International Journal of Science, Technology and Society
2026, Vol. 14, No. 6, pp. 238–248
https://doi.org/10.11648/j.ijsts.20261406.11

SciencePG
Science Publishing Group

Research Article

Integrated Assessment Model for Quality and Safety Resources at a Textile Enterprise

Nasibakhon Sotvoldieva[1, *], Akbarov Khotam[2]

[1]Metrology and Light Industry, Andijan State Technical Institute, Andijan, Uzbekistan

[2]Department of Mechanical Engineering Technology, Andijan State Technical Institute, Andijan, Uzbekistan

Abstract

Ensuring product quality and safety in textile manufacturing depends on the coordinated management of human, material, technological, and informational resources. However, these factors are usually studied separately, and enterprises lack a single interpretable indicator for monitoring them together. The purpose of this study was to develop an integrated index model for assessing the resources that affect quality and safety at a textile enterprise and to test it on real production data. The model was applied to 36 months of monthly operational data. Twenty-seven initial indicators (X1-X27) were grouped into four resource categories: human resources, raw material and chemical resources, technical and technological resources, and information and traceability resources. From these, 18 relative indicators were derived and normalized according to whether an increase or a decrease in the indicator is favorable. Weighting coefficients were determined from expert assessments, and group indices (Q1-Q4) and an overall resource index (Q_{total}), ranging from 0 to 1, were calculated for each month. The overall index rose from 0.09 in the first month to 0.97 in the final month, reflecting improvements in personnel competence, raw-material control, equipment stability, and batch traceability. Human resources and raw material and chemical resources received the highest expert weights (0.261 and 0.278, respectively). This increase should be interpreted as an improvement in the selected resource measures rather than as direct proof of improved product safety. The proposed model makes it possible to identify weak resource groups, monitor the factors affecting quality and safety, and substantiate operational, tactical, and strategic management decisions.

Keywords

Textile Enterprise, Quality Management, Product Safety, Integrated Resource Index, Expert Evaluation, Production Monitoring

1. Introduction

Ensuring product quality and safety at textile enterprises depends on the coordinated management of human resources, the quality of raw materials and chemical agents, the condition of technical and technological equipment, and the information and monitoring system. Discrepancies in these resource groups can lead to product defects, production losses, unscheduled downtime, and non-compliance with consumer requirements. [1, 2].

In the textile and apparel industry, traceability systems serve as an essential tool for quality monitoring, risk management, and identifying the source of defects by integrating data

*Correspondence: Nasibakhon Sotvoldieva (nasibakhon_1992@gmail.com)

Received: 19 October 2026; **Accepted:** 29 October 2026; **Published:** 3 November 2026

Copyright: © The Author(s), 2026. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

on materials, production batches, and processes. In scientific research, risk management, product authentication, transparency, and quality monitoring are recognized as priority factors in implementing traceability. [3-6].

Although quality management, maintenance, supplier control, and traceability have often been studied as separate managerial domains, textile enterprises need an integrated approach that combines heterogeneous operational data into a single interpretable performance indicator. Quality management and risk-based thinking require organizations to identify, assess, and control interconnected risks affecting processes, resources, and product conformity. Therefore, an integrated index that combines human, raw-material, technological, and traceability-related indicators can provide a more comprehensive basis for identifying weak areas and prioritizing corrective actions [7].

Recent studies also show that competence building and quality practices improve product quality and sustainable performance in manufacturing enterprises [8]. In textile production, AI- and IoT-based monitoring is increasingly applied to defect detection and quality control [9, 10], while digital product passports are being developed to strengthen traceability, although technological and data-related challenges remain [11, 12].

The algorithm must be developed in practice based on real production data. In this section, the integral resource assessment algorithm, which was theoretically grounded in the previous stage, is tested using 36 months of practical data from a textile enterprise. The main purpose of the calculations is to evaluate the state of human, raw material and chemical, technical and technological, as well as information and monitoring resources based on a single criterion, to numerically express their impact on product quality and safety, and to create a clear analytical basis for management decisions. For this purpose, a database of initial indicators $X_1 - X_{27}$ collected over 36 months is compiled, from which relative indicators are calculated, the indicators are normalized, expert weights are applied, and as a result, resource groups and the overall resource index are determined.

The practical significance of this article lies in the fact that it allows for the assessment of resource status for each period, the identification of weak links, and the development of measures to eliminate them without limiting itself to a general description of the enterprise's resources. As a result, a convenient mechanism is created for monitoring the state of resources, early detection of risks, and the development of decisions at the operational, tactical, and strategic levels to ensure product quality and safety.

2. Method

The study utilized 36 months of production data from the textile enterprise. The data were divided into four main groups representing human resources, raw material and chemical resources, technical and technological resources, and information and observation resources. Based on the initial indicators $X_1 - X_{27}$, relative indicators were formed, which were normalized according to positive and negative directions, and weighting coefficients were established based on expert assessments. Expert-based weighting is widely used in composite index construction; however, the choice of weighting scheme and normalization thresholds can influence the resulting index values [13, 14]. At the first stage of calculations, a 36-month initial database characterizing the enterprise's activities is formed. These data are divided into four main resource groups: Q1 - human resources, Q2 - raw material and chemical resources, Q3 - technical and technological resources, and Q4 - information and observation resources. Data for each group is placed in separate columns, and their logical interconnection is maintained.

To assess the resources affecting product quality and safety in textile enterprises, the indicators were organized into four groups: human resources (Q1), raw-material and chemical resources (Q2), technical and technological resources (Q3), and information resources (Q4). The system comprises 27 input indicators (X1-X27) and 18 derived indicators (g1-g18), including ratios describing workforce competence, incoming material inspection, equipment readiness, maintenance completion, traceability, and documentation. The desired direction of each indicator is specified to distinguish indicators for which an increase is favorable from those for which a decrease is favorable. This structure provides a basis for standardizing the indicators and calculating group-level and overall indices.

Table 1. *Input and derived indicators used in the assessment model.*

Resource group	Input indicator	Derived indicator / formula	Desired direction
Q1 - Human resources	X1: Total number of employees (persons)	g1 = X2/X1: Share of qualified employees (%)	Increase is positive
Q1 - Human resources	X2: Qualified employees (persons)	g1 = X2/X1: Share of qualified employees (%)	Increase is positive
Q1 - Human resources	X3: Average work experience (years)	g2 = X3: Average work experience (years)	Increase is positive

Resource group	Input indicator	Derived indicator / formula	Desired direction
Q1 - Human resources	X4: Trained employees (persons)	g3 = X4/X1: Share of trained employees (%)	Increase is positive
Q1 - Human resources	X5: Assessment result (score)	g4 = X5: Assessment result (score)	Increase is positive
Q1 - Human resources	X6: Compliance with discipline requirements (proportion)	g5 = X6: Compliance with discipline requirements (proportion)	Increase is positive
Q2 - Raw material and chemical resources	X7: Total production operations (units)	g6 = X8/X7: Operator error rate (%)	Decrease is positive
Q2 - Raw material and chemical resources	X8: Operator errors (units)	g6 = X8/X7: Operator error rate (%)	Decrease is positive
Q2 - Raw material and chemical resources	X9: Total types of raw materials and materials (types)	g7 = X10/X9: Share of certified raw materials and materials (%)	Increase is positive
Q2 - Raw material and chemical resources	X10: Types of raw materials and materials with certificates (types)	g7 = X10/X9: Share of certified raw materials and materials (%)	Increase is positive
Q2 - Raw material and chemical resources	X11: Total batches (batches)	g8 = X12/X11: Share of batches that passed incoming inspection (%)	Increase is positive
Q2 - Raw material and chemical resources	X12: Batches that passed incoming inspection (batches)	g8 = X12/X11: Share of batches that passed incoming inspection (%)	Increase is positive
Q2 - Raw material and chemical resources	X13: Total chemical agents (items)	g9 = X14/X13: Share of agents with SDS/MSDS/TDS documentation (%)	Increase is positive
Q2 - Raw material and chemical resources	X14: Chemical agents with SDS/MSDS/TDS documentation (items)	g9 = X14/X13: Share of agents with SDS/MSDS/TDS documentation (%)	Increase is positive
Q2 - Raw material and chemical resources	X15: Nonconforming batches (batches)	g10 = X15/X11: Share of nonconforming batches (%)	Decrease is positive
Q3 - Technical and technological resources	X16: Required equipment (units)	g11 = X16/X17: Share of operational equipment (%)	Increase is positive
Q3 - Technical and technological resources	X17: Operational equipment (units)	g11 = X16/X17: Share of operational equipment (%)	Increase is positive
Q3 - Technical and technological resources	X18: Scheduled maintenance activities (activities)	g12 = X19/X18: Share of completed maintenance activities (%)	Increase is positive
Q3 - Technical and technological resources	X19: Completed maintenance activities (activities)	g12 = X19/X18: Share of completed maintenance activities (%)	Increase is positive
Q3 - Technical and technological resources	X20: Inspected equipment (units)	g13 = X21/X20: Share of equipment adjusted to requirements (%)	Increase is positive
Q3 - Technical and technological resources	X21: Equipment adjusted to requirements (units)	g13 = X21/X20: Share of equipment adjusted to requirements (%)	Increase is positive
Q3 - Technical and technological resources	X22: Planned operating time (hours)	g14 = X23/X22: Unplanned downtime ratio (%)	Decrease is positive
Q3 - Technical and technological resources	X23: Unplanned downtime (hours)	g14 = X23/X22: Unplanned downtime ratio (%)	Decrease is positive
Q3 - Technical and technological resources	X24: Coded batches (batches)	g15 = X24/X11: Share of coded batches (%)	Increase is positive
Q4 - Information resources	X25: Batches with complete documentation (batches)	g16 = X25/X11: Share of fully documented batches (%)	Increase is positive

Resource group	Input indicator	Derived indicator / formula	Desired direction
Q4 - Information resources	X26: Batches certified under OEKO-TEX® STANDARD 100 (batches)	g17 = X26/X11: Share of batches certified under OEKO-TEX® STANDARD 100 (%)	Increase is positive
Q4 - Information resources	X27: Batches recorded on time (batches)	g18 = X27/X11: Share of batches recorded on time (%)	Increase is positive

Table 2. *Resource factors and their initial Xn indicators over 36 months.*

Resource factors and their initial Xn indicators over 36 months																											
M	Q1 - human resources								Q2 - raw material and chemical resources							Q3 - technical and technological resources								Q4 - information and observation resources			
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22	X23	X24	X25	X26	X27
1	943	218	3,5	10	74	0,84	18200	22	10	7	30	28	8	5	3	600	555	28	22	555	500	16800	68	22	20	18	15
2	945	218	3,5	10	73	0,83	18750	20	10	7	28	27	8	5	3	600	558	30	23	558	556	16600	70	28	27	16	16
3	941	218	3,4	10	75	0,85	19100	20	11	8	32	31	8	5	2	600	560	29	23	560	558	17000	65	25	24	14	16
4	944	218	3,5	10	74	0,84	18600	18	11	8	32	30	9	6	3	600	560	31	24	560	558	16900	67	25	23	15	17
5	947	218	3,5	10	76	0,86	19350	20	11	8	30	30	9	6	3	600	575	30	24	575	572	17200	58	25	24	16	18
6	946	218	3,5	10	75	0,85	19000	20	12	9	32	31	9	6	3	600	575	32	25	575	572	17000	55	27	25	15	17
7	948	228	3,6	12	76	0,86	19600	19	12	9	30	30	9	6	3	600	575	31	25	575	573	17300	54	27	26	16	18
8	944	228	3,5	12	74	0,83	18850	20	12	9	31	28	10	7	4	600	580	30	23	580	578	16700	55	28	25	16	18
9	950	228	3,6	12	77	0,87	20100	22	13	10	32	31	10	7	3	600	580	32	26	580	577	17500	54	29	27	18	20
10	949	228	3,6	12	76	0,86	19750	22	13	10	30	29	10	7	3	600	590	31	25	590	587	17400	52	29	28	17	19
11	946	228	3,6	12	75	0,85	19250	20	13	10	33	30	10	7	4	600	590	30	24	590	588	17100	52	29	28	17	19
12	948	228	3,6	12	78	0,88	20300	22	13	10	34	32	10	7	3	600	590	32	26	590	586	17600	50	28	28	19	21
13	949	240	3,5	15	76	0,88	20000	20	13	11	35	31	10	8	3	620	610	32	28	610	607	17500	50	28	27	20	22
14	950	240	3,6	15	80	0,89	20450	20	14	12	34	31	11	9	3	620	610	33	29	610	605	17700	50	27	25	22	24
15	947	240	3,6	15	80	0,89	20800	18	14	12	36	35	11	9	3	620	608	34	30	608	608	17800	62	28	28	23	25
16	951	240	3,6	15	81	0,9	20300	18	14	12	32	31	11	9	2	650	640	33	30	640	635	17700	50	28	27	24	27
17	953	240	3,7	15	82	0,91	21000	20	14	12	36	35	11	10	3	650	645	34	31	645	643	17900	48	29	26	26	25
18	952	240	3,7	15	82	0,9	20700	21	15	13	38	37	12	10	3	660	655	35	31	655	652	17800	47	30	29	27	29
19	955	255	3,7	22	78	0,91	21400	19	15	13	39	39	12	10	2	660	656	34	32	656	654	18000	49	32	31	29	31
20	954	255	3,7	22	80	0,92	21000	17	15	13	35	35	12	11	2	660	656	35	33	656	656	18100	48	32	30	30	30
21	956	255	3,7	22	80	0,92	21600	17	15	13	38	37	12	11	2	660	658	35	33	658	657	18200	47	33	33	32	30
22	958	255	3,8	22	82	0,93	21300	18	16	14	39	37	13	12	2	660	658	36	34	658	658	18300	45	33	30	28	30
23	959	255	3,8	22	80	0,94	22000	16	16	14	39	39	13	12	2	660	658	36	35	658	657	18400	48	32	31	29	29
24	960	255	3,8	22	75	0,94	22350	16	16	15	40	38	13	12	2	660	658	36	35	658	655	18500	45	34	32	31	31
25	958	277	3,7	22	80	0,9	22100	15	16	15	42	38	13	12	2	680	678	36	35	678	670	18400	47	34	34	31	32
26	960	277	3,8	22	82	0,94	22550	13	16	15	42	40	13	12	2	680	678	36	36	678	675	18600	42	33	33	30	30

Resource factors and their initial Xn indicators over 36 months

M	Q1 - human resources								Q2 - raw material and chemical resources							Q3 - technical and technological resources								Q4 - information and observation resources				
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22	X23	X24	X25	X26	X27
27	962	277	3,8	22	80	0,94	22900	12	17	16	42	41	14	13	2	680	678	37	36	678	675	18700	45	38	37	36	35
28	961	277	3,8	22	79	0,95	22600	10	17	16	42	42	14	13	2	680	677	37	37	677	673	18700	52	37	36	35	34
29	963	277	3,9	22	82	0,95	23200	10	17	16	39	37	14	13	1	680	678	37	37	678	677	18800	54	36	36	34	34
30	964	277	3,9	22	81	0,96	23000	11	17	16	42	42	14	13	1	680	678	38	37	678	677	18900	54	38	37	34	36
31	962	305	3,9	22	80	0,96	23350	10	18	17	42	40	15	14	1	680	678	38	38	678	678	19000	52	38	36	35	35
32	965	305	3,9	22	80	0,96	23600	10	18	17	39	38	15	14	1	700	698	38	38	698	696	19100	42	38	37	36	36
33	963	305	4	22	82	0,97	23450	11	18	17	43	42	15	14	1	700	698	39	38	698	697	19000	40	38	35	35	34
34	964	305	4	22	83	0,97	23800	10	18	17	42	42	15	14	1	700	698	39	39	698	697	19200	42	39	37	36	36
35	965	305	4	22	83	0,97	24100	9	18	17	42	41	15	14	1	700	698	39	39	698	698	19300	40	39	39	36	37
36	965	305	4	22	85	0,97	24300	10	18	18	40	40	15	15	1	700	698	40	40	698	697	19400	37	38	37	36	36

Table 2 presents indicators for human resources: number of employees, qualified personnel, length of service, trained personnel, certification results, compliance with discipline, operations performed, and operator errors; certified materials, batches, access control, chemical agents, and non-compliant batches for raw materials and chemical resources; number of equipment, technical services, adjustments, and unscheduled downtime for technical and technological resources; and coding, documentation, certification, and recording for information resources. In this way, important aspects of the enterprise's activities are consolidated into a single information database.

Table 2 reflects the enterprise's primary information field, which serves as the basis for the analysis. The main significance of the table lies in the fact that it systematizes raw data for all resource groups, and all subsequent calculations are carried out based on this database. The presentation of table data over time allows for the dynamic monitoring of resource status.

3. Results

The proposed integrated assessment model was applied based on 36 months of production data from the textile enterprise. Initially, relative indicators characterizing human, raw material-chemical, technical-technological, and information-observation resources were formed from 27 initial indicators. Indicators were normalized according to their positive and negative directions, and integral indices were calculated for four resource groups - Q_1, Q_2, Q_3va Q_4 - using weighting coefficients determined based on expert assessments.

The identified relative indicators were standardized based on formulas depending on the type of indicator in the positive or negative direction.

Based on the results evaluated by the established expert group, weight values were determined using formulas (Appendix).

Table 3. *Weight coefficients of internal factors determined for Qn.*

Q1							Q2			
№	g1	g2	g3	g4	g5	g6	g7	g8	g9	g10
Group weight Wg	0,178	0,173	0,162	0,146	0,168	0,173	0,254	0,297	0,246	0,203
Check	1				1					
Q3							Q4			
№	g11	g12	g13	g14			g15	g16	g17	g18

Group weight Wg	0,242	0,250	0,258	0,250		0,242	0,267	0,233	0,258
Check	1					1			

Integral index of human resources:

$$Q_{1,t} = \begin{array}{c} 0.17838z_{1,t} + 0.17297z_{2,t} + 0.16216z_{3,t} \\ +0.14595z_{4,t} + 0.16757z_{5,t} + 0.17297z_{6,t} \end{array} \quad (1)$$

$$Q_{1,1} = \begin{array}{c} 0.17838 * 0.01 + 0.17297 * 0.17 + 0.16216 * 0 \\ +0.14595 * 0.08 + 0.16757 * 0.07 + 0.17297 * 1 = 0.06 \end{array}$$

Table 4. *Values obtained by* $Q_{1,t}$.

Month	Q1	Month	Q1
1	0,06	19	0,53
2	0,06	20	0,52
3	0,09	21	0,53
4	0,10	22	0,58
5	0,14	23	0,59
6	0,11	24	0,53
7	0,22	25	0,66
8	0,11	26	0,75
9	0,21	27	0,73
10	0,18	28	0,75
11	0,18	29	0,82
12	0,24	30	0,81
13	0,25	31	0,89
14	0,34	32	0,93
15	0,37	33	0,94
16	0,39	34	0,96
17	0,42	35	1,00
18	0,40	36	0,99

Raw materials and chemical resources index

$$Q_{2,t} = 0.25424z_{7,t} + 0.29661z_{8,t} + 0.24576z_{9,t} + 0.20339z_{10,t} \quad (2)$$

Technical and technological resources index

$$Q_{3,t} = 0.24219z_{11,t} + 0.25000z_{12,t} + 0.25781z_{13,t} + 0.25000z_{14,t} \quad (3)$$

Information and Traceability Index

$$Q_{4,t} = 0.24167z_{15,t} + 0.26667z_{16,t} + 0.23333z_{17,t} + 0.25833z_{18,t} \quad (4)$$

The value of each integral index is in the range from 0 to 1. An index approaching 1 indicates that this resource group is in a high position, and an index approaching 0 indicates that there are resource problems.

Expert weights of resource groups

According to experimental data, the following weights were obtained based on expert assessments for groups Q1, Q2, Q3, and Q4.

Table 5. *Expert weights of resource groups in the integrated model.*

Resource Group	Quality Management Department	Head of Production	Technologist	Laboratory	Warehouse Department Specialist	Digitalization, IT Department	Human Resources	Department Average score	Group Weighs Wg
Human resources	4	4	5	4	5	4	4	4,29	0,261
Raw materials and chemical resources	5	4	5	4	5	5	4	4,57	0,278
Technical and technological resources	4	4	4	4	4	4	5	4,14	0,252
Information and search resources	3	3	4	3	4	3	4	3,43	0,209
Total								16,43	1,000

As seen from the table, human resources and raw materials and chemical resources have the highest priority, their share in the overall model is 28%. Technical and technological resources accounted for 25 percent, while information and observation resources accounted for 21 percent.

For each month, the Q1-Q4 integral indices are multiplied by the group weights, and the total resource index is calculated:

$$Q_{\text{total},t} = \begin{matrix} 0.26087Q_{1,t} + 0.27826Q_{2,t} \\ +0.25217Q_{3,t} + 0.20870Q_{4,t} \end{matrix} \quad (5)$$

This formula reflects the priority influence of human resources and raw materials and chemical resources on product quality and safety. Q3 represents technical and technological stability, and Q4 represents information flows and product traceability.

Over the 36 months, Q_total increased from 0.09 in the first month to 0.97 in the last month. This indicates an improvement in the selected resource-management indicators of the enterprise, including qualification, certification, maintenance and traceability indicators. The index describes the state of the resources that influence product quality and safety; it is not a direct measure of product quality or safety. Because each indicator was min-max normalized within the 36-month observation range, the index values are relative to this range: a value near 0 corresponds to the weakest observed state and a value near 1 to the strongest observed state, not to an absolute level of quality or safety.

Table 6. *Values obtained by* Q_{total}.

Month	Q total	Month	Qtotal
1	0,09	19	0,66
2	0,28	20	0,72
3	0,24	21	0,69
4	0,20	22	0,66
5	0,34	23	0,70
6	0,30	24	0,68
7	0,40	25	0,66

Month	Q total	Month	Qtotal
8	0,27	26	0,72
9	0,40	27	0,80
10	0,43	28	0,80
11	0,33	29	0,83
12	0,39	30	0,83
13	0,40	31	0,83
14	0,45	32	0,92
15	0,49	33	0,85
16	0,59	34	0,91
17	0,57	35	0,92
18	0,56	36	0,97

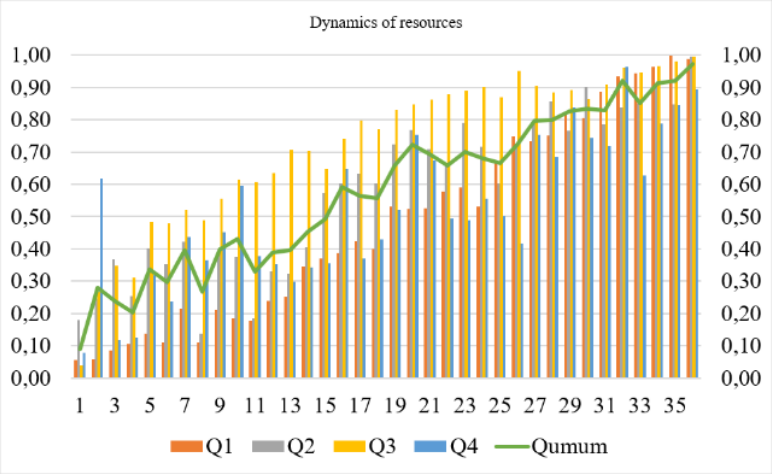


Figure 1. *Dynamics of the total resource index over 36 months.*

Figure 1, showing the dynamics of the total resource index Q_{total} over 36 months, visually demonstrates the growth trajectory of the overall index. The graph shows low points in the initial period, a growth stage in the middle period, and a stabilization phase in the final period. The figure shows a low initial level, a growth stage in the middle period and stabilization at the end of the observation period. This trend is consistent with the management measures implemented at the enterprise, but a causal effect cannot be established from the index alone.

4. Discussion

The results obtained show that the integral resource index is of practical importance for managing product quality and safety at a textile enterprise. The increase in the total resource index from 0.09 to 0.97 during the 36-month observation period is consistent with improvements in the selected indicators of human resources, raw material and chemical supply, technical and techno-logical stability, and information and traceability systems. This result indicates that monitoring resources not individually, but based on a single integral criterion, helps in the timely identification of problematic links in the enterprise.

Based on the calculated index, the following indicative management thresholds are proposed: (i) Q_total ≥ 0.80 - maintain the existing management system, standardize positive experience and continue planned monitoring; (ii) 0.60 ≤ Q_total < 0.80 - take preventive measures in the resource group with the lowest index; (iii) 0.40 ≤ Q_total < 0.60 - warning level: introduce enhanced monitoring, develop a correction plan for the weakest resource group and define responsible departments and deadlines; (iv) Q_{total} < 0.40 - prompt management intervention, internal audit and review of technological and organizational processes. These thresholds are indic-

ative; they have not been validated against independent quality or safety outcomes and should be calibrated on additional data before being used as formal decision rules.

The final decision should be developed not only based on the overall index, but also in depth to the level of the weakest resource group and the most problematic indicator.

If Q1 is low, strengthen the system of personnel training, professional development, certification, and internal discipline;

If Q2 is low, strengthen incoming inspection, raw-material certification and chemical documentation, and reduce nonconforming batches;

If Q3 is low, review the maintenance plan, adjust equipment, and reduce unscheduled downtime;

If Q4 is low, measures will be taken to digitalize the batch coding, documentation, and tracking system. Such AI- and IoT-supported tracking has been reported in recent textile applications [9-11].

This recommendation is supported by studies indicating that planned maintenance and Total Productive Maintenance-oriented practices can improve equipment availability and overall equipment effectiveness in textile manufacturing [15, 16].

It is advisable to divide management decisions into three levels:

Operational decisions - measures to be implemented within a period of up to 1 month; for example, restoring access control discipline, terminating problematic batches, and providing immediate instructions to reduce operator errors.

Tactical decisions - medium-term measures implemented within 3-6 months; for example, personnel retraining, revision of the maintenance plan, standardization of the documentation system.

Strategic decisions - systemic measures designed for a period of 1 year or more; for example, digitalization, modernization of equipment, improvement of the quality management system, transfer of traceability to a fully electronic system.

The main advantage of this approach is that a management decision does not remain a mere general recommendation but rather becomes a system of comprehensive measures linked to a specific resource group, specific indicators, and specific deadlines. As a result, the integrated assessment algorithm serves not just as a simple analytical tool for enterprise management, but as a practical management mechanism for ensuring quality and safety.

Limitations. The index is based on resource and management indicators from a single enterprise over 36 months, so the results cannot be generalized without further testing. Min-max normalization makes the index relative to the observed range of each indicator, and the expert weights reflect the judgment of a seven-member panel; agreement among the experts was statistically significant for the four resource groups (Kendall's W = 0.60, p = 0.006) but not within several groups of indicators. In addition, one input indicator (the share of nonconforming batches) is an outcome-type measure included in the index, while independent outcome data (finished-product defect rates, customer complaints, safety test failures) were not analyzed. Therefore, the rise in the index should be interpreted as a trend in the selected management indicators and not as direct evidence of improved product quality or safety. Future work should validate the thresholds and test the sensitivity of the index to alternative normalization limits and weighting schemes using independent quality and safety data.

5. Conclusion

The study utilized an integral index model for a comprehensive assessment of human, raw material-chemical, technical-technological, and information-observation resources affecting product quality and safety at a textile enterprise. Based on 36-month data, indicators $X_1 - X_{27}$ were normalized, and resource indices $Q_1 - Q_4$ and the total Q_{total} index were determined using expert weights.

The calculations showed an increase in the total resource index from 0.09 to 0.97, indicating an improvement in the selected resource-management indicators. The proposed model makes it possible to identify weak resource groups, monitor the factors affecting quality and safety, and substantiate operational, tactical and strategic management decisions; its thresholds are indicative and require validation against independent quality and safety outcomes.

Abbreviations

g1-g18	Derived (Relative) Indicators Calculated from X1-X27
IT	Information Technology
MSDS	Material Safety Data Sheet
OEKO-TEX® STANDARD 100	International Product-safety Certification of Textiles Tested for Harmful Substances
Q1-Q4	Indices of the Four Resource Groups: Human; Raw Material and Chemical; Technical and Technological; Information and Traceability
Q_total	Total (Overall) Resource Index
SDS	Safety Data Sheet
TDS	Technical Data Sheet
W_g	Weight Coefficient (of a Resource Group or of an Internal Factor)
X1-X27	Initial (Input) Indicators of the 36-month Database

z Standardized (Normalized) Value of a Derived Indicator, in the Range 0-1

Author Contributions

Nasibakhon Sotvoldieva: Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Validation, Visualization

Akbarov Khotam: Conceptualization, Methodology, Project administration, Supervision, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Aakko, M., & Niinimäki, K. (2024). Managing and negotiating: Approaches to quality work in clothing and textiles companies. *Fashion Practice*, *391*-419. https://doi.org/10.1080/17569370.2024.2338995

[2] Agrawal, T. K., & Pal, R. (2019). Traceability in textile and clothing supply chains: Classifying implementation factors and information sets via Delphi study. *Sustainability*, *11*(6), Article 1698. https://doi.org/10.3390/su11061698

[3] Kumar, V., Agrawal, T. K., Wang, L., & Chen, Y. (2017). Contribution of traceability towards attaining sustainability in the textile sector. *Textiles and Clothing Sustainability*, *3*, Article 5. https://doi.org/10.1186/s40689-017-0027-8

[4] Agrawal, T. K., Koehl, L., & Campagne, C. (2018). A secured tag for implementation of traceability in textile and clothing supply chain. *The International Journal of Advanced Manufacturing Technology*, *99*, 2563-2577. https://doi.org/10.1007/s00170-018-2638-x

[5] Badhwar, A., Islam, S., & Tan, C. S. L. (2023). Exploring the potential of blockchain technology within the fashion and textile supply chain with a focus on traceability, transparency, and product authenticity: A systematic review. *Frontiers in Blockchain*, *6*, Article 1044723. https://doi.org/10.3389/fbloc.2023.1044723

[6] Ahmed, W. A. H., & MacCarthy, B. L. (2021). Blockchain-enabled supply chain traceability in the textile and apparel supply chain: A case study of the fiber producer, Lenzing. *Sustainability*, *13*(19), Article 10496. https://doi.org/10.3390/su131910496

[7] Antunes, M. G., Mucharreira, P. R., Teixeira, M. D. S., & Reis, I. A. C. (2022). ISO 9001: 2015 and risk-based thinking: Scientific research insights. *Total Quality Management & Business Excellence*, *33*. https://doi.org/10.1080/14783363.2021.1954898

[8] Karim, M. A., Islam, M. M., & Motamedisedeh, O. (2025). Toward sustainable performance: The role of competence and quality practices in manufacturing. *Sustainability*, *17*(10), Article 4405. https://doi.org/10.3390/su17104405

[9] Kurnia, D., Sutanto, A., & Fakhrurroja, H. (2025). AI and IoT for yarn defect detection in the textile industry: A systematic literature review. *Journal of Scientific & Industrial Research*, *84*, 1254-1264.

[10] Ozek, A., Seckin, M., Demircioglu, P., & Bogrekci, I. (2025). Artificial intelligence driving innovation in textile defect detection. *Textiles*, *5*(2), Article 12. https://doi.org/10.3390/textiles5020012

[11] Domskienė, J., & Gaidule, E. (2024). An overview of technological challenges in implementing the digital product passport in the textile and clothing industry. *AUTEX Research Journal*, *24*(1), Article 20240002. https://doi.org/10.1515/aut-2024-0002

[12] Carvalho, C., Silva, C. J., & Abreu, M. J. (2025). Circular economy: Literature review on the implementation of the digital product passport (DPP) in the textile industry. *Sustainability*, *17*(5), Article 1802. https://doi.org/10.3390/su17051802

[13] Libório, M. P., Karagiannis, R., Diniz, A. M. A., Ekel, P. I., Vieira, D. A. G., & Ribeiro, L. C. (2024). The use of information entropy and expert opinion in maximizing the discriminating power of composite indicators. *Entropy*, *26*(2), Article 143. https://doi.org/10.3390/e26020143

[14] Kelemen, A., Szabó, Z. K., Bozóki, S., Szádoczki, Z., & Hartvig, Á. D. (2024). A sensitivity analysis of composite indicators: Min/max thresholds. *Environmental and Sustainability Indicators*, *23*, Article 100453. https://doi.org/10.1016/j.indic.2024.100453

[15] Hoque, M. R., Noor, R. B., Tushar, S. R., Bappy, M. M., & Rayhan, M. G. S. (2026). Improving the overall equipment effectiveness in the textile dyeing section through total productive maintenance: Implications for economic sustainability. *International Journal of Productivity and Performance Management*, *1*-37. https://doi.org/10.1108/IJPPM-01-2025-0044

[16] Kalwar, M. A., Wassan, A. N., Khan, M. A., Wadho, M. H., Shaikh, S. A., & Memon, B. A. (2025). Application of overall equipment effectiveness in increasing productivity: Case of textile company. *WPOM - Working Papers on Operations Management*, *16*, 1-32. https://doi.org/10.4995/wpom.21168

Biography

Nasibakhon Sotvoldieva is a researcher at Andijan State Technical Institute, Uzbekistan. Her research interests include quality management, product quality and safety, resource management, and integrated assessment models in the textile industry. Her scientific work focuses on developing methods for evaluating resources and improving quality and safety management in textile enterprises.

Akbarov Khotam is a Candidate of Technical Sciences (PhD in Technical Sciences) and a Professor at Andijan State Technical Institute, Andijan, Uzbekistan. His research interests include textile technology, quality management, and production process optimization. He is the scientific supervisor of the first author.

Research Field

Nasibakhon Sotvoldieva: Quality Management, Textile Industry, Product Quality and Safety, Resource Management, Integrated Assessment Models, Risk Management, Production Process Optimization, Industrial Quality Control

Akbarov Khotam: Textile Technology, Quality Management, Product Quality and Safety, Production Process Optimization, Industrial Quality Control