natural life. The green transformation, which aims to achieve economic development by using resources more efficiently and without harming the environment, reflects global priorities and objectives for the future.

Green transformation is a crucial tool in achieving sustainable development goals and a critical step toward resolving global environmental issues. However, the effects and requirements it places on the labor market are increasingly becoming subjects of global discussion. It is clear that a new economic system that values the environment is needed to prevent the damage caused by climate change and environmental degradation, to reach sustainable development goals, and to leave a healthy world for future generations. This new economic order will inevitably impact labor as a production factor, thereby affecting the labor market. The degree to which labor markets—centered around people—are prepared for this transformation and how they respond to it is highly significant.

Within the framework of green transformation, the transition to environmentally friendly jobs—referred to as “green jobs”—is essential to achieving sustainable development goals. These jobs span a wide range of fields, from the production of eco-friendly products to specialization in energy efficiency. Indeed, green jobs encompass vast sectors such as renewable energy, energy efficiency and insulation, sustainable agriculture and food production, recycling and waste management, and green construction and building materials.

Green jobs hold potential for economic growth and increased employment, both locally and globally. According to a joint 2022 report by the International Labour Organization (ILO) Turkey and the United Nations Development Programme (UNDP) Turkey titled “The Social and Employment Impacts of Climate Change and Green Economy Policies in Turkey,” more than 300,000 new jobs could be created in Turkey’s labor market by 2030 if investments are made in renewable energy (ILO & UNDP, 2022).

In parallel with global developments, Turkey's labor market is also expected to undergo a shift in skill demand due to the green transformation, resulting in job losses for workers considered low-skilled. As the climate crisis gains increasing global significance, policies and measures related to the green transformation have taken on greater prominence in Turkey's top-level policy documents.

Within the scope of the Medium-Term Program (2022–2024) in Turkey, structural reforms are planned to improve the efficiency of the labor market, enhance skill alignment, and increase employment through a qualified growth model. These efforts aim to strengthen human capital and raise employability levels (Presidency of Strategy and Budget of the Republic of Turkey, 2021).

The Medium-Term Program (MTP) places specific emphasis on the green transformation in the policies and measures for which the Turkish Employment Agency (İŞKUR) is responsible. One key provision states: "Awareness will be raised regarding future jobs, particularly in the areas of digitalization and green transformation. Studies will be conducted on the current employment status, new employment opportunities, and required skills in regional and sectoral transitions within these fields." Accordingly, this provision was incorporated into İŞKUR's 2022 Fiscal Year Performance Program and 2022 Annual Activity Report (2022 Activity Report, 2023).

In this regard, it is crucial for İŞKUR to urgently implement theoretical and practical Active Labor Market Policies (ALMPs) that will enhance the employability of the workforce in green jobs, along with advisory services and labor market research focused on green employment.

To protect and increase employment, improve the professional qualifications of the unemployed, and reduce unemployment, İŞKUR organizes vocational training courses and on-the-job training programs as part of its active labor market policies. To ensure a just and sustainable transition to a greener economy, İŞKUR should provide vocational training and on-the-job programs tailored to green jobs.

When examining İŞKUR's activities related to green jobs, it is evident that there is partial support through active labor market programs. However, participation in these programs remains low, and there is currently no formal classification of "Green Professions" or "Green Jobs."

Due to the lack of an official classification for green jobs, İŞKUR's green job-related training and programs were identified by examining its classification of "Jobs of the Future." Participants in these future-focused on-the-job training programs benefit from general health insurance, work accident and occupational disease premiums, and daily stipends.

From 2018 to the end of October 2021, a total of 12,911 individuals benefited from training programs in future professions: 8,000 through on-the-job training programs and 4,911 through vocational training courses. Among the top ten most participated professions, the "Electrical-Electronics Engineer" profession—which can be considered a green job—had 527 participants during the same period. The number of identified future professions has been revised based on evaluations, increasing from the previous 25 to 100 to better address the needs arising from new developments (Ayata, 2021).

In 2024, 332 individuals received training in professions classified as future jobs under active labor market programs. However, these participants mostly took part in programs implemented with large-scale enterprises. SMEs remain largely uninvolved in this process.

4.2. Required Skills and Workforce Adaptation Strategies

The success of artisans and SMEs in the twin transformation process—namely the green and digital transitions—is not limited to technological and financial investments. For this transformation to be lasting and effective, employees must be equipped with new skills, and the workforce must be able to adapt to change. Therefore, skill development and workforce adaptation strategies should be considered an integral part of the support and incentive mechanisms provided.

The skills highlighted by the twin transformation involve a holistic and hybrid set of competencies encompassing both digitalization and sustainability. In terms of digital skills, key areas include basic digital literacy, data analysis, the use of digital production tools, and adaptation to automation and artificial intelligence technologies. In addition, expertise in areas such as e-commerce, digital marketing, and customer data management enhances the competitiveness of businesses in the digital market.

From the green transformation perspective, prominent skills include proficiency in energy efficiency practices, knowledge of waste management and recycling processes, carbon footprint measurement, and environmental impact analysis. Furthermore, familiarity with sustainable products and materials is also essential. In addition to technical skills, soft and managerial skills such as adaptability, problem-solving, project management, teamwork, and a customer-oriented approach to sustainability play a critical role in the success of the twin transformation.

To adapt to this transformation, multi-dimensional strategies must be developed within the labor market. In this context, it is crucial to implement sector-specific vocational training and skill development programs. Educational modules designed in collaboration with vocational high schools, universities, and public education centers can provide up-to-date and practical skills. For example, delivering digital manufacturing training in a workshop using CNC machines or offering sustainability training on material use to footwear producers are practical applications of such initiatives.

Within the framework of lifelong learning, micro-certification programs should be expanded to enable employees to receive short, targeted training modules on-the-job or through online platforms. This method offers an accessible and practical solution, especially for artisans and small business workers.

Public-private partnerships are also of great importance to ensure the effectiveness and sustainability of training activities. Training content developed in cooperation with chambers of commerce, technology firms, and public institutions, when combined with supported employment programs and internship opportunities, will help the workforce adapt to the transformation more quickly and effectively.

In addition, offering integrated support mechanisms such as grants, incentives, and tax advantages for employee training as part of green transformation investments is considered a key strategy. For instance, providing additional incentives to a company transitioning to energy-efficient systems to train its employees on the subject can increase the likelihood of a successful transformation.

For groups that are relatively harder to include in the transformation process—such as women, youth, and older workers—it is critical to develop accessible, flexible, and inclusive training programs to promote social inclusion.

In conclusion, for artisans and SMEs, the twin transformation is not merely a technological advancement, but a multi-faceted process that also necessitates the transformation

of human capital. Therefore, skill development, workforce alignment, and education policies must be treated as strategic components of support mechanisms and implemented in an integrated manner through region- and sector-specific solutions.

4.2.1. Essential Digital and Sustainability-Oriented Skills for SMEs

Today, the concepts of digitalization and sustainability have become fundamental requirements for SMEs—not only as part of their growth strategies but also for ensuring their long-term survival. The skills at the core of this transformation are no longer limited to technical expertise; rather, they encompass versatile competencies that must permeate all levels of the business culture.

From a digital skills perspective, SMEs are expected to develop capabilities in areas such as managing customer relationships via digital platforms, utilizing online sales channels, activating digital marketing tools, and making data-driven business decisions. At the same time, sustainability-oriented skills include improving resource efficiency, reducing environmental impact, making eco-friendly choices in the supply chain, and integrating principles of social responsibility into the business model.

These competencies should not be limited to business owners alone, but supported through training and awareness-raising processes that include all employees. Moreover, understanding the interconnection between digital transformation and sustainability—as well as the ability to think systemically and adapt to innovation—is becoming increasingly important.

In this context, equipping SMEs with multi-dimensional skills based on both technology and environmental sensitivity has become an unavoidable necessity to prepare for the future.

4.2.2. Strategies for Reskilling, Upskilling, and Career Transition

Industry 4.0 (I4.0), also known as the Fourth Industrial Revolution, is one of the most pressing issues on the global and Turkish agendas today. Throughout history, every era has been shaped by distinct technological changes. Today, I4.0—described variously by scholars as a philosophy, a technology, or a vision—is influencing the world profoundly.

No country has yet fully adapted to Industry 4.0. Even countries in relatively better positions, such as Germany, China, and the United States, have not achieved full compliance. For full adaptation, all businesses within a country must be prepared for I4.0, and enterprises, individuals, and cities must become “smart.”

Transitioning to I4.0 or acquiring its required technologies demands capital, knowledge, and skilled labor—posing a challenge for businesses. Therefore, enterprises must undergo a preparatory process to meet these conditions. For large companies with capital, knowledge, skilled personnel, and access to technology, the transition is easier than it is for SMEs. SMEs, not just in Turkey but worldwide, face similar challenges. Lacking sufficient information, technology, financial resources, and qualified workers, SMEs require more support and incentives than larger firms to undertake the I4.0 transformation.

The main components of Industry 4.0 include artificial intelligence, machine learning, cyber-physical systems, smart factories, the Internet of Things (IoT), cloud computing, big data, 3D printing, and augmented reality.

It is evident that this transformation will significantly impact the job market. There are differing views regarding the effects of technological advances and this transformation on the workforce and occupations. Some experts argue that labor will be replaced by capital due to technological developments, resulting in job losses. Others suggest that the increased demand for new products and services will give rise to new professions, thus creating new employment opportunities.

It is also anticipated that the digitalization of production will bring changes to the workplace, such as shorter work hours, remote work, and more flexible scheduling. Thanks to flexible working conditions, employees may be able to pursue professional development more effectively and maintain a better work-life balance. Industry 4.0 will also offer diverse and flexible career paths, enabling individuals to remain active and productive for longer periods.

As the demand for human labor declines due to rapid technological change, the workforce will need to be employed in emerging occupations. From this perspective, individuals who wish to work in more technologically advanced sectors and new fields of employment must attain higher levels of education and possess new sets of skills. The technology-driven and rapidly evolving labor market requires constant renewal and adaptation from the workforce.

Primarily, individuals who lose their jobs due to technological transformation must participate in new training programs to acquire relevant skills. Those who are already employed must undergo continuous in-service training to gain updated competencies. Only individuals who can align their personal and professional qualifications with the modern labor market will be able to maintain their employability.

The New Industrial Revolution envisions a system where humans and robots work side by side, both under a centralized intelligent management system. Humans and robots will operate on a shared network, but in unexpected situations, the role of the human becomes crucial. For this reason, the World Economic Forum's report on The Future of Jobs explicitly states the need for individuals with three essential skills:

- Complex Problem Solving
- Critical Thinking
- Creativity

Complex problem solving and critical thinking depend on the ability to assess situations from different perspectives, which in turn makes creativity a prerequisite. Therefore, creativity forms the foundation of future skills.

Core Competencies Required for Employees

Capabilities (Aptitudes)	**Basic Skills**	**Cross-Functional Skills**	
Cognitive Abilities:	**Content Skills:**	**Social Skills:**	**Resource Management Skills:**

- Cognitive flexibility - Creativity - Logical reasoning - Problem identification - Mathematical reasoning -Visualization ability	- Active learning - Verbal expression - Reading comprehension - Written expression - ICT literacy	-Coordinating with others - Emotional intelligence - Persuasion - Negotiation - Service orientation - Teaching and training others	- Financial resource management - Material resource management - Human resource management - Time management
Physical Abilities:	**Process Skills:**	**System Skills:**	**Technical Skills:**
- Physical strength - Manual dexterity and precision	- Active listening - Critical thinking - Monitoring self and others	- Systems analysis - Judgment and decision-making	- Equipment maintenance and repair - Equipment operation and control - Programming - Quality control - Technology and user-experience-oriented design -Troubleshooting
		Complex Problem-Solving Skills	
Source: *World Economic Forum (WEF), 2016*			

According to the report by the World Economic Forum (WEF), based on data and surveys, the 15 most in-demand skills for the year 2025 are listed in Table 3 (WEF, 2020: 36).

Table 3. Top 15 Skills for 2025

No	Core Skill	Skill Group
1	Analytical thinking and innovation	Cognitive skills
2	Active learning and learning strategies	Self-efficacy
3	Complex problem-solving	Cognitive skills
4	Critical thinking and analysis	Cognitive skills
5	Creativity, originality, and initiative	Cognitive skills
6	Leadership and social influence	Working with others
7	Technology use, monitoring, and control	Technological skills
8	Technology design and programming	Technological skills
9	Resilience, stress tolerance, and flexibility	Self-efficacy
10	Reasoning, problem-solving, and ideation	Cognitive skills
11	Emotional intelligence	Self-efficacy
12	Troubleshooting and user experience	Technological skills
13	Service orientation	Working with others
14	Systems analysis and evaluation	Cognitive skills
15	Persuasion and negotiation	Working with others
Source: *WEF, The Future of Jobs (2020)*		

Based on the above findings, it is indicated that the Fourth Industrial Revolution will most significantly impact the following sectors: aerospace and defense, automotive, chemicals, electronics, engineering and construction, forest products, paper and packaging, metals, manufacturing, transportation, and logistics.

In the context of Turkey, the sectors expected to be affected first are:

- Automotive and automotive supply industry
- Machinery
- Home appliances (white goods)
- Food and beverage
- Textile
- Chemicals

To keep pace with change, the digital transformation of companies and employees appears inevitable. Since the demand for new job qualifications will be met through education

and training, such programs must be aligned with the defined needs. Only then can the workforce be fully prepared to meet the future just in time.

4.3. Education Programs and Training Initiatives

In the 21st century, the skills and qualifications of the workforce will increasingly become the key to success in innovative factories, and the importance of the human factor in the advanced manufacturing sector of the future will also grow. It is estimated that 65% of children starting primary school today will work in completely new types of jobs that do not yet exist.

In such a rapidly evolving employment landscape, the ability to anticipate and prepare for future skill requirements is critically important for businesses, governments, and individuals. From the very beginning of the education process—starting with initial instruction and training—it is essential to foster individuals who can stand on their own and think and act independently. This also necessitates equipping educators, academics, and vocational schools with an entirely new set of responsibilities.

Due to the transformation of industry, social competencies are increasingly emphasized. This transformation requires individuals who are interdisciplinary and transdisciplinary, capable of collaborating across different fields, departments, companies, with customers and/or society. Such collaboration, which includes working with others and co-producing with different knowledge and experience sources, becomes a means for individuals to acquire systemic thinking skills.

Similarly, climate change education has become a national education and investment policy priority in Turkey, in the context of achieving Turkey's 2053 Net Zero Emissions Target (emissions reduction), realizing twin transitions (green and digital) across all sectors, implementing the Green Deal Action Plan, and preparing for climate-related disasters (adaptation).

This is particularly urgent since Turkey lies in the Mediterranean Basin—one of the world's most vulnerable regions to climate change—where increasing drought and rising surface temperatures are expected.

The Ministry of National Education (MoNE) is implementing comprehensive projects that combine green and digital transformation under the concept of "twin transition" in the education system. These efforts aim to raise students as environmentally conscious individuals equipped with digital skills.

In the Workshop on Integrating Climate Change Awareness into Basic Education held by MoNE's Directorate General for Basic Education with EU TAIEX support in 2023, the following recommendations were made regarding climate change:

- Identifying educational needs,
- Transforming school environments (into spaces that integrate both green and digital transformation),
- Determining climate literacy and sustainability skills,
- Updating curricula from the perspective of Education for Sustainable Development (ESD),
- Developing educational content and materials aligned with updated curricula,
- Updating teacher competencies and professional development to meet the needs of the era and ensuring continuity,

- Implementing flexible policies at the local level to empower communities and accelerate climate action.

Under the "Century of Türkiye Education Model", MoNE has defined the development of green and digital skills in students as a strategic objective. This approach prioritizes skill-based education and aims to instill environmental responsibility in students.

In line with this, relevant MoNE departments (e.g., DG Basic Education, DG Secondary Education, DG Vocational and Technical Education) have begun adapting curricula to the twin transition. Relevant personnel have been trained in twin transition, joint skill/competency frameworks have been developed, and each competency is being mapped to existing curricula. Once the curriculum revisions are finalized, corresponding adjustments in teacher training, learning environments, and legislation will be implemented.

For example, the DG for Vocational and Technical Education (MTEGM) is carrying out this work across 53 vocational fields and will complete curriculum revisions following the approval of the developed competency frameworks by the Board of Education and Discipline.

MoNE is also supporting twin transition efforts through various internal and externally funded projects. The "Twin Transition Project" implemented in partnership with the EU and OECD encourages students to develop projects in the fields of sustainability, digital technologies, and innovation. As part of this initiative, 28 student projects from middle and high schools in Afyonkarahisar, Sakarya, Konya, Batman, and Ankara were showcased at an exhibition held at Ankara High-Speed Train (YHT) Station on April 15, 2025.

Standout projects included the "Smart School System" and "UV Hydrovoltage Smart Water, Energy and Quality System," which addressed energy efficiency, resource management, and digital integration.

MoNE's work on the twin transition aims to transform the education system through sustainability and digitalization, preparing students as competent individuals in these fields.

The Council of Higher Education (YÖK) is also taking strategic steps to restructure Turkey's higher education system around green and digital transformation. These efforts aim to integrate the twin transition of digitalization and sustainability into higher education.

Similarly, YÖK is conducting several twin transition initiatives in higher education:

1. Strategic Planning and Curriculum Updates

In YÖK's 2024–2028 Strategic Plan, it is stated that formal and non-formal education programs will be skill- and competence-based and aligned with the twin transition process. Accordingly, curricula in vocational schools will be updated in line with the standards and qualifications published by the Vocational Qualifications Authority (MYK).

2. Green University Practices

YÖK promotes sustainability in universities. For example: Süleyman Demirel University is working to reduce single-use plastics and raise awareness of zero waste through festivals and workshops. Munzur University in Tunceli is conducting projects to recover strategic raw materials from electronic waste.

3. Development of Digital and Green Skills

YÖK organizes workshops and informational meetings to help students and faculty align with twin transition goals. These events support adaptation to new demands and help build relevant competencies.

YÖK's twin transition efforts aim to transform Turkey's higher education system along the axes of sustainability and digitalization, with the ultimate goal of raising students as capable individuals in both areas.

In conclusion, given all these developments, all stakeholders—including legislators, academics, universities, the business world, and workers themselves—have responsibilities. Solving the challenges of the twin transition requires collaborative action and cooperation among all these actors.