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The Role Of Agile Practices And Green Innovation On Environmental Sustainability Through Waste Reduction In Indian Garment Manufacturing

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Abstract

The growing urgency to foresee environmental challenges organizations are increasingly adopting strategies that efficiently support environmental sustainability. This study investigates the role of agile practices and green innovation on waste reduction and tested how waste reduction in turn contributes to environmental sustainability. The study provides insights on how organizational strategies in the highly digitalised era can be integrated to enhance environmental sustainability by emphasising waste reduction as major source for environmental sustainability procurement. By analysing the linkage between the variables, the study demonstrated waste reduction in garment sectors as the pivotal factor that forces to integrate green innovation ands agile practices. The study used Smart-PLS structural equation modelling method to test the framed research framework, the study respondents are the production or operation managers of garment industries, the study results revealed that agile practices of the organization and green innovation strategies have significant and positive influence eon waste reduction, and waste reduction significantly contributes to environmental sustainability.

Keywords: *Agile Practices, Green Innovation, Waste Reduction, Environmental sustainability.*

Introduction:

The garment manufacturing sector is one of the most leading sectors in the global context, considered as high resource intensive industry, also it contributes significantly to the degradation of the environment, through the waste of textile, pollution from chemicals used in garment making process and the level of energy used (Niinimäki et al., 2020; Hasanbeigi & Price, 2015). Garment sector remains the most waste intensive and resource intensive industrial sector leading for significant consumption of water, in efficient resource utilization and CO_2 emission, The dynamic and rapid changes in fashion trends along with increased demand of the consumer towards fast fashion are considered as the most countable reason for waste generation in garment industries, that forces the industry to implement innovative strategies that support environment sustainability (Claudio, 2007; Fletcher & Tham, 2019). Adoption of agile practices are observed beyond IT Sectors to provide customer centric services, continuous improvement and emphasize adaptability, agile practices are observed in the context of manufacturing sector (Highsmith, 2002; Conforto et al., 2016). The concept of agile manufacturing enabled in view of flexibility, rapid responsiveness to show efficiency in the context of textile (Gelmez and Zerenler, 2020). The garment sector adopts agile practices to respond to the highly volatile market changes mainly to reduce over production and efficient inventory management (Christopher et al., 2004; Purvis et al., 2014). Agile manufacturing practices are not specific only to IT sector but it has been deployed in fast paces production and manufacturing sector due to the advanced technological transformations. (Yusuf, et al., 1999). The agile practices enhance adaptive planning, collaboration and responding effectively to the market fluctuation and environmental sustainability. Stated how agile capacities work as dynamic capacities in enhancing environmental, operational and social aspects of performance (Ding et al., 2023). Hence it is highly observed that there is a need for exploring strategies that reduces wate and enhances operational

performance of organization. Green Innovation concept is described as a process, product and practices that helps in eliminating environmental harm and drives sustainable manufacturing (Chen et al., 2006). In the garment sector green innovation is design to reduce waste of textile resource consumption with the support of cleaner technologies, circular production method and advancement in sustainable materials (Bocken et al., 2014). It is found that there is growing body knowledge through research is available to highlight the importance of linking (Rabal-Conesa et al., 2022). This study explored the role of green innovation and agile practices mainly in the context of reducing environmental harm generates through garment industry, the study provides theoretical insights to link this knowledge gap; by exploring the integration of agile practices and green innovation the study aims to share knowledge to the literature that support environmental sustainability framework as linking agile practices with green innovation provides a efficient route to point environmental challenges in the context of garment industry (Meidute-Kavaliauskiene et al., 2021). The study variables Agile practices and green are majorly explored with their individual potential, their integrated influence on environmental sustainability practices are found to be limited (Karaosman et al., 2020). This study explored how the integration of agile practices and green innovation can enhance environmental sustainability.

Literature Review

Agile Practices, Green Innovation, Waste Reduction and Environmental Sustainability

Recent research studies have investigated strategies for waste reduction in the context of garment industry that includes agile practices and lean manufacturing (Surdadi & Ahmad et al., 2023). The four elements such as 4R that consist of Reduce, Recycle, Reuse and Recover has been examined as the most important metrics for waste reduction process (Kazerooni Sadi et al., 2012). Explored integrating agile methods and practices in apparel industry resulted in waste reduction (Al Samman, 2014). Studies after use waste management practices of textile consumer in the circular economy (Santos & Campos, 2021).

Environmental crisis and scarcity of resources have made firms to focus on integrating sustainable strategies to positively contribute to the environment. One of the main strategies to retaining environmental sustainability through the organizational practices is green innovations. Green innovations are the development and applications of deploying organizational practices to provide products, products and practices beneficial to the environment, the concepts of green innovation highly linked with waste reduction efficiency in the organizations (Chen et al., 2006). Green Innovation is classified into three types such as green product, green process and green firm innovation (Dangelico & Pujari, 2010). Green organizational innovation deploys strategic alignment cultural shift to achieve waste reduction in the organization (Horbach et al., 2012). From the literature it is observed that the researcher established a link between green innovations aspects with organizational waste reduction (Cherrafi et al., 2018). conducted a systematic review to predict how eco-friendly products enhances waste management (Ghormare et al., 2024). Stated entrepreneurs in digitalised era deploys green practices to enhance waste management yet the concept of waste reduction in vast industrial sector is limited (Mondal et al., 2023). Though the knowledge on the linkage between green innovation and waste reduction is available still linking these variables to agile practices and environmental sustainability is highly recommended to understand how these factors support green innovations and in turn how it achieves environmental sustainability

The garments sectors continuous efforts to contribute to waste reduction management provided a positive note to the circular economy in making the sustainable environment (Saha et al., 2022). The practices of environmental sustainability in garment sector prevailed utmost need for ecological footprint transformation (Niinimäki et al., 2020). Research proves that integrating circularity in manufacturing sector reduces waste of textile and enhances sustainable environment and huge improvements are evident in exploring organizational based sustainable practices however, a gap is still there in understanding the durability and economic viability in long run of these efforts mainly in developing economics (Keßler et al., 2021).. It also observed that very few research studies have been explored that examined the zero waste

policies or waste reduction strategies in the domain of agile practices and green innovation, (Shirvanimoghaddam et al., 2020). Based on the reviewed gaps, further research can focus on collaboration model across regions with the inclusion of waste reduction strategies to measure environmental sustainability in garment industry context

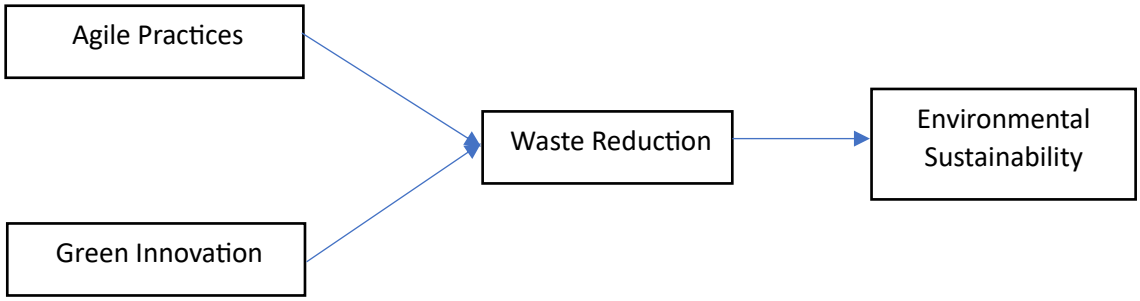

Figure 1: Conceptual Framework

The designed framework explains the influence of agile practices and green innovation on waste reduction of the garment industry and in turn it explores how waste reduction in the garment industry contributes to environmental sustainability.

H1: Agile practices in garment industry significantly influences Waste Reduction

H2: Green Innovation in Garment Industry significantly influences Waste Reduction

H3: Waste Reduction significantly influences Environmental Sustainability

Method

Data collection and sample

Data to investigate the designed research framework were collected from operations/production managers of garment industry in India using a purposive sampling technique. The study applied survey method for collecting data through the distribution of structure questionnaires to the respondents via online and offline modes the study received 233 responses, out of which 227 responses were finalised and the collected data checked for reliability and validity.

Descriptive Statistics:

Table 1: represents the respondents 'demographic data that states 85.46 percentage of the respondents are male and 33 percentage of the respondents are under the age of 31-35 with 36.12 percentage of the respondents holds 6 to 9 years of work experience

Table: 1: Respondents Demographics

Demographic Dimension	Measurement	Frequency	Percentage
Gender	Male	194	85.46
	Female	33	13.92
Age Group	26-30	54	27.78
	31-35	77	33.92
	36-40	45	19.82

	Over 40	51	22.46
Work experience	Less than 3	23	10.13
	3 to 6	82	36.12
	6 to 9	69	30.39
	Above 9	53	23.34

Table 2: Research Instrument

Construct	Source/Author(s)
Agile Practices	(Gelmez, E et al., 2020)
Green Innovation	(Meidute-Kavaliauskiene et al., 2021).
Waste Reduction	Li, C., Ahmad
Environmental Sustainability	

Tables 2 represents scales utilised in the study from the review existing literature. Agile practices, green innovations and wate reduction were measured with 5 items followed the dimension of environmental sustainability consist of 4 items. A total of 19 items with 4 variables were adapted for the study, the items associated with the scale are measure with five-point Likert scale ranging from 1 as strongly disagree to 5 as strongly agree

Data Analysis

The smart PLS Structural Equation modelling method were applied to test the framed hypotheses of the study. PLS-SEM applications are mostly observed in the fields of management, information system and other business fields, PLS-SEM explains variance of dependent variable without considering data distribution assumptions (Hair et., 2011; Sarstedt et al., 2013; Wong, 2013). The study with the applications of SMART PLS-SEM method checked the reliability and validity of the measurement model, four values were considered to test validity and reliability of the study model such as for reliability: composite reliability, average variance explained and Cronbach Alpha. These findings align with established guidelines in psychometrics (Nunnally, 1978) and structural equation modelling (Fornell & Larcker, 1981), for the reliability of the item the outer loading threshold value are expected to higher than 0.7 (Hulland, 1999). After the test result some item are removed due to lower threshold values such as 2 items from agile practices variable and 1 item from environmental sustainability were removed to meet the criterion of the measurement model reliability. In table 3 the values of outer loading, Cronbach alpha, average variance explained are represented the Alpha (≥ 0.70), Composite Reliability (≥ 0.70), and Average Variance Explained (≥ 0.50) of each construct met the threshold value (Bagozzi et al., 1988; Fornell & Larcker, 1981; Hair et al., 2014).

Reliability and Validity of study constructs

The Exploration of Reliability and validity of the research instrument has done by utilising SMART PLS Software.

Table 3: Reliability Test

Dimensions/Items	OL	α	CR	AVE
Agile Practices				
My organization holds required knowledge and skills to manage change.	0.722	0.908	0.911	0.735

My organization respond immediately to connect with the market changes into the production process	0.916			
My organization vision states the need for being flexible and agile to respond to dynamic changes in the market.	0.815			
My organization develops skills to identify and predict market changes	0.850			
My organization develops required technology and technological capabilities to effectively respond to consumer demands	0.924			
Green Innovation				
My organization procures the quality materials for the product that generates the lesser amount of pollution for during product development and design.	0.721	0.818	0.829	0.574
My organization deliberately focused on product is easy to recycle, reuse, and decompose for its development or design.	0.761			
The manufacturing process in my organization minimises the consumption of energy waste such as water, electricity, coal, or oil.	0.790			
The process of manufacturing in my organization reduces the emission of dangerous substances or waste.	0.789			
The process of manufacturing in my organization minimises the use of dangerous raw materials.	0.724			
Waste Reduction				
The waste of my organization gets treated before it leaves facility.	0.785	0.841	0.850	0.612
I believe that changes should be made to technology to reduce waste.	0.833			
I believe that the waste should be recycled for production and to reuse.	0.827			
I believe eco-friendly technology can minimise waste.	0.710			
I believe eco-friendly production can reduce waste.	0.750			
Environmental Sustainability				
My organization actively monitor water usage in our plants.	0.807	0.855	0.858	0.696
My organization actively monitors energy usage in our plants.	0.855			
My organization implement a systematic approach to setting environmental targets.	0.865			
My organization implement a systematic approach to achieving environmental targets.	0.808			

Construct Discriminant Validity

Through discriminant analysis it is observed that the data constructs confirmed Average Variance Extracted (AVE) values for all constructs were above the threshold of 0.5 (Fornell & Larcker, 1981). Discriminant validity was established through the Fornell-Larcker criterion, as inter-construct correlations were lower than the square root of the AVE for each construct (Henseler et al., 2015).

Table 4: Discriminant Validity

	AP	ES	GI
ES	0.813		
GI	0.548	0.569	
WR	0.847	0.827	0.841

Structural Model:

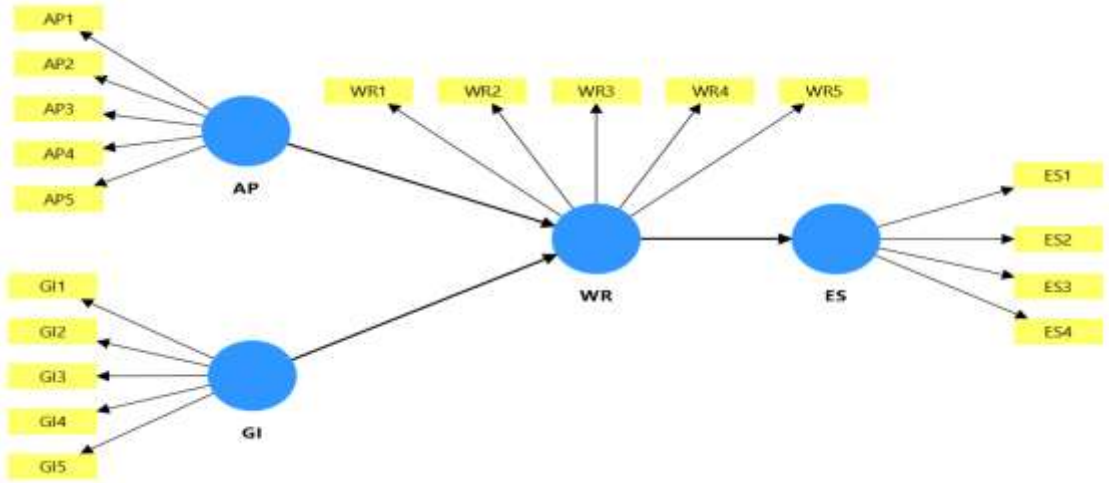

Figure 2: Structural Model

Bootstrapping Model

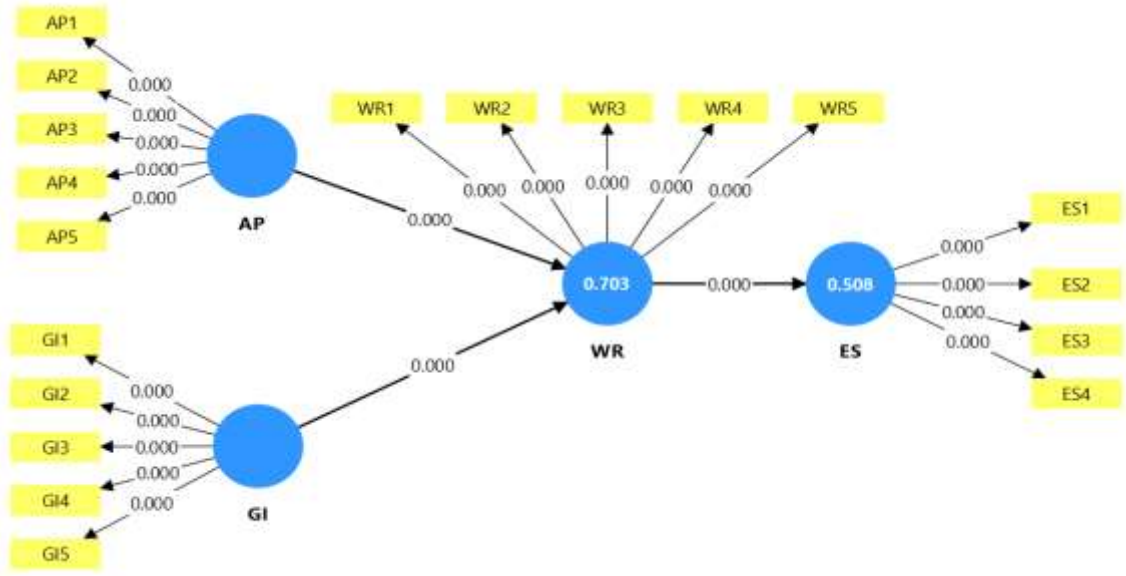

Figure 3: Bootstrapping Model

The data processed for PLS-SEM and Bootstrapping to estimate R^2 value and the path coefficient significant. Through the method of bootstrapping with the support of Smart-PLS software the research can estimate T-statistics for significant testing of the structural path. In this research, 5,000 bootstrap samples were used as suggested by (Hair Jr et al., 2016). The results with the method of bootstrapping are displayed in Table 6 and Table 7.

Table: 5 Results and Discussion

Hypotheses	f^2	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
AP → WR	0.511	0.457	0.460	0.057	8.024	0.000

GI → WR	0.678	0.510	0.511	0.057	9.018	0.001
WR→ ES	1.032	0.713	0.719	0.056	12.623	0.000

From the table it is clearly noted that the variables agile practices and green innovation resulted significant on waste reduction also the role of waste reduction positively signifies the environmental sustainability thus the study hypotheses H_1; H_2; H_3 are supported and signifies the threshold value ($P<0.001$). Also, the estimated R square values of two variables agile practices and green innovation explain 70% of the variance waste reduction and the waste reduction variable explains 50% of the variance on the environmental sustainability. With the notes of (Hair Jr et al., 2016), effect size (f2) (≥ 0.02), defines as weak; (≥ 0.15), moderate and strong respectively (≥ 0.35), f2 values are presented in Table 6, both the variables effect resulted strongly on dependent variable

Conclusion

The study explored the impact of agile practices and green innovation on environmental sustainability with the specific focus on waste reduction factor. The study relied on the context of Indian garment industry, the deployed the structural equation modelling thought the application of Smart-PLS software and estimated the significant of developed hypotheses and the framed research model, the estimated results shown all the variable and their path relationships in framed are model are significant, the f^2 and P-Values resulted with in the threshold values that states the strength and relevance of research model. To test the reliability and validity of the measurement model Cronbach alpha, composite reliability and average variance explained were estimated and the estimated values met the criteria and signified that the consistency the construct and model, the discriminant validly confirmed through Fornell-Larcker method. The results of the study pointed that there is significant contribution of variables agile practices and green innovation on waste reduction and waste reduction significant contributes to environmental sustainability. The findings of the study suggests that the firms or organizations focusing on enhancing sustainability of the environment should concentrate on deploying agile practices in the organization that support greed innovation initiative, as these practices support reduction in waste and enhances sustainability of the environment

Limitation and future scope

Although the research study provides valuable information, the study has limitations that need attention and consideration. Firstly, the study focused on Indian garment sector, that limits the finding applicability to other various sector and context with different cultural, environmental and operational contexts. Secondly, the research model is direct impact model and did not explore any mediators or moderators. Third, the use on complete quantitative method the research could have obtained for qualitative research by conducting interview or case studies among experts. Fourth, the study could include external environmental factor which could other side of insights for better environmental sustainability. Future research could consider expanding the research to other industrial sector such as automative and electronics, to examine how the variables impact overtime with each other longitudinal research could be conducted in the future research

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