Water Air Soil Pollut (2019) 230: 156
https://doi.org/10.1007/s11270-019-4206-x

Analysis of Influencing Factors on Sustainability of Textile Wastewater: a Structural Equation Approach

Punyasloka Pattnaik · G. S. Dangayach

Received: 13 April 2019 / Accepted: 12 June 2019 / Published online: 29 June 2019

Abstract The purpose of this study was the identification of the major factor for sustainable development in textile industries and preferred textile wastewater management practices for environmental protection. Moreover, a structural framework for sustainable textile wastewater management concept in the textile industry was developed, and further, the proposed model was examined based on the effect of economic performance, environmental impact, and operational performance in textile sectors. Therefore, to achieve the above issues, major factors were identified through exhaustive literature, and then a test was conducted for the reliability of the proposed constructs for validation. However, there was no specific study on the sustainability of textile wastewater management principle by using exploratory structural equation modeling (SEM). Finally, the proposed structural model was validated by confirmatory factor analysis (CFA) and structural equation modeling with the help of the SPSS software package.

Keywords Textile wastewater · Sustainability · Structural equation modeling · SPSS · AMOS

P. Pattnaik (✉) · G. S. Dangayach
Department of Management Studies, MNIT, Jaipur 302017, India
e-mail: punyasloka2010@gmail.com

G. S. Dangayach
Department of Mechanical Engineering, MNIT, Jaipur 302017, India

1 Introduction

The textile industry is one of the largest textile processing industries in Asia as well as in the world, mainly textile manufacturing and export. These industries not only help to improve Indian economy but also are one of the most significant service providers (35 million people) and expected to generate 12 million new job opportunities shortly next to agriculture sectors (Gómez Fernández and Crespo Márquez 2012). Textile industries are simultaneously making a massive quantity of textile wastewater effluent, which creates a significant problem regarding chemical water as well as environmental pollution at the time of dyeing and finishing of textile fibers. There is no doubt that nowadays, most advanced techniques are adopted for the treatment of textile fibers and the reuse of effluent water in textile industries (Erdumlu et al. 2012). The textile wastewater effluent contains multiple numbers of dyes and chemical such as basic red 46, reactive blue 198, yellow GR, orange 2R and 3R, Na_2Co_3, NaCl, $NaC_6H_7O_6$, and a large number of solid wastes (Cr, As, Cu, and Zn) (Taran et al. 2011). These chemicals are available in different percentages in different effluent water based on the textile industries dye quantity and quality uses for different types of fibers. Therefore, the treatment process also varies from industry to industry such as ozonation (Wijannarong et al. 2013), electrochemical oxidation (Chatzisymeon et al. 2006), fungal degradation (Taha et al. 2014), screening, sedimentation, homogenization, neutralization, chemical flocculation, activated sludge, aerobic and anaerobic treatment, membrane technologies, adsorption, oxidation techniques, and thermal evaporation (Vineta et al. 2014).

In recent years, based upon the problems in various textile industries starting from dye printing to manufacturing of the final textile product, in each step, a lot of chemical wastes are generated. Hence, in every country, the government is implementing various policies to reduce environmental pollution and simultaneously to improve productivity (Chavan 2001). Therefore, every textile industry is trying to adopt the sustainability of textile wastewater management principle for the survival of the textile sector. Moreover, these industries create environmental problems and also affect human health seriously. Pattnaik et al. (2018) successfully reviewed the last 20 years of research papers, including books on the sustainability of textile sectors wastewater management. Sustainability in textile wastewater management mainly links to the following main dimensions such as economic performance, environmental impact, and operational performance, respectively, as per present desirable. However, researchers were also focusing on the following four dimensions, i.e., environment, social, economic, and political system (Živkovi'c et al. 2017; Cambero and Sowlati 2014; PashaeiKamali et al. 2017; Njoh 2017).

Yuan and Tian (2015) discussed various structural equation modeling (SEM) methodologies to understand the interrelationship between their observed indicators and among latent attributes. They also clearly pointed out various methods limitations part as well as advantages by implementing SEM methodology. Neto et al. (2017) discussed the private education system for higher study, specifically industrial engineering student by using structural equation modeling and suggested that teacher involvement results in major satisfaction to students. Ajayi and Oyedele (2018) reported a reduction of construction waste and simultaneously implemented a lot of design factor using SEM in construction projects. It was suggested that these two major factors purely depend on the reduction of construction waste, i.e., standard materials size as well as a modern method of construction. Therefore, most of the researchers successfully implemented a lot of statistical techniques for factor analysis in their survey data and then developed various dimensional for structural model validation.

In the present study, based on the available literature, it was found that the various textile industries mainly focused on multiple factors and performance measures. Moreover, a conceptual framework for sustainable textile wastewater management concept in the textile industry was developed, and further, the proposed model was examined based on the effect of economic performance, environmental impact, and operational performance in textile sectors.

2 Methodology

After a comprehensive literature review by the same group, Pattnaik et al. (2018) prepared a series of the questionnaire that mainly focused on the significant issues that arise in textile sectors. These selected factors were labor input in the textile industry, policy implications, dyes and additives, wastewater treatment and disposal, energy consumption and carbon dioxide emissions, textile industry productivity, textile reuse, and recycling, improvement of sustainability-related performance, and performance measures were economic performance, environmental impact, and operational performance respectively (Table 1). This research work mainly deals with the detail of site selection for the survey, data collection methodology, analysis of the survey data, normality and reliability analysis, development of structural equation modeling, confirmatory factor analysis, and finally validation of results for sustainability of textile wastewater management.

2.1 Site Selection

The textile fiber manufacturing and processing sectors are one of the oldest as well as largest organized sectors in India. There are over 7000 large-scale textile industries and small-scale industries concentrated mainly in Rajasthan, Gujarat, Maharashtra, and Tamil Nadu states. In the rural part of India, several textile industries are nowadays improving the quality of products and increasing their demand equality in the other part of India as well as in the international market. However, the discharge of solid wastes and textile wastewater effluent are not controlled till date due to the stringent law formed in most of the developing countries. Hence, these wastes are transferred through drains to the nearby rivers, which ultimately pollute the environment and increase water pollution. Therefore, proper disposal

Table 1 Definition of model factors

Factors	Definition
Explained or dependent factors •Economic performance •Environmental impact •Operational performance	1. Applying the results of cost, quality improvement, and related technology controlled in the process of textile wastewater management (TWWM). 2. The textile industry is considered as one of the most polluting industry in the world, and hence the reduction of pollution in the environment is highly required. 3. Operational performance overall depends on the utilization of advanced technology and economic performance also.
Explanatory factors •Labor input in textile industry •Policy Implication •Textile reuse and recycle •Dyes and additives •Wastewater treatment and disposal •Energy consumption and carbon dioxide emission •Textile industry productivity •Improvement of sustainable related performance	1. It measures of the effectiveness and efficiency of an organization in generating output with the resources available. 2. Policy implementation in developing countries called carbon tariffs policy for better performance in the international market. 3. Effective utilization of textile fiber wastes and or other solid wastes for further use in same textile or agriculture or construction applications. 4. Dye and additives are the major ingredients to improve the performance of the textile fibers, and because of these dyes, the final cloth image changes drastically as per present customer desire. 5. Effective utilization of water and reuse of wastewater for different applications again and again to control the environment. 6. Most of the textile industries generate much heat during treatment as well as other sources of heat generated through air conditioner and compressors. 7. Improvement of production rate in textile sectors. 8. The sustainable textile sector needs to be developed environment-friendly by installing pollution-control technology
Mediator factors •Sustainability of textile wastewater management	1. Sustainable textile wastewater management that depends on economic performance, environmental impact, and operational performance.

practices are highly required to improve the performance of textile industries. As far as literature was concerned, most of the developing countries are focussing on the textile industries, conducting many awareness programs and also finding alternative utilization of these textile wastes for manufacturing of low-grade-tiles, ceramic bricks by replacing cement, and also agriculture purposes.

2.2 Data Collection

The leading information was collected purely based on a primary date through survey instrument from all over India, in different textile industries. The authors developed the questionnaire based on available literature on textile wastewater management as well as consulted different textile industry experts (Annexure). The following major factors were selected for sustainable wastewater management, as shown in Table 2, along with their respective sub-factors. These eleven factors and sub-factors will be prepared for the further model and hypothesis development, and model validation, respectively. The study initially selected 352 textile industries from all the parts of India and nearly 300 textile industries responses were received. In the end, 264 textile industries questionnaire were finalized for validation as well as for further structural analysis. All the analyses were performed using the IBM Statistical Package for Social Sciences for MAC (SPSS, v22) and AMOS (v21).

2.3 Data Analysis

The exploratory factor analysis (EFA) was generally performed by using the principal component analysis technique (PCA) through SPSS statistical analysis software tool to evaluate the component scores and loading (eigenvalues of at least one), Varimax rotation method (Kaiser normalization) (Kaiser 1974), reliability statistic, Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy, Bartlett's test of sphericity, degree of freedom (DoF), and degree of significance. In the end, bivariate correlation analysis (BCA) was also performed to observe the inter-correlation of factors. After confirming the above analysis, the next step was to prove the

Table 2 List of factors and sub-factors

Dimensions	Dimension code	Sub-factors	Factor code
Labor input in the textile industry	LITI	Increase in employee wages	LITI-1
		Difficulty in recruiting general staff	LITI-2
		Low rate of worker retention	LITI-3
		Difficulty in recruiting engineer staff	LITI-4
Policy implications	PI	Unstable political and social conditions	PI-1
		Underdeveloped infrastructure (electric power, transportation, communications, etc.)	PI-2
		Unclear policy management by the local government	PI-3
		Complicated tax procedures	PI-4
Dyes and additives	DA	Basic dyes, mordant dyes, and acid dyes (silk, wool, nylon (ionic bond))	DA-1
		Direct dyes and disperse dyes (cotton, polyester, acetate (ionic bond))	DA-2
		Vat dyes and sulfur dyes (cotton, cellulose (dye precipitated in the fiber))	DA-3
		Azoic dyes and reactive dyes (cotton, cellulose (covalent binding))	DA-4
Wastewater treatment and disposal	WTD	Landfill	WTD-1
		Agricultural use	WTD-2
		Recovery	WTD-3
		Building and construction materials	WTD-4
Energy consumption and carbon dioxide emissions	ECCDE	Implementation of a certified Energy-Management-System according to ISO 50.001 as requested by public bodies or customers	ECCDE-1
		Energy footprint of a production order/article regarding the energy consumption in my company	ECCDE-2
		Post calculation: comparison of actual and planned costs in order to identify significant deviations	ECCDE-3
		Establishing services to support carbon-emissions trading (forecast, sourcing)	ECCDE-4
Textile industry productivity	TIP	Regulation influenced technology transfer and R&D activities of your firm	TIP-1
		Has the flow rate of productivity change	TIP-2
		Hasyouadopt to improve productivity?	TIP-3
		Have you plan to increase the degree of automation of your production	TIP-4
Textile reuse and recycling	TRR	Reuse (run your own store)	TRR-1
		Reuse (sell to non-profits or other businesses)	TRR-2
		Reuse (sell to a broker)	TRR-3
		Recycling	TRR-4
Improvement of sustainability-related performance	ISRP	Sludge disposal efficiency	ISRP-1
		Efficiency of sludge treatment	ISRP-2
		Weighted average reagent consumptions	ISRP-3
		Sustainable performance measurement for textile wastewater treatment plants	ISRP-4
Economic performance	EP	Reduction in costs through improved efficiency of production and sales	EP-1
		Expand the range of low price products/services	EP-2
		No measures have been taken	EP-3
		Increased efficiency through management integration within the group	EP-4
Environmental impact	EI	Stricter environmental regulations	EI-1
		In your view, has air pollution ever affected your health	EI-2
		Apart from effects on people's health, are you aware of any other effects of air pollution	EI-3

Table 2 (continued)

Dimensions	Dimension code	Sub-factors	Factor code
		Jobs today are more important than protecting the environment for the future	EI-4
Operational performance	OP	Brand identity is strong and established	OP-1
		Goodwill is already earned due to old customers in the market	OP-2
		Old customer relationship and retaining them successfully	OP-3
		Quality of the fabric is up to the mark	OP-4

proposed hypothetical model and then to fit the model to a structural equation modeling (SEM) analysis by AMOS V-22.0. The proposed model verified by examining the goodness of fit statistics indices: a ratio of chi-square to a DoF, a goodness of fit index (GFI), adjusted goodness of fit index (AGFI), normed fit index (NFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA).

3 Results and Discussion

3.1 Exploratory Factor Analysis

The principal component analysis (PCA) was implemented in the present collected data to find out the number of factors required for sustainable textile wastewater management and performance measures. However, before applying PCA analysis, KMO test (value higher than 0.7) and Barlett's test (BT) were calculated to understand the homogeneity of the data for sampling adequacy (Hair et al. 2006). The KMO and BT results were 0.784 and 6051.79, respectively, with the significance of 0.000, which justify the desired values as per available literature.

Similarly, initial eigenvalues, extraction sums of squared loadings, and rotation sums of squared loadings were calculated with 44 items, which included eight factors and three performance measures, as shown in Table 3. The total variance was 67.106 percentages with more than one eigenvalues. In the present case, the eight factors are (1) labor input in the textile industry, (2) policy implications, (3) dyes and additives, (4) wastewater treatment and disposal,

Table 3 Component scores and loadings

Total variance explained

Component	Initial eigen values			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	7.312	16.619	16.619	7.312	16.619	16.619	3.728	8.473	8.473
2	4.091	9.298	25.916	4.091	9.298	25.916	3.120	7.090	15.563
3	3.091	7.025	32.942	3.091	7.025	32.942	2.841	6.457	22.020
4	2.776	6.308	39.250	2.776	6.308	39.250	2.798	6.359	28.379
5	2.475	5.624	44.874	2.475	5.624	44.874	2.666	6.058	34.437
6	2.044	4.644	49.519	2.044	4.644	49.519	2.649	6.019	40.457
7	1.859	4.226	53.744	1.859	4.226	53.744	2.562	5.823	46.279
8	1.651	3.751	57.495	1.651	3.751	57.495	2.506	5.696	51.976
9	1.613	3.667	61.162	1.613	3.667	61.162	2.291	5.207	57.183
10	1.398	3.177	64.339	1.398	3.177	64.339	2.258	5.132	62.315
11	1.217	2.766	67.106	1.217	2.766	67.106	2.108	4.791	67.106

Extraction method: principal component snalysis.

*1–8 components indicate the factors and 9–11 components indicate the performance measures

Table 4 Factors and its scale reliabilities

Dimension code	Skewness		Kurtosis		Factor loading	Cronbach's α	KMO
	Statistic	Std. error	Statistic	Std. error			
LITI	−0.830	0.150	−0.362	0.299	0.753	0.729	0.717
	−0.238	0.150	−0.397	0.299	0.720		
	−0.976	0.150	0.842	0.299	0.757		
	−0.188	0.150	−0.539	0.299	0.571		
PI	0.131	0.150	−0.661	0.299	0.853	0.795	0.747
	0.113	0.150	0.559	0.299	0.735		
	0.092	0.150	−0.210	0.299	0.824		
	0.384	0.150	−0.605	0.299	0.600		
DA	−0.823	0.150	−0.310	0.299	0.760	0.877	0.738
	−0.331	0.150	0.026	0.299	0.686		
	−0.584	0.150	−0.251	0.299	0.840		
	−0.212	0.150	−0.174	0.299	0.891		
WTD	0.747	0.150	0.028	0.299	0.700	0.682	0.680
	−0.168	0.150	0.211	0.299	0.758		
	0.191	0.150	−1.331	0.299	0.563		
	0.093	0.150	−0.484	0.299	0.687		
ECCDE	−0.009	0.150	−0.472	0.299	0.778	0.798	0.708
	−0.030	0.150	−0.193	0.299	0.787		
	0.401	0.150	−0.307	0.299	0.781		
	0.131	0.150	−0.358	0.299	0.682		
TIP	−0.488	0.150	1.026	0.299	0.651	0.759	0.750
	−0.455	0.150	−0.701	0.299	0.564		
	−0.454	0.150	−0.838	0.299	0.793		
	−0.988	0.150	−0.056	0.299	0.819		
TRR	−0.356	0.150	−0.850	0.299	0.871	0.960	0.847
	−0.423	0.150	−0.654	0.299	0.917		
	−0.518	0.150	−0.629	0.299	0.945		
	−0.491	0.150	−0.645	0.299	0.941		
ISRP	0.445	0.150	0.493	0.299	0.780	0.770	0.766
	−0.026	0.150	−0.121	0.299	0.743		
	−0.005	0.150	−0.679	0.299	0.735		
	0.433	0.150	−0.743	0.299	0.699		
EP	−0.546	0.150	0.173	0.299	0.653	0.640	0.652
	−1.046	0.150	0.083	0.299	0.583		
	−0.043	0.150	−0.086	0.299	0.685		
	−0.087	0.150	−0.266	0.299	0.632		
EI	−0.148	0.150	−1.485	0.299	0.685	0.811	0.789
	0.058	0.150	−0.195	0.299	0.827		
	0.265	0.150	−0.130	0.299	0.828		
	0.237	0.150	−0.537	0.299	0.817		
OP	0.217	0.150	−0.716	0.299	0.615	0.780	0.723
	0.174	0.150	−0.220	0.299	0.742		
	−0.049	0.150	−0.972	0.299	0.852		
	−0.005	0.150	−1.107	0.299	0.700		

Table 5 Bivariate correlation analysis

Correlations

	LITI	PI	DA	WTD	ECCDE	TIP	TRR	ISRP	EP	EI	OP	Mean	Std. deviation
LITI	1											4.19	.512
PI	0.329**	1										4.03	.427
DA	0.408**	0.187**	1									3.97	.622
WTD	0.244**	0.260**	0.326**	1								3.81	.491
ECCDE	0.080	0.092	0.155*	0.259**	1							3.81	.483
TIP	0.234**	0.128*	0.371**	0.182**	0.173**	1						4.31	.444
TRR	0.188**	0.123*	0.290**	0.115	0.103	0.329**	1					4.39	.574
ISRP	0.094	0.158**	0.161**	0.151*	0.313**	0.194**	0.072	1				3.60	.473
EP	0.234**	− 0.005	0.298**	0.103	0.108	0.306**	0.210**	0.150*	1			4.12	.462
EI	− 0.022	0.095	0.102	0.142*	0.011	0.058	− 0.037	0.130*	0.095	1		3.64	.596
OP	− 0.087	− 0.046	− 0.275**	0.107	0.161**	− 0.233**	− 0.208**	0.183**	− 0.291**	− 0.040	1	3.74	.603

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

(5) energy consumption and carbon dioxide emissions, (6) textile industry productivity, (7) textile reuse and recycling, and (8) improvement of sustainability-related performance and the remaining three are performance measures, i.e., (1) economic performance, (2) environmental impact, and (3) operational performance, respectively, in order to achieve sustainable wastewater measurement respectively.

3.2 Normality Test

In this study, the correlational analysis was also performed to test the normality of the proposed data collected through a survey for the sustainability of textile wastewater management and this test was also performed to identify the shape of its distribution. Therefore, based on the analysis of the skewness and kurtosis, measured values were within the range of ± 1.5 as reported earlier (Hair et al. 2006). From Table 4, it was indicated that all the values of skewness and kurtosis are within the range of acceptable limit, and this would indicate whether the data was normally distributed or not. Therefore, based on the test, the data was determined as normally distributed, since the results of skewness and kurtosis were in the range of ± 1.5 for each factor.

3.3 Tests for Reliability and Validity of the Collected Data

Internal consistency of the multiple-item was also calculated for the reliability of the items by using Cronbach's alpha (Kannan and Tan 2005), and it

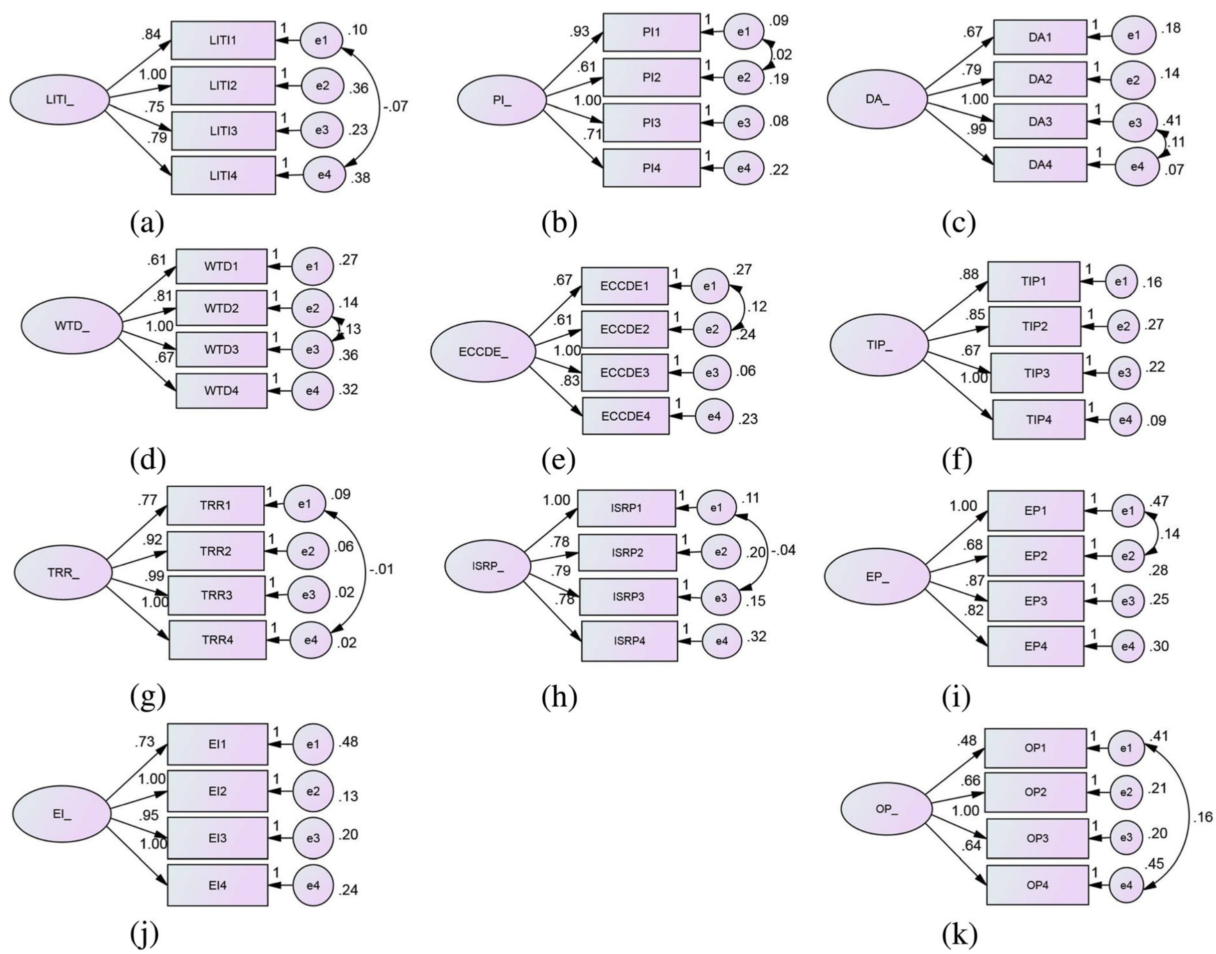

Fig. 1 One-factor congeneric model of all the factors and variables

was observed that for almost all the factors, obtained results were within the acceptable limit (equal to or higher than 0.70) as shown in Table 4 except for two-factor alpha values less than 0.7. However, Cronbach's alpha was higher than 0.6 preferred to reveal internal consistency. Therefore, wastewater treatment and disposal (Cronbach's alpha = 0.672) and economic performance (Cronbach's alpha = 0.640) were considered in this study, for analysis and the construct had satisfactory reliabilities. After that validity of the constructs was derived for the following factors, because for each factor, there were four items, and these items were extracted from exhaustive literature (Pattnaik et al. 2018). Factor loading was also one of major analyses to estimate the correlation among different sub-criteria concerning their factors, and as per available literature, the variables with loading more than 0.4 were considered (Comrey and Lee 1992). Comrey and Lee (1992) elaborated that a variable with loading more than 0.71 was considered excellent, for loading 0.63 was considered very good, but variable loading within 0.55 was considered good. However, any variable with the loading of less than 0.45 was considered fair, but further analysis might be required to improve the factor loading. Hence, by discussing the above criteria, the present rotated component matrix was within the acceptable limit, as shown in Table 4, and cross loading was not observed to remove any factors from this analysis. Again, another alternative was also computed to measure the sampling adequacy, i.e., Kaiser–Meyer–Olkin (KMO) which purely specifies how small the partial correlations were relative to the original correlations. However, smaller values of KMO demonstrate that other variables cannot explain the correlations between pairs of variables. The KMO should be more than 0.60 (Kaiser 1974), but the values lie between closer to 0.80 and 0.90 suggest that the inter-correlation matrix was almost ideal for factor analysis (Pett et al. 2003). Table 4 shows the KMO values of all the eleven having more than 0.60 KMO values, and then the factors were ideal for factors analysis. Table 5 shows the bivariate correlations computed using available data sets through a survey for sustainable wastewater management in textile industries. A negative correlation may cause an inverse relationship, but a positive correlation shows that these fractions may vary in the same direction. Moreover, while a correlation coefficient of value ± 0.5 shows a healthy relationship between the two fractions and for a perfect correlation, the value was 1. Based on the bivariate correlations analysis, a positive and significant correlation coefficient between economic performance and the eight remaining factors was established, as shown in Table 5. In contrast, the negative and significant correlation coefficients were observed between these two performance measures (environmental impact and operational performance).

3.4 Structural Equation Modeling

The labor input in the textile industry, policy implications, dyes and additives, wastewater treatment and disposal, energy consumption and carbon dioxide emissions, textile industry productivity, textile reuse and recycling, improvement of sustainability-related performance, economic performance, environmental impact, and operational performance were built and validated by confirmatory factor analysis (CFA). In this study, two levels of analysis were included, i.e., one measurement model (which indicates how hypothetical constructs were measured regarding the observed variables) and

Table 6 Measurement of model fit indices

	LITI	PI	DA	WTD	ECCDE	TIP	TRR	ISRP	Desired levels
χ^2/df	2.932	4.616	4.714	1.317	3.807	1.826	1.850	2.305	0.02–4.80
GFI	0.994	0.991	0.991	0.998	0.993	0.993	0.997	0.996	0.75–0.99
AGFI	0.945	0.914	0.912	0.975	0.929	0.964	0.965	0.957	0.63–0.97
NFI	0.988	0.987	0.993	0.993	0.990	0.987	0.999	0.992	0.72–0.99
CFI	0.992	0.989	0.995	0.998	0.992	0.994	0.999	0.995	0.88–1.00
RMSEA	0.086	0.117	0.119	0.035	0.103	0.056	0.057	0.070	0.00–0.13

other one structural model (which makes relationships among the constructs) (Anderson and Gerbing 1988). The first step of this part of the analysis was to evaluate each factor and its sub-criteria because at the end, final integration was developed to validate the proposed structural model and any amendments found during analysis to achieve the best-adjusted model; the factor or their sub-criteria may be omitted for further analysis. Figure 1 shows all the eleven factors, one-factor congeneric model. The rectangle indicates an observed item or factor, and the circle displays a latent construct (Anderson and Gerbing 1988).

3.5 First-Order Confirmatory Factor Analysis

After individual factor validation, eight factors were used for first-order confirmatory factor analysis, and

Table 7 Summary of confirmatory analysis (reliability and validity for individual constructs)

Construct	Items	Estimate (standardized)	Squared multiple correlations (R^2)	Average variance extracted (AVE)	Composite reliability (C.R)	Average shared variance (ASV)	Maximum shared variance (MSV)
LITI	LITI1	0.811	0.316	0.496125	0.795611	0.2729	0.2304
	LITI2	0.667	0.413				
	LITI3	0.643	0.445				
	LITI4	0.563	0.657				
PI	PI1	0.814	0.326	0.576703	0.842718	0.1900	0.1369
	PI2	0.538	0.722				
	PI3	0.850	0.290				
	PI4	0.571	0.663				
DA	DA1	0.721	0.854	0.636919	0.87421	0.3086	0.2304
	DA2	0.814	0.514				
	DA3	0.717	0.663				
	DA4	0.924	0.519				
WTD	WTD1	0.549	0.305	0.463376	0.77357	0.2614	0.1369
	WTD2	0.774	0.467				
	WTD3	0.684	0.599				
	WTD4	0.552	0.301				
ECCDE	ECCDE1	0.557	0.457	0.574935	0.843568	0.2071	0.1369
	ECCDE2	0.549	0.830				
	ECCDE3	0.911	0.302				
	ECCDE4	0.676	0.310				
TIP	TIP1	0.707	0.697	0.510377	0.803175	0.2871	0.2025
	TIP2	0.598	0.303				
	TIP3	0.551	0.357				
	TIP4	0.835	0.500				
TRR	TRR1	0.844	0.960	0.844509	0.955952	0.1900	0.1296
	TRR2	0.917	0.946				
	TRR3	0.972	0.841				
	TRR4	0.980	0.713				
ISRP	ISRP1	0.837	0.328	0.547319	0.828442	0.2286	0.0961
	ISRP2	0.661	0.511				
	ISRP3	0.715	0.437				
	ISRP4	0.573	0.701				

Note: CR > average variance explained (AVE), AVE > 0.5, CR > 0.7, (Hair et al. 2006)

Criteria for ensuring discriminant validity are MSV < AVE and ASV < AVE (Hair et al. 2006) the remaining three factors were suggested for performance outcome of implementing sustainable wastewater management principle in textile industries. After confirmatory factor analysis, the full latent variable model was studied. The result of the structural model with the recommended values of the fit indices for the satisfactory fit of a model to obtain data was shown in Table 6. The goodness of fit statistics were in the range of the recommended values, and no sub-criteria were deleted in CFA since all the proposed factors were statistically significant. Therefore, the structural model and measurement model were satisfactorily fit the data. The results suggested that the model met adequately with the data.

Table 7 presents the summary of confirmatory results of sustainable wastewater management (the eight factors) evaluated by using Analysis of Moment Structures (AMOS 22.0) as shown in Fig. 2 and the values of estimate (standardized), squared multiple correlations (R^2), average variance

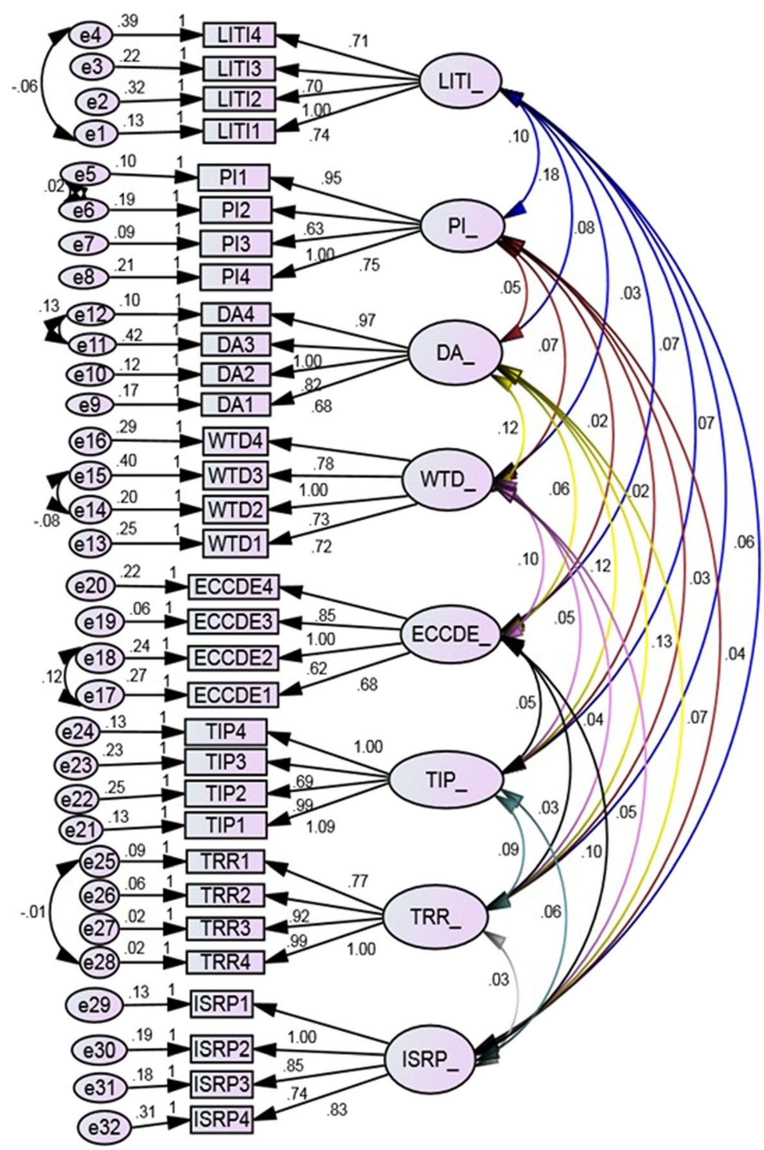

Fig. 2 First-order CFA measurement model

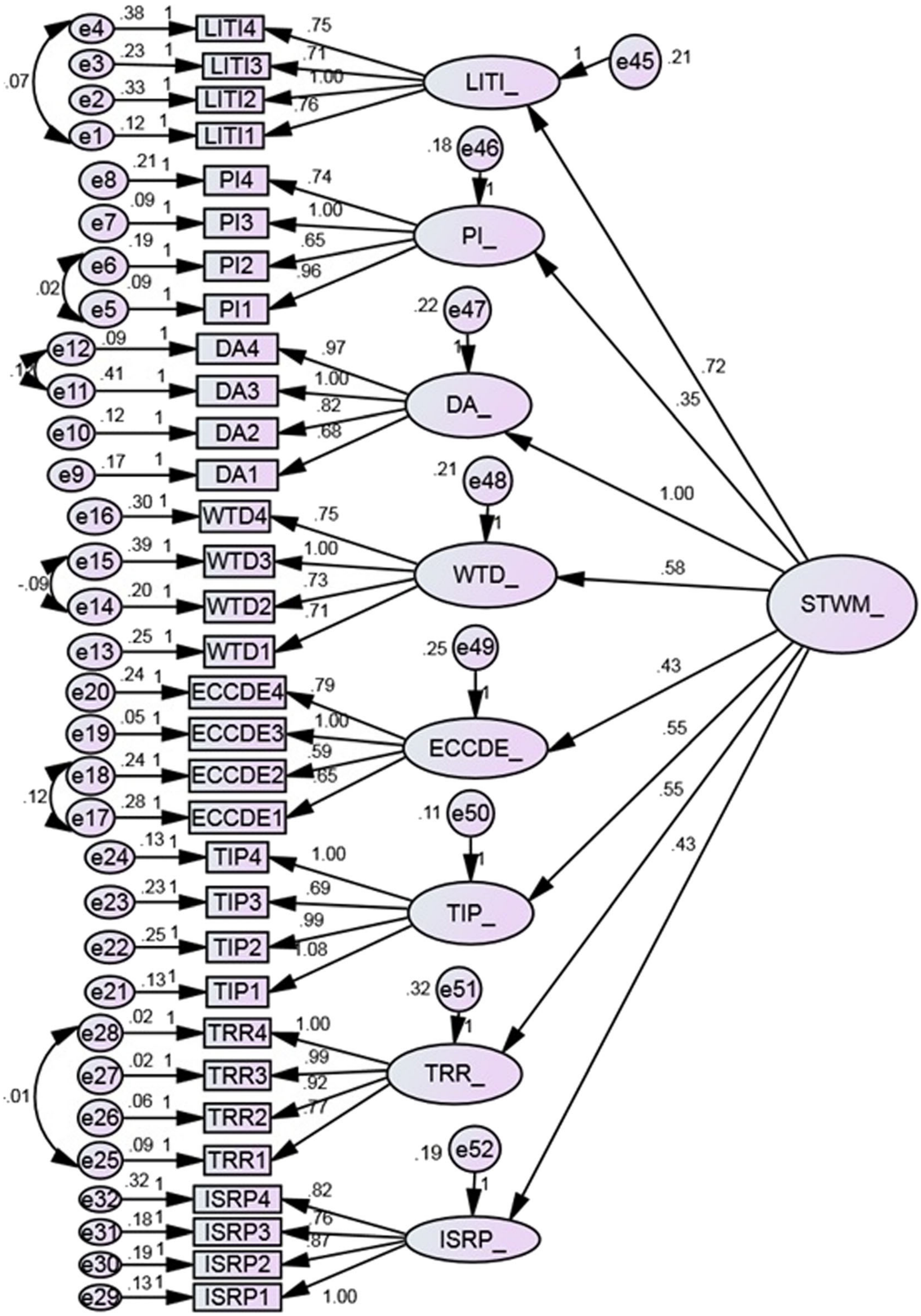

Fig. 3 Second-order CFA measurement model

Table 8 Goodness of fit indices for the proposed model (model fit indices for second order)

Goodness of fit indices	Structural model	Desired levels (Živkovi'c et al. 2017)
Chi-square/degree of freedom (χ^2/df)	1.708	0.02–4.80
Goodness of fit index (GFI)	0.843	0.75–0.99
Adjusted goodness of fit index (AGFI)	0.815	0.63–0.97
Normed fit index (NFI)	0.837	0.72–0.99
Comparative fit index (CFI)	0.924	0.88–1.00
Root mean square error of approximation (RMSEA)	0.052	0.00–0.13
Minimum chi-square (CMIN)		

extracted (AVE), composite reliability (C.R), average shared variance (ASV), and maximum shared variance (MSV) respectively. As per the standard literature available for validation of the above criteria, the AVE should be either greater than or equal to 0.50 and CR should be greater than or equal to 0.60 (Bagozzi and Yi 1988) and criteria for ensuring discriminant validity are MSV < AVE and ASV < AVE (Hair et al. 2006) and squared multiple correlations was also within the range. Table 7 shows the estimate (standardized), standard error (SE), critical ratio for regression weights (CR), and squared multiple correlations. The squared multiple correlations (r^2) values were adequately higher with the ranging from 0.290 to 0.960. Hence, all the constructed eleven factors were a good fit due to the squared multiple correlations (r^2) values and

Table 9 Goodness of fit indices for the proposed structural model (model fit indices for multi-factor factor analysis)

Goodness of fit indices	Structural model	Desired levels (Živkovi'c et al. 2017)
Chi-square/degree of freedom (χ^2/df)	1.805	0.02–4.80
Goodness of fit index (GFI)	0.780	0.75–0.99
Adjusted goodness of fit index (AGFI)	0.753	0.63–0.97
Normed fit index (NFI)	0.752	0.72–0.99
Comparative fit index (CFI)	0.870	0.88–1.00
Root mean square error of approximation (RMSEA)	0.055	0.00–0.13
Minimum chi-square (CMIN)	1598.387	

confirmed that the factors were unidimensional. Again, the critical ratio for regression weights (CR) value in the test statistics was higher than 1.96 with probability $p < 0.05$.

However, the composite reliability for all the factors was higher than the 0.7, but the average variances extracted for one factor was closer to 0.5, but the factor wastewater treatment and disposal (WTD) average variance extracted was marginally lower. These results suggest that the internal consistencies of the constructs are satisfactory. In conclusion, it can be stated that all constructs are reliable.

3.6 Second-Order Structural Model Evaluation

The eight selected factors of sustainable wastewater management were found adequate goodness of fit indices achieved (Hair et al. 2006). The second-order model (Fig. 3) evaluation estimates the following criteria such as the goodness of fit index (GFI) as 0.843, within the recommended threshold of 0.75–0.99, AGFI was acceptable at 0.815, higher than the recommended minimum of 0.63–0.97, normed fit index (NFI) was 0.837, the recommended range was 0.72–0.99, and comparative fit index (CFI) was 0.924, higher than the threshold range 0.88–1.00. The root means square error of approximation (RMSEA) of 0.052 was adequate since it was between 0.00 and 0.13. The evaluation of the other index of the normed chi-square was established to be 0.5 thresholds with $\chi^2/df = 1.708$ as recommended by Schumacker and Lomax (2004). It was concluded that the overall assessment of the criteria for model fit was acceptable for the eight

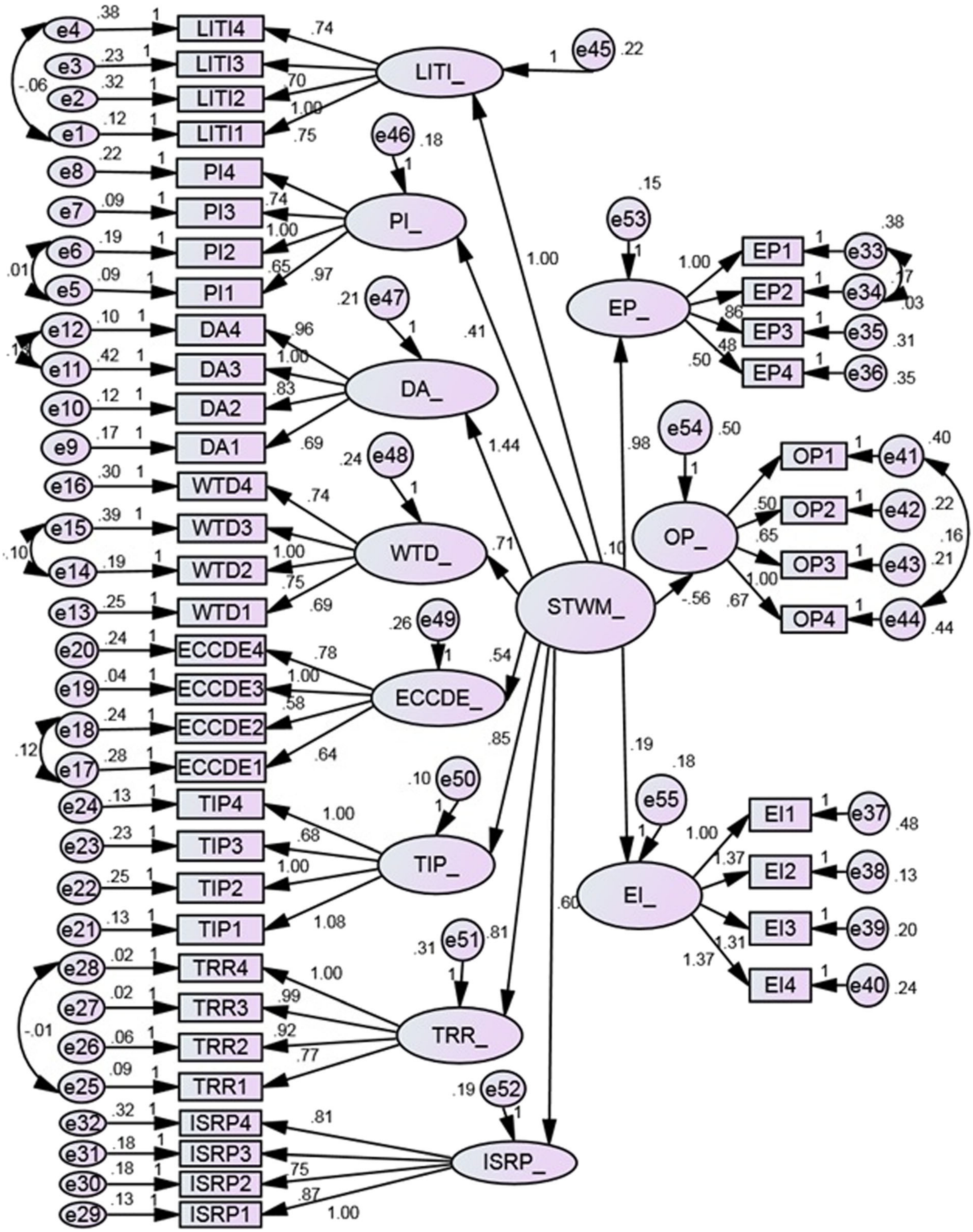

Fig. 4 Multi-factor structural model

items using second-order confirmatory factor analysis in its validation (Table 8).

3.7 Multi-factor Analysis

As seen in Table 9, all the parameters of the structural model conform to be recommended values, and the measurement model fits the data well (Fig. 4). Most of the settings are within prescribed boundaries. The goodness of fit index (GFI) was 0.780, within the prescribed threshold of 0.75–0.99, AGFI was acceptable at 0.753, higher than the recommended minimum of 0.63–0.97, normed fit index (NFI) was 0.752, the recommended range was 0.72–0.99, and comparative fit index (CFI) was 0.870, higher than the threshold range 0.88–1.00. The root means square error of approximation (RMSEA) of 0.055 was adequate since it was between 0.00 and 0.13. Nevertheless, all the indicator sub-factors loaded highly and signed on to their respective factors. Also, all the constructs of the structural model were positively correlated with each other.

4 Conclusions

1. The finding of the present research work was a successful construction of a structural model for the understanding of the sustainability of textile wastewater management in textile sectors. This study also helps the waste management researchers identify the major factors along with their sub-factors during the manufacturing of textile products.
2. The total variance was 67.106 percentages obtained with more than one eigenvalues. The skewness and kurtosis were in the range of ± 1.5 for each sub-criteria in the present analysis. The squared multiple correlations (r^2) values were adequately higher (ranging from 0.290 to 0.960). Hence, all the constructed eleven factors were a good fit due to the squared multiple correlations (r^2) values that confirm that the factors were unidimensional.
3. The KMO values of the factors lie between 0.80 or 0.90, which was higher than 0.60 and suggested that the inter-correlation matrix was almost ideal for factor analysis.
4. However, in first-order confirmatory factor analysis, the composite reliability for all the factors was higher than the 0.7, and the average variances extracted for one factor was closer to 0.5, but for WTD, the average variance extracted was marginally lower. These results suggest that the internal consistencies of the constructs are satisfactory.
5. Whereas in the second-order structural model analysis, the criteria goodness of fit index (GFI) was 0.843, AGFI was 0.815, normed fit index (NFI) was 0.837, comparative fit index (CFI) was 0.924, and the root means square error of approximation (RMSEA) was 0.052 respectively. Hence, it was concluded that the overall assessment of the criteria for the model fit was acceptable for second-order confirmatory factor analysis in its validation.
6. Finally, by constructing multi-factor analysis, the goodness of fit index (GFI) was 0.780, AGFI was acceptable at 0.753, normed fit index (NFI) was 0.752, and comparative fit index (CFI) was 0.870 respectively. The root means square error of approximation (RMSEA) of 0.055 was adequate since it was between 0.00 and 0.13. Hence, all the indicator sub-criteria loaded highly and signed on to their factors and therefore, the structural model were positively correlated with each other.
7. Therefore, based upon the present proposed structural model, the concept may be implemented in any textile industry in India for the sustainability of textile wastewater management principle as a case study analysis.

Acknowledgments The authors are grateful for all the HR managers and workers of textile industries for their active participation in the present survey to shape the initial draft for the sustainability of textile wastewater questioner, and their comments made for successful development of a valid structural model.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Appendix

Table 10 Information on environmental sustainability in textile wastewater management in India

Sl No.	Content	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1.	Labor input in the textile industry	1	2	3	4	5
a)	Increase in employee wages					
b)	Difficulty in recruiting general staff					
c)	Low rate of worker retention					
d)	Difficulty in recruiting engineer staff					
2.	Policy implications	1	2	3	4	5
a)	Unstable political and social conditions					
b)	Underdeveloped infrastructure (electric power, transportation, communications, etc.)					
c)	Unclear policy management by the local government					
d)	Complicated tax procedures					
3.	Dyes and additives	1	2	3	4	5
a)	Basic dyes, mordant dyes, and acid dyes (silk, wool, nylon (ionic bond))					
b)	Direct dyes and disperse dyes (cotton, polyester, acetate (ionic bond))					
c)	Vat dyes and sulfur dyes (cotton, cellulose (dye precipitated in the fiber))					
d)	Azoic dyes and reactive dyes (cotton, cellulose (covalent binding))					
4.	Wastewater treatment and disposal	1	2	3	4	5
a)	Landfill					
b)	Agricultural use					
c)	Recovery					
d)	Building and construction materials					
5.	Energy consumption and carbon dioxide emissions	1	2	3	4	5
a)	Implementation of a certified Energy-Management-System according to ISO 50.001 as requested by public bodies or customers					
b)	Energy footprint of a production order/article regarding the energy consumption in my company					
c)	Post calculation: comparison of actual and planned costs in order to identify significant deviations					
d)	Establishing services to support carbon-emissions trading (forecast, sourcing)					
6.	Textile industry productivity	1	2	3	4	5
a)	Regulation influenced technology transfer and R&D activities of your firm					
b)	Has the flow rate of productivity change					
c)	Have you adopted to improve productivity?					
d)	Have you plan to increase the degree of automation of your production					
7.	Textile reuse and recycling	1	2	3	4	5
a)	Reuse (run your own store)					
b)	Reuse (sell to non-profits or other businesses)					
c)	Reuse (sell to a broker)					
d)	Recycling					
8.	Improvement of sustainability-related performance	1	2	3	4	5
a)	Sludge disposal efficiency					
b)	Efficiency of sludge treatment					

Table 10 (continued)

Sl No.	Content	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
c)	Weighted average reagent consumptions					
d)	Sustainable performance measurement for textile wastewater treatment plants					
9.	Economic performance	1	2	3	4	5
a)	Reduction in costs through improved efficiency of production and sales					
b)	Expand the range of low price products/services					
c)	No measures have been taken					
d)	Increased efficiency through management integration within the group					
10.	Environmental impact	1	2	3	4	5
a)	Stricter environmental regulations					
b)	In your view, has air pollution ever affected your health					
c)	Apart from effects on people's health, are you aware of any other effects of air pollution					
d)	Jobs today are more important than protecting the environment for the future					
11.	Operational performance	1	2	3	4	5
a)	Brand identity is strong and established					
b)	Goodwill is already earned due to old customers in the market					
c)	Old customer relationship and retaining them successfully					
d)	Quality of the fabric is up to the mark					

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