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A TRANSFERABLE CAPACITY-BUILDING FRAMEWORK FOR ETHIOPIAN TEXTILE INDUSTRIES: LESSONS FROM THE COMPLETED GERMAN-ETHIOPIAN TEXTILE SCHOOL (GETS) PROGRAMME

Getnet Belay Tesema[1*], Desalegn Beshaw[1], Million Ayele[1], Aberak Kechi[1], Gashaw Ashagre[1], Belaynesh Zemene[1], Kilole Tesfaye[1], Sarah, Halbauer [2], Anke, Pfau[2]

[1]Ethiopian Institute of Textile and Fashion Technology, Bahir Dar University,
P.O. Box 1037, Bahir Dar, Ethiopia
[2]Verband der Nord-Ostdeutschen, Textil- und Bekleidungsindustrie e.V.,

Annaberger Str. 240

09125 Chemnitz, Germany

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[2]Verband der Nord-Ostdeutschen, Textil- und Bekleidungsindustrie e.V., Annaberger Str. 240

09125 Chemnitz, Germany

*Corresponding Author: getbeltes@gmail.com

ABSTRACT

The Ethiopian textile industry possesses substantial potential for economic growth, employment generation, and value addition within the national manufacturing sector. However, limitations in technical competencies, process optimization, quality management, and sustainable production practices have constrained industrial competitiveness. To address these challenges, the German–Ethiopian Textile School (GETS) programme implemented a comprehensive capacity-building initiative through collaborative engagement between academic institutions and textile enterprises. This study presents the outcomes, lessons learned, and transferable framework derived from the successful completion of the programme.

A mixed-methods approach was employed, involving structured questionnaires, factory visits, stakeholder consultations, and face-to-face discussions across thirteen Ethiopian textile mills. Based on identified industrial needs, seven practice-oriented training modules were developed and delivered to participants from thirteen selected factories during the implementation phase. The modules addressed textile fibers, quality and process control, productivity & quality improvement in spinning, productivity improvement in weaving, wet processing, technical textiles, and sustainable waste management.

The programme strengthened technical competencies in fiber selection, statistical quality control, process optimization, and productivity benchmarking while promoting sustainability awareness and product diversification. The findings further demonstrated the importance of industry-driven curriculum development, practical learning approaches, and long-term university–industry partnerships. Enhanced participation of women professionals and the establishment of institutional knowledge-transfer mechanisms contributed to the sustainability of programme outcomes.

The study proposes a transferable capacity-building framework applicable to emerging textile economies seeking to improve industrial performance through context-specific and practice-oriented training interventions. The experiences gained from the completed GETS programme provide valuable insights for policymakers, educational institutions, and manufacturing industries across Ethiopia.

Keywords: capacity building; Ethiopian textile industry; GETS; quality management; productivity improvement; sustainable manufacturing; university–industry collaboration; technical textiles.

1. Introduction

The German-Ethiopian Textile School (GETS) project was designed to address skill gaps in Ethiopia's textile industry through collaboration between Association of the North-East German Textile and Clothing Industry (vti) and the Ethiopian Institute of Textile and Fashion Technology (EiTEX), Bahir Dar University. The primary objective of this initiative was to enhance the technical capabilities of professionals working in Ethiopian textile mills, thereby improving quality, productivity, waste management, and sustainability.

The project was structured around seven targeted training modules, developed following a thorough industry need assessment:

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1. Textile fibers: Methods of production, processing, and end applications.
2. Quality and process control and optimization.
3. Productivity & Quality improvement in spinning.
4. Productivity improvement in weaving.
5. Waste minimization.
6. Chemical management.
7. Technical textiles.

In addition to the core training, the project supports the development of a digital learning platform in partnership with local industries, ensuring future accessibility to ongoing training resources.

2. Literature Review

2.1 Capacity Building and Human Capital Development in Manufacturing Industries

Human capital development constitutes a fundamental driver of industrial competitiveness and technological advancement. Contemporary manufacturing systems increasingly depend upon skilled personnel capable of operating sophisticated equipment, implementing quality-management systems, and adapting to rapidly changing market demands. According to Becker (1993), investments in education and professional training directly influence productivity, innovation, and long-term economic performance. In developing economies, industrial training programmes play a critical role in reducing technological dependence and strengthening domestic capabilities.

The textile industry, in particular, requires multidisciplinary competencies encompassing fiber science, process engineering, quality assurance, sustainability, and digital manufacturing technologies. Fletcher (2014) argues that sustainable growth within textile value chains depends not only on technological investments but also on continuous workforce development and knowledge dissemination mechanisms.

2.2 Industry-University Collaboration and Knowledge Transfer

Collaborative relationships between higher education institutions and industries have become increasingly important for technological modernization and innovation diffusion. Etzkowitz and Leydesdorff (2000) introduced the Triple Helix model, emphasizing interactions among universities, industries, and governments as catalysts for economic development and knowledge creation.

Within textile manufacturing, university–industry partnerships facilitate curriculum development, applied research, technical consultancy, and professional training programmes. Such collaborations contribute to aligning educational outcomes with industrial requirements while accelerating the transfer of scientific knowledge into practical applications (Perkmann et al., 2013). The GETS initiative represents an example of this collaborative approach, integrating academic expertise with the operational realities of Ethiopian textile enterprises.

2.3 Quality Management and Productivity Improvement in Textile Manufacturing

Global competitiveness in textile manufacturing increasingly depends on effective quality-management systems and continuous productivity improvements. Statistical Process Control (SPC), Lean Manufacturing, Total Quality Management (TQM), and Six Sigma methodologies have become essential tools for minimizing defects, reducing waste, and enhancing operational efficiency (Montgomery, 2020).

Benchmarking systems developed by Uster Technologies provide internationally recognized standards for yarn quality assessment and process optimization. The application of such tools enables manufacturers to compare their performance against global best practices and identify opportunities for improvement (Lawrence, 2010). Similarly, lean production principles emphasize continuous improvement, employee participation, and waste elimination as fundamental mechanisms for achieving sustainable industrial growth (Womack and Jones, 2003).

2.4 Sustainability and Circular Economy in Textile Industries

Environmental sustainability has emerged as a strategic priority within global textile value chains. Growing concerns regarding resource consumption, chemical usage, and textile waste have accelerated the adoption of cleaner production technologies and circular-economy principles. Fletcher and Grose (2012) highlight the necessity of integrating sustainability considerations throughout textile education, manufacturing processes, and product development activities.

Recent studies emphasize the importance of waste valorization, recycling technologies, and sustainable material selection in promoting environmentally responsible textile industries (Niinimäki et al., 2020). Capacity-building programmes that incorporate sustainability themes contribute not only to environmental protection but also to improved economic performance and international market competitiveness.

2.5 Industrial Capacity Building in Emerging Economies

Emerging economies frequently encounter challenges related to technological gaps, workforce shortages, and limited institutional capacities. Effective industrial training programmes must therefore be context-specific, industry-driven, and aligned with national development priorities. According to the United Nations Industrial Development Organization (UNIDO, 2021), sustainable industrial transformation requires integrated approaches combining technical education, innovation systems, and institutional partnerships.

Within Africa, the textile sector presents significant opportunities for employment generation and value addition; however, achieving competitiveness demands continuous investments in human capital and technological capabilities. The experiences derived from the completed GETS programme contribute to this broader discourse by demonstrating how international collaboration and locally adapted training frameworks can support industrial modernization and sustainable development.

3. Methodology

3.1 Research Design

This study employed a mixed-methods research design combining qualitative and quantitative approaches to assess industrial training needs, implement targeted interventions, and evaluate programme outcomes. The methodological framework emphasized participatory engagement among academic institutions, industrial stakeholders, and technical personnel to ensure that training activities addressed practical manufacturing challenges.

3.2 Industrial Needs Assessment

A comprehensive needs assessment was conducted across thirteen Ethiopian textile industries representing different manufacturing segments within the national textile value chain. Structured questionnaires, semi-structured interviews, factory observations, and stakeholder consultations were utilized to identify critical skill gaps and operational challenges.

The assessment focused on areas including:

- textile fiber knowledge and raw-material management;
- quality assurance and process control;
- productivity & quality improvement in spinning operations;
- Productivity improvement in weaving;
- wet processing and chemical management;
- technical textiles and product diversification;
- sustainability and waste-management practices.

The findings informed the development of context-specific training modules aligned with industrial requirements.

3.3 Training Programme Development and Implementation

Based on the identified priorities, seven integrated training modules were developed and delivered through the German–Ethiopian Textile School (GETS) programme. The instructional approach combined theoretical presentations, practical demonstrations, group discussions, and factory-based learning activities.

The GETS implementation phase involved participants from thirteen selected textile factories. Training delivery emphasized interactive participation, practical problem-solving, and direct application of acquired knowledge to industrial processes.

3.4 Data Collection and Evaluation

Programme evaluation employed multiple data sources, including participant feedback questionnaires, management assessments, workshop discussions, and observational records. Qualitative responses were analyzed thematically to identify recurring patterns relating to technical competencies, organizational learning, sustainability awareness, and knowledge-transfer mechanisms.

The triangulation of different data sources enhanced the reliability and validity of the findings while providing a comprehensive understanding of programme impacts.

3.5 Limitations of the Study

The study primarily focuses on the implementation phase of the GETS programme involving thirteen textile factories. Consequently, the findings may not fully represent the entire Ethiopian textile sector. Furthermore, quantitative productivity indicators and long-term industrial performance measurements were constrained by data availability. Nevertheless, the mixed-methods approach provides valuable insights into the effectiveness and transferability of industrial capacity-building initiatives within emerging textile economies.

4. Results and Discussion

4.1 Identification of Industrial Capacity Gaps

The needs assessment conducted across Ethiopian textile industries revealed several critical challenges affecting operational performance and competitiveness. The most frequently reported issues included shortages of skilled technical personnel, inadequate application of statistical quality-control methods, limited knowledge of modern textile technologies, insufficient sustainability practices, and weak linkages between academic institutions and industrial enterprises.

These findings are consistent with broader observations in developing manufacturing economies, where technological advancement often outpaces workforce competencies (UNIDO, 2021). The identified gaps justified the development of a comprehensive and industry-oriented capacity-building framework under the GETS programme.

4.2 Integrated Training Framework and Module Delivery

To address the identified needs, seven interconnected modules were designed and implemented. Rather than functioning as independent instructional units, the modules formed an integrated framework linking raw materials, manufacturing processes, quality management, sustainability, and product innovation.

Table 1 summarizes the major training modules and their industrial significance.

Table 1. Overview of GETS Training Modules

Module	Major Topics	Industrial Relevance
Textile Fibers	Natural and synthetic fibers, processing methods, applications	Improved raw-material utilization
Quality and Process Control	SPC, Lean Manufacturing, TQM, Six Sigma	Enhanced process stability and quality assurance
Productivity & quality improvement in spinning	Machine efficiency, benchmarking, waste reduction	Increased productivity and cost optimization
Productivity improvement in Weaving	Loom performance, fabric defects, process optimization	Better fabric quality and operational efficiency
Wet Processing	Dyeing, finishing, chemical management	Environmental compliance and product quality
Technical Textiles	Medical, agricultural, and industrial textiles	Product diversification and innovation
Waste Management and	Recycling, circular economy, cleaner	Resource efficiency and

Sustainability	production	environmental stewardship

The integration of these themes allowed participants to understand textile manufacturing as an interconnected value chain rather than as isolated production processes.

4.3 Technical Competency Development

One of the most significant outcomes of the completed GETS programme was the enhancement of technical competencies among participating professionals. Participants demonstrated improved understanding of fiber properties, yarn-quality parameters, process optimization methods, and internationally accepted benchmarking tools.

The inclusion of Statistical Process Control (SPC), Uster benchmarking principles, Lean Manufacturing concepts, and Total Quality Management provided practical mechanisms for identifying defects, reducing variability, and improving manufacturing efficiency. Similar approaches have been reported as effective strategies for strengthening industrial competitiveness within textile enterprises (Montgomery, 2020; Lawrence, 2010).

The spinning productivity module further introduced concepts related to machine utilization, preventive maintenance, and global performance benchmarking, enabling participants to compare local practices with international standards. Such benchmarking exercises contribute to continuous improvement cultures and support evidence-based managerial decision-making.

4.4 Organizational Learning and Industry–University Collaboration

The GETS programme demonstrated the importance of collaborative partnerships between universities and industries. The joint development and delivery of training materials ensured that academic knowledge was translated into practical industrial applications while simultaneously exposing educational institutions to real manufacturing challenges.

The interactions established through the programme strengthened communication channels among managers, engineers, technicians, and academic staff. These outcomes align with the Triple Helix model, which emphasizes university–industry cooperation as a driver of innovation and economic development (Etzkowitz and Leydesdorff, 2000).

Beyond immediate technical benefits, the programme contributed to institutional learning by creating networks that may facilitate future collaborations in research, consultancy, and professional development activities.

4.5 Sustainability Awareness and Environmental Responsibility

Environmental sustainability constituted a cross-cutting theme throughout all training modules. Participants gained increased awareness regarding waste minimization, recycling practices, cleaner production technologies, and responsible chemical management.

The introduction of circular-economy concepts encouraged participants to consider alternative approaches to textile waste utilization and resource conservation. Such perspectives are increasingly important as global textile industries seek to reduce environmental impacts while maintaining economic competitiveness (Niinimäki et al., 2020).

The incorporation of sustainability principles into technical training also reflects contemporary educational approaches that advocate integrating environmental considerations throughout engineering curricula rather than treating them as independent subjects (Fletcher and Grose, 2012).

4.6 Product Diversification through Technical Textiles

The technical-textiles component introduced participants to emerging applications beyond conventional apparel manufacturing. Discussions included agro-textiles, medical textiles, protective textiles, geotextiles, and industrial applications.

This exposure broadened participants' perspectives regarding opportunities for value addition and market diversification within Ethiopia's textile sector. Product diversification represents an important strategic pathway for enhancing industrial resilience and reducing dependence on traditional commodity markets.

4.7 Training Modules and Their Industrial Significance

4.7.1 Textile Fibers: Methods of Production, Processing, and End Applications

The textile fibers module established the fundamental scientific basis for understanding raw materials used throughout textile manufacturing systems. The training covered natural fibers (cotton, wool, silk, flax, and jute), regenerated fibers (viscose and lyocell), synthetic fibers (polyester, nylon, acrylic, and polypropylene), and high-performance fibers such as aramids and carbon fibers. Emphasis was placed on fiber morphology, physical and mechanical properties, moisture behaviour, thermal characteristics, and their implications for subsequent manufacturing processes.

The production methods of natural fibers, particularly cotton and silk, were discussed in detail because of their strategic importance to Ethiopian textile industries. Cotton processing stages, including cultivation, harvesting, ginning, cleaning, and baling, were linked directly to fiber quality parameters that determine spinning performance. Similarly, the production of manufactured fibers through polymerization, melt spinning, wet spinning, and dry spinning technologies was examined to provide participants with broader perspectives on global textile-material developments.

Processing characteristics such as fiber opening, cleaning, blending, carding, and drawing were introduced as essential determinants of yarn quality. Participants explored the relationships between fiber fineness, staple length, maturity, and spinning behaviour. Understanding these interactions enabled technical personnel to make informed decisions regarding raw-material selection and process optimization.

The module further addressed end-use applications ranging from apparel products to technical textiles, medical products, automotive components, geotextiles, and protective materials. Such discussions encouraged industries to consider opportunities for value addition and market diversification beyond conventional garment manufacturing.

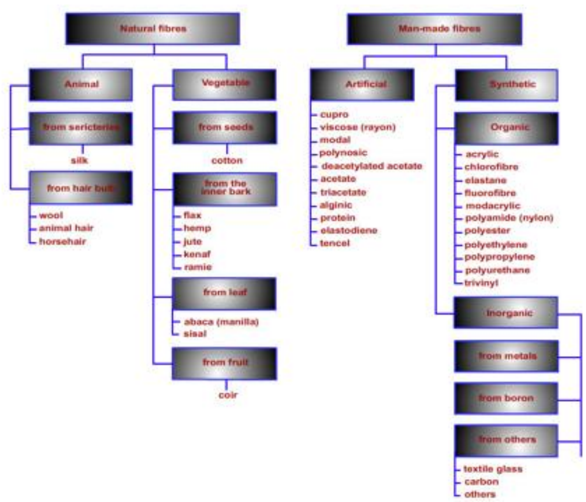


Figure 1 Classification of textile fibers

Figure 2 Cotton value chain

Figure 3 End applications of natural and manufactured textile fibers.

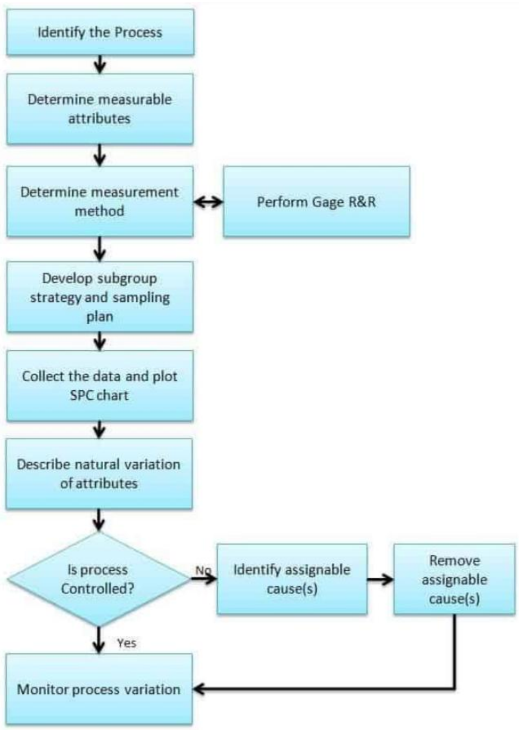
4.7.2 Quality and Process Control and Optimization

Quality management has become a critical factor determining competitiveness within modern textile industries. This module introduced internationally recognized tools and methodologies designed to improve process stability, reduce variability, and enhance product consistency. Topics included Statistical Process Control (SPC), Total Quality Management (TQM), Lean Manufacturing, Six Sigma methodologies, process capability analysis, and continuous-improvement frameworks.

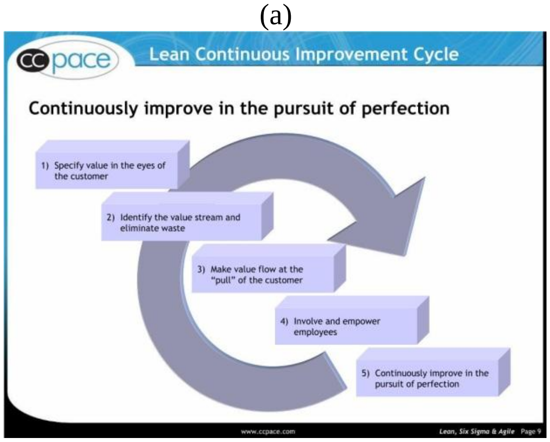
Participants learned to apply control charts for monitoring process variables in spinning, weaving, and finishing operations. The interpretation of process capability indices enabled technical personnel to evaluate whether manufacturing processes consistently satisfied product specifications. Emphasis was placed on proactive quality assurance rather than reliance upon end-product inspection alone.

The integration of Lean Manufacturing principles encouraged the identification and elimination of non-value-adding activities throughout textile production systems. Waste associated with overproduction, excessive transportation, waiting time, defects, and inefficient material handling was analyzed using practical factory examples. Six Sigma concepts further provided structured problem-solving approaches through the Define–Measure–Analyze–Improve–Control (DMAIC) framework.

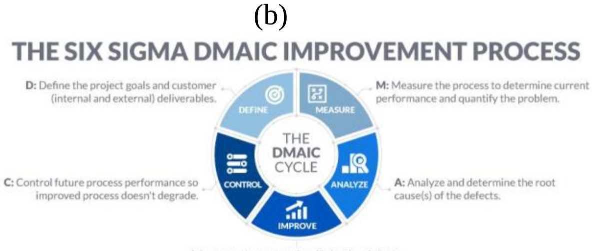
Global benchmarking through Uster quality standards was also introduced to enable participants to compare local performance with international best practices. Such benchmarking exercises strengthened awareness regarding continuous improvement and evidence-based management decisions.



(a)



(b)



(c)

Figure 4. Integrated framework for statistical process control (a), Lean Manufacturing, Six Sigma (b), and continuous improvement in textile production systems (c).

4.7.3 Productivity and Quality Improvement in Spinning

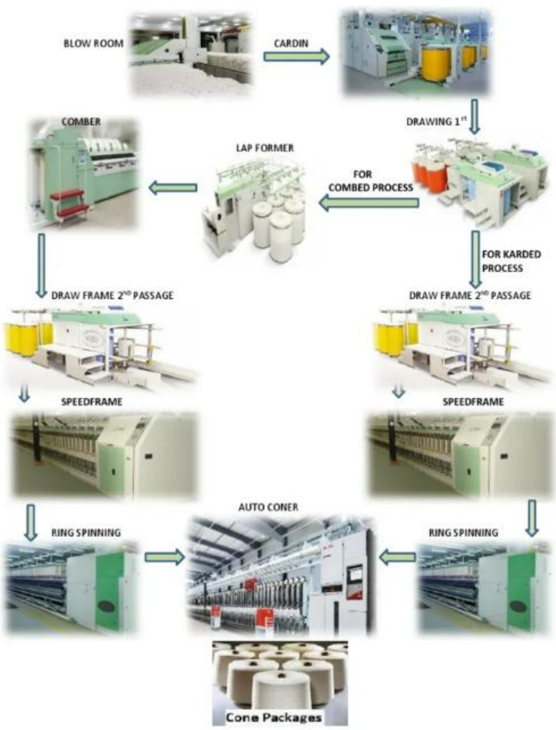
Spinning operations significantly influence downstream fabric quality and overall manufacturing economics. Consequently, this module focused on improving machine utilization, reducing waste, and enhancing yarn-quality characteristics through systematic process optimization.

Participants examined productivity indicators including machine efficiency, production rate, waste percentage, energy consumption, labour productivity, and overall equipment effectiveness. Detailed discussions covered blow-room performance, carding efficiency, draw-frame autolevelling, simplex optimization, and ring-spinning technologies.

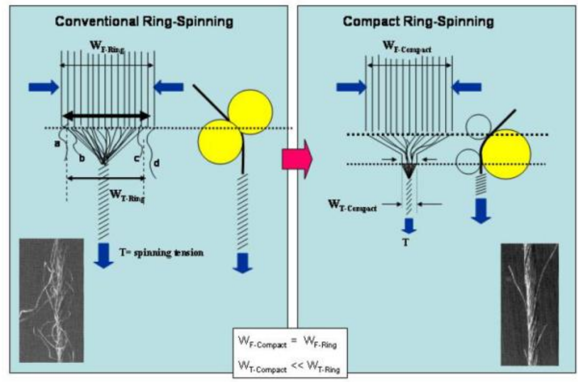
The application of Uster Statistics provided participants with internationally recognized benchmarks for evaluating yarn evenness, hairiness, strength, elongation, and imperfection indices. Comparative analyses demonstrated the performance gap between local production practices and global best-performing mills, thereby encouraging the adoption of continuous-improvement initiatives.

Preventive maintenance strategies were emphasized as critical components of sustainable productivity enhancement. Machine downtime, spare-parts management, lubrication systems, and environmental control within spinning departments were identified as essential determinants of operational efficiency. Participants further explored the influence of temperature and humidity conditions on fiber behaviour and yarn quality.

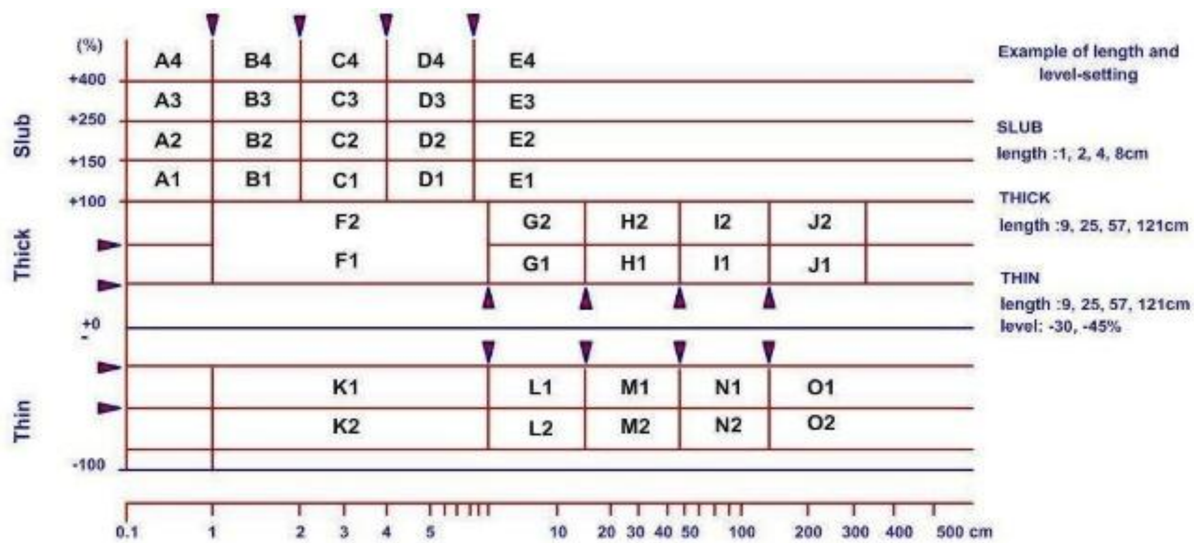
The module concluded by introducing concepts related to digital monitoring systems and Industry 4.0 technologies that increasingly support predictive maintenance and intelligent manufacturing systems.



5(a) spinning process flow chart



5(b) Comparison between Fiber Compactness in Conventional Ring-Spinning and Compact Ring-Spinning [El Mogahzy and Chewning, 2002]



5(c) Example of length and level setting

Figure 5 Cotton spinning process flow and key productivity and quality indicators employed in modern yarn manufacturing.

4.7.4 Productivity Improvement in Weaving

Weaving productivity depends upon effective integration among warp preparation, loom technology, process control, and preventive maintenance. The training module addressed these factors through practical discussions of weaving mechanics, defect analysis, and operational optimization strategies.

Participants studied various shuttleless weaving technologies, including rapier, projectile, air-jet, and water-jet systems. Comparative evaluations highlighted their respective advantages regarding production speed, energy consumption, flexibility, and fabric quality. Warp preparation processes, especially sizing operations, received particular attention because they significantly influence loom performance and warp-break frequencies.

The module introduced key performance indicators such as loom efficiency, machine utilization, stoppage analysis, defect frequency, and labour productivity. Participants learned to identify major causes of productivity losses, including warp breaks, weft insertion failures, mechanical malfunctions, and improper process settings.

Practical problem-solving exercises enabled factory personnel to develop preventive-maintenance schedules and implement corrective measures aimed at minimizing downtime. The discussions emphasized that improvements in weaving productivity require not only technological investments but also skilled human resources and systematic management practices.

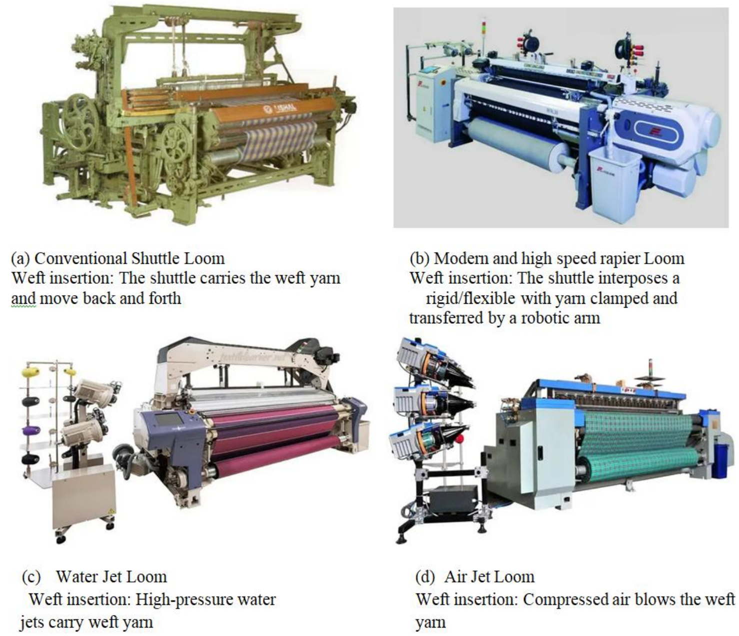


Figure 7 Common types of weaving machines

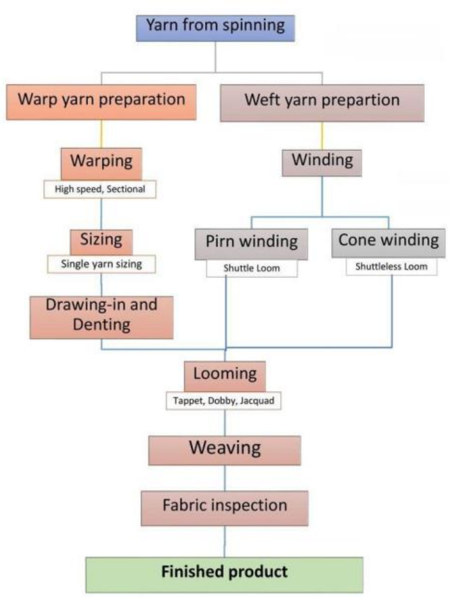
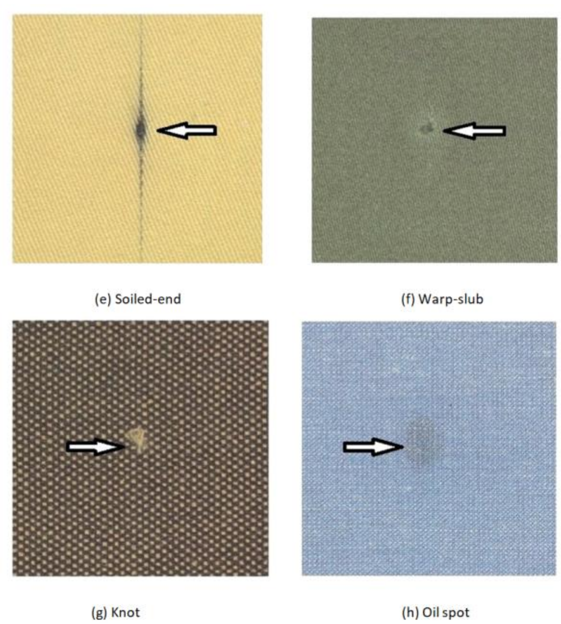
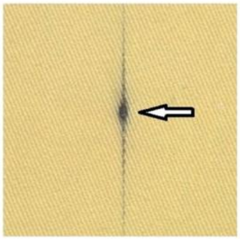
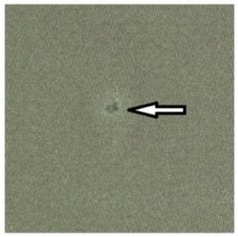


Figure 6. Weaving process flow chart

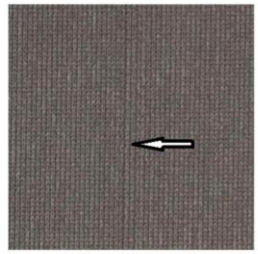




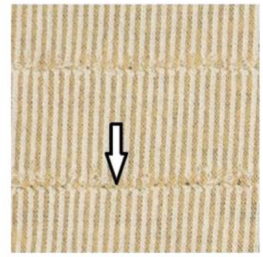
(e) Soiled-end



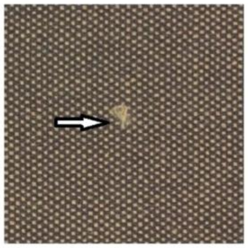
(f) Warp-slub



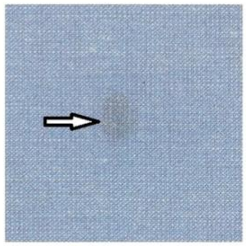
(i) End-out



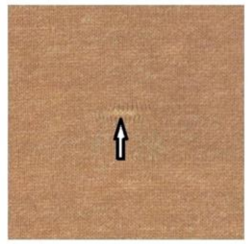
(j) Missing-yarn



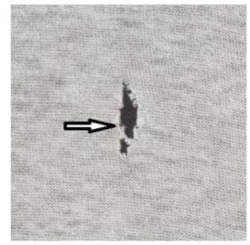
(g) Knot



(h) Oil spot



(k) Slub



(l) Hole

Figure 8 Common types of fabric defects

(m)

Figure 9. Weaving process optimization and major performance indicators influencing fabric quality and productivity.

4.7.5 Waste Minimization

Waste minimization formed an integral component of the sustainability strategy embedded within the GETS programme. The module introduced participants to cleaner-production concepts, circular-economy principles, and resource-efficiency approaches relevant to textile manufacturing industries.

Discussions addressed various forms of textile waste, including fiber losses, yarn waste, fabric offcuts, packaging materials, and post-consumer textile products. Participants examined opportunities for recycling cotton waste into regenerated yarns, converting packaging materials into woven products, and reusing process residues within alternative value chains.

The principles of Reduce, Reuse, and Recycle (3R) were linked directly to economic performance and environmental stewardship. Process optimization measures aimed at minimizing raw-material losses and improving housekeeping practices were presented as cost-effective strategies for increasing industrial competitiveness.

The module further emphasized industrial symbiosis approaches whereby waste generated in one process may serve as input materials for other manufacturing activities. Such perspectives align closely with global sustainability agendas and circular-economy frameworks increasingly adopted by textile industries worldwide.

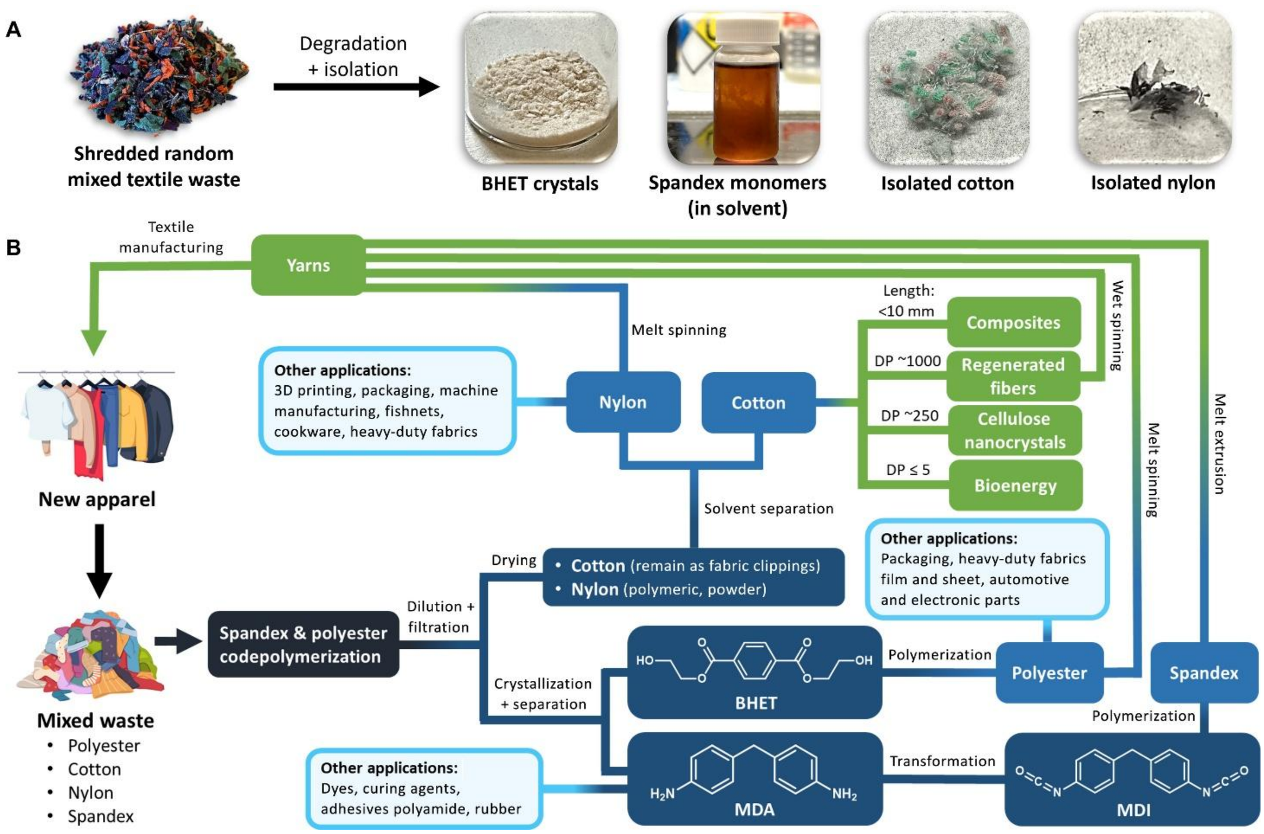


Figure 10 Recycling of mixed textile waste for circularity. (A) Isolated components obtained from real mixed textile waste with unknown compositions. (B) Proposed pathways for textile-to-textile and open-loop recycling. 3D, three-dimensional. MDI, methylene diphenyl diisocyanate.

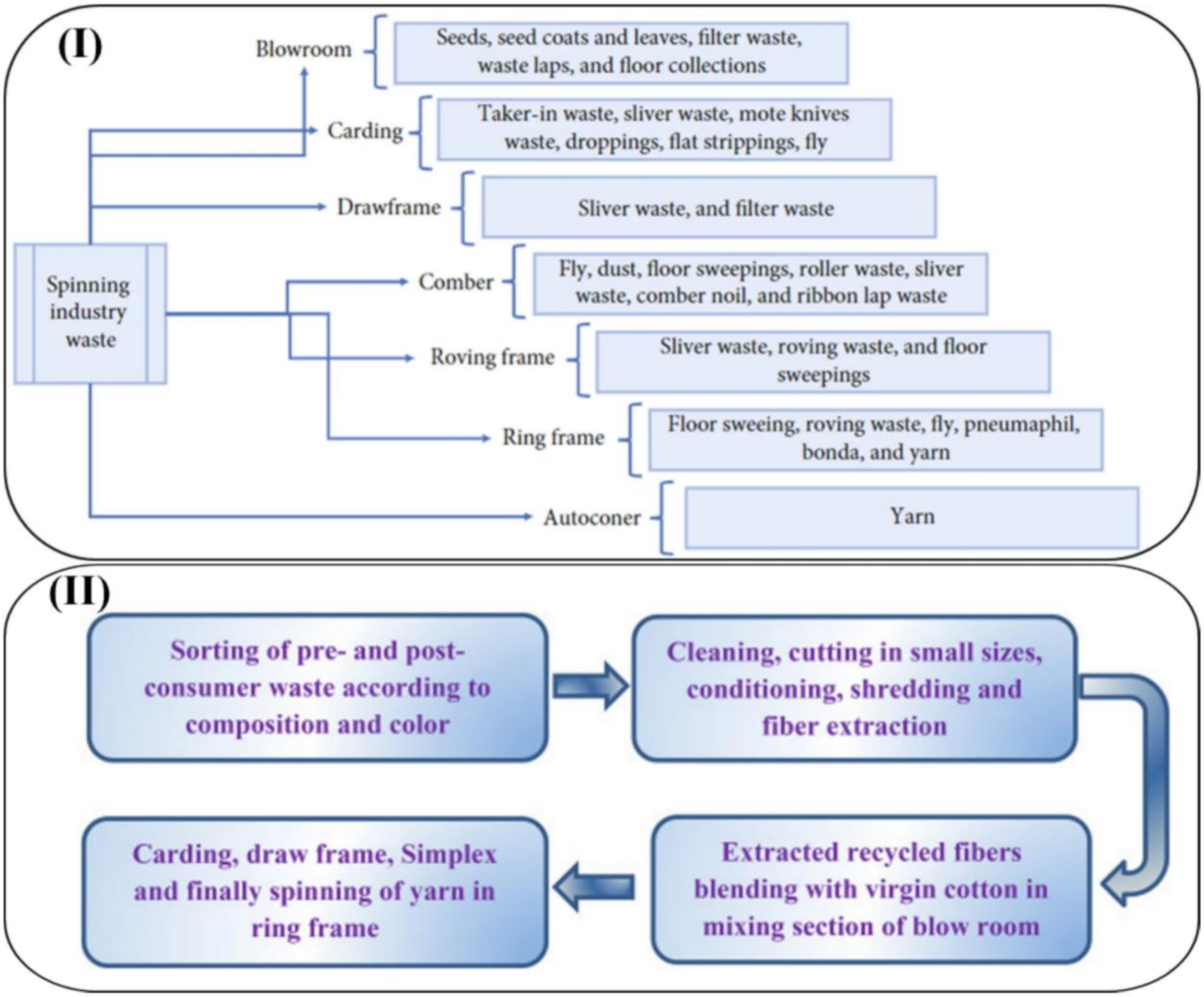


Figure 11 Spinning industry waste types. Özen, İ., Bahtiyari, M.İ., Demiryürek, O. et al. Sustainable Production Applications on Textile-to-Textile Recycling of Pre-consumer Textile Waste in Light of Emerging Trends. Fibers Polym 26, 4691–4714 (2025). https://doi.org/10.1007/s12221-025-01154-1

I) Spinning industry waste types. II Flow chart of preparing yarns from blends of virgin/recycled cotton fibers obtained from pre- and post-consumer fabric wastes.

4.7.6 Chemical Management

Responsible chemical management represents both an environmental obligation and a competitive requirement for contemporary textile industries. This module addressed safe chemical handling, storage systems, occupational health considerations, environmental regulations, and cleaner-production technologies.

Participants received training on chemical classification systems, Material Safety Data Sheets (MSDS), hazard identification procedures, and emergency-response protocols. Emphasis was placed on establishing safe working environments while minimizing risks to employees and surrounding communities.

The module examined wastewater-treatment technologies, chemical-recovery systems, and international initiatives such as Zero Discharge of Hazardous Chemicals (ZDHC) programmes. Discussions highlighted the importance of compliance with global market requirements, particularly for export-oriented textile enterprises.

Cleaner chemical technologies and process optimization strategies were introduced as mechanisms for reducing resource consumption and minimizing environmental impacts. Participants recognized that effective chemical management contributes not only to sustainability objectives but also to improved product quality and operational efficiency.

Chemical-management framework incorporates: occupational safety, environmental protection, and sustainable textile-processing practices.

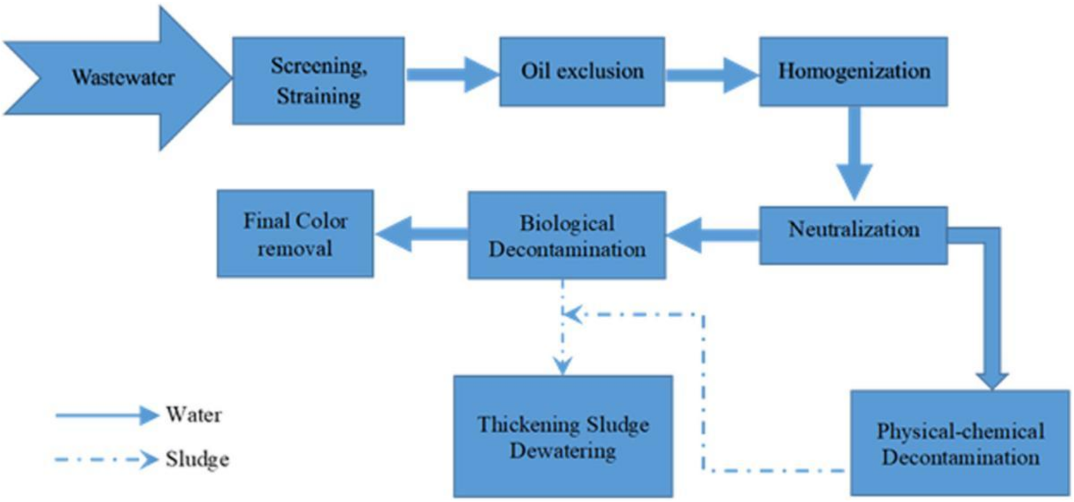


Figure 12 Example of Wastewater Treatment

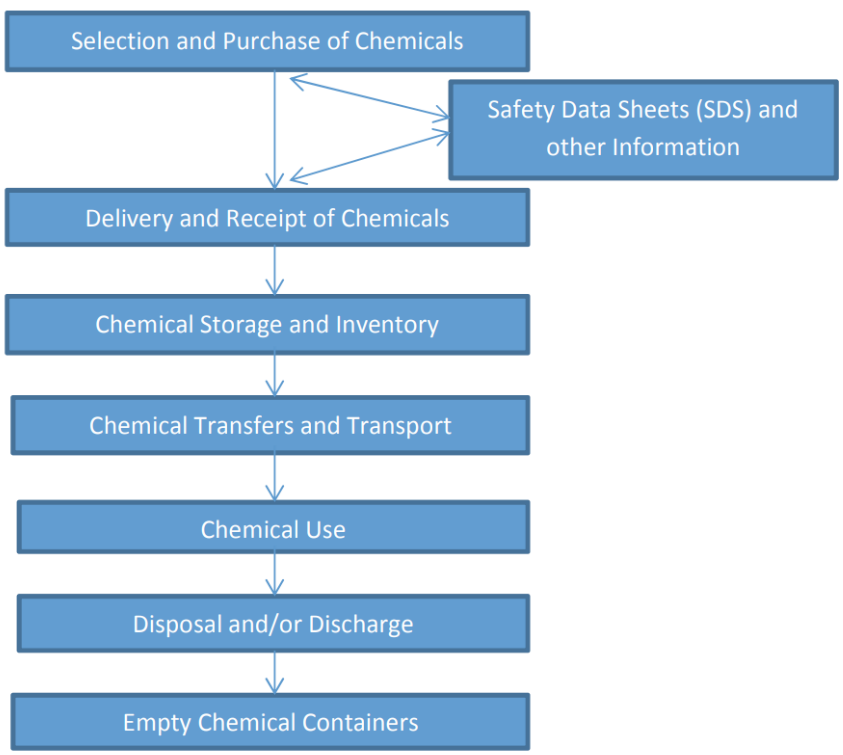


Figure 13 Example of Chemical Life Cycle

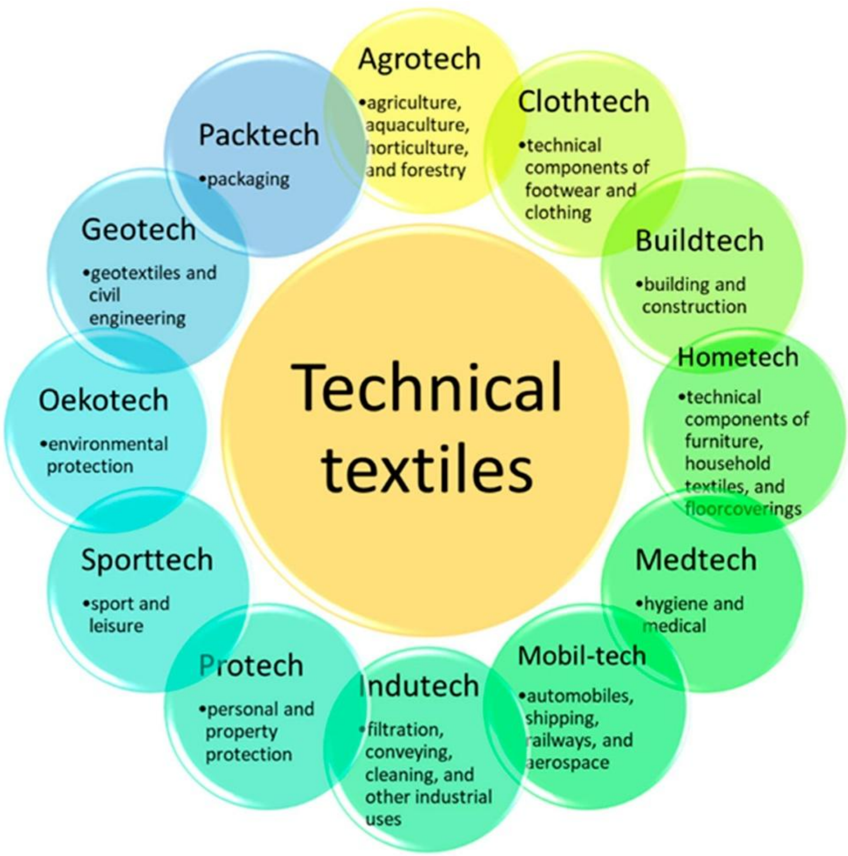
4.7.7 Technical Textiles

The technical-textiles module broadened participants' perspectives beyond conventional apparel manufacturing by introducing specialized applications characterized by functional performance requirements. The training covered medical textiles, agro-textiles, geotextiles, protective textiles, automotive textiles, filtration materials, and smart-textile technologies.

Participants explored the relationships between fiber selection, structural design, finishing treatments, and functional performance characteristics. Discussions emphasized how high-value textile products contribute to industrial diversification and increased economic resilience.

Particular attention was devoted to agricultural applications because of their relevance to Ethiopian development priorities. Agro-textiles used in crop protection, irrigation systems, erosion control, and greenhouse technologies illustrate opportunities for integrating textile engineering with agricultural modernization initiatives.

Emerging technologies involving smart textiles, wearable sensors, and sustainable functional materials were also introduced. These discussions encouraged participants to consider innovation-driven growth strategies capable of expanding the competitiveness of domestic textile industries within international markets.



(a)

(b)

(c)

Figure 14 (a, b, & c). Major sectors and representative applications of technical textiles in contemporary industrial systems.

Collectively, the seven modules formed an integrated capacity-building framework linking raw materials, manufacturing technologies, productivity enhancement, sustainability, environmental stewardship, and product innovation. Their interdisciplinary character strengthened technical competencies while simultaneously promoting organizational

4.7.8 Gender Inclusion and Human-Capital Development

The programme promoted inclusive participation by encouraging the involvement of women professionals in technical training activities. Increased female representation contributed positively to organizational learning processes and knowledge dissemination.

Human-capital development extends beyond technical competence alone; it also encompasses social inclusion, professional confidence, and opportunities for leadership. The experiences of the GETS programme suggest that gender-inclusive approaches strengthen institutional capacities and contribute to more sustainable industrial development outcomes.

4.7.9 Lessons Learned and Best Practices

Several important lessons emerged from the completed programme.

First, industrial needs assessments are essential for designing relevant and effective training interventions. Programmes developed without direct stakeholder engagement may fail to address actual operational challenges.

Second, practical demonstrations and factory-based learning activities proved more effective than conventional lecture-oriented approaches. Participants consistently emphasized the value of interactive problem-solving and real-world applications.

Third, sustainability considerations should be integrated throughout all technical subjects rather than confined to specialized environmental modules.

learning and long-term industrial development. The experiences gained through the GETS programme demonstrate that practice-oriented, context-sensitive, and industry-driven training initiatives constitute effective mechanisms for supporting sustainable textile-sector transformation in Ethiopia and other emerging economies.

Fourth, long-term university–industry partnerships provide stronger and more sustainable outcomes than short-term training initiatives.

Finally, contextual adaptation of international experiences is critical. Successful capacity-building programmes must reflect local industrial realities, raw-material conditions, and workforce characteristics.

4.7.10 A Transferable Framework for Capacity Building in Textile Industries

Based on the experiences gained through the completed GETS programme, a five-stage framework for industrial capacity building is proposed:

1. Industrial needs assessment and stakeholder consultation;
2. Context-specific curriculum development;
3. Factory-based implementation and practical learning;
4. Monitoring and evaluation through participant feedback;
5. Institutional sustainability and knowledge-transfer mechanisms.

The framework emphasizes continuous collaboration among educational institutions, industries, and policymakers, thereby providing a model that may be adapted to other emerging textile economies across Africa.

Conclusions

The successful completion of the German–Ethiopian Textile School (GETS) programme demonstrates the importance of integrated, practice-oriented, and industry-driven capacity-building initiatives in strengthening textile manufacturing competencies. Through comprehensive needs assessments and collaborative programme design, the initiative addressed critical challenges relating to quality management, productivity improvement, sustainability, and technological innovation.

The seven training modules provided participants with multidisciplinary knowledge encompassing textile fibers, process control, productivity & quality improvement in spinning, productivity improvement in weaving, wet processing, technical textiles, and waste management. The outcomes extended beyond technical skills to include organizational learning, enhanced industry–university collaboration, sustainability awareness, and inclusive human-capital development.

The experiences gained highlight several important lessons. Effective industrial training requires active stakeholder participation, practical learning methodologies, contextual adaptation, and long-term institutional partnerships. Furthermore, sustainability considerations should be integrated across all areas of textile education and manufacturing practice.

The transferable framework proposed in this study offers a structured approach for supporting industrial modernization within emerging textile economies. Although developed within the Ethiopian context, its principles may be applicable to other African countries seeking to strengthen domestic textile industries through human-capital development and international collaboration.

Ultimately, the legacy of the completed GETS programme extends beyond immediate training outcomes. It establishes a foundation for continuous professional development, institutional cooperation, and sustainable industrial transformation, thereby contributing to the long-term competitiveness and resilience of Ethiopia's textile sector.

References

Becker, G.S. (1993) Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education. 3rd edn. Chicago: University of Chicago Press.

Camp, R.C. (1989) Benchmarking: The Search for Industry Best Practices that Lead to Superior Performance. Milwaukee, WI: ASQC Quality Press.

Etzkowitz, H. and Leydesdorff, L. (2000) 'The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations', Research Policy, 29(2), pp. 109–123.

Fletcher, K. (2014) Sustainable Fashion and Textiles: Design Journeys. 2nd edn. London: Routledge.

Fletcher, K. and Grose, L. (2012) Fashion and Sustainability: Design for Change. London: Laurence King Publishing.

Horrocks, A.R. and Anand, S.C. (2016) Handbook of Technical Textiles. 2nd edn. Cambridge: Woodhead Publishing.

Klein, W. (2014) The Technology of Short-Staple Spinning. Manchester: Textile Institute.

Lawrence, C.A. (2010) Advances in Yarn Spinning Technology. Cambridge: Woodhead Publishing.

Lord, P.R. (2003) Handbook of Yarn Production: Technology, Science and Economics. Cambridge: Woodhead Publishing.

Montgomery, D.C. (2020) Introduction to Statistical Quality Control. 8th edn. Hoboken, NJ: John Wiley & Sons.

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T. and Gwilt, A. (2020) 'The environmental price of fast fashion', Nature Reviews Earth & Environment, 1(4), pp. 189–200.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A. and Sobrero, M. (2013) 'Academic engagement and commercialisation: A review of the literature on university–industry relations', Research Policy, 42(2), pp. 423–442.

UNIDO (2021) Industrial Development Report 2022: The Future of Industrialization in a Post-Pandemic World. Vienna: United Nations Industrial Development Organization.

Womack, J.P. and Jones, D.T. (2003) Lean Thinking: Banish Waste and Create Wealth in Your Corporation. Revised edn. New York: Free Press.